Akalank's

INDIAN BOILER REGULATIONS

अकलंक पब्लिकेशन
akalank publications

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Akalank's

INDIAN BOILER REGULATIONS

containing

INDIAN BOILERS REGULATIONS, 1950

and

INDIAN BOILERS ACT, 1923

NARENDAR KUMAR JAIN
AKALANK KUMAR JAIN

अकलंक पब्लिकेशन्स
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A WORD FROM PUBLISHERS

Patrons of our Publications have encouraged us to bring out the **eleventh edition** (*revised and updated*) of ***Akalank's* Indian Boiler Regulations**. Our 1st single volume edition (5th Edition, 1998) was much appreciated by our readers. This edition of book is revised by all Gazette Notifications issued by Central Boilers Board, New Delhi published in Gazette of India till date. The Boilers Act, 1923 as amended by the Boilers (Amendment) Act, 2007 (Act 49 of 2007) is given after the Indian Boilers Regulations. All out, efforts have been made to make the book upto date and fool proof in all respects. All the Diagrams, Drawings and Graphs have been incorporated after the relevant Chapter(s), Regulation(s), Para(s) or Appendix for the purpose of quick reference of our valued readers.

However, suggestions pertaining to improvement of the book are always welcome and shall be duly considered. Moreover, we have incorporated the suggestions received from our readers in this edition.

We trust that the book will be of immense practical utility to all Boiler users, manufacturers, engineers, inspecting authorities and all those concerned with the subject matter. The book is widely referred and appreciated by readers in India and in other Countries.

To serve the people is our objective. We have already published the book on Delhi Master Plan (MPD-1962, MPD-2001, MPD-2021), Master Plan for NCR Delhi, Delhi Municipal Corporation Act, Specifications, New Delhi Municipal Council Act, Drugs and Cosmetics Act & Rules, Mandal Commission Report, Environment & Pollution Control Laws, Water Supply & Treatment, Civil Accounts Manual, Statutes of India and Delhi Local Laws, Central Civil Services Rules, etc. We had also published books under special arrangements with International Code Council, USA. If our patrons have any suggestion or any compilation worth publishing, we shall, feel it our pleasure to discuss it with them for its publication.

The Publishers

Dedicated to My Mother

Late Mrs. Raj Rani Jain

(14-11-1947 — 6-2-2007)

Akalank Kumar Jain

INDIAN BOILER REGULATIONS

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INDIAN BOILER REGULATIONS

S.R.O. 600 (New Delhi, the 15th September, 1950)—In exercise of the powers conferred by section 28 of the Indian Boilers Act, 1923 (V of 1923), and in supersession of the Government of India Notification No. A. 470, dated Simla, the 27th October, 1936, the Central Boilers Board is pleased to make the following Regulations, the same having been previously published as required by sub-section (1) of section 31 of the said Act, namely:

REGULATIONS

PRELIMINARY

1. Short Title, Extent, Application and Commencement

(1) These Regulations may be called the Indian Boiler Regulations, 1950.

(2) They extend to the whole of India, except [1][The State of Jammu and Kashmir].

(2a) These Regulations shall apply to all boilers including those working on the principles of natural circulation, forced circulation and forced flow with no fixed steam and water line.

(3) [2]They shall come into force at once.

2. Definitions

In these Regulations, unless the context otherwise requires:—

(a) The "Act" means the Indian Boilers Act, 1923;

(b) "Accident" means an explosion of a boiler or steam-pipe or any damage of a boiler or steam-pipe which is calculated to weaken the strength thereof so as to render it liable to explode;

(c) "Boiler" means any closed vessel exceeding 22.75 litres (five gallons) in capacity which is used expressly for generating steam under pressure and includes any mounting or other fitting attached to such vessel, which is wholly or partly under pressure when steam is shut off;

(cc) "Calculation Pressure", in relation to a boiler, means the design pressure of any part adjusted to take into account the pressure drops corresponding to the most severe conditions of pressure drop and hydraulic head;

(d) "Chief Inspector" and "Inspector" means, respectively, a person appointed to be a Chief Inspector and an Inspector under the Act;

1. In the said Regulations, in clause (2) of Regulation 1, for the words and letter "except Part B States" the words "except the State of Jammu and Kashmir" shall be substituted.
2. 15th September, 1950. See Gazette of India, Extraordinary, Part II, Section 3, dated the 15th September, 1950. pp. 607 to 825.

All Diagrams/Drawings in this book are not to scale.

(dd) "Competent Authority" means an authority recognised by the Central Boilers Board in the manner as laid down in regulations 4A to 4H, as competent to issue certificates to welders for the purposes of regulation 4(b)(ii) and regulation 605;

(ddd) "design pressure" means—

(i) in relation to a natural or assisted circulation boiler, the maximum allowable working pressure in the steam drum of the boiler;

(ii) in relation to a once through forced-circulation boiler, the maximum allowable working pressure at the final superheater steam outlet;

(e) "Economiser" means any part of a feed-pipe that is wholly or partly exposed to the action of flue gases for the purpose of recovery of waste heat;

(ee) "Evaluation Committee" means a committee constituted by the Central Government consisting of—

(a) Technical Adviser (Boilers)	—Chairman
(b) Chief Inspector (Boilers) of the State where the unit is located	—Member
(c) a representative of the manufacturers of boilers/ancillaries in public sector	—Member

(f) "feed-pipe"—

(i) means any pipe or connected fitting wholly or partly under pressure through which feed-water passes directly to a boiler;

(ii) every reference to a steam-pipe or steam-pipes shall be deemed to include also a reference to feed-pipe or feed-pipes respectively;

(g) "Inspecting Authority" means an authority recognised by the Central Boilers Board in the manner as laid down in regulations 4A to 4H, as competent to grant a certificate in Form II, IIA or IIB;

(h) "Inspecting Officer" means—

(i) in respect of material manufactured or boilers constructed in any State an officer appointed by the Inspecting Authority in that State;

(ii) in respect of material manufactured or boilers constructed outside the State an officer acting on behalf of the Inspecting Authority;

(iii) in respect of,—

(a) approval of drawings of boilers of parts thereto with minor changes, where necessary, except for the drawings of the first set of boilers or parts thereof;

(b) inspection at stages of manufacture including examination of repairs;

(c) signing and issue of certificates in the relevant forms except for the certificates of the first set of boilers or parts thereof;

an officer acting on behalf of an Inspecting Authority;

(hh) "Liaison Sub-Committee" means a committee constituted by the Central Boilers Board under bye-law 3(i)(e) of the Bye-laws of the Central Boilers Board;

(i) "owner" includes any person using a boiler as agent of the owner thereof and any person using a boiler which he has hired or obtained on loan from the owner thereof;

(j) "prescribed" means prescribed by regulations or rules made under the Act;

(k) "Steam-pipe" means any pipe through which steam passes from a boiler to a prime-mover or other user or both, if—

(i) the pressure at which steam passes through such pipe exceeds 3.5 Kilograms per square centimetre above atmospheric pressure; or

(ii) such pipe exceeds 254 millimetres in internal diameter; and includes in either case any connected fitting of a steam-pipe.

(l) "State" or "States" means a State or the States to which these regulations extend;

(m) "Structural alteration, addition or renewal" shall not be deemed to include any renewal or replacement, of a petty nature when the part of fitting used for replacement is not inferior in strength, efficiency or otherwise to the replaced part or fitting; and

(n) "Technical Adviser (Boilers)" means Technical Adviser (Boilers) to the Government of India in the Ministry of Industry (Department of Industrial Development).

CHAPTER I

GENERAL REQUIREMENTS, APPLICATION OF STANDARD CONDITIONS AND EXCEPTIONS THERETO

3. General requirements, application of standard conditions and exception thereto

(1) A boiler shall not be registered under sub-section (4) of Section 7 of the Act and a certificate shall not be issued under sub-section (5) of that section with reference to a boiler, unless the standard conditions in respect of material, design and construction, which are specified in the subsequent Chapters of these Regulations, are satisfied in respect of such a boiler.

(2) Notwithstanding anything contained in sub-regulation (1), the Chief Inspector may, subject to the provisions of regulations 7 and 8, register a boiler and order the issue of a certificate authorising the use thereof, under any of the following circumstances, namely—

(i) when the material used in the construction of a boiler, steam-pipe, economiser or superheater is not in conformity with the Indian Boiler Regulations but is known to be commonly used in other countries as being suitable for use in the construction of boilers and steam-pipes, provided that such material is not specifically prohibited by the Regulations and that the methods of manufacture, fabrication and heat treatment conform to the specified Codes or Standards;

(ii) when the constructional features of a boiler, steam-pipe, economiser or superheater are not in conformity with the Regulations but are not considered by the Chief Inspector to be inferior in strength to those prescribed in the Regulations and form part of the usual manufacturing practice of boilers and steam-pipes in other countries;

(iii) when a boiler, steam-pipe, economiser or superheater has obviously been built in conformity with the regulations but no certificate as required under the regulations is forthcoming.

(3) No structural part of a boiler, which is subject to pressure, shall be made of Bessemer process steel or of Cast or Malleable Cast Iron.

(4) Where no specific provision is made in these regulations for design or manufacture of any pressure part, the Inspecting Authority may permit the design, manufacture, stage inspections and certification of such pressure parts including the valves, mountings and fittings conforming to the Codes or Standards like BS, ASME Boiler and pressure vessel code, TEMA, TRD, GOST and JIS, which are known to be commonly used in industrially advanced countries. The decision of Inspecting Authorities shall be binding on all Registering Authorities.

(4A) The tubes of boilers and heat exchangers made of Titanium and other exotic metals may be approved as per international codes, including ASME, BS, DIN, TEMA with the minimum thickness specified in those codes of manufacture.

3A. Inspection of Boiler to comply into any Foreign Code

Notwithstanding anything contained in these regulations, the Inspecting Authority may inspect any boiler meant for export during the various stages of its construction so as to comply with the requirements of any foreign code and may grant a certificate in Form IIA.

STANDARD REQUIREMENTS

4.

(a) Material—All plates, rivets and bars used in the construction of boilers shall be tested and found to conform with the Regulations hereinafter contained.

(b) Construction—(i) All boilers during construction shall be under the supervision of an Inspecting Officer and shall be inspected at all stages of construction prescribed in Appendix J. Tubes and steam-pipes shall also be inspected at the makers' works at the stages prescribed in Appendix J, and the tests conducted by the makers shall also be witnessed by the Inspecting Officer.

(ii) Welders engaged in site welding of boilers, steam-pipes, economisers and super-heaters shall possess and produce to the satisfaction of the Chief Inspector the Welders Performance Qualification Certificate issued by a Competent Authority.

(c) Certificates, etc. under Sec. 14(1)(c) of the Act—In advance of or alongwith an application for registration of a boiler the following certificates and drawings or specifications shall be furnished to the Chief Inspector, namely:—

(i) *A certificate in Form II*—From an Inspecting Authority certifying that the material was tested and the boiler was built under their supervision. Together with such certificate the Inspecting Authority may furnish a Memorandum of Inspection Book in Form I prepared in the manner prescribed by Regulation 386 in respect of the Inspection of the boiler during construction and the hydraulic test applied on completion. In case of a boiler which is to be assembled only at site, requirement of the hydraulic test on a completely assembled boiler by the Inspecting Authority shall not apply provided that the individual parts of such boiler have been hydraulically tested and certified by the Inspecting Authority separately as required under these Regulations.

In case of Waste Heat Boilers, a certificate in Form II may be issued by the Inspecting Authority of the State, where the boiler is installed, after completion of construction at site on the strength of the certificate supplied to him in prescribed forms by the owner for the individual components which are required to be furnished for registration of a boiler under Regulation 4(c), shall be submitted to the Inspecting Authority of the State, where the boiler is installed, before the commencement of construction of such boiler at the site.

(ii) A certificate in Form III of manufacture and test signed by the maker or by a responsible representative of the maker of the boiler containing a description of the boiler, its principal dimensions, particulars of the kind of material used in its construction, the thickness of all plates, the diametre of and method of forming the rivet holes in the shell plates, particulars of any departure from ordinary practice in making the shell, such as, solid rolling or welding, the hydraulic test to which the boiler was subjected, the intended working pressure, the area of heating surface, the maximum continuous evaporative capacity, the year and place of make, and the works number of the boiler.

Note: The Chief Inspector may, however, approve a modified form of certificate wherein items which do not pertain to a particular may be omitted.

(iii) A drawing or print to a scale, in the case of large boilers of not less than 3/4 inch to the foot and in the case of small boilers of not less than 1½ inches to the foot, showing the principal dimensions and a longitudinal section and even view of the boiler of bearing the works number of the boiler and Maker's office stamp. The drawing shall show details of riveting of longitudinal and circumferential seams with pitch of rivets, cross spacing of rivets rows and diameters of rivet-holes, the radii of curvature of dished end plates, fillets and flanges and corners of bent plates, and where gusset stays are fitted the number and diameter of rivet holes in each gusset stay.

In the case of water tube boilers, the foregoing scales shall apply to the main boiler drums only, but in addition a general arrangement drawing of the boiler to a scale of not less than ¼ inch to the foot shall be provided.

Note: For pressure parts, assembly drawings of boiler capacity 200 MW and above, the scale to be used is 1:50 for drum and 1:100 for General Assembly drawing.

(iv) A certificate in Form IV from the steel maker and a certificate from the maker of the plates, rivets or bars, of the nature referred to in Regulations 26 and 27 respectively. The certificate from the maker of the plates, rivets or bars, shall show the charge numbers, the plate or bar numbers and the number and dimensions of the various plates etc. tested, their chemical analysis, their ultimate tensile breaking strength in tons per square inch of section, the percentage of elongation and the length on which measured, the number, kind and result of bend or other tests made and the date of tests:

Provided that where an Inspecting Authority furnished a certificate in Form II together with a Memorandum of Inspection Book in Form I in accordance with sub-regulation (c)(i) the certificates prescribed under clauses (ii) and (iv) need not be furnished to the Chief Inspector when application is made for registration of the boiler. But should any question arise in respect of the fitness of the boilers for the working pressure approved by the Inspecting Authority within a period of three years from the date of their registration, the owner shall if requested by the Chief Inspector obtain and furnish the original documents specified in the said clauses:

Provided further that in respect of the steel made and tested by Well-known Steel Makers recognised by the Central Boilers Board in the manner laid down in regulations 4A to 4H, a certificate of Well-known Steel Maker in Form IVA shall be accepted in lieu of a certificate from an Inspecting Authority:

Provided also that in respect of the tubes/pipes made and tested by well-known tube/pipe maker recognised by the Central Boilers Board in the manner as laid down in regulations 4A to 4H, a certificate of manufacture and test of well-known tube/pipe maker in Form IIID or IIIE, as the case may be, shall be accepted in lieu of a certificate from an Inspecting Authority.

In case where the original certificate from well-known steel makers in Form IV is not produceable, owing to such certificate containing details of plates used for other purposes also, an extract from the original certificate duly signed by the makers of the boiler and countersigned by the Inspecting Authority shall be acceptable in lieu of the certificate in Form IV, provided all information required in Form IV and furnished in the extract.

(v) In the case of fusion welded drums of diagram of welded repairs and temperature charts of heat-treatment shall also be furnished.

In addition, certificates in respect of yield point at service temperature (0.2 per cent proof stress), the average stress to produce an elongation of 1 per cent (creep) in 100,000 hours and the average and the lowest stresses to produce rupture in 100,000 hours in the material, wherever is applicable, are to be furnished.

(vi) For tubes and pipes subject to internal pressure, a certificate giving results of tests regarding chemical analysis, warm yield point (0.2 per cent proof stress), the average stress to produce an elongation of 1 per cent (creep) in 100,000 hours and the average and the lowest stresses to produce rupture in 100,000 hours in the material wherever applicable, shall be furnished:

Note: Until 33,000 hours tests are carried out by National Metallurgical Laboratory or Corporate Research and Development Laboratory of Bharat Heavy Electricals Limited for collecting elevated temperature data of alloy steel produced indigenously against ASME or BS or EN Code, these grades of steel may be accepted and long time elevated temperature properties/maximum allowable stress values given in ASME or BS or EN Code, as the case may be, may be used for the purpose of design.

Provided that:

(I) a certificate is furnished by the producer of the steel to the effect that the steel has been manufactured strictly in accordance with the technical requirements of the ASME or BS or EN Code to assure that the creep rupture requirements are complied with.

(II) the Steel maker furnishes the necessary certificate that the steel conforms to the chemical analysis, room and elevated temperature mechanical properties given in ASME or BS or EN Code as the case may be.

(III) the short-term stress-rupture tests for 1000 hours as described below are carried out by NML/Steel Plants for the purpose of checking whether the steel is up to the specification and also to ensure that the Steel is capable of meeting the long-term rupture stress values/maximum allowable stress values given in ASME or BS or EN Code, as the case may be, and a certificate is given by NML/Steel plant to this effect.

(IV) two numbers of 1000 hour creep rupture tests shall be carried out at a temperature 50°C above the service temperature for each grade of steel for tubing or piping or castings or plates grades; when in furnace and/or in superheater zone. However, the forging to be used in valves should be tested at 550°C for 1000 hours. The stress to cause rupture in 1000 hours at above temperatures may be taken from the master curve corresponding to—20% line. At this stress, a minimum rupture life of 1000 hours is expected. Both the samples should pass 1000 hour tests at the above stress and temperature. These samples may be selected at random by the Chief Inspector of Boilers of the respective State. The samples could be in the form of semi-finished products, say, forged bars of about 25 mm^2 which will undergo heat treatment as prescribed by the relevant specifications.

(vii) For such boilers having a capacity of 20 Tons per hour and above which are required to be assembled at site, the mountings may be supplied separately. All boilers of capacity less than 20 Tons per hour shall carry all the mountings or fittings certificates in respective forms with details mentioned in Form III, issued at the time of manufacture of boilers.

(d) Maker's Stamp—The boiler shall have stamped upon its front plate in a conspicuous position the following particulars:

MAKER'S NAME

Work's Number....................... Year of Make....................... Tested to....................... Lbs....................... on....................... W.P. .... Lbs. ....

Inspecting Officer's or
Inspecting Authority's Official Stamp

(e) Certificates for steam-pipes—A certificate of manufacture and test in Form III-A, signed by the maker and the Inspecting Authority shall be furnished.

(f) Certificates for tubes—A certificate of manufacture and test in Form III-B, signed by the maker and the Inspecting Authority shall be furnished.

Note: In case of tubes made by Well-known Tube Makers [recognised by the Central Boilers Board in the manner as laid down in regulations 4A to 4H] in India or other countries listed in Appendix 'M' material testing including mechanical tests may be carried out by them and the particulars regarding testing of material including mechanical tests as certified by them shall be noted in the appropriate column or paragraphs in the certificate in Form III-B. In case, certificate from the "Well-known Tube Makers" as aforesaid is produced, such certificate may be accepted in lieu of the certificate from the Inspecting Authority insofar as it relates to testing of material including mechanical tests specified in this form.

(g) Certificates for mountings and fittings—A certificate of manufacture and test in Form III-C, signed by the Maker and the Inspecting Authority in respect of boiler mountings and steam-pipe fittings during manufacture, shall be furnished.

Notes:

(1) For the purpose of this clause certificates issued by an authority empowered in this behalf by or under the law in force or the national code in a foreign country, in respect of mountings and fittings in that country and containing the particulars required to be specified in this certificate, may be accepted. Where, however, the material used, is in conformity with the code of the country of manufacture and is covered by those Regulations, the permissible stress figures specified in the Code at different temperatures may be accepted in lieu of figures computed from the data required to be furnished under Regulation 271 in any of the following cases, namely:—

(i) Where a certificate is furnished from an Inspecting Authority to the effect that the steel complies with the requirements of the grade steel (to be specified) and the permissible stress for the working conditions as allowed for in the Code of the country of manufacture falls within the limit permissible under this Regulation.

(ii) Where the basis upon which these stresses have been arrived at is made available and such basis is not found to be such as to give rise to stresses higher than those permissible under the Regulations.

(2) For the purpose of clauses (c), (e), (f) and (g) of this regulation, certificate issued by an authority empowered in this behalf by or under the law in force or national Code or Standard of any foreign country in respect of plates, bars, tubes, pipes, forgings and castings, manufactured in that country and containing the particulars required to be specified in the steel makers certificates referred to in the above mentioned clauses of regulation 4 may be accepted provided such certificates contain a statement duly signed by the Inspecting Authority to the effect that these materials comply with the requirements of the law or the Code or Standard of the foreign country.

(3) Photostat copy of the certificate in Form III-C shall be accepted provided it is endorsed by the manufacturer or the Inspecting Authority.

(h) Certificates of inspection during construction of pipes for which variation from standard conditions have been permitted—A certificate of manufacture and test in Form III-A(i), signed by the maker and the Inspecting Authority shall be furnished.

(i) Certificate of inspection during construction of tubes for which variation from standard conditions have been permitted—A certificate of manufacture and test in Form III-B(i), signed by the maker and the Inspecting Authority shall be furnished.

PROCEDURE FOR RECOGNITION OF COMPETENT AUTHORITY, INSPECTING AUTHORITY, WELL-KNOWN MATERIAL TESTING LABORATORY, WELL-KNOWN STEEL MAKER, WELL-KNOWN FOUNDRY/FORGE, WELL-KNOWN TUBE/PIPE MAKER AND WELL-KNOWN REMANENT LIFE ASSESSMENT ORGANISATION

4A. Application for Recognition

(1) An application for recognition as Competent Authority, Inspecting Authority, Well-known Material Testing Laboratory, Well-known Steel Maker, Well-known Foundry/Forge, Well-known Tube/Pipe Maker and Well-known Remanent Life Assessment Organisation shall be made by a firm to the Secretary, Central Boilers Board, Ministry of Industry (Department of Industrial Development), New Delhi, for recognition as one of the aforementioned areas of activity in which that firm is engaged.

(2) On receipt of application under sub-regulation (1), the Secretary, Central Boilers Board shall send a questionnaire in any of the Forms (Forms XV-A to XV-G) applicable to the area of activity to the applicant who shall send the same after duly completed, to the Secretary, Central Boilers Board.

(3) Any firm applying for recognition under sub-regulation (1) shall have a minimum experience of two years in the area of activity for which recognition is applied for.

(4) In case of firms in foreign countries seeking recognition as "Well-known Steel Maker", "Well-known Pipe/Tube Maker", "Well-known Foundry or Well-known Forge", a fee of US $ 10,000 (Ten Thousand US Dollars) to meet the expenses of the visit of the Evaluation Committee shall be deposited alongwith the completed Questionnaire form:

Provided that where the firm has more than one manufacturing unit in the same country an additional fee at the rate of US $ 2000/- (Two Thousand US Dollars) per additional unit shall be deposited.

The Evaluation Committee shall carry out the evaluation of the manufacturing works of the firm within 120 days of receipt of the fees.

The certificate of recognition shall be from the date of the visit of the plant by the Evaluation Committee and shall be for a period of five years. In the case of renewal of the recognition, if the application is received for renewal alongwith the required fee as per the regulations, the firm may be recognised after following the procedure laid down in the regulations and the certificate shall be issued for a further period of five years.

4B. Scrutiny of Applications by the Evaluation Committee

(1) The Secretary, Central Boilers Board shall send all the applications received under sub-regulation (1) of regulation 4A, along with replies to the questionnaire under sub-regulation (2) of regulation 4A, to the Evaluation Committee.

(2) The Evaluation Committee shall examine all the applications and replies to the Questionnaire under sub-regulation (1) and—

(i) where the application is for recognition as Competent Authority or Inspecting Authority, the Evaluation Committee may, (a) call any of the applicants if it considers necessary, to appear before it to give clarification for additional information that may be required by the said Committee; (b) visit any of the applicant firms on a specific request in writing from such firm to evaluate the performance of the said firm;

(ii) where the applicants are for recognition as Well-known Material Testing Laboratory, Well-known Steel Maker, Well-known Foundry or Forge, Well-known Tube/Pipe Maker or Well-known Remanent Life Assessment Organisation, the Evaluation Committee shall inspect the laboratories of such Material Testing Laboratory and Remanent Life Assessment Organization or the factories of such steel makers, foundry or forge and tube or pipe makers, where the testing and manufacturing activities are being carried out in order to evaluate the performance quality of the tests conducted and products manufactured.

(3) The Evaluation Committee after satisfying itself that the requirements specified in sub-regulations (1) and (2) are fulfilled, shall submit a report along with its recommendations to the Liaison Sub-Committee.

4C. Recognition of a Firm as Competent Authority, Inspecting Authorities etc.

(1) The Liaison Sub-Committee shall consider the reports and the recommendations of the Evaluation Committee submitted under sub-regulation (3) of regulation 4B and after examining all the aspects of such report shall either accord recognition to a firm or refuse recognition to such firm.

(2) In case the Liaison Sub-Committee decides to accord recognition to a firm, a certificate of recognition in one of the Forms (Forms XVI-A to XVI-I) applicable to the area of activity shall be issued by the Secretary, Central Boilers Board and in case the Liaison Sub-Committee decides to refuse recognition, it shall inform the applicant in writing giving reasons therefor.

4D. Validity of Certificate of Recognition

A certificate of recognition issued under regulation 4C, shall be valid for a period of five years.

4E. Renewal of Certificate of Recognition

(a) A firm desiring renewal of the certificate of recognition shall apply for such renewal at least three months before the expiry of the validity of the certificate to the Secretary, Central Boilers Board who after following the procedure laid down in these regulations may renew the certificate of recognition and such renewal shall be valid for a further period of five years.

(b) Notwithstanding anything contained in sub-regulation (a), the period of validity shall be deemed to have been extended till such time the decision on the renewal is communicated to the firm.

4F. Application for Registration of Existing Competent Authority etc.

All the existing firms recognised as Competent Authority, Inspecting Authority, Well-known Material Testing Laboratory, Well-known Steel Maker, Well-known Foundry/Forge, Well-known Tube/Pipe Maker and Well-known Remanent Life Assessment Organisation, shall make an application to the Secretary, Central Boilers Board, within one year from the commencement of the Indian Boiler (4th Amendment) Regulations, 1988, and in case no application is made within the time specified the recognition of such firm shall be deemed to have been withdrawn:

Provided that the firm which has been granted recognition and has not completed a period of three years, shall continue to be so recognised as such till the expiry of the period of three years:

Provided further that if an application is not made in time, the same may be entertained by the said authority that there was sufficient cause for not making application in time.

4G. Appeal

(1) Any firm not satisfied with the reasons given by the Liaison Sub-committee for refusing to accord recognition may file an appeal in writing to the Chairman, Central Boilers Board, for reconsidering its application.

(2) All applications received by Chairman, Central Boilers Board, under sub-regulation (1), shall be decided in the meeting of the Central Boilers Board and the decision of the Board thereon shall be final.

4H. Function of Evaluation Committee

The Evaluation Committee shall evaluate the performance of a firm applying for recognition in accordance with the provisions of these regulations, in particular in the following areas, namely:—

(i) Quality System;

(ii) Organisation;

(iii) Review of quality system;

(iv) Documentation—

(a) Inspection and test procedures;

(b) Records;

(c) Technical data;

(v) Inspection equipment;

(vi) Inspection of purchased material or services—

(a) purchasing;

(b) purchasing data;

(c) receiving inspection;

(d) verification of purchased material;

(vii) In-process inspection;

(viii) Workmanship;

(ix) Corrective action;

(x) Inspection and test of completed items;

(xi) Sampling procedure;

(xii) Control of non-conforming material;

(xiii) Indication of inspection status;

(xiv) Protection and preservation of product quality—

(a) material handling;

(b) storage;

(c) delivery;

(xv) Training.

5. Modification of Formulae

(i) Under the Regulations for determining the working pressure to be allowed on various parts of boilers, the material to which the formulae apply shall in the absence of express provision to the contrary be steel complying with the requirements of Chapter II.

(ii) Where no test certificates for plates and rivets are produced, the material may be treated as iron, if the Chief Inspector is satisfied that the material is of suitable boiler quality. If in such cases the Chief Inspector is clearly satisfied that the material is of good quality, a higher strength than that allowed for iron may be permitted but the strength of the plates shall not, save for special reasons, be assumed to be more than 26 tons per square inch. In such cases the values of tensile and shear strength shall not be more than 26 and 21 tons per square inch for steel, and 21 and 18 tons per square inch for iron. For iron across the grain the tensile strength may be 18 tons per square inch.

(iii) For flat plates of copper, the working pressure as found from the formulae, reduced by 50 per cent shall be the working pressure permitted.

(iv) When the quality of material and the make of steel pipe have not been supported by certificates from the manufacturers in Form III-A, the pipes shall be tested in a test house and the maximum permissible working stress shall be such as the Chief Inspector of Boilers may in his discretion determine.

5A. Material not fully identified

Where the material as for example plate, bar, billet, pipes and tubes are not covered by mill test certificate either due to misplacement or late receipt of the same but otherwise there are reasons to believe that the materials are genuine and of standard specifications registering authority or Chief Inspector of Boilers may permit the use of such materials as a special case after thorough verification test in a Test House to his satisfaction at the rate not less than 25% subject to the following conditions:

(a) In respect of Plates—

(i) The plates shall have a steel maker's stamp.

(ii) Use of such uncertified plates, however, will not be allowed for manufacture of Shell or Drum of the boilers.

(iii) Shipping documents/order documents shall be made available to establish the specifications of the manufacture for inspection and testing of plates.

(b) For Billets, bars, pipes and tubes—

Shipping documents shall be made available to establish the specifications for manufacture for inspection and testing.

6. Standard specifications for materials

The standard specifications for steel wrought iron and copper plates and bars, and the cast steel shall be those prescribed in Chapter II.

7. Registration of second-hand boilers not in accordance with the standard conditions

If a second-hand boiler is not conforming to the requirements of these regulations for its registration, then the same shall not be registered except in the following cases, namely:—

(i) *Water Tube Boilers*—Where the documents required under its code of manufacture for its registration are furnished and its workmanship is not in any way doubtful, the second-hand Water Tube Boiler may be registered by reducing the working pressure of the parts of the boiler as calculated from these regulations by ten percent:

Provided that a higher working pressure, being not more than the working pressure allowed by the code of manufacture, may be allowed on the recommendation of the Board made by it on the basis of life assessment tests carried out on the boiler.

(ii) *Shell Type Boilers*—Where the documents required under its code of manufacture, for its registration are furnished, the second-hand Shell Type Boiler may be registered by reducing the working pressure of the parts of the boiler as calculated under these regulations as per the table given below:

Age of boiler (from the date of first use) in years	25	35	45	50	60	70	80	90	100
Reduction in working pressure (percent)	5	10	15	20	30	40	50	60	70

8. Welding

(a) The use of welding in the construction of boilers shall be permitted only where specifically provided for in the standard conditions.

CHAPTER II

MATERIALS OF CONSTRUCTION STEEL PLATES, RIVETS, SECTION AND BARS IN CARBON STEEL

9. Process of Manufacture

(a) Steel for plates shall be made by the open hearth, electric furnace or basic oxygen process or any other process which gives steel having equivalent specified properties.

(b) General de-oxidation practice shall be appropriate to the type of steel used, particularly where the de-oxidation practice influence the level of the elevated temperature properties of steel.

(c) Rimmed steels may be permitted only for re-riveted drums or shells made of plates having a nominal thickness upto 20 mm.

(d) Plates of Carbon Steel shall conform to one of the following four grades of tensile strength namely:—

(i) 37 to 45 kgf/mm^2
(ii) 42 to 50 kgf/mm^2
(iii) 47 to 56 kgf/mm^2
(iv) 52 to 62 kgf/mm^2

(e) Semi-skilled steel may be used for plates in C and C-Mn Steel with an upper limit of the tensile strength not exceeding 56 Kg/mm^2 and with thickness not exceeding 50 mm under service temperature condition 0-450°C.

10. Chemical Analysis

(a) The Steel shall not contain more than 0.05 per cent of sulphur or phosphorus.

(b) A sulphur print test shall be taken from the material of each charge used for rivet bars for the purpose of ensuring that sulphur segregates are not concentrated in the core. The stage in manufacture at which this test is made shall be at the option of the Steel-Maker.

(c) When the material is required for flame cutting and/or welding the carbon content shall not exceed 0.30% and special precautions shall be taken when the carbon content exceeds 0.26%.

When steels are intended for service temperatures over 700°F the sillicon content shall be not less than 0.10% or alternatively, the material shall pass the proof test for creep quality of carbon steel plates of boiler quality.

(d) Plates having thickness of 12 mm and less than that, not intended for hot forming, can be supplied in unnormalized or as rolled condition subject to the condition that the code of manufacture provides for the same. For plates having thickness more than 12 mm, not intended for hot forming, shall be supplied in the normalized conditions:

Provided that the normalizing may be exempted if it is demonstrated by the manufacturer that equivalent properties can be produced by the rolling subsequent cooling.

Note: The boiler manufacturer may, if he so wishes, order a check analysis.

11. Freedom from defects, etc.

Minor surface defects of the plates may be removed by mechanical means to achieve a smooth level surface provided that the minimum specified thickness is maintained. Surface defects may be repaired by welding, only with the approval of the Inspecting Authority provided that the plate is stress relieved after welding where necessary.

12. Rolling Margin

No plate or rolled section shall be under the specified thickness at any part, not more than 5 per cent over the calculated weight, except that in the case of thin plates and wide plates the weight tolerances shall be as set out in the table below:

Schedule of Percentage of Rolling Weight Tolerances for Boiler Plates

	Width in inches								
Thickness	*Under 48*	*48 to under 60*	*60 to under 72*	*72 to under 84*	*84 to under 96*	*96 to under 108*	*108 to under 120*	*120 to under 132*	*132 and over*
in.	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
1/4 to under 5/16	5	5	5	7	9	12	—	—	—
5/16 to under 3/8	5	5	5	6	7.5	10	11	12	—
3/8 to under 7/16	5	5	5	6	6	8	9	11	15
7/16 to under 1/2	5	5	5	5	6	7.5	8	9	12
1/2 to under 5/8	5	5	5	5	6	6	7.5	9	10
5/8 to under 3/4	5	5	5	5	5	5	7	8	9
3/4 to under 1	5	5	5	5	5	5	6	7	8
1 to under 2	5	5	5	5	5	5	5	9	7

All the above margins will be taken over nett theoretical weight.

13. Testing and Inspecting

The following tests and inspections shall be made at the place of manufacture prior to despatch; but in the event of any the material proving unsatisfactory in the course of being worked into boilers, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same charge shall be made as the Inspecting Officer in attendance may consider desirable.

13A.

Where a steel plant is not able to designate steel as IS: 2002 because of the fact that they have not been able to carry out all the tests required as per IS: 2002, the steel plant may supply steel with a certificate in respect of such of those tests as it has been possible for them to carry out indicating the tests which it has not been possible for them to conduct in order to get the steel certified as IS: 2002. It is open to the manufacturer to take such steel which has the required potentialities of IS: 2002, provided he can arrange the remaining tests to be conducted at any of the independent testing laboratories, namely, the National Metallurgical Laboratory, Jamshedpur; the Central Mechanical Engineering Research Institute, Durgapur; and the National Test House, Alipur or Sewri, provided that samples be drawn in the presence of the Inspecting Authority. Such remaining tests may also be conducted at the Bharat Heavy Electricals Limited, Tiruchirapally in the presence of the Inspecting Authority in respect of plates intended for their use.

If the certificate of tests from steel makers and the National Metallurgical Laboratory, Jamshedpur, or the Central Mechanical Engineering Research Institute, Durgapur or the National Test House, Alipur or Sewri or Bharat Heavy Electricals Limited, Tiruchirapally, be furnished in the manner mentioned above, the boiler quality plates shall be accepted by the Inspecting Authorities/Chief Inspector of Boilers of the States.

13B. Testing and certification of semi-skilled steel for which all tests not carried out in a steel plant

Where a steel plant has not been able to carry out all the tests required under the regulations for testing the semi-skilled steel, the steel plant may supply such steel with a certificate in respect of such tests which have not been possible for them to conduct in order to get the steel certified under the regulations and in such a case it is open to the manufacturers to take such steel which has the potentialities of the semi-skilled steel to any of the independent testing laboratories, namely, National Metallurgical Laboratory, Jamshedpur; Central Mechanical Engineering Research Institute, Durgapur; and National Test House, Alipur or Sewri for conducting the remaining test provided that samples are drawn in the presence of the Inspecting Authority. Such remaining tests may also be conducted at the Bharat Heavy Electricals Limited, Tiruchirapally in respect of plates intended for their use.

If a certificate of test is furnished by the steel makers in respect of tests carried out by them and another certificate is furnished in respect of remaining tests conducted by any one of the independent testing laboratories or the Bharat Heavy Electrical Limited, Tiruchirapally, the plates should be accepted by the Inspecting Authority or the Chief Inspector of Boilers of the States provided all the requirements of the regulations are covered by these certificates.

14. Selection of test pieces

All test pieces shall be selected by the Inspecting Officer and tested in his presence, and he shall satisfy himself that the conditions herein described are fulfilled.

15. Tensile test pieces

(a) The tensile strength and percentage elongation shall be determined from test pieces of gauge length preferably equal to $L_o = 5.65\sqrt{A_0}$ (See regulation 16). Alternatively, other gauge lengths may be used, provided the elongation is expressed as the equivalent value on a gauge length of $5.65\sqrt{A_0}$.

(b) In arbitration cases a test piece of gauge length equal to $5.65\sqrt{A_0}$ for rectangular test pieces of $5d_0$ for round test pieces shall be used. For plate thickness exceeding 60 mm test pieces shall be taken from the exterior third of the plate cross-section. Wherever practicable, the rolled surface shall be retained on two opposite sides of the test piece.

16. Tensile test

(a) The tensile strength of different grades of material shall be within the limits specified in regulation 9(d).

(b) The upper yield point at room temperature shall not be less than 50% of the specified minimum tensile strength at room temperature.

(c) The breaking elongation in percentage shall be not less than

$$\frac{N - R_m}{C}$$

Where,

R_m = tensile strength at room temperature in kgf/mm^2

N = a quality index to 100 for plate thickness upto 50 mm or 95 for plate thickness over 50 mm.

C = 2.2 for only guage lengths of $L_0 = 5d_0$ or

$L_0 = 5.65\sqrt{A_0}$ where

L_0 = gauge length

d_0 = Original diameter of the round test piece.

A_0 = Original cross-section of the rectangular test piece.

Note: C = 1.9 for gauge lengths of $4\sqrt{A_0}$ or for test piece in Appendix B.

(d) The minimum values of the stress at proof limit 0.2% at elevated temperature (Et) may be calculated by multiplying the minimum specified tensile strength at room temperature (R20) by the value of the ratio (Et/R20) given in table below:

Table

Minimum values for the ratio of the stress at proof limit 0.2% at elevated temperature (Et) to the minimum specified tensile strength at room temperature (R20) or carbon Steel boiler plates

Temperature °C	250	275	300	325	350	375	400	425
Et/R20	0.40	0.38	0.36	0.34	0.33	0.32	0.31	0.30

*For temperature lower than 300°C any test required for acceptance purposes (in the absence of records of previous test at these temperatures) shall be at 300°C, in which case the proof stress shall be not less than value obtained by calculation from the specified minimum tensile strength at room temperature and the above proof-ratio of 0.36 for 300°C.

17. Number of Tensile Tests

(a) **Plates**—For shell plates, butt straps and plates, gusset plates, end plates, furnace plates and flanging plates one tensile test piece shall be cut from each plate as rolled.

(b) **Angle, tee, rivet and stay bars**—One tensile test shall be made from each 15 or part of 15 bars rolled of each section or diameter from the same charge, but not less than two tensile tests shall be made unless the total number of bars rolled from the same charge is 8 or less than 8 and the bars of the same section or diameter, in which case one tensile test shall suffice. For round bars of 1¾ inches diameter and under, the numbers 50 and 20 shall be substituted for 15 and 8 respectively for determining the number of tests required.

18. Dump Tests

Short lengths equal to twice their diameter cut from the rivet bars shall, when cold, with-stand without fracture being compressed to half their length. A dump test shall be made for each Tensile Test.

19. Bend Tests—Cold bends

(a) Test pieces shall be sheared lengthwise or crosswise from plates or bars, and shall not be less than 1½ inches wide, but for small bars the whole section may be used. For rivets bars bend tests are not required.

(b) In all cold bend tests, on samples 0.5 inch in thickness and above, the rough edge or arris caused by shearing may be removed by filling or grinding and samples 1 inch in thickness and above may have the edges machined, but the test pieces shall receive no other preparation. The test pieces shall not be annealed unless the material from which they are cut is similarly annealed in which case the test piece shall be similarly and simultaneously treated with the material before testing.

(c) (i) For bend test of plates of all grades of steel, the test piece shall withstands, without fracture, being bent cold through 180° around a mandrel, the radius of which shall have a relationship to the plate thickness as given below:

Tensile strength	*Mandrel Radius*
36-49 kg./mm^2	1T
41-57 kg./mm^2	1T
45-64 kg./mm^2	1.5T

where T = Plate thickness.

(ii) For cold bend test of sections and bars, the test piece shall withstand, without fracture, being doubled over until the internal radius is equal to that shown in Table under regulation 16 and the limbs are parallel.

(d) For small sectional material these bend tests may be made from the flattened bar.

(e) Bend tests may be made either by pressure or by blows.

20. Number of Bend Tests

(a) **Plates**—A bend test shall be taken from each plate as rolled. The bend tests from shell plates, butt straps and other plates which have not to be flanged or worked in the fire or which when in use are not to be exposed to flame shall be cold bend tests.

(b) **Angle Bars**—A cold bend test shall be made from each angle bars rolled:

Provided that the cold bend test need not be carried out if basic material specification does not call for it.

(c) **Stay Bars**—A cold bend test shall be made from every 15 stay bars as rolled from each charge.

21. Manufactured Rivets

(a) **Quality of Material**—Rivets shall be manufactured from steel complying with the aforementioned requirements of this Chapter in respect of rivet bars.

(b) **Tests**—

(i) The rivet shanks shall be bent cold, and hammered until two parts of the shank touch, without fracture on the outside of the bend.

(ii) The rivet heads shall be flattened while hot, without cracking at the edges until their diameter is 2½ times the diameter of the shank.

(c) **Number of Tests**—Upto half per cent of rivets of each size shall be selected by the Inspector or Inspecting Officer from bulk for the above tests.

22. Additional test before rejection

Should the test pieces first selected by the Inspector or Inspecting Officer not fulfil the test requirements, two further tests of the same kind may be made, but should either of these fail, the plates or bars from which test pieces were cut shall be rejected. In all such cases further tests shall be made before any material from the same charge can be accepted.

If the unsatisfactory result of a test is obviously due to technical conditions of the testing method or to a closely limited defect of a test piece, then the failure can be left out of consideration in the decision on the fulfilment of the requirement and another test piece may be substituted. If the unsatisfactory result of test is due to an unfavourable heat treatment the plate and the test strip may be heat treated again. Following this, the entire test shall be repeated.

23. Branding

(i) Every plate, section and bar shall be clearly and distinctly marked by the maker in two places with the number of identification mark by which they can be traced to the charge from which the material was made. As an alternative the rivet bars may be bundle and tabbed to enable the material to be traced to the cast of steel from which they are made.

(ii) Every plate shall also be stamped by the steel maker as provided in IS: 2002. The following information shall necessarily be provided:—

1. Name of the manufacturer;
2. Specification;
3. Heat No.;
4. Plate No.; and
5. Stamp.

24. Defacing of rejected material

In the event to the material failing in any case to withstand the prescribed tests, the identification mark of the Inspecting Officer which has been stamped on the material, shall be defaced by punch marks extending beyond the identification mark, in the form of a cross, thus denoting that the material has failed.

25. Facilities for Inspection

The maker shall adopt a system of making the ingots, billets, slabs, plates, bars, etc. which will enable all finished material to be traced to the original charge, and the Inspector or Inspecting Officer shall be given every facility for tracing all plates and bars to their respective charges, and for witnessing the required tests. When he is satisfied with the material and with the results of the tests, he shall be furnished with two copies of the advice notes of the material for his signature.

26. Steel not produced where rolled

Where steel is not produced in the works at which it is rolled, a certificate in Form IV or Form III-B, as the case may be shall be supplied to the Inspecting Officer deputed to witness the testing of the material stating the Open Hearth or Electric Process or any of the Oxygen Processes by which it was made, the name of the Steel-Maker who supplied it, also the numbers of the charges for reference to the books of the Steel-Maker. The number of the charge shall be marked on each plate or bar for the purpose of identification.

27. Maker's Certificate

Before the mill sheets are singed, the maker shall furnish the Inspecting Officer with a certificate in Form IV or Form III-B, as the case may be, guaranteeing that the material has been made by the Open Hearth or an Electric Process, acid or basic, and that it has been subjected to, and has withstood satisfactorily the test above described in the presence of the Inspecting Officer.

WROUGHT IRON STAY AND RIVET BARS

28. Rivet Bars

The tensile breaking strength shall be between 21 and 25 tons with an elongation of not less than 25 per cent measured on the Standard Test Piece B (as rolled) or 30 per cent measured on the Standard Test Piece B_1 (as rolled).

29. Manufactured Rivet Tests

To comply with Regulation 21.

30. Stay Bars

The tensile breaking strength shall be between 21 and 25 tons with an elongation of not less than 22 per cent measured on the Standard Test Piece B or 27 per cent measured on the Standard Test Piece B_1.

31. Stay Bars-Bend Tests

To comply with Regulation 19.

32. Special Iron for Screw Stays for Fire-boxes and Combustion Chambers

In order that iron screw stays may be approved of the same size as would be required for mild steel, the iron must withstand the following tests:—

(a) **Tensile Tests**—The tensile breaking strength shall not be less than 21½ tons per square inch, with an elongation of not less than 25 per cent measured on the Standard Test Piece B or 30 per cent measured on the Standard Test Piece B_1.

(b) **Bend Test**—Test pieces either of the bar as rolled, or turned down to 1 inch diameter, shall stand bending cold until the sides are parallel and the space between the two sides is not greater than the diameter of the test piece.

(c) **Number of Tensile Tests**—The bars as rolled shall be placed in batches of twenty, and one tensile test shall be taken form each batch. If this is unsatisfactory, two other bars shall be selected for test, and should either of these fail the batch shall be rejected.

(d) **Number of Bend Tests**—One ordinary bend test shall be taken from each batch, and a similar test piece from each batch shall be lightly and evenly nicked on one side with a sharp cutting tool and bent back at this point through an angle of 180 degrees by pressure or by a succession of light blows. The fracture must be clean, fibrous, free from slag or dirt or any coarse crystalline structure. If either of these is unsatisfactory, two other bars shall be selected for test, and should either of these fail the batch shall be rejected.

(e) In all cases the selection of the test pieces shall be made by the Inspector or the Inspecting Officer.

COPPER PLATES, STAY AND RIVET BARS

33. Plates

(a) **Process**—The copper shall be fire-refined or electrolytic and hot-rolled from suitable cracks.

(b) **Chemical Composition**—The chemical composition of the plates shall be as follows:—

	Per cent
Copper	99.2 minimum
Arsenic	.30 to .50
Antimony	0.05 maximum
Bismuth	0.05 maximum
Oxygen	0.10 maximum

(c) **Freedom from Defects**—The plates shall be clean, smooth and free from defects and shall have a workmanlike finish. They shall be thoroughly annealed.

(d) **Rolling Margin**—No plate shall be under the specified thickness at any part, not more than 5% over the calculated weight. The scrap margin, partly sheared and left attached, shall be not less than 3 inches at the ends and 1½ inches at each side.

(e) **Tensile Tests**—One tensile test shall be taken from each plate as rolled.

The tensile breaking strength, from Standard Test Piece A, shall not be less than 14 tons per sq. in. with an elongation of not less than 35%.

(f) **Hot and Cold Bend Test**—One hot (temperature between 1200°F and 1400°F) one cold bend test shall be taken from each plate as rolled.

For either hot or cold bend tests, the test piece shall withstand being doubled over without fracture until the sides are touching and parallel.

34. Stay and Rivet Bars

(a) **Process**—To comply with Regulation 33(a).

(b) **Chemical Composition**—To comply with Regulation 33(b).

(c) **Freedom from Defects**—To comply with Regulation 33(c).

(d) **Rolling Margin**—The bars in any part shall not be more than 1% over or more than ½% under the specified diameter.

(e) **Tensile Tests**—The materials shall have the tensile properties shown in the following table:

Tensile Properties

	Unturned rod (rods upto 1¼ inches dia.)	*Turned rod (rods above 1¼ inches dia.)*
Minimum tensile strength lb. per sq. in.	32,400	32,400
Elongation, minimum per cent in 2 inches gauge length	40	45

(f) **Bend Tests**—To comply with Regulation 33(f).

(g) **Dump Tests**—A piece of rod 1 in. long shall be placed on end and hammered or crushed down cold to a thickness of 3/8 in. without showing either crack or flaw on the circumference of the resulting disc.

(h) **Number of Tests**—One bar, from which the required test specimens shall be taken, shall be selected at random from each batch of 50 (or part thereof) bars of each size from each melt. From each bar selected, one tensile test, one cold bend test, one hot bend test and one dump test shall be made.

COPPER, BRASS AND STEEL TUBES

35. (1) Copper Tubes—

(a) **Process**—The copper shall be fire-refined or electrolytic and shall be made into tubes either by the hot rolling or cold drawing process. The tubes shall be finished by cold drawing.

(b) **Chemical Composition**—To comply with Regulation 33(b).

(c) **Freedom from Defects**—The finished tubes, both externally and internally shall be sound, clean, smooth, well finished and free from surface defects and longitudinal grooving, and the ends must be clean and square.

(d) **Tolerance**—The actual weight of each tube shall not be more than 5% above the calculated weight. Unless, otherwise specified, they shall be straight cylindrical, or uniform thickness and external diameter throughout.

(e) **Tensile Tests**—Tensile tests shall be made on pieces of tubes or strips cut from the tube. If the tensile test is made on a piece of tube, the ultimate tensile stress shall be not less than 14.50 tons (32,480 lbs.) per sq. in. with an elongation of not less than 50 per cent of 2 inches.

If the tensile test is made on strip cut from the tube, the ultimate tensile stress shall be not less than 14 tons (31,360 lbs.) per sq. in. with an elongation of not less than 40 per cent on a test piece having a gauge length of four times the square root of the area.

The results obtained from a batch shall be uniform, and should a variation of more than one ton (2,240 lbs.) per sq. in. be found between any number of tubes tested, the batch shall be liable to rejection. A batch shall not consist of more than 500 tubes.

(f) **Bulging or Drifting Test**—The test piece shall stand bulging or drifting cold (*see* Diagrams 1 and 2 respectively) without showing either crack or flaw, until, the outside diameter of the bulged or drifted and measures not less than 25 per cent more than the original diameter of tube.

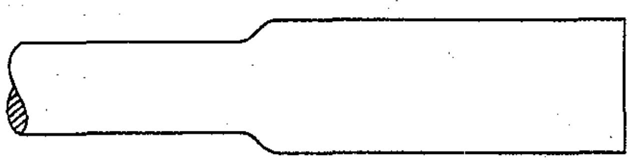


DIAGRAM 1

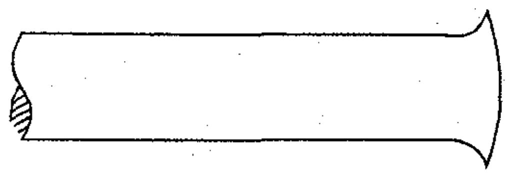


DIAGRAM 2

(g) **Flanging Test**—The test piece shall stand flanging cold (*see* Diagram 3) without showing either crack or flaw until the diameter of the flange measures not less than 40 per cent more than the original diameter of the tube.

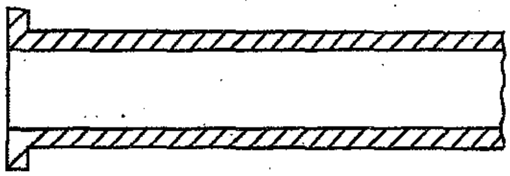


DIAGRAM 3

(h) **Flattening and Doubling over Test**—The test piece shall stand the following test, both cold and at a red heat, without showing either crack or flaw. The test piece shall be flattened down until the interior surfaces of the tube meet and then be double over on itself, that is bend through an angle of 180° (see Diagram 4) the bend being at right angles to the direction of the length of the tube.

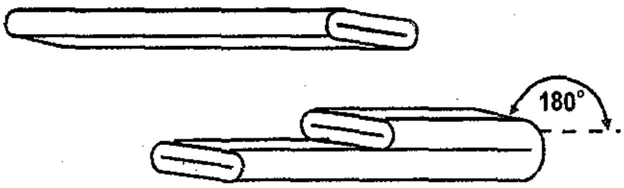


DIAGRAM 4

(i) **Hydraulic Test**—Each tube shall be tested, before the tubes are presented for inspection by an internal hydraulic pressure of 750 lbs. per sq. in. or by such internal hydraulic pressure as may have been specified by the Inspecting Authority and the Inspector may re-test 5 per cent or more as he may deem necessary.

The tubes shall withstand the test without showing any signs of weeping of evidence of defects.

(j) **Treatment of Test Specimens**—All test material, if not already in an annealed condition, shall be annealed before testing and shall comply with the mechanical tests without further heat of mechanical treatment.

35. (2) Brass Tubes—

(a) **Composition**—Brass for boiler tubes may be of either 70/30 alloy or 2/1 alloys as specified.

(b) **Chemical analysis**—The tubes shall consist of an alloy of copper and zinc, and shall contain:—

70/30 alloy. Not less than 70 per cent of copper and not more than a total of 0.75 per cent of materials other than copper and zinc.

2/1 alloy. Not less than 66.70 per cent of copper and not more than a total of 0.75 per cent of materials other than copper and zinc.

The manufacturer shall supply when required free of charge, a copy of his analysis* of the material.

(c) **Freedom from defects**—The tubes shall be clean, smooth and free from surface defects or longitudinal grooving, both internally and externally, and the ends shall be clean and square.

(d) **Tolerances**—The tubes shall be solid drawn and shall be concentric within the working margins for thickness given below. The tubes shall be straight and unless otherwise ordered they shall be uniform diameter throughout.

The working margins shall be as follows:

On length ± 1/16 in.

On thickness ± half the difference between the Standard Wire Gauge (S.W.G.) specified and the next Standard Wire Gauge thicker.

On external diameter ± 0.005 in.

(e) All test material shall be annealed before testing and shall comply with the following mechanical tests:—

(i) **Bulging or Drifting Test**—The test piece shall stand bulging or drifting cold (see Diagrams 1 and 2 respectively) without showing either crack or flaw, until the diameter of the bulged or drifted end measures not less than 25 per cent more than the original diameter of the tube.

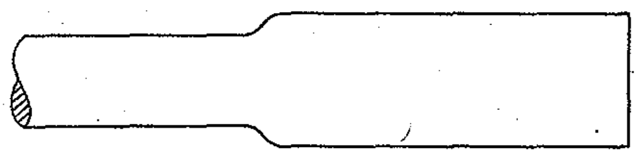


DIAGRAM 1

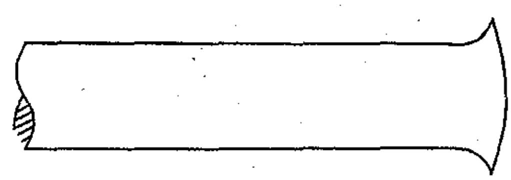


DIAGRAM 2

(ii) **Flanging Test**—The test piece shall stand flanging cold (see Diagram 3) without showing either crack or flaw until the diameter of the flange measures not less than 25 per cent more than the original diameter of the tube.

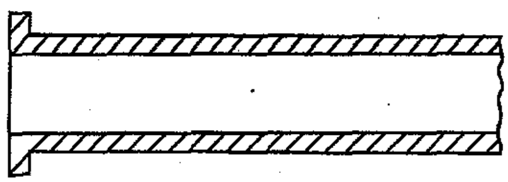


DIAGRAM 3

* A works analysis is defined as the routine analysis taken by or for the manufacturer in order to control the quality of the material.

(iii) **Flattening and Doubling over Test**—The test piece shall stand the following test when cold without showing either crack or flaw. The test piece shall be flattened down until the interior surfaces of the tube meet and then be doubled over on itself, that is, bent through an angle 180° (see Diagram 4), the bend being at right angles to the direction of the length of the tube.

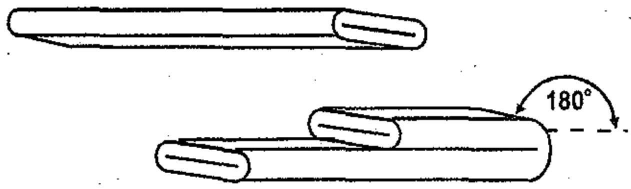


DIAGRAM 4

(f) **Hydraulic Test**—Each tube shall be tested, before the tubes are presented for inspection, by an internal hydraulic pressure of 750 lbs. per sq. in. or by such internal hydraulic pressure as may have been specified by the Inspecting Authority and the Inspector may re-test 5 per cent or more as he may deem necessary.

The tubes shall withstand the test without showing any signs of weeping.

35. (3) Carbon Steel Tubes

Tubes of Carbon Steel for boilers and superheaters subject to internal pressure shall comply with the requirements of regulations 36 to 42, 43 to 46 or 57 to 63, as the case may be.

COLD DRAWN SEAMLESS CARBON STEEL BOILER, SUPERHEATER AND HEAT EX-CHANGER TUBES FOR DESIGN METAL TEMPERATURES NOT EXCEEDING 454°C(850°F)

36.

(a) General

(i) These regulations cover both hot finished and cold drawn seamless boiler, superheater and heat exchanger tubes, which shall conform in all respects with the requirements herein specified.

(ii) The seamless tubes conforming to other national or international standards which are known to be commonly used as being suitable for use as boiler, superheater and heat exchanger tubes can also be used with the designations of the national or international standards, provided such materials are not specifically prohibited by the regulations.

(iii) While making tubes to other national/international standards the allowable stresses of the respective standards shall be strictly followed while designing the tubes.

(b) Material

(i) The tubes shall be seamless and manufactured from steel produced by an open hearth or electric process or any of the oxygen processes. The steel shall be fully killed.

(ii) The steel shall conform to the following limits of chemical composition:

Chemical Composition (%)

Grade	*C*	*Mn*	*Si*	*S*	*P*
TA	0.06-0.18	0.27-0.63	0.25 max	0.035 max	0.035 max
TB	0.27 max*	0.93 max	0.10 min	0.035 max	0.035 max
TC	0.35 max*	0.29-1.06	0.10 min	0.035 max	0.035 max

*For grade TB and TC for each reduction of 0.01% below the specified carbon maximum, an increase of 0.06% Manganese above the specified maximum will be permitted up to a maximum of 1.35%.

(c) **Heat Treatment**—Hot finished tubes need not be heat treated, cold drawn tubes shall be given a sub-critical annealing, a full anneal, or a normalising heat treatment after the final cold finishing process.

(d) **Workmanship and Tolerance**—The tubes shall be well finished, cleaned free from harmful defects. They shall be reasonably straight, smooth, cylindrical and subject to the following tolerances. Finished tubes shall be reasonably straight and have smooth ends free of burrs. They shall have a workmanlike finish. Surface imperfections like any discontinuity or irregularity found in the tube may be removed by grinding, provided that smooth curved surface is maintained, and the wall thickness is not decreased to less than that permitted. The outside diameter at the point of grinding may be reduced by the amount so removed.

(i) Permissible variations in outside diameter.

Outside Diameter (mm)	*Permissible variation over (mm)*	*Permissible variation under (mm)*
Hot finished seamless tubes		
101.6 and under	0.4	0.8
Over 101.6 to 190.5 incl.	0.4	1.2
Over 190.5 to 228.6 incl.	0.4	1.6
Cold finished seamless tubes		
Under 25.4	0.1	0.1
25.4 to 38.1 incl.	0.15	0.15
Over 38.1 to 50.8 excl.	0.2	0.2
50.8 to 63.5 excl.	0.25	0.25
63.5 to 76.2 excl.	0.3	0.3
76.2 to 101.6 incl.	0.38	0.38
Over 101.6 to 190.5 incl.	0.38	0.64
Over 190.5 to 228.6 incl.	0.38	1.14

(ii) Permissible variation in Wall Thickness in percentage.

Outside diameter (mm)	*Wall thickness (mm)*							
	2.4 and under		*Over 2.4 to 3.8 incl.*		*Over 3.8 to 4.6 incl.*		*Over 4.6*	
	Over	*Under*	*Over*	*Under*	*Over*	*Under*	*Over*	*Under*
Seamless Hot Finished tubes								
101.6 & under	40	0	35	0	33	0	28	0
Over 101.6	NA	NA	35	0	33	0	28	0
Seamless Cold Finished tubes								
			Over			Under		
38.1 and under			20			0		
Over 38.1			22			0		

(iii) Permissible variations in length

Method of manufacture	*Outside diameter (mm)*	*Cut length (mm)*	
		Over	*Under*
Seamless hot finished	All sizes	5	0
Seamless cold finished	Under 50.8	3	0
	50.8 and over	5	0

Note: These permissible variations in lengths apply to cut lengths up to and including 7.3 m. For lengths over 7.3 m, an additional over tolerance of 3 mm for each 3 m or fraction thereof, shall be permissible, up to a maximum of 13 mm. Length tolerances on the positive side other than specified may be mutually agreed.

37.

(a) Test Specimens

(i) Test specimens required for flattening and expanding/flaring test specified in regulations 38, 39 and 40 shall be taken from the ends of finished tubes prior to upsetting swaging, expanding or any other forming operations or being cut to length. They shall be smooth on the ends and free from burrs and flaws.

(ii) If desirable and practicable, tensile test may be carried out on full section of the tubes up to the capacity of the testing machine. For large size tubes, the tensile test specimen shall consist of strip cut longitudinally from the tube and which is not straightened within the gauge length and further heat treated.

(iii) If any test specimen shows flaws or defective machining it may be discarded and another specimen substituted.

(iv) All specimens shall be tested at room temperature.

(b) **Number of tests**—The test specified in regulations 38, 39 and 40 shall be made on minimum 2 tubes for first 100 tubes and 1 per 100 or part thereof for tubes over 100 numbers.

38. Tensile and Hardness Tests

The test specimen shall comply with the following requirements. The hardness test may be carried out on the wall cross section or on a flat on the outside surface of the tube sample.

Grade	*Yield Strength Mpa (kg./mm^2) min*	*Tensile Strength Mpa (kg./mm^2) min*	*% Elongation on GL = 50 mm min*	*Hardness (Max)*	
				HRB	*HB*
TA	180 (18.5)	325 (33.1)	35	77	137
TB	255 (26.1)	415 (42.2)	30	79	143
TC	275 (28.2)	485 (49.3)	30	89	179

Note: For longitudinal strip tests a deduction in percentage elongation 1.5% shall be made for each 0.8 mm decrease in wall thickness under 8 mm from the minimum elongation value requirement.

39. Flattening Test

(1) A section of the tubes not less than 63 mm in length shall be flattened cold between two parallel flat surfaces to a distance between the plates (H) as calculated by the formula given below, without showing any sign of a crack or flaw.

$$H = \frac{(1+e)t}{e + \frac{t}{D}}$$

Where,

t = specified thickness of tube (mm)

D = specified outside dia of the tube (mm)

e = a constant, as given below

e = 0.07 for carbon steel with max specified carbon above 0.18%

e = 0.09 for carbon steel with max specified carbon 0.18% or less.

(2)(a) During, the first step, which is a test for ductility, no crack or break, except as provided for in 39(5) below, shall occur on the inside, outside, or end surfaces in seamless tubes or on the inside or outside surfaces of welded tubes.

(b) During the second step which is a test for soundness, the flattening shall be continued until the specimen breaks or the opposite walls of the tube meet. Evidence of laminated or unsound material, or of incomplete weld that is revealed during the entire flattening test shall be cause for rejection.

(3) Surface imperfections in the test specimen before flattening, but revealed during the first step of the flattening test, shall be judged in accordance with the finished requirements.

(4) Superficial ruptures resulting from surface imperfection shall not be cause for rejection.

(5) When low D-to-t ratio tubular products are tested because the strain imposed due to geometry is unreasonably high on the inside surface at the six and twelve O' clock location, cracks at these locations shall not be cause for rejection if the D-to-t ratio is less than 10 and the carbon content of the material is more than 0.25%.

40. Expanding or Flaring test

A section of the tube approximately 100 mm in length shall stand being flared with a tool having a 60 degree included angle until the tube at the mouth of the flare has been expanded to the percentages given below, without cracking:

Ratio of inside diameter to outside diameter	*Minimum expansion of inside diameter %*
0.9	21
0.8	22
0.7	25
0.6	30
0.5	39
0.4	51
0.3	68

41. Additional test before rejection

(i) If any one or more tests specified in these regulations fail, two further tests of the same kind may be made on two other tubes of the same batch. If any of these tests fails, the batch of the tubes represented may be given a further heat treatment and entire set of test shall be repeated.

(ii) If the repeat tests are satisfactory the tubes shall be accepted. If any failure in the tests should occur, the entire batch of the tubes shall be rejected.

42. Hydraulic test

(i) Each tube shall be tested by the manufacturer and shall withstand a hydraulic pressure to one and half times the design pressure subject to a minimum of 1.00 kg./mm^2, but not greater than pressure calculated by the following formula:

$$P = \frac{2St}{D}$$

where P = test pressure

D = specified outside diameter of the tube

t = specified wall thickness of the tube

S = stress which shall be taken as 40% of the minimum tensile strength at room temperature.

(ii) Notwithstanding anything contained in the above clause, the hydraulic test at the maker's works may be dispensed with, provided that the tubes are subject to non-destructive testing by an appropriate method like Ultrasonic or Eddy Current or Stray Flux testing.

SEAMLESS CARBON STEEL PIPES FOR HIGH TEMPERATURE SERVICE FOR DESIGN METAL TEMPERATURES NOT EXCEEDING 454°C (850°F)

43.

(a) General

(i) These regulations cover both hot finished and cold drawn seamless carbon steel pipes for high temperature service. The pipes shall conform in all respects with the requirements herein specified.

(ii) The seamless pipes confirming to other national/internationals standards which are known to be commonly used as being suitable for high temperature service can also be used with the designations of the national/international standards, provided such materials are not specifically prohibited by the regulations.

(iii) While making pipes to other national/international standards the allowable stresses of the respective nation/international standards shall be strictly followed while designing the tubes.

(b) Material

(i) The pipes shall be seamless and manufactured from steel produced by an open hearth or electric process or any of the oxygen processes. The steel shall be fully killed.

(ii) The steel shall conform to the following limits of chemical composition:

Grade	*Chemical composition %*				
	C	*Mn*	*Si*	*S*	*P*
PA	0.25* Max	0.27 0.93	0.10 min	0.035 max	0.035 max
PB	0.30* Max	0.29 1.06	0.10 min	0.035 max	0.035 max
PC	0.35* Max	0.29 1.06	0.10 min	0.035 max	0.035 max

*For each reduction of 0.01% below the specified carbon maximum, an increase of 0.06% manganese above the specified maximum will be permitted up to a maximum of 1.35%.

(b) **Heat treatment**—Hot finished pipes need not be heat treated. Cold drawn pipes shall be given a sub-critical anneal, a full anneal, or a normalising heat treatment after the final cold finishing process.

(c) **Workmanship and Tolerance**—The pipes shall be well finished, cleaned free from harmful defects. They shall be reasonably straight, smooth, cylindrical and subject to the following tolerance. Pipes manufacturer shall explore a sufficient number of visual inspections to provide reasonable assurance that they have been properly evaluated.

(i) Permissible variations in outside diameter:

Hot finished and cold finished seamless pipes

Outside diameter (mm)	*Permissible variations (mm)*	
	Over	*Under*
10.3 to 48.3 incl.	0.40	0.40
Over 48.3 to 114.3 incl.	0.79	0.79
Over 114.3 to 219.1 incl.	1.59	0.79
Over 219.1 to 457.0 incl.	2.38	0.79
Over 457.0 to 660.0 incl.	3.18	0.79
Over 660.0 to 864.0 incl.	3.97	0.79
Over 864.0 to 1219.0 incl.	4.76	0.79

(ii) Permissible variation in wall thickness:

The minimum wall thickness at any point shall not be more than 12.5% under the nominal wall thickness specified.

(iii) Permissible variation in exact length:

Seamless Hot finished and Cold finished pipes can be ordered in specified length or in random length. If ordered in specified length, the tolerances for all sizes shall be +6.0 mm/-0.0 mm.

(d) Test Specimens

(i) Test specimen required for flattening and expanding/flaring test specified in regulations 44(a), 44(b) and 44(c) shall be taken from ends of finished pipes prior to upsetting, swaging, expanding or any other forming operations or being cut to length. They shall be smooth on ends and free from burrs and flaws.

(ii) If desirable and practicable, tensile test may be carried out on full section of the pipe up to the capacity of the testing machine. For large size pipes, the tensile test specimen shall consist of strip cut longitudinally from the pipe and which is not straightened within the gauge length and further heat treated.

(iii) If any test specimen shows flaws or defective machining it may be discarded and another specimen substituted.

(iv) All specimens shall be tested at room temperature.

(e) **Number of tests**—The tests specified in regulations 44(a), 44(b) and 44(c) shall be made on minimum 2 pipes for first 100 pipes and 1 per 100 or part thereof for pipes over 100 numbers.

44.

(a) **Tensile test**—Test pieces cut from the ends of the selected pipes shall comply with the following requirements. The tensile test may be carried out on the test pieces cut out from the pipe in the longitudinal direction which shall not be further heat treated nor straightened with the gauge length. As an alternative, pipes may be tested on full cross section.

Grade	*Yield Strength MPa (kg/mm²) min*	*Tensile Strength MPa (kg/mm²) min*	*% Elongation on G.L. = 50 mm min for full tube testing*
PA	205 (21.1)	330 (33.1)	35
PB	240 (24.7)	415 (42.2)	30
PC	275 (28.2)	485 (49.3)	30

For longitudinal strip test, the minimum required elongation shall be determined by the following equation:

$$e = 1944\,(A^{0.2}/U^{0.9})$$

where e = minimum elongation in 50.8 mm, % rounded to the nearest 0.5%.

A = cross sectional area of the tensile test specimen in mm^2 based on specified outside diameter or nominal specimen width and specified wall thickness rounded to the nearest 6.45 mm^2. If the area thus calculated is more than 484 mm^2 then use area as 484 mm^2. If the calculated area is less than 484 mm^2 then use the actual area thus obtained.

U = specified tensile strength in Mpa.

(b) **Bend test**—For pipes of outside diameter 60.3 mm and under, a bend test shall be conducted. A sufficient length of pipe shall stand being bent cold through 90 degree around a cylindrical mandrel, the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks.

(c) **Flattening test**

(i) For pipes of outside diameter over 60.3 mm, a flattening test shall be conducted. A section of the pipe not less than 63 mm in length shall be flattened cold between two parallel flat surfaces to a distance between the plates (H) as calculated by the formula given below, without showing any sign of a crack or flaw:

$$H = \frac{(1+e)t}{e+t/D}$$

where t = specified thickness of pipe (mm)

D = specified outside diameter of the pipe (mm)

e = a constant, as given below:

e = 0.07 for carbon steel with maximum specified carbon 0.19% or more

e = 0.09 for carbon steel with maximum specified carbon 0.18% or less.

(ii) For pipe whose diameter equals or exceeds 254 mm, a bend test may be conducted instead of the flattening test. The bend test specimens shall be bent at room temperature through 180 degree without cracking on the outside of the bent portion. The inside diameter of the bend shall be 25 mm. Substitution of the bend test for the flattening test shall be subject to the approval of purchaser.

(iii) For pipe whose diameter exceeds 635 mm and whose diameter to wall thickness ratio is 7.0 or less, the bend test described in clause (b) shall be conducted instead of the flattening test.

45. Additional tests before rejection

If any one or more tests specified in these regulations fail, two further tests of the same kind may be made on two other pipes of the same batch. If any of these tests fails, the batch of the pipes represented may be given a further heat treatment and entire set of tests shall be repeated.

If the repeat tests are satisfactory the pipe shall be accepted. If any failure in the tests should occur the entire batch of the pipes shall be rejected.

46. Hydraulic test

(i) Each pipe shall be tested by the manufacturer and shall withstand a hydraulic pressure to one and half times the design pressure, but not greater than pressure calculated by the formula given below.

$$P = 2\,St/D$$

where P = test pressure

D = specified outside diameter of the pipe

t = specified wall thickness of the pipe

S = stress which shall be taken as 40% of the minimum tensile strength at room temperature.

(ii) Notwithstanding anything contained in the above clause, the hydraulic test at the maker's works may be dispensed with provided that the pipes are subject to non-destructive testing by an appropriate method like Ultrasonic or Eddy Current or Stray Flux testing.

SEAMLESS FERRITIC AND AUSTENITIC ALLOY STEEL BOILER, SUPERHEATER AND HEAT EXCHANGER TUBES

47. General

(i) These regulations cover both hot finished and cold drawn seamless boiler, superheater and heat exchanger tubes of ferritic and austenitic alloy steel grades. These shall conform in all respects with the requirements herein specified.

(ii) The seamless tubes conforming to other national/international standards which are known to be commonly used as being suitable for use as boiler and superheater tubes can also be used with the designations of the national/international standards, provided such materials are not specifically prohibited by the regulations.

(iii) While making tubes to other national/internationals standards the allowable stresses of the respective standard shall be strictly followed while designing the tubes.

(iv) The design metal temperatures shall not exceed the following limits:—

Sl. No.	*Grade*	*Temperature*	
		°C	*(°F)*
(1)	*(2)*	*(3)*	
1.	T1, T2	538	1000
2.	T5, T9, T11, T12, T91, $12X1M_o$, X20CrMoV121	649	1200
3.	TP 304, TP 304H, TP 310S, TP 316, TP 316H, TP 321, TP 321H, TP 347, TP 347H	816	1500
4.	TP 304L, TP 316L	427	800

48.

(a) Material

(i) The tubes shall be seamless and manufactured from steel produced by an open hearth or electric process or any of the oxygen processes. The steel shall be fully killed.

(ii) The steel shall conform to the limits of chemical compositions given in Tables 1 and 2.

(iii) The grain size of cold worked grade TP 321H shall be No. 7 or coarser.

(b) Heat treatment

(i) All tubes of grades in Table 1, except T 91, 12X1Mϕ and X20CrMoV121 shall be reheated and furnished in full annealed, isothermal annealed or normalised and tempered condition. If furnished in the normalised and tempered condition, the minimum tempering temperature for Grades T1 and T11 shall be 650 degree C and the minimum tempering temperature for Grades T5, T9 and T22 shall be 675 Degree C.

(ii) Tubing of Grades T1, T2 and T12 either hot finished or cold drawn, may be given a final heat treatment at 650 degree C to 730 degree C, instead of heat treatments specified in sub-clause (i) above, at the option of the manufacture.

(iii) Grade T91 shall be normalised at 1040 degree C minimum and tempered at 730 degree C minimum as a final heat treatment.

(iv) Grade 12x1Mϕ shall be normalised at 950—980 degree C and tempered at 720—750 degree C for a period of 1 to 3 hours.

(v) Grade X20CrMoV121 shall be normalised at 1020 to 1070 degree C and tempered at 730 to 780 degree C for a period of 1 hour minimum.

(vi) All austenitic tubes (Table 2) shall be furnished in the heat treated condition. The heat treatment procedure, except for the H grades shall consist of heating the material to a minimum temperature of 1040° C and quenching in water or rapidly cooling by other means.

(vii) All H grades shall be furnished in the solution treated condition. If cold working is involved in processing, the minimum solution treating temperatures for grades TP321H and TP347H shall be 1100 degree C and for grades TP304H and TP316H shall be 1040 degree C. If the P grade is hot rolled, the minimum solution treatment for grades TP 321H and TP 347H shall be 1050 degree C and for grades TP 304H and TP 316H shall be 1040 degree C.

(c) **Workmanship and tolerance**—The tubes shall be well finished, cleaned free from harmful defects. They shall be reasonably straight, smooth, cylindrical and subject to the following tolerances. Finished tubes shall be reasonably straight and have smooth ends free of burrs. They shall have a workmanlike finish. Surface imperfections like any discontinuity or irregularity found in the tube may be removed by grinding, provided that a smooth curved surface is maintained, and the wall thickness is not decreased to less than that permitted. The outside diameter at the point of grinding may be reduced by the amount so removed.

(i) Permissible variation in outside diameter:

For all grades except 12 × 1Mϕ and × 20CrMoV121

Outside Diameter (mm)	*Permissible Variation (mm)*	
	Over	*Under*
Hot finished Seamless tubes		
101.6 and under	0.4	0.8
Over 101.6 to 190.5 incl.	0.4	1.2
Over 190.5 to 228.6 incl.	0.4	1.6
Cold finished Seamless tubes		
Under 25.4	0.10	0.10
Over 25.4 to 38.1 incl.	0.15	0.15
Over 38.1 to 50.8 excl.	0.20	0.20
50.8 to 63.5 excl.	0.25	0.25
63.5 to 76.2 excl.	0.30	0.30

Contd...

Contd...

76.2 to 101.6 incl.	0.38	0.38
Over 101.6 to 190.5 incl.	0.38	0.64
Over 190.5 to 228.6 incl.	0.38	1.14

For grade 12 × 1Mϕ

Outside Diameter (mm)	*Permissible Variation (mm)*	
	Over	*Under*
Hot finished and cold finished tubes		
Under 30.0	0.30	0.30
30 to 50	0.40	0.40
Over 50.0	0.80%	0.80%

For grade × 20CrMoV121

Outside Diameter (mm)	*Permissible Variation (mm)*	
	Over	*Under*
Hot finished Seamless tubes		
100 and under	0.75% (0.5 mm min)	0.75% (0.5 mm min)
Cold finished Seamless tubes		
120 and under	0.60% (0.25 mm min)	0.60% (0.25 mm min)
Over 120	0.75%	0.75%

(ii) Permissible variation in Wall Thickness:

For all grades except 12 × 1Mϕ and × 20CrMoV121

Outside Diameter (mm)	*Wall thickness %*							
	2.4 and under		*Over 2.4 to 3.8 incl.*		*Over 3.8 to 4.6 incl.*		*Over 4.6*	
	Over	*Under*	*Over*	*Under*	*Over*	*Under*	*Over*	*Under*
Seamless hot finished tubes								
101.6 and under	40	0	35	0	33	0	28	0
Over 101.6	NA	NA	35	0	33	0	28	0

Seamless cold finished tubes

	Over	*Under*
38.1 and under	20	0
Over 38.1	22	0

For Grade 12 × 1Mϕ

Outside Diameter (mm)	*Permissible variation %*	
	Over	*Under*
Hot Finished Seamless Tubes		
108 and under	15	10
Over 108	20	5
Cold Finished Seamless Tubes		
All sizes	10	10

For Grade × 20CrMoV121

Outside Diameter (mm)	*Permissible variation %*	
	Over	*Under*
100 and under	12.5	10
Over 100	9	9

(iii) Permissible variation in length for exact length tubes.

For all Grades except 12 × 1Mϕ and × 20CrMoV121

Method of manufacture	*Outside diameter (mm)*	*Cut length (mm)*	
		Over	*Under*
Seamless Hot finished	All sizes	5	0
Seamless Cold finished	Under 50.8	3	0
	50.8 Over	5	0

Note: These permissible variations in length apply to cut length up to and including 7.3m. For lengths over 7.3 m, an additional over tolerance of 3 mm for each 3 m or fraction thereof, shall be permissible, up to a maximum of 12 mm.

For grade 12 × 1Mϕ

Outside diameter (mm)	*Length of tubes (m)*	*Permissible variation (mm)*	
		Over	*Under*
Under 108	Under 9	15	0
	9 to 12	35	0
108 and over	All lengths	50	0

For grade × 20CrMoV121

Length of tube (m)	Permissible variation (mm)	
	Over	Under
6 and under	10	0
Over 6 to 12 incl.	15	0

(d) Test specimens

(i) Test specimens required for the flattening and expanding/flaring test specified in Regulations 49(a), 49(b) and 49(c) shall be taken from the ends of finished tubes prior to upsetting, swaging, expanding or any other forming operations or being cut to length. They shall be smooth on the ends and free from burrs flaws.

(ii) If desirable and practicable, tensile test may be carried out on full section of the tubes up to the capacity of the testing machine. For large size tubes, the tensile test specimen shall consist of strip cut longitudinally from the tube and which is not straightened within the gauge length further heat-treated.

(iii) If any test specimen shows flaws or defective machining it may be discarded and another specimen substituted.

(iv) All specimens shall be tested at room temperature.

(e) **Number of tests**—The tests specified in Regulations 49(a), 49(b) and 49(c) shall be made on minimum 2 tubes for first 100 and 1 per 100 or part thereof for tubes over 100 numbers.

Table 1: Chemical Requirements for Ferritic Steels

Grade	Chemical composition %									
	C	Mn	Si	S	P	Cr	Mo	V	Ni	Other Elements
T1	0.10 0.20	0.30 0.80	0.10 0.50	0.025 max	0.025 max	—	0.44 0.65	—	—	—
T2	0.10 0.20	0.30 0.61	0.10 0.30	0.025 max	0.025 max	0.50 0.81	0.44 0.65	—	—	—
T5	0.15 max	0.30 0.60	0.50 max	0.025 max	0.025 max	4.00 6.00	0.45 0.65	—	—	
T9	0.15 max	0.30 0.60	0.25 1.00	0.025 max	0.025 max	8.00 10.0	0.90 1.10	—	—	—
T11	0.05 0.15	0.30 0.60	0.50 1.00	0.025 max	0.025 max	1.00 1.50	0.44 0.65	—	—	—
T12	0.05 0.15	0.30 0.61	0.50 max	0.025 max	0.025 max	0.80 1.25	0.44 0.65	—	—	—

Contd...

Contd...

T22	0.05	0.30	0.50	0.025	0.025	1.90	0.87	—	—	—
	0.15	0.60	max	max	max	2.60	1.13			
T91	0.08	0.30	0.20	0.010	0.020	8.00	0.85	0.18	—	Nb = 0.06 -0.10
	0.12	0.60	0.50	max	max	9.50	1.05	0.25		N = 0.030 to 0.070
										Ni = 0.40 max
										Al = 0.04 max
12 × 1Mϕ	0.10	0.40	0.17	0.025	0.025	0.90	0.25	0.15	0.25	Cu=0.20 Max
	0.15	0.70	0.37	max	max	1.20	0.35	0.30	max	
× 20CrMoV	0.17	1.00	0.50	0.030	0.03	10.0	0.80	0.25	0.30	
121	0.23	max	max	max	max	12.5	1.20	0.35	0.80	

Table 2: Chemical Requirements of Austentic Steel

Grade	*Chemical composition %*									
	C	*Mn*	*Si*	*S*	*P*	*Cr*	*Mo*	*V*	*Ni*	*Other Elements*
TP304	0.08	2.00	0.75	0.030	0.040	18.0	—	—	8.00	—
	max	max	max	max	max	20.0			11.0	
TP304H	0.04	2.00	0.75	0.030	0.040	18.0	—	—	8.00	—
	0.10	max	max	max	max	20.0			11.0	
TP304L	0.035	2.00	0.75	0.030	0.040	18.0	—	—	8.00	—
	max	max	max	max	max	20.0			13.0	
TP310S	0.08	2.00	0.75	0.030	0.045	24.0	0.75	—	19.0	—
	max	max	max	max	max	26.0	max		22.0	
TP316	0.08	2.00	0.75	0.030	0.040	16.0	2.00	—	11.0	—
	max	max	max	max	max	18.0	3.00		14.0	
TP316H	0.040	2.00	0.75	0.030	0.040	16.0	2.00	—	11.0	—
	0.10	max	max	max	max	18.0	3.00		14.0	
TP316L	0.035	2.00	0.75	0.030	0.040	16.0	2.00	—	10.0	—
	max	max	max	max	max	18.0	3.00		15.0	
TP321	0.08	2.00	0.75	0.030	0.040	17.0	—	—	9.00	Ti = 5 × C min
	max	max	max	max	max	20.0			13.0	0.60 max
TP321H	0.04	2.00	0.75	0.030	0.040	17.0	—	—	9.00	Ti = 4 × C min
	0.10	max	max	max	max	20.0			13.0	0.60 max
TP347	0.08	2.00	0.75	0.030	0.040	17.0	—	—	9.00	Nb+Ta = 10 × C min
	max	max	max	max	max	20.0			13.0	1.000 max
TP347H	0.04	2.00	0.75	0.030	0.040	17.0	—	—	9.00	Nb+Ta = 8 × C min
	0.10	max	max	max	max	20.0			13.00	1.00 max

49.

(a) **Tensile and hardness tests**—The test specimen shall comply with the requirements as given in Table 3. The hardness test may be carried out on the wall cross section or on a flat on the outside surface of the tube sample.

Table 3: Mechanical Property Requirements

Grade	*Yield strength Mpa (kg/mm²) Min*	*Tensile Strength Mpa (kg/mm²) Min*	*% Elongation on GL=50mm Min**	*Hardness*	
				HRB max	*HB max*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
T1	205 (21.1)	380 (38.7)	30	80	146
T2	205 (21.1)	415 (42.2)	30	85	163
T5	205 (21.1)	415 (42.2)	30	85	163
T9	205 (21.1)	415 (42.2)	30	89	179
T11	205 (21.1)	415 (42.2)	30	85	163
T12	220 (22.5)	415 (42.2)	30	85	163
T22	205 (21.1)	415 (42.2)	30	85	163
T91	415 (42.2)	585 (59.6)	20	25 HRC	250
12 × 1Mϕ	274 (28.0)	441 (45.0)	21	85	163
		637 (65.0)			
× 20CrMoV121	490 (50.0)	690 (70.4)	17	25 HRC	250
		840 (85.7)			
TP 304	205 (21.1)	515 (52.5)	35	90	192
TP304H	205 (21.1)	515 (52.5)	35	90	192
TP304L	170 (17.3)	485 (49.5)	35	90	192
TP310S	205 (21.1)	515 (52.5)	35	90	192
TP316	205 (21.1)	515 (52.5)	35	90	192
TP316H	205 (21.1)	515 (52.5)	35	90	192
TP316L	170 (17.3)	485 (49.5)	35	90	192
TP321	205 (21.1)	515 (52.5)	35	90	192
TP321H	205 (21.1)	515 (52.5)	35	90	192
TP347	205 (21.1)	515 (52.5)	35	90	192
TP347H	205 (21.1)	515 (52.5)	35	90	192

*GL = $5.65\sqrt{SO}$

(b) **Flattening test**—A section of the tube not less than 63 mm in length shall be flattened cold between two parallel flat surfaces to a distance between the plates (H) as calculated by the formula given below, without showing any sign of a crack of flaw.

$$H = \frac{(1+e)t}{e + \frac{t}{D}}$$

where t = specified thickness of tube (mm)

D = specified outside diameter of the tube (mm)

e = a constant, as given below:

e = 0.08 for ferritic alloy steel

e = 0.09 for austenitic steel.

(c) **Expanding or flaring test**—A section of the tube approximately 100 mm in length shall stand being flared with a tool having a 60 degree included angle until the tube at the mouth of the flare has been expanded to the percentages given below, without cracking:

Ratio of inside diameter to outside diameter	*Minimum expansion of inside diameter %*
0.9	21
0.8	22
0.7	25
0.6	30
0.5	39
0.4	51
0.3	68

50. Additional tests before rejection

(i) If any one or more tests specified in these regulations fail, two further tests of the same kind may be made on two other tubes of the same batch. If any of these tests fails, the batch of the tubes represented may be given a further heat treatment and entire set of tests shall be repeated.

(ii) If the repeat tests are satisfactory the tubes shall be accepted. If any failure in the tests should occur the entire batch of the tubes shall be rejected.

51. Hydraulic test

(i) Each tube shall be tested by the manufacturer and shall withstand a hydraulic pressure to one and a half time the design pressure subject to a minimum of 1.00 kgf/mm^2, but not greater than pressure calculated by the following formula:—

$$P = 2\,St/D$$

where P = test pressure

D = specified outside diameter of the tube

t = specified wall thickness of the tube

S = stress which shall be taken as 40% of the minimum tensile strength at room temperature for carbon and ferritic steel and 80% of the minimum yield strength at room temperature for austenitic stainless steel.

(ii) Notwithstanding anything contained in the above clause, the hydraulic test at the maker's works may be dispensed with, provided that the tubes are subject to non-destructive testing by an appropriate method like Ultrasonic or Eddy Current or Stray Flux testing.

SEAMLESS FERRITIC PIPES FOR HIGH TEMPERATURE SERVICE

52. General

(i) These regulations cover both hot finished and cold drawn seamless pipes of ferritic alloy steel grades. These shall conform in all respects with the requirements herein specified.

(ii) The seamless pipes conforming to other national/international standards which are known to be commonly used as being suitable for high temperature service can also be used with the designations of the national/international standards, provided such materials are not specifically prohibited by the regulations.

(iii) While making pipes to other national/international standards the allowable stresses of the respective standard shall be strictly followed while designing the tubes.

(iv) The design metal temperatures shall not exceed the following limits:

Grade	*Temperature*	
	Degree C	*(Degree F)*
P1, P2	537	(1000)
P5, P9, P11, P12, P22, P91, ×20CrMoV121	648	(1200)

53.

(a) Material

(i) The pipes shall be seamless and manufactured from steel produced by an open hearth or electric process or any of the Oxygen processes. The steel shall be fully killed.

(ii) The steel shall conform to the limits of chemical composition as given in Table-4:

Table 4: Chemical Requirements for Ferritic Steels

Grade	*Chemical composition %*									
	C	*Mn*	*Si*	*S*	*P*	*Cr*	*Mo*	*V*	*Ni*	*Other Elements*
P1	0.10 0.20	0.30 0.80	0.10 0.50	0.025 max	0.025 max	—	0.44 0.65	—	—	—
P2	0.10 0.20	0.30 0.61	0.10 0.30	0.025 max	0.025 max	0.50 0.81	0.44 0.65	—	—	—
P5	0.15 max	0.30 0.60	0.50 max	0.025 max	0.025 max	4.00 6.00	0.45 0.65	—	—	—
P9	0.15 max	0.30 0.60	0.25 1.00	0.025 max	0.025 max	8.00 10.0	0.90 1.10	—	—	—
P11	0.05 0.15	0.30 0.60	0.50 1.00	0.025 max	0.025 max	1.00 1.50	0.44 0.65	—	—	—
P12	0.05 0.15	0.30 0.61	0.50 max	0.025 max	0.025 max	0.80 1.25	0.44 0.65	—	—	—
P22	0.05 0.15	0.30 0.60	0.50 max	0.025 max	0.025 max	1.90 2.60	0.87 1.13	—	—	—
P91	0.08 0.12	0.30 0.60	0.20 0.50	0.010 max	0.020 max	8.00 9.50	0.85 1.05	0.18 0.25	—	Nb= 0.06 - 0.10 N = 0.030 - 0.070 Ni = 0.40 max Al = 0.04 max
× 20Cr MoV121	0.17 0.23	1.00 max	0.50 max	0.03 max	0.030 max	10.0 12.5	0.80 1.20	0.25 0.35	0.30 0.80	

(b) Heat treatment

(i) All pipes of grades in Table 1 except P91 and × 20CrMoV121 shall be reheated and furnished in full annealed, isothermal annealed or normalised and tempered condition. If furnished in the normalised and tempered condition, the minimum tempering temperature for grade P1, P2, P11 and P12 shall be 650 degree C and the minimum tempering temperature for grades P5, P9 and P22 shall be 675 degreeC.

(ii) Pipes of grades P1, P2 and P12 either hot finished or cold drawn may be given a final heat treatment at 650 degree C to 705 degree C, instead of heat treatment specified in sub-clause (i) above at the option of the manufacturer.

(iii) Grades P91 shall be normalised at 1040 degree C minimum and tempered at 730 degree minimum as a final heat treatment.

(iv) Grades × 20CrMoV121 shall be normalised at 1020 - 1070 degree C and tempered at 730 - 780 degree C for a period of one hour minimum.

(c) **Workmanship and tolerance**—The pipes shall be well finished, cleaned free from harmful defects. They shall be reasonably straight, smooth, cylindrical and subject to the following tolerances. Pipes manufacturer shall explore a sufficient number of visual inspections to provide reasonable assurance that they have been properly evaluated.

(i) Permissible variation in outside diameter.

For all grades except × 20CrMoV121

Hot finished and Cold finished Seamless pipes

Outside diameter (mm)	*Permissible variations (mm)*	
	Over	*Under*
10.3 to 48.3 incl.	0.40	0.40
Over 48.3 to 114.3 incl.	0.79	0.79
Over 114.3 to 219.1 incl.	1.58	0.79
Over 219.1 to 300 incl.	2.38	0.79
Over 300	1%	1%

For grade X20CrMoV121

Outside diameter (mm)	*Permissible variations (mm)*	
	Over	*Under*
100 and under	0.75%	0.75%
Over 100 to 320 incl.	0.90%	0.90%
Over 320	1.00%	1.00%

(ii) Permissible variations in wall thickness:

For all grades, except × 20CrMoV121

The minimum wall thickness at any point shall not be more than 12.5% under the nominal wall thickness specified.

For grade × 20CrMoV121

Outside diameter (mm)	*Permissible variations (mm)*	
	Over	*Under*
100 and under	12.5	10
Over 100 to 320 incl.	12.5	12.5
Over 320	15.0	12.5

(iii) Permissible variation in length:

Seamless Hot finished and Cold finished pipes can be ordered in specified length or in random length. If ordered in specified length, the tolerance shall be as follows:

For Hot finished and Cold finished pipes

Grade	*Length (m)*	*Permissible variation in (mm)*	
		Over	*Under*
All grades except × 20CrMoV121	All length	6	0
For grade	6 and under	10	0
× 20CrMoV121	Over 6 to 12 incl.	15	0

(d) Test specimen

(i) Test specimens required for flattening and expanding/flaring test specified in regulations 54(a), 54(b) and 54(c) shall be taken from ends of finished pipes prior to upsetting, swaging, expanding or any other forming operations or being cut to length. They shall be smooth on ends and free from burrs and flaws.

(ii) If desirable and practicable, tensile test may be carried out on full section of the pipe upto the capacity of the testing machine. For large size pipes the tensile test specimen shall consist of strip cut longitudinally from the pipe and which is not straightened within the gauge length and further heat treated.

(iii) If any test specimen shows flaws or defective machining it may be discarded and another specimen substituted.

(iv) All specimens shall be tested at room temperature.

(e) **Number of tests**—The tests specified in regulations 54(a), 54(b) and 54(c) shall be made on minimum 2 pipes for first 100 pipes and 1 per 100 part thereof for pipes over 100 numbers.

54.

(a) **Tensile test**—The test specimen shall comply with the requirements given in the Table 5.

Table 5: Mechanical Property Requirements

Grade	*Yield Strength Mpa (kg/mm^2) min*	*Tensile Strength Mpa (kg/mm^2) min*	*% elongation on GL = 50mm min**
P1	205(21.1)	380(38.7)	30
P2	205(21.1)	380(38.7)	30
P5	205(21.1)	415(42.2)	30
P9	205(21.1)	415(42.2)	30
P11	205(21.1)	415(42.2)	30
P12	220(22.5)	415(42.2)	30
P22	205(21.1)	415(42.2)	30
P91	415(42.2)	585(59.8)	20
× 20CrMoV121	490(50.0)	690(70.4)	17
		840(85.6)	

*GL = $5.65\sqrt{SO}$

(b) **Bend test**—For pipes of outside diameter 60.3 mm and under, a bend test shall be conducted. A sufficient length of pipe shall stand being bent cold through 90 around a cylindrical mandrel, the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks.

(c) **Flattening test**

(i) For pipes of outside diameter over 60.3 mm a flattening test shall be conducted. A section of the pipe not less than 63 mm is length shall be flattened cold between two parallel flat surfaces to a distance between the plates (H) as calculated by the formula given below, without showing any sign of a crack or flaw:

$$H = \frac{(1+e)t}{e + \frac{t}{D}}$$

where, t = specified thickness for pipe (mm)

D = specified outside diameter of the pipe (mm)

e = a constant, 0.08 for ferritic alloy steel.

(ii) For pipe whose diameter equals or exceeds 254 mm, a bend test may be conducted instead of the flattening test. The bend test specimens shall be bent at room temperature through 180 degree C without cracking on the outside of the bent portion. The inside diameter of the bend shall be 25 mm. Substitution of the bend test for the flattening test shall be subject to the approval of the purchaser.

(iii) For pipes whose diameter exceed 635 mm and whose diameter to wall thickness ratio is 7.0 or less, the bend test described in clause (b) shall be conducted instead of the flattening test.

55. Additional tests before rejection

(i) If any one or more tests specified in these regulations fail, two further tests of the same kind may be made on two other pipes of the same batch. If any of these tests fails, the batch of the pipes represented may be given a further heat treatment and entire set of tests shall be repeated.

(ii) If the repeat tests are satisfactory, the pipes shall be accepted. If any failure in the tests should occur the entire batch of the pipes shall be rejected.

56. Hydraulic test

(i) Each pipe shall be tested by the manufacturer and shall withstand a hydraulic pressure to one and half times the design pressure but not greater than pressure calculated by the following formula given below.

$$P = 2\,S\,t/d$$

where, P = test pressure

D = specified outside diameter of the pipe

t = specified wall thickness of the pipe

S = stress which shall be taken as 40% of the minimum tensile strength at room temperature.

(ii) Notwithstanding anything contained in the above clause, the hydraulic test at the maker's works may be dispensed with provided that the pipes are subject to non-destructive testing by an appropriate method like Ultrasonic or Eddy Current or Stray Flux testing.

56A. Seamless Chromium-Molybdenum Steel Boiler and Superheater Tubes for design metal temperatures not exceeding 577°C (1070°F)

(i) **General**—The provisions of this regulation apply to both Hot Finished and Cold Drawn Seamless Boiler and Superheated Tubes which shall conform in all respects with the requirements herein specified.

(ii) **Material**—The tubes shall be manufactured from steel produced by the Open Hearth or Electric Process or any of the Oxygen Process and shall conform to the following limits of chemical composition:

Carbon	0.15% maximum
Manganese	0.30 to 0.70%
Silicon	0.1 to 0.50%
Phosphorus	0.04% maximum
Sulphur	0.04% maximum
Chromium	1.90 to 2.6%
Molybdenum	0.87 to 1.2%

The steel maker shall prove to the satisfaction of the Inspecting Authority that the quality of the steel is of the required high temperature creep strength.

(iii) **Heat treatment**—The tubes shall be fully annealed or normalised and tempered, at a temperature approved by the Inspecting Authority.

(iv) **Workmanship and tolerance**—The tubes shall be well finished, clean and free from harmful defects. They shall be reasonably straight, smooth cylindrical and subject to the following tolerances before bending:—

(a) **Diameter**—The external diameter of the tubes measured at any point shall be within the following tolerances if the diameter specified:—

Type of Tube	Outside Diameter of Tube	Tolerance	
Hot finished	Upto and including 64 mm (2½ in.)	+ 0.4 mm (1/64")	– 0.8 mm (1/32")
Hot finished	Over 64 mm (2½ in.)	+ 1%	– 1%
Cold drawn	All sizes	+ 1%	– 1%

(b) **Thickness**—The thickness of the tubes shall be within the following tolerances:—

Type of Tube	Outside Diameter of Tube	Tolerance	
Hot finished	Upto and including 64 mm (2½")	+ 17½%	– 7½%
Hot finished	Over 64 mm (2½")	+ 15%	– 5 %
Cold drawn	All sizes	+ 10%	– 5%

Where the ends of the tubes are swelled or reduced, the thickness at the ends may be decreased below or increased above the nominal thickness of the tubes by an amount in proportion to the percentage of such swelling or reduction and, in addition to this allowance, the tolerances relating to thickness shall also apply. Swelling or reduction shall be carried out before the heat-treatment specified in Regulation 56A(iii).

(c) **Length**—The tubes shall be not less than the nominal length, but may exceed it by the amount given below:

Upto and including 9 meters (30 ft.)	3 mm. (1/8")
Over 9 meters (30 ft.)	6 mm. (1/4")

(v) **Selection of tubes for testing**—After heat-treatment, the tubes shall be presented for mechanical testing in accordance with Regulations 56A(vi), 56A (vii) and 56A (viii), in batches of not more than 100 of the same nominal diameter and thickness. The manufacturer shall provide at his own expense extra tube at the rate of 2 per cent of each diameter and thickness of tube specified and the Inspecting Officer shall select for test such of the tubes as he may think proper to the extent of the percentage mentioned. Should the number of tubes specified of any one nominal size exceed 400, then, for every 100 tubes or part thereof above that number, one additional tube shall be provided. The samples for testing shall not be heat treated after selection.

(vi) **Tensile test**—Test pieces cut from the end of the selected tubes shall comply with the following requirements:

The test may be carried out on test pieces cut out from the tube in the longitudinal direction which shall not be further heat-treated nor straightened within the gauge length. As an alternative, tubes may be tested on full cross-section.

Kind of Steel	*Tensile Strength minimum kg/mm²/tons/sq. in.*		**Elongation on $L_o = 5\ d_o$ or $L_o = 5.65\sqrt{A_o}$ % minimum*
Chromium-Molybdenum Steel	39	25	20

***Note:** L_o = Original gauge length;
d_o = Original diameter; and
A_o = Original area of cross-section.

(vii) **Flattening test**—A ring not less than 51 mm (2 inches) in length cut from one end of each selected tube shall be flattened between two parallel flat surfaces, the width of which shall be not less than 1½ times the diameter of the tube. When the pressure is released, the interior surfaces of the test pieces (at the middle) shall remain at a distance apart of not more than three times the specified thickness of the tubes and the test piece shall then show no sign of crack or flaw.

Flattening test carried out in accordance with any other standard code may be accepted in which case, the Code adopted shall be specified.

(viii) **Expanding test**—The tubes shall withstand expanding by a drift expander having a total included angle of between 40° and 60° (20° and 30° per side) to the following increases in external diameter without showing crack or flaw:

Thickness of Tube	*Increase in Diameter %*
3 mm. (0.128") and thinner	12½
Thicker than 3 mm. (0.128") upto and including 5 mm. (0.192")	9½
Thicker than 5 mm. (0.192")	6½

In lieu of expanding test as above, flaring test carried out in accordance with any other standard code may be accepted in which case, the code adopted shall be specified.

(ix) **Additional tests before rejection**—Should a tube selected for testing purposes show definite signs of failure in any one or more of the tests specified in clauses (vi), (vii) and (viii) two further tests of the same kind may be made at the option of the manufacture from two additional selected test tubes. If the repeat tests are satisfactory, the tubes shall be accepted provided that in all other respects they fulfil the conditions of these Regulations. Should either of the tubes fail in any test, the batch of tubes represented may be re-heat-treated in accordance with the clause (iii) and then re-tested in accordance with clauses (vi), (vii) and (viii) but employing twice the number of test pieces.

If the second repeat tests are satisfactory, the tubes shall be accepted provided that in all other respects they fulfil the conditions of this standard; but if definite defects are again shown, the batch of tubes which the test pieces represent shall be rejected.

(x) Each tube shall be tested at the Maker's works and shall withstand a hydraulic pressure of 1½ times the design pressure, subject to a minimum of 70 kg./sq. cm^2 (1000 lbs. per sq. inch).

(xi) Notwithstanding anything contained in sub-regulation (x), the hydraulic test for tubes in maker's premises shall be dispensed with by the Inspecting Authority provided that the tubes are subject to non-destructive testing by an appropriate method like ultrasonic or/and Eddy current testing.

ELECTRIC-RESISTANCE-WELDED STEEL BOILER AND SUPERHEATER TUBES FOR DESIGN METAL TEMPERATURES NOT EXCEEDING 454°C (850°F)

57. General

(a) These regulations cover electrically welded tubes made of steel and intended for boiler, superheater and heat exchanger.

(b) The welded tubes conforming to other national or international standard which are known to be commonly used as being suitable for use as boiler, superheater or heat exchanger tubes and not specifically prohibited by these regulations can also be used provided such tubes satisfy the requirements of these regulations and are certified as per these regulations:

Provided that if the tubes are not hydraulically tested at the pressure required under this regulations, the Inspecting Authority may accept such tubes after witnessing hydraulic test at the required pressure at the maker's or fabricator's works or user's premises.

58. Material

(a) Tubes shall be manufactured from steel produced by an open hearth, or electric process or any of the oxygen processes.

(b) **Manufacture**—The tube shall be made by electric resistance welding and heat treated as per the table given below. In case of cold finished tubes the heat treatment shall be done after the final cold finishing process.

Tube Grade	*Heat Treatment*
WC 1	Normalized* or sub-critically annealed‡
WC 2 & WC 3	Normalized*

*Temperature range 800 Deg. C to 940 Deg. C.

‡Temperature range 660 Deg. C to 720 Deg. C.

The tube shall be well finished and free from harmful defects. The external weld (flash) shall be removed completely, i.e. flushed with outside surface. The internal weld upset shall be trimmed throughout the length of the tube so that the maximum height shall not exceed 0.25 mm.

(c) **Chemical Composition**—Ladle analysis of the steel grades shall conform to the following requirements:

Tube Grade	*C*	*Mn*	*Si*	*P*	*S*
WC1	0.16 max	0.30/0.70	0.35 max	0.040 max	0.040 max
WC2	0.17 max	0.40/0.80	0.10/0.35	0.035 max	0.035 max
WC3	0.12/0.18	0.90/1.20	0.10/0.35	0.035 max	0.035 max

Note 1: WC1 grade may be fully killed, rimmed or semi-killed.

Note 2: For rimmed or semi-killed steel, in case of grade WC1, the C max is 0.19%.

Where the temperature is below 400 Deg. C either rimming, semi-killed or killed steel may be used. If rimming steel is used, the strips shall be rolled in single width, and not slit longitudinally.

The steel used for design steam temperature above 400 Deg. C shall be of fully killed type.

When Ladle analysis is not available the analysis of sample tube selected at random may be used.

(d) **Thickness**—The thickness of each tube excluding the weld shall conform to the permissible variation given below:

Permissible variation (in per cent) in wall thickness

Tube Grade	*Wall thickness*	*Permissible variation*	
		Over	*Under*
WC1	3.2 mm and under	10	10
WC1	Over 3.2 mm	7.5	7.5
WC2 & WC3	All	10	10

The minimum thickness in the weld area shall not be less than that permitted in the body of the tubes.

(e) **Diameter**—The outside diameter of each tube measured at any position shall conform to the specified diameter within the limits of plus 0.75% and minus 0.75% with a minimum of 0.30 mm over and under.

(f) **Length**—Unless otherwise specified tube shall be supplied as random length. Where the length is specified as exact length or cut length, the permissible variation shall be +6 mm—0 mm for length up to and including 6 meters. For every 3 metre increase in length above 6 metres, the positive tolerance shall be increased by 1.5 mm with a maximum of 12 mm.

59.

(a) **Flattening test**

(i) A section of the tube not less than 40 mm length shall be flattened cold between parallel plates. No cracks or breaks in the metal shall occur unit the distance between the plates is less than the given by the following formula. Evidence of lamination or burnt material or incomplete penetration of the weld shall not develop during the testing.

$$H=\frac{(1+e)t}{e+\frac{t}{D}}$$

Where, t = Specified thickness of tube (in mm)

D = Specified outside diameter of tube (in mm)

e = Flattening test constant as given below:

0.10 for tube grades WC1.

0.07 for tube grades WC2 & WC3.

(ii) The weld shall be placed 90 degree from the line of direction of the applied force.

(iii) Superficial rupture as a result of minor surface imperfections shall not be cause for rejection.

(iv) Flattening test carried out in accordance with any other standard code may be accepted in which case the code adopted shall be specified.

(b) **Flaring test**—A section of tube of length equal to 1.5 times the outside diameter, but not less than 50 mm, shall stand being flared with a tool having 60 or 45 degree included angle until the tube at the mouth of the flare has expanded to the percentage given below without cracking:

Tube Grade	*% expansion in outside diameter D for a d/D of*		
	0.6 and under	*Over 0.6 to 0.8 including*	*Over 0.8*
WC1	12	15	19
WC2	12	15	19
WC3	10	12	17

d = inside diameter of tube.

60. Tensile test

(a) The tensile strength of the material cut from the finished tube shall conform to the following requirement:

Tube Grade	*Yield strength Mpa (kgf/mm sq.) (Min.)*	*Tensile strength Mpa (kgf/mm sq.) (Min.)*	*% Elongations+ (Min.)*
WC1	195 (19.9)	320/480 (32.6/49.0)	25
WC2	235 (24.0)	360/500 (36.7/51.00)	24
WC3	245 (25.0)	440/580 (44.9/59.2)	21

+ On gauge length $5.65\sqrt{A}$, where A is the initial cross-sectional area of the specimen on the gauge length.

(b) Allowable permissible stress at elevated temperature. Allowable permissible stress as per the respective code shall be strictly followed.

61. Hydraulic test

(a) Each tube shall be hydraulically tested at the makers' works and shall withstand a hydraulic pressure to one and half times, the design pressure, subject to a minimum of 1.00 kg/mm sq.

and for tube OD larger than 101 mm outside diameter minimum of 0.8 kg/mm sq. However, the test pressure shall not be greater than the pressure calculated by the following formula:

$$P = \frac{2St}{D}$$

Where P = test pressure (in kg/mm sq.)

D = specified outside diameter of the tube

t = specified wall thickness

S = stress (in kgf/mm sq.) which shall be taken as 40% of the specified minimum tensile strength at room temperature.

(b) Notwithstanding anything contained in the above regulation, the hydraulic test at the maker's works may be dispensed with, provided that the tubes are subjected to non-destructive testing by an appropriate method like Ultrasonic or Eddy Current testing.

62. Test Specimens

(a) Test specimens required for the flattening and flaring test specified in regulations 59(a) and 59(b) shall be taken from the ends of finished tubes prior to up setting, swaging, expanding or other forming operations or being cut to length. They shall be smooth on the ends and free from burrs and flaws.

(b) If desirable and practicable, tensile test, may be carried out on full section of the tubes up to the capacity of the testing machine. For large size tubes, the tensile test specimen shall consist of strip cut longitudinally from the tube and not flattened between the gauge marks and further heat treated. The sides of the specimen shall be parallel between gauge marks.

(c) All specimens shall be tested at room temperature.

63. Number of tests

(a) The test specified in regulations 59 and 60 shall be made on minimum 2 tubes for first 100 and 1 per 100 or part thereof for tubes over 100 number.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If any one or more tests specified in these regulations fail, two further tests of the same kind may be made on two other tubes of the same batch. If any of these tests fails, the batch of the tubes represented may be given a further heat treatment and entire set of tests shall be repeated.

If the repeat tests are satisfactory the tubes shall be accepted. If any failure in the tests should occur the entire batch of the tubes shall be rejected.

COLD DRAWN-RESISTANCE-WELDED STEEL BOILER AND SUPER-HEATER TUBES FOR DESIGN METAL TEMPERATURE NOT EXCEEDING 454°C (850°F)

63A.

(i) **Material**—Material, tube grade and chemical composition for these tubes shall be in accordance with the appropriate clause of Regulation 58.

(ii) **Manufacture**—Tube shall be manufactured as prescribed in Regulation 58(b) and subsequently cold drawn.

(iii) **Tolerances**—Tolerance on thickness and outside diameter shall be as follows:

Thickness	Plus 7.5% minus 7.5%
Outside diameter	Plus 0.5% minus 0.5%

(With a minimum of 0.10 mm over and under).

Tolerance on length shall be in accordance with Regulation 58(f).

(iv) **Heat Treatment**—After final cold finishing the tubes shall be heat treated as follows:

Tubes Grade	*Heat treatment*
WC 1	Normalized* or sub-critically annealed#
WC 2, WC 3	Normalized*

The ends which are subjected to cold working operation shall be suitably normalized or sub-critically annealed as above.

* Temperature range 880 Deg. C to 940 Deg. C.

\# Temperature range 660 Deg. C to 720 Deg. C.

(v) **Tests**—

(a) **Tensile test**—This test shall be comply with the provision of Regulation 60.

(b) **Flattening test**—This test shall comply with the provision of Regulation 59(a).

(c) **Flaring test**—This shall comply with the provision of Regulation 59(b).

(vi) **Hydraulic test**—This shall comply with the provision of Regulation 61.

(vii) **Test specimens**—These shall comply with the provision of Regulation 62.

(viii) **Number of tests**—These shall comply with the provisions of Regulation 63.

STEEL CASTING

73. Scope

(a) This regulation shall cover carbon steel castings used in the construction of boilers and steam pipes including their fittings.

(b) For all types of steel castings conforming to these regulations only the minimum values for tensile strength are fixed. The maximum values shall be between 40 and 50 kgf/mm^2.

(c) **Heat treatment**—All castings shall be supplied in the heat-treated condition. The heat-treatment shall consist of annealing and normalising, and tempering, or hardening and tempering, either at the discretion of the manufacturer or the Inspecting Officer and shall be carried out at suitable temperatures to give the mechanical properties specified in Regulation77.

(d) **Fettlings and Dressing**—All castings shall be properly fettled and dressed and all surfaces shall be satisfactorily cleaned for inspection purposes.

74. Process of manufacture

The steel used for castings shall be made by the Open Hearth or Electric Furnace or any other process which gives steel having equivalent properties.

(b) **Chemical analysis**—The ladle analysis shall conform to the following requirements, namely:

*Carbon	0.25% Maximum
Silicon	0.60% Maximum
Manganese	1.40% Maximum
Phosphorus	0.05% Maximum
Sulphur	0.05% Maximum

* A carbon content not exceeding 0.30% may be subject to the agreement between the boiler maker and the Inspecting Authority.

The steel shall comply with the chemical composition specified in the table above.

75. Freedom from and rectification of defects

The steel castings shall have clean surfaces and shall be free from injurious defects. The specified permissible variations in size or thickness shall not be exceeded. Defects may be repaired by welding only, with the approval of the Inspecting Authority provided that the castings are stress-relieved after welding wherever necessary.

76. Number of test provision of test samples

Tensile and bend test pieces shall be prepared from test samples representative of each melt or heat-treatment batch as follows:—

(a) The test samples shall be cast attached to or separate from the castings as agreed between the manufacturer and the Inspecting Officer. The agreement for attached test samples shall include the precise location and method of attachment. If the Inspecting Officer does not make such an agreement with the manufacturer, the decision as to the manner of providing test samples shall rest with the manufacturer. The discretion of the manufacturer shall not, however, apply to the testing of castings made from more than one melt as indicated in clause (d) below.

(b) If the test samples are attached to the castings, at least one tensile test, and when required one bend test, shall be made from each melt. Such test samples shall not be detached from the castings until heat-treatment of the castings has been completed and they have been stamped by the Inspecting Officer. Test samples shall be stamped by the Inspecting Officer after that heat-treatment process.

(c) If the test samples are cast separately, they shall be provided to the extent of 2 per cent of the number of castings from each melt, but in no case shall there be less than 2 samples per melt, except by agreement between the manufacturer and the Inspecting Officer. The test samples shall be cast in moulds of the same material as is used for the castings and shall be made at the same time as the castings, and run from the same ladle. The samples shall be stamped by the Inspecting Officer so as to identify the castings to which they relate.

(d) When a casting is made from more than one melt, at least four tensile tests, and where required four bends tests, shall be made from test samples situated as far apart as possible on the casting. Some of the test samples shall be taken from as near the top and others near from the bottom of the casting as is practicable.

(e) Test samples shall be heat-treated with the castings they represent.

77. Tensile test

(a) The upper yield point at room temperature shall be not less than 50% of the specified minimum tensile strength at room temperature.

(b) A proportional test piece with $L_o = 5d_o$ shall be used as test specimen.

(c) The minimum values of stress at proof limit of 0.2% at elevated temperature (Et) of the material may be calculated by multiplying the minimum specified tensile strength at room temperature (R20) by the value of ratio Et/R20 given in table under regulation 16.

(d) The breaking elongation % shall be not less than

$$\frac{93-Rm}{2.2}$$

where, Rm = measured tensile strength at room temperature in kgf/mm^2

93 = a quality index

2.2 = a constant which is valid only when $L_o = 5d_o$

where, L_o = gauge length

d_o = original diameter of the round test piece.

(e) If, however, the tensile tests are carried out on specimen conforming to any other standards, the material will be accepted provided the tensile strength and elongation computed on the basis of the dimensions of the test pieces under the regulation shall conform to the above requirements.

78. Bend tests

Cold bend tests shall be made upon test pieces having rectangular section of one inch wide by 3/4 inch thick. The test pieces shall be machined and the edges rounded to a radius of 1/16 inch. The test pieces shall be bent over the thinner section.

Bend tests may be made by pressure or by blows, and the test pieces shall without fracture withstand being bent round a former having a radius of 1 inch through an angle not less than that given in the following table:

Grade of Casting	*Angle of Bend minimum*
A	120°
B	90°
C	No test

79.

(a) **Additional tests before rejection**—Should any of the original test pieces fail to pass the mechanical tests, two further samples which represent the same casting or castings shall be selected and tested in the same manner. The manufacturer shall have the right, if he so desires to re-heat-treat the castings before the two further samples are selected.

Should the two further test satisfy the requirements of this standard, castings represented by them shall be accepted. Should either of the re-tests fail, the castings represented shall be liable to rejection.

(b) **Hardness test after heat treatment**—The Inspecting Officer may call for hardness testing of the heat-treated castings.

(c) **Non-destructive tests**—The Inspecting Officer may call for radiographic examination or other non-destructive testing of the castings.

Castings found to be unsound may be treated in accordance with Regulation 75. If the welding repairs are sanctioned by the Inspecting Officer, they shall be carried out in accordance with Regulation 80.

High class castings for which a factor greater than 80% is taken in computation of permissible working stress shall be subject to the following inspection requirements:

(i) Each casting shall be examined by radiographic or ultrasonic methods at all critical locations and found free from harmful defects. All the castings shall be fully machined to such an extent that all critical sections are exposed for full thickness.

(ii) All castings shall be examined at all critical locations using magnetic-particle or penetrant-fluid procedure, or by grinding or machining or etching.

(iii) Castings found to be defective shall be rejected or repaired to the satisfaction of the Inspecting Authority. If repairs by welding are carried out the castings shall be subsequently stress-relieved or heat treated. Castings found to be unsound may be treated in accordance with regulation 80. Repaired areas of castings shall be re-examined by the Inspecting Officer in accordance with sub-clause (i) and shall be shown to be free from harmful defects.

(iv) Castings to which a quality factor of 0.90 is assigned shall be clearly and permanently marked with G suitable symbol after being examined as above and found satisfactory.

Note: The provisions of the first paragraph of clause (c) of regulation 79 shall apply to the castings other than high class castings for which a factor greater than 80% is used in the computation of permissible working stress for shells of Boiler and integral super-heater Drums and Headers under regulation 271.

80. Procedure for welding

In order to maintain a high standard of workmanship in the practice of arc-welding to steel castings, the following general principles should be followed, but the precise technique will of necessity vary according to the circumstances.

Surface condition—The surfaces of the steel, it is intended to weld should be cleaned and freed from all foreign matter, otherwise poor penetration and unmould weld metal may result.

The preparation for the welding of cracks should be of the U or V types. When the later is used, the included angle should be not less than 70°. Where cracks extend through the section of the casting, the choice between single and double preparation, U or V will be governed by (i) the thickness of the casting; (ii) the location of the defect. In double preparation, U or V the root of the U or V should be sufficiently open to ensure complete penetration.

Electrodes—The electrodes shall comply with Regulations 94 to 98 for Grade A castings. Electrodes for Grades B and C castings should be agreed between the manufacturer and the Inspecting Officer.

The electrode manufacturer's recommendations for the use of the electrode should be strictly followed.

Pre-heating—Variations in composition, mass design and the extent of welding required make it impossible to lay down specific rules to establish conditions under which pre-heating should be applied.

When after consideration of each casting in the light of the above variables it is deemed necessary to pre-heat, such pre-heating should be carried out at a temperature of 150-300°C (302-572°F).

Stress-relieving treatment—When the welding is carried out after the casting has received its normal heat treatment, a further heat treatment may be considered necessary. This treatment need be applied only in cases where welding has been such as to induce either internal stresses which would be detrimental to the casting, or locally hardened areas which would cause difficulty in machining. Where this further heat treatment is applied, the casting, where possible, should not be allowed to go cold after welding, but should be charged into a warm furnace and re-heated to a suitable tempering temperature which in general should be not less than 550°C (1022°F).

When considering the advisability of applying this further treatment, its effect on the physical properties of the castings should be borne in mind. If the treatment, or the welding itself is such that the physical properties will be adversely affected, the full heat treatment required to produce satisfactory qualities should be substituted.

FORGED OR ROLLED PRESSURE PARTS OTHER THAN SEAMLESS DRUMS OR CARBON STEEL

81.

(a) **Process of manufacture**—The steel used for the parts shall be made by the Open Hearth or Electric or basic Oxygen process or by any other process which gives steel having equivalent properties.

(b) **Chemical analysis**—The steel shall not contain more than 0.05 per cent of sulphur or of phosphorus.

(c) **Freedom from and rectification of defects**—Where not machined, the pipes, shall have workman like surfaces as normally obtained by rolling, forging or drawing. Provided that the minimum required thickness is maintained, minor surface defects may be admitted and other defects removed by mechanical means so as to achieve a smooth surface. Surface defects may also be repaired, by welding only, with the approval of the Inspecting Authority provided that the parts are stress-relieved after welding, wherever necessary.

82. Selection of test pieces

(a) For testing, either the parts themselves shall be used or additional material of sufficient size for test pieces shall be available. In the case of headers for example, surplus lengths for test rings may be used. In the case of flanges swaged in dies, the punching left may be used as test pieces in which case the identity of the material of the punching with that of the flange shall be evidenced in an adequate manner. The test may be performed also on the semi-finished material for example a bar or a billet, provided it is given approximately the same reduction and heat-treatment as the finished forgings. For headers with closed ends, the test rings shall be cut off before dishing or reducing and shall be subjected to the same heat treatment as the headers themselves. In the case of headers which are closed by special covers, the test ring shall be cut off after heat treatment. Similar procedures shall be followed for test pieces of other forgings.

(b) For testing, piece of one and the same cast of the same heat treatment batch as well as of similar dimensions may be gathered into one group. At least one test piece shall be made from each group.

(c) A proportional test piece with $L_o = 5d_o$ shall be used as a test specimen.

(d) Tangential test piece shall be used for headers where practicable.

For headers with outside diameter less than 200 mm longitudinal test pieces may be allowed.

(e) **Hydraulic test**—A hydraulic test shall be carried out at the Maker's works in accordance with the requirements of regulation 268, if required by the Inspecting Authority.

83. Tensile strength

(a) The tensile strength of the material shall conform to one of the following four grades:—

(i) 37 to 45 kfg/mm^2

(ii) 42 to 50 kfg/mm^2

(iii) 47 to 56 kfg/mm^2

(iv) 56 to 62 kfg/mm^2

(b) The upper yield point at room temperature shall be not less than 50% of the specified minimum tensile strength.

(c) The minimum values of the stress at proof limit 0.2% at elevated temperature (Et) may be calculated by multiplying the minimum specified tensile/strength of the material at room temperature (R20) by the value of the ratio Et/R20 given in the table under Regulation 16.

(d) The breaking elongation in % shall not be less than

$$\frac{93 - Rm}{2.2}$$

where, Rm = measured tensile strength at room temperature in kfg/mm^2

93 = quality index

2.2 = a constant which is valid only when $L_o = 5d_o$

where, L_o = gauge length

d_o = original diameter of the round test piece.

84. Bend tests

(a) Bend test pieces shall be of rectangular cross-section machined to a finished size of 1 inch wide by ¾ inch thick. In the case of headers, bend test pieces may be cut transversely 1½ T wide by T thick where T is the thickness of the headers: The edges shall be rounded to a radius of 1/16 inch. The test pieces shall be bent over the thinner section.

(b) Test pieces shall be bent when cold through an angle of 180° without fracture, the internal radius of the bend being not greater than that specified in table below for the 1 inch wide by ¾ inch thick test piece and not more than 1½ T for the full thickness test piece.

Ultimate tensile stress	*Internal radius of bend*
Tons/sq. in.	inch
Upto 32	1/4
Above 32 and upto 36	3/8
Above 36 and upto 38	5/8

Bend tests may be made by pressure or by blows.

85. Additional tests before rejection

Should either a tensile or a bend test fail, two further tests of the type which failed may be made on test pieces out from the same forging. If the results obtained from these retests are satisfactory, the forging shall be accepted, provided that in other respects they fulfil the conditions laid down above for steel forgings. If these retests do not give satisfactory results the forgings represented may be re-heat-treated together with the remainder of the test blocks and presented for further testings.

In all cases where final retests do not give satisfactory results, the forgings represented by the test pieces which fail shall be rejected.

GENERAL GREY IRON CASTINGS (GRADE A)

86.

(a) **Process of manufacture**—The castings shall be cast from metal melted or refined in any metallurgical plant other than an iron ore smelting furnace, for the use of which furnace permission in writing must be received from the Inspecting Authority.

(b) **Chemical composition**—The composition of the iron as cast shall be left to the discretion of the manufacturer but the maximum percentage of phosphorus or sulphur or both may be specified by the Inspecting Authority, if he so desires.

(c) **Moulding**—The castings shall be accurately moulded in accordance with the pattern or working drawings supplied by the Inspecting Authority with the addition of such letters, figures or marks as may be specified and the drawings shall include the tolerances specified in the Regulations.

Freedom from defects—The castings shall be sound, clean out of twist and free from blow holes distortion and all surface and other defects. They shall be well dressed or fettled and shall be machinable by normal methods.

87. Provision of test bars

The Inspecting Authority shall state at the time of enquiry whether he requires tensile or transverse tests, or both, and he may also specify cast-on bars where the design of the casting and method of running permit.

When the test bars are cast separately they shall be poured at the same time and from the same ladle, or metal as the casting or castings they represent. The number of test bars specified in Regulation 92 shall be applicable to all castings of each melt.

When the bars are cast-on, the mould for the casting and the mould for the test piece shall be joined together in such a manner that the liquid metal fills both moulds at the same operation.

All test bars shall be cast in green sand or dry sand or in loam moulds according as to whether the casting or castings they represent are moulded in green sand, or in loam or dry sand, respectively.

The test bars shall not be subjected to any heat treatment after leaving the moulds.

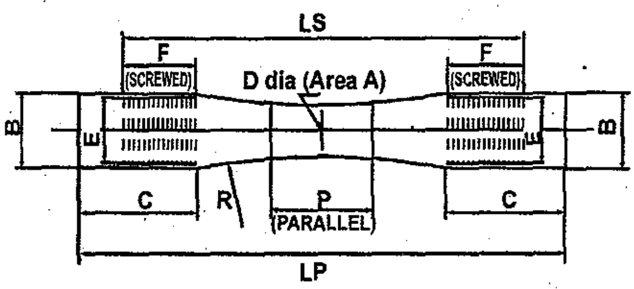
88. Dimension of test bars

(a) **Transverse Test Bars**—The transverse test bars of the diameter specified by the Inspecting Authority according to the main cross-sectional thickness of the casting represented, shall conform to the following dimensions:

Diameter test Bar	Limits on Diameter	Overall length	Main cross-sectional thickness of casting represented
in.	in.	in.	in.
0.6	+0.045	10	Not exceeding 3/8
0.875	+0.065	15	Over 3/8 and not exceeding ¾
1.2	+0.090	21	Over ¾ and not exceeding 1½
1.6	+1.10	21	Over 1½ and not exceeding 1½
2.1	+0.10	27	Over 1½

Bars cast to a size in excess of the limits given above may be machined to a diameter within the specified limits. Bars cast within these limits of diameter may also be machined before the transverse test is made, providing that the finished diameter falls within these limits.

(b) **Tensile Test Bars**—The tensile test bars of the diameter specified by the Inspecting Authority, according to the main cross-sectional thickness of the casting represented shall conform to the dimensions shown in the following table. Bars may be tested with either plain or screwed ends.



(c) For castings over 2 inches in thickness a test bar of larger diameter than 2.1 inches may be used by agreement between the manufacturer and the Inspecting Authority. For diagram and table see under clause (b) of this Regulation.

89. Mechanical test

The casting must comply with the transverse and tensile tests specified in Regulation 90 and Regulation 91. All test pieces shall be selected by the Inspector and tested in his presence and to his satisfaction.

90. Transverse test

A transverse test bar cast in accordance with Regulation 88(a) must when placed on supports set at the distance shown in column 2 of the following table sustain a load applied at the centre of not less than that shown in column 3 and must show before rupture a deflection not less than that shown in column 4. The supports and the point of application of the load shall be rounded to a radius of not less than 1/8 inch.

Diameter of test bar	*Distance between support*	*Minimum breaking load-Grade A*	*Minimum deflection Grade A*
in.	*in.*	*lbs.*	*in.*
0.6	9	530	0.07
0.875	12	1,185	0.10
1.2	18	1,950	0.15
1.6	18	4,280	0.12
2.1	24	6,660	0.15

TABLE

Diameter as cast	Gauge diameter	Area	Min. parallel length	Min. radius	Min. length of plain ends	Screwed ends		Approximate minimum overall length		Main cross-sectional thickness of casting represented
						Size	Min. length	Plain ends	Screwed ends	
B	D	A	P	R	C	E	F	LP	LS	
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
0.6	0.399	0.125	1	1½	1½	½ S.P. 9/16 S.F. p/16 S.W.	9/16	4½	3	Not exceeding 3/8
0.875	0.564	0.25	2	3½	1½	¾ S.F. 7/8 S.W.	¾	7-1/16	4-13/16	Over 3/8 and not exceeding ¾
1.2	0.798	0.50	2	3½	2	1½ S.F. 1½ S.W.	1½	8¼	5-7/8	Over ¾ and not exceeding 1½
1.6	1.128	1.00	2	3½	2½	1½ S.F. 1½ S.W.	1½	9-1/32	7¼ 7¼	Over 1½ and not exceeding 1-5/8
2.1	1.596	2.00	2	3½	3½	2 S.F.	2	11¼	8¼	Over 1-5/8

The test bars shall be cast as parallel bars of the diameters given in column B and then machined to the dimensions C and P in the above table.

If the diameter of a transverse test bar as cast varies within the limits specified in Regulation 88(a) the equivalent breaking load for the factors given in Appendix F.

91. Tensile test

A tensile test bar machined to the dimensions shown in Regulation 88(b) and tested with either plain or screwed ends must show a breaking strength of not less than that shown in the following table:

Diameter of test bar	*Minimum ultimate tensile stress – Grade A*
in.	*Tons per sq. in.*
0.6	12.5
0.875	12
1.2	11
1.6	10.5
2.1	10

Note: Self-aligning grips to ensure axial loading are recommended.

92. Number of transverse and tensile tests

The number of tests required for each batch of castings shall be in accordance with the following table, the various classes of castings being divided into four representative groups. One test shall refer to one transverse and one tensile test, whether taken from one or two test bars as cast.

Group	*Weight of castings*	
1	Upto 28 lbs.	One test for each 30 cwt. of castings or part thereof.
2	Over 28 lbs. and upto 1 cwt.	One test for each 2 tons of castings or part thereof.
3	Over 1 cwt. and upto one ton	One test for each 4 tons of castings or part thereof.
4	Over 1 ton and important castings where mutually agreed upon.	One test for each 4 tons of castings or part thereof or fc each casting weighing 4 tons or more.

In the above groups 1, 2 and 3, all castings represented by one test must be poured from the same ladle or same heat as the bar or bars provided for the test.

93. Additional tests

The additional tests to be carried out before a casting or batch of castings is rejected shall be accordance with the following table:

Test piece	*Event*	*Conditions*
1st	If this fails	The second test piece shall be tested.
2nd	If this passes	The batch or separate casting represented shall be accepted.
	If this fails	The batch or separate casting represented may be rejected.

Provided always that in the case of failure of both test pieces if either show obvious defects a third test piece may be taken from a broken casting or a piece may be cut from a usable casting for further testing as follows:

3rd	If this passes	The batch or separate casting represented shall be accepted.
	If this fails	The batch or separate casting represented may be rejected.

COVERED ELECTRODES FOR METAL ARC WELDING OR MILD STEEL

94. Central requirements

(1) **Application**—The following Regulations apply to electrodes of sizes 3/32 inch (12 S.W.G.) and larger in diameter for metal arc welding of carbon steels having ultimate tensile strength not exceeding 33 tons per square inch and sulphur and phosphorus contents not greater than 0.0_ per cent each. Electrodes less than 3/32 inch in diameter shall not be used in boilers.

The electrodes shall comply with the requirements of physical tests prescribed for each class.

Their characteristics and behaviour under ordinary working conditions shall be such that satisfactory weld deposits can be made by a welder of average skill and experience and that the following characteristics are also obtained:

(a) a relative ease in the control of the slag and weld metal during welding;

(b) a good degree of stability of the arc and of the fusing of the covering;

(c) no undue degree of spatter;

(d) a fair rate of deposition and depth of penetration;

(e) easy removability of the slag;

(f) no undue tendency to under-cut;

(g) a fair contour of the weld deposits; and

(h) a low internal porosity of the weld metal.

(2) **Classification**—The electrodes shall be classified into:

(a) normal penetration electrodes for use in one or more welding positions; and

(b) deep penetration electrodes for close unprepared butt-welding in the flat position and/or fillet welding, in the flat and horizontal vertical positions.

(3) **Manufacture**—Electrodes may be made by any method that shall yield a product conforming to the requirements of these Regulations.

(4) **Size of electrodes**—The nominal size of the electrodes shall refer to the diameter of the core wire and the length shall not exceed 18 inches. Provision shall be made for end or centre gripping.

The tolerance on the specified diameter of the core wire of the electrodes shall be plus or minus 0.002 inch.

(5) **Covering**—The flux covering shall be sufficiently robust to withstand the normal conditions of transport, storage, handling and use, without damage and shall be uniform in thickness all over so that it fuses evenly. The variation in the thickness shall not exceed 3 percent.

(6) (a) **Packing and storage**—Electrodes shall be suitably packed to guard against damage during transportation. When stored, the electrodes shall be kept in their original bundles or packings in a dry store room and under such conditions, the electrodes shall for a period of atleast six months be capable of giving results similar to those which they would have given on the date of their despatch from the manufacturer.

(b) **Marking**—Each package shall be marked with the following information:

- Name of the Manufacturer.
- Trade name of the Electrodes.

- Size and quantity of Electrodes.
- Batch Number.
- Recommended current range.
- Classification as per Indian Boiler Regulation.

(7) **Tests**—The electrodes shall be subjected to Initial tests, Periodic check tests and Production control to ensure that the requirements of these Regulations are fulfilled.

Electrodes intended for use with more than one type of current or polarity shall be tested using each type of current and polarity.

Where any test specimen fails to satisfy the requirements of any particular test, two further test specimens shall be prepared using the electrodes from the same batch and submitted to the same test.

The batch of electrodes shall be accepted as having passed the test provided that the tests of both the additional specimens are satisfactory.

(8) **Test Certificates**—The manufacturers shall, when called upon, produce the results of the most recent Periodic check tests carried out within the preceding 12 months, on electrodes representative of the electrodes supplied.

95. Requirements for normal penetration electrodes—Initial tests

The following initial tests on each brand of electrodes shall be carried out:

(a) **All-weld metal tensile tests**—Three all-weld metal tensile test specimens, one each using the smallest, 6 S.W.G., and the largest diameter electrodes manufactured in this grade shall be prepared, and tested in accordance with the method described in Appendix H-1. The ultimate tensile stress of each test specimen shall be not less than 26 tons per square inch and yield stress not less than 20 tons per square inch. The elongation shall be not less than 25 per cent and the minimum reduction of area shall be not less than 35 per cent.

(b) **Fillet weld hot cracking test**—One fillet weld hot cracking test shall be carried out as specified in Appendix H-1. The electrodes shall be deemed to be satisfactory provided no hot cracking occurs under the conditions of test. Greater cracks may be neglected provided they do not run into the full Section of the weld.

(c) **Transverse tensile test**—One transverse tensile test shall be carried out for each welding position for which the electrode is recommended by the manufacturer except that two tests shall be required for the flat position. For electrodes recommended for all positions, a test in the inclined position is not required.

The ultimate tensile stress shall be not less than 28 tons square inch. The method of preparation of the test pieces is specified in Appendix H-1.

(d) **Transverse bend test**—Two bend tests one with the face and the other with the root in tension shall be carried out for each welding position for which the electrode is recommended by the manufacturer, except that two in each shall be carried out for those intended for flat position only. For electrodes recommended for all positions, a test in the inclined position is not required. The method of preparation and carrying out the test shall be in accordance with Appendix H-1. The electrode shall be deemed to be satisfactory provided that on completion of the test, no crack or defect at the outer surface is greater than 1/8 inch measured across the specimen or 1/16 inch measured along its length. Premature failures at corners of the test specimen shall not be considered a cause for rejection.

(e) **Cruciform fillet weld tensile test**—One Cruciform fillet weld tensile test shall be carried out for each welding position for which the electrode is recommended by the manufacturer, except that when the electrode is recommended for both the flat and the horizontal-vertical positions, a test in the flat position shall not be required. The method of preparation of the test pieces and of carrying out the tests shall be as specified in Appendix H-1. These test pieces shall be capable of withstanding an ultimate tensile load of not less than 36.5×W×C tons: where W is the width of the test piece and C is the average throat thickness of the welds, both in inches. C shall be taken as 0.7 × the average leg length or as the actual mean throat thickness, whichever is the greater.

(f) **All-weld metal impact test**—Three Izod impact test specimen, one each using the smallest size manufactured, 6 S.W.G., and the largest size manufactured electrodes respectively, shall be prepared and tested in accordance with the method specified in Appendix H-1. The average of the three impact values for each test specimen shall be not less than 30 ft. lbs.

96. Requirements for deep penetration butt-welding/electrodes

Initial test—For electrodes recommended for deep penetration butt-welding, the following initial tests shall be carried out:

(1) **Transverse tensile test**—Three transverse tensile test specimens, one each from test pieces shall be prepared according to Table 3 in Appendix H-2 and tested as specified in Appendix H-2. If the diameter of the largest size of electrode manufactured is less than ¼ inch only two specimens need be prepared. The ultimate tensile stress of each specimen shall be not less than 28 tons per square inch.

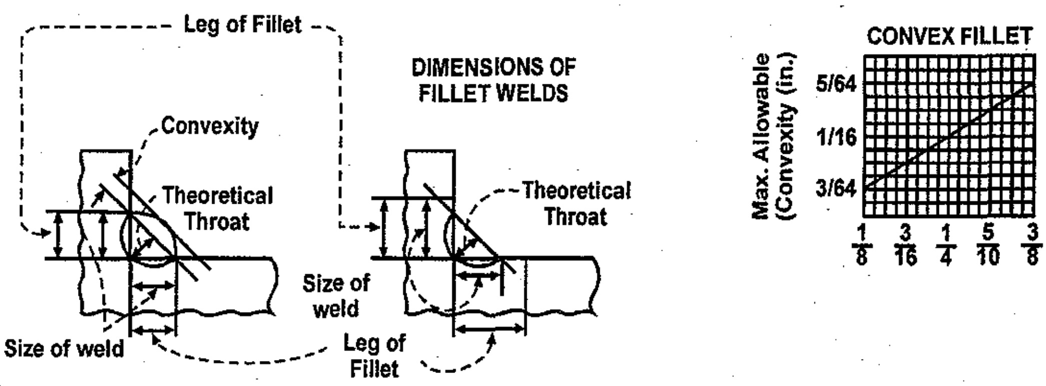
(2) **Transverse bend test**—Six bend test specimens, two each from test pieces, prepared according to the Table 3 in Appendix H-2 shall be tested in accordance with the method specified in Appendix H-2. If the diameter of the largest size of the electrode manufactured be less than ¼ inch, only 4 specimens will be required. Of each pair of specimens, one shall be tested with the side first welded in tension and one with the other side in tension. The electrode shall be deemed to be satisfactory if on completion of the test no crack or defect at the outer surface of the specimen is greater than 1/8 inch measured across it or 1/16 inch measured along its length. Premature failure at corners shall not be considered cause for rejection.

(3) **Butt-weld penetration test**—Examination of the inner edges of the outer discards from the butt-weld test pieces prepared as specified in Appendix H-2 shall show that complete penetration has been achieved.

97. Requirements for deep penetration fillet welding electrodes initial test

The following initial tests on each brand of electrodes shall be carried out:

(a) **Cruciform fillet weld tensile test**—Three test specimens one each from test pieces prepared according to the procedures laid down in Appendix H-2 shall be tested in accordance with the method specified therein. If the diameter of the largest size of electrode manufactured is less than ¼ inch then two specimens only are required. Each specimen shall withstand an ultimate tensile load of not less than 36.5×W×C tons; where W is the width of the test specimen and C is the effective size of the welds, both in inches. For the purpose of calculating the test load, the effective size of deep penetration fillet welds shall be taken either as 0.7 × (the average leg length plus 3/32 inch) or as the actual mean throat thickness plus 1/17 inch whichever is the greater.



CONCAVE FILLET

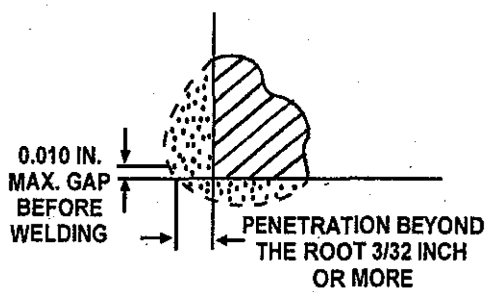
Note 1: Size of fillet weld = length of largest inscribed isosceles right angled triangle.

Note 2: Length of horizontal leg of fillet weld shall not vary more than 1.16 in. from length of vertical leg.

Note 3: Fillet weld size, convexity and leg lengths of fillet welds shall be determined by actual measurement (to nearest 1/64 in.) on a section laid out with inscribed lines as shown.

FILLET WELD PENETRATION TEST—Both legs of each fillet weld deposited shall be of equal length with maximum allowable limits shown in the figure given above.

(b) The outer discards from the cruciform fillet weld test pieces prepared as above shall show a minimum penetration beyond the root of not less than 3/32 as shown in the figure given below:



MEASUREMENT OF PENETRATION OF FILLET WELD

The weld shall also be free from cracking, under-cut trapped slag, and porosity.

98. Periodic check test

The following Periodic Check Tests on each brand of electrodes shall be carried out:

(a) Periodic check tests consist of a selection of the tests prescribed under Regulations 95 to 97 and they shall be repeated at intervals of not more than 6 months to provide evidence that the electrodes currently produced continue to possess the properties recorded in the initial tests:

(i) All-weld tensile test with any two sizes of electrodes within the limits prescribed in clause (a) of Regulation 95.

(ii) One Tee joint fillet weld hot cracking test as prescribed in clause (b) of Regulation 95.

(b) For deep penetration butt-welding electrodes, one transverse tensile test specimen and two transverse bend test specimens shall be prepared and tested as prescribed in Regulation 96 and the specimens shall show that a complete penetration has been achieved.

(c) For deep penetration fillet welding electrodes one cruciform fillet weld tensile test shall be taken as prescribed in Regulation 97(1) and the two outer discards from the test pieces shall show a minimum penetration beyond the root as required under Regulation 97(2).

APPENDIX H-1

(*See* Regulation 95)

(1) Parent metal for test plates

The parent metal used in preparing test pieces and test specimen shall be mild steel of welding quality in the normalised condition (this condition is optional in the case of all-weld metal tests) with an ultimate tensile stress of not less than 28 and not more than 32 tons per square inch and in elongation of not less than 20 per cent on standard test pieces A(1) (Appendix B).

(2) All-weld metal test

Method of preparation of test pieces. The temperature of the parent metal shall be between 50° and 100°F (10°—38°C) immediately before deposition the first run of weld metal. The test specimen shall not be subjected to any mechanical or thermal treatment other than that required herein. All-weld test pieces shall be prepared as shown in Figure 1 by depositing weld metal between the chamfered edges of two plates, each 7/8 inch thick. The preparation of the plates shall give an included angle of 20° and the distance between the plates at the root edges shall be ½ inch to 17/32 inch. The joint shall be closed at the bottom by a backing plate 1¼ inch wide by ¼ inch thick. The two plates shall be 7 inches long and the dimension B from square edge to root edge of each side plate shall be between:

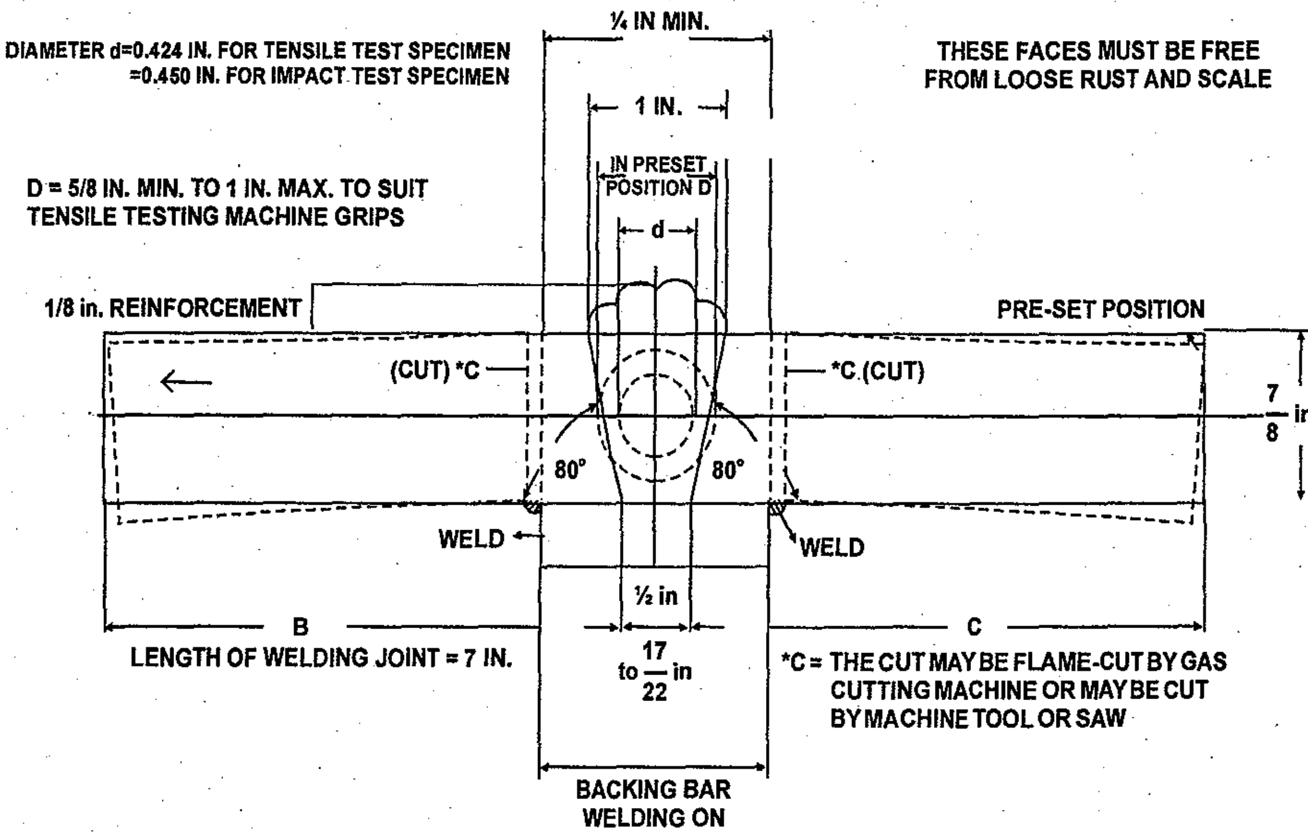


FIG. 1: METHOD OF PREPARATION OF ALL-WELD METAL TEST SPECIMEN

2 inches minimum and 3 inches maximum when testing 12 S.W.G.(3/32) inch electrodes.

3 inches minimum and 4 inches maximum when testing 10 S.W.G. or 8 S.W.G. electrodes.

4 inches minimum and 5 inches maximum when testing 6 S.W.G. electrodes.

5 inches minimum and 6 inches maximum when testing ¼ inch or 5/16 inch electrodes.

The assembly shall be welded together with these plates pre-set so that the gap at the top between the chamfered edges of the plates is 1 inch and the plates may be approximately level when the butt-weld is completed.

The weld metal shall be deposited in single or multi-run layers and the direction of deposition of each layer shall be alternatively from each end of the specimen. Each run of weld metal shall not be less than 1/16 inch and not more than 1/8 inch thick. The time interval between the completion of one run and the commencement of deposition of the succeeding run shall be not less than 5 minutes. The assembly shall not be quenched between the deposition of individual runs. The welding current used shall be within the appropriate range given by the manufacturer. The welding position for the assembly shall be flat, unless this is contrary to the recommended position for the electrode, in which case the position of weld shall be as recommended by the manufacturer.

On completion of the weld the specimen shall be allowed to cool in still air. The portion including the weld shall then be removed by cutting away the excess plates at the places indicated in Figure 1.

The all-weld test piece shall be heat-treated by raising to a uniform temperature of 1112° to 1202°F (600° to 650°C) and maintained at that temperature for the one hour and then allowed to cool slowly outside the furnace, protected from draughts and chilling. A tensile test specimen shall be machined from the test piece to the dimensions given in Figure 1(a) taking care that the longitudinal axis of the specimen coincides with the centre line of the weld and the mid-thickness of the plate as indicated in Figure 1. The specimen then shall be tested for tensile strength.

(3) Impact test specimen

The Izod impact test specimens shall be machined from the weld metal test pieces to the dimensions given in Figure 2, care being taken that the longitudinal axis of the test piece coincides with the centre line of the weld and mid-thickness of the plate. The temperature of the test specimen at the time of testing shall not be less than 50°F (10°C).

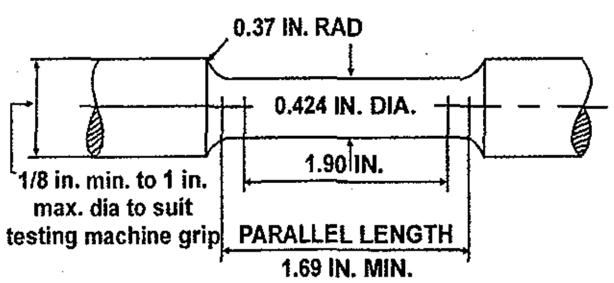


FIG. 1(a): TENSILE TEST SPECIMEN

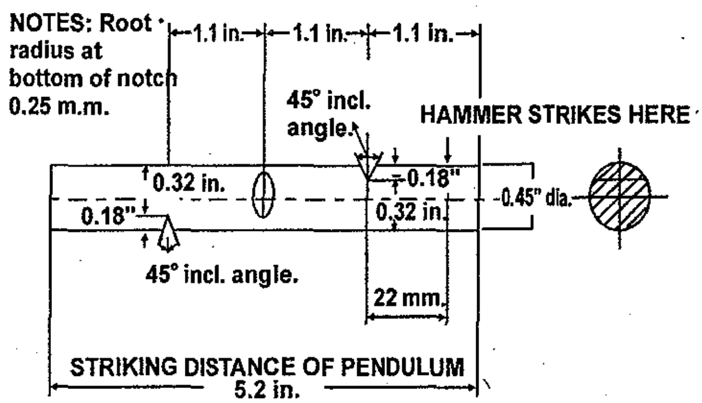


FIG. 2: IMPACT TEST SPECIMEN

(4) Hot cracking test

A 6 inches × 3 inches × 1/2 inch plate shall be welded to a second plate 6 inches × 6 inches × 1/2 inch in the form of a close square Tee joints as shown in Figure 3. The edge of the first plate abutting the surface of the second shall be prepared by machining or grinding. The gaps betwen parts after tack welding at the ends shall not exceed 0.01 inch.

Two fillet welds 5 inches long 1/4 inch in leg length shall be deposited in the flat position with a single 6 S.W.G. (or 0.2 inch) electrode, using the maximum current of the range recommended by the manufacturer. The test piece shall be so positioned that the slope and the rotation of the weld are zero. The second weld shall be started at that end where the first run was finished after time interval of 4 to 5 seconds. The slag shall be removed after the test piece is cooled in still air to the room temperature. The surfaces of the weld shall be visually examined for cracks.

The second plate shall be split and the welds broken open as shown in Figure 4. The weld shall not show any evidence of hot cracking as indicated by oxidation or temper colouring of the surface of the fractures.

(5) Transverse tensile and bend tests

The transverse tensile and bend test pieces shall be made as shown in Figure 5 by butt-welding together two ½ inch plates of suitable length and not less than 6 inches in width. The plate edges shall be prepared to form a single Vee joint the details of which shall be as follows:

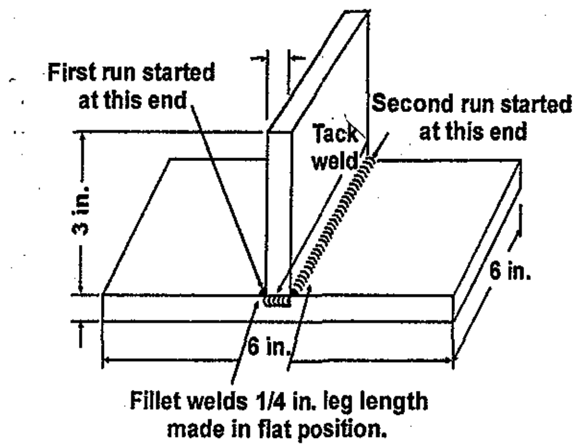


FIG. 3: METHOD OF MAKING HOT CRACKING TEST PIECE

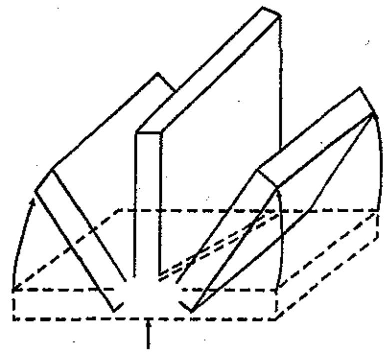


FIG. 4: METHOD OF BREAKING HOT CRACKING TEST PIECE

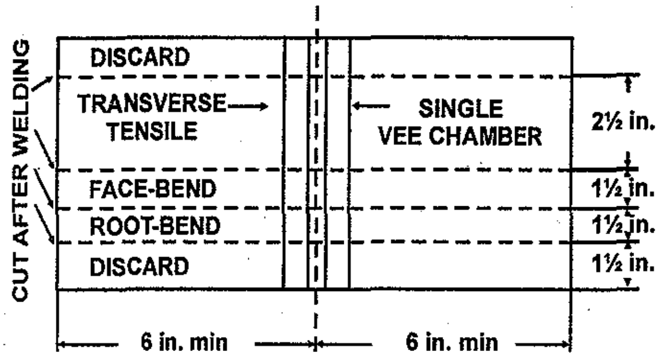


FIG. 5: METHOD OF MAKING TRANSVERSE TENSILE & BEND TEST SPECIMENS

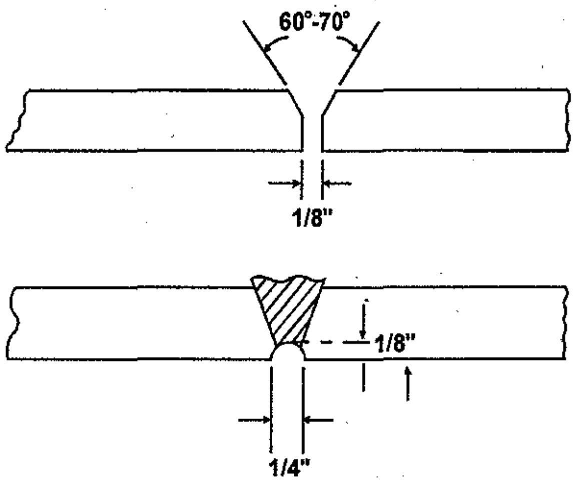


FIG. 5(a): GROOVING IN PREPARATION FOR DEPOSITION OF BACKING RUN

(*See* Figure 5a)

Angle between fusion faces 60°—70°

Root face 1/8 inch.

Maximum gap 1/8 inch.

The plate edges shall be prepared as per Figure 5(a), and pre-set to allow for slight distortion after welding.

The welding procedure in making out the test pieces shall be according to the position of welding as in Table 1 below:

Table 1: Welding procedure for preparation of transverse tensile test and bend test piece

Welding position for test pieces (all angles ≠ 5°) shown in Table 5 below	*Welding Procedure*
FLAT	
Weld slope 0°	1. All runs made with 8 S.W.G. electrodes.
Weld rotation 0°	2. First run—6 S.W.G. electrodes. Subsequent runs—5/16 inch diameter electrodes (or largest size manufactured).
INCLINED	
Weld slope 30°	First run—8 S.W.G. electrodes.
Weld rotation 45°	Subsequent runs—6 S.W.G. electrodes.
HORIZONTAL VERTICAL	
Weld slope 0°	First run—8 S.W.G. electrodes.
Weld rotation 90°	Subsequent runs—6 S.W.G. electrodes
VERTICAL	
Weld slope 90°	All runs made with 8 S.W.G. electrodes.
OVERHEAD	
Weld slope 0°	All runs made with 8 S.W.G. electrodes.
Weld rotation 180°	

In all cases a backing run shall be made with 8 S.W.G. electrodes in the welding position applicable to the test piece, after cutting out a groove of 1/8 inch deep if considered necessary, as in Figure 5(a).

The test pieces for the inclined and vertical positions shall be welded using the 'upwards' method unless the electrodes manufacturer especially recommends that only the 'downwards' method shall be used. If both methods are recommended, test pieces welded by each method shall be made.

After welding, the test pieces shall be cut by sawing on machining to form one transverse tensile, one face-bend and one root-bend test specimen, as indicated in Figure 5.

(6) Transverse tensile test

Transverse tensile tests specimens shall conform to the dimensions given in Figure 6. The upper and lower surfaces of the weld shall be filed, ground or machined level with the respective original surfaces of the plates. Where the surfaces of the plates are not level with each other the metal may be cut away to bring them approximately level, provided that the thickness of the plate is not reduced by more than a total of 0.04 inch.

The test specimens shall then be tested for tensile test as in Appendix B.

(7) Transverse bend test

The bend test specimens shall be 1½ inches in width. The upper and lower surfaces of the weld shall be filled, ground or machined level with the respective original surfaces of the plates, with the proviso as in item (6) above. Tool marks should be avoided as they lead to location of stress and may cause premature failure. For this reason the direction of machining of the surfaces should be along the specimens and transverse to the weld. The sharp corners of the test specimens shall be rounded to a radius not exceeding 1/20 inch.

The test specimens shall be bent through an angle of 180° over a former having a diameter equal to three times the thickness of the specimen, as shown in Figure 7. One test specimen shall be tested with the face of the weld in tension and one with the root of the weld in tension.

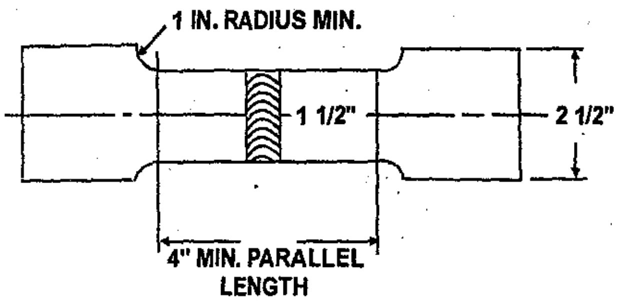


FIG. 6: DIMENSIONS OF TRANSVERSE TENSILE TEST SPECIMEN

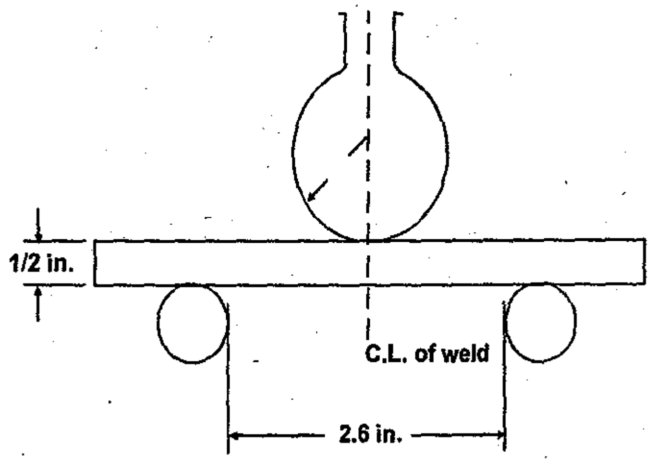


FIG. 7: METHOD OF CARRYING OUT BEND TESTS

(8) Cruciform fillet weld tensile test

Normal Penetration Electrodes—The specimens shall be prepared as shown in Figure 8. Care shall be taken that the centre lines of two vertical plates are in the same plane. The parent metal used shall be at a temperature between 50°-100°F (10°-38°C) immediately before depositing the first run of weld metal. The test specimens shall not be subjected to any mechanical or thermal treatment, other than what is given in this appendix. The plates shall be so placed that each weld shall be deposited in the appropriate welding position, using the procedure specified in Table 2 below:

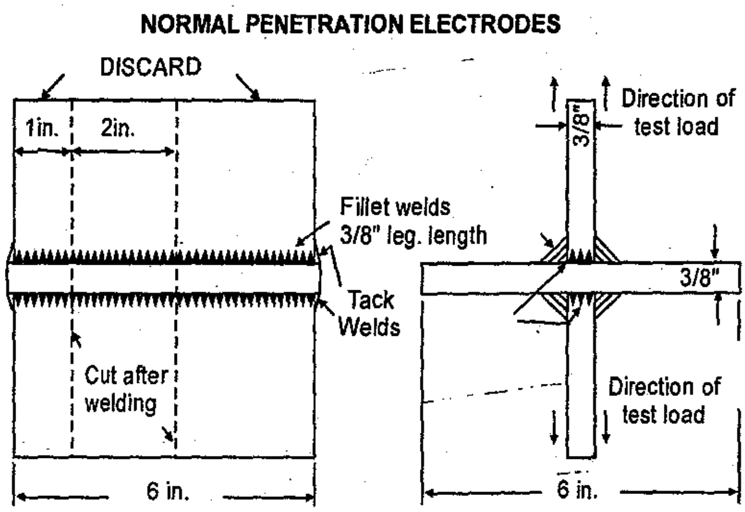


FIG. 8: METHOD OF MAKING CRUCIFORM FILLET WELD TEST SPECIMENS

Table 2: Welding procedures for preparation of cruciform fillet weld tensile test pieces for normal penetration electrodes

Welding position for test pieces (all angles ≠ 5°) shown in Table 5 below	*Welding Procedure*
FLAT	
Weld slope 0°	One run—S.W.G. or 5/16 inches diameter electrodes.
Weld rotation 0°	
INCLINED	
Weld slope 30°	Not more than 3 runs—8 S.W.G. electrodes.
Weld rotation 90°	
HORIZONTAL-VERTICAL	
Weld slope 0°	Not more than 3 runs—6 S.W.G. or 4 S.W.G. electrodes.
Weld rotation 45°	
Vertical weld slope 90°	One run 8—S.W.G. electrodes.
OVERHEAD	
Weld slope 0°	Not more than 3 runs—8 or 6 S.W.G. electrodes.
Weld rotation 180°	

The welding current used shall be as per recommendation of the manufacturer.

The test pieces for the inclined and vertical positions shall be welded using 'upwards' method, unless the manufacturer specifically recommends 'downwards' method. If both methods are recommended, test pieces welded by each method shall be made. The completed test pieces shall be cut into strips by sawing or machining as shown in Figure 8 and the inner strip tested in tension as indicated therein.

APPENDIX H-2

(*See* Regulation 96)

Butt-weld tests—Deep penetration electrodes

The parent metal shall be at a temperature between 50° and 100°F (10°—38°C) immediately before depositing the first run of weld metal and test specimen shall not be subjected to any mechanical or thermal treatment other than that specified in this Appendix. The test pieces shall be made by welding together two plates not less than 6 inches wide and of the thickness specified in Table 3 below:

Table 3: Welding Procedure for Preparation of Butt-weld Test Pieces Deep Penetration Electrodes

Welding position for test pieces (all angles ≠ 5°) shown in Table 5 below	*Welding Procedure*
FLAT Weld slope 0° Weld rotation 0°	1. One run on each side of joint with the largest size of electrode manufactured. Plate thickness equal to twice diameter of the core wire or ½ inch (whichever is less). 2. One run on each side of joint with the smallest size of electrode manufactured (but not less than 1/8 inch diameter). Plate thickness equal to atleast twice diameter of the core wire. 3. One run on each side of joint with 1/4 inch diameter electrodes. Plate thickness not less than 1/2 inch.

The length of the plates shall be sufficient to accommodate on one side the run length of a complete electrode, but in any case shall not be less than 10 inches.

The joint edges of the plates shall be square cut and any gap between the plates after tack welding at the ends shall not exceed 0.010 inches.

The welding procedure shall be as set out in the above table and in addition the first electrode used for welding each side shall be consumed for its full length except for a stub end of not more than 2 inches. The welding current used shall be as recommended by the manufacturer and each weld shall be deposited in the flat welding position and started as shown in Figure 9.

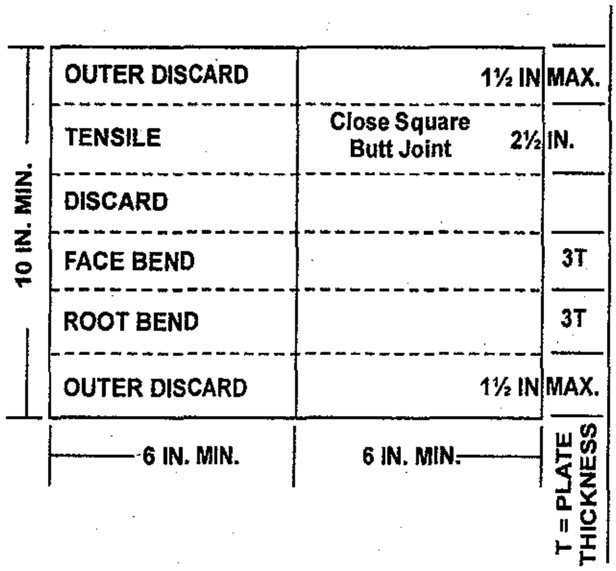


FIG. 9: METHOD OF MAKING BUTT-WELD TEST SPECIMENS

Each test piece shall be so marked that the side first welded remains identifiable after the test specimens have been cut out, as shown in Figure 9. The specimens shall be cut out by sawing or machining to provide arc tensile test specimen and two transverse bend specimens. The two outer discards shall be retained and their inner edges shall be prepared and etched to reveal weld metal one as required for the butt-weld penetration test.

(1) **Transverse tensile test**—Transverse tensile test specimen shall conform to the dimensions given in Figure 6 for such specimens and where the surfaces of the plates are not level they shall be made so by machining or filling provided the thickness of the plate is not reduced by more than a total of 0.04 inch. The specimen shall then be tested for tensile test.

(2) **Transverse bend test**—Each transverse bend test specimen shall be of a width equal to three times its thickness. The upper and lower surfaces of the weld shall be filled, ground or machined level with the respective original surface of the plates provided the thickness of the plates is not reduced by more than a total of 0.04 inch. The direction of machining of the surfaces shall be along the specimen and transverse to the weld. Tool marks shall be avoided to eliminate premature failure, and the sharp corners rounded to a radius not exceeding one-tenth the thickness of the specimen. The test specimen shall be bent through an angle of 180° over a former having a diameter equal to three times the thickness of the specimen as shown in Figure 10. One test specimen shall be tested with the side first welded in tension, and one with the other side in tension.

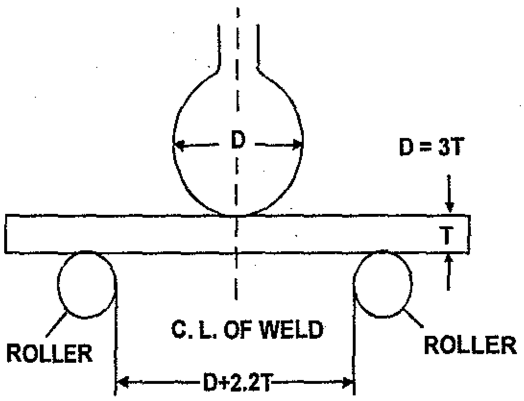


FIG. 10: TRANSVERSE BEND TEST ON BUTT-WELD SPECIMENS

(3) **Cruciform fillet weld test—Deep Penetration Electrodes**—The parent metal shall be at a temperature between 50° and 100°F (10°-38°C) immediately before depositing the first run of weld metal. The test specimen shall not be subjected to any mechanical or thermal treatment other than that specified in this Appendix.

For each test piece, two pieces of plate, of sufficient length to suit the testing machine shall be welded to a third plate by means of fillet welds as shown in Figure 11. Care shall be taken that the centre lines of the vertical plates are in the same plane. The width of the plates shall be sufficient to accommodate on one side the run length of complete electrode, but in any case shall be not less than 10 inches. The thickness of each piece of plate shall be as specified in Table 4 below.

The edge of each vertical plate abutting the surface of the horizontal plate shall be square cut (prepared by machining, grinding or gas cutting), and any gap between the horizontal plate and the vertical plates, after tack welding at the ends in preparation for welding shall not exceed 0.01 inch.

METHOD OF MAKING CRUCIFORM FILLET WELD TEST SPECIMENS

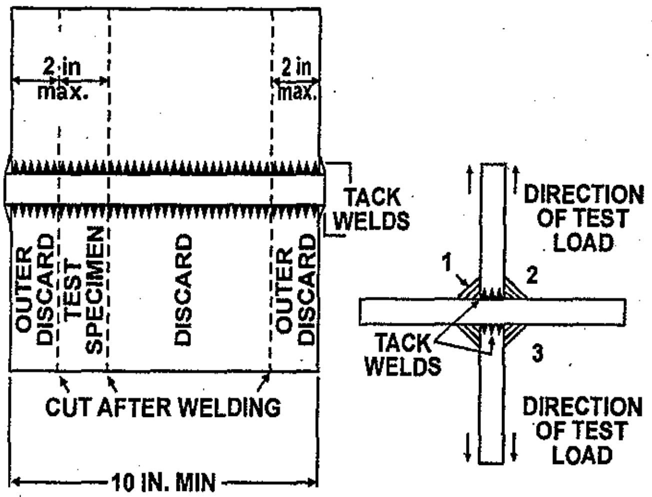


FIG. 11: DEEP PENETRATION ELECTRODES

The welding procedure followed in making the test pieces shall be as set out in Table 4 below with the addition that the first electrode used for welding each fillet shall be consumed for its full length except for a stub end of not more than 2 inches.

Table 4: Welding Procedure for Preparation of Cruciform Fillet Weld Test Pieces (Deep Penetration Electrodes)

Welding position for test pieces as shown in Table 5 below (all angles ≠ 5°)	*Welding Procedure*
Horizontal-Vertical	1. One run on each side of each joint with the largest size of electrode manufactured. Plate thickness equal to at least twice diameter of the core wire or ½ inch (whichever is less). Maximum fillet leg length shall be 1/8 inch less than the plate thickness.
	2. One run on each side of each joint with the smallest size of electrode manufactured (but not less than ½ inch diameter). Plate thickness equal to at least twice diameter of the core wire. Maximum fillet leg length shall be 1/8 inch less than the plate thickness.
Weld slope 0° Weld rotation 45°	
	3. One run on each side joint with ¼ inch diameter electrodes. Plate thickness not less than ½ inch and fillet leg length not to exceed 3/8 inch.

The welding current used shall be within the appropriate range recommended by the manufacturer and each weld shall be deposited in horizontal-vertical position.

The order of laying down fillets shall be as indicated by the number 1, 2 and 4 in Figure 11. The adjacent fillet shall be laid in opposite direction. After welding, the test piece shall be cut by sawing or machining as indicated in Figure 11 and the inner edges of the two outer discards shall be prepared and etched as specified for the cruciform fillet weld tensile tests for normal penetration electrodes in Appendix H-1.

The test specimen shall then be tested for tensile test.

TABLE 5
(*See* APPENDIX - H1 & H2)

DEFINITION OF WELDING TERMS, CLASSIFICATION OF COVERED ELECTRODES, DEFINITIONS & PRINCIPLES—DEFINITIONS

Weld Slope: The slope of a weld is the angle formed between the line of weld root and a horizontal reference plane placed below the lowest portion of the weld. (*See* Fig. 1)

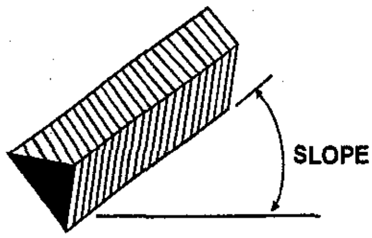


FIG. 1: DIAGRAM TO ILLUSTRATE WELD SLOPE

Weld Rotation: The rotation of weld is the angle formed between the upper portion of vertical reference plane which passes through the line of the weld root and a line drawn from the line of the weld root which intersects the weld surface at a right angle and a point equidistant from either edge of the weld (*see* Fig. 2)

Note: Example of the slope & rotation of various welds are given in Fig. 3.

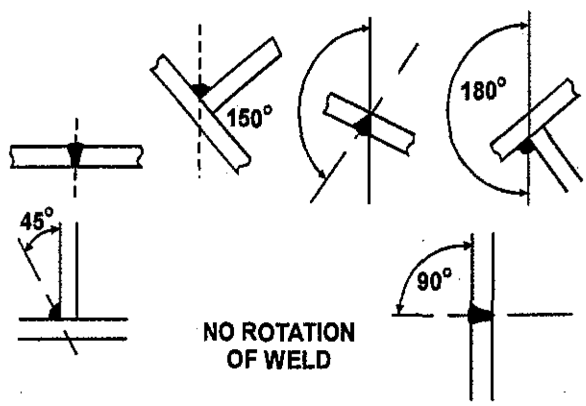
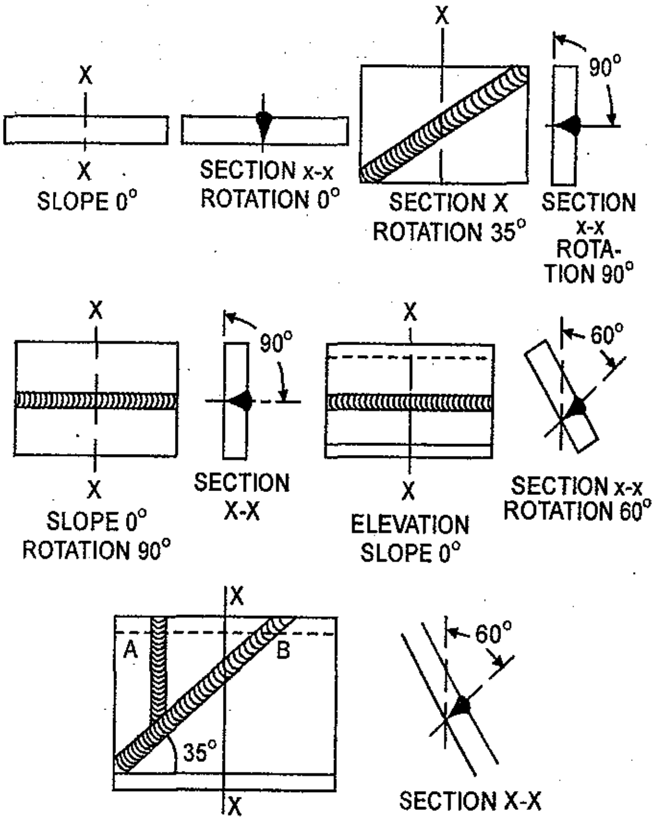


FIG. 2: DIAGRAMS TO ILLUSTRATE WELD ROTATION



WELD A: SLOPE 60° ROTATION 0°
WELD B: SLOPE 35° ROTATION 60°

FIG 3: EXAMPLES OF 'SLOPE' AND 'ROTATION'

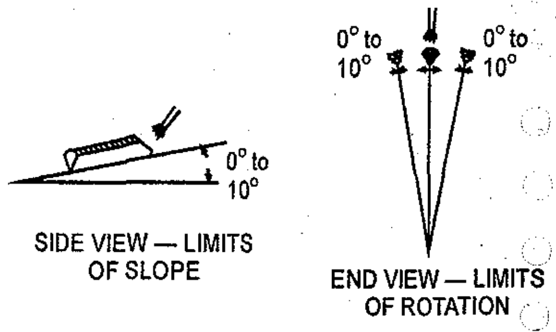


FIG. 4: FLAT (F)

WELDING POSITIONS: WELDING POSITIONS AR
DEFINED AS FOLLOWS

POSITIONS	SLOPE	ROTATION	SYMBOL	ILLUS RATION
FLAT	NOT EXCEEDING 10°	NOT EXCEEDING 10°	F	FIG.
INCLINED	EXCEEDING 10° NOT EXCEEDING 45°	NOT EXCEEDING 90°	I	FIG.
HORIZONTAL VERTICAL	NOT EXCEEDING 10°	EXCEEDING 10° NOT EXCEEDING 90°	H	FIG.
VERTICAL	EXCEEDING 45°	ANY	V	FIG. 7
OVERHEAD	NOT EXCEEDING 45°	EXCEEDING 90°	O	FIG.

Note: The five positions defined above cover any possible combination of slope and rotation so that every weld can be classified in one of these positions

The Table above is for Fig. 4

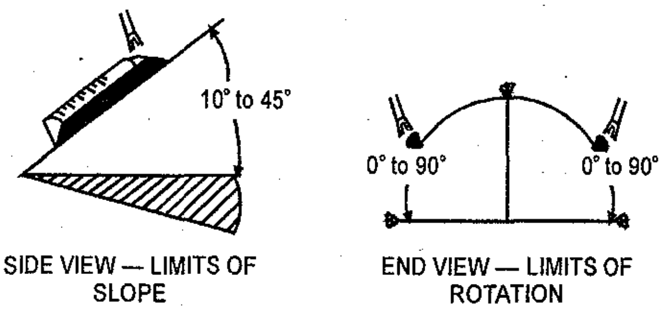


FIG. 5: INCLINED (I)

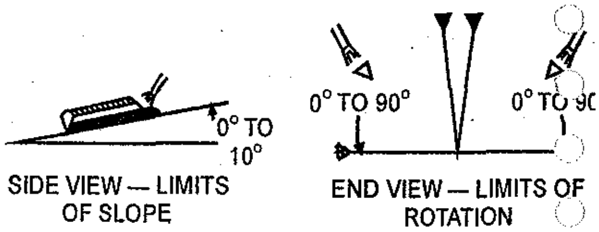


FIG. 6: HORIZONTAL-VERTICAL (H)

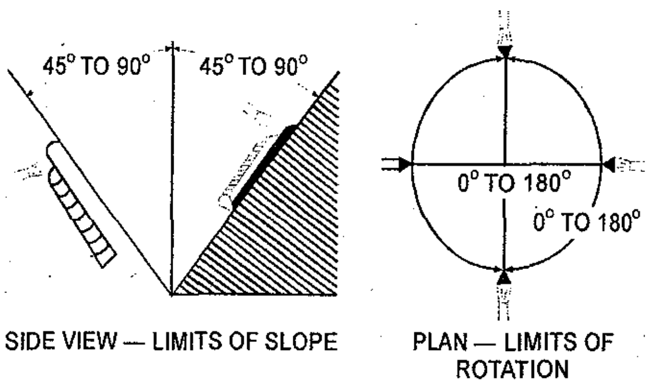


FIG. 7: VERTICAL (V)

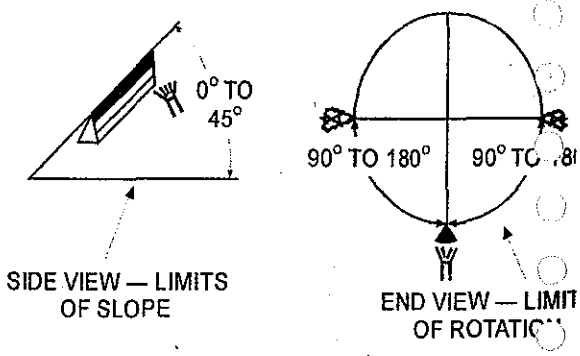


FIG. 8: OVERHEAD (U)

FILLER RODS FOR GAS WELDING OF STEEL

98 A.

(a) The following provision shall apply to filler rods for gas welding of boiler parts and steam-pipes:

(i) **Manufacture**—The filler rods may be made by any method that shall yield a product conforming tu the requirements of these regulations.

(ii) **Size of Rods**—The nominal size of rods shall refer to the diameter of the rod which shall be expressed in millimeter. The tolerances on the specified diameter of the rod shall be plus or minus 0.05 mm for rods 1.6 mm (1/16 in.) and over in diameter, and plus or minus 0.03 mm for rods less than 1.6 mm in diameter.

(iii) **Packing and Marking**—The filler rods shall be suitably packed to guard against damage during transportation and each package shall be marked with the following informations:

- Name of Manufacturer
- Year of Manufacture
- Trade name of Rods
- Size and quality of Rods

(iv) **Test**—The rods shall be subjected to initial tests and periodic tests after every one year to ensure that the requirement of these regulations are fulfilled.

(v) **Test Certificate**—The manufacturer or user shall where called upon by the Inspecting Authority or the Chief Inspector of Boilers produce the results of the most recent periodic check test carried out on filler rods representative of the rods specified.

CHEMICAL COMPOSITION AND APPLICATIONS

(vi) **Carbon Steel Filler Rods—(GRADE-I)**

(a) **Chemical Composition**—The chemical composition of the rods shall be as given below:

Carbon Max	0.10%
Manganese Max	0.60%
Nickel Max	0.25%
Sulphur Max	0.050%
Phosphorus Max	0.050%

(b) **Application**—These rods are intended for application where a minimum butt-weld tensile strength of 35.0 kg/sq. m. (22.0 Tons/sq.in.) is required.

(vii) **Carbon Steel Filler Rods—(GRADE-II)**

(a) **Chemical Composition**—The chemical composition of the rods shall be as given below:

Carbon	1.10 to 0.20%
Silicon	0.10 to 0.35%
Manganese	1.00 to 1.60%
Sulphur Max	0.040%
Phosphorus Max	0.040%

When the carbon content is in the range of 0.10 to 0.12% the manganese content shall be not less than 1.20%.

(b) **Application**—These rods are intended for application where a minimum Butt-weld tensile strength to 44.0 kg/sq. mm (28.0 tons/sq.in.) is required.

(viii) **Carbon Molybdenum Steel Filler Rods—**

(a) **Chemical Composition**—The chemical composition of the rods shall be as follows:

Carbon	0.15% max.
Silicon	0.25 to 0.50%
Manganese	0.60 to 1.50%
Molybdenum	0.45 to 0.65%
Chromium & Nickel	Not more than 0.20% each (if present as a residual).
Sulphur	0.040%
Phosphorus max	0.040%

(b) **Application**—These rods are intended for welding of (alloy steels of the) ½% molybdenum type with or without chromium.

CHAPTER III

CONSTRUCTION AND WORKMANSHIP

GENERAL

99. Preparation of plates

The edges of all plates and butt straps shall be machined or flame-cut by machine and the caulking edges shall be bevelled to an angle not sharper than 20 degrees to the plane of the plate and between 70 and 80 degrees wherever practicable.

Plates which are to be flame-cut by machine without heat treatment or subsequent grinding or machining shall not have a carbon content higher than 0.26 per cent.

Where the carbon content exceeds 0.26 per cent heat treatment, grinding or machining shall be carried out.

The edges of all plates shall have a smooth finish.

100. Normalising of certain Steel Plates

All steel plates which are dished, flanged or locally heated shall be afterwards normalised unless they have been heated during the operation within the normalising range.

101. Minimum Thickness of Plates

No boiler plate shall be less than ¼ inch in thickness.

SHELLS, ANGLE RINGS, BUTT STRAPS, ETC.

102. Cylindrical Shells

Each ring shall be bent while cold to cylindrical form to the extreme ends of the plate. The bending shall be done entirely by machine and heating or hammering is prohibited.

103. Position of Longitudinal Seams

Each ring of plate forming the shell, barrel or drum shell, where practicable, be in one piece and have its longitudinal seam well out of line with those of the adjoining rings. In Lancashire, Cornish, and other types of boilers, where parts of the shell are exposed to flame, the longitudinal seams shell, where practicable, be in the steam space, arranged alternately on each side of the crown and clear of the brick work.

104. Circumferential and End Seams

The calculated efficiencies of circumferential joints based on the thickness of plate determined by Equation 1, shall be not less than 38 per cent for joints connecting end plates with cylindrical shells or 42 per cent for intermediate joints. In no case, however, shall the efficiency of an intermediate joint be less than 50 per cent of that of the longitudinal joints. Where the shell plate thickness exceeds 11/16 in., the intermediate circumferential joints shall be double riveted.

105. Angle Rings

Angle rings for the attachment of end plates to shell plates and/or flue sections shall be rolled or machined so that they fit closely to the flat and cylindrical surfaces to be connected, and shall be machined or machine gas cut on the caulking edges.

106. Thickness of Shell Angle Rings

Where shell plates and end plate are connected by means of an external angle ring, the angle rings shall be no less in thickness than as follows:

(1) For shell plates upto and including 5/8 inch in thickness.	10 per cent in excess of the thickness of the shell plate.
(2) For shell plate exceeding 5/8 inch in thickness and upto and including 1 inch in thickness.	90 per cent of the thickness but not less than 11/16 inch.
(3) For shell plates over 1 inch in thickness.	Made from angle bar having a section thickness of 1 inch.

107. Welded Shell Plates

The requirements of welded shells shall be covered by the provisions made in Regulations in Chapter V or Chapter XII, as the case may be.

108. Longitudinal Seams

The longitudinal seams of shell belts shall be butt-jointed with double straps when the diameter or Working Pressure exceeds the limits stated below:

Type of Boiler	*When Diameter exceeds*	*When Working Pressure exceeds*
	Feet	*Lbs./Sq. in.*
Loco Type	2½	200
Vertical Type	6	125
Other Types	6	80

109. Butt Straps

Butt Straps shall be cut from the shell plates, or alternatively, all the butt straps of each required thickness shall be cut from one plate. The lengths of the straps wherever practicable shall be transverse to the direction of rolling of the plate. Straps shall be pressed or bent in rolls to the shell curvature.

110. Thinning of Butt Straps

Thinning of the ends of the butt straps which tuck under shell rings, shall be done cold by machine and not by heating or hammering. The shell plate shall be notched out to receive that thinned end of the butt strap, so that there shall be no undue thinning of the butt strap.

111. Alternative Construction

As an alternative to the tucking of butt strap ends under the shell rings, the ends may be terminated at the edge of the shell rings or ends and electrically welded thereto.

112. Local Welding of Butt Seams

(a) The ends of longitudinal butt seams of shell rings may be welded for a length not exceeding three times the overlap at the circumferential seam, provided the butt straps are run as closely as practicable to the circumferential seam.

(b) Only metal arc welding of the butt seams of shell rings shall be permitted.

(c) Where hemispherical shell crowns are pressed from plate they shall be pressed to form by machine in progressive stages without thinning and on completion shall be annealed.

END PLATES

113. Flat End Plates

(a) The plates of boilers shall preferably be in one piece made from one rolled plate. Alternatively, the end plates may be built up from two pieces by riveting or by fusion butt-welding. In the latter case, the line of weld shall be parallel to the horizontal axis of the boiler and the entire plate after flanging shall be subjected to stress relieving and the weld shall be radiographed.

(b) The peripheral flanging of end plates shall be done by machine. Such flanging shall preferably be done in one operation, but where this is impracticable sectional or creep machine flanging may be permitted, provided that the plate is worked at a suitable temperature, and the plate is heated to an adequate distance beyond the portion under immediate treatment.

(bb) In the construction of unfired boilers when the dished ends do not form a part of the heating surface, cold spun dished ends conforming to IS: 2825 may be used.

(c) Care must be taken to see that the flanges are circular and of good surface, free from local irregularities, and that they are parallel and square with the flat part of the plate. For the purpose of relieving internal stresses, all plates which have been flanged or locally heated shall afterwards be efficiently annealed unless during the last stage of manufacture they have been uniformly heated throughout.

(d) Flat portions of end plates, on completion of all flanging and machining operations, shall be flat and free from set or distortion.

114. Strengthening of Flat End Plate at Manhole

(a) In the End Plates of Lancashire Boiler type the mudhole in the lower part of the front end plate shall be fitted with a flanged riveted strengthening ring, the thickness of the flat portion of which shall be not less than (1.5T + 1/8 in.) where T equals the thickness of the end plate in inches.

(b) In boilers 7 ft. 6 inches diameter and above, the mudhole frame shall be fitted with a peak to reinforce the portion of the end plate between and below the furnaces, and this peak shall be securely riveted thereto with rivets of similar pitch to the remainder of the frame.

(c) In all cases the front end plate gusset stays below the furnaces shall be placed as closely as possible to the mudhole frame.

(d) Where flat end plates are flanged for connection to the shell, the inside radius of flanging shall be not less than 1.75 times the plate thickness, with a minimum of 1½ inches.

115. End Plates in Steam Spaces

When the end plates of boilers situated in the steam space are liable to contact with hot gases, the end plates shall be efficiently sheilded from such contact.

116. Hemispherical Crowns

(a) All segments shall be pressed in one heat to correct curvature. The adjacent plates shall be closely at the seams and wherever possible at the junction of two seams the plates shall be machined down to provide at a fair surface to the joint. If the thinning is done by heating and hammering the plate shall be subsequently annealed.

(b) The cylindrical portion of the crown shall be tangential to the hemispherical portion and fit truly to the shell.

117. Dished End and Crown Plates

(a) The dished end plates of boilers shall preferably be in one piece made from one-rolled plate. If this is impracticable owing to the large diameter, the dished end plate may be made from two plates fusion butt welded together and in such cases the requirements of stress relieving and radiographic examination as provided for in Regulation 113 shall apply and the line of weld shall be parallel to the horizontal axis of the boiler.

The inside radius to which a plate is dished shall not be greater than the external diameter of the shell to which it is attached, except in the case of Lancashire and Cornish boilers when the radius shall not exceed 1½ times the diameter of the shell.

(b) The inside radius of curvature of the flanges to the shell or firebox shall not be less than four times the thickness of the crown or end plate and in no case less than 2½ inches.

(c) The inside radius of curvature to uptakes shall be not less than twice the thickness of the crown plate and in no case less than 1 inch.

(d) Bunged mouth-pieces may be welded on to end plates in place of the orthodox flanging for the attachment of furnace tubes. Such welding shall comply with provisions of Regulation 125.

(e) Manhole frames may be similarly welded on the front end plates, and will be subject to provisions of Regulation 125.

118. Tube Plates

Smoke box tube plates shall be flanged for attachment to the barrel or shall be flat and connected thereto by an external riveted angle ring.

119. Parts of Flat Tube Plates within the Tube Nests

(a) Where the total area of all tube nests in directly fired multi-tubular boilers exceeds 7 sq. ft., stay tubes shall be fitted.

Where the total number of tubes in horizontal multi-tubular waste heat boilers and direct fired loco type boilers is arranged in one nest, the area of which exceed 21 sq. ft., stay tubes shall be fitted.

In all cases where the total number of tubes is arranged in more than one test, stay tubes shall be fitted.

(b) The parts of tube plates which lie outside the nests of tubes shall be stayed or supported wherever the size of the area of plate subject to steam pressure necessitates staying or support, either by marginal stay tubes or other means.

120. Flanging of End Plates

All flanges shall be a good fit to the shell and flues. Flogging and/or hammering in the fitting of these parts is prohibited. The caulking edges of all flanged plates shall be machined or machine gas cut.

FURNACES

121. Furnaces in General

(a) No furnace or firebox top, whether plain or corrugated, shall exceed 7/8 inch in thickness, and all circular sectioned furnaces when new shall be as near the truly circular form as the type of joint will permit.

(b) The use of Z angle rings for furnace foundation seams shall be prohibited.

(c) As an alternative to riveting furnaces, furnace crowns, uptakes and other plates not in tension may be jointed by fusion welding provided the conditions laid down in Regulations 122 to 129 are complied with. The end connections of such plates to the shell or shell crown shall also comply with such conditions. This construction shall not apply to furnaces of Lancashire and Cornish type boilers consisting wholly or plain sections.

122. Furnaces of Horizontal Boilers

(a) The sections of the internal flues shall each be in one plate and shall be bent while cold to circular form and shall be welded longitudinally.

(b) The maximum permissible variation in diameter at any cross-section shall not exceed the thickness of the plate.

(c) The weld shall be placed at the lower part of the flues, and shall break joint in successive sections by at least 12 inches.

(d) Each flange for the circular seams shall be formed at one heat by suitable machinery.

(e) The sections shall be allowed to cool gradually to avoid internal stresses.

(f) The caulking edges of all flue flanges shall be machined or machine gas cut.

(g) The circular seams shall be arranged so that they do not fall in line with those of the adjacent flue or with the circumferential seams of the shell and are at least 6 inches apart.

(h) When flues are flanged for attachment to both end plates the total length of each completed flue shall not exceed the length of the shell measured from the inner surface of the back end plate to the inner surface of the front end plate, both adjacent to the shell.

(i) Where the flues are flanged for attachment to the end plates, the end sections shall be 1/16 inch thicker than the remaining sections, except in cases where the calculated thickness is over 13/16 inch, when the end section shall be 7/8 inch in thickness.

(j) The flanged portion of furnace rings shall have radius of curvature of not less than 1 inch on water side.

(k) Sections of corrugated flues may be fusion butt welded circumferentially and afterwards stress relieved by heat treatment.

(l) As an alternative to Adamson flanges, furnaces which are partly fitted with corrugated sections shall be strengthened by means of suitable stiffening rings adequately welded to the furnaces. The moment of inertia of the stiffener shall be not less than 63 mm × 13 mm (2½" × ½").

123. Furnaces of Vertical Boilers

(a) The furnaces of vertical boilers may be constructed in one or more lengthwise sections, each section being rolled from one plate to a full circle. In such cases, the component sections may be jointed circumferentially by electrically butt welding or riveting. Where welded, they shall be stress relieved.

(aa) In the case of vertical boilers where tube plates form part of the firebox, the tube plate portion may be constructed in two vertical sections and the vertical seams when welded shall be stress relieved.

(b) Circular furnaces shall preferably be tappered, a tapper of 1½ inches in diameter per 1 foot of height being recommended. The minimum water space at the bottom between the furnaces and the shell shall not be less than 2 inches for boilers upto 2 ft. 6 inches in diameter and shall be not less than 2½ inches for boilers over 2 ft. 6 inches in diameter.

(c) Where hemispherical furnace crowns are pressed from one plate they shall be pressed to form by machine in progressive stages without thinning and on completion shall be annealed.

(d) Ogee flanging where integral with the firebox or in a separate ring shall preferably be formed at one heat by suitable machinery and shall be allowed to cool gradually to avoid internal stresses.

(e) Furnaces of vertical type boilers may be attached to the shell at the firehole by a solid rectangular section steel ring riveted together or by a circular ring of substantial section fusion welded to shell and firebox. Where the latter construction is employed the opening in the shell for firehole shall be substantially compensated by a ring welded on the outside of the shell plate.

(f) At the firehole the firebox plate and the shell plate may be flanged and fusion welded together.

124. Longitudinal Seams

The longitudinal seams of furnaces may be either:

(a) Forge Lap Welded.

(b) Fusion Butt Welded.

(c) Riveted.

Longitudinal seams of furnaces exceeding 3/8" thickness shall not be riveted.

125. Fusion Welded Longitudinal Seams

Where the longitudinal seam is fusion welded the following precautions shall be observed:

(a) Plates 20 mm and above in thickness shall be bevelled from both sides of each abutting edge but the bevel need not necessarily be the same on each side (*see* Figs. 1 and 2). Plates, less than 20 mm in thickness may be bevelled from one side only of each abutting edge (*see* Figs. 3 and 4).

The included angle of the bevel shall be not less than 60° and the bevelling may be any one of the forms shown in Figs. 1-4.

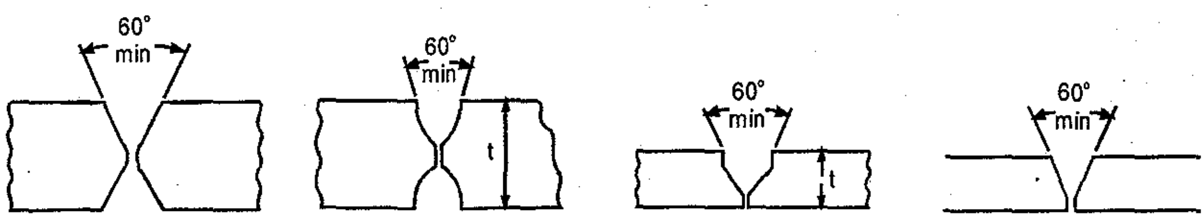


FIG. 1 FIG. 2 FIG. 3 FIG. 4

(b) In order to obtain full penetration of the weld metal a gap shall be maintained between the plates when they are being welded. Joints shall be welded from both sides, and the slag shall be removed after making each run. Before the second side of the joint is welded any slag or defect at the bottom of the first run shall be removed by grinding, chipping or machining. There shall be no appreciable undercutting of the plate.

(c) For the purposes of relieving internal stresses the plates adjacent to a fusion weld shall be efficiently annealed after welding, and when the firebox is forge-welded it should be allowed to cool gradually.

126. Furnace Crown

(a) The furnace crown shall be made from one plate and the seam connecting it to the furnace shall not fall in line with any circumferential seam of the boiler shell.

(b) The furnace crown may be riveted to the vertical portion of the firebox, or alternatively, the joint may be fusion butt welded by the electric arc process, provided the conditions as to fusion welding in Regulation 125 are observed. Where the joint is to be welded the edges of the furnace crown and the firebox body shall be bevelled in accordance with Fig. 3 or Fig. 4. The depth of the flange of the furnace crown plate from the commencement of the curvature of the flanging radius shall be not less than four times the plate thickness with a minimum of 1½ inches. On completion of welding the firebox shall be effectively stress relieved by heat treatment (*see* also Regulation 128).

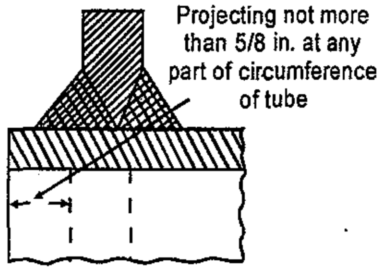
127. Cross Tubes

(a) Cross tubes shall be made from weldless steel pipes or from plate or strip rolled and electric resistance or fusion butt welded pipes by electric arc process. The fusion welding shall conform to the requirements of Chapter XII. Tolerances on these pipes shall conform to the requirements of Regulation 345. Where welded pipes are used, the longitudinal welds shall be so situated that they are not exposed to the direct impact of flame.

(b) Cross tubes shall not exceed 12 inches internal diameter. The minimum thickness shall be 5/16 in.

(c) Where cross tubes are flanged and riveted to the furnace the flanges shall be set to the curvature and tapper of the furnace and shall be a good fit before riveting.

(d) Where welded construction is employed the tubes shall be of sufficient length to enter the furnace plate and the flush with the water side all round or project not more than 5/8 in. into the water space at any part of the curcumference. Where the tubes are fusion welded in position the firebox plates shall be suitably chamfered and the joints shall be welded externally and internally (*see* Fig. 5).



DETAIL OF WELDING

FIG. 5: FUSION WELDING OF CROSS TUBES OF VERTICAL CROSS TUBE BOILERS

128. Uptakes

(a) The uptakes shall be formed from weldless steel pipes or from plate or strip rolled and electric resistance welded or fusion butt welded pipes by electric arc process. The tolerances on these pipes shall comply with the requirements of Regulation 345.

(b) As an alternative to riveting the uptake may be fusion butt welded by the electric arc process to the upward flange of the opening in the firebox crown plate provided the conditions as to fusion welding in Regulation 125 are observed. The edges of the upward flange and the adjacent end of the uptake shall be bevelled in accordance with Fig. 3 or Fig. 4. The depth of the crown plate opening from the commencement of the curvature of the flanging radius shall be not less than twice the plate thickness with a minimum of 1 inch. On completion of welding the uptake and crown plate shall be effectively stress relieved by heat treatment.

Where the firebox crown plate is also fusion welded to the body of the firebox, the firebox complete with uptake shall be effectively stress relieved by heat treatment of completion of the welding.

(c) Welded uptakes shall be so arranged that the weld is directly facing the longitudinal centre line of the manhole.

129. Loco Type Fireboxes

(a) The foundation seam shall be of riveted construction but all other seams may be welded subject to the depth of the flange being such that the welded seams fall between the 1st and 2nd rows of screwed stays or between the flange and the adjacent row screwed stay.

(b) The firehole mouthpiece may be similarly welded when the firebox and shell are flanged for the purpose.

(c) The welding shall comply with Regulation 125.

(d) The welding of copper fireboxes shall comply with the following regulation.

129A. Welded Joints to Copper Fire Boxes

(i) **Scope**—All welding of copper plates shall be carried out by the oxy-acetylene process. The Inspecting Authority may at his discretion also permit the use of propane, butane or other suitable fuel gases.

(ii) **Parent Metal**—Phosphorus deoxidised arsenical copper in the fully annealed condition shall only be used for welded copper fireboxes.

The composition of the copper shall be within the following limits:

Phosphorous Deoxidised Arsenical Copper

Copper (silver being counted as copper) not less than 99.20 per cent.

Antimony not more than 0.01 per cent.

Arsenic not more than 0.50 per cent and not less than 0.30 per cent.

Bismuth not more than 0.003 per cent.

Iron not more than 0.01 per cent.

Lead not more than 0.01 per cent.

Nickel not more than 0.15 per cent.

Phosphorus not more than 0.10 per cent and not less than 0.015 per cent.

Selenium not more than 0.02 per cent.

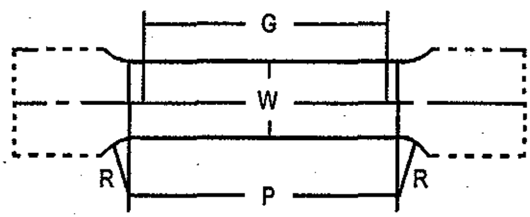
Tellurium not more than 0.02 per cent.

Tin not more than 0.01 per cent.

Pieces cut from the parent material after being heated in hydrogen for ½ hour at 800°C and subsequently cooled, must show no edge or surface cracking when subjected to a close bend test as described below.

The test piece AB is bent by steadily applied pressure or a succession of blows at right angles to the length AC and flattened close until A assumes the position indicated by D (*see* Figure 5A).

TEST PIECE A FOR OXYACETYLENE WELDING OF COPPER



NOMINAL THICKNESS OF TEST PIECE	(i)	(ii)	(iii)	(iv)
	UPTO-BUT NOT INCLUDING 3/8"			3/8" & THICKER
	IN.	IN.	IN.	IN.
WIDTH W	½	1	1½ (MAX.)	1½ (MAX.)
GAUGE LENGTH G	2	4	8	8
PARALLEL LENGTH (MIN) P	2½	4½	9	9
RADIUS AT SHOULDER (MIN) R	1	1	1	1
APPROX. TOTAL LENGTH	8	12	18	18

WHEN THE WIDTH OF THE MATERIAL TO BE TESTED IS INSUFFICIENT TO PERMIT OF THE PREPARATION OF THE STANDARD TENSILE TEST PIECE. A PIECE OF THE FULL WIDTH OF THE MATERIAL MAY BE USED.

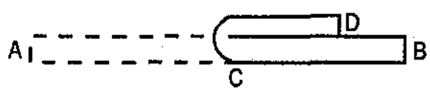


FIG. 5A

(iii) **Filler Rod**—The filler rod shall be phosphorus deoxidised non-arsenical copper and shall contain not more than 0.15 per cent and not less than 0.04 per cent phosphorus with the optional addition of silicon upto 0.15 per cent and with the optional addition of silver.

The basic copper used for the manufacture of the filler rods shall either be cathode copper or electrolytic tough pitch high conductivity copper conforming to the following chemical compositions respectively:

Chemical Composition of Cathode Copper

Copper (silver being counted as copper) not less than 99.90 per cent.

Bismuth not more than 0.001 per cent.

Lead not more than 0.005 per cent.

Total of metallic impurities (excluding silicon, phosphorus and silver) not more than 0.03 per cent.

Chemical Composition of Electrolytic Tough Pitch High Conductivity Copper

Copper (silver being counted as copper) not less than 99.90 per cent.

Bismuth not more than 0.001 per cent.

Lead not more than 0.005 per cent.

Total of all impurities (excluding silicon, phosphorus, oxygen and silver) not more than 0.03 per cent.

Where silicon has been added in the manufacture of the filler rods the amount present in the filler rod shall be stated by the supplier.

Test pieces cut from the filler rod after being heated in Hydrogen for ½ hour at 800°C and subsequently cooled must not show any surface cracking when subjected to a close bend test as described in clause (ii) above.

(iv) **Mechanical Test**—The welding technique shall be tested as follows:

Three test pieces shall be cut from the welded test specimen and shall be prepared to conform to the dimensions of test piece A. The weld shall be left in the unhammered state and shall be machined, filled or ground to remove excess weld metal and a maximum of 5 per cent of the thickness of the plate from each side.

Each of the three test pieces shall be tested and shall show a tensile strength not less than 9 tons per sq. inch for plates over ½ inch upto and including 1 inch in thickness.

(v) **Number of Tests**—One test plate not less than 6 inches long shall be welded by each operator (or pair of operators) employed on the work to represent each 15 ft. of welding or part thereof. The test plate shall be welded, using the same form of joint and welding technique as that employed on the work and wherever practicable shall be directly attached to the welded seam or other welded joint it represents.

STAYS

130. Bar Stays

Bar stays shall not be welded at any part. They shall preferably have plus threads, the ends of the stays being upset or the middle portion being reduced for this purpose. Stay bars which have been worked in the fire shall be subsquently annealed.

131. Longitudinal Stays

(a) Longitudinal and similar solid screwed stays shall be efficiently secured with nuts at each end and not merely riveted over. Where they are over 12 feet in length, they shall be supported at intervals of 6 ft. along its length.

(b) Where the stay is screwed through both plates, the stay and holes shall have a continuous thread and fitted with nuts and washers on the outside. Where the stay passes through clearing holes an internal nut and washer shall also be fitted. Where the stay is not normal to the surface of the plate the washer shall be shaped so as to form a true surface for the nuts or a knuckle joint may be fitted.

(c) In vertical boilers the stays shall either be screwed into both crown plates or screwed into the furnace crown plate and passed through clearing holes in the shell crown plate.

132. Nuts and Washers for Stays

(a) The washers shall be at least 2½ times the diameter of the threaded portion of the stay and not less than ¼ in. in thickness.

(b) The thickness of the external nuts shall be at least equal to the diameter of the threaded portion of the stay. Where bar stays pass through clearing holes in end plates, internal nuts of a thickness not less than two-thirds of the diameter of the threaded portion of the stay shall be fitted.

133. Jointed Stays

Where jointed longitudinal stay are fitted, they shall, where practicable, be fitted with pins having an effective sectional area 25 per cent in excess of that of the stay. If the pins are slack in the holes, the total slackness shall not be more than 1/16 inch. The pins shall be as close as possible to the shoulder of the eye forging. The shoulder of the forging shall be at least ½ inch wide all round, i.e., the diameter at the shoulder shall be not less than the diameter of the hole plus 1 inch.

134. Diagonal Bar or Rod Stays

The sectional area of diagonal rod or bar stay shall bear the same proportion to that of a direct stay as the length of the diagonal stay bears to the length of the perpendicular line from the end of the diagonal stay to the surface supported. The ends of diagonal stays, shall not be bent, but shall be attached to the plate with revelled washers and nuts or with riveted tee, blocks or angles and shackle pins (*see* Regulation 133 for eyes and pins.)

SCREWED STAYS

135. Screwed Stays

(a) Screwed stays and the holes for these shall be screwed with a continuous thread.

(b) The screwed threads of the stay shall be clean free from checks or imperfections, of full depth, correct Whitworth form and a good fit in the holes. The middle portion shall preferably be turned down to the bottom of the thread.

(c) The stays shall be screwed with fine threads of not less than 11 threads per inch.

(d) The diameter of the stay over the threads shall not be less than ½ inch or twice the thickness of the firebox plate whichever is the greater.

(e) The pitch of the stays at the furnace of vertical boilers shall not exceed 14 times the thickness of the furnace plate.

(f) Where the stays are not fitted with nuts, the ends shall be riveted over to form substantial heads.

Alternatively stays may be screwed through the shell and firebox plates and the projecting ends shall be substantially fillet welded in an approved manner. The projection of the end of the stay from the surface of the plate shall be not less than one quarter of the diameter of the stay but in no case less than 1/4 in. The full end of the stay shall be visible on completion of the welding.

(g) Crown stays of Loco type boilers shall either be fitted with nuts or riveted over on the fire side.

136. Axial Drilling

All screwed stays less than 14 in. long should preferably be drilled with a tell-tale hole 3/16 in. diameter to a depth of ½" beyond the inner face of the plate. Stays which are obscure on one side should preferably be made from hollow stay bar.

137. Stay Nuts

(a) Nuts of screw stays in combustion chambers and fireboxes shall not be less than ¾ inch thick for stays upto 1½ inches diameter over threads, 7/8 inch thick for 1-5/8 inches and 1¾ inches stays, 1 inch thick for 1-7/8 and 2 inches stays, and 1-1/8 inches thick for stays over 2 inches in diameter.

(b) The nuts shall be made of solid mild steel or of iron which shall be without weld if exposed to flame.

138. Spacing of End Stays—Allowance for Curves, etc.

For the tops of fireboxes and combustion chambers the distance between the rows of stays nearest to the tube plate or firehole plate or back plate, as the case may be, and the commencement of curvature of these plates at their flanges shall not be greater than the horizontal pitch of the stays.

GIRDER STAYS

139. Girder Stays for Firebox and Combustion Chamber Crowns

(a) Each girder when of the normal type, fitted with stay bolts and nuts, shall be of the double plate interconnected type of sufficient strength to support its proportion of the load on the crown to support plate independently of the crown plate.

(b) The clear waterway between the crown plate and the underside of the girder bars shall be as large as practicable but in no case less than 1½ inches as in Fig. 7.

(c) The ends of the girders shall not rest on the landing of the flat crown plate but shall be carefully fitted to bed directly on the bends of the corners of the vertical end or side plates.

(d) The toes of the girders shall be solid with the girder plates and not separate pieces attached thereto.

(e) Girders shall be properly attached to the crown plate by bolts or screws.

Note: Alternative methods of staying may be used for unstayed firebox, crowns of special or patented design of equivalent strength may be fitted (see Regulations 230, 231 and 232).

(f) Where an all welded firebox is fitted, the girder stays may be welded to the firebox prior to stress relieving. The girder stays shall be recessed for waterways as in paragraph (b) (Figs 6 and 7).

Such girders shall be securely welded by an approved method to the firebox crown. The method of welding and the proportions of attachment shall be to be satisfaction of the Inspecting Authority.

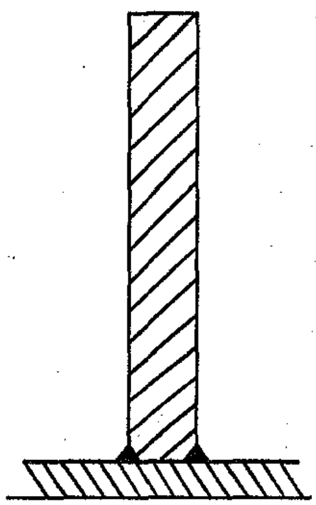


FIG. 6

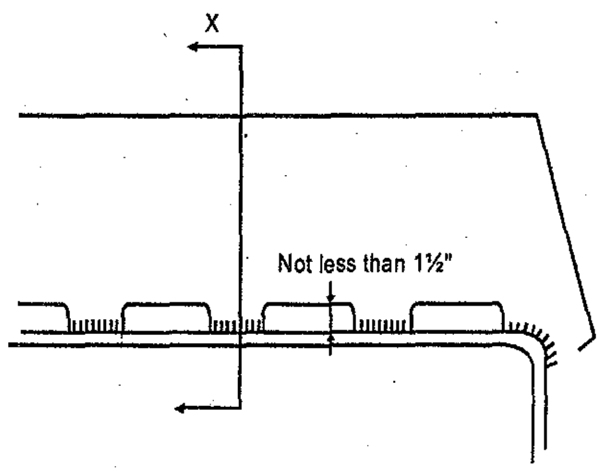


FIG. 7

GUSSET STAYS

140. Gusset Stays

(a) Gusset plates shall be flat and perpendicular to the end plates. The gusset angles shall be fitted to bed closely to the shell end plate and gusset plates. Cranking or setting of the plates is prohibited.

(b) Gusset stays, where fitted, shall comprise flat plates secured by double angles to the shell and end plate respectively, and shall be designed in accordance with the following conditions.

141. Breathing Space

(a) Gusset stays shall be so arranged as to allow sufficient breathing space around furnace connections and the tube nests.

(b) For Lancashire boilers the proportions shown in the table below are recommended for portion of the end plates above the furnaces and flues:

Thickness of End Plate	*L—(Fig. 8)*	*L—(Fig. 9)*
Inches	*inches*	*inches*
1/2	9	10
9/16	10	10
5/8	11	12
11/16		
3/4	12	13
13/16		
Above 13/16	12½	13½

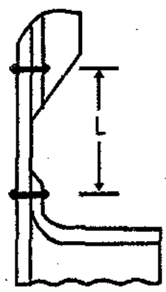


FIG. 8

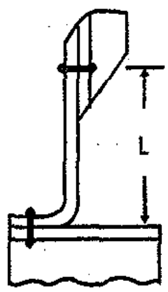


FIG. 9

(c) Fig. 8 shows the breathing space recommended for the following conditions: Flat end, furnace or flues flanged for attachment to end plate, furnaces and flues formed with Adamson flanged seams.

(d) Fig. 9 shows similar conditions to Fig. 8 except that the end plate is flanged outwards for the furnace or flue ring connection, the breathing spaces allowed being 1 in. more than those for the same thickness of plate in Fig. 8.

(e) Where a corrugated section not less than 6 feet long is included in each internal flue of a Lancashire boiler, the dimensions given in the table above may be reduced by approximately 1½ in. throughout.

(f) It is recommended that the breathing space below the furnaces and flues shall be approximately one half of the diamensions given in the table above. Whereas it is desired to use any other arrangement which gives a greater or less degree of flexibility, the amount of breathing space shall be specially considered and modified as the necessity of the case requires.

(g) For gusset stays above tube nests, as fitted in waste heat boilers without internal furnaces, a breathing space of 8 inches from the centre line of the top tubes of the centre of the toe rivets of the gusset angles is recommended (see Fig. 9).

142. Gusset Angles

The gusset angles connecting the stays to the shell and end plates shall be at least 7/8th of the thickness of the shell plate, but shall be not less than ½ in. thickness.

143. Load on Gusset Stay

Each gusset stay supporting the end plate of a boiler shall be designed to carry the whole load due to pressure on the area supported by it.

144. Gusset Riveting

(a) Rivets securing gusset stays shall not be less in diameter than the thickness of the cylindrical shell plate and the riveting shall be arranged so that the strength of the shell plate where drilled for the gusset rivets shall not be less than the strength of the longitudinal seams.

(b) Not less than three rivets shall be used to connect any gusset plate to any angle or any angle to the end plate or to the shell plate.

BOILER TUBES SUBJECT TO EXTERNAL PRESSURE

145. Steel and Wrought Iron Tubes

Both plain and stay smoke tubes may be made either of wrought iron or steel and may be electric-resistance-welded, lap-welded or weldless.

146. Fitting of Plain Tubes

(a) Plain tubes shall be expanded at both ends. The expanding shall be parallel throughout the full thickness of the tube plate. Plain tubes may also be bell-mouthed, beaded, or welded at the gas inlet end.

(b) Where stay tubes are not fitted, the ends of the tubes shall be beaded over at the fire box end and beaded or bell-mouthed at the other end. If bell-mouthed, the tubes shall protrude not less than ½ inch beyond the tube plate.

STAY TUBES

147. Screw Threads of Stay Tubes

(a) Stay tubes shall be screwed at both ends with continuous threads, and the holes in the tube plates shall be tapped with continuous threads. The pitch of the threads shall not be finer than 11 threads per inch. The stay tubes shall be expanded by roller expanders and not made right by caulking only.

(b) Stay tubes may be attached by welding in which case they shall not be adjacent within the same tube nest except in local areas, where not more than two adjacent stay tubes may be attached by welding. The form of attachment shall be such that there is a mechanical hold in addition to the welding, as shown in Figure 9A. On completion of welding the stay tubes shall be lightly re-expanded.

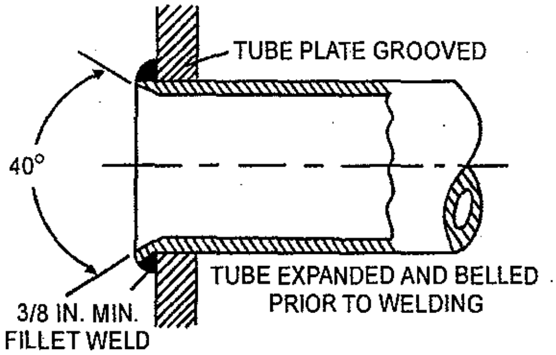


FIG. 9A: TYPICAL EXAMPLE OF WELDED STAY TUBE

148. Stay Tubes

(a) Stay tubes are tubes having a weld depth equal to the nominal tube thickness plus 3 millimetres. These stay tubes are not required within tube nests except when the tube nests comprise tubes which are expanded only.

(b) If tube nests comprise plain tubes that are expanded and beaded, expanded and belled or expanded and welded, welded stay tubes shall be used in boundry rows in sufficient numbers to carry the flat plate loadings outside the tube area.

(c) For plain tubes or stay tubes exposed to flame or gas temperatures exceeding 600°C, the ends of welded tubes shall be dressed flush with the welds. If not so exposed, the ends of welded tubes shall extend a maximum of 10 millimetres beyond the weld or, in the case of expanded tubes the tubes shall project beyond the tube plate upto a maximum of 15 millimetres.

(d) Each stay tube shall be designed to carry its due proportion of the load on the plates which it supports.

(e) The thickness of stay tubes welded into tube plates shall be such that the axial stress on the thinnest part of the tube does not exceed 70N/mm^2.

(f) The thickness of stay tube at any part shall not be less than the values shown in the Table below. Minus tolerances shall be taken into account when ordering tubes.

TABLE

Nominal outside diameter in millimetres				*Minimum thickness in millimetres*
		Not exceeding	38	2.28
Exceeding	38	but not exceeding	51	2.81
Exceeding	51	but not exceeding	70	3.12
Exceeding	70	but not exceeding	76.2	3.38
Exceeding	76.2	but not exceeding	88.9	3.96
Exceeding	88.9	but not exceeding	101.6	4.26
Exceeding	101.6	but not exceeding	127	4.55

149. Thickened Ends of Stay Tubes

If stay tubes are required to have their thickness increased at the screwed ends so that the thickness at the bottom of the threads is approximately the same as in the body of the tube the thickening shall be attained by upsetting and not by welding process, and the tubes shall be annealed after the upsetting.

150. Load on Stay Tubes

Stay tubes shall be designed to carry the whole load due to pressure on the area to be supported. In each case the area to be calculated is as follows:

(a) For a stay tube within the tube nest the net area to be supported shall be product of the horizontal and vertical pitches of the stay tube less the area of the tube holes embraced. Where the pitch of the stay tube is irregular the area shall be taken as the square of the mean pitch of the stay tubes (i.e. one quarter the sum of four sides of any quadrilateral bounded by four adjacent stay tubes) less the area of the tube holes embraced.

(b) For a stay in the boundry row the net area to be supported shall be the area enclosed by lines passing midway between it and the adjacent points of support less the area of any tubes embraced. The adjacent points of support may be other stay tubes, or the commencement of curvature of flanging of centre line of the circle of rivets securing the end plate to the shell angle.

BOILER AND SUPERHEATER TUBES SUBJECT TO INTERNAL PRESSURE

151. Steel Tubes

(a) All tubes which are subject to internal pressure of water or steam shall be cold drawn or hot finished seamless or electric-resistance welded in accordance with Regulations 36 to 63. Except as provided for in clause (b) below they shall be without joint.

(b) Tubes having an external diameter not exceeding 5 inches may be jointed and such joints may be flash welded, machine forge welded, arc or gas welded. Tubes above 5" diameter may also be welded provided they are located outside the furnace. Such welds must conform to the requirements of Chapter VIII.

(c) Flash welding shall be undertaken on a welding machine of a type approved by the Inspecting Officer. The external fin caused by welding shall be removed subject to a maximum height of [illegible] per cent of the tube outside diameter. The internal fin shall also be removed subject to a maximum height of 20 per cent of the wall thickness of the tube.

(d) Arc welded butt joints shall be made by the metallic shielded arc process and post weld heat treated effectively except in the following cases:

for alloy steel—

(i) In case of 0.5 Molybdenum steel if thickness does not exceed 13 mm and outside diameter does not exceed 127 mm.

(ii) In case of 1 Chromium ½ Molybdenum steel if thickness does not exceed 13 mm and outside diameter does not exceed 127 mm and pre-heated to 125°C.

(iii) In case of 2¼ Chromium 1 Molybdenum steel post weld heat treatment is not necessary under the following conditions:

(1) a maximum specified Chromium content of 3.0%,

(2) a maximum nominal outside diameter of 102 mm,

(3) a maximum thickness of 8 mm,

(4) a maximum specified carbon content of 0.15%,

(5) a maximum pre-heat temperature of 150°C.

For carbon steel—

(i) a thickness of 9 mm when the carbon percentage does not exceed 0.300, and

(ii) a thickness of 20 mm when the carbon percentage does not exceed 0.250.

(e) When gas welding is implied the technique followed shall be approved by an Inspecting Officer.

(f) For design metal temperature over 454°C (850°F) material to be used shall be in accordance with the Regulations 48, 53 and 56A.

(g) The technique employed in all field welding of tubes shall be subject to the approval of the Chief Inspector of Boilers.

(h) All butt welds of tubes shall be tested as required hereunder:

(i) **Components Greater than 178 mm (7 inch) Bore**—All welds shall be non-destructively tested by radiographic or other approved methods.

(ii) **Tubes Greater than 102 mm (4 inch) Bore and upto and including 178 mm (7 inch) Bore**—10 per cent of the welds by each welder, selected at random with a minimum of 2 welds per welder, shall be subjected to non-destructive examination by radiographic or other approved method.

(iii) **Tubes 102 mm (4 inch) Bore and Under**—Sample welds simulting the production welds shall be provided for mechanical testing either at a rate of 2 per cent or after each 150 welding hours with a minimum of one sample weld per welder.

Alternatively, 5 per cent of the welds made by each welder selected at random, with a minimum of one weld per welder, shall be subjected to non-destructive examination by radiographic or other approved method. This rate may be reduced to 2 per cent by arrangement with the Inspecting Authority after initial satisfactory results have been produced.

In the event of any non-destructive test not meeting the requirements, defects in the welds represented by that test shall be rectified and the Inspecting Authority may call for an increase in the number of non-destructive tests until such time as a satisfactory standard is achieved.

(i) Butt welded joints as indicated in clause (h) shall be subjected to non-destructive examination by radiographic, radioscopy or other approved methods such as ultrasonic testing, magnetic particle inspection or liquid dye penetrant inspection. When radioscopic examination is to be performed in lieu of radiography on welded components, the following requirements shall be met, namely:

(1) A written procedure shall be submitted for approval to the Inspecting Authority which shall contain the following:—

(i) Material and the thickness range;

(ii) Equipment qualifications;

(iii) Test object scan plan;

(iv) Radioscopic parameters;

(v) Image processing parameters;

(vi) Image display parameters;

(vii) Image archiving requirements;

(viii) Accept-reject criteria (Code reference);

(ix) Performance evaluation;

(x) Operator identification.

(2) The system shall be aided with an image processor to enhance the quality of the radioscopic images and system performance quality shall exhibit—

(i) A thin section contrast sensitivity of 3%;

(ii) A thick section contrast sensitivity of 2%;

(iii) A spatial resolution of 3 line pairs per mm;

(iv) IQI sensitivity - 2% of the joint thickness when wire IQI's are to be used, the wire diameter axis shall be oriented along the axis of the least sensitivity of the system.

(3) Radioscopes are to be properly marked to co-relate with particular part of joint represented.

(4) The radioscopic examination data shall be recorded and stored on video-tape, magnetic disk or optical disk at the maker's plant for a sufficient period after the date of radioscopic examination as specified by the Inspecting Authority, efficient radioscopic examination record recall shall be made available at any time over the record retention period and shall be traceable to the test objects.

(5) When repair has been performed as a result of radioscopic examination, the repaired areas shall be re-examined using the same radioscopic technique to evaluate the effectiveness of the repair.

(6) To aid in proper interpretation of the radioscopic examination data, the details of the technique used shall accompany the data. As a minimum, the information shall include the approved procedure requirements and systems performance test data.

152. Attachment of Steel Tubes

(a) Tubes shall be connected to the tube plates by one of the following methods:—

(1) Expanding.

(2) Strength welding.

(3) Mechanical bolted ball joint.

(b) Drift or roller expanded tubes shall project through the neck or bearing part in the holes by atleast a quarter of an inch and shall be secured from drawing out by being bell mouthed to the extent of 1/32" for each inch in diameter plus 2/32".

(c) Tubes may be seal welded into fittings or headers for both boilers and superheaters after they have been expanded and flared provided the material in the fittings or headers does not contain carbon in excess of 0.35 per cent.

(d) In the case of drifted or roller expanded tubes, the tube holes in the tube plates of drums, pockets, or headers shall be formed in such a way that the tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plate, there shall be a neck or belt of parallel seating of atleast ½ in. depth measured in a plane normal to the axis of the tube at the holes.

(e) Where tubes are strength welded direct to the tube plates, the technique followed shall be approved by the Inspecting Authority and all welds shall be suitably heat treated. In the case of plates below 22 mm thickness, the requirement of stress relieving by heat treatment after welding of the tubes may be waived provided the weld satisfies the requirements of the maximum hardness and also the requirements concerning the impact values of the weld metal. The welding procedure adopted and the weld sequence selected shall also be subject to the approval of the Inspecting Authority. This provision is applicable to only shop welding of tubes at the Manufacturers' Works.

(f) Tubes spacers, supporting clips and lugs may be welded to the tubes. Flash welding of studs for supporting refractories, etc., is also permissible.

(g) The tubes shall be so arranged that they are accessible for cleaning internally and externally.

153. Copper Tubes

Copper tubes upto one inch in external diameter may be used for small boilers; such tubes shall be not less than 12 S.W.G. thick.

HEADERS, MUD BOXES, ETC. OF WATER TUBE BOILERS

154.

(a) (i) Headers and Mud Boxes, etc. of Water Tube Boiler may be of seamless or welded steel, or of cast steel complying with the requirements of the provisions contained in regulations 73 to 80. Where welded, the welding shall be stress relieved, radio-graphed or ultrasonically examined and in all respects shall be to the satisfaction of the Inspecting Authority.

Note: For Carbon Steel material having a maximum Carbon content of 0.25%, the Post held Heat Treatment requirement for tubes welded to Header is not mandatory when all the following conditions are fulfilled, namely:—

(a) The outer diameter (OD) of tubes is not more than 51 MM;

(b) The outer diameter of the Header is not more than 219.1 MM;

(c) The Header thickness is not more than 13 MM;

(d) A minimum pre-heat of 100°C is applied.

(ii) Open ends of seamless steel tube headers may be closed by forging or the ends may be secured by bolting, screwing or welding in an approved manner. Bolting shall not be used where the bolts are exposed to or are swept by gases of combustion.

(iii) The method of attachment of the ends shall be subject to the approval of the Inspecting Authority.

(b) Each piece prior to being fitted in place shall be subjected to hydraulic tests to one-and-a-half times the maximum permissible working pressure of the boiler into which it is to be fitted.

(c) (i) The slighting hold doors and header caps shall be substantial and be capable of being removed or replaced from time to time without loss of efficiency of safety. They may be held in position either by means of bolts or by seal welding.

(ii) The bolts by which they are held in place shall be fitted to them in such a way as to satisfy the above conditions.

(iii) The doors shall be so designed that they will not blow out in the event of breakage of the bolt.

(iv) Circular holes also may be provided in addition to elliptical holes, if provision is made to prevent the door bolts from turning, while securing the joint.

(d) All flanges shall have a fillet with a radius of curvature at least equal to the thickness of the necks to which they are attached.

STAND PIPES, PADS ETC.

155. Stand Pipes and Pads

Stand pipes and seatings for carrying mountings shall be made of wrought, cast or fabricated steel. These shall take the form of short stand pipes, pressed steel plate saddles, forged pads or pads cut from round rolled bar as may be most convenient and secured to the boiler by riveting or welding. Where short stand pipes are used they shall be of solid forged, fabricated or cast steel. They shall be carefully bedded to the shell before attachment and where riveted the rivets shall be so pitched as to ensure a tight joint. The jointing faces to which mountings are to be bolted shall be machined. Pads shall have sufficient thickness to allow the drilling of stud holes for mountings without the inner surface being pierced and the length of the screwed portion of the stud in the pad shall be not less than the diameter of the stud.

156. Design of Stand-Pipes

The design of the branches and stand-pipe shall be regulated in the following manner:

(a) in order to withstand the maximum working pressure or design pressure, the minimum thickness of branch and stand-pipe shall be determined in accordance with the provisions specified in sub-regulation (a) of regulation 338;

(b) compensation requirements for openings in the main pressure parts shall be determined in accordance with the provisions of regulation 279;

(c) the additional thickness shall be considered to withstand superimposed loading due to connecting pipe-work or fittings.

The minimum thickness of the branch or stand-pipe shall be the greatest of the values required above and shall not be less than 0.015 d_o plus 3.2 mm where d_o is the outside diameter of the branch (in mm):

Provided that the provisions of the regulations shall not apply to such tube stub which have been designated as tubes.

157. Pressed Plate Saddles

Where pressed plate saddles are employed they shall be formed to bed closely to the boiler, and machined on the face jointing the mounting and on the edges. The studs for attachment of mountings if screwed through the saddle, shall each be fitted with a nut on the inside having a thickness equal to the diameter of the stud. Where the stud holes do not penetrate through the saddle, the length of the screwed portion of the stud in the plate shall not be less than the diameter of the stud.

158. Seatings for Mountings

For pressures not exceeding 125 lbs. per sq. in. mountings with the screwed ends not exceeding 1 in. S.P.T. may be used; the screwed portion of any such mounting being not less than 3/16 inch.

The mountings may be screwed:

(a) Directly into the boiler shell plate, nuts being fitted on the water side or

(b) Into steel distance pieces the length of thread engaged being in no case less than the bore of the mounting plus ¼ in.

159. Attachment of Mountings

(a) Mountings may be attached directly to any shell or end plate where the plate is of sufficient thickness to allow a suitable surface to be obtained for the attachment of the boiler mountings.

(b) The minimum thickness at the hole in the shell or end plate shall be not less than the thickness required for the maximum permissible working pressure considering the plate as being unpierced.

(c) Where the boiler mountings are secured by studs, the studs shall have a full thread holding in the plate for at least one diameter. If the stud holes penetrate the whole thickness of the plate, the stud shall be screwed right through the plate end be fitted with a nut inside having a thickness equal to the diameter of the stud. Where bolts are used for securing mountings they shall be screwed right through the plate with their heads inside the shell or end plate.

160. Insufficient Thickness of End Plates

(a) In cases where the thickness of the end plate is insufficient for this purpose the mountings shall be joined to suitable steel seatings as provided in Regulation 155.

(b) The following constructions as to stand pipes attached to shells and end plates shall be permissible:

(i) Where the internal diameter of the stand pipe does not exceed 1 inch, the stand pipe may be screwed into the plate end fitted with a nut on the water side.

(ii) Where the internal diameter of the stand pipe exceeds 1 inch but does not exceed 2 inches, it may be screwed in and seal-welded.

(iii) Where the diameter of the stand pipe exceeds 2 inches, it may be welded to the end plate.

The foregoing provisions as to the stand pipe shall be regulated by the following conditions:

(i) When stand pipes are screwed, the screwing shall be of Standard Pipe Thread,

(ii) Where stand pipes, saddles or other forms of seatings are fabricated by fusion welding they shall be stress relieved by heat treatment before attachment to the boiler,

(iii) Where the bore of the stand pipe or seating and the hole in the plate does not exceed 5 inches plus twice the thickness of the plate, the seating may be welded to the plate without subsequent heat treatment of the weld so made. Where the hole in the plate exceeds 5 inches plus twice the thickness of the plate, the plate to which seating is attached shall be stress relieved by the heat treatment.

161. Attachment of Water and Pressure Gauges

Water gauge and pressure gauge siphons may be attached direct to the front end plates without the intervention of a pad or stand pipe, provided they are flanged and secured by studs. If the studs are screwed through the plate, nuts shall be fitted on the inside of the plate.

162. Mountings on Flat Places

Where the flanged mountings are attached direct to a flat plate, such mountings shall be provided with a substantial spigot, the full thickness of the boiler plate.

163. Bolts and Nuts

Bolts and nuts shall be machined where they come in contact with the flanges, and all holes in saddles and pads shall be drilled.

Note: In all cases where boiler is lagged the joint of the mountings shall be clear of the lagging surface or the lagging kept clear of flange so that the joint can be inspected and, when necessary, remade.

MANHOLES, MUDHOLES, ETC.

164. Access

(a) Sufficient slight and cleaning holes shall be provided to permit of efficient inspecting and cleaning. Such holes shall normally be elliptical in form and not less than 3½ in. × 2½ in.

(b) At least one manhole or sight hole shall be provided in the upper part of the cylindrical shell or in the shell crown, or end plate and this shall not be less than:

	inches
Boilers not exceeding 2 ft. 6 inches	09 × 07
Boilers over 2 ft. 6 inches diameter and not exceeding 3 ft.	12 × 09
Boilers over 3 ft. diameter and not exceeding 3 ft. 6 inches	14 × 10
Boilers over 3 ft. 6 inches diameter and not exceeding 4 ft.	15 × 11
Boilers over 4 ft.	16 × 12

(c) Where the size of construction of the boiler does not permit of entry for cleaning and inspection sufficient cleaning holes shall be provided in the shell for these purposes.

(d) Where cross tubes are fitted in Vertical boilers one cleaning hole shall be provided opposite at least one end of each tube. At the bottom of the narrow water spaces at least three cleaning holes shall be provided. The cleaning holes shall be so arranged that the circumferential distance between them does not exceed 3 ft. unless the foundation ring is sufficiently accessible to permit of cleaning and inspection from the inside of the boiler.

Note: Wherever practicable the frames should be secured to the inside of the shells so that the shorter axis is parallel to the longitudinal centre line of the boiler.

(e) Cleaning holes or mudholes in Loco type boilers shall be provided at each bottom corner of the outer firebox casing, above the fire hole ring and on each side of saddle plate in line with bottom of barrel.

(f) In the case of small boilers or where the foregoing provisions are impracticable the cleaning holes or mudholes shall be as nearly as possible in the corner of the outer firebox casing and the holes as large as circumstances permit.

165. Compensating Rings and Frames for Openings in Shells

(a) Compensating rings and frames for openings in shells shall be of wrought or cast steel. The compensation provided shall preferably be flanged frames, which shall be fitted in all cases where the shell plate exceeds 9/16 in. thick. Flanged frames shall be weldless and shall be flanged or pressed to provide a flat jointing surface for the cover.

(b) All compensating rings and frames shall be formed to bed closely to the surfaces to be connected. Where attached to cylindrical shells and are 12 inches × 9 inches or larger they shall be at least double riveted. All caulking edges shall be machined or machine gas cut.

(c) The flat jointing surfaces of all flanged or pressed frames and all doors or covers shall be machined.

166. Internal doors

Internal doors shall be of wrought steel in accordance with Chapter-II and constructed in accordance with the following:—

(a) doors shall be formed to fit closely to the internal joint surface and should be fitted with studs, nuts and crossbars;

(b) doors for circular opening larger than 250 mm or elliptical/rectangular opening larger than 250 mm x 175 mm shall have two studs but for opening of 250 mm x 170 mm or less only one stud may be fitted. Doors for opening not larger than 123 mm x 90 mm may have the stud forged integrally with door;

(c) doors studs shall be of welding quality steel having a minimum specified tensile strength of not less than 360 N/mm^2 and those for manholes shall be not less than 30 mm;

They shall be fixed in any of the following way:—

(1) screwed through the plate and fillet welded on inside;

(2) fillet welded each side of the plate with a leg length of not less than 10 mm;

(3) attached to the door by an intermediate plate or legs so that the strength of the attachment is not less than strength of the studs and the studs are prevented from turning; or

(4) provided with an integrated collar and be riveted or screwed onto the door plate and be prevented from turning in which case the strength of the attachment shall be not less than the strength of the studs;

(d) door spigot when the door is in the central position shall have a clearance of approximately 105 mm all around and at no point shall the clearance exceed 3 mm. The spigot depth shall be sufficient to trap the gasket.

(e) the nuts shall be of appropriate material compatible to that of bolts and be placed on the seating surface;

(f) the cross-bars shall be of substantial proportions and of mild or wrought steel.

Note: Eye bolts of suitable legs on the door plate or headed bolts engaging with slotted sections on the door plate may be used instead of studs.

The minimum calculated thickness of the door of the flat plate construction (i.e. unstiffened made from one plate) shall be not less than that determined by the following formula:—

$$t=\sqrt{\frac{0.35P\times d^2+W}{f}} \quad \text{for a circular door}$$

$$t=\sqrt{\frac{0.35P\left(2-\frac{a}{b}\right)\times a^2+W}{f}} \quad \text{for an elliptical door}$$

where,

t = is the minimum calculated thickness of the flat door (in mm);

P = is the working pressure of boiler (in N/mm^2),

d = is the diameter of the opening to which the door is fitted, if round (in mm),

a = is the minor axis of the opening to which the door is fitted if elliptical (in mm),

b = is the major axis of the opening to which the door is fitted, if elliptical (in mm),

W = is the full load capacity of one stud (effective stud area × design stress value at design temperature in (N),

f = is the maximum allowable stress of the plate at the design temperature (in N/mm^2).

Note: A design stress of value of 50 N/mm^2 may be used for carbon steel bolts for design temperature not exceeding 300°C.

167. Raised Manhole Frames and Cover Plates

(a) Raised circular manhole frames not exceeding 16 inches in diameter shall be at least ¾ inches thick in all parts. The circular cover plates and joint flanges for such frames shall be not less than:

1 inch thick for pressures not exceeding 120 lbs./sq. inch.

1 × 1-11/8 inch thick for pressures over 120 lbs. but not exceeding 200 lbs./sq. inch.

1¼ inch thick for pressures over 200 lbs. but not exceeding 250 lbs./sq. inch.

For pressures 250 lbs./sq. inch and over raised circular manhole frames shall not be fitted.

The cover plates shall be secured by at least sixteen steel bolts not less than 1 inch diameter.

(b) External raised circular mouthpieces shall be:

(1) formed in one piece without welds,

(2) formed from a suitable rolled section and forge welded, or

(3) fabricated by fusion welding provided they are stress relieved by heat treatment after welding and before attaching to the boiler.

Welds should be positioned so that they are located on the transverse centre line of the boiler. The jointing flanges of mouthpieces and covers shall be machined on the face and edge and on the bearing surface for the bolts.

Bolts and nuts shall be machined wherein contact with the flanges and the joints should be formed inside and outside the bolts to preclude the possibility of flange distortion. Cover plates shall be dished outwards to a depth of approximately one-eighth of the internal diameter of the frames.

All frames and mouthpieces shall be closely to the surfaces to which they are to be connected and where riveted to cylindrical shells shall be at least double riveted. All caulking edges shall be machined or machine gas cut.

168. Positions of Manhole in Shell

Manholes in cylindrical shells shall be placed as far as possible from any riveted seams, preferably towards the back end to the boiler top.

169. Compensation Rings to Manholes

(a) Compensation shall be provided in every case for the part cut of a cylindrical shell for a manhole. The strength of the net section of compensating ring and also of the rivets securing them to the shell, compared with that part of the shell cut out, shall not be less than the efficiency of the longitudinal seam.

(b) The spacing of the rivets shell be such as not to reduce the strength of the shell plate below that of the longitudinal seams.

170. Compensation for Cutting Large Holes in Shell Type Boilers

(a) Where holes are cut in the cylindrical shell for the purpose of attaching a seating of frame or door, compensation shall be provided such that the added sectional area, including parts of the frame within 4 inches of the shell and excluding rivet holes, shall be not less than the sectional area of the plate removed which shall be the product of the diameter of the opening and the calculated thickness of the plate as found by Equation 1. Where holes are cut in the cylindrical shell for the purpose of fixing seating for mountings and the diameter of the holes is greater than 2¼ times thickness of the shell plate plus 2¾ inches, compensation shall be provided. Where a large opening is cut in a cylindrical shell to receive another part of the structure, the sides where cut away shall be efficiently cross-stayed or strengthened in some other effective manner.

(b) **Riveted Construction**—Where frames, pads or branches are secured by riveting on shell for fixing of mountings or other pressure parts, the sectional area to be compensated shall be determined as follows (*see* Figure 25A):

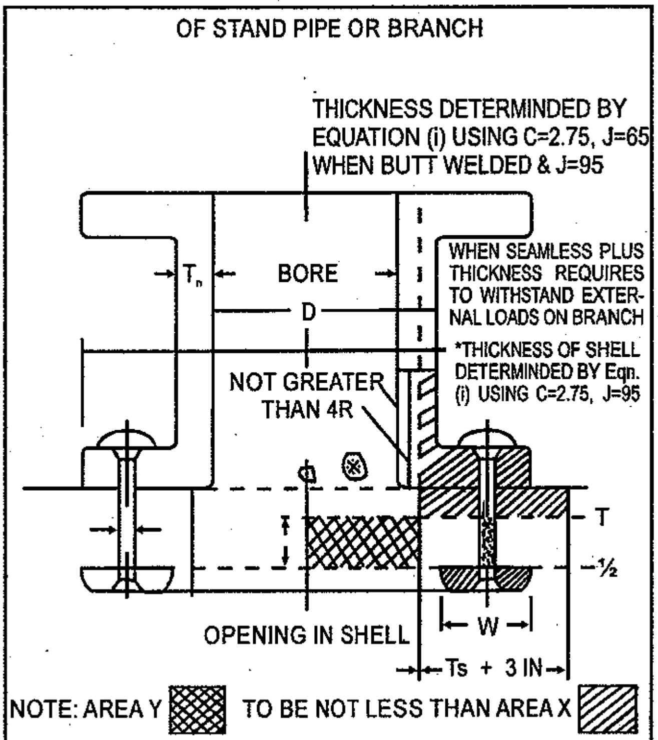


FIG. 25A: COMPENSATION FOR RIVETED STAND PIPES AREA TO BE COMPENSATED AND CORRESPONDING AREA ALLOWANCE FOR COMPENSATION

(i) The cross-sectional area of the frame or pad excluding rivet holes, or in the case of a branch the cross-sectional area of the wall of the branch and flange, excluding rivet holes, minus the sectional area of a branch of the same bore having thickness calculated by Equation 1 for the same design pressure, using C=2.75, J=65 when butt welded, and J=95 when seamless, plus the thickness required to withstand external loads. The area shall be measured within the limit specified in Figure 25A.

Due allowance shall be made in case where the material used for the branch and/or compensating ring differs from that of the plate to which it is attached.

(ii) The area obtained by multiplying the difference between the actual shell thickness and the calculated thickness, by a length

$$2\,(3 \text{ inches} + Ts - D)$$

Ts = thickness of the shell plate in inches.

d = diameter of rivet hole in inches.

In cases where the sum of (i) and (ii) is less than the sectional area to be compensated, a compensating plate shall be fitted having a total net cross-sectional area equal to the amount of the deficit.

171. Rivets Securing Compensating Rings and Stand Pipes

(a) **For Manholes or Frames**—The total effective shear strength of the rivets on each side of the longitudinal centre line shall be not less than the tensile strength of that portion of the shell plate, as found by Regulation 170, which is removed and the rivets securing any compensating ring or frame shall be so arranged that the joint efficiency calculated on any line parallel to the axis of the boiler through any part of such ring or frame shall not be less than the efficiency of the longitudinal seam of the boiler.

(b) **For Stand-Pipes**—Where the hole in the shell to accommodate a stand-pipe does not exceed 8 inches diameter the total effective shear strength of the rivets on each side of the longitudinal centre line shall not be less than 75 per cent of the tensile strength of the portion of the plate, as found by Regulation 170, which has been removed.

The strength of rivets in double shear shall be taken as 1.875 times the strength of rivets in single shear.

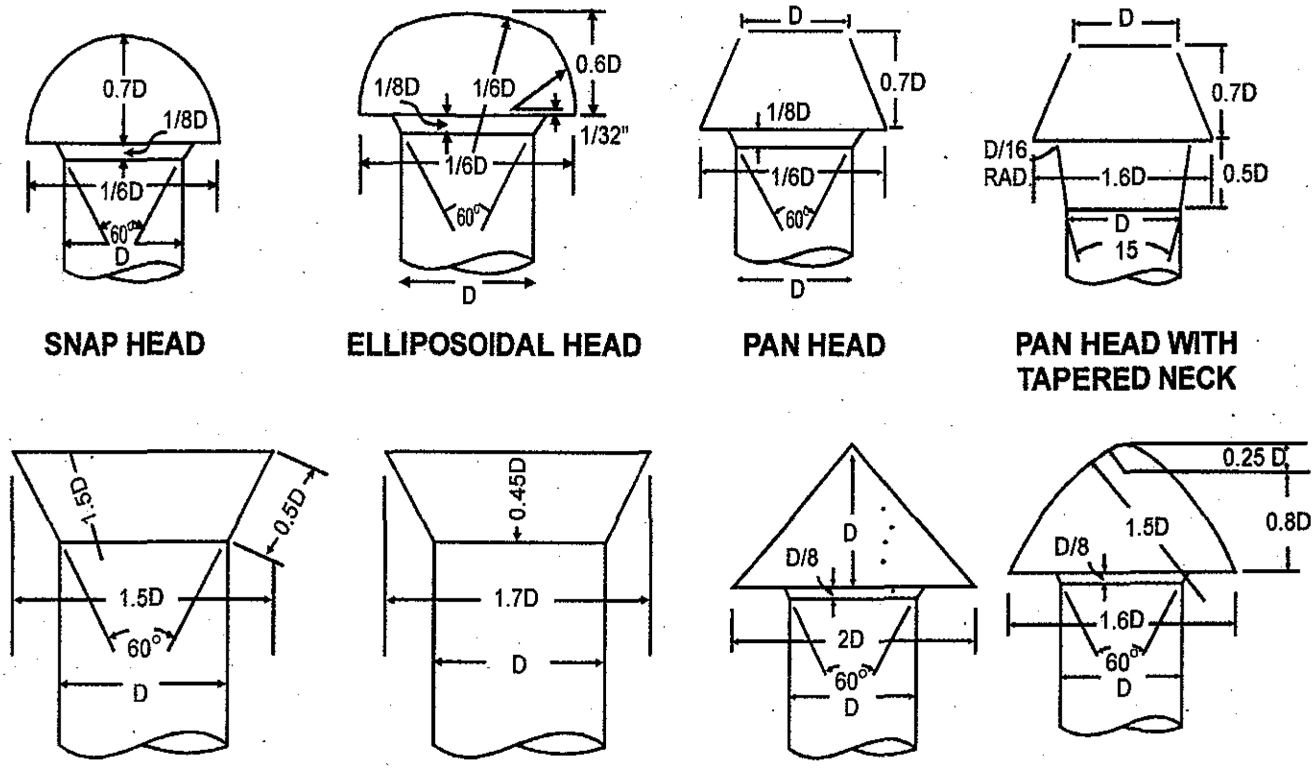
RIVETING

172A. Rivet Heads

The rivet heads shall be of any one of the form (shown in Sketch 1 Appendix H-4) given below:

1. Snap head.
2. Ellipsoidal head.
3. Pan head.
4. Conical head.
5. Round countersunk head.
6. Pan head with tapered neck.
7. Steeple head.
8. Countersunk head.

APPENDIX H-4 — SKETCH 1 — HEADS FOR BOILER RIVETS



SNAP HEAD **ELLIPOSOIDAL HEAD** **PAN HEAD** **PAN HEAD WITH TAPERED NECK**

ROUND COUNTER-SUNK HEAD **COUNTERSUNK HEAD** **STEEPLE HEAD** **CONICAL HEAD**

The dimensions of these rivet heads shall conform to the proportions indicated in the sketch.

The Chief Inspector may, at his discretion, accept any alight variation in the proportion of these dimensions and forms.

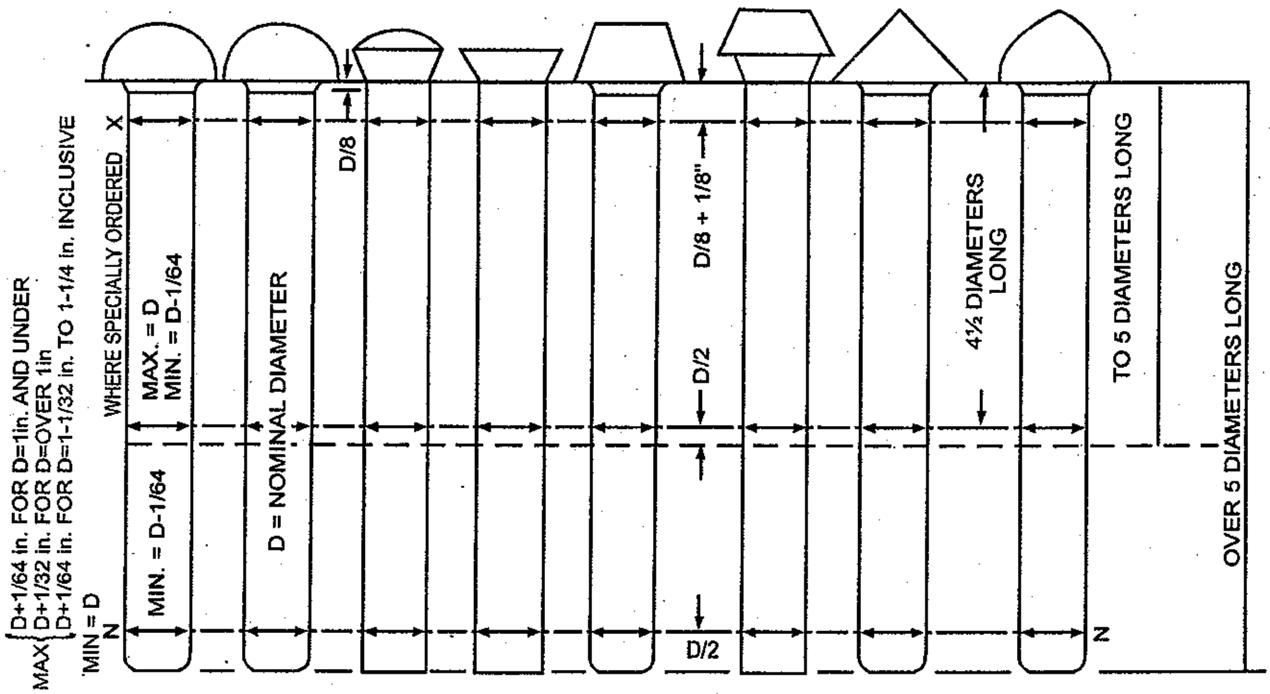
172B. Tolerances on Shanks

The tolerances on the diameters of the shanks measured at position XX, YY, ZZ shown in Sketch 2, Appendix H-4 shall be within the limits given in table below:

DIAMETER OF SHANKS

Reference position as shown in Sketch-2 Appendix H-4	*Distance from rivet head or end*	*For rivets 5D and below in length*		*For rivets over 5D in length*	
		Max.	*Min.*	*Max.*	*Min.*
XX	D/8 plus 1/8 in.	D plus 1/64 inch for D=1 inch and under	D	D plus 1/64 inch for D=1 inch and under	D
YY	D/2 from end	D	D-1/64"	D	D-1/64"
ZZ	D/2 from end	—	—	—	D-1/64"

APPENDIX H-4 — SKETCH 2 — FORMS AND DIMENSIONS OF BOILER RIVETS AS MANUFACTURED



NOTE: FOR RIVETS UPTO 5 DIAMETERS LONG, THE DIFFERENCE IN CROSS DIAMETERS IS NOT TO EXCEED 1/128 IN. FOR RIVETS ABOVE 5 DIAMETERS LONG, THE DIFFERENCE IN CROSS DIAMETERS IS NOT TO EXCEED 1/64 IN. THE DIAMETER OF SHANK ANYWHERE SHALL NOT BE GREATER THAN THE MAXIMUM SPECIFIED POSITION 'X' OR LESS THAN THE MIN. SPECIFIED AT POSITION 'Y' OR 'Z'.

172C. Rivet Holes

(1) Rivet holes shall not be punched, but shall be drilled full size from the solid plate, and wherever possible rivet holes shall be drilled in place with plates, straps and ends bolted in position. After drilling the plates shall be separated, the burrs and the sharp edges of the holes shall be removed and the contact surfaces of the plates shall be cleaned. All tackling holes shall be drilled to a size which will allow the holes to be enlarged to the required rivet size by drilling or reamering. All rivet holes shall be slightly countersunk under each rivet head.

(2) The diameter of the rivet hole shall be not more than 1/16 in. larger than the standard diameter of the cold rivet as manufactured.

(3) Where sizes of rivets are mentioned the sizes refer to the diameters of the rivet holes not to the diameters of the rivets used before closing.

173. Riveting

(a) Rivets shall be closed by hydraulic machinery wherever the design of the boiler permits; the rivets may be closed by hand or pneumatic hammer in position where hydraulic riveting is impracticable.

(b) Rivets shall be of sufficient length to fill rivet holes and form sound and substantial heads. The heads shall be finished concentrically with the rivets shanks. Rivets shall be heated uniformly throughout their full length.

(c) Drift pins shall not be used with such force as to distort the rivet holes. If the rivet holes are found not to be fair when the plates are bolted up for riveting the holes shall be reamered fair before the riveting is commenced.

(d) For hydraulic riveting the pressure shall be the least necessary to ensure a tight joint, and only sufficient pressure shall be used to close the rivets properly and securely without indenting, buckling or otherwise damaging the plate. The rivets shall be allowed to shrink while under pressure from the riveting machine.

174. Fullering and Caulking

All seams shall be fullered or caulked inside & outside and this shall be done in such a manner that the plates are not sprunt or damaged.

CHAPTER IV

REGULATIONS FOR DETERMINING THE WORKING PRESSURE TO BE ALLOWED ON VARIOUS PARTS OF BOILERS OTHER THAN FUSION WELDED AND SEAMLESS FORGED DRUMS

175. Maximum Pressure

The maximum pressure at which a boiler may be used shall be determined in accordance with the provisions of this Chapter. The Regulations in this Chapter refer to material subjected to steam temperature not exceeding 500°F.

SHELLS

176. Formula for Working Pressure of Shell

(a) For cylindrical shells, barrels, steam and water drums, and domes of boilers the maximum working pressure per square inch to be allowed shall be calculated from the following formula:

[**Note:** Where parts of drums of water tube boilers are perforated for tubes, the working pressure shall be calculated by Equation (53) under 'Tube Plates']

$$W.P. = \frac{(t-2)\times S\times J}{C\times D} \qquad \text{Eqn. (1)}$$

where, W.P.= the working pressure in lbs. per square inch;

t = the thickness of shell plates in 32nds of an inch;

S = the minimum tensile breaking strength of the shell plates in tons per square inch or whatever strength is allowed under Regulation 5;

J = the percentage of strength of the longitudinal seams of shell or of a line of holes in the shell or stays, or rivets, or of an opening in the shell not fully compensated, whichever is least calculated by the methods hereafter described;

C = is a co-efficient as follows:

2.75 when the longitudinal seams are made with double butt straps and when small shells are formed from solid sections;

2.83 when the longitudinal seams are made with lap joints and are treble riveted;

2.9 when the longitudinal seams are made with lap joints and are double riveted;

3.0 when the longitudinal seams are welded and are fitted with a single butt strap;

3.3 when the longitudinal seams are made with lap joints and are single riveted;

D = the inside diameter of the outer strake of plating of the cylindrical shell measured in inches.

(b) The factor of Safety shall in no case be less than 4.

The actual factor of Safety in each case may be found from the equation:

$$F = 1.4 \times C \times \frac{1}{t-2}$$

With the best form of joint and least co-efficient (C) the Factor of Safety for shell plates, ¼ inch to 1¾ inches in thickness, varies from 5.13 to 3.99.

(c) An addition of 10 per cent shall be made to the appropriate co-efficient for shells of boilers in which the longitudinal seams are lap jointed and are not accessible to close visual inspection and for shell plates of externally fired boilers exposed to the direct impact of furnace flame; provided that this addition shall not apply to the steam and water drums of water tube boilers where the drums are not close to the fire-grate and there are tubes between the fire-grate and the drum.

(d) The above co-efficient are standards and shall be used only for boiler open to inspection by an Inspecting Officer during the whole period of construction and which are certified by him as having been constructed in accordance with the standard conditions laid down in these regulations.

177. Methods of Calculating the Strength of Riveted Joints

(a) The percentage of strength of a riveted joint (J) shall be found from the following formulae (i), (ii), (iii); (i) and (ii) are applicable to any ordinary type of joint, (iii) is applicable only to that type of joint in which the number of rivets in the inner rows is double that of the outer row, the lowest value given by the application of these formulae is to be taken as the percentage of strength of the joint compared with the solid plate.

(i) $\frac{100(P-D)}{P}$ = Plate percentage Eqn. (2)

(ii) $\frac{100 \times A \times N \times C \times S_1}{P \times T \times S}$ = Rivet percentage Eqn. (3)

(iii) $\frac{100(P-2D)}{P} + \frac{100 \times A \times C \times S_1}{P \times T \times S}$ = Combined plate and rivet percentage Eqn. (4)

where, P is the pitch of rivets at outer row in inches,

D is the diameter of rivet holes in inches, A is the sectional area of one rivet hole in square inches,

N is the number of rivets per pitch (P),

T is the thickness of plate in inches,

C=1 for rivets in single shear as in lap joints, and 1.875 for rivets in double shear as in double butt strapped joints.

S_1 is the shearing strength of rivets, which shall be taken to be 23 tons per square inch for steel and 18 tons per square inch for iron.

S is the minimum tensile breaking strength of shell plates in tons per square inch, or whatever strength is allowed under Regulation 5 of Chapter I.

In the first formula (i) D is the diameter of the rivet holes in the outer rows and in the third formula D is the diameter of the rivet holes in the next rows. In the last formula A is the area of one rivet hole in the outer row.

(b) When the sectional area of the rivet holes is not the same in all rows, and when some of the rivets are in double shear and others in single shear the rivet sections per pitch of each size in shear shall be computed separately and added together to form the total rivet section.

178. When Pitch Exceeds Maximum Allowed

Should the pitch of the rivets exceed the maximum pitch allowed, the permissible pitch shall be used in place of the actual pitch in determining the percentage of plate section. No greater percentage than 85 shall be allowed for any type of riveted joint.

179. Butt Straps and Spacing of Rivets Below Requirements

Should the spacing of the rows of rivets or the distance between edge of plate and rivet hole or the thickness of butt straps be less than that specified in Regulations 182 and 194 the percentage representing the strength of joint shall be modified as prescribed in those regulations.

180. Percentage of Welded and Strapped Seams

In determining the percentage of strength of a welded seam covered by a strap or straps the formulae and allowances in Regulations 177, 178 and 179 shall be applied, but 50 per cent shall be added to the rivet percentage for the weld.

181. Percentage to be Allowed for Solid Rolled Shells

When small shells are rolled from the solid, J, in Equation (1) shall be taken as 100 per cent.

182. Thickness of Butt Straps

The minimum thickness of butt straps for the longitudinal seams of cylindrical shells shall be determined by the following formulae but all straps should be of sufficient thickness to permit of efficient caulking and in any case shall not be less than 3/8 inch in thickness.

Single butt straps having ordinary riveting—

$$1.125T = T1 \qquad \text{Eqn. (5)}$$

Single butt straps having every alternate rivet in the outer rows omitted—

$$1.125T = \frac{(P-D)}{(P-2D)} = T_1 \qquad \text{Eqn. (6)}$$

Double butt straps of equal width having ordinary riveting—

$$.625T = T_1 \qquad \text{Eqn. (7)}$$

Double butt straps or equal width having every alternate rivet in the outer rows omitted—

$$.625T \times \frac{(P-D)}{(P-2D)} = T_1 \qquad \text{Eqn. (8)}$$

Double butt straps of unequal width either having ordinary riveting, or having every alternate riveting the outer rows omitted—

$$.75T = T_1 \text{ (wide strap)} \qquad \text{Eqn. (9)}$$

$$.625T = T_1 \text{ (narrow strap)} \qquad \text{Eqn. (10)}$$

where T_1 = the thickness of the butt straps in inches.

The other symbols have the same significance as in Regulation 177.

Single and wide butt straps shall, wherever practicable, be on the inside of the shell.

Should the thickness of butt straps be less than that above described, the least percentage of joint as determined under Regulation 177 shall be reduced in the proportion of the actual thickness to the prescribed thickness.

183. Maximum Pitch of Rivets in Longitudinal Joints

The maximum pitch of the rivets in the longitudinal joints of boiler shells shall be—

$$C \times T + 1.625 = \text{maximum pitch in inches} \qquad \text{Eqn. (11)}$$

where, T = the thickness of the shell plate in inches,

C = a co-efficient as given in the following tables:

Number of Rivets per pitch	*Co-efficients for Lap joints*	*Co-efficients for single Butt-strapped joints*	*Co-efficients for double Butt-strapped joints*
1	1.31	1.53	1.75
2	2.62	3.06	3.50
3	3.47	4.05	4.63
4	4.14	—	5.52
5	—	—	6.00

184. Spacing of Rows of Rivets

(a) In joints, whether lapped or fitted with butt straps, in which there are more than one row of rivets and in which there is an equal number of rivets in each row, the distance between the rows of rivets shall be not less than—

Zig-zag riveting—

$$0.33P + 0.67D = \text{distance between centre lines of rows (R)} \qquad \text{Eqn. (12)}$$

Chain riveting—

$$2D = \text{Distance between centre lines of rows (R)} \qquad \text{Eqn. (13)}$$

(b) In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows, and in which the inner rows are chain rivets the distance between the outer rows and the next rows shall be not less than as required by Equations (12) and (13) whichever is the greater, and the distance between the rows in which there are the full number of rivets shall be not less than 2D (R_1).

(c) In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows and in which the inner rows are zig-zag, the distance between the outer rows and the next rows shall be not less than—

$$0.2P + 1.15D = \text{distance between centre lines of outer and next rows (R)} \qquad \text{Eqn. (14)}$$

The distance between the rows in which there are the full number of rivets shall be not less than—

$$0.165P + 0.67D = \text{distance between centre lines of inner rows (R1)} \qquad \text{Eqn. (15)}$$

where, P is the pitch of the rivet in the outer rows,

D is the diameter of the rivet holes in inches or the mean of the diameter of rivet holes when the distance to be determined is between two rows of rivets of different diameters.

(d) Should the distance between rows of rivets be less than as prescribed above the plate percentage determined by Equation (2) shall be modified thus—

$$\frac{100\left[P-\left(2-\frac{\text{actual distance}}{\text{prescribed distance}}\right)D\right]}{P} = \text{modified plate percentage} \qquad \text{Eqn. (16)}$$

(e) In all cases the clear space between a rivet hole and the edge of a place shall not be less than the diameter of the rivet holes, i.e., the centre of the rivet hole shall be at least 1½ diameters distant from the edge of the plate (E):

Provided that if this condition be not observed, the strength value of the rivet affected shall be reduced in the proportion of the actual distance between the outer edge of the rivets and the edge of the plate to the prescribed distance.

185. Circumferential and End Seams of Water Tube Boilers

The suitability of circumferential seams including the seams joining ends to shells shall be verified by the following formula:

$$\frac{K \times J \times (t-2)}{D \times C} \text{ is equal to or greater than W.P.} \quad \text{Eqn. (17)}$$

where, K = 150 for 26/30 tons tensile plates,

K = 157 for 28/32 tons tensile plates,

Due to higher stresses, see Regs. 271 and 340.

WP = the working pressure in lbs. per sq. in.

D = the diameter of shell in inches, measured inside the outer ring of plates.

J = circumferential Joint efficiency calculated by Eqn. 2 or 3.

C = 8.24 where the seams are made with lap joints and are treble riveted.

= 8.44 where the seams are made with lap joints and are double riveted.

= 9.60 where the seams are made with lap joints and are single riveted.

t = thickness of plate in 32nds of an inch.

186. Compensation for Manholes and Other Openings

The percentage of compensating section shall be determined by the following formulae—

$$\frac{200(W-D) \times Tr}{(L+2D)+Ts} = \text{Percentage strength of compensating section} \quad \text{Eqn. (18)}$$

$$\frac{80 \times A \times N}{(L+2D)+Ts} = \text{Percentage strength of rivet section.} \quad \text{Eqn. (19)}$$

where, W is the width of compensation ring in inches measured in the direction of the longitudinal axis of the boiler,

L is the length of opening in shell in inches measured in the direction of the longitudinal axis of the boiler,

D is the diameter of rivet holes in inches,

Tr is the thickness of compensation ring in inches,

Ts is the thickness of shell plate in inches,

A is the area of one rivet hole in inches,

N is the number of rivets on one side of the longitudinal line.

When the rivets are in double shear 1.875 times the single rivet section shall be allowed.

Parts of raised manhole mouthpieces within four inches of the shell shall, in addition to the ring, be included in the compensating section.

187. Uncompensated Holes in Water Tube Boilers

The maximum diameter of any unreinforced opening shall not exceed 'd' as shown in Figures 9B and 9C (*see next page*) subject to a maximum of 203 millimetres.

The notations in Figures 9B and 9C are defined as follows:

$$K = \frac{P.D.}{1.82 f.e} \qquad \text{Eqn. (20)}$$

where, d = maximum allowable diametre of opening (in the case of an opening of elliptical or of round form, the mean value of the two axes of the opening shall be taken for d);

D = outer diameter of the shell;

e = actual thickness of the shell;

f = allowable stress;

When K has a value of unity or greater, the maximum size of an unreinforced opening should be 51 millimetres (2 inches).

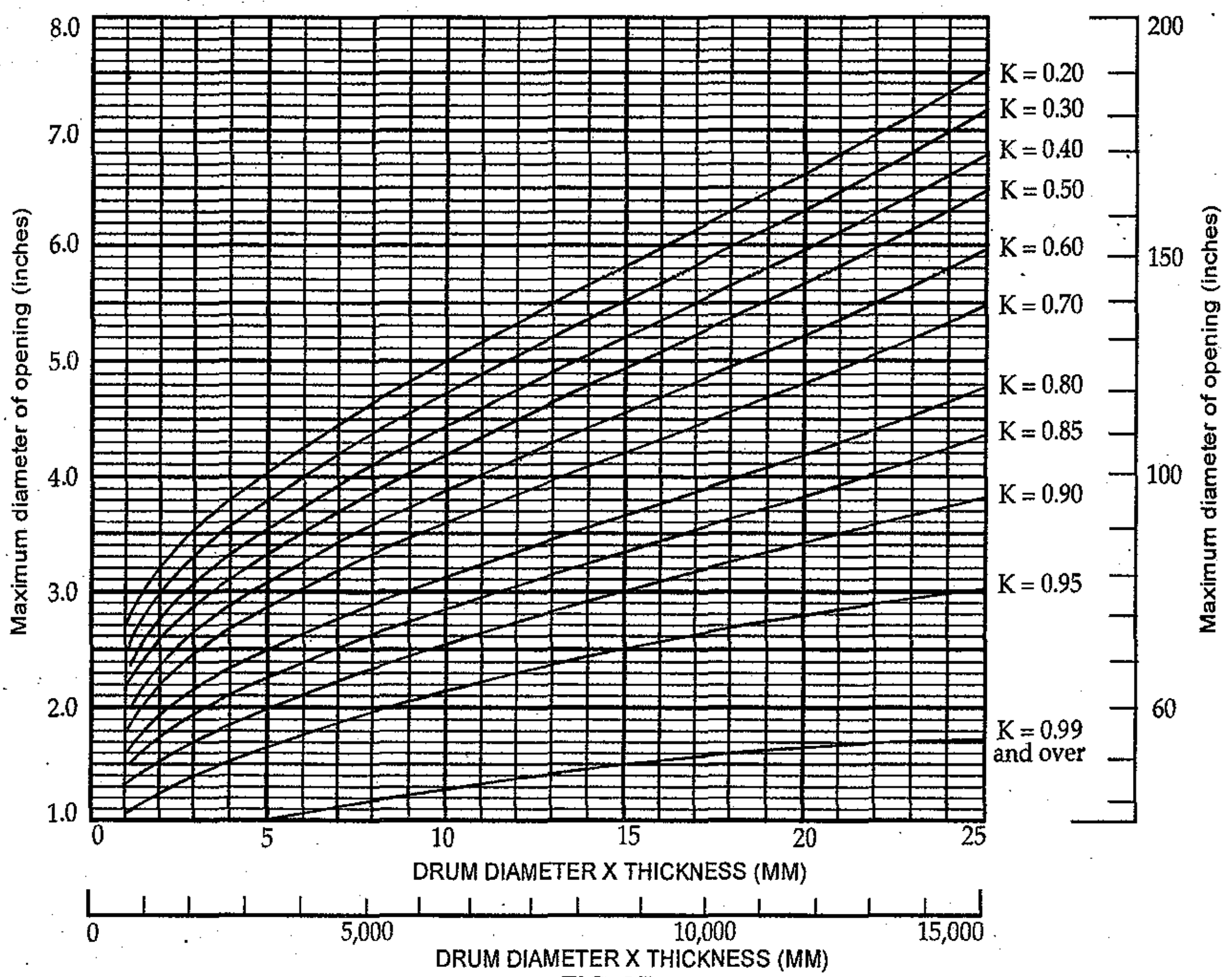
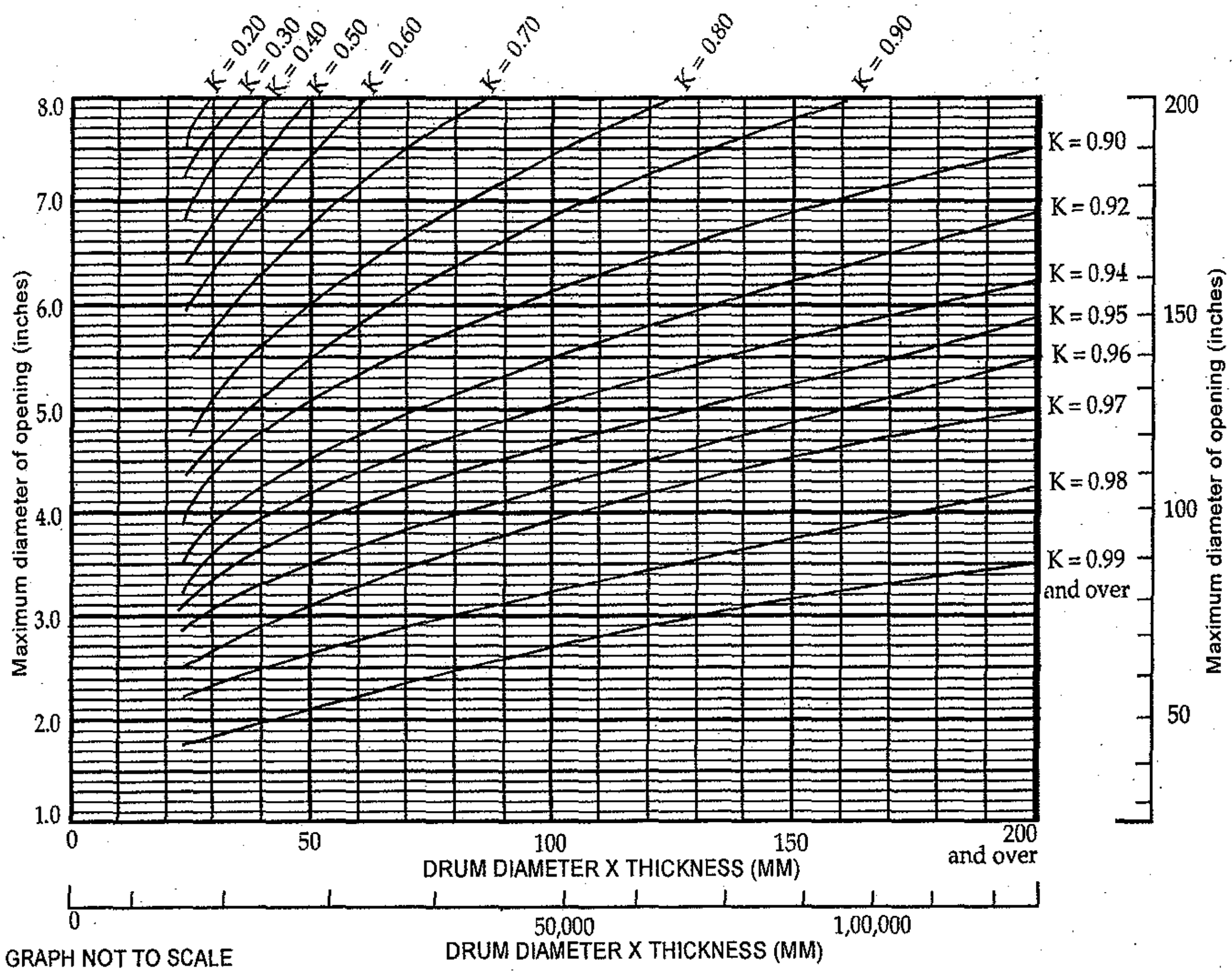


FIG. 9B

Graph not to scale.



GRAPH NOT TO SCALE

FIG. 9C

DISHED END PLATES

188. Complete Hemisphere Without Stays or Other Support Made of One or More Plates and Subject to Internal Pressure

The maximum working pressure shall be determined by the following formula—

$$\text{W.P.} = \frac{(t-2)\times S\times J}{C\times R} \qquad \text{Eqn. (23)}$$

where, W.P. is the working pressure in lbs. per square inch,

t is the thickness of the end plate in 32nds of an inch,

S is the minimum tensile breaking strength of the end plates in tons per square inch, or whatever strength is allowed for them,

J is the least percentage of strength of the riveted joints of the plates forming the hemisphere or securing it to be cylindrical shell,

R is the inner radius of curvature in inches,

C for single riveting is 3.3,

C for double riveting is 2.9,

C for treble riveting is 2.83.

189. Dished Ends Subject to Internal Pressure

(a) For unstayed ends of steam and water drums, tops of vertical boilers, etc., when dished to partial spherical form the maximum working pressure shall be determined by the following formula:

$$W.P. = \frac{15 \times S \times (t-1)}{R} \qquad \text{Eqn. (24)}$$

where, W.P. is the working pressure in lbs. per square inch,

t is the thickness of end plates in 32nds of an inch,

R is the inner radius of curvature of the end in inches, which shall not exceed the external diameter of the shell to which it is attached,

S is the minimum tensile breaking strength of plate in tons per square inch or whatever is allowed for it.

(b) The inside radius of curvature of the flange shall be not less than 4 times the thickness of the end plate, and in no case less than 2½ inches.

(c) When the end has a manhole in it (t – 5), shall be substituted for (t – 1) in the formula.

(d) The total depth of flange of manhole from the outer surface in inches measured on the minor axis shall be at least equal to

$$\sqrt{T \times W} = \text{depth of flange in inches} \qquad \text{Eqn. (25)}$$

where, T is the thickness of the plate in inches, and

W is the minor axis of the hole in inches.

Note: The foregoing provisions shall not preclude the use of dished ends in compliance with Regs. 275 to 278, where not fitted with an uptake.

190. Dished Ends Subjects to External Pressure

In the case of unstayed dished ends, for the co-efficient 15 in Equation (24) the co-efficient 12 shall be substituted and R shall be the outer radius of curvature of plate which shall not exceed the external diameter of the shell to which it is attached. For plates expose the furnace flame the co-efficient shall be 10.5.

In no case shall $\frac{R}{t}$ exceed 2.75.

191. Dished Ends of Lancashire and Cornish Type Boilers

(a) For dished ends of Lancashire and Cornish bodies formed in one piece, without stays and subject to internal pressure the maximum working pressure shall be determined by the following formula:

$$W.P. = \frac{(t-8) \times 30 \times S}{R} \qquad \text{Eqn. (26)}$$

where, W.P. is the working pressure in lbs. per square inch,

t is the thickness of the end plate in 32nds of an inch,

R is the inner radius of curvature of the end in inches which shall not exceed one and a half times the external diameter of the shell to which it is attached,

S is the minimum tensile breaking strength of the plate in tons per square inch or whatever is allowed for it.

(b) The inside radius of curvature at the flange shall be not less than 4 times the thickness of the plate end in no case less than 3½ inches.

192. Dished Shell and Firebox Crowns

(a) In determining the working pressure in accordance with Regulations 189 and 190 no account shall be taken of the influence of the uptake tube in vertical boilers. If dished crown plates having uptakes are fit for higher pressures, when considered as flat plates, under Reg. 197 such higher pressure shall be allowed.

(b) The radius R of the dished part may be found as follows—

$$R = \frac{C^2 + H^2}{2H} \qquad \text{Eqn. (27)}$$

C and H are the lengths in inches of half the base line or chord on which H measured and the height of the dish or camber at the middle of the chord respectively.

FLAT PLATES

193. Flat Plates supported by Solid Screwed Stays, Marginal Seams or Flanges

(a) For plain flat plates supported by solid screwed stays or riveted marginal seams or flanges, the maximum working pressure shall be as follows—

$$W.P. = \frac{C(t-1)^2}{A^2 + B^2} \qquad \text{Eqn. (28)}$$

In this formula and in those following in the succeeding regulations relating to "Flat Plates" unless otherwise specified—

W.P. is the working pressure in lbs. per square inch,

t is the thickness of the flat plate in 32nds of an inch,

t_1 is the thickness of the washers, strip, or doublings employed in 32nds of an inch,

A is the horizontal pitch of stays in inches,

B is the vertical pitch of the stays in inches, C is a co-efficient which varies in value with method of vaxing the stays and nature of the support.

Where the plates are exposed to the direct impact of the flame the following of C shall be reduced 12½ per cent—

C 60 for stays screwed into the plate with their ends riveted over,

C 90 for stays screwed into the plate and fitted with nuts on the outside,

C 100 for stays passed through the plate and fitted with nuts inside and outside,

C 110 for a riveted seam or flange, in the flat plate securing it to the shell side plate, end plate, furnaced or uptake.

Where portions of plate are supported by stays or riveted seams or flanges having various values of support, the value of C, shall be taken as the mean of the points of support concerned.

The support of a riveted seam shall be assumed to be at the line through the centres of rivets in the nearest row and of a flange at the commencement of curvature. In the latter case, if the inner radius of curvature of the flange exceeds 2½ times of the thickness of the plate, the support shall be assumed to be at a distance of 2½ times the thickness of the plate from the inner side of the flange.

(b) For portions of plate where the stays are irregularly pitched D2 shall be used instead of $A^2 + B^2$, D being the diameter in inches of the largest circle which can be drawn passing through not less than three points of support, viz., the centres of stays, or rivets or the commencement of the curvature of flanging whichever is applicable.

(c) For the tops and sides of combustion chambers and fireboxes the distance between the rows of stays nearest to the back tube plate, or the back or firehole plate respectively, and the commencement of curvature of these plates at their flanges shall not be greater than the maximum pitch of the stays.

(d) For the tops of combustion chambers and fireboxes where they are joined to the sides by curved portions, if the outer radius of the curved portion is less than half the allowable distance between the girders, the distance between the first girder and the inner surface of the side plates shall not exceed the allowable distance between the girders. If the radius of curvature is greater than half the allowable distance between girders, the width of the flat portion measured from the centre of the girder shall not be more than half the allowable distance between the girders.

(e) Where stay tubes are not fitted in nest of tubes, as in tube plates of loco type boilers, and parts of plate outside the space occupied by tubes are supported, in accordance with Regulation 212(b), by screwed stays each stay in the row nearest the tube shall be of sufficient strength to support the plate upto the edges of the tube holes in addition to its share of the plate on the opposite side of the line of stays.

The working pressure for the plate between tubes and stays shall be determined by Eqn. (28). A being the horizontal pitch of the stays in the nearest row, B twice the distance between the centre line of stays and a line touching the tubes opposite them and C the co-efficient appropriate to the kind of stay.

194. Flat Plates supported by Stays and Nuts and Large Washers or Strips or Doublings

(a) Where the plates are supported by stays passing through them and are fitted with nuts inside and washers and nuts outside, the diameter of the washers being at least 3½ times that of the stay, and their thickness at least two-thirds, that of the plate, but not greater than that of the plate, the maximum working pressure shall be—

$$W.P. = \frac{100}{A^2+B^2}\left[(t-1)^2 + .15t_1^2\right] \qquad \text{Eqn. (29)}$$

(b) Where the washers have a diameter of at least two-thirds of the pitch of the stays and a thickness of at least two-thirds of the thickness of the plate, but not greater than that of the plate, and are riveted to the plate in an efficient manner, the maximum working pressure shall be—

$$W.P. = \frac{100}{A^2+B^2}\left[(t-1)^2 + .35t_1^2\right] \qquad \text{Eqn. (30)}$$

(c) Where the plate is stiffened by strips at least two-thirds of the pitch of the stays in breadth which have a thickness of at least two-thirds of that of the plate but not greater than that of the plate, and are riveted to the plate in an efficient manner, the maximum working pressure shall be—

$$W.P. = \frac{100}{A^2+B^2}\left[(t-1)^2 + .55t_1^2\right] \qquad \text{Eqn. (31)}$$

(d) Where the plates are fitted with doubling plates having a thickness of at least two-thirds of that of the plate but not greater than that of the plate, and are riveted to them in an efficient manner, the maximum working pressure shall be—

$$W.P. = \frac{100}{A^2+B^2}\left[(t-1)^2 + .85t_1^2\right] \qquad \text{Eqn. (32)}$$

195. Flat Tube Plates

(a) For the portions of the tube plates in the nests of tubes where stay tubes are required and where the minimum thickness and cross-section of tube plate are not less than as prescribed in Regulation 211, the maximum working pressure shall be—

$$W.P. = \frac{C(t-1)^2}{P^2} \qquad \text{Eqn. (33)}$$

where, P = is the mean pitch of the stay tubes supporting any portion of the plate (being the sum of the four sides of the quadrilateral divided by four)

C = 70 for stay tubes screwed and expanded into the plate and no nuts fitted and for those attached by welding in accordance with Regulation 147(b)

C = 85 for stay tubes screwed and expanded into the plate and fitted with nuts.

(b) No nuts shall be fitted to stay tubes at the combustion chamber or firebox end.

(c) Where the plates are exposed to the direct impact of flame the co-efficient C shall be reduced by 12½ per cent, and where the thickness or cross-section of tube plate between tubes is less than as prescribed in Regulation 211, the appropriate co-efficient shall be reduced in proportion to the deficit.

(d) For the wide water spaces of tube plates between the nests of tubes and between the wing rows of tubes and the shell, the maximum working pressure shall be—

$$W.P. = \frac{C}{A^2 + B^2}\left[(t-1)^2 + .55t_1^2\right] \qquad \text{Eqn. (34)}$$

where, A = the horizontal pitch of stay tubes in inches measured across the wide water spaced from centre to centre,

B = the vertical pitch of stay tubes in the bounding rows in inches measured from centre to centre,

C = 60 for stay tubes screwed and expanded into the tube plates and no nuts are fitted and for those attached by welding in accordance with Regulation 147(b),

C = 80 for stay tubes screwed and expanded into the tube plates and fitted with nuts,

C = 70 for stay tubes screwed and expanded into the tube plates and nuts are fitted only to alternate stay tube,

t = is the thickness of the flat plate in 32nds of an inch,

t_1 = is the thickness of the washers, strips or doublings employed in 32nds of an inch.

(e) Where the plates are exposed to the direct impact of flame, the co-efficient shall be reduced to 12½ per cent.

196. Plates supported by Gusset Stays

(a) For the end plates of Lancashire, Cornish, Vertical and Locotype boilers, and other flat surfaces supported by irregularly pitched gusset stays, the maximum working pressure shall be—

$$W.P. = \frac{C(t-1)^2}{D^2} \qquad \text{Eqn. (35)}$$

where, D = the diameter in inches of the largest circle which can be drawn passing through not less than three points of support, viz. the centre lines of rivets or the commencement of the curvature of flanging, whichever is applicable, C = 100 for plates not exposed to flame,

C = 88 for plates exposed to flame.

(b) Where such plates are stiffened by suitable tee or angle bars securely riveted to the plates within the circle D, the appropriate co-efficient may be increased thirty per cent. Such stiffening bars shall be placed so as to transmit their loan in a direct manner to the gusset stays or shell plate.

(c) For the part of the end plate containing the manhole in Lancashire boiler the maximum working pressure shall be—

$$W.P. = \frac{C}{D^2}\left[(t-1)^2 + (t^2-1)^2\right] \qquad \text{Eqn. (36)}$$

where, D is the diameter in inches of the largest circle which can be drawn enclosing the manhole and passing through the centres of the rivets in the end plates connecting the shell and gusset angles and furnaces or to the commencement of curvature of flanging, whichever is applicable where the circle passes through only three of the possible five points of support mentioned the remaining two shall be embraced within the circle,

t is the thickness of the flat plate in 32nds of an inch,

t is the thickness of the base of the mouthpiece of flat ring in 32nds of an inch,

C 90 where the manhole mouthpiece is either of mild or cast steel, and has a turned-in flange of a depth, measured from inside of end plate, of not less than 4 times the thickness of the end plate and thickness not less than the thickness of the end plate,

C 70 where only a flat steel compensating ring is fitted,

C is to be taken as the mean of the points of support through which circle passes in accordance with Regulation 193 where there is no mouthpiece or flat ring and the end plate is flanged around the manhole to the depth required in Regulation 201.

197. Flat Crown Plates of Vertical Boilers

(a) For the flat crown plates of vertical boilers either with or without bolt stays, Equation (35) shall be used in determining the working pressure with C = 80, when the plates are not exposed to flame, and 70 when they are exposed to flame. In this case, D is the diameter of the largest circle in inches that can be drawn passing through the centres of the rivets or bolt stays when fitted, or the commencement of the curvature of the flanging, whichever is applicable. Where bolt stays are fitted with washers of the same thickness as the plate securely riveted thereto, the circle shall pass through the centres of the riveted thereto, the circle shall pass through the centres of the washer rivets but where the washers are not riveted or where none are fitted the circle shall pass through the centre of the stays.

(b) Where the crown plate is flanged the inside radius of curvature at the flange shall not be less than 4 times the thickness of the end plate, but in no case less than 2½".

(c) The thickness of flat crown plates shall in no case be less than the thickness of the cylindrical portion to which it is attached.

198. Circular Flat Ends of Drums, etc., supported only at Edges

(a) For these ends C in Equation (35) shall be taken as 140 when the plates are not exposed to flame, and 122.5 when they are exposed to flame. In this case circle D shall pass through the centres of rivets or bolts securing the end be less than 4 times, the thickness of the end plate but in no case less curvature.

(b) Where flanged the inside radius of curvature at the flange shall not be less than 4 times, the thickness of the end plate, but in no case less than 2½".

199. Bar or Bulb Stiffened End Plates and Smokebox Tubes Plates of Locotype Boilers

Where such plates instead of being supported by stays are stiffened in the steam space by substantial tee or angle bars securely riveted to the plate and extending across the plate to within the margin allowed by Equation (37) or where such plates are formed with a deep bulb extending across the plate to well within the margin allowed, for the support thus given.

C shall be taken as equal to 80 and 70 for plates not exposed, and exposed to flame respectively. The margin or pitch for such stiffening shall be measured from the centre line of rivets or commencement of curvature of bulb provided it is not more than 2 inches from the centre line of bulb.

For the flat plate above the stiffener or bulb, C shall be taken as the mean of the values appropriate for the points of support.

200. Plate Margins

The amount of support in relief of stays which may be credited to the sides of shells, furnaces, uptakes, fireholes and foundation rings to which flat plates are attached shall not exceed that found by the following formula:

$$\text{Width of margin in inches} = \frac{C(t-1)}{\sqrt{(W.P.)}} \qquad \text{Eqn. (37)}$$

where, t = thickness is 32nds of an inch,

W.P. = working pressure in lb. per sq. inch,

C = 3.47 for plates exposed to flame,

C = 3.70 for plates not exposed to flame.

Where the plates are flanged the margin shall be measured from the commencement of curvature or from a line 2½ times the thickness of the plate distant from the side of the flange next to the inner radius of the corner whichever is the less. In other cases, the margin shall be measured from the centre line of rivets in the nearest row of the seam by which the flat plate is attached.

Doubling plates shall cover the area supported between the stays and extend beyond the stays so that the centre of the rivets securing the doubling plate to the end plate shall be at least half the distance from the outermost stays to the nearest substantial point of support.

Where flat end plates are flanged for connection to the shell the inside radius of flanging shall be not less than 1.75 times the plate thickness with a minimum of 1½ inches.

201. Manholes and Mudholes in Flat Plates

Where a flat plate is flanged to stiffen it at a manhole or sighthole, to permit same working pressure as would be allowed upon as unpierced plate, the depth of the flange measured from the outer surface shall be at least equal to—

$$\sqrt{(T \times W)} = \text{depth of flange in inches} \qquad \text{Eqn. (38)}$$

where, T = the thickness of the plate in inches, and

W = the minor axis in the hole in inches.

STAYS

202. Solid Screwed Stays

For screw stays to combustion chambers and fireboxes and for longitudinal and cross-stays the maximum working pressure for the stays is to be calculated from the appropriate one of the following two formulae:

$$W.P. = \frac{C}{A}\left\{D - \frac{1.28}{N}\right\}^2 \qquad \text{Eqn. (39)}$$

$$W.P. = \frac{C \times D_1^2}{A} \qquad \text{Eqn. (40)}$$

where, W.P. = the working pressure in lbs. per square inch,

D = the diameter of stays over threads in inches,

D_1 = the diameter of body of stay at its smallest part in inches,

N = the number of threads of stay per inch,

A = the area in square inches supported by one stay [for area to be supported by stays near tubes in firebox tube plates of locotype boilers, *see*, Regulation 193(e)],

C = 7100 for steel or special wrought iron screw stays to combustion chamber or fireboxes,

C = 8640 for steel longitudinal or cross-stays fitted with nuts,

C = 4700 for copper screws stays to fireboxes.

Where stays are made with enlarged ends and the body of the stays is smaller in diameter than at the bottom of the thread the working pressure shall be calculated from the second formula.

203. Stresses in Steel Jointed Stays

(a) The section of least strength whether of stay, rivets, shackle or pin shall be used in calculating the working pressure for the stay. For parts in tension a stress of 9,000 lbs. per square inch of net section shall be allowed, and for parts in shear stress of 8,000 lbs. per square inch of net section.

(b) Parts in double shear shall be allowed a section of 1.875 times the single section.

204. Stay Tubes

For stay tubes, whether of wrought iron or steel, seamless or electric resistance welded or lap-welded the maximum working pressure shall be calculated from the following formula:

$$W.P. = \frac{5900}{A}\left\{\left(D - \frac{1.28}{N}\right) - D_1^2\right\}^2 \qquad \text{Eqn. (41)}$$

where, D = the diameter of the tube over threads in inches,

D_1 = the internal diameter of the tube under the threads in inches,

N = the number of threads of stay per inch.

A is the area in square inches supported by one stay tube, measured from centre to centre of stay tubes. When the area contains tubes or parts of tubes their aggregated area, calculated from their smallest external diameter of body when in tension and smallest internal diameter when in compression, shall be deducted from the area of the containing figure and the remainder used as A in the formula.

205. Stays in Tension and Compression

(a) The same stress shall be allowed in compression as in tension. The strength of short stays in compression and not liable to bending shall be calculated on the net section of the stay at bottom of thread or in body, whichever is less.

(b) The stress to be allowed on any stay or part of a stay not provided for in foregoing shall be the same as that allowed for stays or parts of stays of approximately like kind in similar conditions.

206. Measurement of Stayed Areas in the End Plates of Locotype and Vertical Boilers

When the areas supported by stays are semi-circular as in the upper parts of the end plates and smokebox tube plates of locotype boilers, or annular as in the crown plates of vertical type boilers, the area to be supported by stays A in Eqns. 39 and 40 shall, in the first case, be the area of plate contained within the margins credited to casing or barrel sides, screw stays, fire door ring or tube stays, as the case may be, and in the second case be the area of the annulus between the margins credited to uptake and shell. When bolt staying is necessary the stays shall be properly distributed; the aggregate stay section shall then be used in the formula for calculating the working pressure.

207. Gusset Stays

The maximum working pressure for gusset stays shall be calculated by the following formula:

$$W.P. = \frac{900 \times C}{A} \qquad \text{Eqn. (42)}$$

C, the co-efficient, is the number representing the least of the following—

(1) $N_1 \times A_1$

(2) $N_2 \times A_2 \times 1.875$

(3) $N_3 \times A_3 \times 1.875$

(4) $N_4 \times A_4$

(5) $(G - N_2 D_2) \times (t - 2) \times 0.037$

(6) $(G_1 - D_3) \times (t - 2) \times 0.037$

N_1, N_2, N_3, N_4, D_1, D_2, D_3, and A_1, A_2, A_3, A_4 are respectively the numbers, diameters and sectional areas of the rivets in the joints of each gusset stay only rivets in the supported area, to be considered effective, the order of the joints, being (1) angles to end plate, (2) end plate angle to gusset, (3) shell angles to gusset, and (4) angles to shell,

G is the depth in inches of gusset plate measured through the line of rivet attaching it to the end plate angles,

G_1 is the depth in inches of gusset plate measured normal to the slant edge of plate through the rivet nearest to the end plate in the joint attaching gusset plate to shell angles,

t is the thickness of the gusset plate in 32nds of an inch,

A is the area in square inches of flat plate supported by the gusset edge of plate through the rivet nearest to the end plate in the joint attaching as follows—

(a) The margins allowed under flat plate regulations for shell and furnace shall be marked on end plates and the lengths of the centre lines of gussets between them measured, also the distance between each pair of gusset lines from the middle of the smaller in a direction normal to the greater. If L and L_1 be the lengths of two adjacent gusset lines if the distance between them be W, the area contained by the gusset lines and the shell and furnace margin lines may be apportioned between the stays thus:

$$\frac{W(3L+L_1)}{8} = \text{portion of area in square inches, apportioned to L line gusset} \qquad \text{Eqn. (43)}$$

$$\frac{W(3L_1+L)}{8} = \text{portion of area in square inches, apportioned to } L_1 \text{ line gusset} \qquad \text{Eqn. (44)}$$

(b) The portion of the area on the other side of each gusset line shall except when of triangular form, be found in like manner and its amount added to that already found to form the total.

(c) For the triangular portions in the wing spaces the area shall be taken as half the product of the length of gusset line into the perpendicular distance between it and the intersecting point where the marginal curves meet.

208. Bolts and Studs

(a) Bolts and studs connecting parts by boilers such as shell, end plate, tube plates, furnaces, uptakes, externally fitted manhole covers, mountings, etc., may be made either of steel or good quality wrought iron.

(b) The maximum working pressure for the bolts or studs shall be calculated by the following formula:

$$W.P. = \frac{N \times C}{A}\left\{D - \frac{1.28}{n}\right\}^2 \qquad \text{Eqn. (45)}$$

where, D is the diameter of bolt or stud over threads in inches,

N is the number of bolts or studs securing the part,

n is the number of threads of screws per inch,

C 4,700 for steel bolts or studs of 28 tons/sq. in. minimum ultimate tensile stress where the diameter over thread is less than 3/4 inch,

C 5,100 for steel bolts or studs of 30 tons/sq. in. minimum ultimate tensile stress where the diameter over thread is less than 3/4 inch,

C 5,600 for steel bolts or studs of 35 tons/sq. in. minimum ultimate tensile stress where the diameter over thread is less than 3/4 inch,

C 5,600 for steel bolts or studs of 28 tons/sq. in. minimum ultimate tensile stress where the diameter over thread is not less than 3/4 inch and not greater than 7/8 inch,

C 7,000 for steel bolts or studs of 28 tons/sq. in. minimum ultimate tensile stress where the diameter over thread is greater than 7/8 inch.

When the material is iron, a reduction, of 15 per cent shall be made in the working pressure as calculated by the formula.

A is the area in square inches of the surface supported by the bolts or studs. For jointed flanges the area shall be taken to extend to midway between the pitch line of the bolts and the inner edge of the flange by which the part is secured.

TUBE PLATES

209. Compression of Tube Plates

(a) For firebox or combustion chamber tube plates which are subject to compression due to the pressure on the roof plate, the maximum working pressure shall be—

$$W.P. = \frac{C \times (P-D)t}{L \times P} \qquad \text{Eqn. (46)}$$

where, t is the thickness of the tube plate in 32nds of an inch,

P is the pitch of the tubes in inches, measured, horizontally where the tubes are chain pitched, and diagonally where the tubes are zig-zag pitched, and the diagonal pitch is less than the horizontal,

D is the internal diameter of the plain tubes in inches,

L is the internal length of the firebox or combustion chamber in inches measured at top between the tube plate and firehole plate or back plate, or between tube plates in double ended boilers with combustion chambers common to two opposite furnaces,

C 875 for steel and 437.5 for copper:

Provided that the above formula shall not apply in the case of fireboxes where the girders do not rest on the tube plate, or where the roof plate is stayed direct to the outer shell or to girders supported by the shell.

(b) Where girders rest on the side plates or the roof plate is so formed that the load is carried both by side and end plates, in no case shall be compressive stress on the plates exceed 14,000 lbs. per square inch for steel or 7,000 lbs. per square inch for copper.

210. Parts to be Stayed

(a) The stiffness of tube plates and pitch of stays within the nests of tubes where stay tubes are required and where marginal stay tubes are required in support of blank spaces adjacent to or between the nests shall be determined by flat plate rules under Regulation 195.

(b) Tubes plates within the nests of tubes whether fitted with stays tubes or shall not comply with the requirements of Regulation 211 in regard to thickness and cross-section between tubes.

211. Minimum Thickness and Cross-Section

To provide a secure attachment for plain tube plates the thickness and cross-section of the plate between the tube holes shall be not less than:

Steel tube plate

.125 D +.2	= minimum thickness in inches	Eqn. (47)
.17 +.025	= minimum cross-section in square inches	Eqn. (48)

Copper tube plate

.2 D +.4	= minimum thickness in inches	Eqn. (49)
.527 D –.263	= minimum cross-section in square inches	Eqn. (50)

D is the diameter in inches of the tube at the part of attachment to tube plate.

Where the thickness and cross-section of the tube plates are less than the minimum the appropriate co-efficient in Eqn. (51) shall be reduced in proportion to the deficit.

212. Holding Power of Plain Tubes

(a) Where tube plates are not specially stayed in nests of tubes the working pressure, based on the holding power of the tubes shall not exceed that found by the following formula:

$$W.P. = \frac{C \times D}{A} \qquad \text{Eqn. (51)}$$

where, D = the diameter of tube at the part of attachment of tube plate in inches,

A = the area in square inches of the tube plate supported by each tube which generally may be taken as the product of the horizontal and vertical pitches of the tube less the area of the tube itself,

C = 470 for tubes expanded into parallel holes in steel or iron tube plates,

C = 530 for tubes expanded into taper holes in steel or iron tube plates, for copper tube plates or copper or brass tubes the appropriate co-efficient should be deducted 20 per cent.

(b) In the unstayed tube plates of locotype boilers and in other tube plate in which stay tubes are not required the support afforded by the plain tube shall not be taken to extend beyond the lines enclosing the outer edges of the tubes. Part of flat plate outside this line shall either lie in the plate margin or be separately supported. No account need be taken of the stiffness of tube plate in the nests of tubes when the above conditions are fulfilled.

Ordinarily, the requirements of this clause are applicable only to expanded smoke and water tubes in flat continuous tube plates containing more than one row of tubes. (*See* Reg. 152 for attachment of tubes in Water Tubes Boiler).

213. Tube Plates, other than Ends of Vertical Boilers Forming Parts of Outer Shell

(a) When vertical boilers have a nest or nests of horizontal tubes so that there is direct tension on the tube plates due to the vertical load on the boiler ends, or to their acting as horizontal ties across the shell, the thickness of the tube plates and the spacing of the tubes shall be such that the section of metal taking the load is sufficient to keep the stress within that allowed on the steel plates.

(b) Each alternate tube in the outer vertical rows of tubes shall be a stay tube. The tube plates between the stay tubes shall be of accordance with the rules for tube plates and in addition, considered as part shell, the maximum working pressure:

$$W.P. = \frac{17.24(t-2)\times(P-D)\times S}{R\times P} \qquad \text{Eqn. (52)}$$

where, t is the thickness of the tube plate in 32nds of an inch,

P is the vertical pitch of the tubes in inches,

D is the diameter of the tube holes in inches,

S is the minimum tensile breaking strength of the tube plates in tons per square inch, or whatever is allowed for them,

R is the radial distance of the centre of the outer row of tube hole from the axis of the shell in inches.

214. Curved Tube Plates of Water-Tube Boilers

For tube plates forming part of cylindrical drums the maximum working pressure shall be—

$$W.P. = \frac{33.3(t-4)\times E\times S}{D} \qquad \text{Eqn. (53)}$$

where, t = thickness of tube plate in 32nds of an inch,

E = efficiency of the longitudinal joint or the ligament between the tube holes, whichever is less,

S = minimum tensile stress of the tube plate in tons per sq. in. or whatever is allowed for it,

D = inside diameter of the drum in inches.

215. Efficiency of Ligament

(a) When a shell or drum is drilled for tubes in a line parallel to the axis of the shell or drum, the efficiency of the ligament between the tube holes shall be determined as follows—

(a) When a pitch of the tube holes on every row is equal (as in Fig. 10), the formula is—

$$\frac{p-d}{p} = \text{efficiency of ligament} \qquad \text{Eqn. (54)}$$

where, p = pitch of tube holes, inches,

d = diameter of tube holes, inches,

The pitch of the tube holes shall be measured either on the flat plate before rolling or on the median line after rolling.

Example—Pitch of the tube holes in the drums as shown in Fig. 10 = 5¼ in. diameter of tube = 3¼". Diameter of tube holes = 3 – 9/32".

$$\frac{p-d}{p}=\frac{5.25-3.281}{5.25}=0.375\text{, efficiency of ligament.}$$

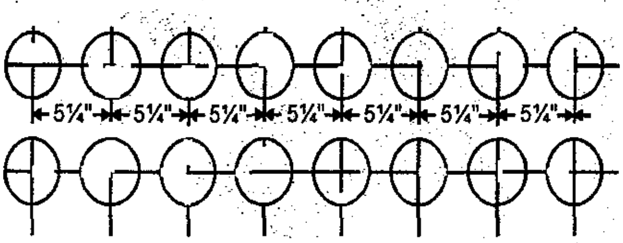


FIG. 10 — EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES EQUAL IN EVERY ROW

(b) When the pitch of tube holes on any one row is unequal (as in Figs. 11 & 12), the formula is—

$$\frac{p-nd}{p}=\text{efficiency of ligament} \qquad \text{Eqn. (55)}$$

where, p = unit length of ligament, inches.

n = number of tube holes in length p.

d = diameter of tube holes, inches.

Example—Spacing shown in Fig. 11 Diameter of tube holes = 3-9/32".

$$\frac{p-nd}{p}=\frac{12-2\times 3.281}{12}=0.453\text{, efficiency of ligament.}$$

Example—Spacing shown in Fig. 12 Diameter of Tube holes = 3-9/32".

$$\frac{p-nd}{p}=\frac{29.25-5\times 3.281}{29.25}=0.439\text{, efficiency of ligament.}$$

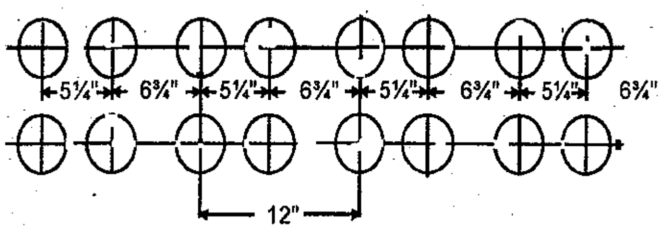


FIG. 11 — EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES UNEQUAL IN EVERY ROW

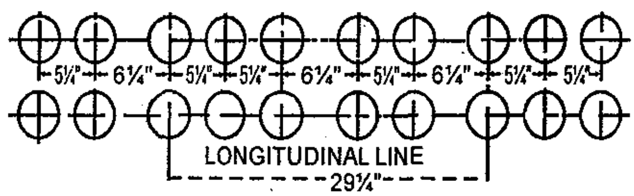


FIG. 12 — EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES VARYING IN SECOND AND THIRD ROW

(c) The strength of those ligaments between the tube holes which are subjected to a longitudinal stress shall be at least one-half the required strength of those ligaments which come between the tube holes which are subjected to a circumferential stress.

(d) (i) When bending stresses due to weight are negligible and the tube holes are arranged along a diagonal line with respect to the longitudinal axis, the efficiency (z) of corresponding ligaments is given in Figure 14, with the ratio b/a on the abscissa and the ratio

$$\frac{2a-d}{2a} \text{ or } \frac{d}{a} \text{ used as a parameter}$$

where, a and b are measured as shown in Figs. 13A and 13B,

d = diameter of the tube holes.

Notes: 1. The dimension should be measured either on the flat plate before rolling or on the medium line after rolling.

2. The data given on Figure 14 are based on the following formulae:

$$Z = \frac{2}{A + B + \sqrt{(A-B)^2 + 4C^2}}$$

$$\text{where, } A = \frac{\cos^2\alpha + 1}{2\left\{1 - \dfrac{d\cos\alpha}{a}\right\}};\ B = \frac{1}{2}\left\{1 - \frac{d\cos\alpha}{a}\right\}\left(\sin^2\alpha + 1\right);\ C = \frac{\sin\alpha\cos\alpha}{\left\{1 - \dfrac{d\cos\alpha}{a}\right\}};$$

$$\cos\alpha = \frac{1}{\sqrt{1 + \dfrac{b^2}{a^2}}};\ \sin\alpha = \frac{1}{\sqrt{1 + \dfrac{a^2}{b^2}}}$$

(α = angle of centre line of cylinder to centre line of diagonal holes).

(ii) The same rule as in paragraph (i) should apply for the case of drilling holes to a regular saw-tooth shown in Figure 13C.

(iii) In the case of a regular staggered spacing of tube holes (*see* Figure 13A), the smallest value of the efficiency z of all the ligaments, longitudinal, circumferential and diagonal, is given in Figure 15 by the ratio P_c/P_L on the abscissa, and the ratio

$$\frac{P_L - d}{P_L} \text{ or } \frac{d}{a} \text{ used as a parameter}$$

where, d = diameter of the tube holes,

$P_C = 2b$ = twice the distance between circumferential rows of holes,

$P_L = 2a$ = twice the distance between axial row of holes.

Note: The dimension P_c should be measured on the flat plate before rolling or on the median line after rolling. The data on Figure 15 are based on the same formulae as shown in Figure 13A (given after Fig. 15).

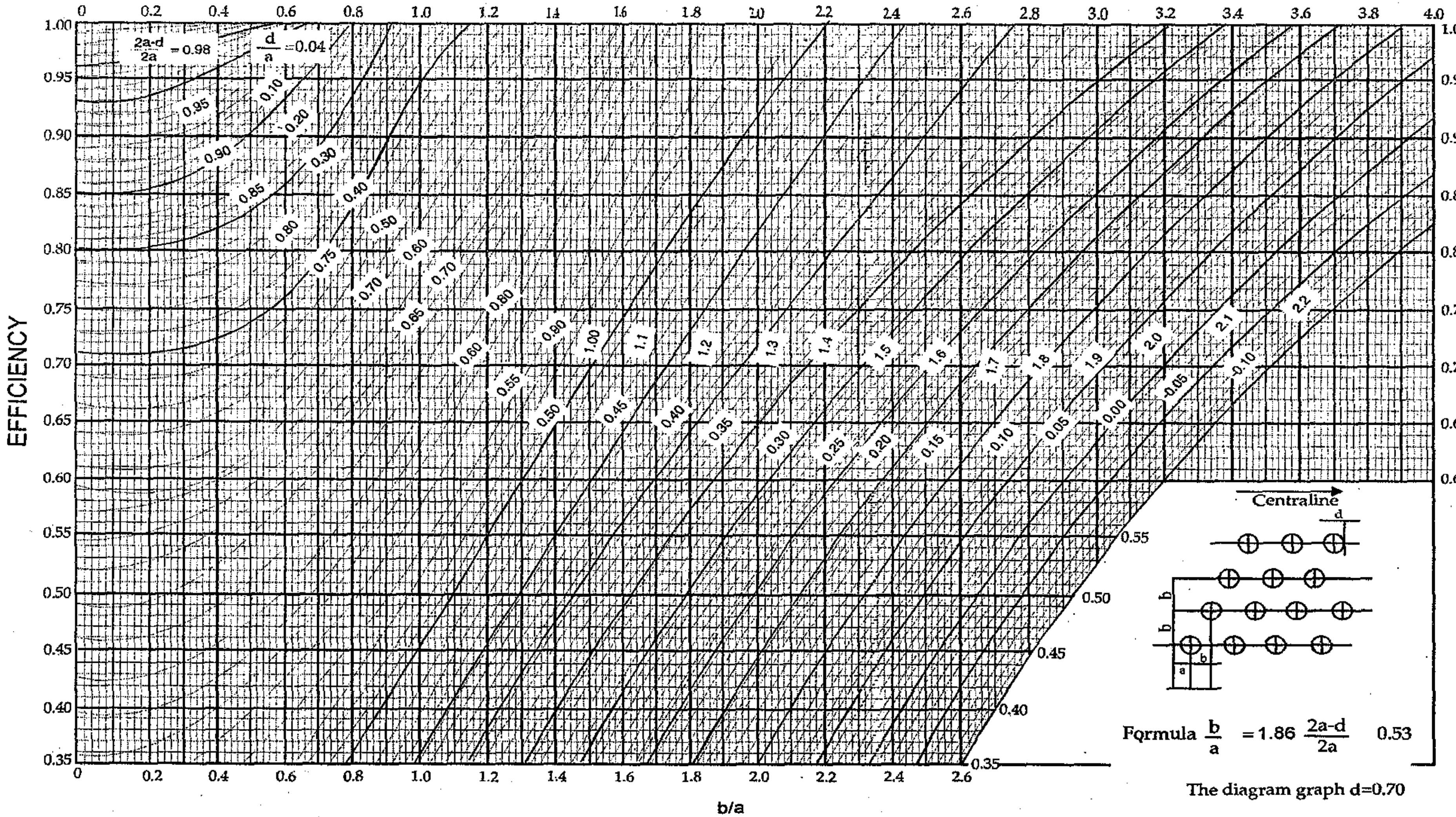


FIG. 14 — EFFICIENCY OF LIGAMENT ALONG A DIAGONAL LINE

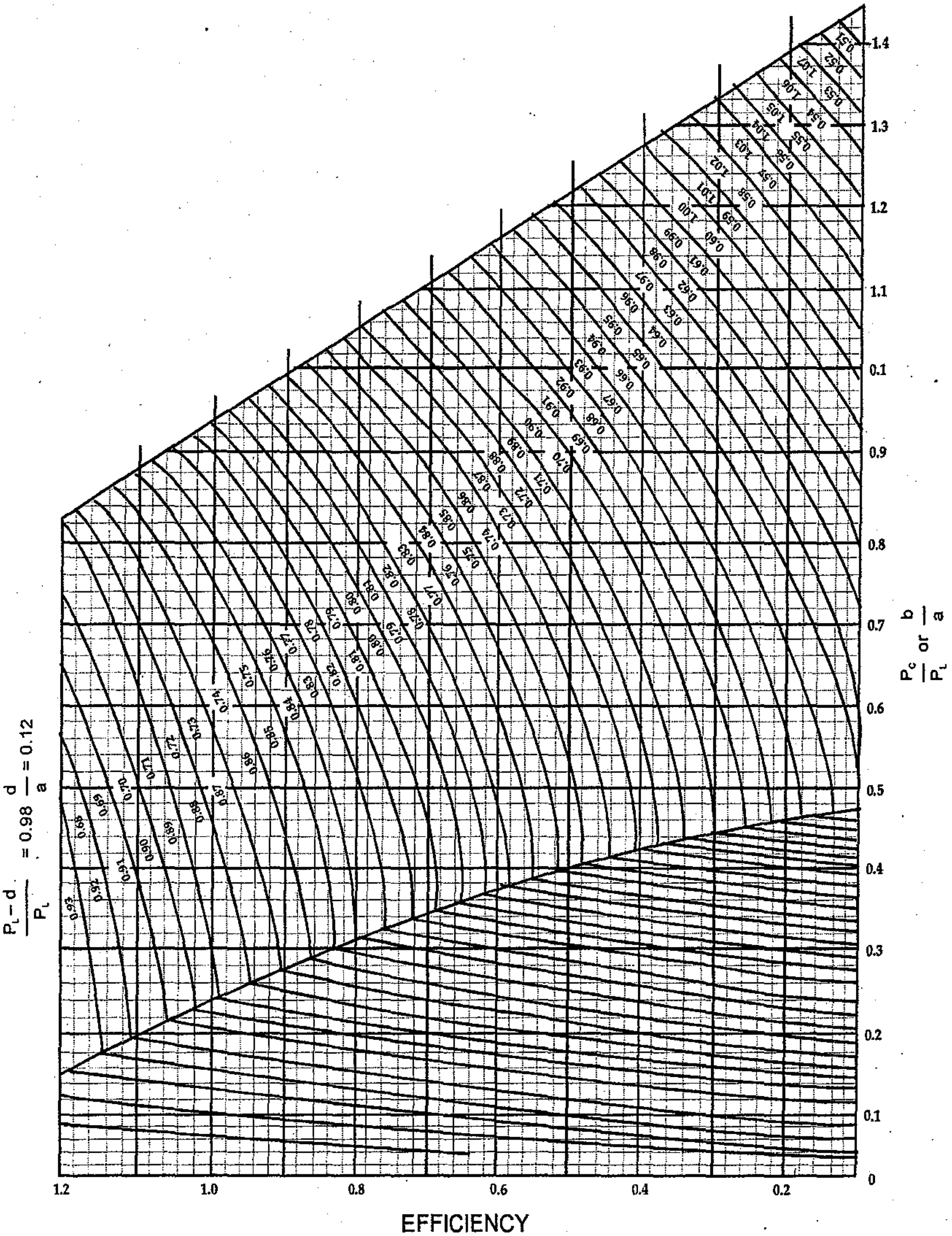


FIG. 15 : EFFICIENCY OF LIGAMENTS BETWEEN HOLES

(e) When holes spaced longitudinally along a drum are not in a straight line, the equivalent longitudinal pitch for each spacing may be used in the application of the above rules. The equivalent pitch is obtained by multiplying the actual longitudinal pitch by the equivalent efficiency obtained from Figure 14 for each spacing.

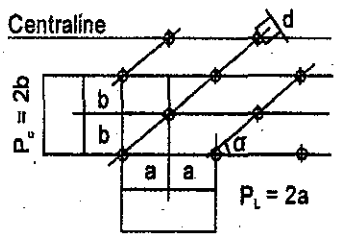


FIG. 13A — REGULAR STAGGERING OF HOLES

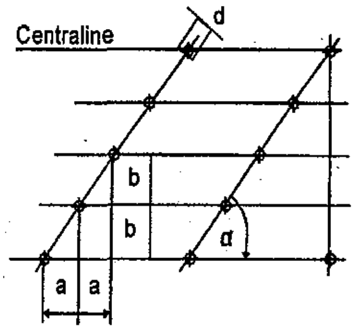


FIG. 13B.— SPACING OF HOLES ON A DIAGONAL LINE

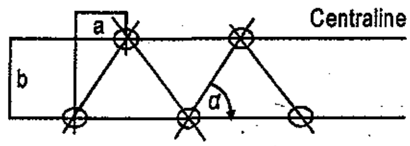


FIG. 13C — REGULAR SAW-TOOTH PATTERN OF HOLES

BOILER AND SUPERHEATER TUBES SUBJECT TO INTERNAL PRESSURE

216.

The maximum working pressure for the tube shall be determined by Equation No. 87 (see Regulation 338).

The minimum thickness of the tubes shall comply with the table given in Regulation 338(b).

HEADERS AND SECTION BOXES OF WATER TUBE BOILERS

217.

See Eqn. (88), Reg. (340).

BOILER TUBES (SMOKE) SUBJECT TO EXTERNAL PRESSURE

218. Steel and Wrought Iron Tubes

(a) The maximum working pressure for the tubes shall be

$$W.P. = \frac{100(t-6)}{D} \qquad \text{Eqn. (56)}$$

where, t = the thickness of the tubes in 100th of an inch,

D = the external diameter of the tubes in inches.

(b) No tube shall be less than 12 S.W.G. (.104") thick.

219. Brass and Copper Tubes

The thickness of tapered brass and copper smoke tubes for locomotive boilers shall, in the case of tubes of an external diameter of 1½ to 1-7/8 inches inclusive, be not less than 12 S.W.G. (.104 inch) at the smoke-box end and 10 S.W.G. (.128 inch) at the other end in the case of tubes of an external diameter of 2 to 2-3/8 inches inclusive, the thickness, at the smoke-box end shall not be less than 11 S.W.G. (.116 inch) and at the other end not less than 9 S.W.G. (.144 inch).

FURNACES

220. Plain Furnaces of Horizontal Boilers

For plain furnaces or furnaces strengthened by Adamson or other joints or stiffeners of sufficient strength and for the semi-cylindrical tops of fireboxes and bottom of combustion chambers where the sides are securely stayed, the working pressure shall not exceed the smaller of the values obtained from the following formulae :

$$W.P. = \frac{C}{D} \times \frac{(t-1)^2}{(L+24)} \qquad \text{Eqn. (57)}$$

$$W.P. = \frac{C_1}{D} \times [10(t-1)-L] \qquad \text{Eqn. (58)}$$

where, D = the external diameter of the furnace of chamber top or bottom in inches,

t = the thickness of the furnace plate in 32nds of an inch,

L = the length of the furnace or other part in inches measured between points of substantial support, i.e., centres of rows of rivets in end seams of commencement of curvature of flange, whichever is applicable,

C = 1450 where the longitudinal seams of steel furnaces are welded and 1300 where they are riveted,

C = 725 where the longitudinal seams of circular copper fireboxes or furnaces are fitted with double butt straps and 650 where they are lapped,

C = 50 where the longitudinal seams of steel furnaces are welded and 45 where they are riveted,

C_1 = 25 where the longitudinal seams of circular copper fireboxes or furnaces are fitted with double butt straps and 22.5 where they are lapped.

221. Corrugated Furnaces of Horizontal Boilers

The maximum working pressure to be allowed on corrugated furnaces shall be determined by the following formula :

$$W.P. = \frac{C}{D}(t-1) \qquad \text{Eqn. (59)}$$

where, D = is the least external diameter in inches measured at the bottom of the corrugations on the water side,

t = is the thickness of the furnace plate in 32nds of an inch measured at the bottom of the corrugation or chamber,

C = 480 for the Fox, Morrison, Deighton, Purves and other similar furnaces and 510 for the leeds Forge Bulb Suspension Furnace.

222. Plain Furnaces of Vertical Boilers

The same formulae as for the plain furnaces of horizontal boilers shall be used, but where tl furnaces are tapered the diameter to be taken for calculation purposes shall be the mean of that at tl top and of that at the bottom where it meets the substantial support from flange or ring. The leng' f the same purpose shall be the distance from the centre of the row of rivets connecting the crown ai the body of the furnace to the substantial support at the bottom of the furnace, or to a row of screwi stays connecting the furnace to the shell, provided that the pitch of stays at the furnace doe r exceed 14 times the thickness of the furnace plate when the stays are riveted at their ends or 16 tim when the stays are fitted with nuts. Such screwed stays shall be in diameter over the threads not le than twice the thickness of the furnace plate and in no case less than 3/4" diameter [*see* Reg. 135(u)]

223. Hemispherical Furnaces of Vertical Boilers

When furnaces hemispherical in form and subject to pressure on the convex side and are withc support from stays of any kind, the maximum working pressure shall be :

$$W.P. = \frac{275(t-1)}{R} \qquad \text{Eqn. (6}$$

where, t is the thickness of the top plate in 32nds of an inch,

R is the outer radius of curvature of the furnace in inches.

224. Corrugated Fireboxes of Vertical Boilers

For the semi-spirally corrugated fireboxes of "Sentinel" standard motor wagon boilers the wo i pressure shall be determined by the following formula :

$$W.P. = \frac{C(t-1)}{D} \qquad \text{Eqn. (6}$$

where, t = the thickness of the firebox plate in 32nds of an inch,

D = the mean of the external diameter of firebox measured over the plain part at ea end at commencement of curvature of flange,

C = 390.

225. Foundations of Vertical Boilers Furnaces

Where circular furnaces, or fireboxes of vertical boilers are not connected to the shell crown uptake tubes, smoke tube or bolt stays and the whole load on the firebox vertically is borne by t bottom part of the firebox where it is connected to the shell the working pressure for the part, if fi b is joggled out to meet the shell or if an ogee ring is fitted, shall not exceed that found by the followi formula :

$$W.P. = \frac{140(t-1)^2}{D(D-D_1)} \qquad \text{Eqn. (6}$$

where, t = the thickness of the joggled firebox plate or ogee ring in 32nds of an inch,

D = the inside diameter of the boiler shell in inches,

D_1 = the outside diameter of the joggled firebox at the commencement of curvature above joggled part or the outside diameter of the firebox where it joins the ogee ring.

226. Foundations of Locotype Boiler Fireboxes

Where the firebox roof in locotype boilers is not stayed direct to the external casing crown or to girders carried by the casing or is not connected to the casing, by slings in accordance with Regulation 229(c) and the whole load on the firebox vertically is borne by the bottom parts of the firebox where connected to the external casing, the working pressure for the parts, if plates are joggled out to meet the casing or if an ogee ring if fitted, shall not exceed that found by the following formula :

$$W.P. = \frac{70(t-1)^2 \times (L+W)}{L \times W(W-W_1)} \qquad \text{Eqn. (63)}$$

where, t = is the thickness of joggled firebox side plates or fire hole plate (whichever is less), or ogee ring in 32nds of an inch,

L = is the length of firebox casing in inches measured between the water sides of front end plate and saddle plate at the foundation seam,

W = is the width of firebox casing in inches measured between the water sides of casing side plates at the foundation seam,

W_1 = is the width of firebox in inches measured between the water sides of firebox side plates at the commencement of curvature above joggled part or where it joins the ogee ring.

Where only a comparatively narrow strip of the firebox roof is stayed directly to the casing crown the area so stayed shall be deducted from the area represented by $L \times W$ in the bottom line of the formula thus $(L \times W - A)(W - W_1)$ and so used in Equation (63) in determining the working pressure for the parts, "A" being the area in square inches of roof supported by the casing crown.

227. Cross Tubes

The working pressure of the tubes shall be determined by the following formula :

$$W.P. = \frac{200(t-7)}{D} \qquad \text{Eqn. (64)}$$

where, W.P. = working pressure in lbs. per sq. inch,

t = minimum thickness in 32nds of an inch,

D = the internal diameter in inches of the cross tube.

228. Uptakes of Vertical Boilers

The working pressure for uptake tube of vertical boilers shall be determined by Eqns. 57 and 58 but only half the least pressure so found is to be allowed for uptake tubes.

SUPPORTS FOR COMBUSTION CHAMBER AND FIREBOX CROWN

229. Girder Stays for Firebox Crowns

(a) For girders supporting crown plates of rectangular fireboxes, where the ends of the girders are supported by the vertical end or side plates, their proportions shall be calculated from the following formula :

$$W.P. = \frac{CSTD^2}{L^2 Y} \qquad \text{Eqn. (65)}$$

where, W.P. = working pressure in lb. per sq. inch,

S = minimum tensile stress of the material in tons per sq. inch,

T = total thickness of the stay in thirty-seconds of an inch,

D = depth of the girder stay in inches,

L = length of girder stay in inches measured between the inside of the tube plate and the firehole plate, or between the inside of the side plates, according to the method of support,

Y = pitch of girder stays in inches,

C = 22 for steel plates or steel forgings, 19 for steel castings.

(b) Where girders are supported in any other way than by the end or side plates of the firebox or combustion chamber the calculations for determining the working pressure shall be made in accordance with the actual conditions of support.

In such cases the length of the strip of firebox or combustion chamber top plate to be supported by the girder shell, subject to the limit imposed on the distance of the nearest stay, be taken as equal to the product of the number of bolts carried by the girder into the pitch of the bolts. A maximum nominal stress of 14,000 lbs. per square inch on girder section shall be allowed for steel.

(c) Slings, links pins, rivets, and connections to shell of slung girders shall be sufficient to carry the whole load that would otherwise be carried by the girder, and each girder must be equally slung or supported. For stresses allowed on the sections, *see* Regulation 203.

(d) In the case of girders supported at the ends only by angle bars riveted to casing crown, the length L may, when the girder extends over the full breadth of the angle face, be taken as the distance between the centres of the angle faces. When this distance does not exceed that of L in the formula, the pressure shall be determined in the ordinary way. The supporting angles and rivets shall be of sufficient section for the intended purpose. For stresses allowed on the sections, *see* Regulation 203.

PATENT FIREBOX ROOFS OF LOCOTYPE BOILERS

230. Marshall Type

For Messrs Marshall Sons and Company's patent stayless roof for fireboxes of locotype boilers made of steel in which the centre lines of the corrugations meet the centre lines of the end riveted seams at points not farther distance from the side plates than one-half the inner radius of curvature of the corner formed by the roof and side plates, in order to ensure that the thickness and height of the pressed diagonal corrugations of the chamber are satisfactory, the working pressure shall not exceed the smaller of the values obtained from the following formulae:

$$W.P. = \frac{25000(t-1)\times H^2}{W\times L\times\sqrt{(W^2+L^2)}} \qquad \text{Eqn. (66)}$$

$$W.P. = \frac{55(t-1)^2\times\left[W+\sqrt{(W^2\times L^2}\right]^2}{W^2\times L^2} \qquad \text{Eqn. (67)}$$

where, t is the thickness of the roof plate in 32nds of an inch,

H is the height of the corrugation at its highest part measured perpendicularly on one side of the plate in inches,

W is the width of the roof plate between the flat of side plates at top less the inner radius of curvature of corner or roof and side plate in inches, i.e., W + radius = internal width of firebox at top,

L is the length of the roof plate between centre lines of rivets in inches.

231. Garret Type

For Messrs Richard Garret and Son's corrugated stayless roof for fireboxes of locotype boilers made of steel in which the side corrugations are parts of true circles and the radius of the middle corrugation is not more than about ¼th of the radius of the outer corrugations and the corrugations are cambered longitudinally, the working pressure shall not exceed the smaller of the values obtained from the following formulae :

$$W.P. = \frac{C}{R}\times\frac{(t-1)^2}{(L+24)} \qquad \text{Eqn. (68)}$$

$$W.P. = \frac{C_1}{R}\times\left[10(t-1)-L\right] \qquad \text{Eqn. (69)}$$

where, t = is the thickness of the corrugated plate in 32nds of an inch,

L = is the length of the roof plate between centre lines of rivets in inches,

R = is the external radius of the side corrugations at the middle of the length in inches,

C = 363 where the roof and side plates are in one piece and 325 when they are riveted,

C_1 = 12.5 where the roof and side plates are in one piece and 11.25 where they are riveted.

232. Fowler Type

(a) For Messrs John Fowler and Company's (Leeds) corrugated roof for fireboxes of locotype boilers made of steel in which the crown of the roof is transversely curved and corrugated in the style of Fox's corrugated furnace and the roof plate, if not solid with the side plates of the firebox, is securely riveted thereto and to the flanges of the tube plate and firehole plate and there is a row of suitably sized and spaced screw stays below the commencement of corrugations on each side attaching the roof plate to the external casing, when the conditions hereunder are complied with, the working pressure shall not exceed the smaller of the values obtained from the following formulae :

$$W.P. = \frac{C(t-3)}{R} \qquad \text{Eqn. (70)}$$

$$W.P. = \frac{C_1(t_1-1)}{W} \qquad \text{Eqn. (71)}$$

where, t = is the thickness of roof plate before corrugations are formed, in 32nds of an inch,

t_1 = is the thickness of side plates of firebox to which roof plate is attached, in 32nds of an inch,

R = the radius of transverse curvature or camber of middle part of corrugation measured from the bottom of corrugation on water side in inches,

W = the width of firebox in inches measured over water sides of side plates at the seams attaching them to roof plate,

C = 240,

C_1 = 875.

(b) The corrugations measured from top to bottom on one side, shall not be less than three times the thickness of the finished plate in depth and not more than 12 times the thickness of the finished plate apart.

(c) The inner radius of corner at sides where corrugations merge into the flat sides shall be not less than 4 times the thickness of the finished plate.

(d) The length of the plain parts at ends of roof between the centre lines of riveted seams and commencement of curvature of corrugations shall not exceed that allowed for flat plate margins under Regulation 200.

CHAPTER V

FUSION WELDED AND SEAMLESS FORGED DRUMS FOR WATER TUBE BOILERS AND SUPERHEATERS

233. General Requirements

Where applicable the general terms of Chapter I relating to Certificates from Makers, Inspecting Authorities, etc., and of Chapter III concerning construction should be followed.

MATERIALS OF CONSTRUCTION

234. Materials for Fusion Welded Boiler Drums

(a) The requirements of Chapter II, so far as they relate to plates, shall apply, excepting that the chemical composition, tensile strength and elongation of the material used shall conform to the following, as may be applicable to the quality of steels concerned—

CHEMICAL COMPOSITION (LADLE ANALYSIS)

Carbon steels

*Carbon	0.25% maximum
Silicon	0.35% maximum
Manganese	0.40 to 0.90%
Phosphorus	0.05% maximum
Sulphur	0.05% maximum

Manganese Steels

Carbon	0.23% maximum
Silicon	0.15 to 0.60%
Manganese	0.90 to 1.40%
Phosphorus	0.05% maximum
Sulphur	0.05% maximum

Molybdenum Steels

Carbon	0.21% maximum
Silicon	0.15 to 0.35%
Manganese	0.50 to 0.90%
Phosphorus	0.05% maximum
Sulphur	0.05% maximum
Molybdenum	0.25 to 0.60%

* A carbon content not exceeding 0.35% may be permitted, subject to the approval of the Inspecting Authority.

Chromium-Molybdenum Steels

Carbon	0.21% maximum
Silicon	0.15 to 0.35%
Manganese	0.40 to 0.80%
Phosphorus	0.04% maximum
Sulphur	0.04% maximum
Chromium	0.07 to 1.15%
Molybdenum	0.40 to 0.65%

Mechanical Properties at 20°C (68°F)

Kind of Steel	*Tensile strength minimum*		**elongation on $L_o = 5d_o$ or $L_o = 5.65\sqrt{A_o}$ % minimum*
	Kg/mm²	*Tons/sq. inch*	
1	*2*	*3*	*4*
Carbon Steels:			
(1)	35	22	22
(2)	38.5	24.5	21
(3)	41	26	20
(4)	44	28	19
(5)	47	30	18
Manganese Steels:			
(1)	47	30	18
(2)	52	33	16
Molybdenum Steels:	44	28	19
Chromium-Molybdenum Steels:	42	27	20

***Note:** L_o = original gauge length,

d_o = original diameter, and

A_o = original area of cross-section.

Note: A range of not more than 20 per cent of the minimum tensile strength shall be permitted in each class of material.

(b) Plates over 2" in thickness before being fabricated, shall be uniformly heat treated to produce grain refinement. Heat treatment involving quenching in a liquid medium is not permitted.

SEAMLESS FORGED DRUMS

235. Manufacture

(a) Carbon Steel for seamless Forged Drums shall be made by the Open Hearth or electrical furnace or basic oxygen process or any other process which gives steel having equivalent properties.

(b) Forging which may have integral ends, ends closed by means of dished plates, open ends for multi-joints drums or any combination of these shall be made from solid cast ingot which is punched, bored or trepanned, or from a hollow cast ingot and shall comply entirely with the relevant requirements of Chapter II.

236. Chemical Analysis

The steel shall not contain more than 0.050 per cent of sulphur or of phosphorus.

237. Freedom from Defects

The drum shall be free from surface defects and shall be machined to the prescribed dimensions.

Defects in forgings shall not be repaired without the previous sanction of the Inspecting Officer.

Where not machined, the forgings shall be workman like surfaces as normally obtained by hot working. Provided that the minimum specified thickness is maintained, minor surface defects may be admitted and other defects removed by mechanical means so as to achieve a smooth surface. Surface defects may be prepared, by welding only, with the approval of the Inspecting Authority provided that the drum is stressed relieved after welding, wherever necessary.

238. Heat Treatment

Each drum shall be efficiently heat treated:

(a) At various stages during manufacture, as required.

(b) On completion of the forging process but prior to the hydraulic test.

239. Mechanical Tests

Material shall comply with the mechanical tests herein specified.

Sufficient material shall be left on the open end or ends of each forging to enable tangential test pieces to be taken. These tests shall consist of not less than one tensile and one bend test from each open end. In the case of drums with open ends the test material shall not be parted off before heat treatment. If the drums are closed in at the ends the test rings shall be parted off immediately before this operation; subsequently the test rings and the forging shall be similarly, and simultaneously heat treated in the same furnace.

240. Selection of Test Pieces

(a) All test pieces shall be selected by the Inspecting Officer and shall be tested in his presence and he shall satisfy himself that the conditions herein prescribed are fulfilled.

(b) **Tensile Tests Pieces**—The tensile strength and percentage elongation shall be determined from round test pieces and gauge lengths of $5d_o$.

(c) **Tensile Test**—

(i) The tensile strength and percentage elongation shall be in accordance with the requirements of Regulations 9 and 16.

(ii) The upper yield point at room temperature shall be not less than 50% of the specified minimum tensile strength at room temperature. The minimum values of the stress at proof limit 0.2% at elevated temperature (Et) of the material may be calculated by multiplying the minimum specified tensile strength at room temperature (R20) by the value of the ratio (Et/R20) given in the table under Regulation 16.

(iii) The breaking elongation in percentage shall be not less than

$$\frac{100 - Rm}{2.2}$$

where, Rm = tensile strength at room temperature, in kgf/mm^2,

100 = quality index,

2.2 = a constant which is valid only when $L_o - 5d_o$,

where, L_o = gauge length,

d_o = original diameter of round test piece.

(d) **Bend Test Pieces**—Bend test pieces shall be of rectangular section 1 inch wide by 3/4 inch thick. The edges shall be rounded to a radius of 1/16 inch. The test pieces shall be bent over the thinner section.

(e) **Bend Tests**—The test pieces shall, when cold, be capable of being bent without fracture, through an angle of 180°, the internal radius of the bend being not greater than that specified in table below:

	Internal radius of bend
Upto 32	3/8
Above 32 and upto 36	½
Above 36 and upto 38	¾

Bend tests may be made by pressure or, by blows.

241. Additional Tests before Rejection

Should either a tensile or bend test fails, two further tests of the type which failed may be made on test pieces cut from the same test rings. If the results obtained from these re-tests are staisfactory, the drum shall be accepted, provided that in other respects it fulfils the conditions of this Chapter. If these re-tests do not give satisfactory results the drum represented may be re-heat-treated together with the remainder of the test rings, and presented for further testings.

In all cases where final re-tests do not give statisfactory results, the drum represented by the test pieces which fail shall be rejected.

242. Discard

Sufficient discard shall be made from the top and bottom of each ingot to ensure soundness in the portion for forging.

243. Forging

The forging shall be made from a solid cast ingot, punched, bored or trepanned, or alternatively, hollow, cast ingots may be used. The resultant wall in the case of the solid cast ingot, or the wall of hollow ingot as cast shall be reduced in thickness by at least one-half in the process of forging.

TUBES, PIPES IN BOILERS, HEADERS AND STEEL CASTINGS

244. Tubes

(a) Tubes shall be of cold drawn weldless or hot finished weldless or electric-resistance-welded steel and shall comply with Regulations 36 to 63.

(b) **Pipes**—Pipes forming an integral part of the boiler unit shall comply with the provisions of Chapter VIII.

Tests on butt welds on pipes shall be required under Regulation 151(h).

245. Headers

Headers and similar pressure parts shall be of forged steel, seamless steel pipes or of cast steel and shall comply with the relevant provisions of Chapter II, in all other respects excepting the chemical compositions tensile strength and elongation of the respective materials, which shall comply with the following, as may be applicable:

CHEMICAL COMPOSITION (LADLE ANALYSIS)

***Carbon Steels**

Carbon	0.25% maximum
Silicon	0.35% maximum
Manganese	0.30% minimum
Phosphorus	0.05% maximum
Sulphur	0.05% maximum

* A carbon content not exceeding 0.35% may be permitted, subject to the approval of the Inspecting Authority.

Manganese Steels

Carbon	0.23% maximum
Silicon	0.20 to 0.60%
Manganese	0.90 to 1.30%
Phosphorus	0.05% maximum
Sulphur	0.05% maximum

Molybdenum Steels

Carbon	0.20% maximum
Silicon	0.10 to 0.45%
Manganese	0.35 to 0.80%
Phosphorus	0.05% maximum
Sulphur	0.05% maximum
Molybdenum	0.25 to 0.65%

Chromium-Molybdenum Steels

(1)	Carbon	0.18% maximum
	Silicon	0.10 to 0.60%
	Manganese	0.35 to 0.70%
	Phosphorus	0.05% maximum
	Sulphur	0.05% maximum
	Chromium	0.7 to 1.25%
	Molybdenum	0.4 to 0.7%
(2)	Carbon	0.15% maximum
	Silicon	0.10 to 0.50%
	Manganese	0.35 to 0.70%
	Phosphorus	0.04% maximum
	Sulphur	0.04% maximum
	Chromium	2.0 to 2.5%
	Molybdenum	0.9 to 1.2%

Mechanical Properties at 20°C (68°F)

Kind of Steel	*Tensile strength minimum*		**elongation on $L_o = 5d_o$ or $L_o = 5.65\sqrt{A_o}$ % minimum*
	Kg/mm^2	*Tons/sq. inch*	
1	*2*	*3*	*4*
Carbon Steels:			
(1)	31.5	20	25
(2)	45	28	21
Manganese Steels:			
(1)	47	30	23
(2)	52	33	19
Molybdenum Steels:	37.5	24	22
Chromium-Molybdenum Steels:			
(1)	39	25	20
(2)	39	25	20

***Note:** L_o = original gauge length;

D_o = original diameter; and

A_o = original area of cross-section.

246. Steel Castings

Steel castings for pressure parts shall comply with Regulations 73 to 80 (28 to 35 tons per sq. inch).

FUSION WELDED DRUMS

247. Definition of Term 'Fusion Weld'

The term 'Fusion Weld' is, for the purpose of this Chapter, applicable to all welded joints made by the metal arc process with covered electrodes or other electric arc process in which the arc stream and the deposited weld metal are shielded from atmospheric contamination.

It is intended that this Chapter shall apply to the single run or heavy run welding process and that welded boiler drums manufactured by that process shall conform with all Regulations of this Chapter, excepting those in which divergence is necessary solely because of special requirements essential for the most efficient utilisation of that process. Thus all Regulations governing quality of material, construction workmanship and testing (both non-destructive and otherwise) are applicable.

When welded drums ordered to this Chapter are made by the single run or heavy run process it will be understood that Regulations 252 and 267 do not apply in their entirety.

248. Equipment of Workshop

(a) The welding plant and equipment are to be of good quality and maintained in an efficient working condition. The welding apparatus is to be installed under cover and arranged so that the welding work may be carried out in positions free from draughts and adverse weather conditions. The procedure is to be such that there is regular and systematic supervision of the welding works, and the welding operators are to be subjected by the works officials to periodic tests for quality of workmanship. Records of these tests are to be kept and are to be available to the Inspecting Officers for scrutiny.

(b) The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests micro-examination of specimens and x-ray examination of the actual joints in pressure vessels. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control, but as an alternative arrangements may be made whereby the drums can be heat-treated elsewhere.

249. Constructional Details and Preparation for Welding

The manufacturer shall supply the Inspecting Authority with a fully dimensioned sectional drawing showing in full details the construction of the drum(s) for approval before putting the work in hand.

Fully dimensioned drawings of the proposed welds preparations of the main seams drawn to a scale which clearly shows all the relevant details shall be furnished.

Sketches showing details of the welds preparations for the attachment of the stand pipes, branch pipes and seating and their locations relative to the longitudinal and circumferential seams and to other openings shall be furnished.

250. Preparation of Plates

The edges of all plates shall be prepared and surfaced by machining or chipping or flame cutting.

Before welding is commenced, the grooves shall be thoroughly cleaned of rust, oil or other foreign matter.

Before welding of the joint is commenced (apart from tack welding) it shall be ascertained that the chamfered edges are in alignment and that the defects in alignment between the surface of the plates do not exceed the limits indicated in the following table:

ALIGNMENT TOLERANCE OF SECTIONS TO BE BUTT-WELDED

Section Thickness, mm	*Direction of joints in cylindrical shells*	
	Longitudinal	*Circumferential*
Upto 13 mm incl.	1/4 t	1/4 t
Over 13 mm upto 19 mm	3 mm	1/4 t

Contd...

Contd...

Over 19 mm and upto 38	3 mm	5 mm
Over 38 mm and upto 51 mm	3 mm	3 mm
Over 51 mm	Lessor of 1/16 t or 9 mm	Lessor of 1/8 t or 19 mm

If plate edges of unequal thickness are abutted and the difference between the surfaces exceeds the limit mentioned as above on either side, the thicker plate shall be thinned to a smooth taper for a distance not less than 4 times the offset including, if so desired, the width of the weld. In longitudinal joints, the middle line of the plates shall be in alignment within 10 per cent of the thickness of the thicker plate with a maximum of 3 mm (1/8 inch).

251. Cylindrical Shell of Drums

Each drum shell plate shall be of cylindrical form to the extreme edges of the plate. The bending shall be done entirely by machine and local heating or hammering is prohibited. Where the plates are bent to an internal diameter less than 20 times the plate thickness, they shall be efficiently heat-treated after bending to relieve internal stresses unless during the last stages of bending they have been uniformly heated throughout.

252. Method of Making Welded Joints

Provided the requisite quality of welding is achieved, the seams may by welded from both sides of the plate or from one side of the plate with or without a backing strip. If a backing strip is used, it shall be removed and the surface so exposed shall be dressed.

Additional runs of metal shall be deposited at the surface of the welded seams so that the welded metal at the level of the surfaces of the plate is refined as far as possible. The surfaces of the weld shall thereafter be machined or ground so as to provide smooth contours and to be flush with the respective surfaces of the plate. There shall be no undercutting at the junctions.

When affixing standpipes, branch pipes, seatings, compensating plates, doubling plates or manhole frames, not less than two runs of metal shall be deposited at each weld. Each run of weld shall be thoroughly cleaned and freed from slag that may adversely affect the quality of the succeeding runs. Welds shall be marked permanently to facilitate their location.

253. Types of Welded Joints

The longitudinal circumferential seams shall be made with butt joints of the single or double U or Vee type.

254. Number of Joints

Where, having regard to the approved design, the dimensions are such that the shell cannot be made from a single plate, it shall be made with the minimum number of joints and the longitudinal seams in successive rings shall not fall in line, except where the rings of the drum are in two halves of unequal thickness.

255. Position of the Tube Holes

Tube holes in welded seams should be avoided. Where they are unavoidable they may be machined through welded seams after these seams have been radiographed, and stress relieved. The efficiency of the ligament in the direction of weld shall be multiplied by a weld factor not exceeding 0.95 except where the distance from the edge of the tube hole to the edge of the weld is greater than 13 mm (½"). The edge of the weld shall be considered to be the edge of the weld groove as machined in the plate prior to welding.

Notwithstanding anything contained in this regulation, efficiency of the ligament in the direction of weld shall not be multiplied by a weld factor 0.95 where 100 per cent radiography of weld joint is done.

256.

(a) **Circulatory of Drums**—The difference between the internal diameter of the drum measured at any cross-section and the nominal internal diameter of the drum should not exceed 1 per cent of the latter.

Any departure of profile measured on the outside of the drum with a gauge of the designed form of the exterior of the drum and of length equal to a quarter of the internal diameter, shall not exceed the percentage given in table below:

Nominal internal diameter of drum	*Percentage of nominal Internal diameter*
Upto and including 36 inches	0.375
Over 36 inches upto and including 45 inches	0.35
Over 45 inches	0.3

Flats at the welded seams shall not be permitted and any local departure from circularity shall be gradual.

(b) **Tolerance**—

(i) The deviation from circularity in any section shall, in the case of normalised drums, not exceed 2% and in case of stress relieved drum 1%. The deviation from a straight line shall not exceed 0.3% of the cylindrical length.

(ii) In order to determine the deviation from circularity of the drums the maximum and minimum internal diameter at one cross-section shall be measured. From these measured values the percentage deviation from circularity shall be calculated according to the following formula:

$$C = \frac{2(D_{max} - d_{min})}{(d_{max} + d_{min})} \times 100$$

where, C = percentage deviation from circularity of the drums,

d = internal diameter at one cross-section.

In order to determine the deviation from a straight line, a stretched line should be placed longitudinally against the sides and its largest distance from the shell line concerned shall be measured. From this distance, and from the cylindrical shell, the deviation from the straight line shall be calculated.

257. Mechanical Test and Test Plates for Fusion Welded Seams

(a) Fusion welded joints shall comply with the mechanical tests herein specified.

Not less than one set of test plates shall be provided to represent the welding of each longitudinal seam.

The test plates may by attached at each end of the longitudinal seam or the set may be located at one end only.

(b) Where the drum shell is formed in two or more courses, the staggered longitudinal seam shall be regarded as a continuous longitudinal seam provided the welding be effected in one reasonably continuous operation and by the same operator or operators.

(c) Where there are circumferential seams only or where the method of welding the circumferential seam differs from that employed for the longitudinal seams, the method of providing the test plates shall be decided by the Inspecting Authority.

(d) The test plates shall be of a size sufficient for the preparation of the test pieces specified in Regulation 258(a) and for any repeat test pieces that may be required. The material for each set of test plates shall be cut from the respective plate or plates forming the appropriate seam, and before being cut shall be stamped by the Inspecting Officer.

(e) When the analysis of the plates is approved by the Inspecting Authority and is considered sufficiently similar, the test plates may be cut from one drum shell plate only.

(f) In the case of insufficient material being available on the shell plate to permit the cutting of test pieces, these shall be acceptable if they are made from another plate provided it is made from the same cast.

(g) The weld groove in the test plates shall be similar to that adopted for the corresponding edges of the longitudinal seam, and the respective fusion faces shall be in continuous alignment. The test plates shall be reinforced or supported during welding in order to prevent under warping.

The weld metal in the plates and the seam shall be of the same grade of electrode and shall be deposited continuously at the same operation.

(h) The weld in any test plate shall not be repaired unless agreed by the Inspecting Authority and the repairs shall be done in such a manner as will ensure that the repaired seam in the test plate is still representative of the material in the main seam.

(i) Where it is desired to strengthen test plates which have warped during welding they may be strengthened at a temperature below the temperature of heat treatment of the drum to which they belong. Strengthening shall take place before final heat treatment.

(j) For heat treatment, *see* Regulation 267.

(k) If any defects in the weld metal of a test plate are revealed by radiographical examination, the position of these shall be clearly marked on the plate and test pieces shall be selected from such parts of the test plates as may be decided by the Inspecting Authority.

258. Selection of Test Pieces*

(a) From the test plate or plates on each longitudinal seam, test pieces shall be selected for the following tests, the specimens being cut out as shown in Figs. 16 and 17 and stamped by the Inspecting Officer for identification:

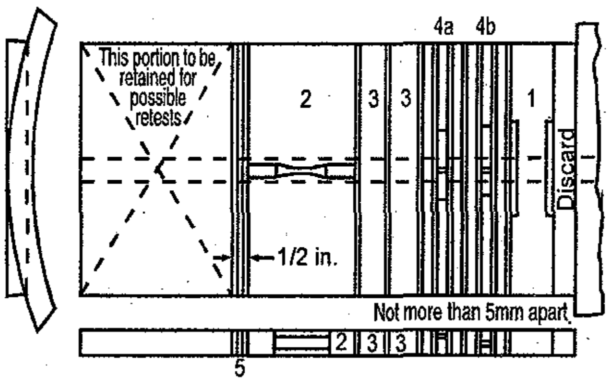
(i) One tensile test specimen for the welded joint.

(ii) One all-weld metal tensile test specimen.

(iii) Two bend test specimens.

(iv) Three notched-bar impact test specimens.

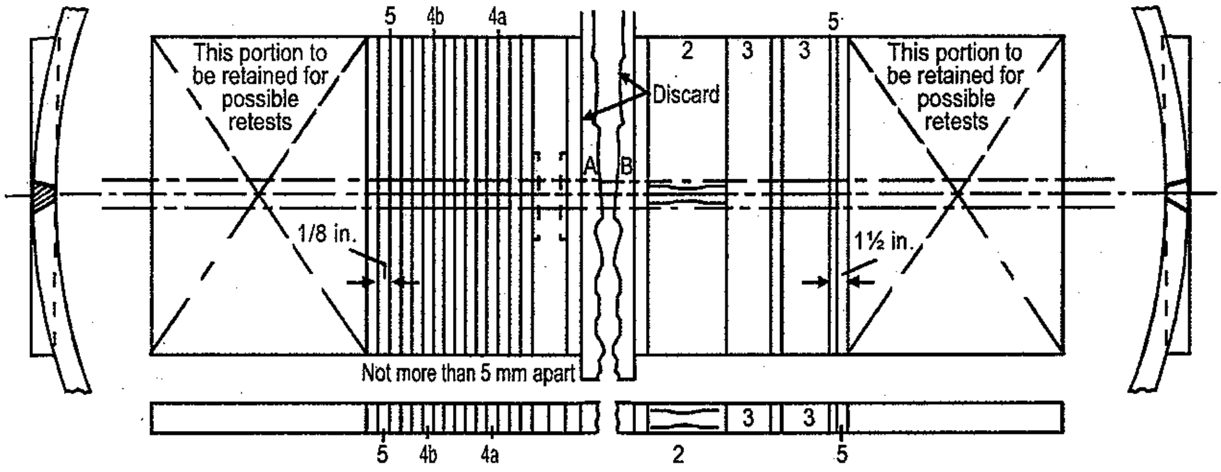
(v) One specimen for micro and macro examination.



1. Tensile test for joint.
2. Tensile test for all-weld metal.
3. Bend test, outer and inner surfaces of plate (at weld).
4. Notched bar impact test specimen.
5. Micro and macro specimen.

FIG. 16 — DETAILS OF TEST PLATES

* Examples showing approximate dispositions of the test pieces in the test plates are shown in Figs. 16 and 17.



1. Tensile test for joint.
2. Tensile test for all-weld metal.
3. Bend test, outer and inner surfaces of plate (at weld.)
4. (a) Izod impact test, outer surface of plate.
   (b) Izod Impact test, inner surface of plate.
5. Micro and macro specimen.

FIG. 17 — DETAILS OF TEST PLATES

The remainder of each set of test plates shall be retained for any re-tests required. Any specimen for re-test shall be cut off from the same set of test plate, as the original specimen.

(b) Surfaces of tensile, bend and impact test specimens corresponding with the outside or inside of the drums shall be only lightly dressed so that the rolled surface of the parent metal is not wholly removed, except that where the rolled surfaces of the abutting plates are not level with one another, one plate may be machined at each face of the weld provided the depth of metal removed does not exceed 0.8 mm.

259. Tensile Test Pieces

(a) **Welded Joint**—The dimensions of the reduced tensile section shall be there shown in Fig. 18A, the width of the reduced section shall be at least 25 mm.

If the thickness of the plate does not exceed 30 mm, the thickness of the specimen shall be equal to the plate thickness and the plate surface of the specimen shall be machined to take away the surface irregularities of the plate and the weld.

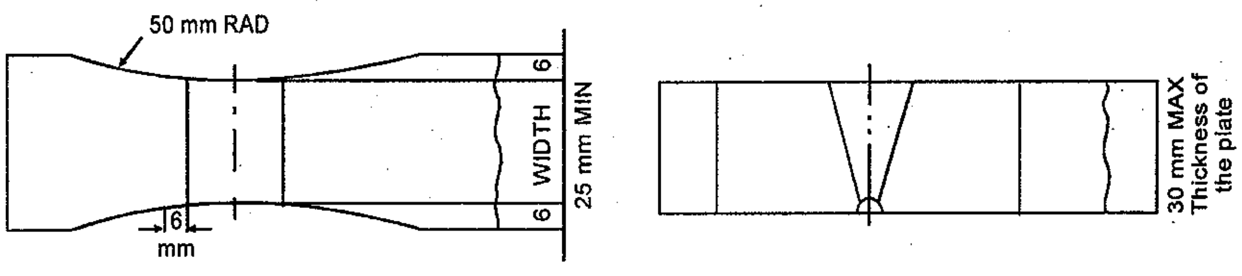


FIG. 18A — REDUCED SECTION TENSILE SPECIMEN

If the plate thickness exceeds 30 mm, the tensile test shall be carried out on several reduced section specimens, each having a thickness of at least 30 mm and a width at the effective cross-section of at least 25 mm. These specimens shall be taken out of the test piece in such a way that the tensile test covers the whole thickness of the weld joints as shown in Fig. 18B. In this case the result of the test of every test specimen concerned shall meet the requirements specified in Regulation 260(a).

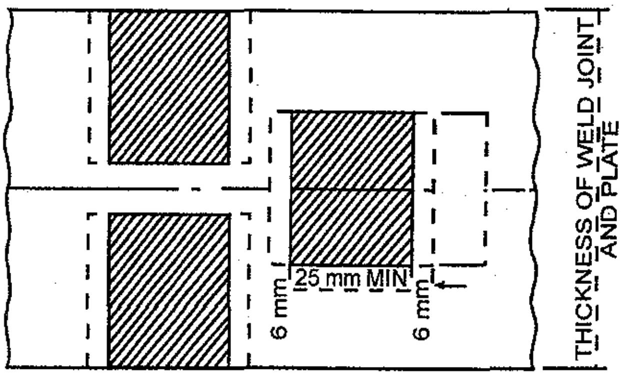


FIG. 18B — REDUCED SECTION TENSILE SPECIMEN IN THICK PLATE

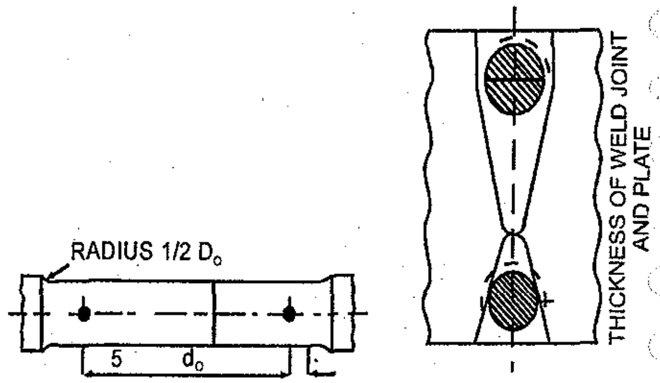


FIG. 19 — ALL-WELD METAL TEST SPECIMEN

(b) **All-Weld Metal**—The dimensions of the all-weld metal tensile test specimens shall be those given in Fig. 19.

The diameter shall be the maximum possible consistent with the cross-section of the weld but in no case more than 20 mm. The gauge length shall be equal to five times the diameter.

260. Tensile Tests

(a) The tensile strength of different grades of material shall be within the limits specified in clause (d) of regulation 9.

(b) The upper yield point at room temperature shall be not less than 50% of the specified minimum tensile strength at room temperature.

(c) The breaking elongation in percentage shall be not less than $(N - R_m)/C$

Where,

R_m = Tensile strength at room temperature in kgf/mm^2

N = a quality index of 100 for plate thickness upto 50 mm or 95 for plate thickness over 50 mm.

C = 2.2 for only gauge lengths of $L_o = 5\,d_o$ or $L_o = 5.65\sqrt{A_o}$

Where,

L_o = gauge length

A_o = original cross section of the rectangular test piece.

d_o = original diameter of the round test piece.

Note: C = 1.9 for gauge lengths of $4\sqrt{A_o}$ for test piece of Appendix-B.

(d) The minimum values of the stress at proof limit 0.2% at elevated temperature (Et) may be calculated by multiplying the minimum specified tensile strength at room temperature (R_{20}) by the value of the ratio (Et/R_{20}) given in the Table below:—

TABLE

Minimum values for the ratio of the stress at proof limit 0.2% at elevated temperature (Et) to the minimum specified tensile strength at room temperature (R_{20}) of carbon steel boiler plates.

Temperature	*250°C	*275°C	300°C	325°C	350°C	375°C
Et/R_{20}	0.40	0.38	0.36	0.34	0.33	0.32
Temperature	400°C	425°C				
Et/R_{20}	0.31	0.30				

*For temperatures lower than 300°C any test required for acceptance purposes (in the absence of records of previous tests at these temperatures) shall be made at 300°C, in which case the proof stress shall be not less than value obtained by calculation from the specified minimum tensile strength at room temperature and the above proof-ratio of 0.36 for 300°C.

261. Bend Test Pieces

(a) One for direct and one for reverse bending shall be taken transversely to the weld and where the thickness of the plate permits, one should be above the other. The specimens shall be rectangular in section so as to have a width equal to one and half times the thickness of the specimen but not less than 30 mm. The surface of the specimens shall be machined just to remove the surface irregularities of the plate and the weld. The corners of the specimens shall be rounded to a radius not exceeding 10% of the thickness of the specimen.

(b) Where plate thickness does not exceed 1½ in., the thickness of the specimen shall be equal to the full thickness of the test plate. Where the plate thickness exceeds 1½ in., the specimen shall in all cases have a thickness of at least 1½ in. The specimen to be tested with the outer surface of the weld in tension shall be prepared by cutting to waste the metal local to the inner surface of the weld so that the desired specimen thickness is obtained (*see* Fig. 20., Specimen A). The specimen to be tested with the inner surface in tension shall be prepared by cutting to waste the metal local to the outer surface of the weld so that the desired specimen thickness is obtained (*see* Fig. 20, Specimen B). Where the thickness of the plate permits, both specimens may be cut from the same piece of plate, the specimen being located in the plate one above the other (*see* Fig. 20, Specimen C).

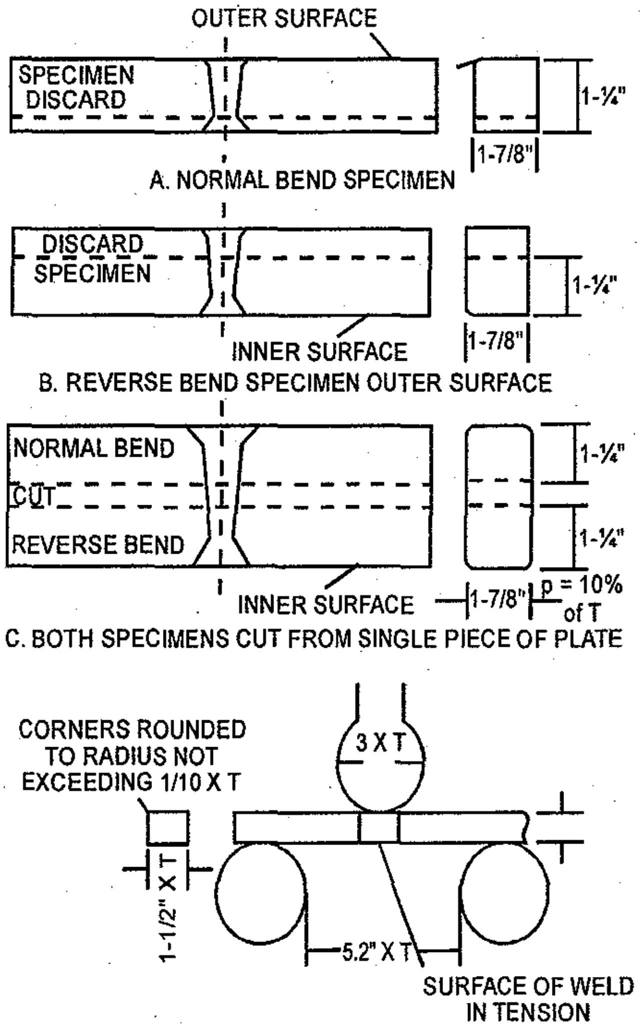


FIG. 20 — SPECIMEN 3 BEND TEST

262. Bend Tests

The specimen shall be mounted in such a way that the axis of the former is in the middle of the weld, and on roller supports the faces of which are separated by a distance determined by the thickness of the specimen.

The test specimen shall be pushed through the supports by a former having a diameter also determined by the thickness of the specimen. The requirements of table below, relating to the thickness of the test specimen, shall apply.

On completion of the test, no crack or defect on the outer surface of the specimen shall be greater than 1.5 mm measured across the specimen, or 3 mm measured along the specimen. Premature failure at the corners of the specimen shall not be considered as a cause for rejection.

Table—Bend Test Requirements

Specified minimum tensile strength of plate	*Diameter of former*	*Free space between support at the end of test*
Below 44 kgf/mm^2	2 T	4.2 T
From 44 to 54 kgf/mm^2	3 T	5.2 T
Above 54 kgf/mm^2	4 T	6.2 T

263. Notched-Bar-Impact Test

The notched-bar-impact test specimens are to be one of the two types and dimensions shown in Figures 21A and 21B, the notch shall be contained in the weld-metal at approximately the axis of the weld and the axis of the notch is to be perpendicular to the surface of the plate.

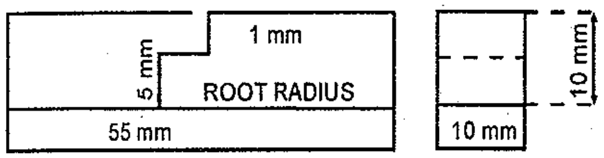


FIG. 21A — STANDARD U-NOTCH TEST PIECE

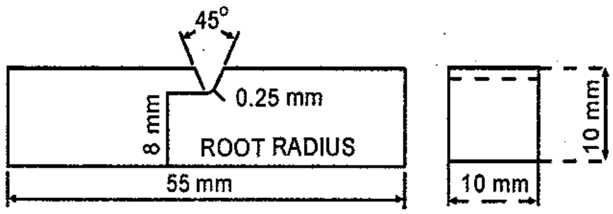


FIG. 21B — STANDARD V-NOTCH TEST PIECE

The test shall be carried out as follows:

For the U-Notch specimen as a temperature of 20 ± 2°C. For the V-notch specimen, at a temperature of 50 ± 2°C. In the case of V-notch specimen, the machining of the bottom of the notch shall be done very carefully.

The choice between U-Notch and V-Notch specimen shall be at the discretion of the Inspecting Authority. The minimum result to be obtained from the impact test pieces shall be:

(a) U-Notch specimen 5.50 kgfm/cm^2

(b) V-Notch specimen 3.46 kgfm/cm^2

Note: Above values are equivalent to 2.76 kgfm divided by sectional area below the notch.

264. Additional Tests before Rejection

(a) Should any of the test specimens taken in accordance with Regs. 257 to 263 fail to meet the specified requirements one re-test shall be allowed for each specimen that fails, provided the following minimum figures have been obtained:

(i) Reduction in area 30 per cent.

(ii) Any other test except the bend and impact tests, 90 per cent of the specified requirements.

(b) If a cold bend specimen should fail to meet the specified requirements, two re-tests shall be taken from the same test plate and these shall comply with the requirements of Regulations 261 and 262.

(c) If an Izod impact test fails to meet the specified requirements, two re-tests shall be taken from the test plate, one each side of the original specimen and separated from it by not more than 5 mm. Both re-tests shall show a minimum Izod impact test value of 20 ft. lb.

(d) If it be found there is insufficient metal to permit the preparation of specimens for re-test from the remainder of the test may be cut from the test plate relating to the opposite end of the same longitudinal seam.

265. Non-Destructive Test

(a) **Micro and Macro Examination**—A specimen, the full thickness of the plate and not less than 13 mm wide may be taken from each set of test plates by the Inspecting Authority for the purpose of micro and macro examination.

Macro-etching of a complete cross-section of the weld including the heat effected zone, should show satisfactory penetration, fusion and absence of significant inclusions or other defects. In case of a doubt as to the condition of the weld as shown by micro-etching, the area concerned is to be microscopically examined for defect investigation.

(b) **Radiographical Examination**—Every portion of the longitudinal and circumferential welded joints of the drums shall be subjected to radiographical examination or ultrasonic examination. Where ultrasonic examination is used, it shall be demonstrated to the satisfaction of the Inspecting Authority that the equipment and the technique used are satisfactory. The manufacturer shall ensure that the operator employed is competent to use the equipment, apply the technique interpret the results of the examination.

The method employed in obtaining the radiographs shall be such as to show clearly defects having a magnitude equal to 2 per cent of the thickness of the welded joint. To determine whether this result is being obtained and indicator of approved form which includes a portion equivalent to not more than 2 per cent of the joint thickness, shall be placed in the vicinity of the weld so as to make a record on each radiograph. Each section of every weld shall be marked so that the radiographs can be easily correlated to the particular part of the joint represented.

The examination shall be made from the original films and the acceptability of the welds shall be decided by the Inspecting Authority. The welds deemed unsatisfactory shall be rejected or dealt with under Regulation 266 and be radiographed again.

(c) **Magnetic Particle Flaw Detection**—Magnetic method of flaw detection shall be employed wherever possible for ferritic steel.

(d) **Dye-Penetrant Flaw Detection**—Dye-penetrants or equivalent method of flaw detection shall be employed for Austenetic or other non-magnetic Steel.

(e) All butt welded joints shall be subjected to non-destructive examination by radiographic, radioscopy or other approved methods such as ultrasonic testing, magnetic particle inspection or liquid dye-penetrant inspection. When radioscopic examination is to be performed in lieu of radiography on welded components, the following requirements shall be met, namely:—

(1) A written procedure shall be submitted for approval to the Inspecting Authority which shall contain the following:

(i) material and the thickness range;

(ii) equipment qualifications;

(iii) test object scan plan;

(iv) radioscopic parameters;

(v) image processing parameters;

(vi) image display parameters;

(vii) image archiving requirements;

(viii) accept-reject criteria (code reference);

(ix) performance evaluation;

(x) operator identification.

(2) The system shall be aided with an image processor to enhance the quality of the radioscopic images and system performance quality shall exhibit:

(i) a thin section contrast sensitivity of 3%;

(ii) a thick section contrast sensitivity of 2%;

(iii) a spatial resolution of 3 line pairs per mm;

(iv) IQI sensitivity - 2% of the joint thickness when wire IQI's are to be used, the wire diameter axis shall be oriented along the axis of the least sensitivity of the system.

(3) Radioscopes are to be properly marked to co-relate with particular part of joint represented.

(4) The radioscopic examination data shall be recorded and stored on video-tape, magnetic disk or optical disk, at the maker's plant for a sufficient period after the date of radioscopic examination as specified by the Inspecting Authority. Efficient radioscopic examination record recall shall be made available at any time over the record retention period and shall be traceable to the test objects.

(5) When repair has been performed as a result of radioscopic examination, the repaired areas shall be re-examined using the same radioscopic technique to evaluate the effectiveness of the repair.

(6) To aid in proper interpretation of the radioscopic examination data, the details of the technique used shall accompany the data. As a minimum, the information shall include the approved procedure requirements and system performance test data.

266. General

(a) Any repair to a weld carried out by the manufacturer shall first be agreed to by the Inspecting Authority.

Where defects occur in distributed positions in a seam, repairs to the extent of 15 per cent, of the total length of the seam shall be permitted to replace the defective welding.

Where the defects are located in a single continuous length, the permissible extent of repair shall be decided by the Inspecting Authority.

(b) **Longitudinal Seams**—Where the weld metal in any way fails to comply with the requirements specified the whole of the weld metal may be removed and the seam re-welded provided that:

(i) the original test plates are similarly treated, or

(ii) new test plates of the same thickness as the joint and of similar quality of material are attached to the end of the seam and re-welded with it.

In either case the plates shall be tested in accordance with Regulations 257 to 265 and the requirements for heat treatment shall be in accordance with Regulation 267.

(c) **Circumferential Seams**—With regard to the extent of permissible repair and when agreed by the Inspecting Authority a circumferential seam shall be treated in the same manner as a longitudinal seam. The Inspecting Authority shall be entitled to call for representative tests for a re-welded circumferential seam.

(d) **Removal of Defects**—Defects shall be cut out by chipping or machining or by burning out by the Air Arc Weld Process.

(e) **Examination Before Re-Welding**—Where a defective part has been cut out, the Inspecting Authority shall be entitled to make an examination before re-welding.

(f) **Process Used for Repairs**—Only metallic arc welding shall be used for repairs.

(g) **Radiographical Examination After Repairs**—All repaired areas shall be subjected to Radiographic or Radioscopic examination by the approved techniques.

(h) **Specimen Representing Repairs**—The Inspecting Authority shall be entitled to call for specimens representing any welded repair, for the purpose of examination and test.

(i) **Diagram of Welded Repairs**—On completion of all welded repairs the manufacturers shall, if requested, supply for record purposes a detailed diagram showing the position, length, depth and width of all such repairs.

267.

(a) **Heat Treatment**—After the completion of the welding of the seams and the welding on of the stand pipes and including welding repairs but before the hydraulic test, each drum shall be heat treated for stress relieving; during this heat treatment the official test plates shall be lying inside the drum.

(aa) The heat treatment referred to in clause (a) shall not be necessary in case of Carbon Steel:

Provided that the thickness of the part weld recess does not exceed 20 mm. and the Carbon content does not exceed 0.25 per cent.

(ab) Where the welded joint connects parts that are of different thickness, the thickness to be considered in applying the limiting thickness of 20 mm for carbon steel shall be the following nominal thickness including corrosion allowance:

(i) the thinner of two adjacent butt welded component including shell to end connection;

(ii) the thickness of the shell in connections to flat ends;

(iii) the thickness of the shell or end in nozzle attachment welds;

(iv) the thickness of the nozzle at the joint in nozzle to flange corrections;

(v) the thickness of the pressure part at the point of attachment where a non-pressure part is welded to a pressure part, in case of butt welds;

(vi) the thickness of the fillet weld at the point of attachment where a non-pressure part is welded to a pressure part, in case of fillet welds.

(b) Where the shell is subjected to a primary stress relieving treatment identical to the final heat treatment to be given to the drum, the test plates may be placed inside the shell during the primary treatment and thereafter cut up and tested without waiting for the final treatment of the drum.

(c) Where the shell is not subjected to primary stress relieving treatment or is subject to a primary stress relieving treatment which is not identical with the final heat treatment, the test plates may be placed inside any other drum of comparable dimensions which is to be heat treated in accordance with this Chapter. The heat treatment is to take place in the furnace in which the drum relating to the test plates will eventually be given its final heat treatment.

(d) Temperature charts shall be submitted to indicate that the test plates and the drums they represent have been subjected to identical heating, soaking and cooling treatment.

(e) For the heat treatment, the drum shall be placed in a furnace sufficiently larger to accommodate the whole drum. The furnace shall have proper means of temperature measurement and control and shall be capable of heating the whole of the drum to a uniform temperature. It shall be so designed as to prevent direct impingement of flame on the drum. The temperature of the furnace at the time the drum is placed in it shall not be higher than 300°C. For carbon steel a stress relieving heat treatment shall be performed by heating the part to at least 600 ± 20°C.

When required by the characteristic of the material, different temperatures may be necessary to obtain proper stress-relieving. The part to be stress relieved shall be brought up slowly to the specified temperature and held at that temperature for a period proportioned on the basis of at least 2½ minutes per millimeter of the maximum thickness of the part (approximately one hour per 25mm of the thickness) and shall be left to cool in the furnace to a temperature not exceeding 400°C. For carbon steels and when stress-relieving temperature is at least 615 ± 20°C, the soaking time shall be 2½ minutes per mm of thickness up to 50mm and 15 minutes for every additional 25mm thickness over 50mm and shall be left to cool in the furnace to a temperature not exceeding 400°C.

After withdrawal from the furnace the part shall be allowed to cool in a still atmosphere. A temperature time diagram of the stress-relieving process shall be provided for a welded shell or drum and a similar diagram for other welded pressure part shall be provided where Inspecting Authority requires at.

Note: Other stress-relieving heat treatment at a temperature as low as 55°C may be adopted provided attention is given to the holding time in order to ensure a sufficient degree of stress-relieving.

TABLE

Type of Steel	*Range of temperature in degree centigrade*	*Time at temperature per mm of thickness of plate*
½MO	620 – 660	2.5 minutes (30 minutes min.)
½ Cr ½ MO 1 Cr ½MO	630 – 670	2.5 minutes (30 minutes min.)
1½ Cr - ½MO 2¼ Cr - 1MO	650 - 750	2.5 minutes (1 hour min.)

Note: For pipes of 2¼ Cr 1MO specification upto and including 127 mm outside diameter and upto 13 mm wall thickness, the time may be 30 minutes minimum.

The heat treatment of steels having Cr Mo V shall be carried out as per the requirements of the code of manufacture of plates, pipes.

(f) Alternative procedure for the heat treatment of the drum may be submitted to the Inspecting Authority for approval.

(g) In special cases it may be permissible to heat treat the test plates separately from the drum, provided the Inspecting Authority is satisfied with the means adopted to ensure that the following factors will be the same for the drum as far the test plates.

Rate of heating.

Maximum temperature.

Time held at maximum temperature.

Conditions of cooling.

268. Hydraulic Test at Makers' Works

(a) Boiler drum and other cylindrical component having internal diameters greater than 600 millimeters shall be hydraulically tested on completion of manufacture at the makers' works in the presence of Inspecting Officer to 1½ times the maximum permissible working pressure without indication of weakness and defects.

(b) All components which are not reasonably accessible for inspection after assembly into the boiler or have been tested hydraulically prior to welding at a pressure less than that specified in sub-regulation (a) shall be tested hydraulically to 1½ times the maximum working pressure before assembly into the boiler.

(c) Tubular products that have been hydraulically tested to the required pressure prior to welding or ultrasonically tested shall not require further hydraulic testing as components provided they were joined during assembly by circumferential but joint which have been welded and non-destructively tested as per relevant provisions of these regulations.

(d) Components other than tubular products shall not require hydraulic testing before assembly into the boiler if the completed boiler is tested hydraulically to 1½ times the maximum permissible working pressure at site.

(e) In case of drums, headers which are to be fitted with tubes, the test may be made before drilling of tube holes but after attachments of nozzles and similar fittings.

(f) The test pressure shall be raised gradually under proper control at all times so that it never exceeds by more than 6% of the required pressure and maintained for 30 minutes whereupon the pressure shall be reduced to maximum allowable working pressure and maintained for sufficient time to permit close visual inspection for leakages of the pressure parts.

(g) The temperature of water used as medium of pressure testing shall not be less than 20°C and more than 50°C.

(h) In case of drums of 'composite' construction and partly riveted and partly welded seams or seamless forged drum shell with ends attached by fusion welding, the test pressure shall be the same as for fusion welded drums.

(i) Should the hydraulic test reveal any defects in the welded steam, it shall not be repaired unless the Inspecting Authority permits to do so.

(j) On completion of agreed repairs to a drum which has previously been stress relieved by heat-treatment, further heat-treatment, if required by the Inspecting Authority, shall be done and the drums shall again be subjected to hydraulic test.

INSPECTION AND TESTING

269. Inspection during Construction

Inspection during construction and fees therefore shall be governed by the rules in Appendix 'J' and Regulation 395A.

REGULATION FOR DETERMINING THE WORKING PRESSURE OF WATER TUBE BOILERS WITH FUSION WELDED AND SEAMLESS FORGED DRUMS SHELLS

270. Shell of Steam and Water Drums

(a) The working pressure shall be determined by the following formula:

$$W.P. = \frac{2fE(T-0.03)}{D+T-0.03} \qquad \text{Eqn. (72)}$$

where, T = thickness in inches,

D = maximum internal diameter in inches,

W.P.= working pressure in lb. per sq. inches,

f = permissible working stress in lbs. per sq. inch at working metal temperature (*see* Reg. 27),

E = the efficiency of ligaments between the tube holes or other uncompensated openings in shell, or the weld factor of the longitudinal joints,

For Class I boilers, the weld factor shall be taken as 1,

In the particular case of an unpierced wrapper plate of a fusion welded drum,

E = 1.

(b) Irrespective of the thickness obtained by the use of the foregoing formula 'T' shall not be less than:

(i) For tube plates (where the tubes are expanded therein) the thickness shall be at least such as to allow a minimum parallel belt width of tube seat of 3/8 inch, this seating to be measured as explained below.

(ii) All tubes shall be carefully expanded into the holes in the tube plates. The tubes shall be belled of beaded to resist withdrawal and if belled they shall project through the parallel tube seat at least ¼ inch.

(c) The belling shall be as shown in table below:

TABLE

Outside diameter of tube	*Amount of diameter of belling over diameter of the tube hole*
	in.
Upto and including 1½ in.	3/32
Over 1½ in. upto and including 2 in.	4/32
Over 2 in. upto and including 3¼ in.	5/32
Over 3¼ in. upto and including 4 in.	6/32

(d) The tube holes in the tube plates of drums, pockets of headers shall be formed in such a way that the tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plate, there shall be a neck or belt of parallel seating at right angles to the axis of the tube at least ½ in. in depth measured in a plane containing the axis of the tube at the hole.

(e) Where the tubes are practically normal to the tube plate or the header this parallel seating shall, wherever practicable, be not less than 3/8 in. in depth.

271. Permissible Working Stresses for Shells of Boiler and Integral Super-Heater Drums and Headers

The maximum permissible stress for drum shells and headers shall be taken as available in governing Boiler codes of the country of the material to which it belongs. In case of non-availability of the value, the following procedure for evaluating shall be adopted:

(i) For temperatures at or below 454°C, the smaller of the two values:—

$$f = \frac{Et}{1.5} \text{ or } \frac{R}{2.7}$$

(ii) For temperatures above 454°C, the least of the following three values:—

$$\text{(a) } \frac{Et}{1.5} \qquad \text{(b) } \frac{SR}{1.5} \qquad \text{and (c) } Sc$$

where, t = working metal temperature,

R = minimum specified tensile strength of the steel at room temperature,

E = minimum specified Yield point at room temperature,

Et = yield point (0.2% proof stress) at the temperature 't',

Sc = the average stress to produce an elongation of 1% (creep) in 100,000 hours at temperature 't',

SR = the average stress to produce rupture in 100,000 hours at the temperature 't' and in no case more than 1.33 times the lowest stress to produce rupture at the temperature.

Note: In case Sc values are not available in Material Standard and such materials are known to have been used in boilers in India or abroad, then for such materials the allowable stress may be taken as the lower of

$$\frac{Et}{1.5} \text{ or } \frac{Sr}{1.5}$$

For fusion welded drums, when the wall thickness exceed 60mm (2-3/8"), a deduction of 1 per cent in the value of "f" so determined shall be made for each increase of 5mm (3/16") in the thickness. Such deduction need not be made provided the minimum specified values of R and E at any part of the section of the steel plate used in the manufacture of the Boiler drum are guaranteed by a "Well-known Steel Maker" or certified by an Inspecting Authority.

The working metal temperature shall be taken as:—

(a) For saturated steam, water and mud drums, the saturation temperature corresponding to the pressure WP plus 50°F.

(b) For superheated steam the designed maximum steam temperature for that drum plus 50°F.

Where the drums are adequately protected from the gases of combustion or swept by such gasses in the third or subsequent pass of a boiler, the working metal temperature shall be taken as the saturation or designed maximum steam temperature as defined above, whichever applies. A covering of refractory or insulating material which may be liable to become dislodged shall not be deemed adequate protection.

Note: Where steels are for service at temperatures in excess of 370°C (700°F) it shall be so stated as the silicon content shall be 0.10 per cent minimum or alternatively the material must pass the "Proof Test for Creep Quality of Carbon Steel Plate of Boiler Plate Quality" as in the Appendix D.

272. The Ligament Efficiency of Drum Shells shall Comply with Reg. 215.

273. Longitudinal Stress

Notwithstanding the working pressure as calculated by Equation 72, the thickness of drum or cylindrical header shells shall be such that in no case does the longitudinal stress resulting from the combination of stress arising from internal steam pressure, the self-weight of the drum or header and its contents and all externally applied loads, exceed the permissible working stress corresponding to the working metal temperature as prescribed in Regulation 271.

(a) The maximum direct longitudinal stress due to the internal steam pressure acting on the drum ends shall be calculated as follows:

$$f_d = \frac{PD^2}{1.273A} \qquad \text{Eqn. (72a)}$$

where, f_d = maximum direct longitudinal stress in pounds per square inch,

P = design pressure in pounds per square inch,

D = internal diameter of the drum or header in inches,

A = nett cross-sectional area of the drum or header in square inches taken through the tube holes in a plane at right angle to its axis.

(b) The resultant bending moments M at any section shall be the algebraic sum of the bending moments due to the eccentricity of the end pressure and that due to the externally applied loads.

$$M_R = M_e + M_w \qquad \text{Eqn. (72b)}$$

The bending movement due to the eccentricity of end pressure shall be calculated as follows:

$$M = \frac{PD^2.e}{1.273} \qquad \text{Eqn. (72c)}$$

where, M = resultant bending moment due to eccentricity in pound inches,

P = design pressure in pounds per square inch,

D = internal diameter of drum or header in inches,

e = eccentricity of the nett cross-section i.e., the distance from the neutral axis of the nett section to the drum or header axis in inches.

The bending moment (M_w) due to externally applied loads shall be calculated by treating the drum or header as a beam carrying the externally applied loads, including the self-weight of the drum or header and its contents under working conditions.

(c) The stress due to bending shall be calculated as follows:

$$f_b = \frac{M_r\ Y}{I} \qquad \text{Eqn. (72d)}$$

where, f_b = stress due to bending in pounds per square inch,

M = resultant bending moment at the section in pound-inches,

Y = distance from the neutral axis of the nett cross-section to the extreme fibre of the drum or header shell in inches,

I = moment of inertia of the nett cross-section taken about its neutral axis in (inches^4).

The resultant longitudinal stress is the algebraic sum of the stresses given under (a) and (c).

(d) In calculating the longitudinal stress due to bending in a drum supported at or near its ends and connected to a lower drum by a bank of tubes (so arranged as to form substantial struts between the drums) the value of the moment of inertia I_a used in the formula in sub-regulation

(c) shall be:—

Moment of inertia of upper drum (I_a) plus a proportion (S) of the moment of inertia of lower drum (I_c).

$$S = 1 - \frac{\alpha^2}{240} \qquad \text{Eqn. (72e)}$$

where, a the angle in degrees between the vertical and the line joining the centres of the upper and lower drums. Where α is equal to or greater than 15½°; S shall be taken as O. In no case shall the actual value of I_a used in Equation 72d be taken as more than 1.33 times the moment of inertia of the upper drum (I_b).

In the foregoing, unless otherwise agreed the term "bank of tubes" shall be defined as consisting of four or more rows of tubes extending over at least three quarters of the drum length between supports, and pitched longitudinally at not greater than an average pitch of four tube diameters.

274. Intermediate Boiler Drum Supports

Where a boiler drum is supported at Intermediate points in its length at a distance greater than one internal diameter from the end of the parallel portion of the drum shell, the shell shall be thickened locally to the supports or so designed that when the local stress set up by the supports in the drum shell are added, algebraically to those caused by the internal steam pressure and supported loads, the maximum resultant stress does not exceed the permissible working stress at the working metal temperature.

END PLATES

275. Shape of Dished End Plate

When the end plate is dished to semi-ellipsodial, partial spherical or hemi-spherical form, it shall comply with the following (*see* Figures 23A, 23B and 23C):

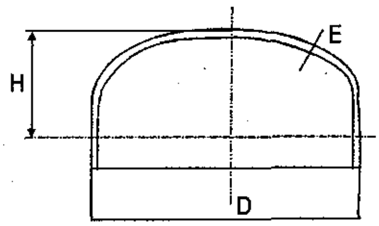


FIG. 23A — ELLIPTICAL HEAD

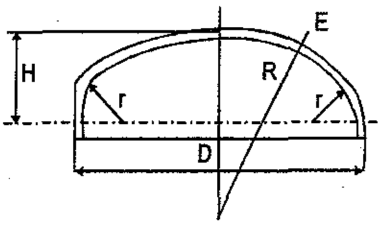


FIG. 23B — TORISPHERICAL HEAD

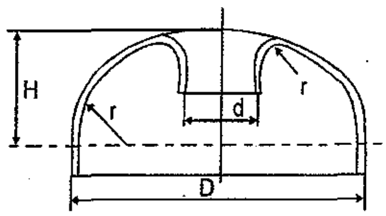


FIG. 23C — HEAD WITH MANHOLE (Elliptical or Torispherical)

(a) hemispherical heads without limitation;

(b) elliptical heads sufficiently dished so that

$H \geq 0.2D$;

(c) partial spherical heads satisfying all the following requirements:

$r \geq 0.1D$

$r \geq 3T$

$R \leq D$

$H \geq 0.18D$

A value of $R < 1.2D$ is permitted for ends in which the ratio H/D falls between 0.18-0.2.

In accordance with Figures 23A, 23B, 23C, 23D, 23E, 23F—

D = outside diametre of the head;

H = height of the head measured on its outside surface from the junction of the dished part with the cylindrical shell;

R = inside radius of the spherical part of partial spherical heads;

r = inside knuckle radius of partial spherical heads.

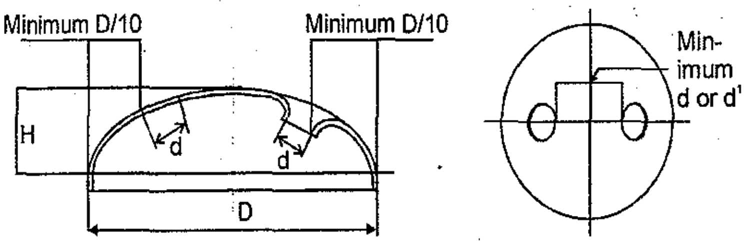


FIG. 23E — OPENING IN HEADS

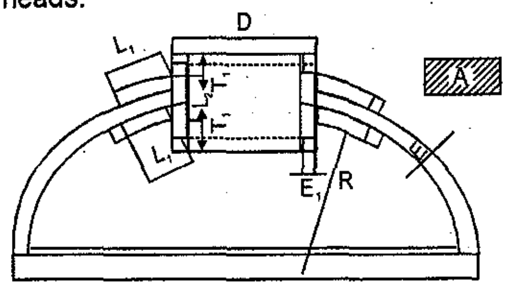


FIG. 23F — REINFORCED OPENING

(Figure 23D given on Next Page).

276. General

The thickness T specified in Equation 74 of Regulation 278 is the thickness of the end plate after manufacture and is applicable over the whole area of the end plate upto the point where, for ends of partially spherical shape, the dishing radius joins the corner radius; from this joint a gradual thinning is permissible upto maximum of 10 per cent of the thickness T at the point where the corner radius joins the straight portion of flanged end plate. A similar gradual thinning is permissible for end plates of semi-ellipsoidal shape. This permissible reduction in thickness applies also to the flange for the manhole opening. In no case, however, when the end plate is butt welded to the drum shell, shall the thickness of the edge of the flange for connection to the shell be less than the thickness of an unpierced seamless shell of the same diameter and material, determined by Equation 72.

277. Dished End with Opening

(a) **Heads with opening—**

(i) Holes cut in the heads (manholes or tube holes) should be round or elliptical.

(ii) Small size openings complying with conditions of sub-regulation (c) do not require any additional thickness of head or reinforcement of opening.

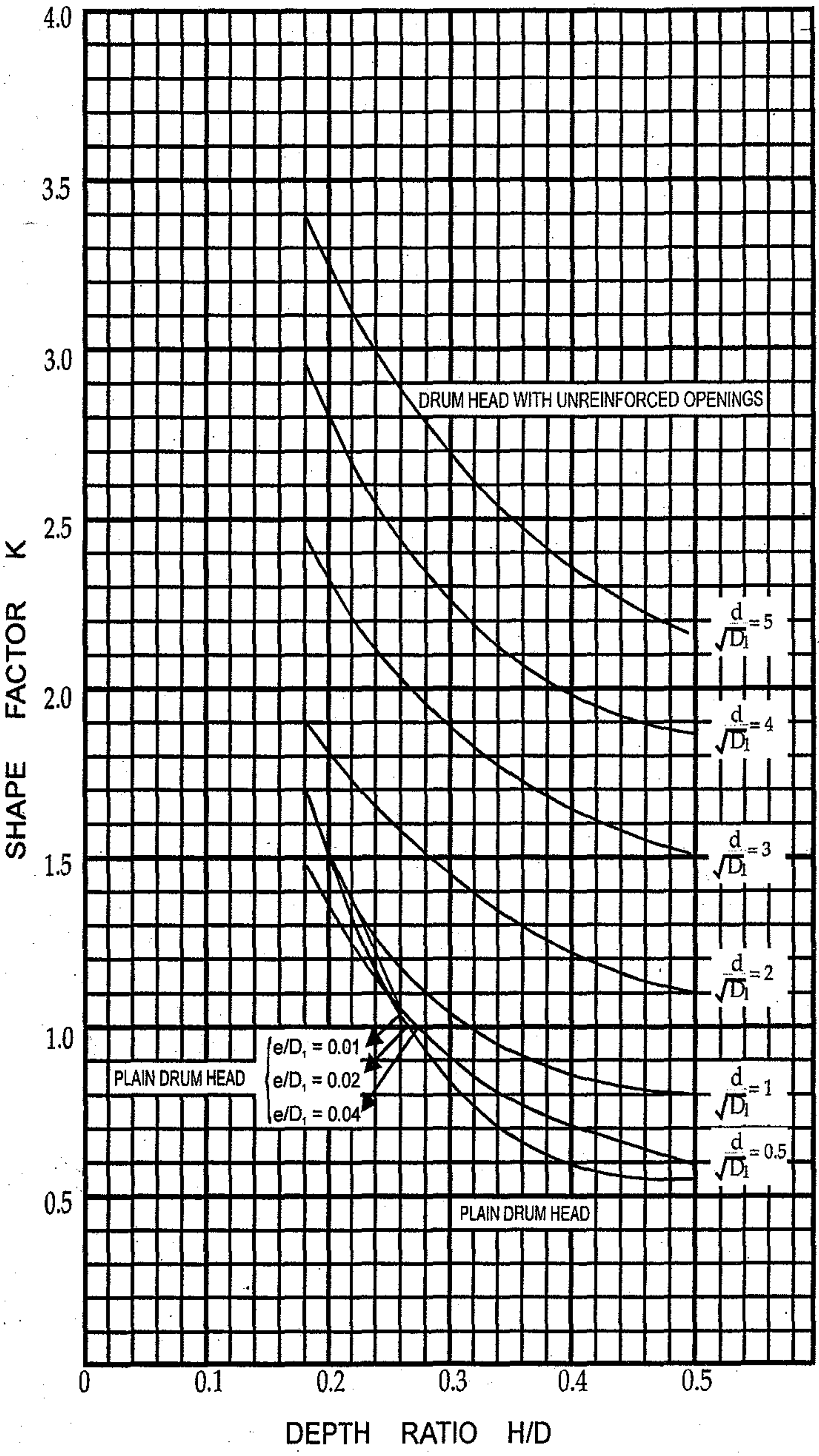


FIG. 23D — GRAPH OF SHAPE FACTOR K FOR DISHED HEADS

(iii) Large size openings require an increase in thickness of the head, according to sub-regulation (b) or a reinforcement of the opening according to sub-regulation (d).

(b) **Shape factor K for heads with large unreinforced openings**—The shape factor K to be used in calculating the thickness of heads varies depending on the height of the head H and on the dimensions of the largest opening. The value of K is indicated in Figure 23D, by means of curves, each of which corresponds to a value of the ratio—

$$\frac{d}{\sqrt{DT}}$$

where, d = diameter of the largest opening in the head (in the case of an elliptical opening, the larger diameter of the ellipse);

D = outside diameter of the head; and

T = minimum thickness after dishing.

In addition, the following conditions shall be satisfied:

$$\frac{T}{D} \leq 0.1$$

$$\frac{d}{D} \leq 0.5$$

The same condition and the same curves apply for openings simply cut in the plate of the head as well as to those which are flanged inwards. In the latter case, the radius 'r' of the flanging (*see* Figure 23C) should not be smaller than 25mm (1 inch). The thickness of the flanged portion may be smaller than the calculated thickness T.

Unreinforced openings and flanged-in openings in dished heads shall be arranged so that the distance from the edge of the head is not less than as shown in Figure 23E.

In all cases the width of the band separating two adjacent openings should, in projection, be at least equal to the diameter of the smallest opening as shown in Figure 23E.

(c) **Small openings which do not require any reinforcement**—Figure 23D indicates that for a given ratio of H/D, the shape factor K of a plain head corresponds to a certain value of the ratio,

$$\frac{d}{\sqrt{DT}}$$

Piercing of holes with a diameter smaller than or equal to that which corresponds to this value can thus be made without any reinforcement in a head, the thickness of which is equal to the minimum required for a plain head.

The position of those openings shall however comply with the conditions stated in sub-regulation (b).

(d) **Reinforcement of large openings**—Large holes may be cut without increasing the thickness of the head, provided they are sufficiently reinforced.

The reinforcement may consist either of a welded nozzle or one or two reinforcing welded plates, or of a combination of these two procedures.

To determine the strength of the construction, one shall proceed as follows (*see* Figure 23F): Let the imaginary diameter 'd' of the opening be given by the formula:

$$d' = d - \frac{A}{T}$$

where, d = actual diameter of the opening in the head (outside diameter of the nozzle);

T = minimum thickness of the head; and

A = effective cross-section of reinforcement.

This effective area A corresponds, within the limits given below, with the actual cross-section of the reinforcing plates and with the cross-section of the nozzle decreased by the cross-section necessary to support the pressure, for those parts of the nozzle situated outside the internal surface of the head.

The shape factor K can then be read from Figure 23D, corresponding to the ratio $\frac{d'}{\sqrt{DT}}$

The maximum limits for the area of reinforcement that should be taken into account are

(a) $L_1 = \sqrt{2RT}$ for the width of a reinforcing plate;

(b) $L_2 = \sqrt{dTt}$ for the length of a nozzle;

where, R = internal radius of the spherical part of the head (or for elliptical heads the internal radius of curvature of the meridian at the centre of the opening);

Tt = actual thickness of the nozzle;

L_1 and L_2 = dimensions given in Figure 23F.

The position of the outer edges of the reinforcement shall comply with the provisions of sub-regulation (b) and Figure 23E.

In cases where the allowable stress of a part of the reinforcement is lower than that of the head, the corresponding area A should be multiplied by the ratio:

$$\frac{\text{allowable stress of the reinforcement material}}{\text{allowable stress of the head material}}$$

278. End Plate subject to Pressure on the Concave Side

Dished ends subjected to pressure on the concave side shall be determined by the following formula:

$$W.P. = \frac{2f(T-C)}{DK}$$

where, T = minimum thickness;

P = maximum working pressure, design pressure;

D = outside diameter;

f = permissible stress;

K = shape factor as defined in sub-regulation (a) of Regulation 277 and Figure 23D; and

C = an additive thickness equal to 0.75 mm.

The minimum head thickness should not be, however, less than 5 mm.

278A. Internal doors

Internal doors shall be of wrought steel in accordance with Chapter II and constructed in accordance with the following:—

(a) doors shall be formed to fit closely to the internal joint surface and should be fitted with studs, nuts and crossbars;

(b) doors for circular opening larger than 250 mm or elliptical/rectangular opening larger than 250 mm x 175 mm shall have two studs but for opening of 250 mm x 170 mm or less only one stud may be fitted. Doors for opening not larger than 123 mm x 90 mm may have the stud forged integrally with door;

(c) doors stud shall be of welding quality steel having a minimum specified tensile strength of not less than 360 N/mm^2 and those for manholes shall be not less than 30 mm.

They shall be fixed in any of the following way:—

(1) screwed through the plate and fillet welded on inside;

(2) fillet welded each side of the plate with a leg length of not less than 10 mm;

(3) attached to the door by an intermediate plate or legs so that the strength of the attachment is not less than strength of the studs and the studs are prevented from turning; or

(4) provided with an integrated collar and be riveted or screwed on to the door plate and be prevented from turning in which case the strength of the attachment shall be not less than the strength of the studs;

(d) door spigot when the door is in the central position shall have a clearance of approximately 105 mm all around and at no point shall the clearance exceed 3 mm. The spigot depth shall be sufficient to trap the gasket;

(e) the nuts shall be of appropriate material compatible to that of bolts and be placed on the seating surface;

(f) the cross-bars shall be of substantial proportions and of mild or wrought steel.

Note: Eye bolts of suitable legs on the door plate or headed bolts engaging with slotted sections on the door plate may be used instead of studs.

The minimum calculated thickness of the door of the flat plate construction (i.e. unstiffened made from one plate) shall be not less than that determined by the following formula:—

$$t = \sqrt{\frac{0.35P \times d^2 + W}{f}} \quad \text{for a circular door}$$

$$t = \sqrt{\frac{0.35P\left(2 - \frac{a}{b}\right) \times a^2 + W}{f}} \quad \text{for an elliptical door}$$

where,

t = is the minimum calculated thickness of the flat door (in mm),

P = is the working pressure of boiler (in N/mm²),

d = is the diameter of the opening to which the door is fitted, if round (in mm),

a = is the minor axis of the opening to which the door is fitted if elliptical (in mm),

b = is the major axis of the opening to which the door is fitted, if elliptical (in mm),

W = is the full load capacity of one stud (effective stud area × design stress value at design temperature in (N),

f = is the maximum allowable stress of the plate at the design temperature (in N/mm²).

Note: A design stress of value of 50 N/mm² may be used for carbon steel bolts for design temperature not exceeding 300°C.

STANDPIPES AND NOZZLES

279.

(a) **Standpipes and Nozzles Welded to Shell**—Where standpipes or nozzles are secured by welding, adequate compensation for the hole cut shall be provided. Compensation shall be considered adequate when the sectional area 'X' to be compensated measured through the axis of the shell is less than the compensating area 'Y' given in Figure 25B.

Sectional area $X = (d_n \times e_s)$

Sectional area $Y = 2(t_n - e_n)b \times \frac{f_n}{f_s} + 2t_n \times b \times \frac{f_n}{f_s} + 2(t_s - e_s)C_1 \div C_2$

where,

d_n = internal diameter of the standpipe or nozzle;

t_s = actual thickness of shell;

t_n = actual thickness of standpipe or nozzle;

e_s = equivalent thickness of shell i.e., thickness of a seamless shell of similar material unpierced by tube holes and is designed for the same conditions of pressure and temperature as the shell in question;

e_n = equivalent thickness of the standpipe calculated similarly as for e plus any thickness if required to withstand any external load on the standpipe or nozzle;

b = the least of the values of

2.5 times t;

2.5 times t_n;

or if the length of the standpipe or nozzle outside or inside the shell is less than this value; 'b' shall be limited to the actual length in each case;

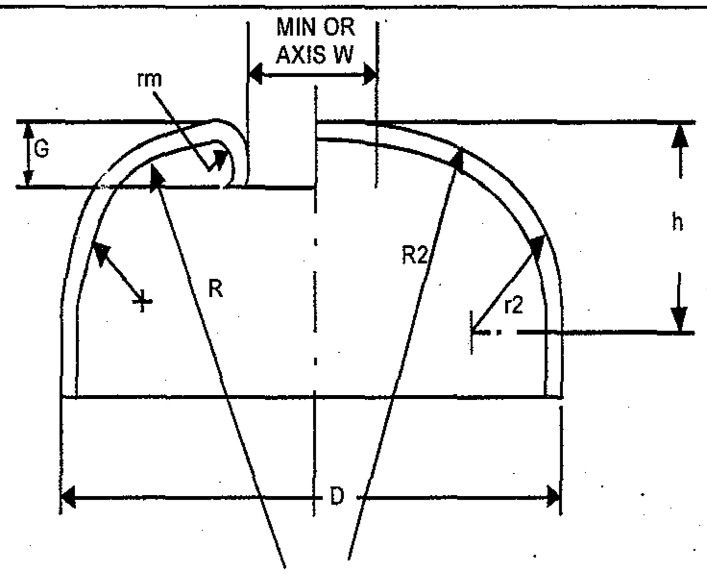


FIG. 23

C3 = the aggregate cross-sectional area of the fillet welds;

C1 = t_s + 76 mm (3 in.) or $d_n/2$, whichever is greater;

f_s = the permissible stress for the material of the shell at the working metal temperature;

f_n = the permissible stress for the material of the standpipe or nozzle at the working metal temperature.

In cases where 'Y' is less than 'X' a compensating plate shall be fitted to the shell at the standpipe and secured by fillet welds as in Figure 25B.

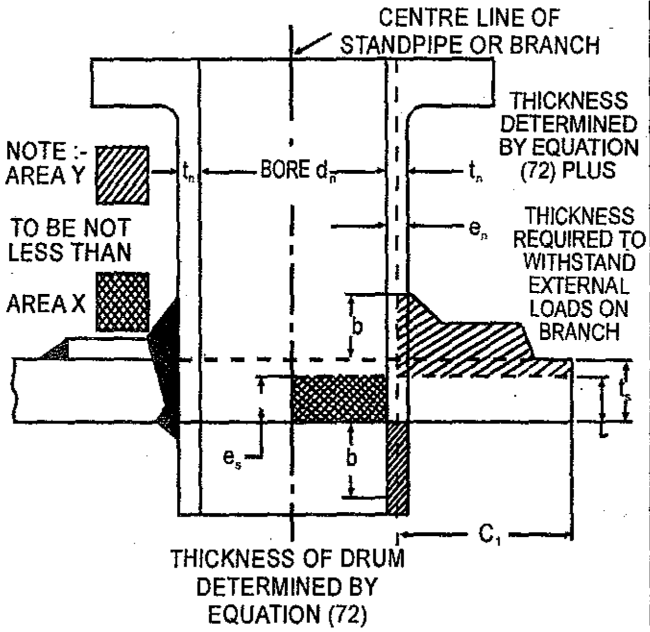


FIG. 25B — COMPENSATION FOR WELDED STANDPIPES

The area of cross-section of the compensation plate shall be governed by the ratio between the permissible stress at the working metal temperature for the materials of the shell and the compensating plate.

(b) **Standpipe and Nozzles Welded to Dished End Plates**—Where the standpipe or nozzles are welded to dished end plates, the compensation shall be considered adequate if calculated on the same basis as in (a) above. But the cross-sectional area of the end plate to be compensated shall be calculated on the basis of Equation 74 and the height of standpipe above the outer surface or within the inner surface of the end plate shall be measured along the radial line passing through the centre of the opening.

(c) **Minimum Thickness of Flanges**—The minimum thickness of the flanges and the body of standpipes shall be in accordance with the table under Regulation 156.

280. Attachment of Stand Blocks and Branch Pipes by Welding

(a) Typical methods of attachment are shown in Figures:

24A, 24B, 24C, 24D, 26A, 26B, 26C, 26D, 26E, 27A, 27B, 27C and 27D. (Figures given on *next pages*)

All weld dimensions shown shall be regarded as minimum dimensions those defining the grooves refer to the actual preparation for welding.

t_n = specified thickness of standpipe or branch pipe,

t_s = specified thickness of drum or header shell at standpipe or branch connection,

t_e = actual thickness of compensating ring.

The application of certain of the constructions illustrated may be limited by consideration of design pressure and temperature or size (in combination) and although certain dimensions are given, each case must be considered on its merits.

Other methods may be adopted subject to agreement between the Inspecting Authority and manufacturer.

(b) Electrodes shall comply with the requirements of Regulations 94 to 98 (Covered Electrodes for Metal Arc Welding).

(c) Not less than two runs of metal shall be deposited at each weld. Each run of weld metal shall be thoroughly cleaned and freed from slag before the next run is deposited.

In the case of water tube boiler or boilers fitted with superheater, the feed water connection and stop valve need not be sheet off and if the total valve area is lifted and found to be adequate by calculations, the requirement of the accumulation test may be assumed to have been satisfied if the valves area has been found so adjusted that at least one safety valve on each boiler shall lift at or below the designed working pressure of the boiler and all valves shall lift so that arc steam which can be generated by the boiler can be discharged with a pressure rise not exceeding 10 per cent of the designated working pressure.

(d) The final finish of the weld shall be such that the change of section from drum to standpipe, or from flange to standpipe is gradual and free from sharp notches. After completion of welding (except in the case of seal welds) the drum shall be stress-relieved by heat treatment.

(Figures No. 24A, 24B, 24C, 24D, 26A, 26B, 26C, 26D, 26E, 27A, 27B, 27C and 27D given on Next Pages)

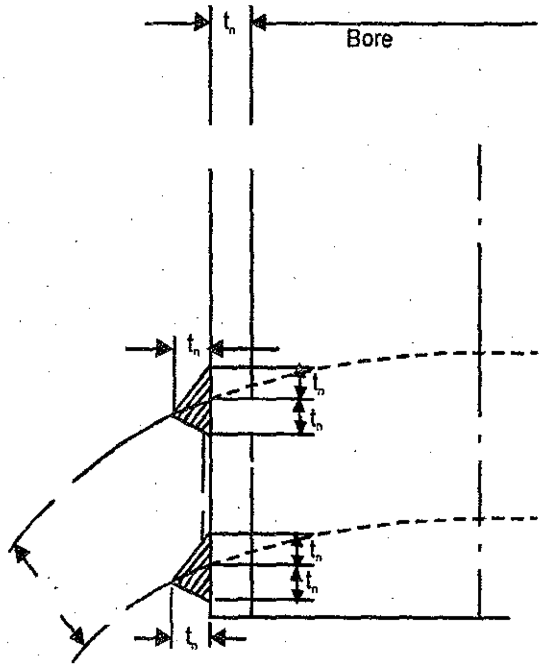


FIG. 24A — WELDED IN STANDPIPE OR BRANCH FOR STANDPIPES AND BRANCHES UPTO AND INCLUDING 4 IN. BORE

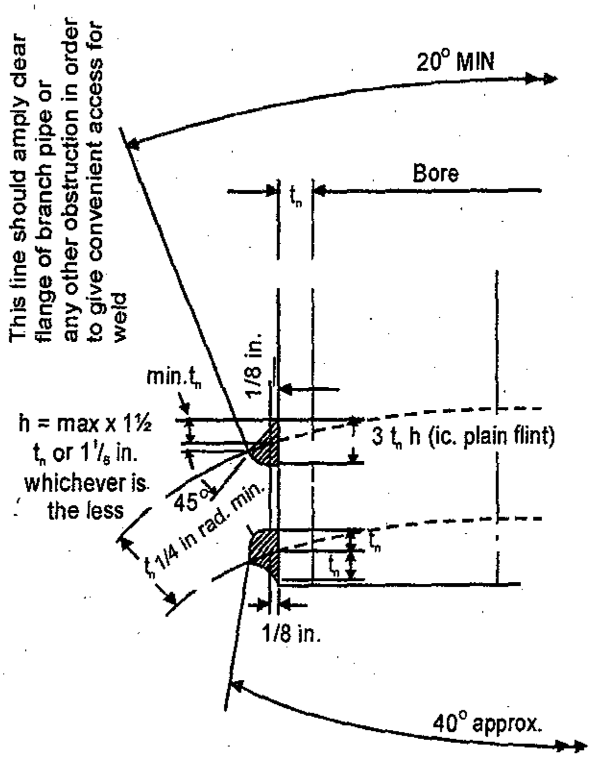


FIG. 24B — WELDED TO STANDPIPE OR BRANCH OR BRANCHES UPTO ANY AND INCLUDING 4 IN. BORE

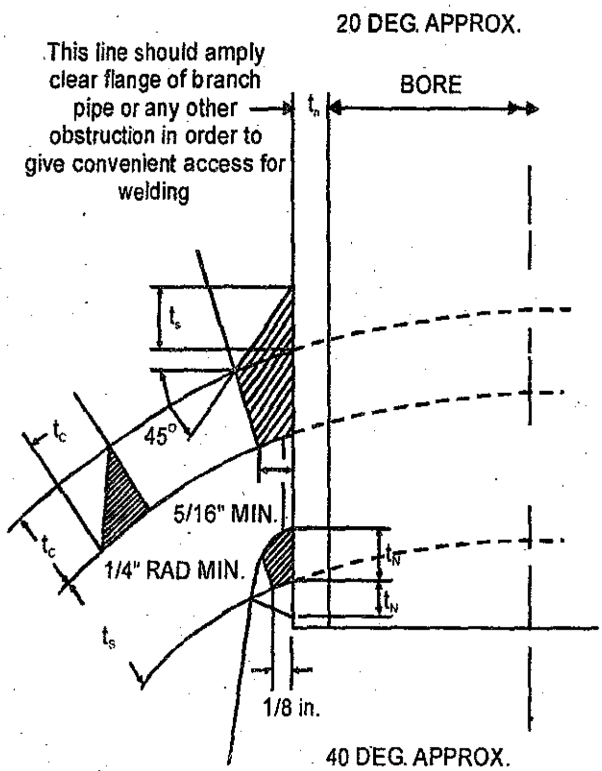


FIG. 24C — WELDED IN STANDPIPE OR BRANCH WITH COMPENSATING RING FOR STANDPIPES OR BRANCHES INCLUDING 4 IN. BORE

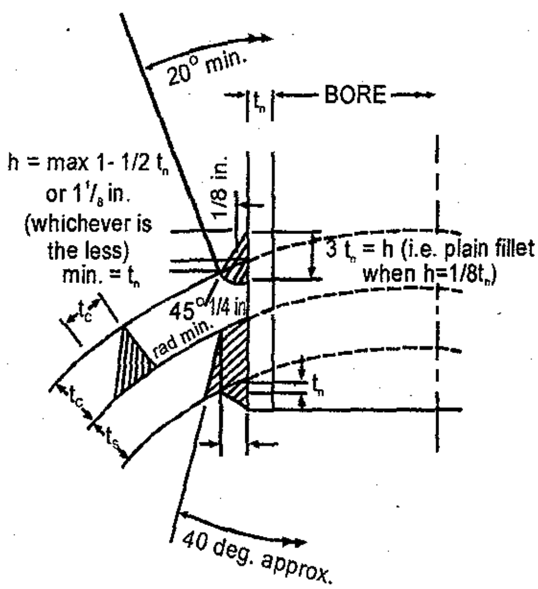


FIG. 24D — WELDED IN STANDPIPE OR BRANCH WITH COMPENSATING RING FOR STANDPIPES AND BRANCHES UPTO AND INCLUDING 4 IN. BORE

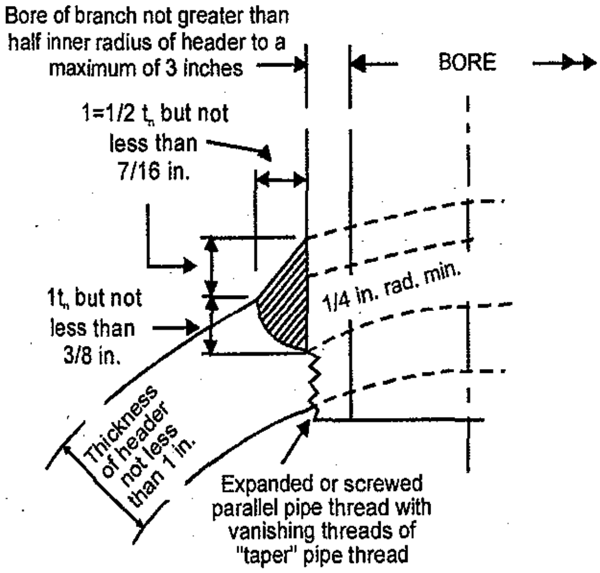


FIG. 26A

A header branches. Welding accessible from outside only. Maximum design pressure 450 1b./sq. in. maximum design temperature 55°F. Applicable to the circular section of headers with above limiting size of branch or flat sides of headers without limiting size of branch.

Note : This type of weld is not recommended where the inside of the header is accessible for welding.

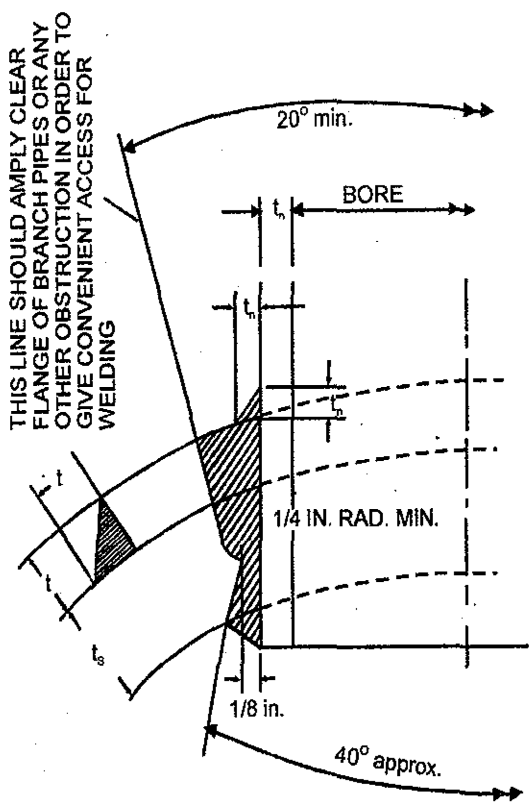
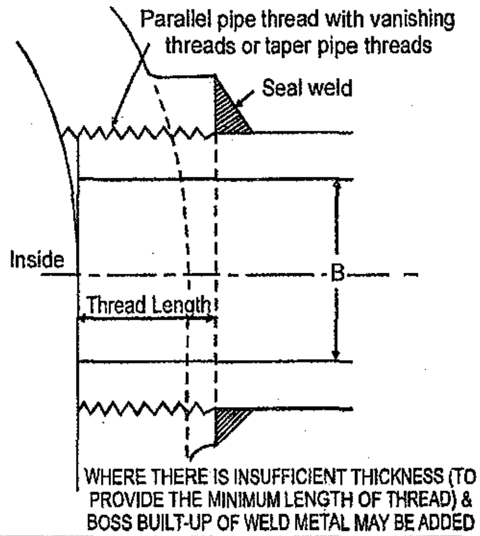


FIG. 26C — WELDED IN STANDPIPE OR BRANCH WITH COMPANSATING RING



NOMINAL BORE OF PIPE (B) IN	TOTAL LENGTH OF THREAD (MIN)(T) IN
1=1/2 and 1=1/4	1
1	7/8
3/4	3/4
1/3 and below	5/8

FIG. 26B — SCREWED AND OZAL WELDED CONNECTION

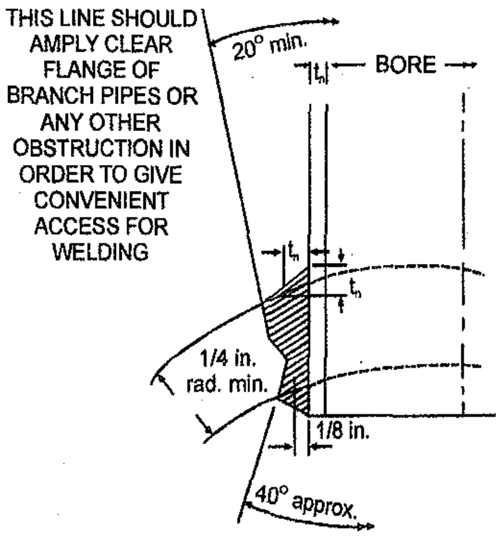


FIG. 26D — WELDED IN STANDPIPE OR BRANCH

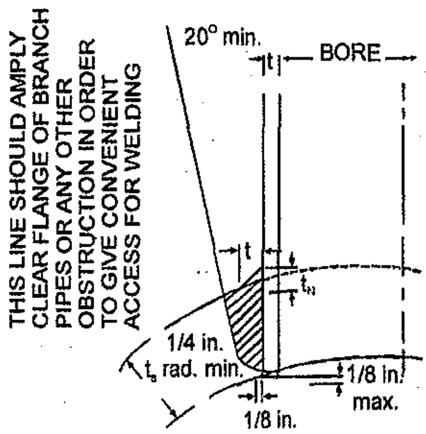


FIG. 26E — WELDED IN STANDPIPE OR BRANCH

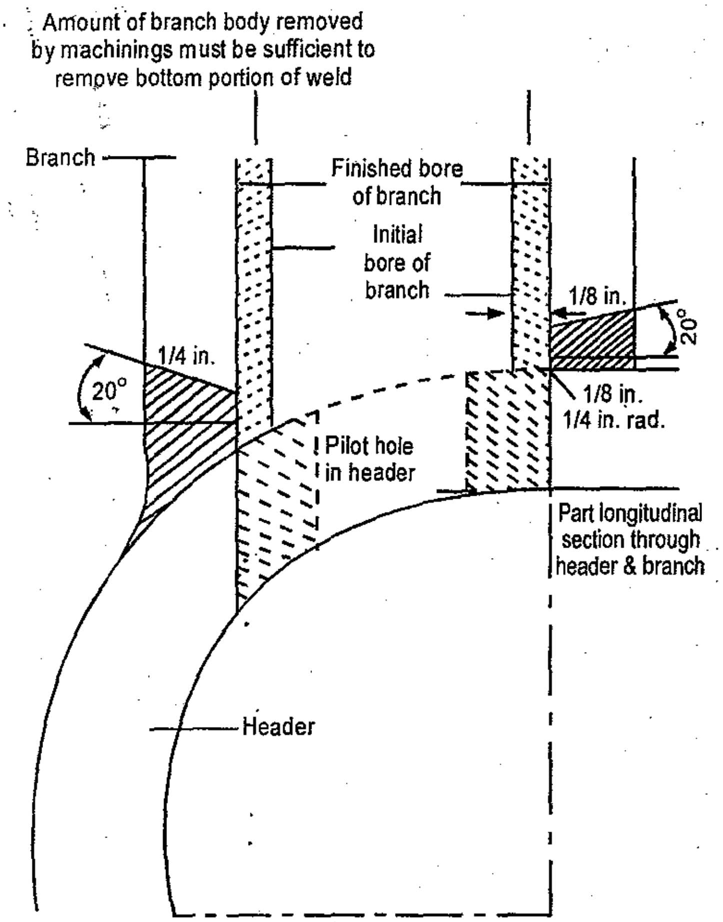


FIG. 27A — BRANCH WELDED ON HEADER WITH INTERNAL MACHINERY

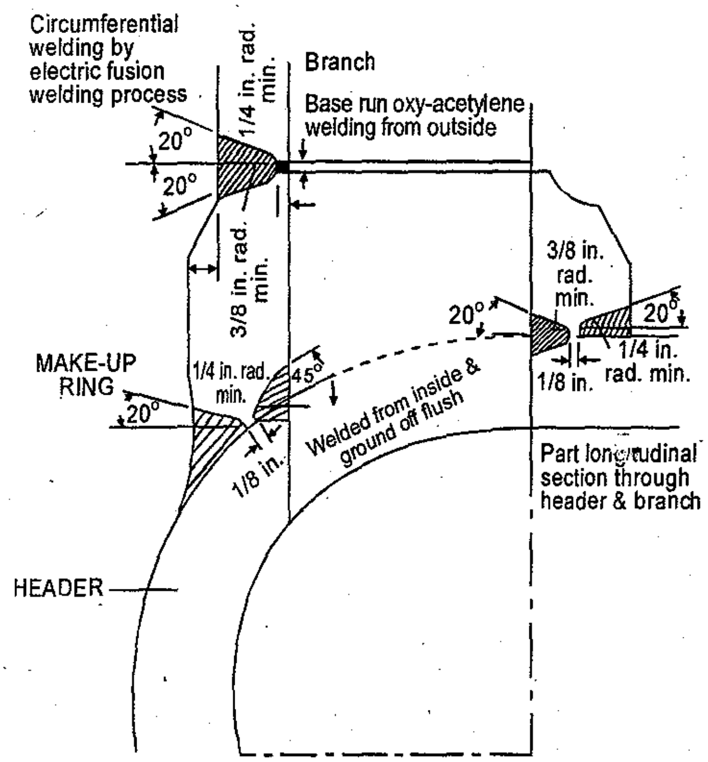


FIG. 27B

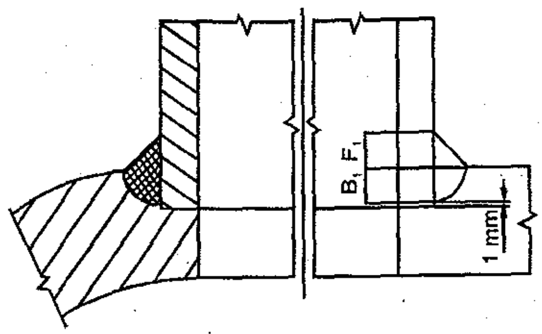


FIG. 27C — UNREINFORCED BRANCHES INACCESSIBLE FOR WELDING INSIDE SHELL

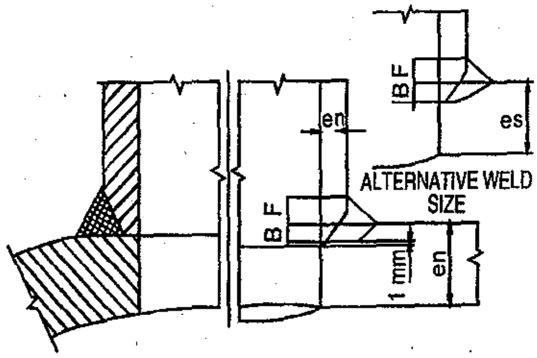


FIG. 27D — UNREINFORCED BRANCHES INACCESSIBLE FOR WELDING INSIDE SHELL

Notes:

The branch must be loose fit in the hole but the gap at any point, should not exceed 3 mm or en/2 whichever is less.

Welded sizes $B_1 + F_1 = 1.5$en.

F_1 should not exceed 16 mm not be less than en/2. Weld size B + F = 1.5en minimum or 1.5es minimum, whichever is less.

F should not exceed 16 mm nor be less than en/2.

en = Thickness of nozzle.

es = Thickness of shell.

CHAPTER VI

VALVES, GAUGES AND AUXILIARIES

281. *Requisite Mountings, Fittings and Auxiliaries

Every boiler shall be provided at least with the following:—

Two safety valves, one of which may be a high steam and low water type safety valve. In no case should the bore of the seat of the valve be less than 19 mm (3/4").

Two means of indicating water level:

A steam pressure gauge;

A steam stop valve;

A feed check valve;

One feed apparatus: When the heating surface exceeds 200 square feet—two independent feed apparatus, each such apparatus shall have a capacity of not less than the maximum continuous rating of the boiler. (For boilers in battery *see* Regulation 336A); and

A blow-down cock or valve;

Fusible plugs as provided under Regulation 331;

An attachment for Inspector's test gauge;

A manhole, where size and construction permit, and such mudholes or sightholes as are necessary for effectively cleaning the boiler.

In the case of boilers fitted with integral superheaters, an additional safety valve shall be fitted at the end of the superheaters outlet header.

In the case of boilers with no fixed steam and waterline, the fitting of such accessories that are manifestly not needed or used, such as water gauges, water columns and gauge cocks, may not be insisted upon.

Two independent feed apparatus mean feed apparatus to which power is supplied from two independent sources or from a main or mains to which two sources of generation are connected or from a common steam main feed by two or more active boilers or, a combination of any of the above.

In the case of automatic or semi-automatic oil-fired or gas-fired boilers, low water alarms may be fitted in preference to fusible plugs provided such boilers are equipped with automatic tripping device to

* **Note:** It is recommended that in Lancashire and Cornish Boilers one of the safety valves should be of a high steam and low water type. In Water Tube and Horizontal Multi-tubular Boilers, a low water alarm directly operated by steam should be fitted. Rams-bottom type safety valves consisting of two valves and with spring and lever in common may be considered as two safety valves for the purpose of this Regulation.
In the case of Marine Type boilers low water alarm may be fitted in place of a fusible plug.

disconnect fuel supply and to start the feed pump simultaneously in the event of low water in the boilers.

In the case of a single boiler of the Shell type and not connected in a battery with other boilers, the heating surface of which does not exceed 102/2 (1 : 100 sq. ft.) two independent sources of power supply to the two feed apparatus will not be necessary.

In the case of miniature boilers coming under Chapter XIV the Steam pressure gauge may be connected to the steam space or to a steam connection to the water column by a syphon tube or equivalent device that will keep the gauge tube filled with water. If brass or bronze composition is used the minimum size of the syphon tube shall be 6 mm. (¼ in.) standard pipe size; for other materials the minimum inside diameter of the pipe or tube shall be 13 mm. (½ in.)

For Electrode boilers, *see* Regulation 437.

281A. Additional Requirements for Automatic Boilers only

(1) **General**—Every boiler which is provided with the appropriate water level and/or firing control, to allow for automatic working, shall comply with the following requirements:

(a) In the event of failure of automatic control, boiler shall be capable of being brought under immediate manual control.

(b) In those cases where the control and alarm devices are housed in chambers external to the boiler, the following shall apply:

(i) The boiler shall have provision made for isolating the steam and water connections of the chambers from the boiler. Such isolating valves shall be capable of being locked in the open position and should preferably be of the parallel slide type but if screw down stop valves are fitted, those on the water connection shall be mounted with the spindle horizontal to avoid the possibility of an air lock. The steam and water connections of the chambers shall be not less than 25 mm. bore. In those cases where sequencing control water valves are fitted, the steam isolating valve may be omitted;

(ii) The boiler shall have means provided to test the operation of the control or alarm and to blow through separately the water connection and the chamber to prevent the accumulation of deposits. The means provided for flowing through shall be sequencing valves or equivalent devices so arranged that the water connection to the boiler cannot be shut off unless the drain connections to the chamber is open;

(iii) The boiler shall have a drain system from the chambers which provides a visual indication of flow. Tundishes of adequate size, placed in a prominent position shall be used wherever practicable.

(c) Where the boiler is provided with electrical equipment for water level and firing control, it shall have this equipment so designed that any fault in the circuits caused both in the fuel and air supply the boiler to be automatically shut off. Positive means requiring manual resetting shall be provided to cut off the fuel and air supplies to the boilers should there be a failure of electricity supply to water level and/or firing control equipment. All electrical conductors and equipment in connection with water level and firing controls shall be of adequate size and shall be properly insulated and protected against danger including adequate protection against the ingress of moisture and the effects of high temperature.

(d) Where the evaporating capacity of the boiler is greater than 3700 kg/h, it shall have automatic water level alarms and firing controls and can be tested regularly without altering the level of water in the boiler. The water level alarms may be incorporated in the automatic control system.

With a perceptable water level which are arranged for automatic working and not intended for continuous supervision shall be provided with an entirely independent and separately operated over-riding control in addition to the water level and firing controls specified in clauses (2) and (3). The over-riding control shall comply with the following requirements:

(i) Cut off fuel supply to the burners or the fuel and air supply to solid fuel stoker and operate an audible alarm when the water level in the boiler falls to a pre-determined low water level;

(ii) Be of the lock-out type and so arranged that control or its electrical circuit has to be manually reset before the boiler can be brought back into operation;

(iii) Be provided with its own entirely independent electrical control circuit.

(e) Where mounted externally to the boiler, the over-riding control shall—

(i) be provided with its own chamber;

(ii) comply with the requirements of clause (b).

(2) **Automatic Water Level Control**—Automatic water level controls shall be as follows:

(a) float or displacer operated; or

(b) operated by electrical probe or thermostat; or

(c) operated by other approved principle subject to satisfaction of the Inspecting Authority.

The control equipment shall regulate the feed-water supply to the boiler in order to maintain effectively the level of water in the boiler between pre-determined limits.

(3) **Automatic Firing Controls**—Automatic firing controls shall comply with the following requirements—

(a) At all times they shall control effectively the supply of fuel and air to the combustion equipments.

(b) They shall shut off the fuel supply to the burners or the fuel and air supply to the stoker under the following conditions:—

(i) Flame failure or pilot flame failure in the cases of gas, oil or pulverised fuel fired boilers. This control shall be of the lock-out type required to be manually reset;

(ii) Failure to ignite the fuel at the burner within a pre-determined time. The control shall be of the lock-out type required to be manually reset;

(iii) When the water level in a boiler with a perceptible water level falls below a pre-determined safe level. The control shall also cause an audible alarm to sound;

(iv) Failure of forced or induced draught fans or any automatic flue damper;

(v) Increase in furnace pressure to a pre-determined valve.

Note: The above provisions do not apply to once-through forced circulation boiler.

GENERAL REQUIREMENTS

282. Materials, Temperature and Pressure Limits

(a) **Materials**—The materials used in the manufacture of the boilers of the fittings shall comply with the following requirements:—

(i) Steel castings shall comply with Regulations 73 to 80.

(ii) Steel forgings shall comply with Regulations 81 to 85.

(iii) Iron casting shall comply with the Regulations 86 to 93.

(iv) Bronze castings shall comply with the following requirements, namely:

Chemical Composition		*Grade A*	*Grade B*
Tin		5.5 to 8.0%	4 to 6%
Lead		1.0 to 3.0%	4 to 6%
Zinc		3.0 to 6.0%	4 to 6%
Total of all elements other than those set out above and excluding Copper and incidental Nickel		0.50%	0.50%
Copper plus incidental Nickel		Balance	Balance
	Physical Properties Ultimate tensile Strength	22 kg/mm^2 (14 tons/sq. in.)	20.5 kg/mm^2 (13 tons/sq. in.)
Sand Cost (cast on)	Elongation per cent minimum on standard test piece C	8%	15%
	Ultimate tensile Strength	23 kg/mm^2 (14.5 tons/sq. in.)	20.5 kg/mm^2 (13 tons/sq. in.)
Sand cost (separately cast)	Elongation per cent minimum on standard test piece C	12%	15%

(v) The seats and discs of valves shall be made of non-corrodible metal.*

* By non-corrodible metal is meant specially Resident to Corrosion and/or erosion.

(b) **Limits of Cast Iron**—Cast Iron shall not be used for:—

(a) Temperatures above 220°C.

(b) Pressure exceeding 13 bar gauge.

(c) Valves exceeding 200 mm nominal bore which are connected directly to the boiler.

(d) Wedge or double disc gate valves which are connected directly to the boiler.

(e) Boiler blow down fittings.

Explanation—The expression connected directly to the boilers covers and valve which cannot itself be isolated from the boiler.

Note: Spheroidal iron may be used for temperature not exceeding 282°C and pressure not exceeding 17.58 kg/cm^2 provided it complies with the following requirements in respect of the physical properties.

(a) 0.2% proof stress 250 kg/mm^2;

(b) minimum elongation per cent 12.

(c) **Limits of Copper Alloy**—Copper alloy shall not be used for temperatures above 225°C where the valves are connected directly to the boiler. In the case of valves not connected directly to the boiler this temperature limitation may be increased to 260°C.

METHOD OF CONSTRUCTION

283. Castings

(a) All castings shall be smooth, sound and free from flaws, or other injurious defects. Variations in thickness at any part shall be gradual and substantial fillets shall be provided.

(b) The body of a boiler mounting shall be connected to the boiler flange by a strong and stiff neck. In no case shall the thickness of the neck of bronze mounting be less than 3/16 inch for sizes upto and including 3/4 inch bore or 1/4 inch for sizes over 3/4 inch bore.

284. Packing of Cocks

The bodies of all cocks except those for pressure gauges shall be packed with asbestos or other heat resisting material and shall be of substantial design, those over one inch bore shall have special provision, other than the gland for securing the plug.

Water gauge column cocks may be either asbestos packed or solid plug type.

285. Covers and Spindles

(a) Valves of 1½ inch bore and over directly connected to boilers, and other valves of 2½ inch bore and over where fitted with a cover shall have such cover secured by bolts or studs and the screwed portion of the spindle shall be outside the stuffing box. All valves for superheated steam shall be fitted with an external screwed spindle.

(b) Where the covers of valves are secured by studs, the studs screwed into the body with full thread for a length of at least one diameter. The stud holes shall not penetrate into the pressure space of any casting.

(c) Valves with screwed covers shall be fitted with suitable locking device to prevent rotation of the cover.

286. Direction of Operation

Valves shall be clearly marked to indicate the direction of flow. Valves directly connected to boilers shall be fitted with indicators to show clearly whether the valve is closed or open and all valves shall open by anti-clockwise rotation.

287. Moving Parts

The valves and spindles shall be efficiently guided and means shall be provided in every case to prevent them leaving their guides. The working parts shall have sufficient clearance to ensure freedom of movement under all conditions of service.

288. Flanges

(a) Flanges shall be in accordance with the tables for the appropriate pressure (Appendix E).

(b) In the case of safety valves the drilling, thickness and bolting of inlet flanges shall be in accordance with tables for the appropriate pressure and material and for the diameter of flange adopted. In the case of outlet flanges the pressure taken shall be the pressure on the outlet side of the valve.

(c) For the purpose of determining particulars of flanges for blow down and scum pipe fittings, the design pressure of the fittings shall be assumed to be the working pressure of the boiler.

(d) All flanges shall be machined on the face, spot faced, or machined at the back, and the bolt holes shall be drilled.

289. Valve Seatings

Where separate seats are fitted they shall be efficiently secured. Means shall be provided in every case to prevent the valves leaving their guides.

290. Chests etc. in General

(a) All chests and fittings shall be smooth, sound and free from flaws, cracks or other injurious defects. After completion, the chests shall be tested hydraulically at the manufacturing works to at least twice the working pressure of the boiler for which they are intended.

Hydraulic test shall be made with water which may contain a corrosion inhibiter, with kerosene or with other suitable liquid provided its viscosity is not greater than that of water at a test temperature not above 52°C.

(b) Valves may be fabricated from seamless steel pipes of pressures not exceeding 250 pounds per square inch and temperatures not exceeding 800°F. The welding should conform to Regulation 125 and valve chest should be stress relieved after fabrication. Valves meant for use in pipe work may also be fabricated by welding from seamless steel pipes but no restriction as above regarding pressure and temperature shall apply to them provided the welding complies with all the relevant requirements of fusion welding such as stress relieving and radio-graphic inspection of the weld and the liked prescribed in Chapter V of these Regulations.

The working pressure of the chests shall be determined by Equation 21 or 91A, whichever is applicable, where the term '2 Se' shall be substituted by the term '1.8 × S'.

(c) The working pressure and the thickness of the Bronze and Cast Iron Valve chests shall be determined by the following formulae, subject to the minimum thickness as specified in Regulation 283(b):

$$W.P. = \frac{R \times (T - C)}{4.5 \times D} \qquad \text{Eqn. (76)}$$

$$P = \frac{4.5 \times WP \times D}{R} + C \qquad \text{Eqn. (77)}$$

where, R is the minimum specified tensile strength of the grade of the material,

D is the external diameter of the chest,

T is the minimum thickness of the chest, excluding tolerance, and

C is the minimum positive tolerance as specified hereunder:

For Bronze Chests C = 1.5 mm

For Cast Iron Chests C = 5 mm

(d) The working pressure and the thickness of the steel valve chests of circular cross-section shall be determined by the following formulae, namely:

$$\text{Working Pressure} = \frac{2f(T - C)}{D - T + C}$$

$$T = \frac{WP \times D}{2f + WP} + C$$

where, f = allowable stress in kg/mm^2 for the material at the working metal temperature 't' to be determined on the basis given below:

The allowable stress 'f' at or below 454°C is the lower of the following two values:

$$f = \frac{Et}{1.5} \qquad f = \frac{R}{2.7}$$

For temperature above 454°C the least of the following three values—

$$\text{(a) } f = \frac{Et}{1.5} \qquad \text{(b) } f = \frac{Sr}{1.5} \qquad \text{(c) } f = Sc$$

where, Et = minimum value of yield point (0.2 per cent proof stress) at temperature 't',

R = minimum specified tensile strength for the grade of steel concerned at room temperature,

Sr = the average stress for the grade of steel concerned to produce rupture in 100,000 hours.

If the width of the scatter band of results obtained when determining this value exceeds ± 20 per cent of the average value, then SR shall be taken as 1.25 times the minimum stress at temperature 't' to produce rupture in 100,000 hours;

Sc = the average stress to produce an elongation (creep) for the grade of steel concerned of 1 per cent in 100,000 hours at temperature 't'. For metal temperature 't' below 250°C values 'f' for 250°C shall be used.

Note: In case Sc values are not available in Material Standard and such materials are known to have been used in boiler in India or abroad, then for such materials, the allowable stress may be taken as the lower of

$$\frac{Et}{1.5} \text{ or } \frac{Sr}{1.5}$$

Note: The allowable stress for cast steel shall be 80 per cent of that determined on the above basis.

D = the external diameter of the chest,

T = the minimum positive tolerance as specified hereunder:

For Cast Steel Chest	C = 5 mm
For Forged or Stainless Steel Chest	C = 2.5 mm

Note: Over and above the calculated thickness, additional thickness needed for assembly stresses, valve closing stresses, shapes other than circular and stress concentrations, shall be provided by the manufacturers to the satisfaction of the Inspecting Authority.

(e) The number of valves and fittings which shall be made available to the Inspecting Officer (excluding mechanical tests) shall be as follows:—

upto and including 51 mm	10 per cent
over 51 mm and upto and including 76 mm	15% of the number of chests
over 76 mm and upto and including 114 mm	20% of the number of chests
over 114 mm	100 per cent

If the Inspecting Authority is satisfied that the manufacturer has adequate facilities for testing and inspection of valves intended for service pressure exceeding 10.5 kg/cm^2 or temperature exceeding 204°C and actually tests each fitting at his works, the Inspecting Authority may, at his discretion, undertake test on a sample basis.

(f) The working pressure and the minimum thickness of the steel valve chest of spherical cross-section shall be determined by the following formula, namely—

$$\text{Working Pressure} = \frac{4f(T-C)}{D-0.8(T-C)}$$

$$T = \frac{WP \times D}{4f + 0.8\,WP} + C$$

where, T = the minimum thickness of the chest,

D = the external diameter of the chest,

f = allowable stress for the material to be determined on the basis given in clause (d) above,

C = the minimum positive tolerance as specified hereunder:

For Cast Steel Chest	C = 5 mm.
For Forged or Stainless Steel Chest	C = 2.5 mm.

SPECIAL REQUIREMENTS SAFETY VALVES

291. General

Safety valves, ordinary, high lift and full lift, shall be so constructed that breakage of any part will not obstruct the free and full discharge of steam from the boiler.

292.

(a) **Ordinary Lift Safety Valve**—A safety valve in which the valve head lifts automatically a distance of at least D/24 with an over-pressure not exceeding 10% of the set pressure. There shall not be any mechanical stop which would prevent the valve head from being lifted a distance of at least D/8. D is the minimum bore of the Body seat.

(b) **High Lift Safety Valve**—A safety valve in which the valve head lifts automatically a distance of at least D/12 with an over pressure not exceeding 10% of the set pressure. There shall not be any mechanical stop which would prevent the valve head from being lifted a distance of at least D/8. D is the minimum bore of the body seat.

(c) **Full Lift Safety Valve**—A safety valve in which the valve head lifts automatically a distance such that the area of discharge which limits the flow through the valve is between 100% and 80% of the minimum area at any section at or below the body seat. This lift is achieved by a rapid opening within an over-pressure not exceeding 5% of the set pressure.

293. Minimum Aggregate Area

(a) **Discharged Capacity of Safety Valves:**

(a) **Saturated Steam**—The rated discharge capacity of a safety valve which discharges saturated steam shall be calculated using the following equation:

$$E = CAP \qquad \text{Eqn. (78)}$$

where, E = is the rated discharged capacity of saturated steam (kg/h),

P = is the highest pressure of any safety valve mounted on the boiler (bar absolute),

A = is the area (mm^2).

For the ordinary lift and high lift safety valve, A is the area of the minimum bore of the body seat. For full lift safety valves A is the area of discharge described in clause (c) of Regulation 292 and its valve can only be obtained from the safety valve manufacturers. C is a constant taken from the following table, appropriate to the type of the valve or as established by tests carried out in accordance with Appendix L:

Type of valve	*Value of the constant 'C'*
Ordinary lift	0.05
High lift	0.10
Full lift	0.24

(b) **Superheated Steam**—The rated discharge capacity of a safety valve which discharges superheated steam shall be calculated using the following equation:

$$Es = \frac{E}{\sqrt{1 + \frac{2.7\,Ts}{1000}}} \qquad \text{Eqn. (79)}$$

where, Es = is the rated discharge capacity of superheated steam (kg/h),

E = is the rated discharge capacity of saturated steam calculated using Equation 78 (kg/h),

Ts = is the degree of superheat (°C).

Equation 79 may be used to determine the rated discharge capacity of safety valves at super-critical steam pressure. In these cases the saturation temperature of the steam shall be taken as 375°C.

(c) The total peak load evaporation of a boiler shall be calculated on the basis of evaporation not less than 30 kg/hr/m^2 of heating surface (exclusive of superheater and non-steaming economiser). In the case of Waste Heat Boilers, however, when the evaporation per square metre of the heating surface is certified by the manufacturers to be less than 30 Kg. the minimum number of safety valves required may be calculated on the basis of the actual maximum evaporation of the boiler.

294. Over-Pressure of Safety Valves

The safety valves shall be so designed that they attain rated discharge capacity with the over-pressure not greater than that given in Regulation 292; provided that the safety valves which have a discharge area less than 80 per cent of the flow area, the over-pressure at which the design lift is attained shall not exceed 10 per cent of the set pressure. For safety valves having discharge area 80 per cent or more of the flow area, the over-pressure at which the design lift is attained shall not exceed 5 per cent of the set pressure.

295. Pressure Drop

The safety valves shall be reset at a pressure at least 2.5% below, but not more than 5% below the safety valve set pressure. The 5% limit is increased to 10% for valves having a body seat bore less than 32 mm and or having a set pressure of 2 bar gauge or less.

296. Mountings of Safety Valves

(a) Safety valves shall be mounted, without any intervening valve, on pads or branches used for no other purpose. The axis of the valve shall be vertical. The cross-sectional area of the bore of each pad or branch shall be at least equal to the area of the bore at the inlet of the safety valve, or where two or more safety valves are mounted on the same pad or branch, at least equal to the sum of the areas of the inlet bores of all the safety valves.

(b) Branches shall be as short as possible so as not to impair the proper action of the safety valves or impose any undue stress on the branches at their point of attachment to the boiler. Nothing shall obstruct free flow to the safety valve. Branches, particularly when full lift safety valves are mounted on them, should be radiused at the inlet. The inlet and outlet flanges shall be drilled in accordance with the approximate table in Appendix E for the diameters of flanges adopted.

297. Openings in Shell

No accessories other than those integral with the Safety Valve shall obstruct the openings in the boiler shell. Discharging steam shall have direct access to the safety valve without flowing through internal pipes.

298. Discharge Passage

The safety valve discharge pipes shall comply with the requirements of clauses (a) and (b) of this regulation. The discharge pipe shall be as short and straight as possible and be fitted with open drain to prevent accumulation water in the pipe. Suitable arrangement shall be provided in the discharge pipe system so that the discharge can readily be heard by the Boiler Attendant.

(a) **Steam Safety Valves:**

(i) **Ordinary and High Lift Valves**—Where a waste steam pipe is fitted the pipe and the passage leading to it shall have a cross-sectional area not less than the minimum combined area of the safety valves required by Regulation 293.

(ii) **Full Lift Valves**—For full lift valves the area of waste steam pipe and passages leading to it shall have a cross-sectional area not less than twice A, or such area above this minimum as may be required for valves having a higher approved constant, where A, E and P are as defined in Regulation 293.

(b) **Economiser Safety Valves**—The area of the discharge pipe from an economiser safety valve shall be at least twice the area of the valve seating.

Where the discharge from several economiser safety valves is connected to the main discharge pipe, the diameter of the main discharge pipe shall be designed to prevent accumulation of pressure due to the formation of steam under the particular conditions of temperature and pressure which may be applicable.

299. Drainage

For each enclosed safety valve chest a means of draining shall be provided. The drain pipe shall be laid with a continuous downward gradient clear of the boiler to a place where the discharge is visible and cannot do injury to any person.

300. Moving Parts

The valves and spindles shall be efficiently guided and means shall be provided in every case to prevent their lifting out of their guides. The working parts shall have sufficient clearance to ensure freedom of movement under all conditions of service. The spindle shall not be fitted with a stuffing box.

301. Bearings for Levers

The bearings of the levers of lever valves shall be so designed as to allow of free working of the valve under all conditions of service. Where the lever is mounted on pin bearings, the holes in the lever shall be bushed with non-corridible metal, or the pins shall be of non-corrodible metal.

302. Attachments of Weights and Springs

(a) In a lever and weight safety valve the weight shall be in one piece and attached to the lever in such a way that the safety valve cannot be over-loaded.

(b) In the case of spring loaded safety valves, washers or ferrulus shall be fitted under the adjusting screws so that the valves cannot be over-loaded when under the steam. Interference with load on the spring, after the safety valve has been adjusted, shall be prevented by the fitting of a ferrule under the adjusting screw collar or by using a lock nut on the adjusting screw which shall be further safeguarded by means of a padlock or other suitable device. Where springs are in tension, links or other suitable stops shall be fitted to prevent the spring being extended a greater amount than that corresponding to a valve lift of D/4.

where, D = diameter of valve seating.

303. Easing Gear

Safety valves shall be so arranged that they can be eased off their seats when under pressure and the easing lever shall positively lift the valve.

304. Lift

Safety valves shall be capable of being lifted a distance such that the area of the discharge edge shall not be less than the minimum aggregate area. A in Reg. 293.

305. High and Low Water Alarms

High and low water alarms shall be adjusted so that the alarm is sounded with the water level visible in the gauges.

306. Final Settings

Each safety valve shall, before leaving the maker's works be adjusted to blow-off at the specified pressure.

306A. Adjustment of Safety Valve Set Pressure

The set pressure of a safety valve may be adjusted using air or other gas as the test medium provided that the safety valve has been subjected previously to hydraulic test in accordance with the requirement of clause (a) of Regulation 290.

307. Materials

(a) **Springs**—The springs shall be manufactured from steel made by the Acid Open Hearth or Electric Process and the Chemical composition shall be within the following limits:

Carbon Steel

Element	*Per cent*	
	Min.	*Max.*
Carbon	0.90	1.20
Silicon		0.30
Manganese	0.45	0.80
Sulphur		0.050
Phosphorus		0.050

Silicon Manganese Steel

Element	*Per cent*	
	Min.	*Max.*
Carbon	0.50	0.65
Silicon	1.50	2.00
Manganese	0.70	1.00
Sulphur		0.050
Phosphorus		0.050

Alloy Steel

	Grade I	*Grade II*	*Grade III*	*Grade IV*
Carbon %	0.55 to 0.65	0.46 to 0.54	0.55 to 0.65	0.55 to 0.65
Manganese %	0.70 to 1.00	0.70 to 0.90	0.70 to 1.00	0.70 to 1.00
Silicon %	0.10 to 0.35	0.10 to 0.35	0.10 to 0.35	1.70 to 2.10
Chromium %	0.60 to 0.90	0.80 to 1.10	0.40 to 0.60	0.20 to 0.40
Molybdenum %	—	—	0.15 to 0.25	0.20 to 0.30
Vanadium %	—	0.15 min.	—	—
Nickel %	—	—	0.40 to 0.70	—
Phosphorous %	—	—	—	—
Sulphur %	—	—	—	—

The manufacturers shall supply an analysis of each cast when required by the Inspecting Authority to do so. Should independent analysis be required, these shall be made at the rate of one per cent.

All springs shall be formed hot and suitably hardened and tempered.

All the springs above 16 mm bar diameter shall be formed hot and the springs below 16 mm bar diameter shall be formed hot or cold. The springs shall be suitably hardened and tempered.

(b) **Torsion Bars**—Torsion bars shall be manufactured from steel which shall have a yield point of not less than 141 Kg/mm^2 (90 tons/sq. in.)

Note: Special steels developed by individual manufacturers may be accepted by the Chief Inspector of Boilers at their discretion.

308. Dimensions

For ordinary lift valves, the compression or extension of safety valve springs required to load the valves to the set pressure shall not be less than one quarter of the diameter of the valve due consideration being given in the case of spring loaded lever safety valves to the ratio of leverage. The proportion of unloaded length to external diameter of the spring shall not exceed 4:1.

These requirements do not apply to full lift and high lift safety valves.

309. Determination of Working Pressure

(1) The maximum working pressure to be allowed for steel springs of round, square or rectangular section shall be determined from the following formulae for springs in extension:

(a) Round section—

$$W.P. = \frac{10,000\pi d^3}{DACK} \qquad \text{Eqn. (80)}$$

(b) Square section—

$$W.P. = \frac{33,333 d^3}{DACK} \qquad \text{Eqn. (81)}$$

(c) Rectangular section—

$$W.P. = \frac{160,000 B^2 H^2}{DACK(3B + 1.8H)} \qquad \text{Eqn. (82)}$$

For Springs in Compression—The working pressure calculated by the above equation may be increased by 25 per cent.

where, (all dimensions in inches):—

$$K = \frac{4\left(\frac{D-1}{d}\right)}{D} + \frac{0.615}{D} \qquad \text{Eqn. (83)}$$

(In case of rectangular section substitute B for d)

W.P. = working pressure in lb. square inch (set pressure),

A = loading area of valve,

d = diameter of round or side of square steel,

B = breadth of wire (radial to spring axis),

H = depth of wire (parallel to spring axis),

D = mean diameter of coil,

C = constant = $\frac{L_1 + L_2}{L_1}$ Eqn. (84)

L_1 = initial compression or extension of the spring to give the required loading (W.P. × A),

L_2 = the further compression or extension of the spring to give the lift as defined in Regs. 292 and 304.

EXAMPLES:

C = 2 where compression or extension of spring to give the required loading is ¼ diameter of valve.

C = 1.5 where compression or extension of spring to give the required loading is ½ diameter of valve.

C = 1.25 where compression or extension of spring to give the required loading is full diameter of valve.

Note: (1) The above formulae are based on the maximum allowable safe stress of 5,624 kg/cm^2 (80,000 lbs. per square inch) on the sections of the springs under extension and 7,030 kg/cm^2 (100,000 lbs. per square inch), where they are in compression.

(2) The above values of "C" apply only to the case of "full-lift" Safety Valves, where L_2 is equal to D/4. In case of "high-lift" and "ordinary lift" Safety Valves, respective values of "C" may be worked out by using appropriate values of L_2.

(2) In the case of torsion bars the maximum shear stress as calculated from the following formula shall not exceed 55 kg/mm^2 (80,000 lbs. per square inch).

$$fs = \frac{TDC}{2J}$$

where, fs = shear stress,

T = torque at set pressure,

D = outside diameter of the bar,

J = polar moment of inertia of the section of the bar, and

$$C = \frac{\text{angle of twist at full lift valve}}{\text{angle of twist at set pressure}}$$

(as furnished by the manufacturer).

The dimensions of sleeve transmitting the torque shall be of substantial proportions for the material used.

310. Test

(1) The permanent set in the spring (defined as the difference between free height and height measured ten minutes after the spring has been compressed solid three additional times, after pre-setting at room temperature) shall not exceed 0.5% of the free height.

(2) Torsion bars shall not show a permanent distortion after being twisted to an angle fifty per cent in excess of the working angle.

311. Extension Springs

Extension springs shall be made from round section wire.

312. Number of Effective Coils

The number of effective or free coils in a compression or extension spring shall be determined from the following formulae:

(i) For Round or Square Wire

$$N = \frac{KCd^4}{SD^3} \qquad \text{Eqn. (85)}$$

(ii) For Rectangular Wire

$$N=\frac{66B^3H^3K}{(B^2+H^2)SD^2} \qquad \text{Eqn. (86)}$$

where, N = number of effective coils,

K = compression or tension in inches at set pressure,

C = 22 for round, 30 for square steel,

d = diameter or side of square steel in 16th of an inch,

S = load on spring in lbs. at blow off pressure,

D = mean diameter of coil in inches,

B = breadth of wire in 16th of an inch,

H = depth of wire in 16th of an inch.

313. Spacing of Coils

The space between the coils when the valve is lifted to 1/4th of its diameter, shall be not less than 1.6 mm (1/16 inch) for full lift valves and 0.8 mm (1/32 inch) for ordinary and high lift valves.

314. Finishing of Ends

Compression springs shall have their ends ground flat and smooth and at right angles to the axis of the springs over the full circumference so that when placed on end on a horizontal plane the springs will stand perpendicular.

STOP VALVES

315. Lever Valves

Where the valve is operated by means of a lever, whether hand or mechanically controlled, the lever shall be of ample strength and the bearings shall be so designed as to allow of free working of the valve under all conditions of service.

316. Steam Stop Valve

(a) The stop valve connecting the boiler or superheater to the steam-delivery pipe shall be located as near the outlet from the final superheater header as is convenient and practicable or in case of boilers without superheaters as close as practicable to the drum. Where two or more boilers are connected with a steam receiver or any other vessel, a steam stop valve shall be fitted between the boiler and such receiver or vessel.

(b) Steam stop valves shall be attached direct to the boiler shell or to suitable pads or stand blocks and the neck or the valve chest shall be reasonably short and of strong construction. The steam stop valve may also be attached to a stand pipe, a connecting pipe or the superheater header. The attachment may be made by bolted flanges or butt-welded joints. Such butt-welded joints shall be suitably stress relieved, where necessary:

Provided that in the case of a larger boiler in which it is proposed for the purpose of drainage or owing to obstruction, to connect the steam-pipes to the steam stop valve at a higher level than would be obtained under this Regulation, a vertical stand pipe not exceeding 5 diameters in height will be permitted between the stop valve and the boiler. Such stand pipes shall be of strong construction and of wrought iron, mild steel, or cast steel. The flanges of wrought iron or mild steel pipes shall be riveted or welded to the pipes, and there shall be no branch on the stand pipe for any other connection:

Provided also that in the case of large boiler in which it is desired to fit a tee piece for the purpose of providing a branch connection between the stop valve and the boiler, such a tee piece may be so fitted. The tee piece shall be of strong construction, of wrought iron, mild steel, or cast steel and shall not exceed 2½ diameters in height. A stop valve shall be fitted direct to each tee piece branch.

(d) When two or more boilers are connected to a common steam main and there are no combined stop and isolating valves fitted to them, an automatic isolating valve shall be compulsory. In the case of boilers fitted with welded pipes, fitting of an independent automatic isolating valve shall be compulsory.

BLOW-DOWN COCK OR VALVE AND PIPES

317. General

The blow-down cock or valve shall be of substantial construction. The waste pipe attached to the cock or valve shall not be bound fast in earth or brick work and shall discharge at a point where there is no danger of injury to any person. These pipes shall not be connected to a pipe common to another boiler. The continuous blow-downs may, however, be connected to a common header discharging freely to an adequately vented tank or sump. The headers shall be of sufficiently large cross-section and the blow-off tank shall be provided with a vent pipe free from valves and of sufficient size to prevent accumulation of pressure. If, however, the tank is intended for collecting flash steam, a safety valve of adequate capacity shall be provided. The tank shall be so located that all parts will be accessible for inspection.

318. Blow-Down Mountings

(a) Each boiler shall be fitted with a suitable blow-down valve or cock placed at, or as near as practicable, to the lowest point of the boiler.

(b) For locomotive, vertical and marine type boilers, the valve or cock shall be attached direct to the boiler or to a suitable pad or stand pipe. For water tube boilers the valve or cock shall be outside the brick work with a substantial steel pipe between it and the mud box.

(c) For Cornish and Lancashire boilers the cock or valve may be attached to a cast steel elbow pipe of substantial section bolted to a suitable stand pipe or pad riveted to the boiler. But cast iron elbow pipes shall not be permitted.

319. Blow-Down Valve or Cock

(a) Each valve or cock shall be fitted with a device which shall indicate clearly its open and closed positions, and any key or similar device for operating the valve or cock shall be such that it cannot be removed unless the valve or cock is fully closed.

(b) The locking feather shall be secured by welding.

(c) Cocks fitted with taper plugs shall be of the bolted cover type with separate packing glands.

WATER GAUGES

320.

(a) Every boiler shall have two means of indicating the water in it of which one shall be conventional gauge glass:

Provided that in the case of boiler drums below 3 feet (91 cm) diameter where there is difficulty in fitting two water gauges, two test cocks and a glass water gauge shall be fitted.

(b) The lowest visible part of the glass of the water gauge and lower test cock shall be fixed at safe working level. For locomotive type and vertical boiler this shall not be less than 50 millimetres above the highest part of the firebox roof plate. Minimum length of the visible portion of the gauge glasses shall be 200 mm. The length may be increased depending upon the capacity of the boiler by the Chief Inspector/Director of Boiler of the manufacturing State.

(c) Glass water gauges shall be so placed as to be easily seen and reached by the boiler attendant. The fittings of glass water gauges and test cocks shall be of substantial make with large passage ways through them to facilitate cleaning. The gauge cocks when open shall have their handles in a vertical direction and each handle at its junction with the plug shall be plainly marked with a deep line to indicate the direction of the passage way through the plug. When detachable handle are provided arrangement shall be made to prevent incorrect fitting of the handles.

321. Drains

A drain cock or valve with a suitable discharge pipe shall be fitted to each water gauge.

322. Protectors

Where tubular glass water gauges are fitted, substantial protectors shall be provided. The glass shall be suitably treated to prevent splintering.

323. Glass Size

Tubular water gauge glasses shall be not less than 1/2 inch and not more than 3/4 inch outside diameter.

324. Safety Devices

Water gauge glass mountings shall be fitted with self-closing devices in the bottom arms and it is recommended that a similar device should be fitted in the top arm.

325. Gauge Columns

Where the gauges are mounted on a column there shall be no connecting passage between the top and bottom arms of the column unless valves or cocks are fitted between the columns and the boiler.

326. Isolating Cocks

Where isolating cocks or valves connecting water gauge pipes to the boiler are fitted, they shall be not less than 1 inch bore and of the bolted cover type with separate packing gland.

PRESSURE GAUGES

327. Dials

(a) For pressure upto and including 35 Kg/cm^2, pressure gauge dials shall be graduated in Kg/cm^2 from Zero to twice the pressure as nearly as may be practicable.

(b) For pressure exceeding 35 Kg/cm^2 the range of the graduation shall be from Zero to one and a half times the maximum permissible working pressure, as nearly as may be practicable, but in no case shall the maximum graduation on the gauge be less than 70 Kg/cm^2.

(c) The scale on the dial shall be clearly and permanently marked in Kg/cm^2.

(d) The dial of each pressure gauge shall have to be marked upon it in red. The maximum permissible working pressure.

(e) Where the gauge is compensated for a head of water between the gauge and the boiler connection, the amount of such compensation shall be marked on the dial. Pressure gauge shall be calibrated within an accuracy of +1 per cent. Boiler pressure gauges shall not be less than 150 mm in diameter.

(f) The travel of the pointer of the dial gauge shall not exceed 325°C.

328. Connections

All pressure gauges shall be fitted with a syphon pipe and a cock or valve integral with, or adjacent to, the gauge in such manner that the gauge may be shut off and removed whilst the boiler is under steam.

329. Gauge Cocks

The handles of the gauge cocks shall be parallel to the pipes in which they are located when the cocks are open and marks shall be cut on the shank of the cock indicating open position.

330. Test Connections—Inspector's Pressure Gauge Attachment

Every boiler shall be fitted with a valve or cock carrying in a vertical position a receiving screw for attachment of the Inspector's pressure gauge. The receiving socket shall be tapped for M/20 × 1.5 metric threads and shall be fitted with an easily removable cap.

FUSIBLE PLUGS

331. General

(1) Fusible plugs shall be of sufficient height and fitted in such a position as to give early protection to all parts of the boiler liable to damage by the direct application of furnace heat in the event of shortness of water.

> **Note:** For example—In Lancashire Boilers the fusible plugs should be in the crowns of the furnaces from 12 inches to 18 inches in front of the brick work fire bridge.

(2) On boilers having wet back reversing chamber, a minimum of two fusible plugs shall be fitted; one on the crown of the reversing chamber and the other on one of the tube plates. On boilers not having wet back reversing chamber, at least one fusible plug shall be provided on the front end tube plate. The plug shall be fitted in such a way that in the event of fusion of the plug, the pressure inside the boiler shall push the pellets out.

332. Type

Fusible plugs shall consist of an outer body with a central conical passage the smallest part to be not greater than ½ inch for plugs suitable for pressure upto 100 lbs. per sq. in. and not greater than 3/8 inch for plugs for pressures exceeding 100 lbs. per sq. in. The passage shall be closed by a plug secured by an annual lining of fusible alloy so that the plug may drop clear if the lining melts.

The portion of the body carrying the fusible metal should preferably be detachable from the base to allow of easy replacement without removing the whole fitting from the boiler.

333. Material

The non-fusible portions of the plug shall be of bronze except where the nature of the boiler water precludes the use of a non-ferrous material. The fusible metal shall be an alloy melting readily at a temperature not less than 150°F in excess of the saturated steam temperature at the maximum permissible working pressure of the boiler.

334. Attachment to Boiler

Wherever practicable fusible plugs shall be screwed into the boiler plates from the water side. The screwed portion shall have threads of Whitworth form not more than 11 per inch.

FEED VALVES

335. General

(a) Feed check valves shall be of the non-return type.

(b) Where the valve is not of screw-down non-return type a separate screw-down valve shall be provided.

(c) The discharge from the feed check valve or from the internal feed pipe (if provided) shall be above low water level and in the case of Lancashire and Cornish boilers shall be at least 5 ft. beyond the fire bridge. Provided that the restriction aforesaid regarding the position of feed discharge level would not apply in the case of water tube boilers.

(d) The discharge end of feed pipe shall be so located that it is not close to any riveted joint of the furnace plates or of the shell.

336. Operating Position

Feed check valves or regulating valves shall be so arranged as to enable them to be satisfactorily operated from the boiler floor.

336A. Requirements as to Feed Apparatus in Certain Cases

In the case of a battery of boilers connected to a common feed range, the requirements of Regulation 281 in respect of the number of feed apparatus shall be considered to have been fulfilled provided a total supply of feed water, not less than the combined maximum continuous rating of all active boilers can be maintained even if any one of the sources of power supply should fail.

CHAPTER VII

BOILER AND SUPERHEATER TUBES, HEADERS & OTHER PARTS

TUBES

337. Material and Construction

(a) All tubes which are subject to internal pressure of water or steam shall be cold drawn or hot finished seamless or electric resistance welded in accordance with Regulations 36 to 63. Except as provided for in clause (b) below they shall be without joint.

(b) Tubes having an external diameter not exceeding 5 inches may be jointed and such joints may be flashed welded, machine forge welded arc or gas welded. Tubes have 5 inches diameter may also be welded provided they are located outside the furnace. Such welds must conform to the requirements of Chapter VIII.

(c) Flash welding shall be undertaken on a welding machine of a type approved by the Inspection Officer and the external fin caused by welding shall be completely removed. The internal fin caused by welding shall also be removed subject to a maximum height of 20 per cent of the wall thickness of the tube.

(d) Arc welded butt joints shall be made by the metallic shielded arc process and post-weld heat treated effectively except in the following cases:

For alloy steel—

(i) in case of 0.5 Molybdenum steels if thickness does not exceed 13 mm and outside diameter does not exceed 127 mm;

(ii) in case of 1 Chromium ½ Molybdenum steel if thickness does not exceed 13 mm and outside diameter does not exceed 127 mm and pre-heated to 125°C;

(iii) in case of 2¼ Chromium 1 Molybdenum steel, post-weld heat treatment is not necessary under the following conditions:

(1) a maximum specified Chromium content of 3.0%,

(2) a maximum nominal outside diameter of 102 mm,

(3) a maximum thickness of 8 mm,

(4) a maximum specified Carbon content of 0.15%,

(5) a minimum pre-heat temperature of 150°C.

For carbon steel—

(i) a maximum Carbon percentage of 0.30;

(ii) a maximum thickness of 9 mm.

(e) When gas welding is implied the technique followed shall be approved by an Inspecting Officer and all welds shall be suitably heat treated.

(f) For design metal temperature over 454°C (850°F) material to be used shall be in accordance with Regulations 48, 53 and 56A.

(g) The technique employed in all field welding of tubes shall be subject to the approval of the Chief Inspector of Boilers.

Where, however, material used is in conformity with the Code of the country of manufacture and it is covered by these Regulations, the permissible stress figures specified in the Code at different temperatures may be accepted in lieu of figures computed from the data required to be furnished under Regulations 338 and 340 in any of the following cases:

(i) Where a certificate is furnished from the Inspecting Authority to the effect that the steel complies with requirements of the grade steel (to be specified) and that the permissible stress for the working conditions as allowed for in the code of the country of manufacture falls within the limits permissible under the Regulations.

(ii) Where the basis upon which these stresses have been arrived at is made available and such basis is not found to be such as to give rise to stresses higher than those permissible under the Regulation.

(h) The finning of the tubes by any method duly approved by the Inspecting Authority and subsequently inspected and certified by them shall be accepted.

338.

(a) The Working Pressure of the tubes shall be determined by the following formula:

$$W.P. = \frac{2f(T-C)}{(D-T+C)} \qquad \text{Eqn. (87)}$$

where, T = minimum thickness of tubes, that is, nominal thickness less the permissible negative tolerance in mm (inch),

C = 0.75 mm (0.04") for working pressure upto and including 70 kg/cm^2 (1000 lbs./sq. inch)

or C = 0 for working pressure exceeding 70 kg/cm^2 (1000 lbs./sq. inch),

W.P. = working pressure of boiler in kg/cm^2 (lbs./sq. inch),

D = external diameter of tube in mm (inch),

f = permissible stress for the material at the working metal temperature in kg/cm^2 (lbs./sq. inch) to be determined on the basis given below:

The working metal temperature shall be taken as—

(a) For integral economiser tubes, the maximum water temperature for which the part of the element is designed plus 11°C (20°F).

(b) For furnace and boiler tubes, the saturation, temperature corresponding to the working pressure plus 28°C (50°F).

(c) For convection superheater tubes, the maximum steam temperature for which the part of the element is designed plus 39°C (70°F).

(d) For radiant superheater tubes the designed maximum steam temperature plus 50°C (90°F).

Permissible working stress for tubes:—

For temperature at or below 454°C,

$$\frac{Ts}{2.7} \text{ or } \frac{Et}{1.5} \text{ whichever is lower}$$

For temperature above 454°C

$$\frac{Sr}{1.6} \text{ or } Sc \text{ whichever is lower}$$

where, Ts = minimum tensile strength of the material at room temperature,

Et = yield point (0.2% proof stress) at working metal temperature 't',

Sr = the average stress to produce rupture in 100,000 hours and in no case more than 1.33 times the lowest stress to produce rupture at the working metal temperature,

Sc = the average stress to produce an elongation of 1 per cent (creep) in 100,000 hours, at the working metal temperature.

Note: In case Sc values are not available in Material Standard and such materials are known to have been used in boilers in India or abroad, then for such materials the allowable stress may be taken as the lower of

$$\frac{ET}{1.5} \text{ or } \frac{Sr}{1.5}$$

(b) In no case, however, shall the thickness of tubes as supplied be less than those given in the table below (subject to tolerances specified in Regulations 36(d), 43(d), 48(c), 53(c), 56A(IV) and 58(d):

TABLE

Outside diameter	*Seamless Hot finished*	*Seamless Cold drawn or electric resistance welded*
Upto and including 32 mm. (1¼")	2.9 mm. (0.116 in.)	2.03 mm. (0.08 in.)
Upto and including 51 mm. (2")	3.25 mm. (0.128 in.)	2.34 mm. (0.092 in.)
Over 51 mm (2 in.) upto and including 76 mm. (3 in.)	3.35 mm. (0.128 in.)	2.64 mm. (0.104 in.)
Over 76 mm. (3 in.) upto and including 89 mm. (3½ in.)	3.25 mm. (0.128 in.)	3.25 mm. (0.128 in.)
Over 89 mm. (3½ in.) upto and including 114 mm. (4½ in.)	3.66 mm. (0.144 in.)	3.66 mm. (0.144 in.)

In the case of coiled tubes for boilers of the forced flow of forced circulation type, the minimum thickness of tubes as supplied may, however, be as follows:

Outside diameter of tubes in inches	*Minimum thickness*
Upto and including 29 mm. (1-1/8")	1.62 mm. (0.064")
Over 29 mm. upto and including 35 mm. (1-3/8")	1.83 mm. (0.072")
Over 35 mm. (1-3/8") upto and including 42 mm. (1-5/8")	2.34 mm. (0.092")

(c) (i) **General**—Tubes that are hot or cold bent for parts of boilers, including economizers, furnace walls, superheaters and reheaters, shall comply with this clause and suitably heat treated.

Butt welds shall not be permitted within bends.

Thinning and departure from circularity limits shall be demonstrated by one of the following methods:

(a) relevant and satisfactory service experience;

(b) a procedure test;

(c) by measurement of 2% of the bends, including the first bend of each shift.

The method selected shall be at the option of the manufacturer.

(ii) **Thinning on tube bends**—Thinning on tube bends shall comply with the following:

(a) At any location around the bend extrados, the reduction in thickness (in per cent) below the calculated minimum permissible design thickness of the straight tube, except where permitted by (b), shall not exceed:

$$\frac{100}{\frac{4R}{D} + 2}$$

where, R = is the mean radius of the bend to the centre line of the tube (in mm),

D = is the ordered outside diameter of the tube (in mm).

(b) Bend thickness below the minimum value required under (a) shall be permitted in cases where the manufacturer can demonstrate by bursting tests carried out on at least three bends that the strength of the bend is not less than that of the straight tube.

(c) Where the amount of thinning at any location around the bend extrados on cold formed bends exceeds 25% of the actual thickness of the tube on the straight the bends shall be suitably heat treated. The actual thickness of the same plans as the line of the extrados at each and of the bend.

(iii) **Departure from circularity in tube bends**—The departure from circularity at the bend apex shall not exceed 10% for bends performed in a single bending operation and 15% for bends which are hot pressed after the primary, bending operation.

The departure from circularity (in per cent) shall be calculated from:

$$\frac{D_{max} - D_{min}}{D} \times 100$$

where, D_{max} = is the maximum outside diameter measured in the tube bend apex (mm),

D_{min} = is the minimum outside diameter measured at the same cross-section as D_{max} (mm),

D = is the ordered outside diameter of the tube (in mm).

HEADERS AND SIMILAR PRESSURE PARTS

339. Material and Construction

The materials and construction shall comply with Regulations 154-245.

340. Rectangular Headers Symmetrical in Form

(a) The working pressure shall not exceed the smaller of the value obtained from the following formula:

(i) $$W.P. = \frac{cf\,(t - C_1)^2}{b^2}$$ Eqn. (88a)

(ii) $$W.P. = \frac{6.25t^2.f.E}{w^2}$$ Eqn. (88b) where, W.P. = working pressure,

t = thickness,

b = internal breadth between the supporting sides of the header,

c = 3.413 for wrought steel and 2.926 for steel castings,

Where the sides are corrugated or otherwise reinforced by substantial supports so that the length of the portion between the corrugations or supports does not exceed b, shall be taken as 5.82 for wrought steel and 5.12 for steel castings,

f = permissible stress at working metal temperature as given in the table under clause (c),

c_1 = 0.08 cm. (0.03 in.),

w = internal width of the header between the tube plate and the opposite side,

E = efficiency of ligaments between the holes.

(b) If the faces of the headers are machined locally at the tube holes or hand holes the thickness at the part may be as much as 4.8 mm (3/6 in.) less than given by the above equation; but irrespective of the thickness obtained by the use of the formulae, the thickness of the headers at the tube holes shall be not less than:—

$$t = \sqrt{(C \times d + C_1)} \qquad \text{Eqn. (89)}$$

where, t = thickness,

d = diameter of the hole,

C = 0.2235 mm. (0.088 in.),

C_1 = 6.4 mm. (1/4 in.).

In no case shall the thickness be less than 8 mm (5/16 in.) except that in small patches not exceeding 322 mm^2 (one-half sq. in.) in area, the thickness may be 50 per cent of the thickness used in the Equations 88(a) and 88(b).

(c) The permissible stress at working metal temperature shall be as given in the table below:—

Table: Permissible Stress at Working Metal Temperature for Rectangular Section Heaters

Working Metal Temperature in degrees		*Cast steel 44-45 Kg. mm^2 (28 to 35 tons/sq.in.)*		*Carbon and Alloy Steels*
C	F	Kg/cm^2	lbs./sq.in.	The lower value obtained in each case at the specified temperature calculated on the following basis:

Contd...

Contd...

288	550	703	10,000	For temperatures at or below 454°C (850°F) $\frac{Ts}{2.7}$ or $\frac{Et}{1.5}$
316	600	635	9,000	For temperatures above 454°C (850°F)
343	650	562	8,000	$\frac{Sr}{1.6}$ or Sc
371	700	532	7,560	
399	750	505	7,200	
427	800	475	6,750	
454	850	443	6,300	
482	900	309	4,400	

where, Ts = minimum tensile strength of the material at room temperature,

Et = yield point (0.2% proof stress) at the working metal temperature 't',

Sr = the average stress at the temperature 't' to produce rupture in 100,000 hours and in no case more than 1.33 times the lowest stress to produce the rupture in 100,000 hours,

Sc = the average stress at the temperature 't' to produce an elongation of 1% (creep) in 100,000 hours.

(d) The working metal temperature shall be taken as:

For saturated steam and water drums and headers the saturation temperature corresponding to the working pressure of the boiler plus 28°C (50°F).

For superheater headers the designed maximum steam temperature for the header plus 28°C (50°F).

(e) Where headers are adequately protected from the gases of combustion or swept by such gases in the third or subsequent pass of a boiler, the working metal temperature shall be taken as the saturation or designed maximum steam temperature as defined above, whichever applies. A covering or refractory or insulating material which may be liable to become dislodged shall not be deemed adequate protection.

(f) **End Attachments**—The ends of rectangular headers may be formed integral with the header or attached by welding.

The working pressure for the flat ends shall be calculated by the following formula:—

$$W.P. = \frac{f(t-C)^2}{d^2K} \qquad \text{Eqn. (89A)}$$

where, W.P. = working pressure,

f = permissible stress for the material at the working metal temperature,

t = thickness of the plate at the weakest part,

d = the least width between the walls of the rectangular header,

C = 1 mm (0.04"),

K = 0.32 for ends integral with or flanged and butt welded to the header,

= 0.40 for ends directly strength welded to the header in an approved manner.

341. Headers Irregular in Form

In cases where the headers are of such irregular form as to render impracticable the application of a formula for the determination of thickness, the manufacturer shall show the suitability of the headers for the working conditions by indicating practically the maximum internal hydraulic pressure which a header, made to the same design and of similar material, will withstand without permanent deformation. The maximum working pressure for similar headers may then be determined by the following formulae:—

Permissible stress at working metal temperature

$$W.P. = \frac{P_1 \times C}{F \times D} \qquad \text{Eqn. (90)}$$

where, W.P. = The working pressure in lbs. per sq. in.,

P_1 = The maximum internal hydraulic pressure withstood without permanent deformation,

F = 1.75 for wrought steel and 2 for cast steel,

C = 15500 for wrought steel of 24 tons per sq. in. minimum ultimate tensile stress,

= 16500 for wrought steel of 26 tons per sq. in. minimum ultimate tensile stress,

= 18000 for wrought steel of 28 tons per sq. in. minimum ultimate tensile stress,

= 21000 for wrought steel of 32 tons per sq. in. minimum ultimate tensile stress,

= 22000 for wrought steel of 34 tons per sq. in. minimum ultimate tensile stress,

= 15500 for cast steel of 28 tons per sq. in. minimum ultimate tensile stress.

342.

(a) **Cylindrical Headers**—Where cylindrical headers are provided their working pressure shall be determined by Equation 72.

(b) **End Attachments**—The attachment of ends and the method of calculating the working pressure shall be in accordance with clause (i) of Regulation 340.

Subject to the following modifications:—

K = 0.19 for ends integral with or flanged and butt welded to the header,

= 0.28 for ends directly strength welded to the header in an approved manner, and

d = internal diameter of the header.

CHAPTER VIII
STEAM-PIPES AND FITTINGS

343.

(1) **Pipes**—Steam-pipes may be carbon steel, cast steel, alloy steel and in some cases of copper. Steel pipes may be solid drawn (cold or hot finished), butt welded or electric resistance welded. Copper pipes shall be solid drawn and no pipe made from electro-deposition of copper on a mandrill shall be used for steam delivery:

Provided that subject to satisfactory flattening test, pipes to IS: 1239 of 13 mm to 51 mm nominal bore for working pressure up to 10.5 Kg/cm^2 at saturation temperature shall be allowed for use for the pipes.

(2) Where, however, material used is in conformity with the Code of the country of manufacture and it is covered by these Regulations, the permissible stress figures specified in the Code at different temperatures may be accepted in lieu of figures computed from the data required to be furnished under Regulation 350 in any of the following cases:—

(i) Where a certificate is furnished from the Inspecting Authority to the effect that the Steel complies with requirements of the grade steel (to be specified) and that the permissible stress for the working condition as allowed for in the Code of the country of manufacture falls within the limits permissible under the Regulations.

(ii) Where the basis upon which these stresses have been arrived at is made available and such basis is not found to be such as to give rise to stresses higher than those permissible under the Regulations.

Where pipes have to be fabricated by longitudinal fusion butt electric arc welding of plates rolled to shape, the limits prescribed for butt welded pipes in Table 2 under Regulation 349 shall not apply. The requirements other than those relating to the minimum thickness of shell for fusion butt welding prescribed in Chapter XII shall be applicable to such pipes.

(3) Notwithstanding anything contained in Chapter VIII, the hydraulic test for pipes in maker's premises may be dispensed with by the Inspecting Authority:

Provided that these pipes have been fully tested by approved radiographic or ultrasonic techniques:

Provided further that in the case of pipes having internal diameter 600 mm and more, the plates used for the manufacture of pipes and the long seam welds of pipes are fully tested by approved non-destructive test; for example, ultrasonic or radiographic testing and the soundness of pipes both in the parent material and in the weld is established in the maker's premises; and the whole component of the pipes, after completion of any further fabrication and erection at site, are hydraulically tested at a pressure not less than 1.5 times the design pressure of piping system:

Provided also that in the event of detection of any defect after conducting hydraulic test of these pipes at site, it shall be the responsibility of the manufacturer to repair or replace the defective pipes, as may be deemed necessary by the Inspecting Authority.

(4) Electric fusion welded pipes in which the butt-welds are fully radiographed or ultrasonically tested need not be hydraulically tested in the shops provided the pipe system as a whole is hydraulically tested at site to the requisite test pressure in accordance with Regulation 374.

(5) In the case of fusion welded pipes test plates to represent all welded seams shall be attached at each end of longitudinal seam and tested in accordance with the requirements of Chapter XII except that one test plate may represent a lot of pipes upto 60 metres in length and of the same grade of material and same thickness of the pipe subject to the same heat treatment.

MATERIAL

344. Steel Pipes

(a) The pipes shall be made from steel made by an Open Hearth of Electric Process or by any of the Oxygen Processes. Hot finished seamless pipes may, however, be made of Bessemer Steel. Bessemer Steel shall not be used for pressures exceeding 21 Kg/cm^2 (300 $lbs.in.^2$) or temperatures exceeding 260°C (500°F). If the Bessemer Process is used, the steel shall be made by a manufacturer approved by the Inspecting Authority.

When used for temperatures exceeding 399°C (750°F) the steel shall be of non-segregated or fully skilled type.

(b) Carbon and alloy steel pipes shall not be used for design temperature exceeding those given in Table 2 of Regulation 349.

(c) For designed temperature over 427°C (800°F) special precaution shall be taken to ensure that the surface condition of the pipe is suitable for these requirements.

(d) The materials from which seamless and electric resistance welded pipes are made shall conform to the appropriate specification of tubes in Chapter II. The materials from which butt welded pipes are to be made shall conform to the requirements of Table 1 under Regulation 347.

345. Condition of Pipes

(a) All pipes shall be commercially straight free from longitudinal seaming, grooving, blistering or other injuries surface marks. The ends of the pipes shall be cut square.

(b) The pipes shall be made within the limits of tolerances given below—

Class	*Tolerance on*		
	Outside diameter		*Nominal thickness*
	Upto and including 51 mm. (2")	*Over 51 mm. (2")*	
Seamless E.R.W.	+ 0.4 mm (1/64") – 0.8 mm (1/32")	±1%	+ no limitation – 12.5%
Butt-welded	+1%	±1%	+ no limitation – 12.5%

MECHANICAL TEST

346. Number of Sets of Tests

The number of pipes on which mechanical tests shall be perfomed shall be as follows:—

Upto and including 114 mm. (4½ in.) o.d.	*As per requirements of Chapter II*
Over 114 mm. o.d.	5 per cent of the lengths of pipe as made, or 2 per cent of the pipes from each cast where the cast (i.e. melt) can be identified.
Welded pipes	2 per cent of the lengths of pipes as made.

In the case of pipes for designed temperatures over 454°C (850°F) every pipe over 114 mm. (4½ in.) outside diameter shall be tested.

347.

(a) **Flattening Test [for pipes upto and including 102 mm. (4 in.) nominal bore]**—As per requirements of Chapter II—

(i) For cold drawn seamless construction—Regulation 39.

(ii) For hot finished seamless construction—Regulation 44(b).

(iii) For molybdenum seamless construction—Regulation 49(b).

(iv) For chrome molybdenum seamless construction—Regulation 54(b).

(v) For electric-resistance welded tubes—Regulation 59(a).

(vi) For copper steam pipes—Regulation 35.

For pipes where the ratio between the wall thickness and the diameter would not permit the maintenance of the distance between the flat surfaces specified in the above regulation, this shall be limited to 2/3rd the bore of the pipe.

(b) **Cold Bend Test [for pipes over 102 mm. (4 in.) nominal bore]**—A strip not less than 38 mm. (1½ in.) wide cut circumferentially from one end of each selected pipe shall when cold withstand, without showing either crack or flaw being doubled over in the direction of original curvature round a bar, the diameter of the bar being:

For pipes upto and including 10 mm. (3/8 in.) thick	3 times the thickness
For pipes over 10 mm. thick	4 times the thickness.

(c) **Bend Test on the Weld**—A strip not less than 38 mm. (1½ in.) wide cut circumferentially from one end of each selected pipe with the weld near the middle of the strip, shall when cold withstand, without showing either crack or flaw, being doubled over in the direction of original curvature round a bar, the diameter of the bar being equal to eight times the thickness of the test piece, the weld being placed at the point of maximum bending.

In cases where the outside diameter of the pipe is less than 8 times the wall thickness, the diameter of the former shall be equal to 4 or 2/3rd of the nominal bore of the pipe, whichever is less.

(d) **Additional Test**—Should a pipe selected for testing fail in any one or more of the tests specified above, two further tests of the same kind may be made from the same or another pipes from the same batch. Should either of these further tests fail, the pipes represented may be reheat treated and then re-tested. If the repeat tests are satisfactory, the pipes shall be accepted provided they comply with other requirements but if failure again occurs, the pipes which the test pieces represent shall be rejected.

(e) **Tensile Test**—As per requirements of Chapter II.

(f) **Test for Valves and Fittings**—As per requirements of clause (e) of Regulation 290.

Table 1: Carbon Steel

Kind of pipes	*Butt-welded pipes*						*Sulphur per cent max.*	*Phosphorus per cent max.*
	Ultimate tensile strength in Kg/sq. mm (tons per sq. in.)		*Minimum elongation per cent*					
			On 203 mm. (8 in.)		*On 51 mm. (2 in.)*			
	Not less than	*Not more than*	*6 mm. (¼") thick & over*	*Less than 6 mm. (¼") thick*	*6 mm. (¼") thick & over*	*Less than 6 mm. (¼") thick*		
Strips cut from the pipes clear of the welds and tested in their curved position	35 (22)	44 (28)	20	18	32	30	0.05	0.05
Test lengths taken from finished pipes (ends of pipes to be plugged for grips)	35 (22)	44 (28)	25	23	—	—		

Contd...

Contd...

Selected Samples cut transversely	Ultimate tensile strength in kg./sq. mm (tons per sq. in.)		Minimum elongation per cent on 203 mm. (8")			Sulphur maximum %	Phosphorus maximum %
	Not less than	Not more than	13 mm. (½") thick & over	Less than 13 mm. thick and not less than 6 mm. (¼" thick)	Less than 6 mm. thick		
	36	44	23	20	20	18	0.06
	(23)	(28)		0.06	0.06	0.06	
						0.06	0.06

348. Method of Manufacture, Heat Treatment and Marking

(a) On completion of any work which involves heating, whether for hot bending of the pipe or for any other similar purpose, the pipe shall be carefully annealed.

(b) (i) The cold drawn seamless carbon steel pipes and welded carbon steel pipes shall be supplied in normalised condition.

(ii) Hot finished seamless carbon steel pipes shall be supplied in hot finished condition or in normalised condition at the option of the manufacturer.

(iii) The seamless alloy steel pipe either cold finished or hot finished and welded pipes shall be supplied in normalised and tempered condition.

(iv) By agreement between the users and the manufacturer, the pipes may be delivered in a condition other than normalised and tempered condition in which case they shall be suitable for subsequent manipulation and the user shall be informed of the heat treatment necessary to give required properties.

(c) (i) Pipe bending and forming (viz. reducing/swaging) operation shall be done by any hot or cold method and to any radius which shall result in a surface free from cracks, buckles or other defects as determined by the method of inspection specified in the design. A post-bending or post-forming heat treatment for carbon steel material is required with a nominal wall thickness in excess of 19.0 millimetres unless the bending or forming operations are performed and completed at normalizing temperatures, where no further heat treatment is required. The heat treatment where required shall be normalised or stress relieved, as the case may be.

(ii) A post-bending or post-forming heat treatment shall be required for all ferritic alloy steel material with nominal pipe size 100.00 millimetres and larger or with a nominal thickness 13.0 millimetres or greater.

(iii) If hot bending or forming is performed, the material shall received normalize and temper or tempering heat treatment as required by the design. For cold operation, tempering heat treatment shall be applied.

(d) **Marking**—Marking shall be carried out in accordance with Regulation 395F.

349. Steam Pipes and Fittings

The pressure and temperature limits within which pipes, tees, branches, etc., shall be used, shall be in accordance with Table 2.

TABLE 2: Maximum Permissible Working Pressure and Temperature

Material	*Method of manufacture*	*Maximum permissible working pressure*	*Maximum permissible temperature*		*Form*
			°C	°F	
Carbon Steel	Cold drawn seamless	No restriction	454	850	Straights, bends or fittings
	Hot finished seamless	-Do-	454	850	-Do-
	Butt-welded [Max. nominal bore allowable 102 mm. (4 in.)]	21 Kg./cm^2 (300 lb./sq.in.)	260	500	-Do-
	Electric resistance welded	No restriction	454	850	-Do-
Cast Steel	Castings	No restriction	454	850	-Do-
Molybdenum Steel	Cold drawn seamless and castings	No restriction	624	975	-Do-
Chromium Molybdenum Steel	Cold drawn seamless and hot finished seamless	No restriction	621	1150	-Do-
Copper	Solid drawn upto and including 127 mm. (5 in.) dia	12.6 Kg./cm^2 (180 lbs/sq. in.)	Not allowed for superheated steam		-Do-

350. Steel Pipes

The maximum working pressure allowed on steel pipes shall be determined by the following formulae:—

(a) Where the outside diameter is the basis for calculation

$$W.P. = \frac{2fe(t-c)}{D-t+c} \qquad \text{Eqn. (91)}$$

(b) Where the inside diameter is the basis for calculation

$$W.P. = \frac{2fe(t-c)}{D+t-c} \qquad \text{Eqn. (91A)}$$

where, t = minimum thickness,

W.P. = maximum working pressure,

f = allowable stress as provided under Regulation 271,

g = outside diameter of pipe,

d = inside diameter of pipe,

e = efficiency factor,

= 1.0 for seamless and for electric resistance welded steel pipes and for electric fusion welded steel pipes complying with the requirements of Chapter II in which the weld is fully radiographed or ultrasonically tested,

= 0.95 for electric fusion welded steel pipes complying with the requirements of Chapter II,

= 0.90 for welded steel pipes for values of t upto and including 22 mm,

= 0.85 for welded steel pipes for values of t over 22 mm and upto and including 29 mm,

= 0.80 for welded steel pipes for values of t over 29 mm,

C = 0.75 mm.

351. Cast Steel Pipes

(a) The material shall comply with Regulations 73 to 80.

(b) The maximum working pressure allowed on cast steel pipes shall be determined by the following formula:—

$$W.P. = \frac{2S(t-0.1.5D-C)}{D} \qquad \text{Eqn. (92)}$$

where, t = minimum thickness,

W.P. = working pressure,

D = external diameter of pipe,

S = allowable working stress as specified in Table 4 or Regulation 343,

C = 0.64 cm (0.25 in.).

TABLE 4: Maximum Permissible Working Stress for Carbon and Alloy Cast Steel Pipes (*See* Regulation 351)

Lower value obtained in each case at the specified temperature calculated on the following basis:—

For service temperature at or below 454°C (850°F)

$$\frac{Ts}{2.7} \text{ or } \frac{Et}{1.5} \text{ and } \frac{Et}{1.5} \text{ or } \frac{Sr}{1.5} \text{ or } Sc$$

For service temperature above 454°C (850°F) $\frac{Sr}{1.6}$ or Sc

352. Copper Pipes

(a) The material shall comply with Regulation 35.

(b) Copper pipes may be used for maximum design pressures and temperatures as given in the Table below:

TABLE: Maximum Design Pressures and Temperatures for Copper Pipes

Material	*Nominal size*	*Maximum design pressure*	*Maximum design temperature*	*Form*
Solid drawn copper pipes (Steam)	Upto and including 127 mm	17.5 kg/cm^2	207°C	Straight or bend
	Above 127 mm. and including 203 mm (8 in.)	12.3 kg/cm^2	207°C	
Solid drawn copper pipes (feed)	Upto and including 203 mm	21 kg/cm^2	149°C	

(c) Copper pipes shall not be used for superheated steam.

(d) The maximum working pressure on such pipes shall be determined by the following formula:—

$$W.P. = \frac{200 S \times 1}{D - t} \qquad \text{Eqn. (93)}$$

where, W.P. = Working pressure is kg/cm^2,

t = minimum thickness of tubes, that is nominal thickness less the pemissible negative tolerance in mm.,

D = Outside diameter of pipe in mm.,

S = maximum permissible design stress at the appropriate maximum design temperature in kg/mm.^{2} (*See* Table below)

Maximum Design Stress Value of S for Copper Pipes (in kg per sq. mm)
Maximum design stress for temperature not exceeding

60°C	121°C	149°C	177°C	207°C
4.9	4.31	3.5	2.66	1.75

Note: Where the conditions of service are such that corrosion, erosion or mechanical damage to the surface of tubes may occur, an appropriate thickness allowance shall be added to the minimum thickness of the tube.

FLANGES

353.

(a) **Flanges of Carbon Steel Pipes**—The material for carbon steel flanges, where forged, cast or cut from the plates (excluding branches forged integral with the pipes) shall be made of steel produced by an Open Hearth or Electric process or any of the Oxygen processes.

Carbon steel flanges shall not be used for temperatures exceeding 454°C (850°F). Flanges shall be made without a weld and shall be free from lamination or other defects, they may be secured by screwing, riveting or welding.

Blank flanges shall be of mild steel or cast steel and shall be not less in thickness than the flanges to which they are attached. The material shall comply with the requirements specified in relevant regulations of Chapter II or Chapter V of these Regulations.

(b) **Flanges of Alloy Steel Pipes**—The material for alloy steel flanges where forged, cast or cut from plates (excluding branches forged integral with the pipes), shall be made from the steel produced by an Open Hearth or Electric process. Flanges should be made without a weld and shall be free from lamination or other defects. The material of alloy steel flanges shall comply in all respects with the requirements of Regulation 234. The material for flanges shall be similar to that of the pipes to which they are to be attached. The flanges are to be so designed that the total stress induced in them does not exceed the maximum permissible stress as may be determined by the criteria laid down under Regulation 271.

Blank flanges of alloy steel shall be not less in thickness that the flanges to which they are to be attached. The material shall be similar to that of the flanges.

(c) **Non-ferrous Flanges**—The material for non-ferrous flanges shall be of bronze. The chemical composition shall comply with the requirements of sub-clause (iv) of Regulation 282(a). When flanges are attached to copper pipes by brazing, they shall be secured in such additional way (i.e. by riveting or forming a conical bore in the flange) so that the resistance to withdrawal from the flange does not depend wholly on the brazing.

354. Screwed on Flanges

Where flanges are secured by screwing the screw thread on the pipes and in the flanges shall be arranged to end at a point just inside the back of boss of the flange. After the flange has been screwed on, the pipe shall be expanded into the flange by a roller expander. Such screwed and expanded flanges may be used for steam for a maximum working pressure of 31.5 kg/cm^2 (450 lbs./sq. in.) and maximum temperature of 399°C (750°F) and for feed for a maximum pressure of 42 kg/cm^2 (600 lbs./sq. in.).

355. Loose Flanges

Loose flanges may be used where the joints are made by metal faces integral with ends of the pipes. Alternatively these joints may be welded or seal welded. The loose flange shall conform to the table given in Appendix E.

Where the joint is formed by integral flanges, these after machining shall be not less in thickness than the designed thickness of the pipe as calculated by Equation 91.

356. Riveted on Flanges

(a) Riveted on flanges shall only be used for pipes of 7" bore and above and for a maximum pressure of 350 lbs. per sq. in. and/or a maximum temperature of 750°F.

(b) The shear stress in the rivets shall not exceed 6000 lbs. per sq. in. when calculated by the following formula:

$$Sr = \frac{A_o \times P}{AN} \qquad \text{Eqn. (94)}$$

where, Sr = the shear stress in the rivets in lbs. per sq. in.,

A_o = cross-sectional area, calculated on outside diameter of pipe in sq. inches,

P = working pressure in lbs. per sq. in.,

N = number of rivets,

A = area of one rivet hole in sq. in.

(c) The stress in the pipe shall not exceed that specified in Table 3 when calculated by the following formula:

$$Sp = \frac{(A_o \times P)}{(A_o - A_1) - (N \times d \times t)} \qquad \text{Eqn. (95)}$$

where, Sp = the stress in the pipe in lbs. per sq. in.,

A_o = P and N have the values given above, and

A_1 = cross-sectional area, calculated on inside diameter of pipe in sq. inches,

d = diameter of rivet hole in inches,

t = minimum thickness of pipe in inches.

(d) The flange hub thickness shall not be less than 0.2 in. thicker than the minimum thickness of the pipe.

(e) The distance from the edge of the hub to the centre line of the rivets shall be not less than one and a half times the diameter of the rivet hole.

(f) The pipes shall first be properly expanded into the flanges or alternatively the flanges shrunk on to the pipes, the rivet holes shall then be drilled through the pipe and hub, and the holes afterwards countersunk to remove turrs.

(g) After riveting the flange hub shall be fullered at the back.

357. Welded on Flanges

(a) Where flanges are welded on, the welding shall be done by the oxy-acetylene or metal arc process the latter with covered electrodes which shall comply with Regulations 94 to 98.

(b) The proportion of the weld shall be as indicated in the Figure Nos. 28 to 34A of the following types:—

Type 1. Welding Neck Flange, Figure 28.

2. 'Face and Back' welded-on flange for metal arc welding, Fig. 29.

3. 'Bore and Back' welded-on flange for metal arc welding, Figs. 30 and 30 A.

4. 'Face and Fillet' welded-on flange for metal arc welding, Fig. 31.

5. 'Bore and Fillet' welded-on flange for metal arc welding, Figs. 32 and 32A.

6. 'Slip on' welded-on flange for metal arc welding, Fig. 33.

7. 'Slip on' welded-on bossed flange for oxy-acetylene welding, Fig. 34.

8. Socket welded flange, Fig. 34A.

The flange shall not be a tight fit on the pipe.

The maximum clearance between the bore of the flange and the outside diameter of the pipe shall be 3 mm (1/8") at any point, and the sum of clearance diametrically opposite shall not exceed 5 mm (3/16 in.).

Note: All dimensions shown in the figures of Types 1 to 7 relate to finished sizes.

The design conditions for each type are as follows:

Types 1, 2 and 3 flanges for all design pressure and temperature conditions.

Types 4 and 5 flanges for all pressure conditions upto and including 42 Kg/cm^2 (600 lbs./sq. in.) and design temperature not exceeding 399°C (750°F).

Types 6 and 7 flanges for all pressure conditions upto and including 17.6 Kg./cm^2 (250 lbs./sq. in.) and temperature not exceeding 399°C (750°F) except that Bossed flanges of Type 6 shall not be used on pipes over 304 mm (12") in nominal bore, nor Bossed flanges of Type 7 on pipes 152 mm. (6") in nominal bore.

Type 8 flanges for all design pressure and temperature conditions. This type shall be used only for pipes upto and including 51 mm (2 inches) nominal bore. These flanges shall not be used where severe erosion or corrosion is expected to occur.

(c) **Heat Treatment after Welding**—Types 1, 2, 3, 4 and 5 Carbon Steel types flanges welded on by the metal arc process shall have the welds stress relieved where the design depth of the weld recess is greater than 20 mm.

All welds joining flanges to alloy steel pipes shall be stress relieved.

(d) Where Type 1 flanges are attached by oxy-acetylene welding the welds shall be normalised.

(e) The procedure to be observed in the stress relieving and normalising of welds shall be in accordance with the following requirements:—

(i) **Stress Relieving**

(a) For Carbon Steel, a stress relieving heat treatment shall be performed by heating the part to at least 600°C ± 20°C.

When required by the characteristics of the material, different temperatures may be necessary to obtain appropriate stress-relieving. The part to be stress-relieved shall be brought slowly upto the specified temperature and held at that temperature for a period proportionate on the basis of at least two and a half minutes per millimeter of the maximum thickness of the part (approximately one hour per twenty-six millimeter of the thickness) and shall be left to cool in the furnace to a temperature which, for parts with the thickness greater than 20 millimeter does not exceed 400°C. After withdrawal from the furnace, the part shall be moved in a still atmosphere. A temperature time diagram of the stress-relieving process shall be provided when the Inspecting Authority requires it.

Note: Other stress-relieving heat treatments at a temperature as low as 550°C may be adopted, provided attention is given to the holding time in order to ensure a specific degree of stress relieving.

(b) For Alloy Steel, a stress-relieving heat treatment shall be carried out on the basis of the composition of the alloy as shown in the table below:

TABLE

Type of steel	*Range of temperature in degree centigrade*	*Time at temperature per mm of thickness of plate*
½ Mo ½ Cr ½ Mo	620 - 660	2.5 minutes (30 minutes min.)
1 Cr ½ Mo 1½ Cr ½ Mo	630 - 670	2.5 minutes (30 minutes min.)
2¼ Cr 1 Mo	650 - 750	2.5 minutes (1 hour min.)

Note: For pipes of 2¼ Cr 1 MO specification upto and including 127 mm outside diameter and upto 13 mm wall thickness, the time may be 30 minutes minimum.

The heat treatment of steels having Cr Mo V shall be carried out as per the requirements of the code of manufacture of plates, pipes.

(c) Stress-relieving shall be carried out by any of the following methods:

(1) Local heating using a portable muffle furnace, induction coils or other suitable appliances. Particular care shall be taken to apply heat uniformally over the area to be treated. The use of procedures that do not provide adequate control for this purpose, such as manual operation gas torches is not permissible. The temperature shall be measured by the thermo-couples pinned, welded or otherwise suitably attached to the surface of the pipe and where necessary, protected from flame impingement.

(2) Heating in a stationary industrial furnace. The temperature of the joint shall be measured by thermo-couples so disposed within the furnace as to give a true measure of the joint temperature.

(ii) **Normalising**—Welds in mild steel pipes shall be normalised by heating the metal to a temperature between 900 and 950°C (1650—1740°F), the temperature then being maintained for not less than two minutes for pipes upto and including 102 mm (4") bore, and for not less than five minutes for pipes over 102 mm (4") bore. Welds in pipes made from the alloy steel shall be normalised by heating the metal to a temperature between 925 and 975°C (1700—1790°F), the temperature then being maintained for not less than two minutes for pipes upto and including 102 mm (4") bore, and for not less than five minutes for pipes over 102 mm (4") bore. The higher temperatures of between 950 and 975°C (1740—1790°F), shall be used for alloy steels having a carbon content upto and including 0.12 per cent and the lower temperatures of between 925 and 950°C (1700—1740°F) shall be used for alloy steels having a carbon content of more than 0.12 per cent. After normalising the joint shall be covered with a suitable muff or asbestos cloth to ensure slow and even cooling. The normalising of welds in pipes upto 102 mm (4") bore may be carried out with welding flames the temperature being judged with the aid of a colour card, or measured by means of one or more thermo-couples or an optical pyrometer. The normalising of welds in pipes over 102 mm (4") bore shall preferably be carried out in a portable pipe normalising furnace or muffle, the temperature being measured by means of one or more thermo-couples or an optical pyrometer. The width of the zone to be heat treated to the specified temperature shall extend at least 13 mm. (1/2") on either side of the weld reinforcement.

358. Flanges of Copper Pipes

Flanges of copper pipes may be made of bronze. When flanges are attached to copper pipes by brazing they shall be secured in such additional way (e.g. by riveting the ends or forming a conical end so as to fit into the conical bore in the flange) that the resistance to withdrawal from the flange does not depend wholly on the brazing.

359. Standard Flanges

The size and thickness of flanges and the number and size of their bolts should be as shown in Appendix E.

360. Joints

(a) These Regulations provide for ordinary bolted flange joints. Special types of joints may be used, subject to the approval of the Chief Inspector.

(b) Arc welded butt joints of pipes or socket welded joints for pipes, valves and fittings shall be made by metallic shielded are process and post weld heat treated effectively except in the following cases:

For carbon steel—

(i) The nominal wall thickness in case of butt joints does not exceed 20 mm or carbon content does not exceed 0.25%;

(ii) The throat thickness of fillet weld for socket welded joints or other types of joints does not exceed 20 mm or carbon content does not exceed 0.25%.

Note: In case of carbon content for above cases lies between $0.25\% < C \leq 0.30\%$, the PWHT is not required for maximum thickness of 9 mm.

For alloy steel—

(i) In case of 0.5 Molybdenum steel, if the thickness, does not exceed 13 mm and outside diameter does not exceed 127 mm and for any fillet welds, the throat thickness does not exceed 13 mm.

(ii) In case of 1 Chromium and 1/2 Molybdenum steel, if the thickness does not exceed 13 mm and outside diameter does not exceed 127 mm and pre-heated to 125°C and for any fillet welds if the throat thickness does not exceed 13 mm.

(iii) In case of 2¼ Chromium 1 Molybdenum steel, post weld heat treatment is not mandatory under the following conditions:

(1) a maximum specified Chromium content of 3.0%;

(2) a maximum nominal outside diameter of 102 mm;

(3) a maximum thickness of 13 mm;

(4) a maximum specified carbon content of 0.15%;

(5) a minimum pre-heat temperature of 150°C;

(6) a maximum throat thickness of 13 mm in case fillet weld.

Method of Heat Treatment:

(1) For carbon steel, a stress relieving heat treatment shall be performed by heating the part to at least 600 ± 20°C.

When required by the characteristics of the material, different temperatures may be necessary to obtain proper stress-relieving. The part to be stress-relieved shall be brought slowly up to the specified temperature and held at that temperature for a period proportionate on the basis of at least 2½ minutes per millimetre of the maximum thickness of the part (approximately one hour per twenty-five millimetres of thickness) and shall be left to cool in the furnace to a temperature which, for parts with thickness greater than 20 millimetres, does not exceed 400°C. After withdrawal from the furnace, the part shall be allowed to cool in a still atmosphere.

A temperature-time diagram of the stress-relieving process shall be provided when the Inspecting Authority requires it.

(2) For alloy steel a stress relieving heat treatment shall be carried out on the basis of the composition of the alloy as shown in the table below:

Table

Type of steel	*Range of temperature*	*Time at the temperature per 25 mm of thickness of the plate*
1Cr 1/2Mo-1/2Cr 1/2Mo	620°C – 650°C	1 hour (1 hr. min.)
1Cr 1/2Mo-1¼Cr 1/2Mo	620°C - 660°C	1 hour (1 hr. min.)
2¼Cr 1Mo	625°C - 750°C	1 hour (1 hr. min.)

Note: This wide range for the post-weld heat treatment temperature is necessary because of the marked dependence of the mechanical properties of this steel on the tempering temperature. In production a definite temperature with a tolerance of ± 20°C would be selected to ensure that the mechanical properties upon which the design was based are in fact achieved.

Heat treatment shall be carried out by one of the following methods:—

(i) Local heating using portable muffle induction coil or other suitable heating appliance. Particular care shall be taken to apply heat uniformly over the area to be treated. The use of procedure that does not provide adequate control for this purpose, such as manual operation of gas torches, is not permissible. The temperature shall be maintained symmetrically over peripheral band of metal of a minimum width of three times the width of the butt-welded preparation. The temperature shall be measured by thermo-couples pinned, welded or otherwise suitably attached to the surface of the pipe and, where necessary, protected from flame impingement.

(ii) **Heating in stationary furnace**—The temperature of the joint shall be measured by the thermo-couples so disposed within the furnace as to give a true measure of the joint temperature.

In case the materials made to the foreign codes or standards are accepted under Regulation 3(2)(i), the method of heat treatment shall conform to that specified in the codes or standards.

(c) Such butt-welded joints conform to Fig. 28.

(d) Test on completed welds on pipelines:

(1) CLASSIFICATION

For the purpose of tests, pipelines shall be divided into two classes:

Class I. Pipelines for service conditions in which any one of the following limits is exceeded.

Design temperature	218°C (425°F)
Design pressure	17.6 kg/cm^2 (250 lbs./sq. in.)
Feed water	24.6 kg/cm^2 (350 lbs./sq. in.)

Class II. Pipelines for service conditions in which none of the foregoing limits is exceeded.

(2) IDENTIFICATION OF WELDS

The welders' identification mark shall be stamped without indentation, or stencilled adjacent to each completed weld.

(3) TESTS FOR CLASS I PIPELINES

(i) Where the completed pipelines are not subjected to hydraulic test:

Where the completed pipelines are not tested by the application of hydraulic pressure, the welds shall be subjected to the following inspection procedure:

Piping over 102 mm. (4 in.) bore—All butt-welds shall be subjected to non-destructive examination by radiographic or other approved methods. The entire circumference of the first five welds made by each welder shall be non-destructively examined. If these are found to be satisfactory and the Inspecting Officer or Inspector is in other respects satisfied with the welding techniques, methods of control and supervision employed, relaxation in the extent of non-destructive examination may be considered, but this relaxation shall in no case permit the non-destructive examination of less than one-third of the circumference of each of remaining welds made by the welder concerned.

Piping 102 mm. (4 in.) bore and under, but not less than 38 mm. (1½ in.) bore—Five per cent of the butt-welds made by each welder with a minimum of two welds per welder, selected at random shall be subjected to non-destructive examination by either radiographic or other approved methods or may be cut out for visual examination and bend tests.

Piping less than 38 mm. (1½ in.) bore—Special tests are not normally required but two per cent of the welds by each welder on a pipeline may be cut out from the pipeline for visual examination and bend tests.

(ii) Where the completed pipelines are subjected to hydraulic test:

Where the completed pipelines are tested by the application of hydraulic pressure, the welds shall be subjected to the following inspection procedure:

Piping over 102 mm (4 in.) bore—Ten per cent of the welds made by each welder on a pipeline with a minimum of two welds per welder, selected at random, shall be subjected to non-destructive examination by radiographic or other approved methods.

Piping 102 mm. (4 in.) bore and under, but not less than 38 mm. (1½ in.) bore—Two per cent of the welds made by each welder on a pipeline with a minimum of one weld per welder, selected at random, shall be subjected to non-destructive examination by radiographic or other approved methods or may be cut out for visual examination and bend tests.

Piping less than 38 mm. (1½ in.) bore—Special lists are not normally required but two per cent of the welds by each welder on a pipeline may be cut from the pipeline for visual examination and bend tests.

(4) TESTS FOR CLASS II PIPELINES

(i) All pipelines under this classification shall be subjected to hydraulic test on completion of erection.

(ii) On completion of the first ten production welds made by each welder, one of the welds shall be cut out for test purposes or alternatively, the welder shall prepare a test specimen made up of two similar lengths of piping welded in a position as closely representative of a selected production weld as is practicable. The test specimen shall be subjected to visual examination and bend tests.

(iii) Two per cent of the remainder of the welds made by each welder shall be selected at random and cut out for test purposes, or, alternatively the welders shall prepare a test specimen made up of two similar lengths of piping welded in a position as closely representative of a selected production weld as is practicable. The test specimen shall be subjected to visual examination and bend tests.

(iv) Notwithstanding anything contained in sub-clauses (ii) and (iii), the bend tests shall be dispensed with in case the welds have been non-destructively tested in the following manner:

A. **Piping over 102 mm. (4 in.) bore**—Five per cent of the welds made by each welder on a pipeline with a minimum of two welds per welder, selected at random shall be subjected to a non-destructive examination by radiographic or other approved methods.

B. **Piping 102 mm. (4 in.) bore and under**—One per cent of the welds made by each welder on a pipeline with a minimum of one weld per welder, selected at random shall be subjected to non-destructive examination by radiographic or other approved techniques.

(5) RE-TESTS

If any tests specimen is unsatisfactory, two further weld specimen for re-test shall be selected from the production welds and subjected to tests. In the event of failure of any of the re-test specimens, the production welds carried out by this welder subsequent to the previous test shall be subject of special consideration.

(e) **Socket Weld Joints**—Socket weld joints may be used with carbon and low alloy steel pipes not exceeding 60.3 mm. outside diameter. Such welds shall not be used where fatigue, severe erosion or severe corrosion is expected to occur. The working pressure of the socket weld fittings shall be determined in accordance with Equation 91 (Regulation 350). The thickness of the socket weld fittings shall not be less than 1¼ times the nominal thickness of pipe. The material shall be compatible with the associated piping.

(f) All butt-welded joints shall be subjected to non-destructive examination by radiographic, radioscopy or other approved methods such as ultrasonic testing, magnetic particle inspection or liquid dye penetrant inspection. When radioscopic examination is to be performed in lieu of radiography on welded components, the following requirements shall be met:—

(1) A written procedure shall be submitted for approval to the Inspecting Authority which shall contain the following:—

(i) material and the thickness range;

(ii) equipment qualifications;

(iii) test object scan plan;

(iv) radioscopic parameters;

(v) image processing parameters;

(vi) image display parameters;

(vii) image archiving requirements;

(viii) accept-reject criteria (Code reference);

(ix) performance evaluation;

(x) operator identification.

(2) The system shall be aided with an image processor to enhance the quality of the radioscopic images and system performance quality shall exhibit—

(i) a thin section contrast sensitivity of 3%;

(ii) a thick section contrast sensitivity of 2%;

(iii) a spatial resolution of 3 line pairs per mm;

(iv) *IQI sensitivity*—2% of the joint thickness when wire IQI's are to be used, the wire diameter axis shall be oriented along the axis of the least sensitivity of the system.

(3) Radioscopes are to be properly marked to co-relate with particular part of joint represented.

(4) The radioscopic examination data shall be recorded and stored on video-tape, magnetic disk or optical disk at the maker's plant for a sufficient period after the date of radioscopic examination as specified by the Inspecting Authority. Efficient radioscopic examination record shall be made available at any time over the record retention period and shall be traceable to the test objects.

(5) When repair has been performed as a result of radioscopic examination, the repaired areas shall be re-examined using the same radioscopic technique to evaluate the effectiveness of the repair.

(6) To aid in proper interpretation of the radioscopic examination data, the details of the technique used shall accompany the data. As a minimum, the information shall include the approved procedure requirements and system performance test data.

STEAM-PIPE FITTINGS AND CONNECTIONS

361. Wrought Bends

(a) Pipes of thickness determined in accordance with Equation 91 with increase of 12.5% shall not be bent to radii less than those given in the following Table. Where sheller radii are necessary, further allowance shall be made for thinning at the back of the bend except where it can be demonstrated to the satisfaction of the Inspecting Authority that the use of t b will not reduce the thickness below y t at any point after bending:

where, t = min. thickness as per Eqn. 91,

tb = min. thickness before bending.

TABLE: Minimum Bending Radii for Pipes of Thickness Determined in Accordance with Clause (a) of Regulation 361

Radii measured to centre line of pipe		
Outside diameter	*tb = 1.125 t* *all thickness*	*tb = 1.1 t* *tb = 34.92 mm. or above*
mm	*mm*	*mm*
26.9	63.5	
33.7	76.2	
42.4	101.6	
48.3	114.3	
60.3	152.4	
76.1	190.5	
88.9	228.6	
101.6	266.7	
114.3	304.8	
127.0	355.6	
139.7	381.0	
152.4	431.8	
168.3	457.2	
193.7	635.0	
219.1	711.2	
244.5	812.8	1143.0
273.0	1016.0	1270.0
298.5	1117.0	1397.0
323.9	1219.2	1524.0
355.6	1498.6	1778.0
406.4	1727.2	2032.0
457.0	2032.0	2086.0

(b) The thickness of the pipes, from which bends are made shall be such that the minimum thickness required by Equation 91 is maintained throughout after the bending operation. The deviation from circularity in percentage at any cross-section of a bend shall be calculated by the following formula:—

$$C = \frac{D_{max} - D_{min}}{D} \times 100$$

This deviation shall not exceed $\dfrac{20D}{R}$

where, C = the percentage deviation of circularity,

$D_{max.}$ = maximum external diameter of the pipe as gauged at the bend,

$D_{min.}$ = minimum external diameter of the pipe as gauged at the bend,

D = nominal external diameter of the pipe,

R = radius of the bend on the central line of the bend.

(c) Fabricated pipe bends may be made by welding together bevelled section of straight pipe, provided—

(i) the angle between the axis of the adjoining sections does not exceed 30°, and

(ii) the thickness is at least $\dfrac{K-0.5}{K-1}$ times the minimum thickness required for the straight pipe to which the bend is joined.

where, K = ratio of the radius of the bend (from centre of curvature to centre of pipe) to the inside radius of the pipe.

Note: Gusseted Bends shall be used for pressure not exceeding 21 kilogram per square centimetre and temperature not exceeding 260 Degree Centigrade.

(d) For the forged bends, the radii shall be not less than those given below:—

Long radii forged bends – R = 1.5 × d

Short radii forged bends – R = 1.0 × d

The thickness at any point of the bend shall not be less than 87.5% of the nominal thickness of the bend. The thickness at any point of the bend shall be such that the minimum thickness required by Equation 91 is maintained throughout after finishing operation.

361A. Butt-Welding Fittings

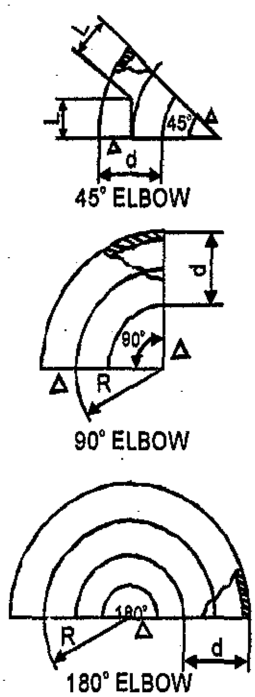
The butt-welding fittings shall conform to the dimension and tolerances given in the figure and table given below:

STEEL BUTT WELDING FITTINGS - REG. 361A

Nominal Diameter	d	R	L=
25	33.7	38	22
32	42.4	48	25.5
40	48.3	57	28.5
50	60.3	76	35
65	76.1* 73.0	95	45
80	88.9	114	51
100	114.3	152	63.5
125	139.7* 141.3	191	80
150	168.3	229	95
200	219.1	305	127
250	273.0	381	159
300	323.9	457	190
350	355.6	533	223
400	406.4	610	254
450	457.2	686	286
500	508.0	762	318
600	609.6	914.5	381

*Required O D to be specified

NOTES:
1. d = Outside diameter in mm.
2. R = Radius of bend in mm.
3. L = Approximate tangent length in mm.



STEEL BUTT WELDING FITTING

362.

(a) **Branches, Bosses and Drain Pockets**—Branches, bosses and drain pockets welded to the pipes shall conform to the requirements of Regulations 249 to 253. Branches shall not be welded to any main at an angle of less than 60°.

(b) **External Reinforcement**—If the thickness of the main or branches of a single or multiple branch piece is less than that given by the Equation 91A external reinforcement shall be provided. Such reinforcement may take the form of multiple radial plates of 'horse shoe' form or the form of collars or other reinforcement, approved by the Chief Inspector, applied to or around the junction between the branch and the main.

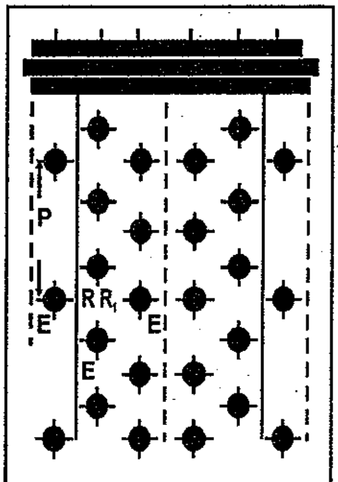


FIG. 30

(c) **Thickness where no External Reinforcement is Provided**—Where more than one branch is attached to a pipe the opening of each branch shall be projected perpendicularly on the axis of the main and the distance between each pair of these projections measured. If the distance so measured between two branches is less than the sum of their bores, the two branches are deemed to affect each other; if this distance is equal to or greater than the sum of their bores, the two branches are deemed not to affect each other.

In calculating the reinforcement required, each branch is to be considered in turn together with all the branches by which it is affected.

(i) **A branch not affected by any other branch**—Where no external reinforcement is to be applied to a branch piece the thickness of the branch shall be determined from Equation 91A.

$$t_m = \frac{PD}{(2Se+P)X} + C \qquad \text{Eqn. (91A)}$$

where, t_m = nominal thickness of the branch less the permissible negative tolerance,

P = working pressure,

D = outside diameter of branch,

S = maximum permissible stress a specified in Table 8,

e = factor given in Regulation 350,

$x = 1.\ B\ (1 - 0.7 \sin y)$ Eqn. (91B)

B = ratio of bore of branch to bore of main,

y = angle between branch and main in degrees,

C = 0.75 mm.

The value of t_m derived from Equation 91A is the minimum thickness and further provision shall be made for any minus tolerance.

No reinforcement is required if—

$$B \text{ is less than} - \frac{Y}{Y+90} \qquad \text{Eqn. (91C)}$$

(ii) **A branch affected by one or more other branches**—(*See* Figure 362A) Determine the 'X' values for each branch alone from Equation 91B. Let 'X' be the value for the branch under consideration and Xa, Xb, etc. the value for the other branches.

$$\text{Then} \quad \left.\begin{aligned} X_1 &= 1 - C\,(1 - Xa) \\ X_2 &= 1 - C\,(1 - Xb) \end{aligned}\right\} \qquad \text{Eqn. (91D)}$$

where, C is a factor the value of which is to be taken from Table 362/4.

TABLE 362/4

$\frac{L}{d_1 + d_2}$	C
1 or greater	0
.9	0.10
.8	.34
.7	.66
.6	.80
.5	.90
.4	.94
.3	.97
.2	.98
.1	.99
.0	1

(L = distance between projections of bores, d_1 and d_2)

Intermediate values by linear interpolation:

It is to be specially noted that a branch may form part of two distinct, multiple branches, when its thickness shall be the greater of the thickness calculated for it as a component of each multiple branch.

The thickness of each branch which is a component of a multiple branch shall then be determined from Equation 91E. Equation 91C shall not apply:

$$^{*}t_m = \frac{Pd}{2(Se+P)X} \times \frac{1}{X_1 . X_2} + C \qquad \text{Eqn. (91E)}$$

where C = 0.75 mm

* **SHAPE OF PROFILE**—Unless the weld is dressed flush, there shall be external weld reinforcement, preferably within the limits recommended in Table below and this reinforcement shall be substantially symmetrical about the centre line of the joint. The shape of the reinforcement may vary according to the type of electrode or welding technique used and the welding position, but shell in all cases be of smooth contour, the profile running out smoothly into the pipe on each side without notching or reduction of thickness of the pipe at the edges of the weld.

Amount of Weld Reinforcement

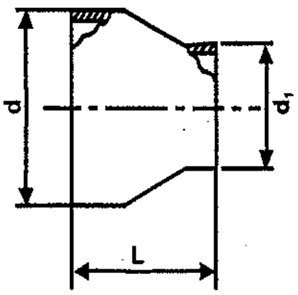
Over		*Pipe thickness*		*Recommended limits*			
		Upto and including		*Minimum*		*Maximum*	
mm.	*in.*	*mm.*	*in.*	*mm.*	*in.*	*mm.*	*in.*
-	-	6	1/4	1.6	1/16	5	1/8
6 mm	1/4	13	1/2	1.6	1/16	5	3/16
13 mm	1/2	-	-	1.6	1/16	6	1/4

(iii) **Mains** (*See* Figures 362/A, 362/B, 362/C and 362/D)—The thickness of a main carrying a single or a multiple branch shall be determined as for the single branch or one component of the multiple branch except that the symbols 'D' and 'e' shall apply to the main.

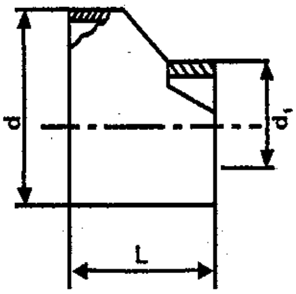
The thickness of a main carrying more than one branch, single or multiple shall be the greatest of the thickness of the main calculated in connection with each branch separately.

The additional thickness of a main for branch reinforcement shall extend over the length covered by the branch and beyond it for a distance not less than the bore of the branch on each side.

STEEL BUTT WELDING REDUCERS



CONCENTRIC REDUCER



ECCENTRIC REDUCER

Nominal Diameter	*Outside Dia.*		
	d	*d_1*	*L*
25 × 10		17.2	
25 × 15	33.7	21.3	51
25 × 20		26.9	
32 × 15		21.3	
32 × 20	42.4	26.9	51
32 × 25		33.7	
40 × 16		21.3	
40 × 20	48.3	26.9	64
40 × 25		33.7	
40 × 32		42.4	
50 × 20		26.9	
50 × 25	60.3	33.7	76
50 × 32		42.4	
50 × 40		48.3	
65 × 25		33.7	
65 × 32	76.1*	42.4	89
65 × 40	73.0	48.3	
65 × 50		60.3	
80 × 25		33.7	
80 × 32		42.4	
80 × 40	88.9	48.3	89
80 × 50		60.3	
80 × 65		76.1	

Nominal Diameter	*Outside Dia.*		
	d	*d_1*	*L*
100 × 25		33.7	
100 × 32		42.4	
100 × 40	114.3	48.3	102
100 × 50		60.3	
100 × 65		76.1	
100 × 80		88.9	
125 × 50		60.3	
125 × 65	139.7*	76.1	127
125 × 80	141.3	88.9	
125 × 100		114.3	
150 × 50		60.3	
150 × 65		76.1	
150 × 80	168.3	88.9	140
150 × 100		114.3	
150 × 125		139.7	
200 × 80		88.9	
200 × 100	219.1	114.3	152
200 × 125		139.7	
200 × 150		168.3	
250 × 80		88.9	
250 × 100		114.3	
250 × 125	273	139.7	178
250 × 150		168.3	
250 × 200		219.1	

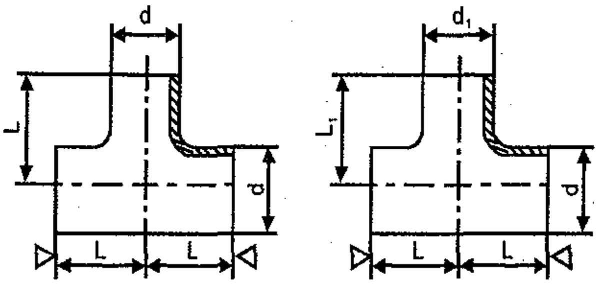
Nominal Diameter	*Outside Dia.*		
	d	*d_1*	*L*
300 × 100		114.3	
300 × 125		139.7	
300 × 150	323.8	168.3	203
300 × 200		219.1	
300 × 250		273.0	
350 × 150		168.3	
350 × 200	365.6	219.1	330
350 × 250		273.0	
350 × 300		323.8	
400 × 200		219.1	
400 × 250	406.4	273.0	356
400 × 300		323.8	
400 × 350		355.6	
450 × 250		273.0	
450 × 300	457.2	323.8	381
450 × 350		355.6	
450 × 400		406.4	
500 × 300		323.8	
500 × 350	508	355.6	508
500 × 400		406.4	
500 × 450		457.2	
600 × 400		406.4	
600 × 450	609.6	457.2	508
600 × 500		508.0	

* Required O.D. to be specified.

Notes:

1. d = Outside diameter of the big end.
2. d_1 = Outside diameter of the small end.
3. L = Overall length.

STEEL BUTT WELDING TEES



EQUAL TEE **UNEQUAL TEE**

Nominal Diameter	*Outside Dia. d*	*d1*	*L*	*L1*
25 × 25 × 10		17.2		
25 × 25 × 15	33.7	21.3	38	38
25 × 25 × 20		26.9		
25		—		
32 × 32 × 15		21.3		
32 × 32 × 20	42.4	26.9	48	48
32 × 32 × 25		33.7		
32		—		
40 × 40 × 15		21.3		
40 × 40 × 20		26.9		
40 × 40 × 25	48.3	33.7	57	57
40 × 40 × 32		42.4		—
40		—		
50 × 50 × 20		26.9		45
50 × 50 × 25		33.7		51
50 × 50 × 32	60.3	42.4	64	57
50 × 50 × 40		48.3		60
50		—		—
65 × 65 × 25		33.7		57
65 × 65 × 32	76.1*	42.4		64
65 × 65 × 40	73.0	48.3	76	67
65 × 65 × 50		60.3		70
65		—		—
80 × 80 × 25		35.7		67
80 × 80 × 32		42.4		70
80 × 80 × 40	88.9	48.3	86	73
80 × 80 × 50		80.3		76
80 × 80 × 65		76.1		83
80		—		—

Nominal Diameter	*Outside Dia. d*	*d1*	*L*	*L1*
100 × 100 × 40		48.3		86
100 × 100 × 50	114.3	60.3		89
100 × 100 × 65		76.1	105	95
100 × 100 × 80		88.9		98
100		—		—
125 × 125 × 50		60.3		105
125 × 125 × 65	139.7*	76.1		108
125 × 125 × 80	141.3	88.9	124	111
125 × 125 × 100		114.3		117
125		—		—
150 × 150 × 50		60.3		121
150 × 150 × 65		76.1		121
150 × 150 × 80	168.3	88.9		124
150 × 150 × 100		114.3	143	130
150 × 150 × 125		139.7		137
150		—		—
200 × 200 × 80		88.9		152
200 × 200 × 100		114.3		156
200 × 200 × 125	219.1	139.7	178	162
200 × 200 × 150		168.3		168
200		—		—
250 × 250 × 80		88.9		184
250 × 250 × 100		114.3		184
250 × 250 × 125	273	159.7	216	190
250 × 250 × 150		168.3		194
250 × 250 × 200		219.1		203
250		—		—

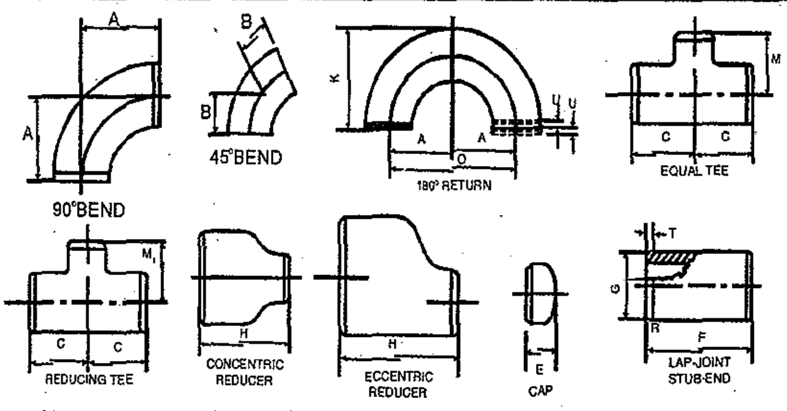
Nominal Diameter	*Outside Dia. d*	*d1*	*L*	*L1*
300 × 300 × 100		114.3		216
300 × 300 × 125		139.7		216
300 × 300 × 150		168.3		219
300 × 300 × 200	323.9	219.1	254	229
300 × 300 × 250		273		241
300		—		—
350 × 350 × 150		168.9		238
350 × 350 × 200		219.1		248
350 × 350 × 250	355.6	273	279	257
350 × 350 × 300		323.9		270
350		—		—
400 × 400 × 150		168.3		264
400 × 400 × 200		219.1		273
400 × 400 × 250		273		283
400 × 400 × 300	406.5	323.9	305	295
400 × 400 × 350		355.6		305
400		—		—
450 × 450 × 200		219.1		298.4
450 × 450 × 250		273		308
450 × 450 × 300		323.9		320.7
450 × 450 × 350	457.2	355.6	342.9	330.2
450 × 450 × 400		406.4		330.2
450		—		—
500 × 500 × 200		219.1		323.8
500 × 500 × 250		273		333.4
500 × 500 × 300		323.9		346.1
500 × 500 × 350	508	355.6	381	355.6
500 × 500 × 400		406.4		355.6
500 × 500 × 450		457.2		368.9
500		—		—

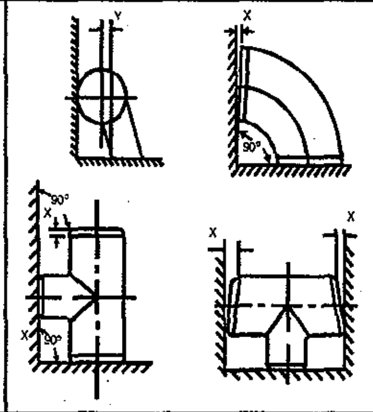
* Required O.D. to be specified.

Notes:

1. d = Outside diameter of the run pipe and branch in case of equal tee.
2. d_1 = Outside diameter of the branch in case of unequal tee.
3. L = Distance of centre to end of run.
4. L_1 = Distance of centre to end of branch.

TOLERANCE OF STEEL BUTT WELDING FITTINGS





All Fittings				90° & 45° Elbows and Toes	Reducers	180° Returns			Caps	Lap-joint stub-end			
DN	O. D. of bevel	I.D. at end	Wall thickness	Centre to end A,B,C M_2M_1	Over all length H	Centre to Centre O	Back to face K	Alignment of end U	Over all length E	End to end F	Radius	Dia of lap G	Thickness of lap T
15 to 65	+1.6 -0.8	±0.8	Not less than 87½% of nominal thickness	±1.6	±1.6	±6.4	±6.4	±0.8	±3.2	±1.6	+0 -0.8	+0 -0.8	+1.6 -0
80 to 90	±1.6	±1.6		±1.6	±1.6	±6.4	±6.4	±0.8	±3.2	±1.6	+0 -0.8	+0 -0.8	+1.6 -0
100	±1.6	±1.6		±1.6	±1.6	±6.4	±6.4	±0.8	±3.2	±1.6	+0 -1.6	+0 -1.8	+1.6 -0
125 to 200	+2.4 -1.6	±1.6		±1.6	±1.6	±6.4	±6.4	±0.8	±6.4	±1.6	+0 -1.6	+0 -1.8	+1.6 -1.6
250 to 450	+4.0 -3.2	±3.2		±2.4	±2.4	±9.5	±6.4	±1.6	±6.4	±2.4	+0 -1.6	+0 -1.6	+1.6 -0
500	+6.4 -4.8	±4.8		±2.4	±2.4	±9.5	±6.4	±1.6	±6.4	±2.4	+0 -1.6	+0 -1.6	+1.6 -0

"OFF-SQUARE" TOLERANCES		
Nominal size of Fitting	Off-square Tolerance, X	Off-square Tolerance, Y
Upto and including 100	0.8	1.6
125 to 150	1.2	2.4
200 to 600	1.6	3.2
> 600	3.2	6.4

For wall thickness $T \leq 20$ mm

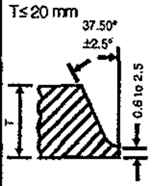


Fig. 28(IX)

For wall thickness $T > 20$ mm

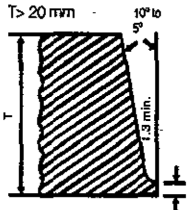
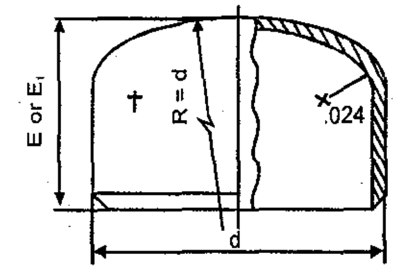


Fig. 28(X)

DIMENSIONS OF CAPS



1	2	3	4	5
Nominal pipe size	Diameter d	Length E [*See* Note 2]	Limiting wall thickness for Length E	Length E_1 [*See* Note 3]
20	26.9	25	3.91	25.4
25	33.7	38	4.85	38.1
32	42.4	38	4.85	38.1
40	48.3	38	5.08	32.1
50	60.3	38	5.54	44.5
65	*76.1/73.0	38	7.01	50.6
80	88.9	51	7.62	63.5
100	114.3	64	8.56	76.2
125	*139.7/141.3	74	9.53	88.9
150	168.3	89	10.97	102
200	219.1	102	12.70	127
250	273	127	12.70	152
300	323.9	152	12.70	178
350	355.6	165	12.70	191
400	406.4	178	12.70	203
450	457.2	203	12.70	229
500	508	229	12.70	254
600	609.6	267	12.70	305
700	720	267		
800	820	267		
900	920	267		

*Required O.D. to be specified.

Notes:

1. Caps are to be of semi-ellipsoidal shape and are to have a length of straight to make the overall length as specified in columns 3 and 5. The height of the semi-ellipsoidal portion, measures externally, is to be not less than one-quarter of the internal diameter of the cap.
2. Lengths E apply to caps of wall thicknesses not exceeding those given in Col. 4.
3. Lengths E_1 apply to caps of wall thicknesses greater than those given in Col. 4.
4. d = Outsids diameter in mm.
   E or E_1 = over all length.

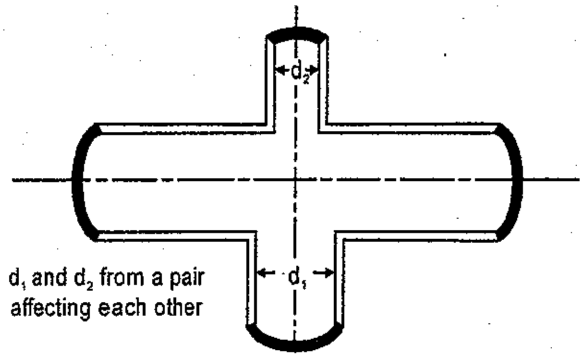
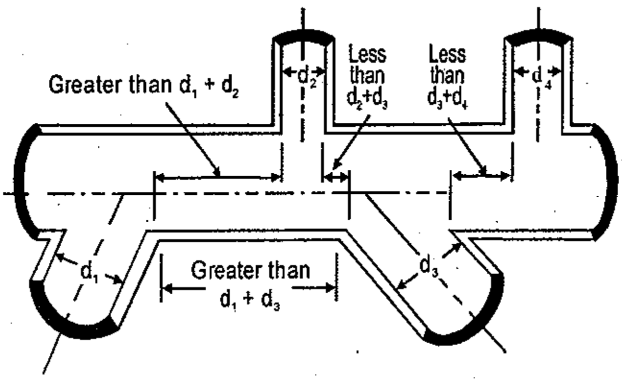
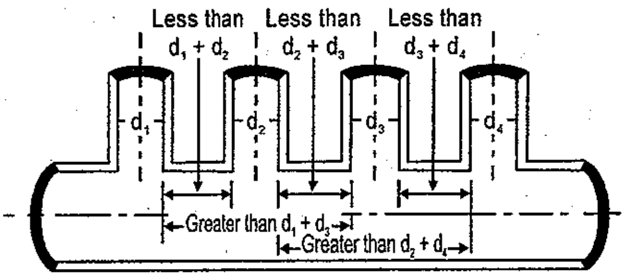


FIG. 362/A — TYPICAL BRANCH PIECES



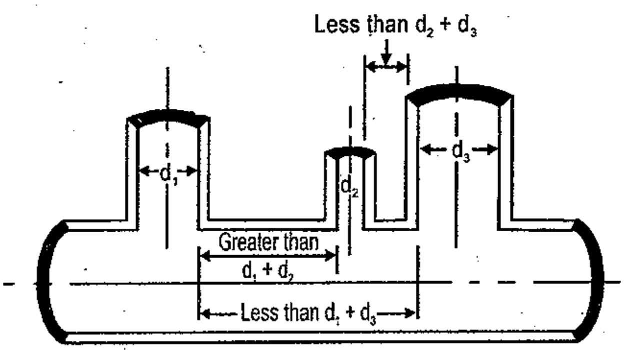
d_1 is unaffected by other branches
d_3 is affected by d_2 and d_1
d_2 is affected by d_3
d_4 is affected by d_3

FIG. 362/B



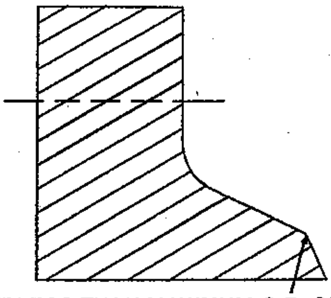
d_1 is affected by d_2
d_2 is affected by d_1 and d_3
d_4 is affected by d_3
d_3 is affected by d_2 and d_4

FIG. 362/C — TYPICAL BRANCH PIECES



d_1 is affected by d_3
d_2 is affected by d_3
d_3 is affected by d_1 and d_3

FIG. 362/D — TYPICAL BRANCH PIECES



NOT LESS THAN MAXIMUM O.D. OF PIPE
THIS FLANGE IS SUITABLE FOR ALL DESIGN PRESSURE AND TEMPERATURE CONDITIONS
NOTE: FOR DETAILS OF WELD PREPARATION SEE FIG. Nos. 28(i) to 28(x)

FIG. 28 — WELDING NECK FLANGE

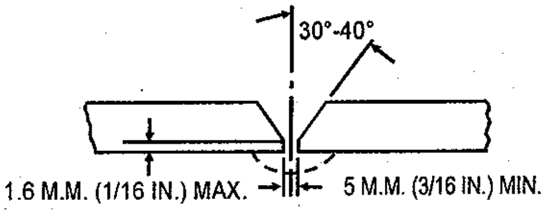
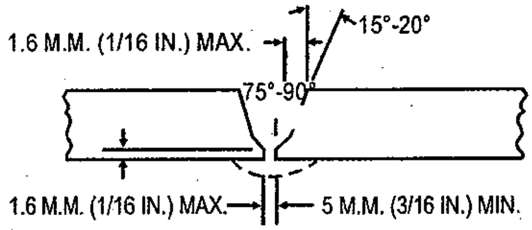
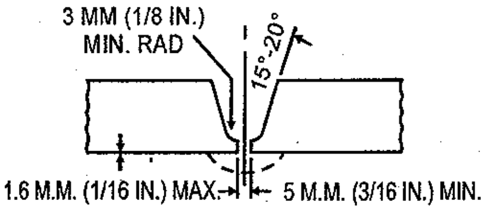


FIG. 28 (i) — PLAIN VEE FOR USE WITH BACKING RING



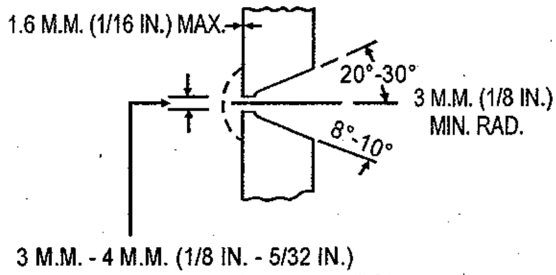
[PIPES OVER 13 M.M. (1/2 IN.) THICK]

FIG. 28 (ii) — DOUBLE ANGLE VEE FOR USE WITH BACKING RING



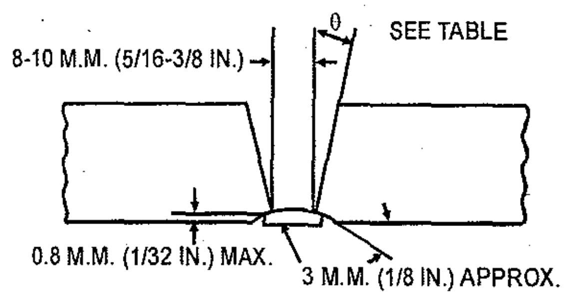
[PIPES OVER 13 M.M. (1/2 IN.) THICK]

FIG. 28 (iii) (a) — NORMAL PREPARATION U-GROOVE FOR USE WITH BACKING RING



3 M.M. - 4 M.M. (1/8 IN. - 5/32 IN.)
[PIPES OVER 13 M.M. (1/2 IN.) THICK]

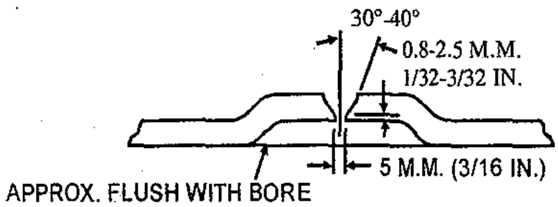
FIG. 28(iii)(b) — PERMISSIBLE ALTERNATIVE PREPARATION FOR VERTICAL OR NEARLY VERTICAL PIPE U-GROOVE FOR USE WITH BACKING RING



PIPE THICKNESS		θ
M.M.	IN.	DEGREES
≤ 25	≤ 1	16-20
> 25 ≤ 38	>1 ≤ 1½	20-24
> 38	> 1½	23-27

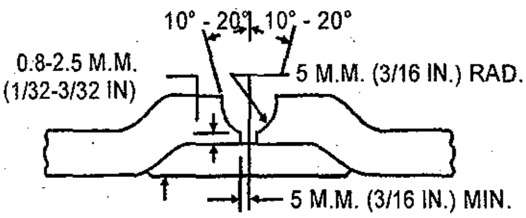
[FOR PIPES OVER 8 M.M. (5/16 IN.) THICK]

FIG. 28 (iv) — PREPARATION OF GROOVE FOR USE WITH TAPER BACKING RING AND DOUBLE ROOT RUN



FOR PIPES 13 M.M. (1/2 IN.) AND THINNE

FIG. 28 (v) (a) — GROOVE FOR USE WITH RECESSED BACKING RING



APPROX. FLUSH WITH BORE FOR PIPES THICKER THAN 13 M.M. (1/2 IN.)

FIG. 28 (v) (b) — GROOVE FOR USE WITH RECESSED BACKING RING

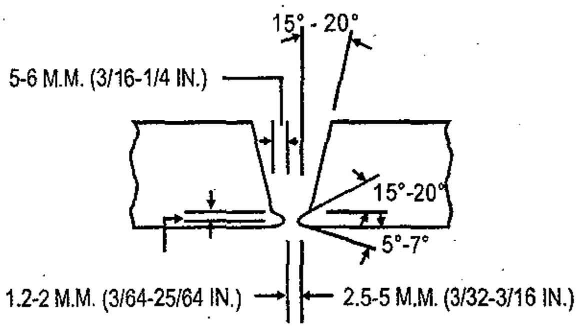
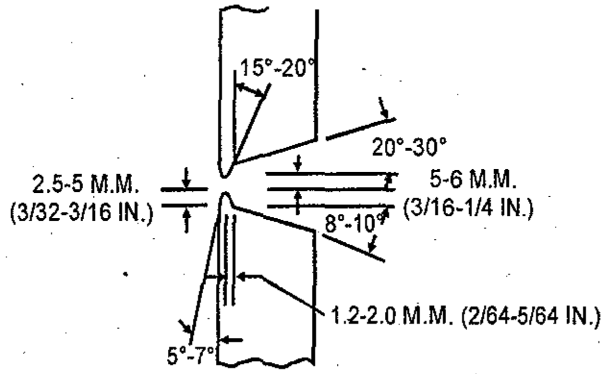
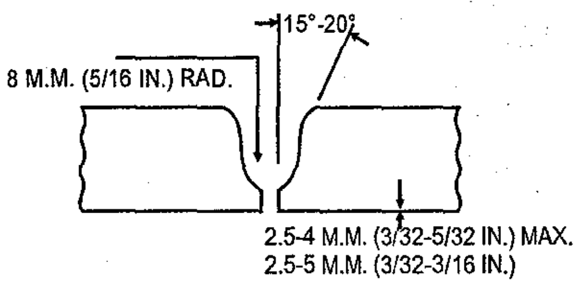


FIG. 28 (vi) (a) — NORMAL PREPARATION DOUBLE ANGLE VEE FOR USE WITH OXY-ACETYLENE BASE RUN



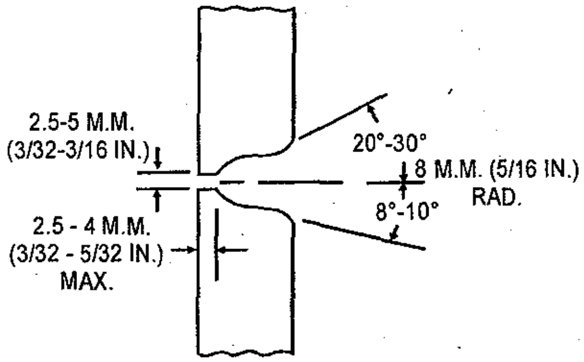
PERMISSIBLE ALTERNATIVE PREPARATION FOR VERTICAL OR NEARLY VERTICAL PIPE

FIG. 28 (vi) (b) — DOUBLE ANGLE VEE FOR USE WITH OXY-ACETYLENE BASE RUN



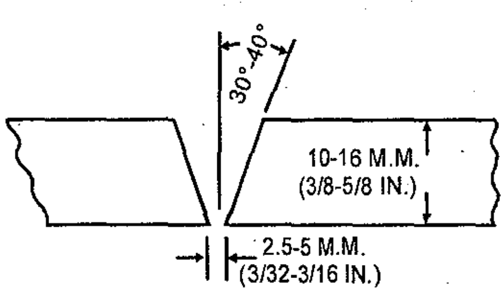
NORMAL PREPARATION

FIG. 28 (vii) (a) — U-GROOVE FOR USE WITH OXY-ACETYLENE BASE RUN



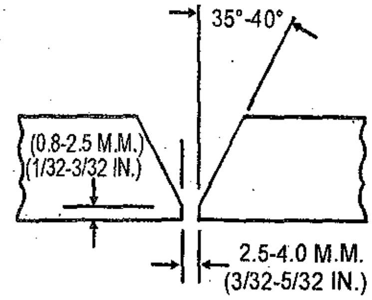
PERMISSIBLE ALTERNATIVE PREPARATION FOR VERTICAL OR NEARLY VERTICAL PIPE

FIG. 28 (vii) (b) — U-GROOVE FOR USE WITH OXY-ACETYLENE BASE RUN



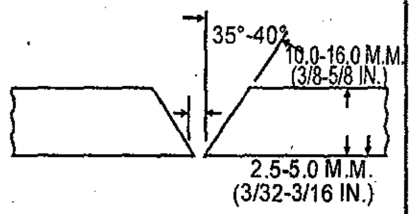
[PIPES 10 TO 16 M.M. (3/8 TO 5/8 IN.) THICK INCLUSIVE]

FIG. 28 (viii) — PLAIN VEE FOR USE WITH OXY-ACETYLENE BASE RUN



NORMAL PREPARATION

FIG. 28 (ix) (a) — PLAIN VEE FOR USE WITHOUT BACKING RING



FOR USE WITH SPECIAL WELDING TECHNIQUE

FIG. 28 (ix) (b) — PLAIN VEE FOR USE WITHOUT BACKING RING

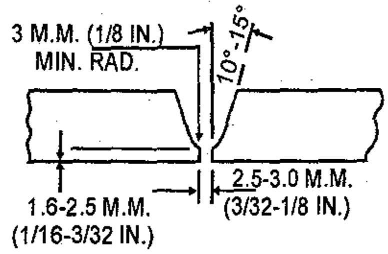
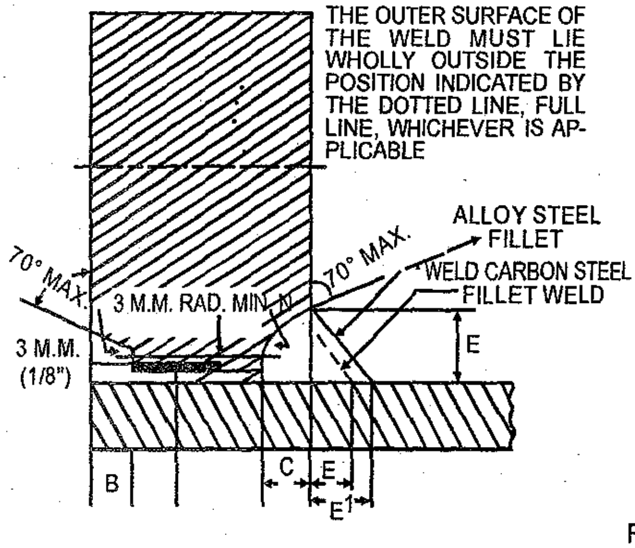


FIG. 28 (x) — SINGLE U FOR USE WITHOUT BACKING RING

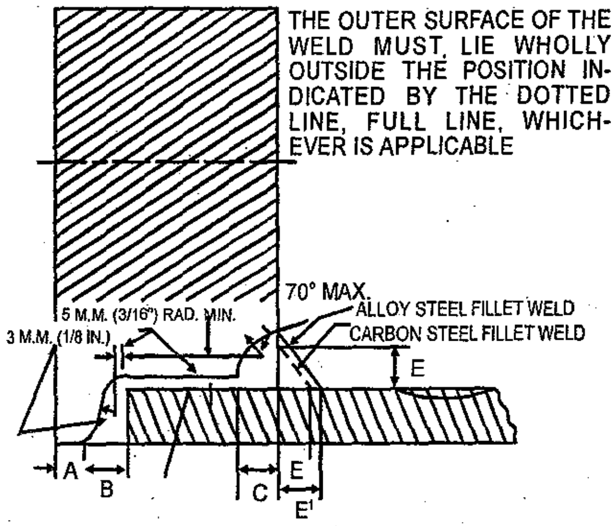


FOR CLEARANCE BETWEEN FLANGE BORE AND O.D. OF PIPE [SEE REGN. 357(b)]

CARBON STEEL PIPES		B = t BUT NOT LESS THAN 5 M.M. (3/16")
ALLOY STEEL PIPES		B = t BUT NOT LESS THAN 5 M.M. (3/16")
CARBON STEEL PIPES	t BUT C = NOT LESS THAN	6 M.M. (1/4 IN.) FOR PIPES 13 M.M. (1/2 IN.) AND 19 M.M. (3/4") BORE 8 M.M. (5/16") FOR PIPES 25 M.M. (1") TO 38 M.M. (3/2") BORE 10 M.M. (3/8") FOR PIPES 21 M.M. (2") BORE OVER
ALLOY STEEL PIPES	2t BUT C = NOT LESS THAN	6 M.M. (1/4 IN.) FOR PIPES 13 M.M. (1/2 IN.) AND 19 M.M. (3/4") BORE 8 M.M. (5/16") FOR PIPES 25 M.M. (1") TO 38 M.M. (3/2") BORE 10 M.M. (3/8") FOR PIPES 21 M.M. (2") BORE OVER
CARBON STEEL PIPES		E = t BUT NOT LESS THAN 6 M.M. (1/4")
ALLOY STEEL PIPES		E' = HEIGHT OF WELD RECESS

DIMENSIONS B AND C ARE MINIMA AFTER MACHINING FLANGE TO FINAL THICKNESS. THIS FLANGE IS SUITABLE FOR ALL DESIGN PRESSURE AND TEMPERATURE CONDITIONS. FACE AND BACK WELDED ON FLANGE FOR METAL ARC WELDING

FIG. 29

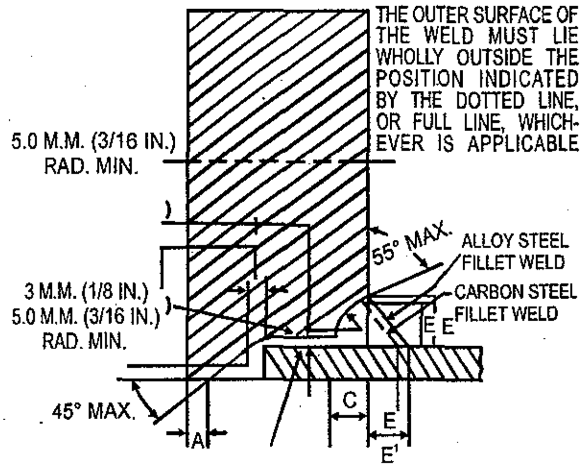


FOR CLEARANCE BETWEEN FLANGE BORE AND O.D. OF PIPE [SEE REGN. 357(b)]

CARBON STEEL AND ALLOY STEEL PIPES	A=1/2 t BUT NOT LESS THAN 5 M.M. (3/16 IN.)
CARBON STEEL AND ALLOY STEEL PIPES	B = { 8 M.M. (5/16 IN.) MIN. WHERE t IS NOT MORE THAN 8 M.M. (5/16 IN.) t-1.6 M.M. (1/16 IN.) WHERE t IS OVER 8 M.M. UPTO AND INCLUDING 14.5 M.M. (9/16 IN.) t-3 M.M. (1/8 IN.) WHERE t IS OVER 14.5 M.M. UPTO AND INCLUDING 22 M.M. (7/8 IN.) t-6 M.M. (1/4 IN.) WHERE t IS OVER 22 M.M. (7/8 IN.)
CARBON STEEL PIPES	C = t BUT NOT LESS THAN 10 M.M.
ALLOY STEEL PIPES	C = 2t BUT NOT LESS THAN 10 M.M.
CARBON STEEL PIPES	E = t BUT NOT LESS THAN 6 M.M.
ALLOY STEEL PIPES	E_1 = HEIGHT OF WELD RECESS.

DIMENSIONS A AND C ARE MINIMA AFTER MACHINING FLANGE TO FINAL THICKNESS. THIS WELD PREPARATION SHALL NOT BE USED WITH PIPES OF LESS THAN 76 M.M. MIN. BORE. BORE AND BACK WELDED ON FLANGE FOR METAL ARC WELDING

FIG. 30

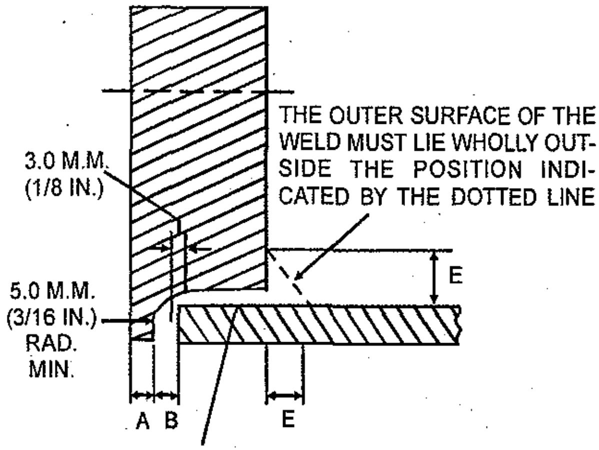


FOR CLEARANCE BETWEEN FLANGE BORE & O.D. OF PIPE [SEE REGN. NO. 357(b)]

CARBON STEEL AND ALLOY STEEL PIPES	A = 1/2t BUT NOT LESS THAN
CARBON STEEL PIPES	C = t BUT NOT LESS THAN
ALLOY STEEL PIPES	C = 2t BUT NOT LESS THAN
CARBON STEEL PIPES	E = t BUT NOT LESS THAN
ALLOY STEEL PIPES	E' = 6.0 M.M. (1/4 IN.) + 2/3t BUT NOT LESS THAN t

t = CALCULATED THICKNESS OF PIPE AS DERIVED FROM EQN. 91 DIMENSIONS A & C ARE MINIMA AFTER MACHINING FLANGE TO FINAL THICKNESS. THIS WELD PREPARATION SHALL NOT BE USED WITH PIPES LESS THAN 76 M.M. (3 IN.) MIN. BORE WELD PREPARATION FOR USE ONLY WITH FLANGES POSITIONALLY WELDED ON 'BORE AND BACK' WELDED-ON FLANGE FOR METAL ARC WELDING

FIG. 30A



FOR CLEARANCE BETWEEN FLANGE BORE & O.D. OF PIPE [SEE REGN. 357(b)]

A = 1/2t BUT NOT LESS THAN 5.00 M.M. (3/16 IN.) = 8.0 M.M. (5/16 IN.) MINIMUM WHERE t IS NOT MORE THAN 8.0 M.M. (5/16 IN.)

B = [t = 1.6 M.M. (1/16 IN.)] WHERE t IS OVER 8.0 M.M. (5/16 IN.) UPTO AND INCLUDING 14.50 M.M. (9/16 IN.)

B = [t-3.0 M.M. (1/16 IN.)] WHERE t IS OVER 14.50 M.M. (9/16 IN.) UPTO AND INCLUDING 22.00 M.M. (7/8 IN.)

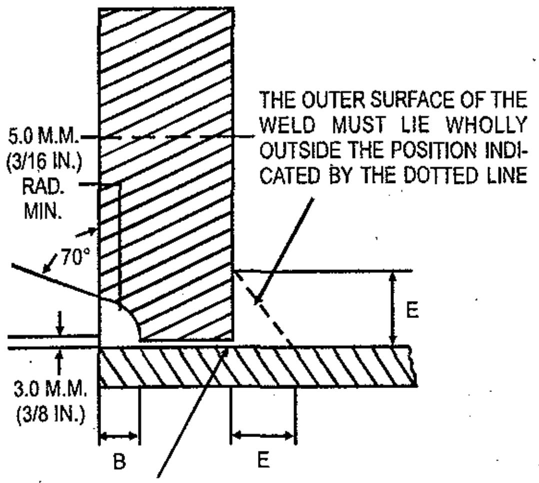
= t-6.0 M.M. (1/4 IN.) WHERE t IS OVER 22.0M.M. (7/8 IN.)

E = 1½t BUT NOT LESS THAN 6.00 M.M. (1/4 IN.)

t = CALCULATED THICKNESS OF PIPE AS DERIVED FROM EQN. 91.

DIMENSION 'A' IS THE MINIMUM AFTER MACHINING FLANGE TO FINAL THICKNESS. THIS WELD PREPARATION SHALL NOT BE USED WITH PIPES OF LESS THAN 76.00 M.M. (3 IN.) BORE. 'BORE & FILLET' WELDED-ON FLANGE FOR METAL ARC WELDING

FIG. 32



FOR CLEARANCE BETWEEN FLANGE BORE AND O.D. OF PIPE [SEE REGN. 357 (b)]

B = t BUT NOT LESS THAN 5.0 M.M. (3/16 IN.)

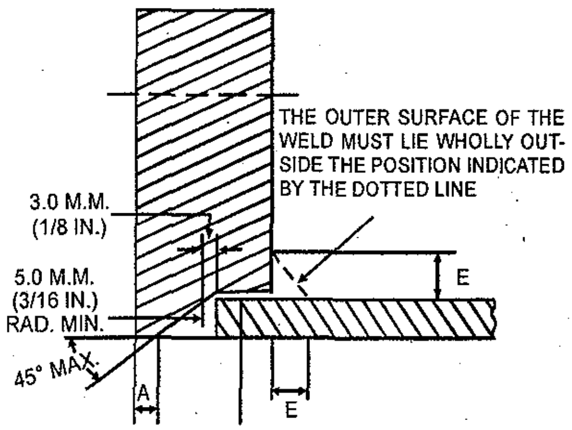
E = 3/2t BUT NOT LESS THAN 6.0 M.M. (1/4 IN.)

t = CALCULATED THICKNESS OF PIPE AS DERIVED FROM EQN. 91.

DIMENSION B IS THE MINIMUM AFTER MACHINING FLANGE TO FINAL THICKNESS

FACE AND FILLET WELDED-ON FLANGE FOR METAL ARC WELDING

FIG. 31



FOR CLEARANCE BETWEEN FLANGE BORE AND O.D. OF PIPE [SEE REGN. 357(b)]

A = 1/2t BUT NOT LESS THAN 5.0 M.M. (3/16 IN.)

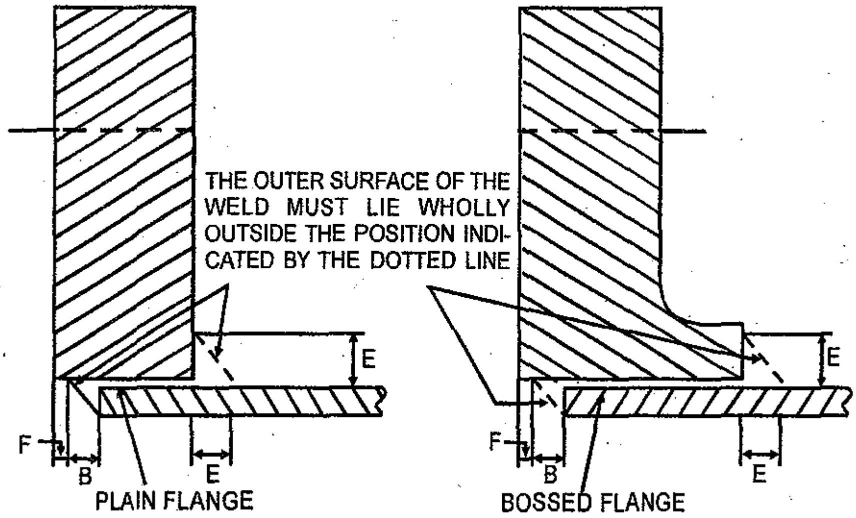
E = 1½t BUT NOT LESS THAN 6.0 M.M. (1/4 IN.)

t = CALCULATED THICKNESS OF PIPE AS DERIVED FROM EQN. 91.

DIMENSION 'A' IS THE MINIMUM AFTER MACHINING FLANGE TO FINAL THICKNESS THIS WELD PREPARATION SHALL NOT BE USED WITH PIPES OF LESS THAN 76.0 M.M. (3 IN.) MINIMUM BORE.

WELD PREPARATION FOR USE ONLY WITH FLANGES POSITIONALLY WELDED-ON. 'BORE AND FILLET' WELDED-FLANGE FOR METAL ARC WELDING

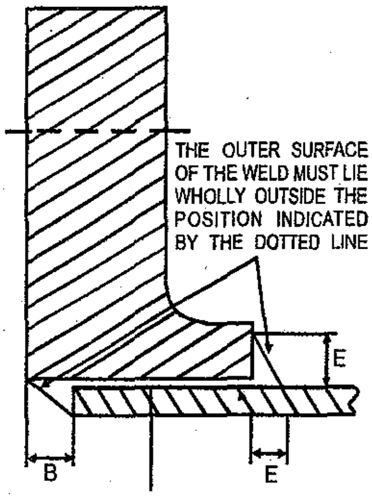
FIG. 32A



B = T
E = 3/2t BUT NOT LESS THAN 5.0 M.M. (3/16 IN.)
F = 1.6 M.M. (3/16 IN.) MAX.
t = CALCULATED THICKNESS OF PIPE AS DERIVED FROM EQN. 91.

ALL DIMENSIONS ARE FINISHED SIZES.
THE BOSSED FLANGE MAY BE USED ON PIPES UPTO AND INCLUDING 305 M.M. (12 IN.) NOMINAL BORE
'SLIP-ON' WELDED-ON FLANGE FOR METAL ARC WELDING

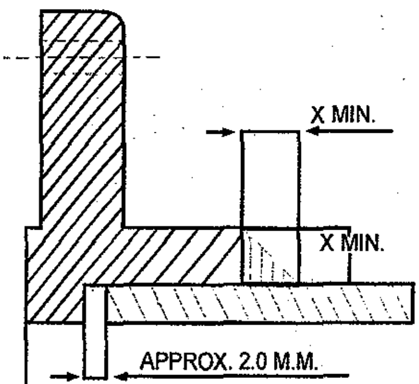
FIG. 33 — FOR CLEARANCE BETWEEN FLANGE BORE & O.D. OF PIPE [SEE REGN. 357(b)]



B = T
E = 3/2t BUT NOT LESS THAN 5.0. M.M. (3/16 IN.)
t = CALCULATED THICKNESS OF PIPE AS DERIVED FROM EQN. 91.

ALL DIMENSIONS ARE FINISHED SIZES.
THIS TYPE SHALL BE USED ONLY FOR PIPES UPTO AND INCLUDING 153 M.M. (6 IN.) NOMINAL BORE 'SLIP-ON' WELDED-ON BOSSED FLANGE FOR OXY-ACETYLENE WELDING

FIG. 34 — FOR CLEARANCE BETWEEN FLANGE BORE & O.D. OF PIPE [SEE REGN. 357(b)]



BEFORE WELDING
DIMENSION X MIN. IN. 1.09 IN. (NOMINAL PIPE WALL THICKNESS) OR THICKNESS OF FLANGE HUB, WHICHEVER IS SMALLER

FIG. 34A — SOCKET WELDED FLANGE

363. Blow-Down Pipes

(a) Blow-down pipes which cannot be subjected to full boiler pressure shall be considered as saturated steam-pipes at that pressure.

(b) Blow-down pipes which cannot be subjected to full boiler pressure shall be considered as saturated steam-pipes at half the working pressure of the boiler.

364. Valves Chests

(a) Chests of stop-valves, isolating valves, reducing valves, steam traps, etc., forming parts of wrought steel main steam piping when for use with saturated steam upto a gauge pressure of 160 lbs. per square inch or a temperature of 400°F may be made of cast iron, cast steel or wrought steel in accordance with the requirements of Regulation 290.

(b) When superheated steam is used above 400°F or when pressures are above 160 lbs. per sq. in. gauge, such chests shall be made of cast or wrought steel or other approved material in accordance with the requirement of Regulation 290.

STEAM RECEIVERS, SEPARATORS, CATCH WATERS, ACCUMULATORS AND SIMILAR VESSELS

365.

(a) **Materials—**

(1) **Plates, Bars, Sections and Rivets**—Materials for plates, bars, sections and rivets used in the construction of Steam Receivers, Separators, Catch Waters and Similar Vessels shall comply in all respects with the requirements of relevant regulations of Chapters II and V, depending upon the mode of construction.

(2) **Branches, Bosses and Drain Pockets**—Branches, bosses and drain pockets may be solid forged, fabricated by fusion welding, machined from solid bars or made from tubes.

(3) **Flanges**—Materials for flanges shall comply with the appropriate provisions of Regulation 353.

(4) **Forgings**—Forgings shall comply with the requirements of Regulation 243.

(5) **Steel Castings**—Steel castings for shells or pressure parts of shell shall comply with Regulations 73 to 80.

(b) **Construction and Workmanship—**

(1) **Shell Ends**—Shell ends formed separately from the shell may be dished or flat. Alternatively, the ends of the shell may be forged down and closed by manhole doors or by plugs or branches welded in.

(2) **Dished Ends**—Each dished end shall be made from one rolled plate. If this is impracticable, owing to the large diameter, the dished end plate may be made from two plates fusion butt welded together and in such cases the line of weld shall be parallel to the horizontal axis of the vessels and the weld shall be radiographed after forming. The shape of dished end shell conform to the requirements of Regulation 275. Dishing end peripheral flanging shall be done by machine. Cold flanging shall not be adopted. All plates which have been dished, flanged or locally heated shall afterwards be efficiently heat treated for the purpose of relieving internal stresses, unless during the last stage of manufacture, they have been uniformly heated throughout to a suitable temperature. Care shall be taken to see that the flanges are cylindrical of good surface and free from local irregularities.

Where flats are pressed in dished ends for the attachment of connections they shall be formed with an ample radius at the junctions of the flat and curved surfaces and shall be free from sharp corners and tool marks.

Dished ends shall be attached to the cylindrical part of the shell by one of the following methods:

(i) **Riveting**—Dished ends shall be machined to fit closely into the cylindrical part of the shell and flogging or hammering in the fitting of ends shall not be adopted.

The caulking edges of all flanged plates shall be machined or flame cut by machine.

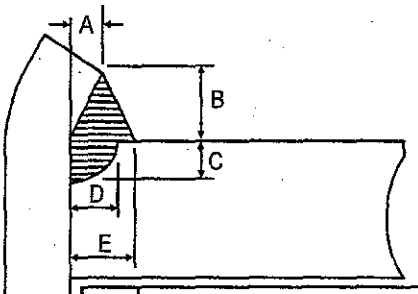
(ii) **Welding with Butt Joints of the Single or Double U or V Type**—Where the internal diameter of the shell, 24 ins. or over, the joints shell in all cases, be welded from both sides of the plate. Where the internal diameter of the shell is less than 24 ins. the joints may be welded from one side only, when efficient welding from inside is considered impracticable.

(iii) In the construction of unfired boilers when the dished ends do not form of the heating surface, cold spun dished ends conforming to IS: 2825 may be used.

(3) **Flat Ends**—Flat ends shall be of forged steel and shall be welded to the cylindrical part of the shell or bolted to flanges which shall be attached to the cylindrical part of the shell in accordance with Regulation 356 or 357.

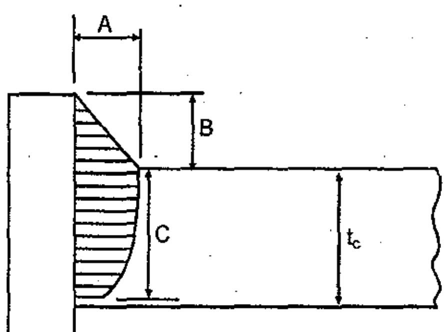
The attachment of flat ends shall be by one of the methods shown in Fig. Nos. 365/2, 365/2A, 365/3 and 365/4.

When ends are attached as shown in Fig. 365/4, welding shall be from both sides of the shell plate where practicable. Where welding is done from one side only, care shall be taken to ensure full penetration using backing strips.



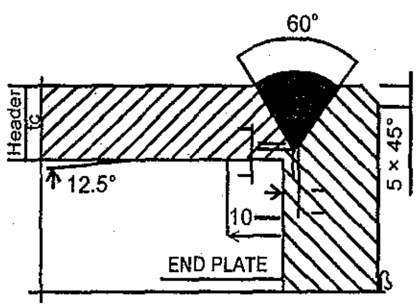
A =	1/3 t_s BUT NOT LESS THAN 3/16 IN.
B =	t_s
C =	1/2 t_s BUT NOT LESS THAN 5/16 IN.
D =	2/3 t_s BUT NOT LESS THAN 3/8 IN.
E =	t_s BUT NOT LESS THAN 3/8 IN.

FIG. 365/2



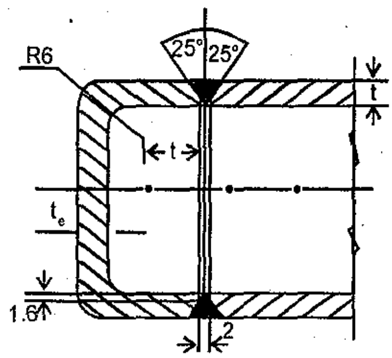
A =	C
B =	t_s
C =	2 t_s OR T_s 1/16 IN. WHICHEVER IS SMALLER

FIG. 365/3



NOTE : WELD DETAILS ADDED WITH REFERENCE TO FIG. 23D.

FIG. 365/2A



t = STUB THICK; t_e = END PLATE THICK

FIG. 365/4

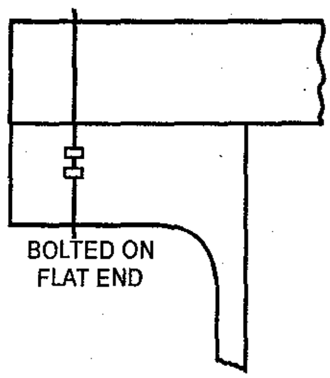
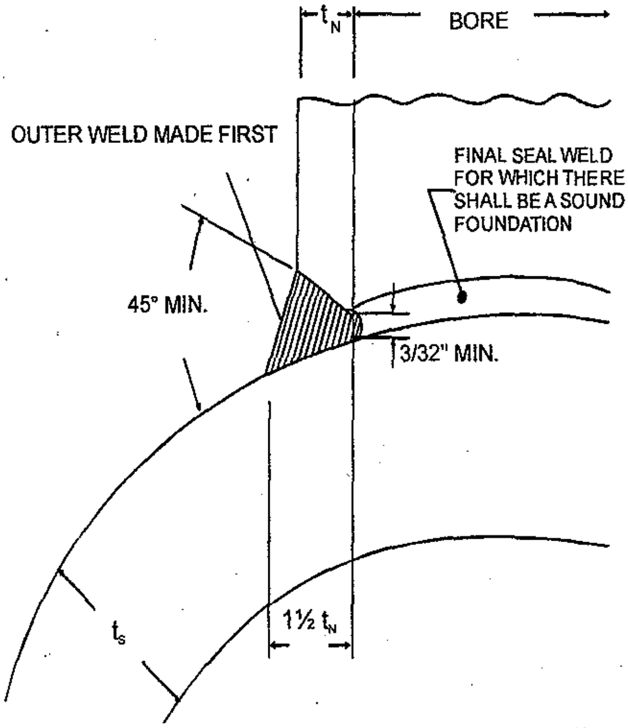


FIG. 365/5

(c) **Access to Shells**—At least one manhole shall be provided to allow access for thorough cleaning and inspection, except that where the shell is too small to permit entry, cleaning and inspection openings of sufficient size and numbers shall be provided. Where there is an elliptical opening in the cylindrical part of the shell, the minor axis shell, wherever practicable be parallel to the longitudinal axis of the shell.

(d) **Compensating Rings to Openings and Doors**—The material, construction and workmanship of compensating rings and doors shall comply with the appropriate Regulations of Chapters II, III and XII.

(e) **Branches and Other Connections**—Connections to shell shall be made by means of branches, pressed plate saddles, forged pads or bosses. Alternatively, where the thickness of the shell is sufficient to allow a suitable surface to be obtained, connections may be attached directly to the shell, provided that the minimum thickness at the hole in the shell is not less than the thickness required for the design pressure and temperature, considering the shell as being unpierced and that the diameter of the hole does not exceed the maximum diameter of an uncompensated hole as defined in Regulations 170 and 279. Studs for securing such connections shall have a full thread holding in the shell for a length of at least one diameter and the stud holes shall not penetrate the whole thickness of the shell. All holes for bolts, studs and rivets in branches, saddles and forged pads shall be drilled. Where such connections are secured by welding alone, a minimum of two runs of metal shall be deposited at each weld, except for seal welds. Each run of weld metal shall be thoroughly cleaned and free from slag before the next run is deposited. The final finish of the welds shall be such that change of section from shell to branch is gradual and free from sharp notches. Where the diameter of the shell is 24 inches and over, welding shall be from both sides of the plate. Where the internal diameter of the shell is less than 24 inches, external and internal welds shall be applied unless it is considered that efficient welding from both sides is impracticable. This does not apply to the methods of attachment shown in Figs. 365/6 and 365/7 in which the welding shall always be from both sides.

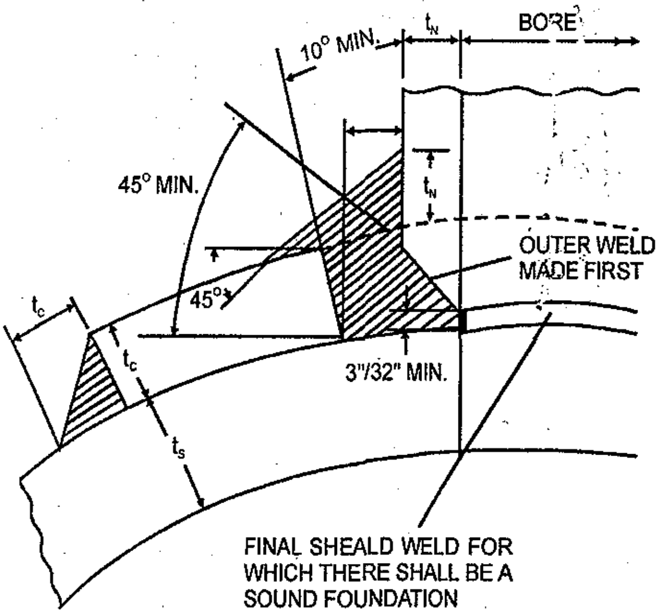


WHERE THE APPLICATION OF THE SEALWELD FROM INSIDE THE VESSEL IS PRACTICABLE, THIS TYPE IS NOT PERMITTED UNLESS THE BORE OF THE BRANCH IS 4" OR LARGER AND THE LENGTH FROM FACE OF BRANCH OUTSIDE OF SHELL DOES NOT EXCEED THE FOLLOWING :

BORE OF BRANCH	LENGTH OF BRANCH
4"	9"
5"	10"
6"	12"
7" TO 10" INCLUSIVE	15"
OVER 10"	18"

NOTE: THE ABOVE ARE NOT RECOMMENDED BRANCH LENGTHS AND BRANCHES SHOULD BE AS SHORT AS POSSIBLE.

FIG. 365/6



WHERE THE APPLICATION OF THE SEALWELD FROM INSIDE THE VESSEL IS IMPRACTICABLE, THIS TYPE IS NOT PERMITTED UNLESS THE BORE OF THE BRANCH IS 4" OR LARGER AND THE LENGTH FROM FACE OF BRANCH TO OUTSIDE TO SHELL DOES NOT EXCEED THE FOLLOWING:

BORE OF BRANCH	LENGTH OF BRANCH
4"	9"
5"	10"
6"	12"
7" TO 10" INCLUSIVE	15"
OVER 10"	18"

NOTE: THE ABOVE ARE NOT RECOMMENDED BRANCH LENGTHS AND BRANCHES SHOULD BE AS

FIG. 365/7

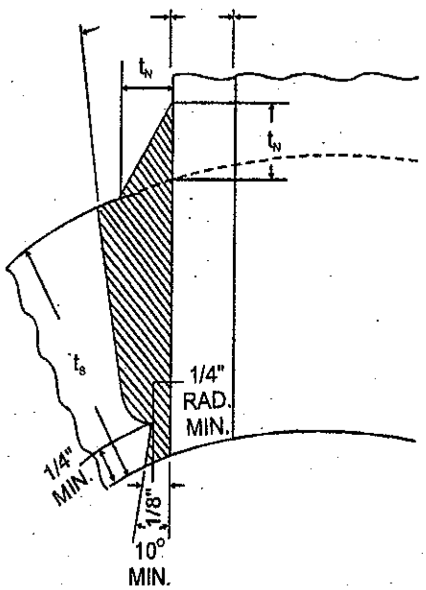


FIG. 365/8

WELDING PROCEDURE FOR TYPES SHOWN IN FIG. 365/8 AND FIG. 365/9 TO BE AS FOR DOUBLE WELDED BUTT JOINT. OUTER WELD TO BE MADE FIRST. BACK OF OUTER WELD TO BE CHIPPED OUT. BEFORE COMMENCEMENT. OF INNER WELD BUTT DEEP PENETRATION WELDING MAY BE USED SUBJECT TO PROOF OF REQUISITE PENETRATION BEING PRODUCED BY THE MANUFACTURER WHERE CALLED FOR BY THE INSPECTING AUTHORITY.

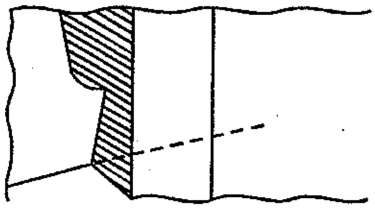


FIG. 365/9

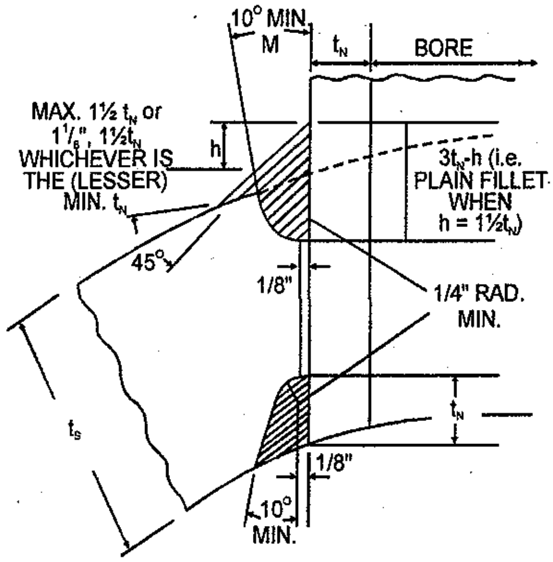


FIG. 365/10

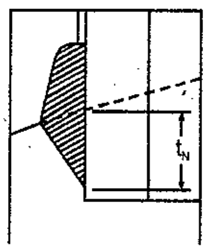


FIG. 365/11

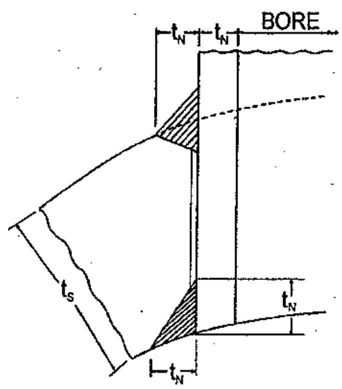
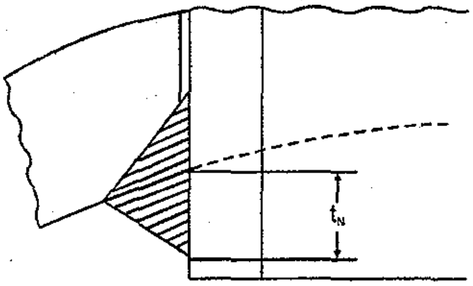
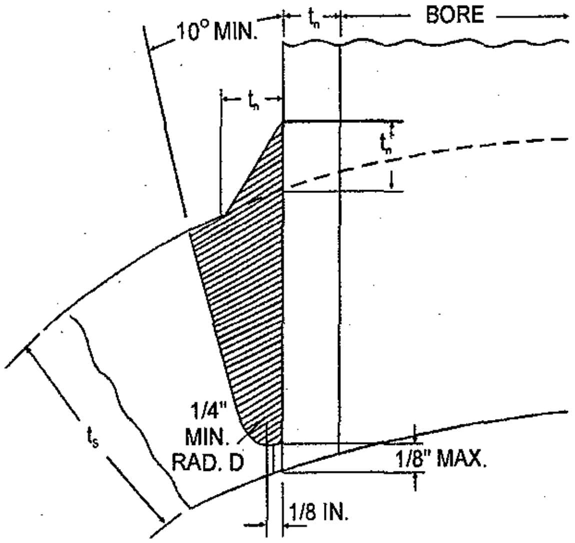


FIG. 365/112



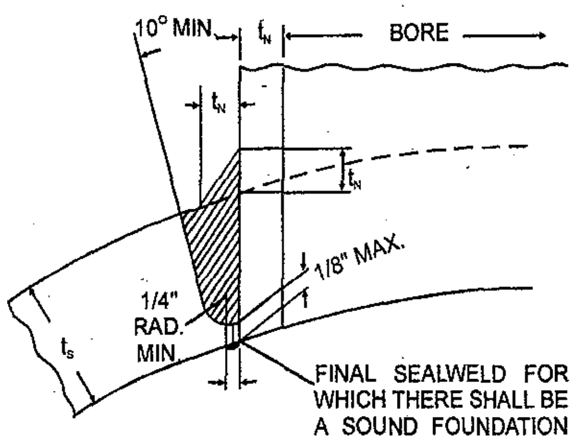
THE TYPES SHOWN IN FIG. 365/13 ARE ONLY PERMITTED WHERE THE ELECTRODES AND TECHNIQUE TO BE USED HAVE BEEN SHOWN, BY SEPARATELY PREPARED TEST SPECIMENS, TO GIVE FULL PENETRATION WITH SOUND WELD METAL AT THE ROOT OF THE GROOVES. THEY ARE NOT PERMITTED WHERE THE BORE OF THE BRANCH EXCEEDS 5 INCHES.

FIG. 365/13



THE TYPE SHOWN IN FIG. 365/14 IS NOT PERMITTED WHERE THE INSIDE OF THE VESSEL IS ACCESSIBLE FOR WELDING FIG. IS PREFERRED WHERE THE INSIDE OF THE BRANCH IS ACCESIBLE FOR WELDING, WHERE IT JOINS THE SHELL.

FIG. 365/14



THE TYPE SHOWN IN FIG. 365/15 IS NOT PERMITTED WHERE THE SHELL THICKNESS EXCEEDS 1 INCH.

FIG. 365/15

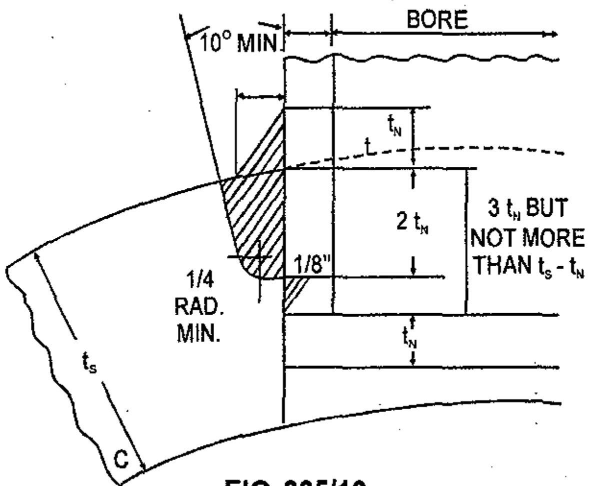


FIG. 365/16

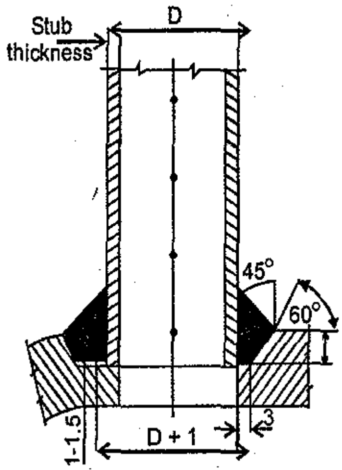


FIG. 365/17

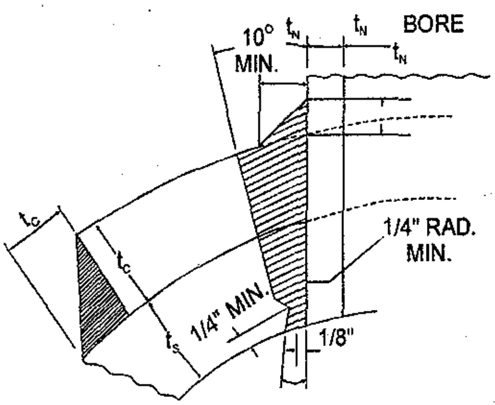


FIG. 365/18

WELDING PROCEDURE FOR TYPES SHOWN IN FIGS. 365/18 AND 365/19 TO BE AS FOR DOUBLE WELDED BUTT JOINT. OUTER WELD TO BE MADE, FIRST BACK OF OUTER WELD TO BE CHIPPED OUT BEFORE COMMENCEMENT OF INNER WELD. BUT DEEP PENETRATION WELDING MAY REUSED SUBJECT TO PROOF OF REQUISITE PENETRATION BEING PRODUCED BY THE MANUFACTURER WHERE CALLED FOR BY THE INSPECTING AUTHORITY.

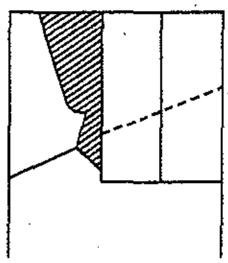


FIG. 365/19

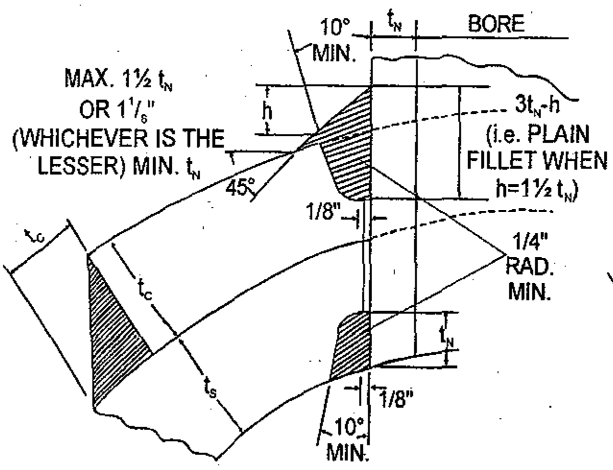


FIG. 365/20

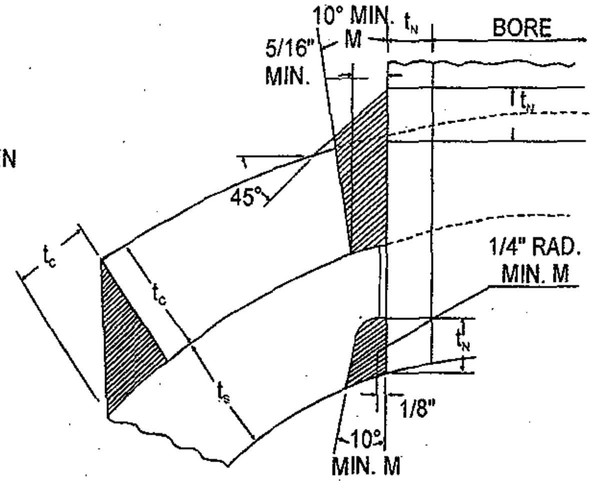


FIG. 365/24

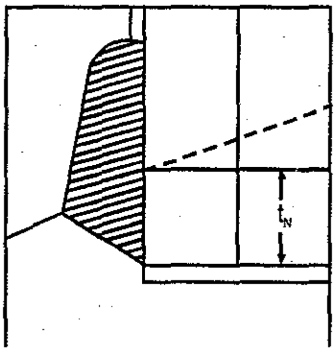


FIG. 365/21

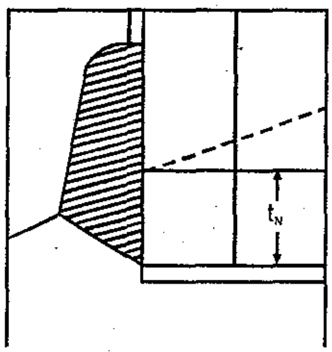


FIG. 365/25

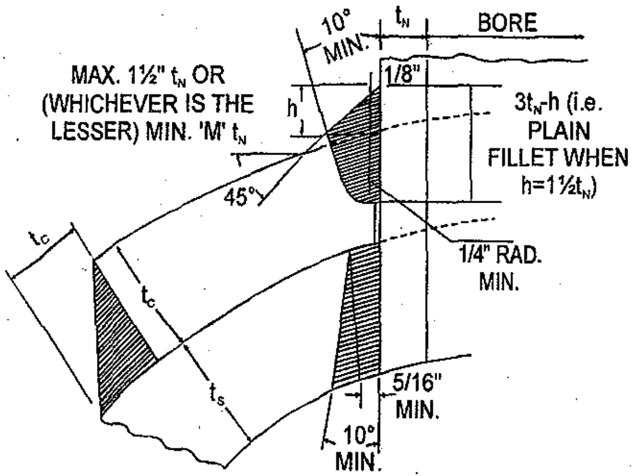
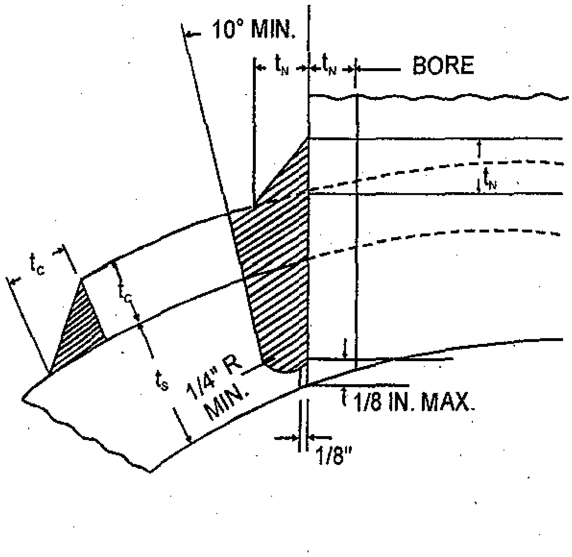


FIG. 365/22



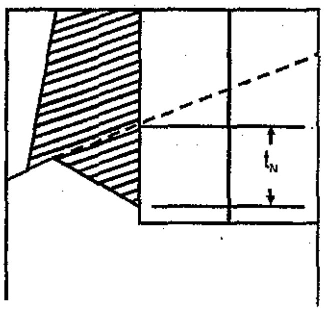
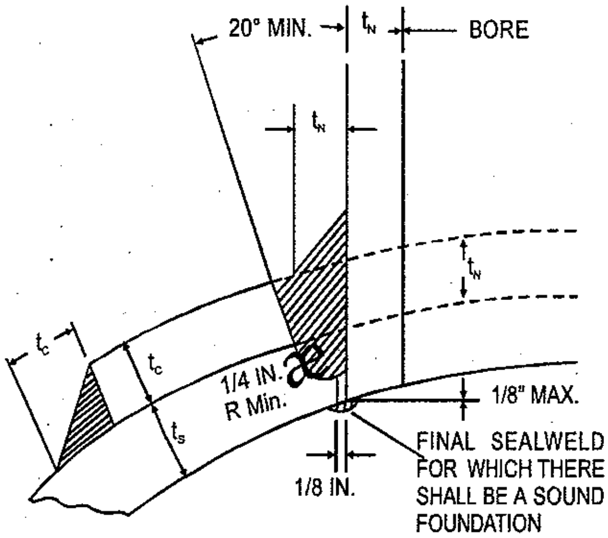


FIG. 365/23

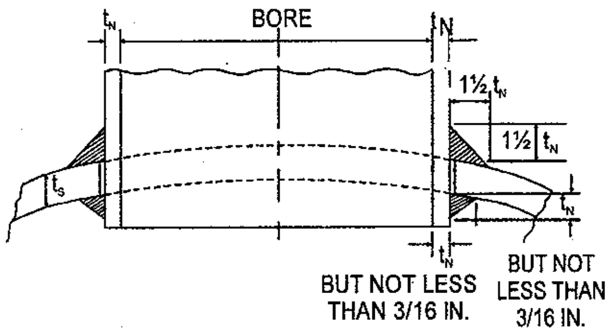
THE TYPE SHOWN IN FIG. 365/26 IS NOT PERMITTED WHERE THE INSIDE OF THE VESSEL IS ACCESSIBLE FOR WELDING. FIG. 365/27 IS PREFERRED WHERE THE INSIDE OF THE BRANCH IS ACCESSIBLE FOR WELDING WHERE IT JOIN THE SHELL.

FIG. 365/26



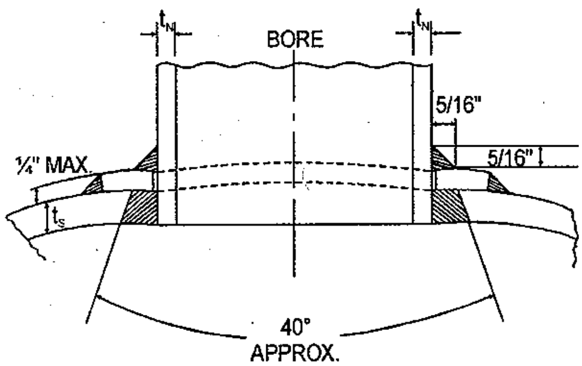
THE TYPE SHOWN IN FIG. 365/27 IS NOT PERMITTED WHERE THE SHELL THICKNESS EXCEEDS 1 INCH.

FIG. 365/27



TYPE SHOWN IN FIG. 365/28 IS NOT PERMITTED WHERE ANY OF THE FOLLOWING LIMITS IS EXCEEDED SHELL THICKNESS 3/4 IN. DESIGN PRESSURE 105 LBS/SQ. IN. DESIGN TEMPERATURE 340°F.

FIG. 365/28



THIS TYPE AVOIDS THE PREPARATION OF GROOVES IN THIN STEEL PLATE. THE RING IS A BACKING RING ONLY AND NOT A COMPENSATING RING. THE TYPE SHOWN IN FIG. 365/29 IS NOT PERMITTED WHERE ANY OF THE FOLLOWING LIMITS IS EXCEEDED : SHELL THICKNESS 1/2"; DESIGN PRESSURE 105 LBS/SQ. IN.; DESIGN TEMPERATURE 340°F.

FIG. 365/29

Branches of not more than 1½ ins. nominal bore may be screwed into the shell with a taper thread and seal welded, provided that the thickness of the shell is sufficient to allow for a length of thread equal to the diameter of the branch. Where the thickness of the shell is not sufficient for this purpose, a boss may be welded on so that the total thickness of the boss and shell is atleast equal to the required length of thread. Methods of attachment of such bosses are shown in Figs. 365/30 to 365/34.

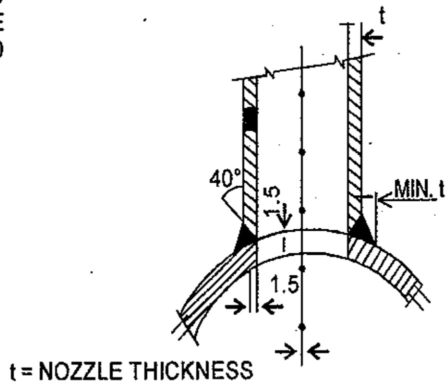
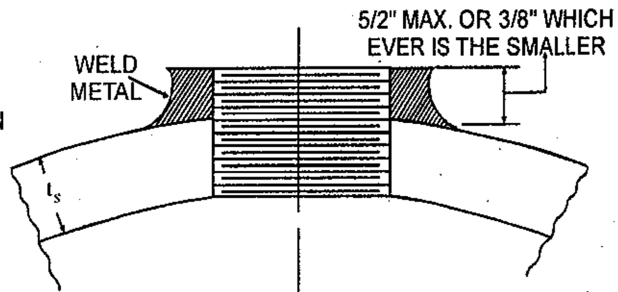


FIG. 365/29A



TAPPED BOSSES EXCEEDING 3/2 IN. STANDARD PIPE SIZE ARE NOT PERMITTED.

FIG. 365/30

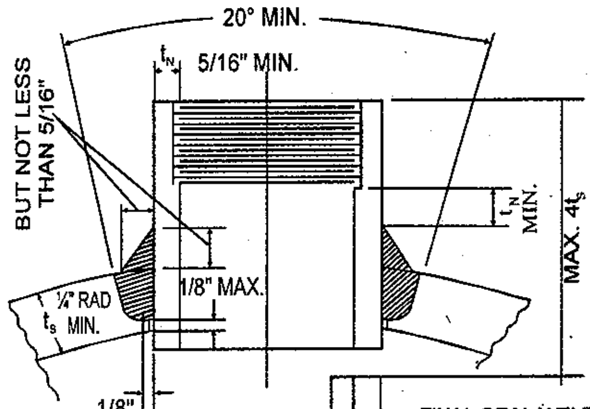


FIG. 365/31

THE TYPE SHOWN IN FIG. 365/31 IS NOT PERMITTED WHERE THE INSIDE OF THE SHELL IS ACCESSIBLE FOR WELDING.

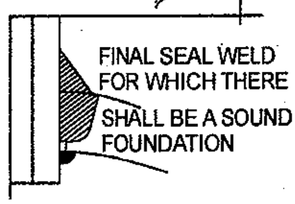


FIG. 365/32

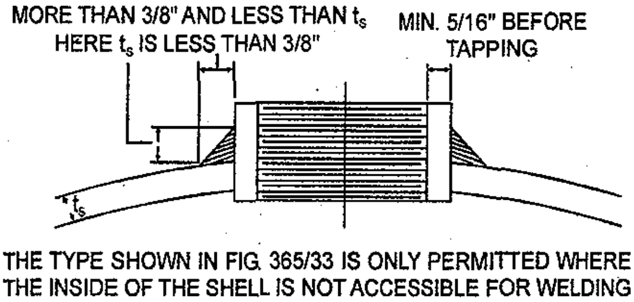


FIG. 365/33

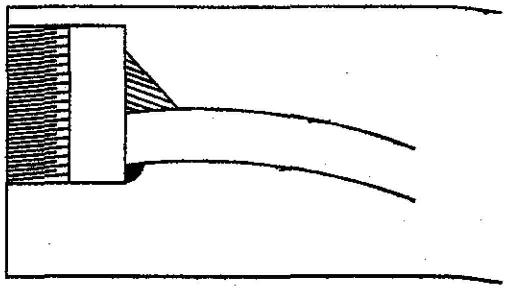


FIG. 365/34 — FINAL SEALWELD

THE TYPES SHOWN IN FIGS. 365/33 & 365/34 ARE NOT PERMITTED WHERE ANY OF THE FOLLOWING LIMITS IS EXCEEDED: SHELL THICKNESS 3/4 INCH; DESIGN PRESSURE 150 LBS/SQ. IN.; DESIGN TEMPERATURE 500°F; TAPPED BOSSES EXCEEDING 1½ IN. STANDARD PIPE SIZES ARE NOT PERMITTED

Branches, Pressed Plate Saddles, Forged Pads of Bosses shall be secured to the shell by one of the following methods:

(i) Riveting.

(ii) Welding.

(iii) Screwing and Seal Welding.

Where branches are riveted on, the flange in contact with the shell shall be closed. The caulking edge shall be machined or flame cut by machine.

Methods of attachment for branches secured by welding are shown in Figs. 365/6 to 365/29A.

Branches may be provided with flanges for ordinary bolted joints. Joints of special type may also be used. Flanges for ordinary bolted joints shall be in accordance with the appropriate table in Appendix E and shall be forged solid with the branches or attached in accordance with Regulations 356 or 357. They shall be machined on the jointing and bolt bearing surfaces.

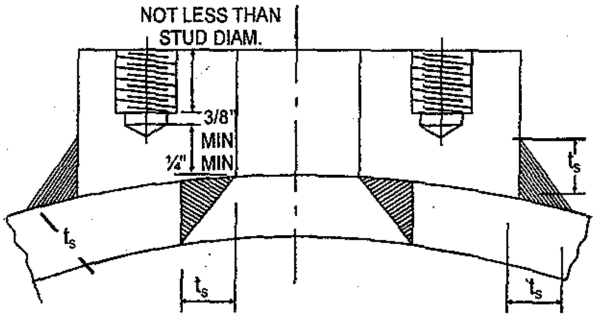
Where pressed plate saddles are used, they shall be formed to bed closely to the shell and shall be machined on the face adjoining the connection and machined or flame cut by machine on the edges. The studs for the attachment of the connection. If screwed through the saddle, shall each be fitted with a nut on the inside. Where the stud holes do not penetrate through the saddle, the length of the screwed portion of the stud in the plate shall be not less than the diameter of the stud.

The join faces of all pads shall be machined.

The pads shall be sufficiently thick to allow the drilling of stud holes for connections without the inner surface being pierced. The length of the screwed portion of the stud in the pad shall be not less than the diameter of the stud. Methods of attachment of pads secured by welding are shown in Figs. 365/35 to 365/41, but where pads of the type shown in Fig. 365/35 are used they shall be formed to bed closely to the shell.

Tapped bosses of not more than 1½ ins. standard pipe welded to the shell, may be used for design pressures not exceeding 200 lbs./sq. in. and design temperatures not exceeding 650°F.

Such bosses shall have taper threads. Methods of attachment of bosses secured by welding are shown in Figs. 365/30, 365/34.



THE TYPE SHOWN IN FIG. 365/35 IS NOT PERMITTED WHERE THE SHELL THICKNESS EXCEEDS 3/4 INCH.

FIG. 365/35

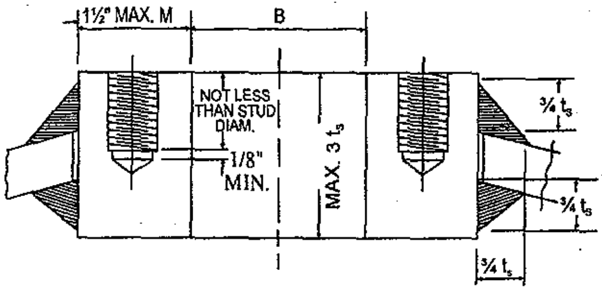
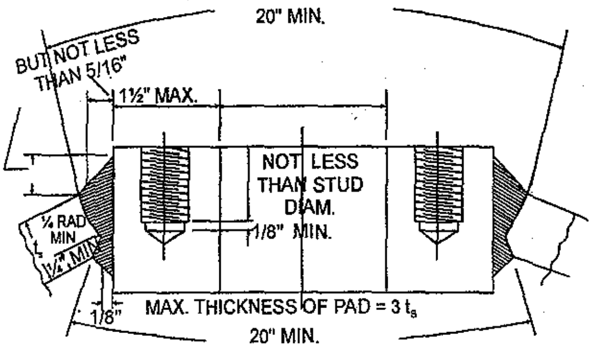


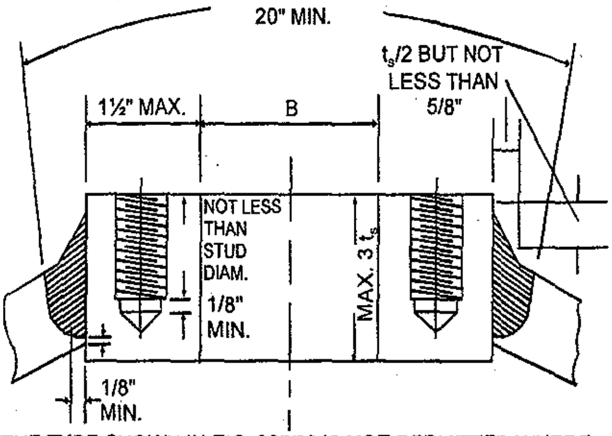
FIG. 365/37



DIMENSION B MAY BE GREATER THAN NOMINAL BORE OF CONNECTION BUT MUST NOT EXCEED : PITCH CIRCLE DIAMETER MINUS (STUD DIAMETER + 1/2 IN.)

WELDING PROCEDURE FOR TYPE SHOWN IN FIG. 365/36 TO BE AS FOR DOUBLE WELDED BUTT JOINT. OUTER WELD TO BE MADE FIRST. BACK OF OUTER WELD TO BE CHIPPED OUT BEFORE COMMENCEMENT OF INNER WELD. BUT DEEP PENETRATION WELDING MAY BE USED SUBJECT TO PROOF OF REQUISITE PENETRATION BEING PRODUCED BY THE MANUFACTURER WHERE CALLED FOR BY THE INSPECTING AUTHORITY.

FIG. 365/36



THE TYPE SHOWN IN FIG. 365/38 IS NOT PERMITTED WHERE THE INSIDE OF THE SHELL IS ACCESSIBLE FOR WELDING.

FIG. 365/38

FINAL SEAL WELD FOR WHICH THERE SHALL BE A SOUND FOUNDATION

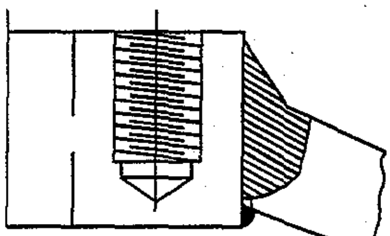
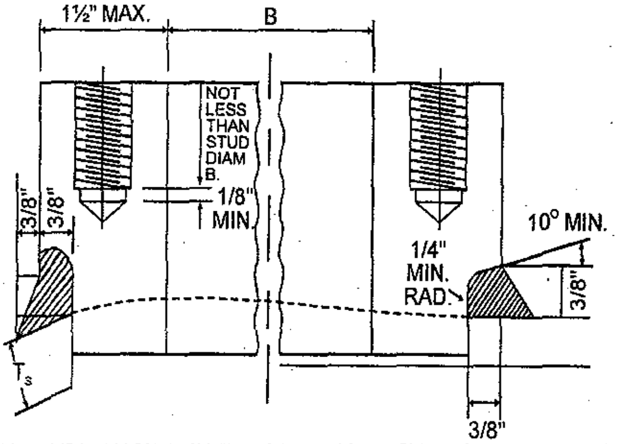


FIG. 365/39

All welded attachments other than flange connections shall be by the Metal arc process and the electrodes used shall comply with the requirements of Regulations 94 to 98. Where tack welds are used they shall be sound and unless cut out, shall be carefully fused into the main runs.

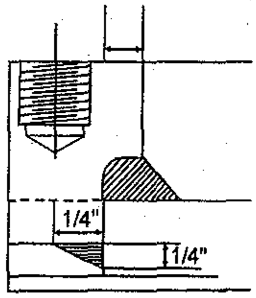
All parts secured by welding shall be effectively heat treated after completion of all welding and before hydraulic test.

DIMENSION B MAY BE GREATER THAN NOMINAL BORE OF CONNECTION BUT MUST NOT EXCEED :
PITCH CIRCLE DIAMETER MINUS (STUD DIAMETER + ½ IN.)
THE TYPES SHOWN IN FIGS. 365/37, 365/38 AND 365/39 ARE NOT PERMITTED WHERE THE SHELL THICKNESS EXCEEDS ¾ INCH.



THE TYPE SHOWN IN FIG. 365/40 IS NOT PERMITTED WHEN THE INSIDE OF THE SHELL IS ACCESSIBLE FOR WELDING.

FIG. 365/40



DIMENSION 'B' MAY BE GREATER THAN NOMINAL BORE OF CONNECTION BUT MUST NOT EXCEED : PITCH CIRCLE DIAMETER MINUS (STUD DIAMETER + ½ IN.) THE TYPES SHOWN IN FIGS. 365/40 AND 365/41 ARE NOT PERMITTED WHERE THE SHELL THICKNESS EXCEEDS ¾ INCH.

FIG. 365/41

(f) **Shell Joints—**

(1) **Riveted Shells**—Preparation of plates, butt straps, rivet holes and riveting shall comply with the relevant Regulations of Chapter III.

Longitudinal joints, of riveted shells may be lap jointed or fitted with double but straps, but in cases where the design pressure exceeds 130 lbs./sq. in. or the product of the design pressure in lbs./sq. in. and maximum internal diameter in inches exceeds 9,500, the longitudinal joints shall be butt jointed with double cover strap. The design of riveted joints shall be in accordance with Regulations 177 to 184.

(2) **Fusion Welded Shells**—These shall be classified as follows:

Class I—No limit to scantlings.

Class II—When none of the following limits is exceeded—

(i) Working Pressure 35 kg/sq. cm. (500 lbs./sq. in.).

(ii) Product of Working Pressure and Internal Diameter—3750 (21000).

(iii) Design Temperature—343°C (650°F).

Class III—When none of the following limits is exceeded—

(i) Working Pressure 7—4 kg/sq. cm. (105°p si).

(ii) Product of Working Pressure and Internal Diameter—940 (5250).

(iii) Design Temperature 171°C (340°F).

Fusion welds, preparation of seam, the method of formation of cylindrical shells including heat treatment after bending method of making welded seams, types of welded joints, test plates and circularity of shells shall conform to the requirements of Chapter V, except for the following, namely:—

Whenever practicable, seams shall be welded from both sides of the plate. Additional runs of metal shall be deposited at both surfaces of the welded seams to build upto a thickness 10 per cent greater than thickness of the plate. The surfaces of welds wherever carried out on both sides shall be ground smooth and flush with the respective surfaces of the plates. Where the seam is welded from one side only, these provisions shall apply to the exposed of the surface weld.

Tests for Class I fusion welded seams shall comply with the requirements of the relevant Regulations of Chapter V.

Tests for Class II fusion welded seams shall comply with the requirements of those of Chapter XII, except that an additional provision for one micro and macro examination shall be made.

Tests for Class III fusion welded seams shall comply with the requirements of those of Chapter XII.

Class I and Class II shells shall be effectively stress-relieved by heat treatment when the wall thickness exceeds 20 mm. or the carbon content exceeds 0.25% or the pipes are made of alloy steel.

366. Determination of Working Pressure

(a) **Shells**—The maximum working pressure of shells shall be determined by the following formula:—

$$W.P. = \frac{2fE(T-.03)}{D+T-.03}$$

where, T = is thickness in inches,

D = is maximum internal diameter in inches,

WP = is working pressure in lbs./sq. inch,

f = is maximum permissible working stress as prescribed in Regulation 271 or 350 whichever is applicable in lbs./sq. inch at the working metal temperature,

E = is efficiency of longitudinal riveted seam as given in Regulation 117,

is efficiency factor for fusion welded shells as given in table below,

is 1.00 for seamless shells or shells made from seamless tubes,

is efficiency of ligaments between holes or openings in shell expressed as a fraction.

Class	Efficiency factor E
I	0.90
II	0.75 if welded from both sides
	0.50 if welded from one side only
III	0.45

Minimum thickness of shells shall be as given in table below:

Classification	Internal diameter ins.	Minimum thickness in.
Fusion welded Class I,		1/4
Fusion welded Class II and Class III, and	Upto and including 24	1/4
Shells other than fusion welded	Over 24 and upto & including 36	5/16
Shells	Over 36	3/8

Where steels are intended for service at temperatures in excess of 700°F this shall be so stated and silicon contents shall be not less than 0.10 per cent or alternatively, the material must pass the 'Proof test for creep quality of carbon steel plate of boiler plate quality' as in Appendix D.

Compensation for Openings in Shells—Where the major axis of diameter of any hole cut in cylindrical part of the shell is greater than 2½ times the thickness of the shell plate plus 2¾ inches, compensation shall be provided.

The sectional area to be compensated measured in the plane parallel to the longitudinal axis of the shell, which makes this area a maximum, shall be the product of the length of the opening (including any rivet holes in the plane) and the thickness of a seamless shell of similar material calculated in accordance with Equation 72 (Regulation 270) for the same conditions of pressure and temperatures.

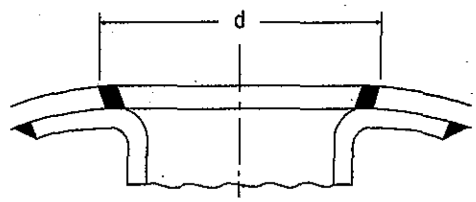
Where frames, pads or branches are secured by rivets, the compensating area shall be calculated by the method given in Regulation 170.

Where frames, pads or branches are secured by welding, the compensating area shall be calculated by the method given in Regulation 170.

(b) **End Plates**—(1) **Dished End Plates**—The maximum working pressure or dished end plates with 'pressure on concave side' shall be determined by Regulations 276 to 278.

For manholes formed by welding on pressed frames to dished end plates as in Fig. No. 366/1.

The value of E may be taken as unity when the diametral cross-sectional area of the compensating frame and/or ring is equal to or greater than the diametral cross-sectional area of the opening in the end plate to be compensated.



NOTE: THE DIAMETER OF THE COMPENSATING PLATE SHALL NOT EXCEED TWICE OF THE OUTSIDE DIAMETER OF THE BRANCH

FIG. 366/1 — ELLIPTICAL MANHOLE FRAME WELDED TO DISHED END PLATE

For ends which are butt-welded to the cylindrical parts of the shell the thickness of the edge of the flange for connection to the cylindrical part of the shell shall be not less than that required for seamless unpierced shell as determined by Equation 72.

(2) **Flat End Plates**—The maximum working pressure for welded in flat end plates as in Fig. Nos. 365/2, 365/3 and 365/4, shall be determined by the following formula:—

$$W.P. = \frac{f\,T^2}{C\,d^2}$$

where, T = minimum thickness of end plate in inches,

d = internal diameter of shell in inches,

W.P. = working pressure in lbs./sq. in.,

C = 0.28.

Maximum permissible working stress in pounds per sq. inch at working metal temperature as prescribed in Regulation 271.

Where steels are intended for service at temperatures in excess of 700°F. This shall be so stated and silicon content shall not be less than 0.10 per cent or alternatively, the material shall pass the 'Proof test for creep quality of carbon steel plates of boiler plate quality' as in Appendix D.

Where flat end plates are bolted to flanges as in Fig. 365/5 the dimensions of the flanges shall be as given in Appendix E. The thickness of the end plates shall be not less than that of the corresponding flanges.

Where the diameter of a hole in the flat end plate exceeds 2½ T + 2¾ inches compensation shall be provided in accordance with Regulations 170 and 279.

(c) **Branches**—Where branches of saddles are secured to the shell by riveting or by studs, the minimum thickness of the flange adjoining the shell shall be in accordance with the following table:—

Table

Thickness of shell plate *in.*	*Minimum thickness of flange* *in.*
3/8 to 3/4	1/2
above 3/4 to 1	5/8
above 1 to 2	3/4
above 2	1

The actual dimensions of the flanges shall be governed by the requirements of compensation for the opening.

The dimensions of flanges of branches remote from the shell for ordinary bolted joints and those of bolts of all pads and saddles shall be in accordance with the appropriate table given in

Appendix E for the working pressure and temperature corresponding to the design pressure and temperature of the shell. The dimensions of the flanges for special joints shall be subject to approval of the Chief Inspector of Boilers concerned.

The working pressure for the body of the branch shall be determined by the equation as given in sub-regulation (a) above subject to the requirements of compensation for the opening.

Notwithstanding the result obtained from the equation the minimum thickness of the body of the branches shall be such that in no case does the total stress, resulting from the combination of the stress due to internal pressure and to all externally applied loads, exceed the permissible stress corresponding to the design temperature. The method of calculating the total stress shall be subject to the approval of the Chief Inspector of Boilers concerned. Where the magnitude of the externally applied loads cannot be determined, the minimum thickness of the body of the branch shall be as given in the following table:—

Minimum Thickness of Branches where External Loads are not Known

Nominal bore of branch	*Thickness of cylindrical part of shell*	*Minimum body thickness*
in.	*in.*	*in.*
Upto and including 2½	¾ and above 3/8	For thinner shells not less than
Over 2½ upto and including 4½	7/8 and above 7/16	one half the thickness of the
Over 4½ upto and including 8	1 and above ½	cylindrical part of the shell.
Over 8 upto and including 10	1¼ and above 5/8	Subject to approval of the Chief
Over 10	1¼ and above	Inspector of Boilers concerned.

(d) **Inspection during Construction**—All parts of steam receivers, separators catch waters and similar vessels shall be inspected at all appropriate stages of construction detailed in Appendix J of the Indian Boiler Regulations.

367. Steel Screwed and Socketed Joints and Mountings of Steel

Steel couplings or sockets may be used on pipes within the limits below:—

Nominal bore	*Maximum permissible pressure*		*Maximum permissible pressure*	
	Lbs./sq. in.	*kg./cm²*	*°C*	*°F*
Upto and including 25 mm (1 in.)	175	12.25	260	500
Over 25 mm (1") upto and including 38 mm (1½")	150	10.5	260	500
Over 38 mm (1½") upto and including 76 mm (3")	125	8.75	260	500
Over 76 mm (3") upto and including 102 mm (4")	100	7	260	500
	120	8.5	177	350
Over 102 mm (4") upto and including 127 mm (5")	100	7	171	340

Screwed joints are permitted at temperatures exceedings 260°C and size or pressure limits in excess of those given in the table provided that the following conditions are satisfied, namely:—

(1) All threads are tapered unless pressure tightness depends on a sealweld or a seating surface other than the threads and experience or test demonstrates the suitability of the joint.

(2) Pressure or temperature rating in appropriate component standard like BS, ASME, DIN etc. or as calculated under relevant regulation of these regulations are not exceeded.

(3) Minimum specified tensile strength of screwed pipes is greater than 330 N/mm^2.

(4) The minimum thickness of screwed pipes is not to be less than that given in Table No. 1.

(5) The design temperature does not exceed 495°C.

(6) The pressure limits given in Table No. 2 are not exceeded.

Screwed joints are permitted for temperatures in excess of 495°C and pressure in excess of those given in Table No. 2 for instrument insertion and tapping and for plug for access opening for radiographic inspection provided following conditions are satisfied:—

(a) They do not exceed 50 mm nominal bore size or one quarter of nominal pipe size, whichever is the smaller.

(b) The minimum thread engagement is not less than—

6 for up to and including 20 mm nominal bore;

7 for over 20 mm up to and including 40 mm nominal bore;

8 for 40 mm up to and including 50 mm nominal bore.

(c) The connection is seal-welded.

(d) The design of instrument insertion withstands the fluid characteristics, fluid flow and any vibrations.

Screwed joints are permitted for pressure in excess of those given in Table No. 2 up to 345 bar for dead end instrument lines at the outlet end and downstream of shut off valves and instruments, control apparatus or discharge of a sample cooler provided that the nominal bore size of the pipe does not exceed 12 mm.

Table No. 1: Minimum Thickness of Screwed Pipes

Nominal pipe size (mm)	*Minimum thickness*	
	17.5 bar or less for steam 7 bar and less for water over 105°C (mm)	*Over 17.5 bar for steam Over 7 bar for water over 105°C (mm)*
8	2.24	3.02
10	2.31	3.20

Contd...

Contd...

15	2.77	3.75
20	2.87	3.91
25	3.38	4.55
32	3.56	4.85
40	3.68	5.08
50	3.91	5.54
65	5.16	7.01
80	5.49	7.62

Table No. 2: Maximum Pressure for Screwed Pipes

Nominal pipe size (mm)	*Maximum pressure bar*
Over 50 up to and including 80	27.5
Over 25 up to and including 50	41.5
Over 20 up to and including 25	83
Up to and including 20	103.5

368. Bronze Screwed and Socketed Joints and Mountings and Fittings of Bronze

Mountings and fittings of bronze upto 76 mm (3") diameter may be attached directly to steel pipes by screwing when the pressures and temperatures do not exceed 8.5 kg/cm^2 (120 lbs./sq. in.) and 225°C (435°F) respectively; where tapered threads are employed, such joints may be used for pressures not exceeding 17.6 kg/cm^2 (250 lbs./sq. in.). Bronze fittings above 76 mm (3") diameter shall be of flanged construction.

369. Reducing Valve

Where a reducing valve is installed in a pipeline, the pipeline and accessories on the low pressure side of the reducing valve shall be protected by a suitable safety valve or valves so adjusted as to permit the steam to escape as soon as the safe working pressure is exceeded or by a suitable appliance for cutting off automatically the supply of steam as soon as the safe working pressure is exceeded.

370. Flexibility

(a) The pipes shall be arranged so that the system is sufficiently flexible to absorb, the whole of their expansion and the imposed movement of the connected equipment without the actual expansion stress (SE) exceeding the allowable stress range (SA) as is determined from the following equation:—

$$SA = f\,(1.25\,SC + 0.25\,SH)$$

where, SC = basic material allowable stress at the minimum (cold) temperature,

SH = basic material allowable stress at maximum (hot) temperature,

SE = actual calculated expansion stress obtained from the stress analysis,

f = stress range reduction factors of cyclic conditions for total number N of full temperature cycles over the total number of years during which the system is expected to be in operation as given in table below:

TABLE: Stress Range Reduction Factors

N			F
7,000	and	less	1.0
7,000	—	14,000	0.9
14,000	—	22,000	0.8
22,000	—	45,000	0.7
45,000	—	100,000	0.6
100,000	and	above	0.5

Notes: 1. Value of SC and SH shall be guaranteed by the manufacturer of steel from which pipes are made and furnished to the pipe makers/Inspecting Authority until such time such values of SC and SH are incorporated in the Regulations.

2. In case of imported pipes conforming to a recognised foreign standard or code the values of SC and SH may be taken from the table of allowable stress as given in that code or the value may be determined on the basis given in that code.

3. The sum of the longitudinal stress due to pressure, weight and other sustained load including bending stresses caused by external loads shall not exceed the allowable stress in the hot conditions (SH). Where the sum of these stresses is less than SH, the difference between SH and this sum may be added to the term 0.25 SH, in the above formula for determining the allowable stress range SA.

4. Calculation of the expansion stress, SE shall be based on modulus of elasticity at room temperature.

(b) Where practicable, the requisite flexibility shall be provided in the layout of the pipes without having recourse to special expansion bends or expansion joint except for the safety valves discharge piping. Where lack of space or other considerations prohibits the use of this method, expansion fittings like expansion joints or the belows type of corrugated pipes may be used provided that the limitations imposed by maximum design pressure, drainage etc., are taken into account. If the expansion fittings are used, detailed consideration shall be given to the design of anchors, guides and ties to ensure that they adequately protect the expansion fitting and accommodate the additional loads due to pressure.

(c) Notwithstanding anything contained in clause (a) of this regulation the complete analysis of the piping system may be waived if the system meets any of the following criteria:

(1) The piping system duplicates a successfully operating installation or replaces a system with a satisfactory service record.

(2) The piping system can be adjudged adequately by comparison with previously analysed system.

(3) The piping system is of uniform size with not more than two anchors and no intermediate restraints and satisfied the following:—

$$\frac{DY}{(L-U)^2} = 208$$

where, D = nominal pipe size in mm.,

Y = resultant of movements to be absorbed by pipelines in mm.,

L = developed length of line axis in metres,

U = anchor distance (length of straightline joining anchors) in metres.

Notes: 1. If the system is not meeting the above criteria or where reasonable doubt exists as in the adequate flexibility of the system, shall be analysed on the basis given in clause (a) of this regulation by simplified, approximate or comprehensive methods of analysis that are appropriate for the specific case.

2. Approximate or simplified method may be applied only if they are used for the range or configurations for which their adequate accuracy has been demonstrated.

3. Data for thermal expansion, modulus of elasticity, poisson's ratio, flexibility factors and stress intensity factors may be taken from any code/specification.

4. Nominal diameter and nominal thickness may be used in the calculation of expansion stress.

371. Pipe Work Supports

All pipe work shall be adequately supported in order to permit free movement for expansion and contraction, and the amount of such movement shall be proportioned throughout the whole of any main by the provision of anchors at suitable points. Where pipes may be subject to vertical movement, spring supports designed to carry the load under all conditions shall be provided. It is desirable that points of supports should, as far as practicable, be arranged adjacent to the pipe joints. Slings are in general preferable to roller supports and these latter should be used only where necessary. All pipe supports should as far as practicable, be of mild steel and pipe anchors either of mild steel or cast steel.

372. Drainage

(a) In the case of steam mains, attention should be paid to the adequate provision of drainage points in the form of drain pockets. Drainage points connected to stream-traps, shall be provided wherever water can collect under working conditions. Hand drains shall be provided at all points at which water can collect in any portion of the steam main, by valve leakage or other means, when shut down, or when warning up prior to use.

(b) Where practicable a suitable gradient shall be provided in the pipe work to ensure the passage of condensed water in the direction of flow of steam towards the drainage points.

(c) It is recommended that a bypass should be fitted at each steam trap.

(d) Where the volume of water deposited is likely to be of serious proportions, separator should be installed. Each separator shall be furnished with a steam trap which shall be connected to it by means of a three-way cock one end of which is connected to a manually operated drain.

373. Freedom from Rust and other Foreign Matter

All pipes, valves and fittings shall be thoroughly cleaned as far as possible of rust and other foreign matter before erection and pipelines shall be blown through with steam or air before being put into service.

374. Test Pressures

(a) Each completed pipe and fitting shall be tested by hydraulic pressure as per requirement of Chapter II.

(b) Pipes and fittings with flanges for steam pressure exceeding 7 kg/cm^2 (100 lbs. per sq. in.) shall be tested with blank flanges bolted or clamped on. All other pipes, if straight, may be tested between the heads of an ordinary hydraulic pipes testing machine.

(c) The piping system shall, after erection, be subjected to a hydrostatic test pressure. The hydrostatic test pressure at any point in the piping system shall not be less than 1.5 times the design pressure but shall not exceed the maximum allowable test pressure of any non-isolated components such as vessels, pumps or valves. At no time during the hydrostatic tests shall any part of the piping system be subjected to a stress greater than 90 per cent of its yield strength (0.2 per cent off set) at test temperature.

Notwithstanding anything contained in this clause, for boiler external piping and non-boiler external piping which are open to atmosphere such as vent and drain pipes, the hydraulic test for the portions of such pipes located beyond the last isolation valve may be dispensed with provided the weld joints in the pipe under reference are tested 100% by approved non-destructive examination and found satisfactory.

(d) Special arrangements shall be made, according to circumstances, for testing bends and other fittings which are not flanged.

(e) Hydraulic testing of butt-welded and socket-welded joints shall be conducted either at maker's work or at user's premises on completion of fabrication of pipes by the Inspecting Authority.

(f) Hydrostatic testing of fabricated pipes having attachments of flanges, fittings, butt joints, branch joints and weldolets shall be done at manufacturer's works or alternatively at site at 1.5 times the design pressure. Where hydraulic testing of fabricated pipe joints is not carried out at manufacturer's works, dye-penetrant test shall be carried out on the welded joints alongwith five per cent radiography of such joints.

CHAPTER IX

REGULATIONS FOR THE REGISTRATION OF BOILERS AND INSPECTION OF BOILERS AND STEAM-PIPES

375.

*The procedure to be followed in connection with applications for the registration of a boiler and with examinations of boilers under the Act shall be regulated in accordance with the provisions of this Chapter read with the relevant Sections of the Act.

376. Preparations for Inspection

(a) At every examination of boiler or the grant of renewal of a certificate, the boiler shall be empty and thoroughly clean in all its parts. Except as provided as for in sub-regulation (f) all doors of manholes, handholes and sightholes and cleaning plugs and all caps in the leaders and mud drums of water tube boilers, all firebars, bearers, front plates, bridge plates, fire bridges brick arches, oil fuel burners and mechanical stoker fittings shall be removed. All valves and cocks comprising the boiler mounting shall be opened up and taken apart and the valves or cocks ground, when necessary, before the Inspectors' visit.

(b) Provision shall, if required by the Inspector, be made for the removal of lagging or brick-work or other concealing part and for the drilling of plates, and for verifying the pressure gauge and safety valve dimensions and weights.

(c) All smoke tubes, exterior of water tubes, smoke boxes, and external flues shall be swept clean.

(d) Provision shall be made for the effective disconnection of all steam and hot water communication with another boiler under steam as required in Chapter XI-A of these Regulations.

(e) No blank flange/plug shall be inserted between a safety valve chest and the boiler generally and where it is permitted by the Inspector, the blank flange/plug shall be removed in his presence.

(f) At alternative annual inspections and subject to a minimum of three bottom rows or all tubes subject to the first pass of heat being opened up for inspection, the Inspector may at his discretion relax the preparation for inspection called for under (a) above in favour of boilers having an evaporative capacity of 200,000 lbs. per hour and over, and fed either water treated to the satisfaction of the Inspectors.

(ff) For boilers used exclusively for electric power generation, the inspection shall be carried out in accordance with the provisions of Appendix JA.

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* **Note:** In accordance with Sections 7 & 8 of the Act, Inspectors are requested to measure and examine boilers for registration, to examine boilers for renewal certificates, to determine subject to the approval of the Chief Inspector, the pressure at which they may be allowed to work, to grant certificate therefor and generally to convey to the owners such orders as the Chief Inspector may issue.

(fff) For Captive Boilers and Waste Heat Boilers (Fired and Unfired) used exclusively in continuous process plants, the inspection shall be carried out in accordance with the provisions of Appendix JB. The boilers used in corrosive environment such as Sulphuric acid plants shall not be covered under the provisions of Appendix JB.

(g) In the case of forced flow and forced circulation types of boilers, provisions shall be made for checking that proper circulation is maintained through all sections of the circuit by the flow of water.

377. Hydraulic Test of Boilers for Registration

(a) Every boiler shall be hydraulically tested in the presence of an Inspector.

(b) Boiler working at a pressure 50 kg/cm^2 or more, and used exclusively for electric power generation need not be hydraulically tested for issue of certificate every year, provided that the inspection of such boiler is carried out as per the provisions of Regulation 376.

(c) Captive Boilers and Waste Heat Boilers (Fired and Unfired) used exclusively in continuous process plants need not be hydraulically tested for issue of certificate every year:

Provided that the inspection of such boilers is carried out as per the provisions of regulation 376.

378. Preparation for Hydraulic Tests

(a) The chest of all mounting subject to the steam pressure shall be in place and shut tight or blank flanged.

(b) The safety valves should invariably be removed and the chest opening blank flanged.

(c) The attachment for the Inspector's pressure gauge shall be in order.

(d) All doors shall be properly jointed and tightened up. The boiler shall be completely filled with water, care being taken to allow all air to escape and, if possible, a preliminary test not exceeding the working pressure of the boiler shall be taken before the Inspector's visit, to test the tightness of the joints.

*(e) When a boiler is hydraulically tested for the first time, it shall be entirely cleared of lagging or brick work; at subsequent tests the lagging or brick work, or portions thereof, shall be removed if required by the Inspector:

Provided that the Inspector may, at his discretion, allow the lagging and brick work to remain *in situ*, in case of boilers where the covered parts have been fabricated and tested before erection in position.

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* **Note:** These deflection measurements should be entered in the memorandum of Inspection Book before its submission to the Chief Inspector.

379. Procedure of Hydraulic Tests

(a) (i) Subject to the provisions of sub-regulation (e) of Regulation 381, every boiler shall be hydraulically tested after erection at site in presence of the Inspector to 1¼ times the maximum working pressure as certified by the Inspecting Authority in Form II, to be stamped on the boiler, as free from any indication of weakness or defects.

(ii) If all components of the boiler in the manufacturers's premises have not been tested hydraulically as per Regulation 268, the test, on completion, shall be taken to 1½ times the maximum working pressure.

(iii) The temperature of the water used as medium of pressure testing shall not be less than 20°C and greater than 50°C.

(iv) The test pressure shall be raised gradually under proper control at all times so that it never exceeds by more than 6% of the required pressure and maintained for 30 minutes whereupon the pressure shall be reduced to maximum allowable working pressure and maintained for sufficient time to permit close visual inspection for leakage of pressure parts.

(b) The boiler shall satisfactorily withstand such pressure without appreciable leakage or undue deflection or distortion of its parts for at least ten consecutive minutes. If the test is not satisfactory, the working pressure allowable by calculation shall be suitably reduced, unless the owner desires to make such alterations as will enable the boiler to withstand satisfactorily the hydraulic test, in which case the boiler shall again be examined after the alterations have been made, the pressure recalculated, if necessary and the boiler tested to satisfaction of the Inspector.

*(c) At the first hydraulic test of a boiler prior to the issue of an original certificate deflection measurements shall be made before, during and after test of each furnace length, fire-box and flat end or other plates.

(d) After the application of the hydraulic test the Inspector shall carefully examine the boiler inside and outside and satisfy himself that it has satisfactorily withstood the test.

(e) In any case in which the safe working pressure to be allowed for a boiler cannot, owing to peculiar construction of any of its parts, be determined by calculation in the ordinary way, the Inspector shall, under the direction of the Chief Inspector, subject the boiler to hydraulic test for the purpose of determining the fitness of such parts. The amount of the test pressure to be applied in such a case shall not exceed the test pressure prescribed for the least working pressure found by calculation for other parts of the boiler or the intended working pressure whichever is less.

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* **Note:** These deflection measurements should be entered in the memorandum of Inspection Book before its submission to the Chief Inspector.

(f) Should any part of the boiler show undue detection or indication of permanent set during the progress of the test, the pressure shall be released immediately such indications are observed. The working pressure for the part shall be 40 per cent of the test pressure applied when the point of permanent set was reached. This procedure shall apply to any boiler at any test.

(g) Hydraulic tests of boilers at subsequent examination shall, except when the Inspector expresssly requires otherwise, be made after the inspection. The test pressure to be applied to boilers at such subsequent examinations shall be from one and quarter to one and a half times the working pressure of the boiler.

(h) When the internal construction of size of a boiler does not permit of the Inspector getting inside it or of examining closely all its parts, he shall see it tested by hydraulic pressure to one and a half times the working pressure at each inspection or the grant or renewal of a certificate.

(i) Water tube locomotive type and all tubular boilers shall be hydraulically tested at each inspection for the grant or renewal of a certificate, unless such test is waived under the orders of the Chief Inspector.

(j) The Inspector may if he considers it necessary, apply a hydraulic test to any boiler at any inspection.

*(k) Except in the case of vertical boilers heating surface of which is less than 18.50 sq. m. (200 sq. ft.) portable and vehicular boilers, which do not require re-erection or building in brick work, the hydraulic tests of all boilers shall be conducted only after the erection of the boiler *in situ* and all boilers shall after re-erection in a position different from that in which were last examined be hydraulically tested.

***Note:** These deflection measurements should be entered in the memorandum of Inspection Book before its submission to the Chief Inspector.

(l) A hydraulic test shall also be taken granting an increased pressure certificate and after repairing a boiler. However, in the case of minor repairs to the Water Tube Boilers where NDT has been carried out, hydraulic testing may be dispensed with provided NDT is carried out by an approved method.

(m) When carrying out hydraulic test, Inspectors shall use pressure gauges supplied by the Chief Inspector.

#380. Steam Tests

(a) Every newly registered boiler and every other boiler of which the working pressure has been altered shall, before the issue of an original or renewal certificate for such boiler, be tested under steam to the satisfaction of the Inspector.

\# **Note:** A steam test is primarily intended for the purpose of ascertaining by actual test whether the safety valves are sufficient to relieve boilers effectively of excess steam and whether they operate at the time when the maximum working pressure is reached. Inspectors shall always send to the owner due notice of the date fixed for the steam test. On completion of the test the Inspector should enter all details in the Memorandum of Inspection Books.

(b) At the time of test the safety valves shall be left free and capable of being adjusted to the approved working pressure.

(c) After adjustment of the valves to the correct blowing pressure the boiler shall be tried under full steam and firing with the feed water shut off and the stopvalve closed, during which time the Inspector shall note the accumulation of pressure and other details of the test as well as the loading and adjustment of the safety valves.

In the case of water tube boiler or boilers fitted with superheater, the feed water connection and stop valve need not be shut off and if the total valve area is lifted and found to be adequate by calculations, the requirement of the accumulation test may be assumed to have been satisfied if the valves are or have been found so adjusted that at least one safety valve on each boiler shall lift at or below the designed working pressure of the boiler and all valves shall lift so that all steam which can be generated by the boiler can be discharged with a pressure rise not exceeding 10 per cent of the designed working pressure.

(d) Before the safety valve test, the Inspector shall satisfy himself that the water gauges are in working order and that the feed apparatus is capable of supplying the boiler with sufficient water.

(e) Where the State Government does not require a person-in-charge of a boiler to hold a certificate of competency, the Inspector may, when he thinks fit, satisfy himself by questioning or by practical test whether the person-in-charge of the boiler understands the use and purpose of the water gauges, the pressure gauge, the safety valves, the feed water supply and blow down.

(f) When witnessing safety valves test, Inspectors shall use the standard pressure gauges supplied by the Chief Inspector unless the boiler pressure gauge has, since the time of inspection, been tested and found correct with an authorised testing machine.

(g) No steam gauge shall be used without a syphon filled with water between it and the boiler.

(h) When the accumulation of pressure at a steam test exceeds ten per cent of the maximum working pressure, the area of the safety valves shall be considered insufficient, and a certificate shall be refused until the safety valve area is increased.

(i) An Inspector may, when visiting a factory for any purpose, verify the correctness of the safety valves and pressure gauge of any boiler under steam by comparison with his standard pressure gauge.

381. Procedure for Registration

(a) On receipt of an application for registration under Section 7(1) of the Act, the Inspector shall, when the boiler has been properly prepared for examination proceed to measure incomplete detail all its parts, ascertain the working pressure allowed by the Regulations by making a series of calculations being based on his measurement and if he is satisfied with the correctness of the maker's certificate, on the dimensions and other particulars relating to the material and construction as stated therein [vide Section 14(1)(c) of the Act and Regulation]. In making his calculations he shall after examination of the material, take due account of the workmanship and details of the construction of each part. In his examination the Inspector may, if he deems necessary bore the plates or other parts to ascertain their thickness and in making his calculations he shall be guided by the requirements of relevant Chapters of the Regulations.

(b) If no formulae of co-efficient applicable to any part is contained in the relevant Chapters of the Regulations, the Chief Inspector shall in his discretion determine the fitness of such part.

(c) The strength of the weakest part so calculated or determined, subject to any discretionary power exercised by the Chief Inspector, shall determine the permissible working pressure of the boiler. After inspecting the boiler and ascertaining by the prescribed calculations the maximum pressure at which the boiler may be worked, the Inspector shall hydraulically test and steam test it in accordance with requirements of Regulations 379 and 380 and a provisional order under Section 9 of the Act in Form V may be issued after the hydraulic test.

(d) The Inspector shall enter the above particulars and dimensions of the boiler and calculations of strength of the various parts, together with details of the hydraulic and of the steam tests, in a "Memorandum of Inspection" Book (vide Regulation 386) which, together with all the makers' papers for the boiler, shall be submitted to the Chief Inspector with the Inspector's report under sub-section (3) of Section 7 of the Act in Form I.

(e) Where a certificate in Form II and a Memorandum of Inspection Book in Form I are furnished by an Inspecting Authority in accordance with sub-regulation (c) of Regulation 4 the Inspector shall, on receipt of an application for registration under sub-section (1) of Section 7 of the Act, proceed to make such examination and measurement of boiler as will satisfy him that the boiler is the one certified by the Inspecting Authority and carry out a thorough examination and check the measurements to ensure the correctness of the Inspecting Authority's certificate and that no damage has been caused in transit.

The Inspector shall, if he is satisfied with the condition of the boiler, the correctness of the particulars and approved working pressure entered in "Form I by the Inspecting Authority subject the boiler to hydraulic test in accordance with Regulation 379".

Then the Inspector is satisfied that the boiler has satisfactorily withstood the test, he shall issue a provisional order to enable the boilers to be worked.

382. Engraving of Registry Number

(a) The registry number of every boiler shall, within a period of one month from the date of receipt thereof be cut in the front plate or any such position as shall be pointed out by the Inspector. The device for each State and Union Territory shall be distinguished by the following letters:—

Andaman and Nicobar Islands	A&N	Chhattisgarh	CG
Andhra Pradesh	AP	Dadra & Nagar Haveli	DNH
Assam	A	Daman & Diu	DU
Bihar	BR	Delhi	D

Goa	G	Nagaland	NL
Gujarat	GT	Orissa	OR
Haryana	HA	Pondicherry	PY
Himachal Pradesh	HP	Punjab	PI
Karnataka	KTK	Rajasthan	RJ
Kerala	K	Tamilnadu	T
Laccadive, Minicoy & Aminidivi Islands	LI	Tripura	TR
Madhya Pradesh	MP	Uttar Pradesh	UP
Maharashtra	MR	Uttaranchal	UR
Manipur	MA	West Bengal	WBL
Meghalaya	ML		

The distinguishing letters shall be engraved above a number and separated therefrom by a horizontal line 64 mm in length. The letters and figures shall be 25 mm in height and of suitable breadth, provided that in the case of small boilers the letters and figures of the device may, in the discretion of Chief Inspector, be reduced to 10 mm in height. The whole shall be enclosed in a rectangle, the upper and lower sides of which shall be 76 mm apart and 6 mm clear of the top of the letters and the bottom of the figures respectively as indicated below:—

MR
1234

In the case of registration of small industrial boilers, the letter "S" shall be added as a prefix to the registration number below the distinguishing letters for State or Union Territories as indicated below:—

UP
S-.........

The side lines shall be at equal distance clear from the figures. The engraving shall not be less than 0.4 mm in depth.

(b) The engraving shall be completed and ready for verification within one month from the date of receipt of registry number, and the fact shall be reported to the Chief Inspector of Boilers within this period.

(c) Boilers having registry devices different from those prescribed herein shall have such devices altered or crossed out and engraved a new one in conformity with those prescribed above. The original numbers of such boilers shall be retained in the new device, provided that in the case of boilers which were registered in a State or Union Territory which has since become extinct, a new number shall be given by the State or Union Territory where the boiler is operating. A number once allotted to a boiler shall not be used again for another boiler.

383. Measurement of Heating Surface

(a) For the purpose of regulating the area of the safety valves and the amount of registration and inspection fees the "heating surface" of a boiler shall be the total surface of all plates and tubes exposed to heat on one side and in contact with water on the other measured on the water side or the fire side, whichever is larger.

(b) For Lancashire and Cornish boilers the total heating surface shall include the wetted surface of the furnaces between the end plates, the fire surface of cross tubes where fitted, and the part of the external shell below the side flue covers. In estimating the areas furnaces shall be considered as plain cylinders the area of their wetted surface shall be taken as their mean external circumference X the length of the boiler between end plates. For the shell the width of that part of the circumference below the flue covers shall be taken as = 2D, and this width + the length between end plates shall be taken as the area of shell heating surface. The part of the surface of the back end plate exposed to heat shall be omitted from the calculation.

Example—The formula for the total heating surface of a Lancashire boiler having plain furnaces without cross tubes is as follows:—

H.S. in square feet = 2 L (3.14 d +D). L is the length of the boiler between end plates in feet, d is the mean external diameter of the furnaces in feet and D is the internal diameter of the largest belt of shell in feet.

(c) For steam and water drums of water tube boilers the heating surface of the drum shall be taken as half the external means circumference multiplied by the clear length of drum between the outer brick walls or centres of cross boxes, as the case may be. The heating surface of the tubes shall be taken as the external surface of the tubes between the tube plates or heaters. The heating surface of the heater shall be omitted from the calculation.

(d) For marine boilers of the fire-tube type the heating surface shall include the wetted surface of the furnaces between the tube plates (considered in the same way as for Lancashire boilers), the wetted surface of the combustion chambers (less the area of the tube holes) and the wetted surface of the tubes between tube plates. The parts of the front tube plate exposed to heat shall be omitted from the calculation.

(e) For locomotive type boilers the heating surface shall include the wetted surface of the fire-box above the foundation ring (less the area of the tube holes and the firehole and ring) and the wetted surface of the tubes between the tube plates. The smoke box tube plate shall be omitted from the calculation.

(f) For vertical boilers or ordinary type the heating surface shall include the wetted surface of the fire-box above the foundation ring (less the area of firehole and ring and tube holes if any) and the surface of any cross or other tubes and uptake below the lowest water level shown in the gauge glass.

(g) For Electrode Boilers the heating surface shall be calculated as follows:

$$\text{Heating surface} = \frac{E}{6}$$

where, E = the equivalent evaporation at 212°F under normal load, which × KW,

K.W. = the kilowatts absorbed at the stated voltage when the water in the boiler has a specific resistance of not less than 200 ohms per inch tube at 150°F and while the boiler is delivering its normal output of steam at its working pressure with the feed water temperature of 60°F.

(h) No deduction shall be made for stays, etc. in calculating the heating surface.

(i) For any other heating surface not provided for in the foregoing instructions the same general procedure shall be observed.

384. Boiler Rating

The boiler rating shall be the number of square meters (to the nearest whole number) in the heating surface of the boiler as determined under Regulation 383.

385. Registration Fee

The required fee to accompany an application under Sub-section (1) of Section 7 of the Act shall be:

				(Rs.)
For Boiler Rating not exceeding	10 sq. meters			720
For Boiler Rating exceeding	10 sq. meters	but not exceeding	30 sq. meters	960
For Boiler Rating exceeding	30 sq. meters	but not exceeding	50 sq. meters	1080
For Boiler Rating exceeding	50 sq. meters	but not exceeding	70 sq. meters	1320
For Boiler Rating exceeding	70 sq. meters	but not exceeding	90 sq. meters	1560
For Boiler Rating exceeding	90 sq. meters	but not exceeding	110 sq. meters	1800
For Boiler Rating exceeding	110 sq. meters	but not exceeding	200 sq. meters	2040
For Boiler Rating exceeding	200 sq. meters	but not exceeding	400 sq. meters	2280
For Boiler Rating exceeding	400 sq. meters	but not exceeding	600 sq. meters	2640
For Boiler Rating exceeding	600 sq. meters	but not exceeding	800 sq. meters	2880
For Boiler Rating exceeding	800 sq. meters	but not exceeding	1000 sq. meters	3240
For Boiler Rating exceeding	1000 sq. meters	but not exceeding	1200 sq. meters	3840
For Boiler Rating exceeding	1200 sq. meters	but not exceeding	1400 sq. meters	4320
For Boiler Rating exceeding	1400 sq. meters	but not exceeding	1600 sq. meters	5040

Contd...

Contd...

For Boiler Rating exceeding	1600 sq. meters	but not exceeding	1800 sq. meters	5400
For Boiler Rating exceeding	1800 sq. meters	but not exceeding	2000 sq. meters	6000
For Boiler Rating exceeding	2000 sq. meters	but not exceeding	2200 sq. meters	6480
For Boiler Rating exceeding	2200 sq. meters	but not exceeding	2400 sq. meters	7200
For Boiler Rating exceeding	2400 sq. meters	but not exceeding	2600 sq. meters	7560
For Boiler Rating exceeding	2600 sq. meters	but not exceeding	2800 sq. meters	8160
For Boiler Rating exceeding	2800 sq. meters	but not exceeding	3000 sq. meters	8640

Above 3000 sq. meters, for every 200 sq. meters or part thereof an additional fee of Rs. 240 shall be charged:

Provided that the Chief Inspector may direct that no fee shall be payable in respect of a fresh application made in pursuance of sub-section (2) of Section 14 of the Act.

Inspection fee for Super-heater, Re-heater and Feed water heater shall be charged at the same rate as the registration fee.

The surface area of Super heater and Re-heater shall be included in the surface area of the Boiler for the purpose of charging the fee only.

386. *Memorandum of Inspection Book

(a) A Memorandum of Inspection Book shall be prepared for each boiler in Form I. In this book the Inspector shall enter in ink all particulars and dimensions of the boilers with the calculations for the various parts in details, particulars of hydraulic test and steam test and his inspection notes.

(b) At subsequent inspection Inspectors shall enter the dates of the inspections hydraulic tests and steam tests, when such are made with their notes thereon.

(c) Inspectors should also enter in the Memorandum of Inspection Book the general condition of the boiler and of repairs, to what extent boilers have been cleared of brick work, etc., a report of all casual visits for inspection of repairs, for inspection of main steam pipes, and reports on accidents, etc., in this way the Memorandum of Inspection Book will provide a useful record of the boiler's history for the information and guidance of Inspectors at subsequent inspections.

(d) On submission of the Memorandum Book to the Chief Inspector he will in the case of newly registered boilers, check all particulars and calculations and approve of the working pressure that is to be permitted. In the case of old boilers, the Chief Inspectors will examine the Inspector's notes of inspection and proposals made for repairs or reduction of pressure. A pressure once approved for the boiler should not be altered without the written authority of the Chief Inspector.

* The Memorandum of Inspection Book should always be kept clean and up-to-date Inspection Books except when actually required by the Inspector, should be filed in the office of the Chief Inspector.

387. Registration Book

(a) A Registration Book or copy of Memorandum of Inspection Book containing all the particulars required for registration shall be maintained in the office of the Chief Inspector in Form I and any orders passed by him regarding the boiler shall be entered in the registration Book under his initials.

(b) The Chief Inspector should also see that the note of subsequent inspections entered in the Memorandum of Inspection Book are copied in the Registration book.

387A. Maintenance of Records

(a) The Inspecting Authority shall maintain the records pertaining to the boiler or the Economiser, as the case may be, including all the certificates in the prescribed forms, namely Form II, Form III, Form III-A, Form III-B, Form III-C, Form IV, Form IV-A and Form VIII and the copies of the approved drawings for a period of at least 3 years after registration of the boiler. Thereafter these records may be sent to the owner of the boiler by the Inspecting Authority.

(b) The owner of a boiler of economiser shall maintain the records pertaining to the boiler of economiser, as the case may be, including the certificates in Forms II, IIIA, IIIB, IV and VII and the copies of the approved drawings for the entire life of the boiler or economiser as the case may be.

(c) In the event of any transfer of the ownership, the records mentioned above shall be transferred to the new owner and the new owner will maintain the record in accordance with the provision of clause (b) above.

(d) The manufacturer of boiler of economiser or steam pipe shall maintain the record pertaining to the boiler or economiser or steam pipe, as the case may be, including the certificate in Form II, IIIA, IIIB, IIIC, IV, IVA, VII and VIII and the copies of the approved drawings for a period of at least 5 years.

388. Transfer of Memorandum of Inspection Book and Registration Book

On a boiler passing from one State to another, the Memorandum of Inspection Book and the Registration Book shall, on the request of Chief Inspector of the State to which the boiler has been transferred, be forwarded to that officer who shall take over their custody and maintain them as hereinbefore prescribed.

389. *Grant of Certificate

A certificate for the use of a boiler shall be granted in Form VI. In the certificate shall be entered the maximum pressure at which the boiler shall be worked, the load to be placed on the safety valves or the thickness of the washers or ferrules required as safeguard against overloading and the date and pressure of the last hydraulic test of the boiler.

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* The Inspectors remarks should be as brief as possible.

390. Procedure for Inspection of Installed Boilers

(a) **General Instructions**—It is essential to have every part of the boiler, that is accessible, open and properly prepared for examination, internally and externally. All boilers have openings through which an examination may be made and which for operation are closed; all such parts shall be opened whether for access to water surfaces, or heater surfaces. In cooling a boiler down for inspection or repairs, the water should not be withdrawn until the setting is sufficiently cooled to avoid damage to the boiler and when possible allowed to cool down naturally. It is not necessary, in order to comply with ordinary prudence, to remove insulation material, masonry, or fixed parts of the boiler, unless defects or deterioration peculiar to certain types of in accessible parts of boilers are suspected and where there is moisture or vapour showing through the covering should be removed at once and a complete investigation made. Particular attention should be paid to the external parts of boilers in the way of seating blocks, especially when the situation is damp. Saddle tanks and engine fittings of locomotive type boilers should be removed to facilitate the inspection of the parts underneath at the first inspection, and at any reasonable period afterwards if the Inspector cannot otherwise satisfy himself as to the condition of those parts. Upon sufficient visible evidence or suspicion due to age or other causes, every effort shall be made to discover the true condition, even to the removal of insulating material, masonry or fixed parts of a boiler. Sometimes drilling or cutting away of parts is justifiable and necessary to positively determine this condition.

The Inspector should, whenever the size permits, go inside it and make a thorough inspection of all its internal parts. Before doing so, he should of course, satisfy himself that proper provision has been made for disconnecting the boiler from any other boiler under steam. Should he find that proper provision for disconnection has not been made or that the boiler has not been made or that the boiler has not been properly cleaned, or scaled, or that is unreasonably hot, he should decline to proceed with the inspection and should report the facts to the Chief Inspector for orders. When a boiler is of such a size or its construction is such that the Inspector cannot go inside it, there should be sufficient sight holes or handholes provided to enable him to see the principal internal parts; if any important part of a boiler is so constructed that the Inspector cannot examine it, he should report the facts to the Chief Inspector for orders.

In the case of forced circulation and forced flow boilers which are not accessible to close visual inspection, the Inspector should, besides thorough examination, ensure by the flow of water that proper circulation is maintained through all sections of the water circuits.

(b) **Scale Oils, etc.**—Upon entering a boiler, the Inspector shall examine all surfaces of the exposed metal to observe the action caused by the use of water, oil scale solvents, or other substances which may have intentionally or unintentionally gone in with the feed water. Any evidence of oil is dangerous and immediate steps shall be taken to prevent any further entrance of oil into the boiler. Oil or scale in the tubes of water-tube boilers or on plates over the fire of any boiler is particularly bad, often causing them to rupture.

(c) **Corrosion, Grooving**—A given amount of corrosion along or immediately adjacent to a seam is more serious than a similar amount of corrosion in the solid plate away from the seams. Grooving along longitudinal seams is especially significant as grooving or cracks are likely to occur when the material is highly stressed. Severe corrosion is likely to occur at points where the circulation of the water is poor and such places should be examined most carefully for evidences of corrosive action.

If the Inspector decides that a boiler in one or more of its parts is no longer fit for the pressure approved for it, he must without delay report his proposal for reducing the pressure to the Chief Inspector and at the same time submit his calculation for the wasted parts for check and approval of pressure.

With regard to the pitting and wasting of shell plates, the Inspector should bear in mind that shell plates may become reduce in thickness to an appreciable extent and still be stronger than longitudinal seams.

All flanging shall be thoroughly inspected and particularly the flanges of circular end plates that are not stayed. Internal grooving in the fillet of such heads and external grooving in the outer surfaces of heads concave to pressure is very common since there is slight movement in the heads of this character which produces this kind of defect. Some types of boilers have what is known as the OG or reversed flange construction in some of their parts that may be inaccessible to the eye, but the condition shall be determined by the insertion of a mirror which at a proper angle will reflect back to the eye the condition of such a place, or any other feasible manner.

(d) **Stays**—All stays, whether diagonal or through, shall be examined to note that they are in even tension. All fastened ends shall be examined to note whether cracks exist where the stays are punched or drilled for rivets or bolts and, if not found in proper tension, the Inspector should recommended their proper adjustment.

(e) **Manholes and Other Openings**—The manhole and other reinforcing plates, as well as nozzles or other connection flanged or screwed into a boiler, shall be examined internally as well as externally to see that they are not cracked or deformed, and wherever possible observation shall be made for the inside of the boiler, as to the thoroughness with which its pipe connections are made to the boiler. All openings to external attachments, such as water column connections, openings in dry pipes and opening to safety valves, shall be noted to see that they are free from obstructions.

(f) **Fire Surfaces—Bulging, Blistering, Leaks**—Particular attention shall be given to the plate or tube surface exposed to the fire. The Inspector shall observe whether any part of the boiler has become deformed during operation by bulging or blistering; the former is a distortion of the entire thickness of the plate or tube where it takes place, while the latter is a lamination or separation of the plate due to forging material being embedded in the ingot before the plate is rolled. If bulges or blisters are of such size as would seriously weaken the plate or tube and especially when the leakage is noted coming from those defects, the boiler shall be discontinued from service until the defective part or parts have received proper repairs. Careful observation shall be made to defect leakage from any portion of the boiler structures, particularly in the vicinity of seams and tube ends. Fire tubes sometimes blister but rarely collapse, the Inspector should look through the tubes for such defects and if they are found with a sufficient degree of distortion they should be removed.

(g) **Lap Joints, Fire Cracks**—Lap joint boilers are apt to crack where the plates lap in the longitudinal or straight seam; if there is any evidence of leakage or other distress at this point, it shall be thoroughly investigated and, if necessary, rivets removed or the plate slotted in order to determine whether cracks exist in the seam. Any cracks noted in shell plates are usually dangerous except fire cracks that run from the edge of the plate into the rivet holes of girth seams. A limited number of such fire cracks is not usually a very serious matter.

(h) **Testing Staybolts**—The Inspector shall test staybolts by tapping one end of each bolt with a hammer and when practicable a hammer or other heavy tool should be held on the opposite end to make the test more effective.

(i) **Tubes—Their Defects, etc.**—

(i) Tubes in horizontal fire tube boilers deteriorate more rapidly at the ends toward the fire, and they should be carefully tapped with a light hammer on their outer surface to ascertain whether there has been serious reduction in thickness. The tubes of vertical tubular boilers are more susceptible to deterioration at the upper ends open when exposed to the products of combustion without water protection. They should be reached as far as possible either through the handholes if any, or inspected at the ends.

(ii) The surfaces should be carefully examined to detect bulges or cracks, or any evidences or defective welds. Where there is a strong draft, the tubes may become thinned by corrosion produced by the impingement or particles of fuel and ash, or the improper use of soot blowers. A leak from a tube frequently causes serious corrosive action on a number of tubes in its immediate vicinity.

(iii) Where short tubes or nipples are employed in joining drums or headers, there is a tendency for waste products of the furnace to lodge in the junction points and such deposits are likely to cause corrosion if moisture is present. All such places should be thoroughly cleaned and examined.

(j) **Ligaments between Tube Holes**—The ligaments between tube holes in the heads of all types of fire-tube boilers and in shells of water-tube boilers should be examined. If leakage is noted, it may denote a broken ligament.

(k) **Steam Pockets**—Steam pockets on surfaces are sometimes found in new or replacement work, and wherever, this is possible or likely the Inspector should make observation and, if any are found, recommend the necessary changes.

(l) **Pipe Connection and Fittings**—The steam and water pipes, including connections to the water column, shall be examined for leaks, and if any are found it should be determined whether they are the result of excessive strains due to expansion and contraction, or other causes. The general arrangement of the piping in regard to the provisions, for expansion and drainage, as well as adequate support at the proper points, shall be carefully noted. The location of the various stop valves shall be observed to see that water will not be pocketed when the valves are closed and thereby establish cause for water-hammer action.

The arrangement of connections between individual boilers and the main steam pipes shall be especially noted to see that any change of position of the boiler due to setting or other causes, will not produce an undue strain on the piping.

It shall be ascertained whether all pipe connections to the boiler possess the proper strength in their fastenings, whether tapped into the boiler, a fitting, or flange rivetted to the boiler.

The Inspector shall determine whether there is provision for the expansion and contraction of such piping, and that there is no undue vibration tending to crystalize the parts subjected to it. This includes all steam and water pipe; and special attention should be given to the blow off pipes with their connections and fittings, because the expansion and contraction due to rapid changes in temperature and water-hammer action create a great strain upon the entire blow off system, which is more pronounced when a number of blow off pipes are joined in one common discharge. The freedom of the blow off connection on each boiler shall be tested whenever possible by opening the valve for a few seconds, at which time it can be determined whether there is excessive vibration. Blow off pipes should be free from external dumpness to prevent corrosion.

(m) **Water Column**—The piping to the water column shall be carefully noted to see that there is no chance of water being pocketed in the piping forming the steam connection to the water column. The steam pipe should preferably drain towards to the water column. The water pipe connection to the water column must drain towards the boiler.

The relative position of the water column to the fire surfaces of the boiler shall be observed to determine whether the column is placed in accordance with the Regulations. The attachments shall be examined to determine their operating condition.

(n) **Baffling-Water-Tube Boilers**—In Water-Tube Boilers, it should be noted, as far as possible, whether or not the proper baffling is in place. In many types of boilers the absence of baffling of ten causes high temperatures on portions of the boiler structure which are not intended to be exposed to such temperatures, from which a dangerous condition may result. The location of combustion arches with respect to tube surfaces shall be carefully noted. These are sometimes arranged so as to cause the flame to impinge on a particular part of a boiler and produces overheating of the material and consequent danger of the rupture of the part.

(o) **Localization of Heat**—Localization of heat brought about by improper or defective burner or stoker installation or operation creating a blow pipe effect upon the boiler, shall be condemned.

(p) **Suspended Boilers—Freedom of Expansion**—Where boilers are suspended the supports and setting shall be carefully examined specially at points where the boiler structure comes near the setting walls or floor. Often accumulation of ash and soot will bind the boiler structure at such points and produce excessive strains on the structure owing to the expansion of the parts under operating conditions.

(q) **Safety Valves**—As the safety valves are the most important attachments on the boiler, they shall be inspected with the utmost caution. There should be no accumulations of rust, scale, or other foreign substances located in the casings so as to interfere with the free operation of the valves. The setting and freedom of the safety valves should be tested preferably by raising the steam pressure to the blow-in-off point, or if this cannot be done, the valves shall be tested by means of the try levers to ascertain if they are free. Where the steam discharged from a safety valve is led through a pipe the Inspector shall determine at the time the valve is operating whether or not the drain, opening in the discharge pipe is free and in accordance with the Regulations.

If the Inspector deems it necessary, in order to determine the freedom of discharge from a safety valve, the discharge connections should be removed. Under no circumstances should a stop valve be permitted between a boiler and its safety valve.

(r) **Steam Gauges**—The steam gauges on all boilers shall be removed and the Inspector shall test them and compare their readings with a standard test gauge. The readings of the steam gauges shall be observed and compared when making an inspection with steam on the boiler, where several boilers are in service connected to a common steam main. The location of the steam gauges shall be noted to see whether or not it is exposed to high temperature either externally, as would be the case if placed close to the smoke flue or other high heated part of the boiler or setting, or exposed to heat internally due to lack of protection of the gauge spring with a proper syphon or trap to prevent steam from coming in contact with the spring. The Inspector shall see that the provisions are made for blowing out the pipe leading to the steam gauge.

391. Calculation of Wasted Shell

(a) When any part is wasted and the Inspector is doubtful of its fitness for the pressure, he shall cause one or more small holes to be bored and from them ascertain the average thickness of the parts from which he can satisfy himself by calculation in accordance with the formula applicable to the part. Such gaugings and calculations he shall enter in the Memorandum of Inspection Book.

(b) In making calculations for a wasted part of a boiler shell, e.g., along the line of seating blocks of a Lancashire boiler, the Inspector shall use the following formula:

$$\text{W.P.} = \frac{2t \times S}{D \times F} \qquad \text{Eqn. (96)}$$

where, t = thickness of wasted plate, where thinnest, S = minimum tensile strength of material of shell in lbs. per sq. in.,

D = internal diameter of shell in inches,

F = factor of safety, which shall not be less than 4.

391A. Ageing of Boilers

(a) *Shell Type Boilers:*

(i) In order to take the ageing effect on boilers, the working pressure of the parts of them as calculated from the formulae in these regulations shall be reduced as per the table given bleow:

TABLE

Age of boiler exceeding (in years)	25	35	45	50	60	70	80	90	100
Maximum permitted working pressure per cent.	95	90	85	80	70	60	50	40	30

(ii) For those boilers the plates of which have already been cut and tested shall be given a further lease of life of fifty years from the date of the test of the boilers. The working pressure that shall be allowed after the testing shall be reduced as per the table given below:

TABLE

Period after date of test (in years)	10	20	30	40	50
Maximum working pressure allowed (percentage)	90	80	70	50	30

(b) *Water Tube Boilers:*

(i) The boilers which are operating at a temperature of 400°C and above including utility or industrial boilers and all boiler parts operating in the creep range of the boiler shall be non-destructively tested as per the Table 1 given below after they are in operation for 100,000 hours for assessment of the remanent life of the parts;

(ii) The parts of a boiler when it completes a life of twenty five years are to be tested as per Table 2 for assessment of the remanent life of such parts. If results are acceptable as per the standards laid down by the Central Boilers Board, a certificate shall be issued by the Chief Inspector of Boilers for extending the life of the boiler for a further period of ten years or such less period as recommended by the Remanent Life Assessment Organisation. This assessment of remanent life shall be carried out thereafter every five years by the organisations working in the field of boilers and remanent life and extension thereof after such organisation is approved by the Central Boilers Board. Such organisation shall work in close coordination with the office of the Chief Inspector of Boilers in the field of remanent life assessment and extension. The working pressure of such boilers may be reduced on the recommendations of such approved organisation.

Notwithstanding anything contained in this regulation, for boilers working at a pressure less that 50 kg/cm^2, such elaborate remnant life assessment is not mandatory. However, in such cases, drums and headers of such boilers shall be inspected by Ultrasonic testing, Magnetic particle testing and Dye penetrant test.

Table 1

Component	*Visual*	*Ultrasonic testing*	*Magnetic particle inspection*	*Liquid Dye Penetrant inspection*	*Replication*	*Sampling*	*Deposit Analysis*	*Outside Diametre and thickness*	*Fibre Optic inspection*	*Hardness*	*Others*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Drum (Steam)	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	
Water Drum	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	
Low Temperature Header	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	
Attemperator Header	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Swell measurement
High Temperature Economiser Tubes	Yes	No	No	No	No	Yes	No	Yes	No	No	
Low Temperature Economiser Tubes	Yes	No	No	No	No	Yes	No	Yes	No	No	
Convection Super-heater Coils	Yes	No	No	No	No	Yes	Yes	Yes	No	Yes	
Primary Super-heater Coils	Yes	No	No	No	No	Yes	No	Yes	No	Yes	Non-destructive oxide thickness inspection
Prefinal Super-heater Coils	Yes	No	No	No	No	Yes	No	Yes	No	Yes	
Final Super-heater Coils	Yes	No	No	No	No	Yes	No	Yes	No	Yes	
Reheater Coils	Yes	No	No	No	No	Yes	No	Yes	No	Yes	
High Temperature Headers	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	
Final Super-heater Header	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Swell measurement
Reheater Headers	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Swell measurement
Main Steam Piping	Yes	No	No	No	Yes	No	No	Yes	No	Yes	
Platen Super-heater Header	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	
Primary Super-heater Header	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	
Economiser Header	Yes	No	No	Yes	No	No	No	Yes	No	No	

Contd...

Contd...

Auxiliaries	Yes	No	No	No	No	No	No	Yes	No	No	
Boiler Bank Tubes	Yes	No	No	No	No	No	No	Yes	No	No	
Water Wall	Yes	No	No	No	No	Yes	No	Yes	No	No	
Furnace Water Walls	Yes	No	No	No	No	Yes	No	Yes	No	No	

Table 2

Component	*Visual*	*Ultrasonic testing*	*Magnetic particle inspection*	*Liquid Dye Penetrant inspection*	*Replication*	*Sampling*	*Deposit Analysis*	*Outside Diametre and thickness*	*Fibre Optic inspection*	*Hardness*	*Others*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Drum (Steam)	Yes	No	No	Yes	No	No	No	Yes	No	No	
Water Drum	Yes	No	No	Yes	No	No	No	Yes	No	No	
Economiser Tubes	Yes	No	No	No	No	Yes	No	Yes	No	No	
Convection Superheater Coils	Yes	No	No	No	No	Yes	No	Yes	No	No	
Primary Superheater Coils	Yes	No	No	No	No	Yes	No	Yes	No	No	
Final Superheater Coils	Yes	No	No	No	No	Yes	No	Yes	No	No	
High Temperature Headers	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	
Final Superheater Header	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	
Economiser Header	Yes	No	No	No	No	No	No	Yes	No	No	
Auxiliaries	Yes	No	No	No	No	No	No	No	Yes	No	
Boiler Bank Tubes	Yes	No	No	No	No	No	No	Yes	No	No	
Water Wall	Yes	No	No	No	No	Yes	No	Yes	No	No	
Main Steam Piping	Yes	No	No	No	No	Yes	No	Yes	No	No	

392. Repairs to Boilers and Steam Pipes

(1) Major repairs such as fusion welded or riveted patches to shells, fireboxes and end plates of boilers and extensive building up of wasted parts of boilers permitted under these regulations, the renewal of furnaces and end plates, parts of shell, fireboxes, girders and steam-pipes, etc. shall only be entrusted to a firm who is recognised as a repairer under these regulations.

(2) Any firm seeking recognition shall apply to Chief Inspector of Boilers of the State in which the recognition is sought.

(3) A firm seeking recognition as a repairer shall meet the following requirements depending upon the class of boilers, namely:—

(i) **Class I boiler repairer**—The owner of the firm himself shall have a degree in mechanical engineering or the firm shall have on its rolls a permanently employed engineer having a degree in mechanical engineering with the firm having at least five years' experience in fabrication, erection, repair or maintenance and quality control of boilers, and qualified and permanently employed welders as per the provisions of these regulations;

(ii) **Class II boiler repairer**—The owner of the firm himself shall have a diploma in mechanical engineering or the firm shall have on its rolls a permanently employed engineer having a diploma in mechanical engineering with the firm having at least three years' experience in fabrication, repair and maintenance of boilers;

(iii) **Class III boiler repairer**—The firm shall have the experience of five years in repair, maintenance, operation, erection or inspection of boiler;

(iii-a) **Special class boiler repairer**—The owner of the firm himself shall have a degree in mechanical or welding engineering alongwith specialized experience in welding technology for a minimum period of three years or the firm shall have on its rolls a permanently employed engineer having a degree in mechanical or welding engineering alongwith specialized experience in welding technology for a minimum period of three years and have permanently employed welders as per the provisions of these regulations. The welders should also have valid certificate for carrying out Tungsten Inert Gas (TIG) welding;

(iv) (a) Where the power stations, fertilizer plants, chemical and petrochemical plants or refineries apply for repair of their own boilers, they shall have all the facilities in-house and may apply to the Chief Inspector of Boilers of the State for permission to repair their own boilers in accordance with these regulations,

(b) On receipt of the application for permission to repair to a boiler, the Chief Inspector of Boilers of the State shall reply to the request within a period of fifteen days of the receipt of the application.

(4) On receipt of the application under sub-regulation (3), the Chief Inspector shall send a questionnaire in 'Form XVIII' to the applicant.

(5) The Chief Inspector will scrutinize and evaluate the application along with the replies to the questionnaire and after satisfying himself that the following requirements are fulfilled, shall recognise the firm as a repairer in the category applied for, namely:—

(i) that the firm possesses rectifier or generator, grinder, general tools and tackles, dye-penetrant kit, expander and measuring instruments;

(ii) that the electric arc or oxy-acetylene welding sets and all other tools and plant in his possession for carrying out repairs are suitable for the work undertaken;

(iii) that the quality of material used conforms to the specifications prescribed in these regulations;

(iv) that the supervisory and operational staff employed by the firm possesses the necessary training and experience for the work undertaken;

(v) that all welders employed by the firm possess certificates issued as required under Chapter XIII of these regulations;

(vi) standard of work should be of high order and comply with all the requirements and test that may be prescribed by the Chief Inspector.

(6) The recognition of the firm as a repairer shall be for a period of two years. Thereafter they shall apply for renewal of their recognition at least two months before the expiry of said period.

(7) In case the repairer is found indulging in violating the provisions of the Act/Regulations knowingly or unknowingly, the firm shall be blacklisted under intimation to Chief Inspector or Director of Boilers of all the States/Union Territories and renewal shall not be done in any case.

392A.

(a) **Procedure for Repairs**

(1) The repair work shall be carried out under the supervision of Inspector, and when the fireboxes and smoke tubes of locomotive tube boilers are withdrawn, the internal parts, which are otherwise inaccessible to close inspection, shall be inspected by the Inspector.

(2) Repair to boiler shells shall be carried out by patching or by removing a strip of worn or damaged plate and inserting the new strip with covering straps over the longitudinal butt ends, the strength of the riveted joints to be not less than that of the longitudinal joints of the shell.

(3) (a) Patches for fire exposed plates shall be fitted metal to metal without joint of any description.

(b) The affected part shall be cut out, leaving the corners of the hole well-rounded.

(c) Patches shall be secured, wherever possible, properly spaced rivets with a width of plate at least equal to the diameter of rivet between the edge of the rivet hole and the edge of the plate.

(d) Where riveting is impracticable, the plate shall be secured by welt fitting countersunk headed screw pins.

(4) The thickness of a patch plate shall not be less than the original thickness of the plate which it is used to patch.

(5) Bulged or distorted furnaces or circular section may, if the bulge or distortion is not too great, be pressed back to shape.

(6) Circular furnaces of horizontal boilers that have become distorted may be suitably reinforced.

(7) (a) Anti-collapse rings shall be of substantial section either of single or double angles bolted back to back with screw stays not less than 22 mm in diameter and about 178 mm in pitch passed through flat of angle and screwed into the furnace, the ends being either rounded or riveted over on the fire side and fitted with nuts at the other.

(b) The stay bolts shall be fitted with ferrules not less than 1 inch in depth between furnace and angle ring.

(8) Welding shall not be accepted for the repair of any part of a boiler for which welding is forbidden for a new boiler under these regulations and boiler shells shall not be repaired by welding beyond the filling up of a small isolated corroded or pitted part or the making up of wasted edges of openings.

(9) Cracks or grooving in dished or flat end plates of cylindrical shells or in the bends of furnace flanges in a circumferential direction may be weed out and welded.

(10) Wasted parts of circular furnaces and fireboxes and fire exposed flat plates as in rectangular fireboxes and combustion chambers may be cut out and be replaced by new pieces welded in or they may be built-up by welding.

(11) Longitudinal cracks in circular furnaces and fireboxes and cracks in rectangular fireboxes and combustion chambers may be welded.

(12) No stay bar shall be welded.

(13) Smoke tubes may be butt-welded either by fusion welding, flush welding or oxy-acetylene welding, and these may be tested hydraulically at the discretion of the Chief Inspector.

(b) **Welding**—The repairer shall satisfy the Chief Inspector—

(i) that the electric arc or oxy-acetylene welding sets and all other tools and plant in his possession for carrying out repairs are suitable for the work undertaken;

(ii) that the quality of material used conforms to the specifications that are prescribed;

(iii) that the supervisory and operational staff employed by him possess the necessary training and experience for the work undertaken;

(iv) that all welders employed by him possess certificates issued as required under Chapter XIII of these Regulations;

(v) standard of work should be of high order and comply with all the requirements and test that may be prescribed by the Chief Inspector.

(c) **Riveting and Other Repairs**—The repairer shall satisfy the Chief Inspector:

(i) that he possesses the necessary equipment and tools and engages trained and experienced workmen and staff for the work undertaken.

(ii) standard of work should be of a high order and comply with all the requirements and test that may be prescribed by the Chief Inspector, and all material used shall be of boiler quality.

(d) The repairs should be supervised, so far as his other duties permit by the Inspector when the fire boxes and smoke tubes of locomotive tube boilers are withdrawn, the opportunity should be taken to inspect the internal parts which are otherwise inaccessible to close inspection.

(e) Repairs to boiler shells shall be effected either by patching or by removing a strip of worn or damaged plate and inserting the new strip with covering straps over the longitudinal butt ends, the strength of the riveted joints to be not less than that of the longitudinal joints of the shell.

(f) Patches for fire exposed plates shall be fitted metal to metal without joint of any description. The affected part shall be cut out, leaving the corners of the hole well rounded. Patches shall be secured, wherever possible, properly spaced rivets with a width of plate at least equal to the diameter of rivet between the edge of the rivet hole and the edge of the plate. Where riveting is impracticable, the plate shall be secured by welt fitting countersunk headed screw pins.

(g) The thickness of a patch plate shall not be less than the original thickness of the plate which it is used to patch.

(h) Bulged or distorted furnaces of circular section may, if the bulge or distortion is not too great, be pressed back to shape.

(i) Circular furnaces of horizontal boilers that have become distorted may be suitably reinforced.

(j) Anti-collapse rings shall be of substantial section either of single or double angles bolted back to back with screw stays not less than 7/8th inch in diameter and about 7 inches in pitch passes through flat of angle and screwed into the furnace, the ends being either rounded or riveted over on the fire side and fitted with nuts at the other. The stay bolts shall be fitted with ferrules not less than 1 inch in depth between furnace and angle ring.

(k) Welding shall not be accepted for the repair of any part of a boiler for which welding is forbidden for a new boiler under these Regulations. Boiler shells shall not be repaired by welding beyond the filling up of a small isolated corroded or pitted part or the making up of wasted edges of openings.

(l) Cracks or grooving in dished or flat end plates of cylindrical shells or in the bends of furnace flanges in a circumferential direction may be weed out and welded.

(m) Wasted parts of circular furnaces and fire boxes and fire exposed flat plates as in rectangular fire boxes and combustion chambers may be cut out and be replaced by new pieces welded in or they may be built up by welding. Longitudinal cracks in circular furnaces and fire-boxes and cracks in rectangular fire-boxes and combustion chambers may be welded.

(n) No stay shall be welded.

(o) For the purposes of these Regulations renewed parts shall be deemed to be parts of a new boiler intended for use at the pressure at which the boiler under renewal is used.

(p) **Butt Welding of Smoke Tubes**—Smoke tubes may be butt welded either by fusion welding, flush welding or oxy-acetylene welding, and these should be tested hydraulically at the discretion of the Chief Inspector.

393. Submission of Manufacturing Drawings and the Particulars of Boilers in Advance

(a) In the case of land boilers made in India for use in the States, the manufacturing drawings and the particulars of materials, design and construction of boilers shall be submitted by the makers of the boilers to the Inspecting Authority of the State, where the principal parts of the boilers will be manufactured, for examination and approval before commencement of the manufacture of boilers.

(b) In the case of boilers made outside India for use in the State, the manufacturing drawings and particulars of the material, design and construction, of boilers shall be submitted initially to the Inspecting Authority in the country of manufacture for examination and approval.

The manufacturing drawings and the particulars of materials, design and construction in the case of fired boilers of steam generating capacity 100 Tons/hour and above and that of Waste heat boiler of 20 Tons/hour and above shall then be submitted to the Technical Adviser (Boilers) for selection of latest materials with high strengths and use in high temperature and pressure, energy conservation and increased thermal efficiency and remote control and instrumentation for the safety of the Boilers. Thereafter, the manufacturing drawings and the particulars of materials, design and construction shall be sent to the Chief Inspector of Boilers of the State where the boiler will be installed and used, for final examination and approval before commencement of manufacture so as to avoid questions arising at the time of erection and registration of the boiler.

(c) The Inspecting Authority or the Chief Inspector or both, as the case may be, shall, after examination of the manufacturing drawings and the particulars intimate to the proposer whether they are satisfied with the materials, design, construction and fitness of the parts for the intended pressure and, if not, what modification is necessary therein. When the manufacturing drawings and the particulars of boilers have been approved, the Inspector in making his examination shall see that the design and the particulars of construction as approved have been carefully followed and that the material corresponds with the approved particulars.

(d) The fees for the scrutiny of the manufacturing drawings and the particulars of the materials design and construction of boilers under sub-regulations (a) or (b) shall be on the scale prescribed in Regulation 385 subject to a maximum of Rupees 20,000/- When the manufacturing drawings have been scrutinised and in respect of them alterations have been suggested and the same are resubmitted for scrutiny, separate fee at the rate of 10 per cent of the fee for the first scrutiny of the drawings shall be payable if the manufacturing drawings contain alterations other than those previously suggested.

(e) The arrangement drawings showings the broad details of modifications or conversions of the existing boiler shall be subject to the approval of the Chief Inspector of Boilers of the State where the boiler is intended for modification or conversion is registered.

(f) If the detailed manufacturing drawings are got approved by the Inspecting Authority of the State where parts will be manufactured and inspected, no separate compliance of sub-regulation (e) is required.

394. Inspections of Steam Pipes

(a) Steam pipes shall be inspected and hydraulically tested before erection in place, in test pressure to be that prescribed in the standard conditions for steam pipes. A certificate from the Inspecting Authority in Form IIIA, stating that this has been done by him may be accepted. If the Inspector is satisfied with the test, the pipes may be erected in position. The Chief Inspector shall intimate his approval to the owner regarding the suitability of the pipeline for use at the pressure and temperature to be specified.

(b) At subsequent inspections of the boiler or at any other time, the Inspector may make an external inspection of the steam pipes and for this purpose may require a part of the lagging at the flanges to be removed, and the pipe made bare. If as a result of this inspection the Inspector is of opinion that the pipes or any positions of them are in an unsatisfactory condition he shall report the matter to the Chief Inspector, who may require the whole of the lagging to be removed and may require any pipe or pipes to be hydraulically tested. The test pressure at such hydraulic test shall be not less than one and a half times the working pressure of the boiler or the intended working pressure of the pipe, as the case may be.

(c) A Memorandum of Inspection Book shall be prepared in respect of steam pipe and fittings in Form No. XIV. In this book, the Inspector shall enter in ink all particulars and dimensions of the steam pipe and fittings with calculations for the various parts in detail, particulars of hydraulic test and his inspection notes.

At subsequent inspection, the Inspector shall enter the date of the inspection and hydraulic test together with notes thereon.

The Inspector shall also enter in the Memorandum of Inspection Book remarks regarding the general condition of the steam pipes and fittings, and repairs, replacements or alterations, if any, and the extent to which the steam pipes have been cleaned of lagging and covering so that the book provides a useful record of the steam pipes and fittings for the information and guidance of Inspectors at subsequent inspection.

In the event of an accident to a pipeline or its fittings, necessary remarks shall also be entered in the book.

The Memorandum Book shall be submitted to the Chief Inspector, who will check all particulars and calculations and approve the working pressure and temperatures that are to be permitted for the various parts of the pipeline and fittings. The pressure and temperature once approved for the particular steam pipeline shall not be altered except on a written authority from the Chief Inspector.

395. Submission of Plans of Steam Pipes

(a) Plans of steam pipes shall be submitted with the prescribed fee to the Chief Inspector before construction or at the time of registration of the boiler for his decision whether the pipes and their arrangement comply with the Regulations.

(b) (i) The fees for examination of plans and the particulars of materials, design and construction of steam pipes before the commencement of manufacture of the steam pipes shall be at the rate of Rs. 40/- for 30 metres of piping or part thereof, subject to a minimum of Rs. 60/-, inclusive of all fittings excepting the fittings like de-superheaters, steam receivers, feed heaters and separately fired superheaters. For any fittings like de-superheaters, steam receivers, separators and flanges, the fee shall be Rs. 180/- for each category of such identical fittings.

(ii) The fees for examination of layout plans of steam pipes shall be Rs. 30/- per 30 metres of piping or part thereof, subject to a minimum of Rs. 60/-, inclusive of all fittings, except fittings like de-superheaters, steam receivers, feed heaters and separately fired superheaters. For any fittings like de-superheaters, steam receivers and separators, the fee shall be Rs. 180/- for each such fittings.

395A. Inspection Fee for Boilers and Part Thereof Constructed in India

(1) The inspection fee for boilers shall be calculated on the following basis:

(i) at four times the registration fee for a boiler of riveted construction;

(ii) at four times the registration fee for a boiler of welded construction.

(2) Fees for inspections of boiler scantlings shall be charged as under:

(i) upto 10 square feet (0.929 sq. metre) of outside surface—Nil;

(ii) above 10 square feet (0.929 sq. metre) of outside surface—one-half of the registration fee of the boiler for which the part is intended.

(3) For inspection of tubes and pipes, the fee shall be charged at the rate of Rs. 180/- per metric tonne or a fraction thereof.

(4) Fees for inspection of boiler at the side of construction shall be charged at the rate of four times the registration fee.

(5) For inspection of forged pipe fittings, the fees shall be charged at the rate specified for forged and cast flanges under clause (i) of sub-regulation (2) of Regulation 395C.

(6) For inspection of pipe fittings other than forged pipe fittings, the fees shall be charged as under:

(a) Upto and including 50 mm, for 100 kg. or a fraction thereof	Rs. 60/-
(b) Over 50 mm and upto and including 100 mm for 450 kg. or fraction thereof	Rs. 300/-
(c) Over 100 mm for 900 Kg. or a fraction thereof	Rs. 600/-

395B. Fees for Inspection of Pipes

(a) For the pipes of nominal bore not exceeding 100 mm inclusive of all fittings excepting fittings like de-superheaters, steam-receivers, feed heaters and separately fired superheaters Rs. 250/- for 30 metres of pipe or part thereof;

(b) for pipes of nominal bore exceeding 100 mm inclusive of all fittings excepting fittings like de-superheaters, steam receivers, feed heaters and separately fired superheaters Rs. 600 for 30 metres or part thereof;

(c) fees for inspection of fittings like feed water heater, de-superheater, steam receiver, separators and separately fired superheaters Rs. 600 for each such fitting.

395C. Fees for Inspection of Valves

Fees for inspection of valves shall be charged as under:

(1) Subject to a minimum inspection fee of Rs. 600 per inspection for the valves, the inspection fee shall be charged as under:

(a) Upto 25 mm	Rs. 10 per piece.
(b) Above 25 mm and upto 100 mm	Rs. 30 per piece.
(c) Above 100 mm and upto 250 mm	Rs. 180 per piece.
(d) Above 250 mm	Rs. 480 per piece.

(2) Fees for inspection of flanges shall be charged as under:

(i) *For forged and cast flanges:*

(a) upto and including 25 mm for a batch of 50 or part thereof	Rs. 150
(b) upto and including 25 mm for a batch of 100 or part thereof	Rs. 260
(c) over 25 mm upto and including 50 mm for a batch of 50 or part thereof	Rs. 290

(d) over 50 mm upto and including 100 mm for a batch of 25 or part thereof — Rs. 290

(e) over 100 mm upto and including 250 mm for a batch of 10 or part thereof — Rs. 310

(f) over 250 mm for a batch of 5 or part thereof — Rs. 360

(ii) *For plate flanges*: The fees shall be charged at half the rate as charged for forged and cast flanges.

395D. Fees for Inspection of Components of Valves

The fees for Inspection of components of valves shall be charged as under:

(i) 50% of the Inspection fees of the valves shall be charged by the Chief Inspector of the State where the components of the valves, are manufactured, for inspection of the components manufactured in a State other than the State where the valves are assembled and remaining 50% of the inspection fees shall be charged by the Chief Inspector of the State, where the valves are assembled, for inspection of assembly and final inspection of the valves.

(ii) Where the inspection, so far as the material testing is concerned, has been carried out by a "Well-Known Foundry" or "Well-Known Forge" full inspection fees shall be charged by the Chief Inspector of the State where the valves have been assembled and finally tested.

(iii) Where the components of the valves are inspected and tested in the same manufacturing work where the valves are assembled and finally tested, full inspection fee shall be charged by the Chief Inspector of the State where the manufacturing work is located.

(iv) In case, in a State, components are manufactured by one firm and finally fittings and assembly of the valves are made by another, both the firms shall pay inspection fee on 50: 50 basis.

395E. Fees for Inspection of Feed Water Heaters and other Fittings

Fees for inspection of feed water heaters and other fittings shall be charged as under:

(i) Fees for inspection of feed water heaters shall be equal to the registration fee of the boiler subject to a maximum of Rs. 5,000.

(ii) Fees for inspection of other fittings like de-super-heaters, steam receivers and separately fired superheaters shall be charged equal to half the registration fee of the boiler to which the steam pipe or feed pipe, as the case may be, is attached subject to a maximum of Rs. 2,500.

Note: In case of fittings, like de-superheaters, feed heaters and separately fired superheaters, which are parts of the steam pipes or feed pipes attached to a battery of the boilers, the fees shall be charged equal to half the registration fee of any one of the boiler of the battery of the boilers.

395F. Markings

(a) Carbon steel tubes or pipes which are both over 50 mm outside diameter or over 1000 mm in length shall be marked legibly to show—

(i) the identification symbol for the type of the steel;

(ii) the brand of the manufacture; and

(iii) whether seamless or electric resistance welded tubes or pipes.

(b) In the case of Carbon steel tubes or pipes less than 50 mm outside diameter or less than 1000 mm in length, the information specified in sub-regulation (a) of this regulation shall be marked on a tag securely attached to the bundle or box.

(c) For alloy steel tubes or pipes markings shall not be stamped on the body of the tubes or pipes. The information specified in sub-regulation (a) of this regulation shall be stamped on the end face of plain end pipes or on the rims of flanges or on identification plates suitably attached to the pipes or tubes. Inspection or identification marks may be painted on the alloy steel tubes or pipes provided iron oxide base or titanium base paints are used.

(d) Tubes or pipes conforming to a foreign standard or code, which have been accepted by the Board under Regulation 3(2), marking shall be stamped in accordance with the provision of that standard or code, as the case may be.

395G. Fee for Inspection of Spares and Scantlings

(i) **Spares**—For all types of coils, namely, economiser coils, superheater coils, reheater coils, the fee for inspection shall be charged on the basis of surface area as provided in Regulation 385.

(ii) **Scantlings**—The fee for inspection of scantlings shall be charged as under:

(a) For outside surface area not exceeding 1 sq. metre	Rs. 600
(b) For outside surface area exceeding 1 sq. metre but not exceeding 3 sq. metres	Rs. 720
(c) For OSA exceeding 3 sq. metres but not exceeding 5 sq. metres	Rs. 840
(d) For OSA exceeding 5 sq. metres but not exceeding 7 sq. metres	Rs. 1200
(e) For OSA exceeding 7 sq. metres but not exceeding 9 sq. metres	Rs. 1440
(f) For OSA exceeding 9 sq. metres but not exceeding 11 sq. metres	Rs. 1800

For outside surface area exceeding 11 sq. metres a fee of Rs. 60 shall be charged for every 2 sq. metres or part thereof subject to a maximum of Rs. 6,000.

CHAPTER IXA

SAFETY OF PERSONS INSIDE BOILERS

396. Safety of Persons Working Inside Boilers

(a) No person shall be compelled or allowed, by the owner or person-in-charge, to go inside a steam boiler for any purpose whatsoever unless the boiler is effectively disconnected in the manner hereinafter prescribed from any steam or hot water communication with any other boiler.

(b) Effective disconnection shall be made either by the removal of the boiler stop valve or of a length of piping from all steam and hot water connection with any other boiler, vessel or pipe containing steam or hot water by the insertion of substantial blank flanges between the boiler stop valves and piping. The shutting of a stop valve, stop cock or automatic isolating valve alone shall not be deemed to compliance with this regulation. In the case of welded pipe work, however, if a vent pipe of not less than 2" internal diameter (bore) is fitted between the main stop valve and the intermediate stop valve on the steam main and between the feed check valve and intermediate check valve on the feed line, this regulation shall be considered to have been complied with, provided such vent pipes are fitted with bolted-on blank flanges and the flanges are removed so as to effectively discharge any leakage steam or water to the atmosphere when the valves on either side of its have been closed.

(c) The owner of a boiler to which this regulation is applicable shall obtain the approval of the Chief Inspector in writing to the method of disconnection which he proposes to use and shall be responsible for ensuring that the method so approved is followed in practice.

(d) When electric light is used for work inside a boiler shell or drum or any confined space within a boiler, the voltage shall not exceed 24 Volts and the owner of the boiler shall provide a hand lamp with lamp-guard, keyless socket, insulated handle and extension cord of approved type.

Where power is used for working any equipment inside a boiler the metallic portion of the equipment shall be effectively earthed.

CHAPTER X

ELECTRODE BOILERS

GENERAL REQUIREMENTS

397. Application

This Chapter applies to Electrode Steam Boilers for all voltages for any working pressure and for temperatures not exceeding 650°F.

Electrode Boilers shall only be of the following construction:

(a) Riveted Steel Boilers.

(b) Fusion Welded Steel Boilers.

(c) Seamless Shell Steel Boilers.

398.

Where applicable the general terms of Chapter I relating to certificates from makers, Inspecting Authorities, etc., and of Chapter III concerning construction shall be followed.

399.

The material specifications for structural parts of Electrode Boilers shall comply with Chapter II as regards the process of manufacture, chemical composition mode of manufacture and tests, and the certificates for the steel plates, rivets and bars where applicable, provided that the ultimate tensile stress and elongation of materials shall be between the limits given below:—

(1) For riveted construction as in Regulation 16.

(2) For fusion welded construction as in Regulation 234.

(3) For seamless construction as in Regulation 344. Table I as for seamless carbon steel pipes.

RIVETED STEEL BOILERS

400. Construction and Workmanship

The requirements as regards the preparation of plates, cylindrical shells, butt-straps, end plates, bar stays, angle rings, inspection, openings, rivet holes, riveting, fullering and caulking shall comply with the relevant provisions of Chapter III.

401. Working Pressure of Shells

Determination of working pressure of shells shall comply with Regulation 176.

402. Strength of Riveted Joints

Strength of riveted joints shall comply with Regulations 177, 178 and 179.

403. Thickness of Butt-Straps

Thickness of butt-straps shall comply with Regulation 182.

404. Maximum Pitch of Rivets in Longitudinal Joints

Maximum pitch of rivets in longitudinal seam shall comply with Regulation 183.

405. Spacing of Rows of Rivets

Spacing of rows of rivets and distance between rivet hole and edge of plate shall comply with Regulation 184.

406. End and Circumferential Seams

End and circumferential seams shall comply with Regulation 104.

407. Manholes and Other Openings in Shells

(a) Uncompensated opening shall comply with Regulation 187.

(b) Compensated opening shall comply with Regulations 170, 171 and 186.

408. Dished End Plates with Pressure on Concave Side

Where an end plate is dished to semi-ellipsoidal or partially spherical form, the inside radius of dishing shall be not greater than the outside diameter of the flange (*see* Figure 23).

Wherever practicable, the inside corner radius shall be 12.5 per cent, of the inside diameter and in no case shall be less than 6 per cent of the inside diameter.

For ends of semi-ellipsoidal from the ratio of the major axis to the minor axis shall be not greater than 2.

Where an end plate is dished to semi-ellipsoidal or partially spherical form and has a flanged-in-manhole or access opening, the thickness shall be increased by not less than 15 per cent of the thickness computed by the formula for an end plate without an opening, but in no case shall this increase be less than 1/8 inch.

The depth in inches of the flange G (*see* Fig. 23) forming the access opening measured from the outer surface of the place at the minor axis of the opening shall be not less than

$$G = \sqrt{(T \times W)}$$

where, T = thickness of the end plate in inches,

W = length of minor axis in inches.

The corner radius of the manhole flange vm (*see* Fig. 23) shall be not less than 1 in.

In case where full compensation is provided for an unflanged opening cut in a dished end plate, no additional thickness is necessary.

Where it is not practicable to make dished end plate in one piece, fusion welded seams welded from each side of the plate may be employed provided the appropriate constraints as given below are introduced into the formula for obtaining the thickness. The limits of pressure and diameter specified in Regulation 416 shall, however, apply.

The maximum working pressure shall be determined by the following formula but in no case shall the thickness at the edge of the flange for connecting to the shell be less than the thickness of the unpierced seamless shell as determined by Equation 1.

$$WP = \frac{(t-2)}{D \times K} \times C \times S \qquad \text{Eqn. (97)}$$

where, t = thickness of plate in thirty-seconds of an inch,

WP = working pressure in pounds per square inch,

D = outside diameter of the flange in inches,

K = a factory dependent upon the ratio h/D where h is the external height generally obtained from the curve shown in Fig. 22 or by Equation 75.

In no case shall K be taken as less than:

$$11.5\frac{R}{D} \text{ or } 0.12\frac{D}{R}$$

S = minimum ultimate stress of plate in tons per square inch,

C = constant as follows:

(a) Where the end plate is not one piece. $C = 35$,

(b) Where the end plate is in one piece,

C = 82 where Class I requirements are complied with,

= 27 where Class II requirements are complied with.

The thickness to be used in the formulae is the thickness of the end after manufacturer and is applicable over the whole area of the end upto the point where for ends of partially spherical shape, the dishing radius joins the corner radius; from this point a gradual thinning is permissible upto a maximum of 10 per cent of the thickness 't' at the point where the corner radius joins the straight portion of the flange end. A similar gradual thinning is permissible for ends of semi-ellipsoidal shape. This permissible reduction in thickness also applies to the flange for manhole opening.

Where a dished end plate is pierced with more than one opening for electrodes or other fittings, the openings shall be so arranged as to provide an unpierced annulus not less than 2 in. wide measured from the centre of the corner radius.

Where the diameter of such opening is not greater than 2½ inches and the value of the ligament $\frac{(p-d)}{P}$ is not less than $\frac{1}{K}$ compensation is not required.

Where d is greater than 2½ inches or $\frac{(p-d)}{P}$ is less than $\frac{1}{K}$ full compensation shall be provided where—

p = pitch of openings in inches,

d = diameter of openings in inches,

K = factor (*See* Equation above).

409. Seatings for Mounting

Where the working pressure is not greater than 250 lb/sq. in. mountings having screwed ends not exceeding ¾ inch, Standard Pipe Thread may be used.

The mountings may be screwed:

(i) Directly into the boiler shell plates, nuts being fitted on the waterside; or

(ii) Into steel distance piece (*see* Fig. 35), the length of thread engaged being is no case less than the bore of the mounting plus one quarter inch.

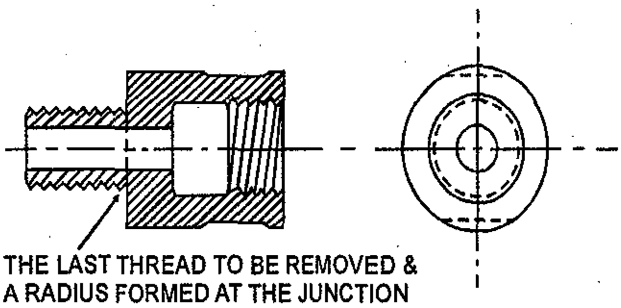


FIG. 35 : TYPICAL MILD STEEL DISTANCE PIECE FOR MOUNTINGS

The distance piece shall be made solid from mild steel and shall be screwed into the boiler pieces and fitted with nuts on the water side. The walls of the distance plates shall be not less in thickness than one quarter inch at the bottom of the thread.

Where seatings are finished by fusion welding they shall be stress-relieved heat treatment before attachment to the boiler.

Method of attachment by welding of connectors to shells are shown in Figs. 36 to 40.

Water gauges and pressure gauge syphons may be attached direct to the boiler shell or ends without the intervention of a pad or standpipe, provided they are flanged and secured by studs. If the studs are screwed through the plate, nuts of full thickness shall be fitted on the inside of the boiler.

WELDED ATTACHMENT OF CONNECTORS TO SHELL

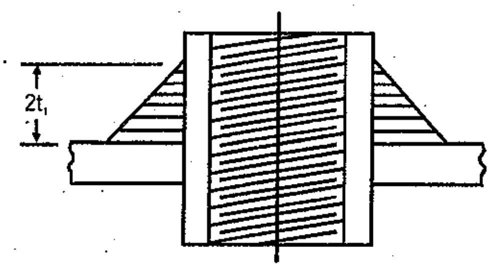


FIG. 36

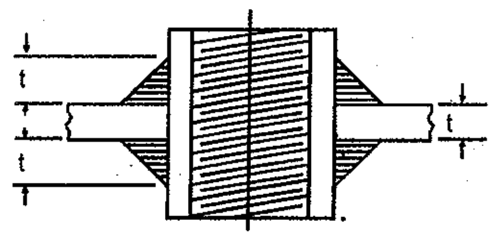


FIG. 37

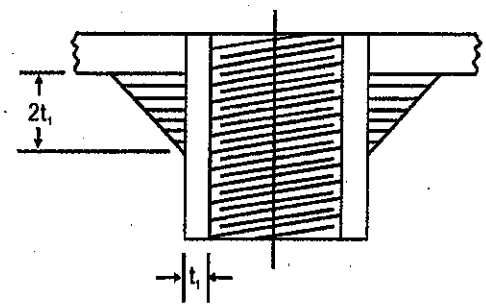


FIG. 38

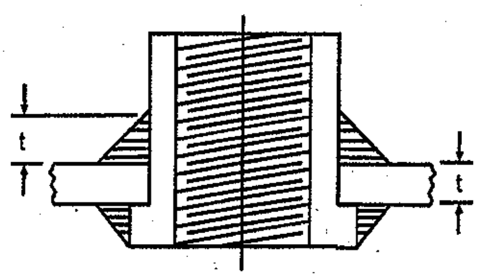


FIG. 39

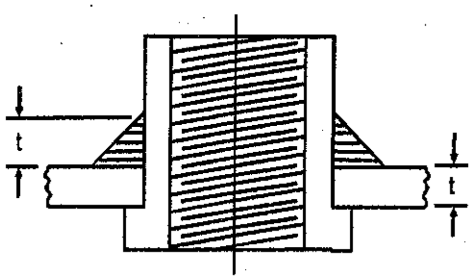


FIG. 40

Where the design pressure exceeds 250 lb/sq.in. or the nominal bore of the mounting exceeds 3/4 inch mountings shall be attached by short standpipes or pads.

Flanges and pads in contact with the boiler shall be formed to bed closely to the plate to which they are attached.

Standpipes—Where short standpipes are used the flanges shall be machined on the jointing and bolting surfaces and shall be closely to the plate. The caulking edge of the flange shall be machined or flame cut by machine. Where separate flanges are fitted they shall be attached as shown in Figs. 28, 29, 30 and 33.

Standpipes fabricated by fusion welding shall be stress-relieved by heat treatment before attachment to the boiler.

Where the outside diameter of a standpipe is not greater than 5 inches plus twice the thickness of the shell plate in inches, the standpipe may be secured by fusion welding in the manner shown in Figures 41A and 41B without subsequent stress-relieving by heat treatment.

Minimum weld attachment for standpipes 5 in. bore and under, with plate thickness to Ts equal to 1.5 Tn or greater.

Fig. 41A and 41B—Minimum weld attachments for standpipes upto and including in bore not requiring compensating plates.

Where the outside diameter of the standpipe exceeds 5 inches plus twice the thickness of the shell plate in inches, the standpipe may be secured by fusion welding as shown in Figs. 42 and 43. The standpipe and the entire plate to which it is attached shall be stress-relieved by heat treatment.

Standpipes shall be designed to withstand the internal pressure, but additional thickness may be required for:

(1) Compensation (*see* Regulation 407).

(2) Stresses imposed on the standpipe by expansion and contraction of externally attached pipe work.

The thickness of the standpipe shall be not less than 1/4 inch or that given by the following formulae, whichever is the greater:

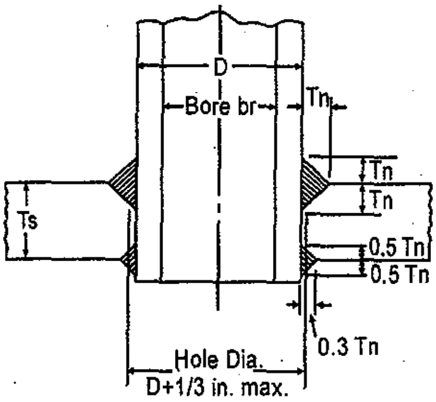


FIG. 41A

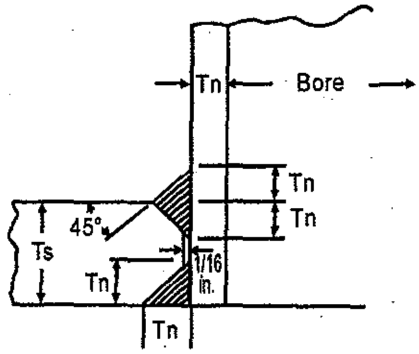


FIG. 41B

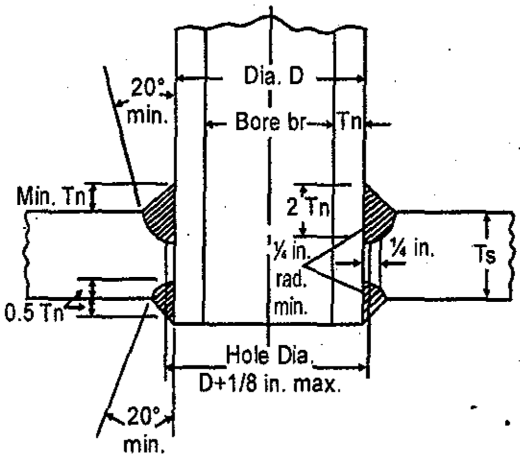


FIG. 42A

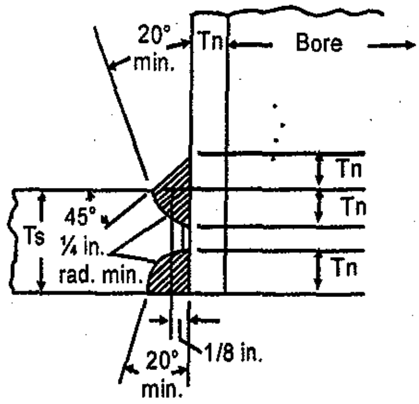


FIG. 42B

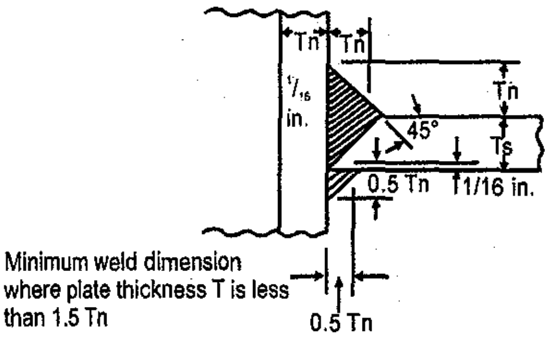


FIG. 42C

FIG. 42A, 42B AND 42C— MINIMUM WELD ATTACHMENTS FOR STANDPIPES OVER 5 IN. BORE NOT REQUIRING COMPENSATING PLATES.

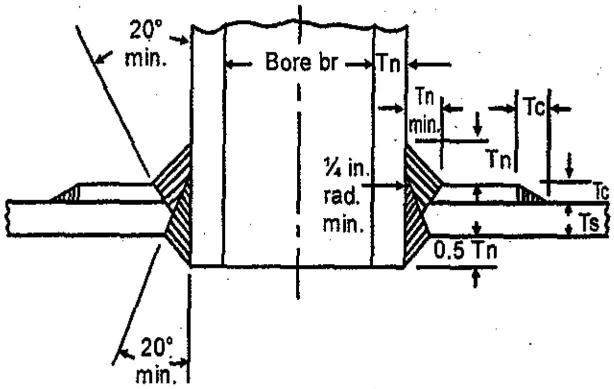


FIG. 43 — MINIMUM WELD ATTACHMENT FOR STANDPIPES OVER 5 IN. BORE REQUIRING COMPENSATING PLATES

(a) for working pressure upto and including 250 lb./sq. in. ... t = D+4

(b) for working pressure above 250 lb./sq. in. ..... t = 1.4 D + 6

where,

t = thickness of standpipe in thirty-seconds of an inch,

D= outside diameter of the standpipe in inches.

410. Flanges Thickness and Drilling

The thickness and drilling of flanges of standpipes shall be in accordance with Appendix E.

411. Pads

These shall comply with Regulation 155.

412. Unstayed Flat-End Plates

The working pressure of unstayed flat-end plates shall be determined by the following formula:

$$W.P. = \frac{2S\,(t-2)^2}{D^2} \qquad \text{Eqn. (98)}$$

where, t = thickness of plate in thiry-seconds of an inch,

W.P. = working pressure in pounds per square inch,

D = diameter in inches of the pitch circle of the bolts or rivets when the plate is attached to an outside flange or the internal diameter of the shell when the plate is attached to an inside flange,

S = minimum tensile stress of the plate in tons per square inch.

In no case shall the thickness of an unstayed flat-end plate be less than 3/8 inch.

Where an unstayed flat-end plate is pierced for electrodes or other fittings by opening having a diameter not greater than 2½ inches and the pitch of the openings in inches is not less than four times the diameter of the openings in inches, compensation is not required.

Where the diameter of the openings in an unstayed flat-end plate is greater than 2½ inches or the pitch in inches is less than four times the diameter of the openings, adequate compensation shall be provided in the manner described in Regulations 170, 171 and 186.

413. Thickness of Angle Rings

Where flange or angle rings are used for pressure purposes in no case shall the thickness after machining be less than 5/16 inch. The thickness shall be as given in Regulation 106.

414. Bolts, Nuts and Studs

These shall conform to Regulation 208.

415. Hydraulic Test

Each completed boiler shall pass the hydraulic adopted (*See* Figures 44 to 49.)

FUSION WELDED BOILERS

416. Construction and Workmanship

Construction and workmanship shall comply with the provision made in Chapter V for fusion welded drums subject to the following conditions, namely:

Class I boilers shall comply with the requirements of Chapter V.

For end plate connection by welding, the type of seam shown in Figure 44 may be adopted.

Class II boilers shall comply with the following requirements:

The longitudinal seam shall comply with Regulation 253. For end plate connections by welding any of the following types of seams, may be adopted (*See* Figs. 44 to 49).

FORMS OF WELDED JOINTS FOR CIRCUMFERENTIAL SEAMS—ACCEPTABLE FOR ALL CLASSES OF BOILERS

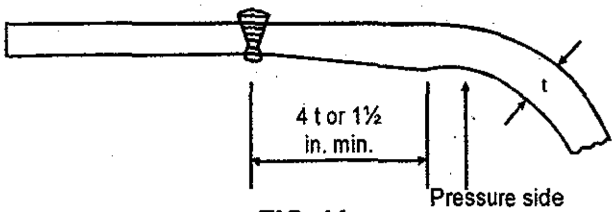


FIG. 44

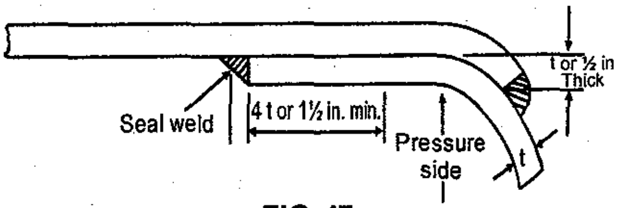


FIG. 47

ACCEPTABLE FOR CLASS II BOILERS

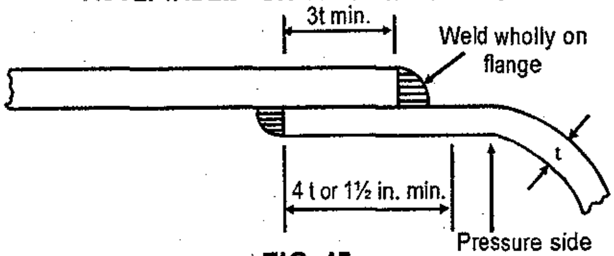


FIG. 45

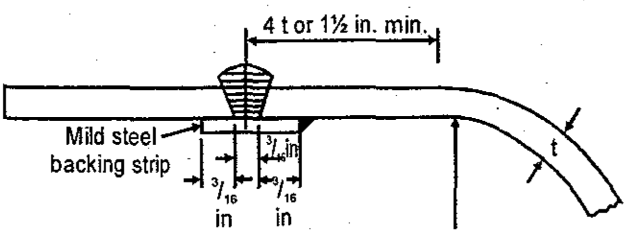


FIG. 46

FORMS OF WELDED JOINTS FOR FLAT END PLATES FOR CLASS II BOILERS NOT EXCEEDING 20 IN. DIAMETER

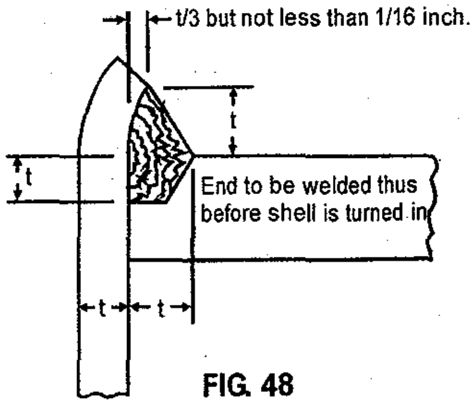


FIG. 48

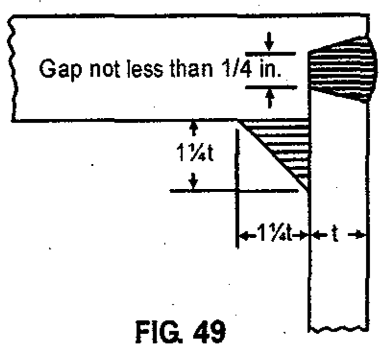


FIG. 49

Class I Boilers, the working pressure of which exceeds 165 lbs./sq. in. or the product of the working pressure in pounds per square inch and the internal diameter in inches exceeds 8250.

Class II Boilers, the working pressure of which is 165 lbs./sq. in. and below or the product of the working pressure in pounds per square inch and the internal diameter in inches is below 8250.

Forms of welded joints for circumferential seams acceptable for seamless shell boilers and for Class II welded boiler for plates over 3/4 in. thick with gap between theoges of the plates to be agreed upon by inspecting authority, manufacturer.

TESTS FOR CLASS I FUSION WELDED SEAMS

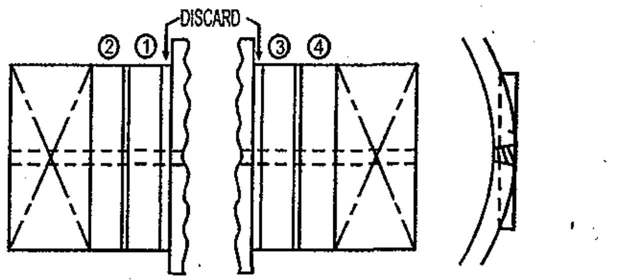
417. Selection of Test Pieces

From the test plate or plates on each longitudinal seam, test pieces shall be selected for the following tests the specimens being cut out as shown in Fig. 50 given below and stamped by the Inspector for identification:

(a) One tensile test specimen for the welded seam.

(b) Two bend test specimens.

(c) One nick break test specimen.



THESE PORTIONS TO BE RETAINED FOR POSSIBLE RE-TEST
1. TENSILE TEST FOR WELDED SEAM
2. BEND TEST: OUTER SURFACE OF THE WELD IN TENSION
3. BEND TEST: INNER SURFACE OF THE WELD IN TENSION
4. NICK BREAK TEST.

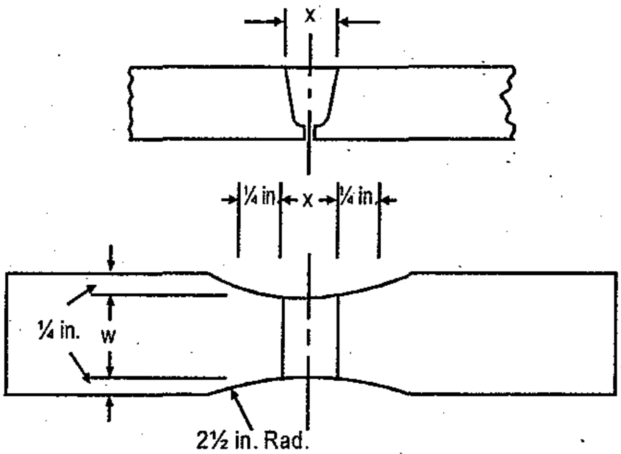
FIG. 50 — DETAILS OF TEST PLATES

The remainder of each set of test plates shall be retained for any re-test required. Any specimen for re-test shall be cut from the same set of test plates as the original specimen.

Surfaces of tensile and bend specimens corresponding with the outside and inside of the shell shall be only lightly dressed so that the rolled surface of the parent metal is not wholly removed, except that where the rolled surfaces of the abutting plates are not level with one another, one plate may be machined at each face of the weld provided the depth of metal removed does not exceed 1/32 in.

418. Tensile Test

The specimen shall be cut out transversely to the welded seam (*see* Fig. 50) and shall be of the full thickness of the plate at the welded seam and the breadth W shall be as great as the testing machine will reasonably allow provided the effective cross-sectional areas is not less than 1/2 sq. in. (*see* Fig. 51). The ultimate tensile stress of the welded seam specimen shall be not less than the lower limit specified for the plate (*see* Table under Regulation 16).



W = NOT LESS THAN FULL PLATE THICKNESS WITH A MINIMUM WIDTH OF 1½ INCHES SPECIMEN (I) TENSILE TEST FOR JOINT

FIG. 51 — TENSILE TEST FOR JOINT

419. Bend Test

Two bend tests shall be made.

One specimen shall be tested with the outer surface or the weld in tension, and the other with the inner surface in tension. The specimens shall be rectangular in section and shall be cut out transversely to the weld so as to have a width of not less than one-and-a half times the thickness of the plate. The sharp corners of the specimens shall be rounded to a radius not exceeding ten per cent of the thickness of the specimen.

Where the plate thickness does not exceed 1¼ inches the thickness of the specimen shall be equal to the full thickness of the test plate. Where the plate thickness exceed 1¼ inches the thickness of the specimen shall be at least 1¼ inches. The specimen to be tested with the outer surface of the weld in tension shall be prepared by cutting to waste the metal local to the inner surface of the weld, so that the desired specimen thickness is obtained.

The specimen to be tested with the inner surface in tension shall be prepared by cutting to waste the metal local to the outer surface of the weld so that the desired metal thickness is obtained. Where the thickness of the plate permits, both specimens may be cut from the same piece of plate, the specimens being located in the plate one above the other. Each specimen shall be mounted with the weld midway between the supports, set apart at a distance of not more than 5.2 times the thickness of the specimen and pushed through the supports with a former having a diameter equal to three times the thickness of the specimen (*see* Figure 20).

On completion of the test no crack or defect at the outer surface of the specimen shall be greater than 1/16 inch measured across the specimen or 1/8 inch measured along the length of the specimen. Premature failure at corners of the specimen shall not be considered cause for rejection (*see* Fig. 20, Specimen A).

420. Nick Break Test

The specimen shall be rectangular in section and cut transversely to the well so as to have a width not less than one-and-half times its thickness. The slot shall be cut in one side of the specimen through the centre of the weld and perpendicular to the outer face of the vessel. The specimen shall than be broken in the weld and the fracture shall reveal a sound homogeneous-weld, substantially free from slage inclusions, porosity and coarse crystallinity.

421. Re-tests

Should any of the tests fail, two re-tests shall be made on specimens cut from the same plate and both re-tests shall meet the specified requirements.

422. Specimens after Tests

If required by the Inspecting Authority, the specimens after test shall be forwarded for examination.

423. Heat Treatment

All fusion welded electrode boilers shall be stress-relieved by heat treatment. The heat treatment shall be in accordance with Regulation 267.

424. Hydraulic and Hammer Test

This shall comply with Regulation 268.

425. Determination for Working Pressure

The working pressure of cylindrical shells with fusion welded seams shall be calculated from the following formula:

$$W.P. = \frac{(t-2) \times S \times c}{D} \qquad \text{Eqn. (99)}$$

where, t = thickness of shell plate in thirty-seconds of an inch,

D = internal diameter of shell in inches,

S = ultimate tensile stress in tons per square inch,

c = 32 for Class I boilers,

c = 27 for Class II boilers.

In no case the thickness of cylindrical shells with fusion welded seams be less than those in table below:

Minimum Thickness for Fusion Welded Shells

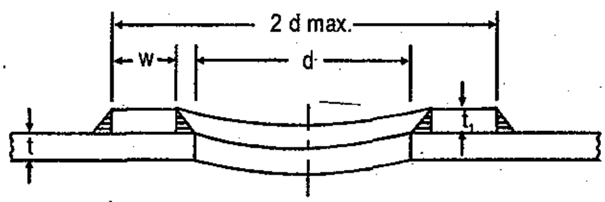
Class	*Internal diameter inches*	*Minimum thickness inches*
II	Upto and including 24	1/4
	Over 24 upto and including 36	5/16
	Over 36	3/8

In no case shall the factor of safety of the cylindrical shell and ends be less than 4.

426. Welds and Compensation for Manholes and Branches

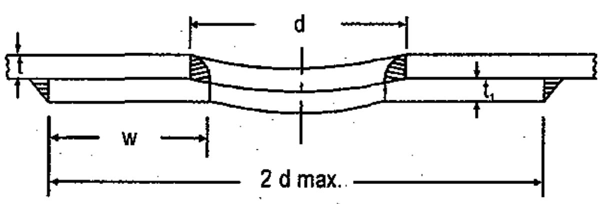
Welded compensating ring fitted to manhole and other openings shall conform to Figs. 52 to 56.

WELDS AND COMPENSATION FOR MANHOLES AND BRANCHES



NOTE : 2wt : SHALL BE NOT LESS THAN dt WHERE t IS THE CALCULATED PLATE THICKNESS.

FIG. 52 — EXTERNAL COMPENSATING RING



NOTE : 2wt : SHALL BE NOT LESS THAN dt WHERE t IS THE CALCULATED PLATE THICKNESS.

FIG. 53 — INTERNAL COMPENSATING RING

427. Manholes and Other Openings in Shells

Manholes and other openings in boiler shall shell be placed away from any welded seam. Oval openings shall be arranged with their minor axis parallel to the longitudinal centre line of the boiler:

(a) Uncompensated openings shall comply with Regulation 187.

(b) Compensated openings shall comply with Regulations 170, 171, 186 and 279.

428. Dished End Plates with Pressure on Concave Side

This shall comply with Regulation 408.

429. Unstayed Flat End Plates

The working pressure of unstayed flat-end plates shall comply with Regulation 412.

Where the diameter of the openings in an unstayed flat-end plate is greater than 2½ inches or the pitch in inches is less than four times the diameter of the holes full compensation shall be provided as in Regulation 279.

430. Thickness of Angle Rings

Thickness of angle rings shall comply with Regulation 379(a).

431.

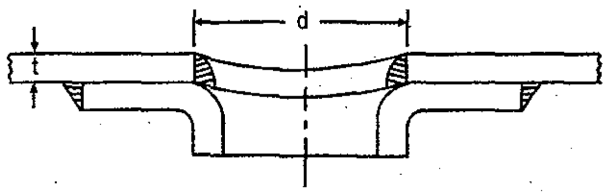
Bolts, nuts and studs shall comply with Regulation 208.

432.

Seatings and mountings shall comply with Regulation 409.

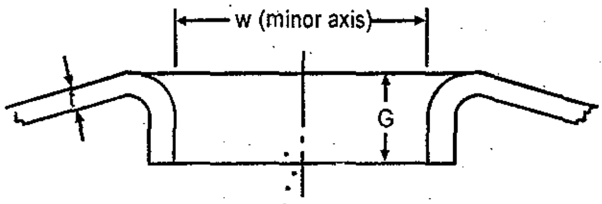
433. Hydraulic Test

The requirement of Hydraulic Test shall comply with Regulation 379(a).



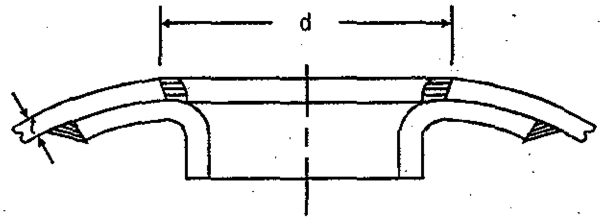
NOTE: WHERE THE CROSS-SECTIONAL AREA OF THE FRAME MEASURED ALLOWS ALINE PARALLEL TO THE AXIS OF THE SHELL IS LESS THAN dt. THE DIFFERENCE SHALL BE MADE UP BY AN EXTERNAL COMPENSATING RING. WHERE t IS THE CALCULATED PLATE THICKNESS.

FIG. 54 — ELLIPTICAL MANHOLE FLANCED FRAME WELDED TO SHELL



NOTE : T IS CALCULATE PLATE THICKNESS IN INCHES PLUS 1/5 IN. G (IN INCHES) = TW.

FIG. 55 — ELLIPTICAL PRESSED MANHOLE IN DISHED-END PLATE



NOTE: WHERE THE CROSS-SECTIONAL AREA OF THE FRAME MEASURED ON THE MAJOR AXIS OF THE OPENING d IS LESS THAN dt. THE DIFFERENCE SHALL BE MADE UP BY AN EXTERNAL COMPENSATING RING. WHERE t IS THE CALCULATED PLATE THICKNESS.

FIG. 56 — ELLIPTICAL MANHOLE FRAME WELDED TO DISHED END PLATE

SEAMLESS SHELL BOILERS

434. Determination of Working Pressure

The working pressure shall be determined in accordance with Regulation 425 except that the minimum thickness of the shell shall comply with the following table:—

Internal diameter inches	*Minimum thickness inches*
Upto and including 24	1/4
Over 24 upto and including 36	5/16
Over 36	3/8

In no case shall the factor of safety of the cylindrical shell and ends be less than 4.

The value of C in the equation shall be taken as 35. Where the ends are welded to shell or mechanically secured and welded they shall be stress-relieved.

435. End Plates

The end plates shall comply with Regulation 408 or 412 according as they are dished or flat. When end plates are mechanically secured and welded to seamless shell as shown in Figures 47 and 48 and the weld are stress-relieved, the pressure and other limitations specified in respect of Class II boilers in Regulation 416 shall not apply.

436. Manholes and Other Opening in the Shells

These shall comply with Regulation 407.

437. Mountings, Fittings and Connections (for All Types of Electrode Boilers)

Mountings, fittings and connections shall comply with Regulation 281.

In the case of electrode boilers one means of indicating water level of the tubular water level gauge-glass type and one means of feeding the boiler shall suffice and the Safety Valves shall be of spring loaded type.

If an electrode boiler is fitted with a magnetic valve, the said valve will be accepted in lieu of the second safety valve provided the source of power supply to both the valve and the boiler is the same and both are operated by one single switch.

CHAPTER XI

STANDARD CONDITION FOR THE DESIGN AND CONSTRUCTION OF ECONOMISERS, FEED PIPES, FEED HEATERS AND OTHER SIMILAR VESSELS

ECONOMISERS

500. Application of Standard Conditions and Exceptions Thereto

(a) An economiser shall not be registered under sub-section (4) of Section 7 of the Act and a certificate shall not be issued under sub-section (5) of that section with reference to an economiser unless the standard conditions in respect of material design and construction, which are specified in this Chapter are satisfied in respect of such economiser:

Provided that an economiser in use at the time Chapter XI of these Regulations came into force, may be so registerd and such certificate may be issued in respect thereof notwithstanding that such standard conditions are not satisfied in respect of such economiser.

(b) Notwithstanding anything contained in sub-regulation (a) the Chief Inspector may, subject to the provisions of Regulation 502, register an economiser and order the issue of a certificate authorising the use thereof, although the standard conditions are not fully satisfied in respect of such economiser.

501. General Requirements

(a) All cast iron and steel headers and the parts used in the assembly of an economiser shall conform with the requirements of this Chapter in respect of material specification and test workmanship and structural requirements.

(b) All economisers under construction shall be under the supervision of an Inspecting Authority and must be so certified by that authority.

(c) A certificate from the Inspection Authority in Form VII certifying that material was tested and the economisers built under their supervision shall be furnished to the Chief Inspector before or with the first application for registration.

(d) In advance of or along with an application for registration, the following shall be furnished—

(i) a certificate in Form VIII of manufacture and test signed by the Maker or by a responsible representative of the Maker, containing the description of the economiser, particulars of the material used in its construction and the dimensions of the several parts with the declaration that the limits or tensile breaking strength and tests comply with the standard conditions;

(ii) a certificate from the Maker of the material stating the tensile breaking strength and the elongation provided that if the Maker and manufacturer be the same, the Manufacturer's precise statement showing the above information shall be accepted.

(e) To suit owners' convenience where possible it recommended that economiser be installed in two or more sections.

502. Modification of Formula

Where no certificates are produced, the working pressure as found by formula will be reduced by 10%. When the workmanship is, however, in any way doubtful and the Chief Inspector is not satisfied that any of the foregoing conditions would be sufficient to meet the circumstances he may at his discretion reduce the working pressure by such percentage as he deems fit.

503. Maker's Certificates for Steel Economisers

The maker shall furnish the Inspecting Officer with a certificate in the following form:

We hereby certify that the material described below has been made by the Open Heart or an Electric process acid/basic and has been satisfactorily tested in the presence of the Inspecting Officer/our Test House Manager in accordance with the Standard Tests.

504. Hydraulic Test for New Economisers

For all new economisers the hydraulic test must be applied as shown below:

On components before assembly	*Design pressure lb./ sq. in.*	*Hydraulic test pressure lb./sq. in.*
Cast iron tubes, headers and bends		Twice working pressure. Minimum pressure 700.
Steel tubes and bends	500 or less	1,000
Steel tubes and bends	Above 500 but not exceeding 1,000	Twice the working pressure.
Steel tubes and bends	Above 1,000	1,000 above the working pressure.
Headers	Below 1,000	Twice the working pressure.
Headers	Above 1,000	Working pressure plus 1,000 lbs./sq.in.

For all assembled sections the Hydraulic Test Pressure shall be not less than 1½ times the working pressure.

"Working pressure" shall be the highest pressure at which the economiser relief valves are to be set.

The above test pressure shall be held for a minimum period of ten minutes.

505. Workmanship and Manufacture

All material used in the construction of pressure parts shall be tested and shall conform with the following requirements:

(a) The workship throughout shall be of the highest standard. All castings shall be well-finished, free from defects, porous places and below holes, and true to dimensions without wrapping. Where chaplets are used, there must be satisfactory fusion with the metal. Chaplets must be properly tinned with metal free from lead.

(b) The screw threads of all bolts must be of Whitworth forms.

(c) All component parts shall where necessary, be manufactured to limit gauges to secure interchangeability throughout.

CAST IRON, TUBES AND HEADERS

506. Process of Manufacture

(a) The castings shall be cast from metal melted or refined in any suitable metallurgical plant other than an iron ore smelting furnace.

The minimum test results required on test bars 1.2 in. in diameter shall be in accordance with the following table:

Materials for tubes and other pressure parts	*Minimum tensile strength*		*Transverse test on span of 45.8 Cm (18 in.)*			
			Minimum transverse breaking load in		*Minimum deflection in*	
	Kg/mm	*Tons/sq. in.*	*Kg.*	*Lbs.*	*Cms.*	*Inches*
Grade 16.5	26.00	16.5	1,052	2,320	0.434	0.17
Grade 14 iron	22.00	14.0	0.934	2,060	0.407	0.16
Grade 12 iron	18.75	12.0	0.839	1,850	0.382	0.15

Note: Grade 16.5, 14 and 12 iron correspond to 26, 22 and 18.73 kg/cm^2 (16.14 and 12 tons) minimum tensile strength respectively.

(b) On analysis, the Sulphur and Phosphorus content shall not exceed the following percentages:

Components	*Sulphur per cent max.*	*Phosphorus per cent max.*
Tubes	0.15	1.00
Headers	0.15	1.00

(c) Minimum Manganese content shall be related to Sulphur content by the following formula:

$$(\%\ \text{Sulphur} \times 1.7) + 0.3 = \%\ \text{Manganese}.$$

Which must be shown to be satisfied by routine quality control Laboratory analysis. In any event the Manganese shall not be less than 0.5 per cent and shall be within the range 0.5 per cent and shall be within the range 0.50-0.90 per cent. Phosphorus content shall be kept as low as economically possible but in no circumstances shall it exceed 1.0 per cent.

507. Test Bars

(a) When the test bars are cast separately, they shall be poured at the same time and from the same ladle of metal as the casting or castings they represent. The number of test bars specified in Regulation 508 shall be applicable to all castings of each melt.

(b) When the bars are cast on the mould for the casting and the mould for the test piece shall be joined together in such a manner that the liquid metal fills both moulds at the same operation.

(c) All test bars shall be cast in green sand or in loam or dry sand moulds according as to whether the casting or castings they represent are moulded in green sand, or in loam or dry sand respectively.

(d) The test bars shall not be subjected to any heat treatment after leaving the moulds except where the castings are heat treated.

508. Number of Tensile Tests

(a) The number of tests required for each batch of castings shall be in accordance with the following table the various classes of castings being divided into 4 representative groups:

Group	*Weight of casting*	*Test requirements*
1	Upto 28 lbs.	One test for each 30 cwts. of castings or part thereof.
2	Over 28 lbs. and upto 1 cwt.	One test for each 2 tons of castings or part thereof.
3	Over 1 cwt. and upto 1 ton	One test for each 3 tons of castings or part thereof.
	In the above Groups 1, 2 and 3, all castings represented by one test must be poured from the same ladle of same heat as the bar or bars provided for the test.	
4	Over 1 ton and important castings	One test for each 4 tons of castings or part thereof or for each casting weighing 4 tons or more.

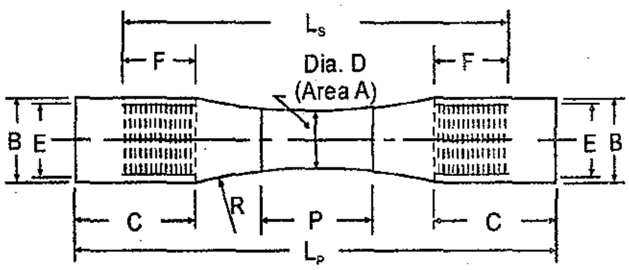
(b) Conditions for Acceptance and for Rejection:

Test	*Result*	*Conclusion*
1st	Pass	The batch or separate casting represented shall be accepted.
	Tensile or Transverse test fails	Two more tests shall be made.
2nd	If both pass	The batch or separate casting represented shall be accepted.
	If either fails	The batch or separate castings represented shall be rejected.

Provided always that, in the case of failure of any test piece showing obvious casting defects, another test piece shall be taken from spare test bars or cut from a casting from the same batch and the results obtained from this substituted for those obtained from the defective test bars.

509. Standard Test Piece

The tensile test bar shall confirm to the dimensions shown in the following. Bars may be tested with either plain or screwed ends.



B	D	A	P	R	C	E	F	Lp	Ls
in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
1.20	0.798	0.50	2	3½	2	1-1/8 SF	1-1/8	8-1/8	5-7/8
						1-1/8 SW			

The test bars shall be cast as cylindrical bars of the diameters given in Col. B and machined to the dimensions given in Cols. D & P in the above Table.

CONSTRUCTION REQUIREMENTS

CAST IRON ECONOMISERS

510.

The manufacturer shall, on the basis of design details, satisfy the Inspecting Authority regarding the design and the strength of all parts of cast iron economisers subject to the following maximum working pressures:

	Max. W.P.
(1) Ordinary Vertical Tube	325 lbs./sq. in.
(2) Ordinary Vertical Tube with Strengthened Tubes	375 lbs/sq. in.
(3) Ring Stay Vertical Tube	475 lbs./sq. in.
(4) Gilled Tube Type approved Design	45.7 kg./cm^2 (650 lbs./sq. in.)

511. Joint Bolts and Studs for Cast Iron Economisers

(a) The maximum working pressure for the bolts and studs shall be calculated by Regulation 518.

(b) The use of studs tapped into cast iron is permissible where:

(i) The studs and nuts are not in the path of the flue gases;

(ii) The studs are carefully threaded to gauge and fitted into tapped holes of ample depth.

For economiser of Gilled Tube type of approved design made from 16.5 grade iron the limitation for a maximum working pressure may be increased to 52.7 kg./cm^2 (750 lbs./sq. in.).

512. Economiser Water Outlet Temperature

The design conditions shall be such that the maximum outlet water temperature of the economiser shall be at least 40°F below the saturated steam temperature in the boiler drum:

Provided that this requirement shall not apply to economisers used on low pressure water heating systems working at pressure less than 120 ft. head of water.

STEEL ECONOMISERS WITH OR WITHOUT CAST IRON SLEEVES ON THE TUBES

513. Tubes: Construction

(a) The tubes shall be manufactured in accordance with Regulation 151.

(b) Suitable provision shall be made for supporting horizontal tubes at one or more intervals in their length to relieve bending stresses and these supports as well as the end connections must permit free expansion.

514. Tubes: Working Pressure

The working pressure of the tubes shall be calculated in accordance with Regulation 338 (a), but the working metal temperature shall be taken as the maximum water temperature for which the part of the element is designed plus 11°C (20°F).

515. Headers: Construction

(a) The headers shall be constructed in accordance with Regulation 154.

(b) Branches shall be secured by one of the following methods:

(1) Expanded, belled and welded.

(2) Strength welded with additional securing means.

(3) Full depth strength weld.

(4) Branches less than 2 inch bore may be screwed and seal-welded.

(c) Open ends of forged for seamless steel tube headers may be closed by forging, or the ends may be secured by bolting, screwing, or welding in an approved manner.

516. Headers: Working Pressure

(a) **Rectangular Headers**—The working pressure shall be calculated in accordance with Regulation 340.

(b) **Cylindrical Headers**—The working pressure shall be calculated in accordance with Regulations 270 and 271.

517. Attachment of Tubes to Headers

(a) Tubes shall be connected to the tube plates by one of the following methods:

(1) Expanding with bell mounting or seal welding.

(2) Strength welding.

(3) Mechanical bolted joint.

(b) Roller expanded tubes shall project through the neck or bearing part in the holes by at least quarter of an inch and shall be secured from drawing out by being bell mouthed to the extent of 1/32" for each inch in diameter plus 2/32".

(c) Tubes expanded into headers may be seal-welded inside or outside the header. Where a seal weld is provided inside the header, the tube end projection and bell mouthed specified in (b) is not required.

(d) In the case of roller expanded tubes the tube holes in the headers shall be formed in such a way that the tubes can be effectively tightened in them, there shall be a neck or belt of parallel seating of at least ½ inch.

(e) Where the tubes are strength welded direct to the headers, the technique followed shall be approved by the Inspecting Authority and all welds shall be suitably heat treated.

(f) Bolted joints shall be designed in accordance with Regulation 518.

(g) Tubes spacers supporting clips and lugs may be welded to the tubes.

(h) The tubes shall be so arranged that they are accessible for cleaning internally and externally.

JOINT BOLTS AND STUDS

518. Joint Bolts, Studs and Flanges

(a) The maximum working presssure for the bolts shall be determined by the following formula:

$$W.P. = \frac{N \times C}{A}\left(D - \frac{1.28}{n}\right)^2 \qquad \text{Eqn. (121)}$$

where, N = no. of bolts securing the parts,

n = no. of screws threads per inch,

D = bolt Diameter in inches measured over the threads,

A = the area exposed to pressure which is assumed to be bounded by a line midway between the pitch line of the bolts and the inner edge of the flange where flat joints are used with joint rings. Where conical joints are used with joint rings of curvilinear cross-section, the area exposed to pressure shall be assumed to extend to the root of the thread where the tube ends are screwed, or to a corresponding boundary if the flanges are attached by other means,

C = 4,700 for steel bolts or studs of 28 tons/sq. in. minimum ultimate tensile stress where the diameter over thread is less than 3/4 inch,

C = 5,100 for steel bolts or studs of 30 tons/sq. in. minimum ultimate tensile stress where the diameter over thread is less than 3/4 inch,

C = 5,600 for steel bolts or studs of 35 tons./sq. in. minimum ultimate tensile stress where the diameter over thread is less than 3/4 inch,

C = 5,600 for steel bolts or studs of 28 tons/sq. in minimum ultimate tensile stress where the diameter over thread is not less than 3/4 inch and not greater than 7/8 inch,

C = 7,000 for steel bolts or studs of 28 tons/sq. in minimum ultimate tensile stress where the diameter over thread is greater than 7/8 inch.

Where the bolts or studs used have a tensile strength exceeding 32 tons sq. in., a plate shall be permanently fixed to the economiser structure in a prominent position drawing attention to this fact in case replacements of bolts or studs are necessary. In no case shall the nuts be exposed to the action of the flue gases.

(b) The thickness of each flange shall be not less than that given by the following equation:

$$t = \frac{\sqrt{[P.D. (D_1 - D)]}}{2}$$

where, t = thickness of flange in thirty-seconds of an inch,

P = working pressure, in pounds per square inch (gauge),

D = outside diameter of the tube in inches,

D_1 = pitch circle diameter of bolts or studs in inches. Provided that such flange is cast integral with the body and with the appropriate internal corner radius.

In no case, however, shall the thickness of a flange be less than 24 thirty-seconds of an inch.

VALVES AND MOUNTINGS

519.

(a) **Thermometers**—All economisers shall be provided with Thermometers for measuring water temperature adjacent to the inlet and outlet connections.

(b) **Relief Valves**—A valve which shall prevent increase of pressure beyond a predetermined limit shall be fitted to every economiser and the design shall provide against unauthorised interference with the loading. Economisers with pressure parts of cast iron and arranged in groups of tiers connected by circulating piping shall have a relief valve fixed on each group or tier. Relief valves should have a minimum diameter of 2".

(c) **Pressure Gauge**—Means for indicating the pressure in the economiser shall be provided by a Pressure Gauge constructed on the lines of Regulation 327.

(d) **Air Release Valves**—Means must be provided for the release of air at all points where air accumulation may occur.

(e) **Blow Off Drain Valves**—Means must be provided for draining the economiser completely of water.

(f) **Non-Return Valves in Return Feed Line**—Economiser provided with means for heating the incoming feed by mixing it with hot water from the economiser outlet must have a non-return valve in the hot water return line.

(g) **Reserve Flues**—In every case a reserve flue shall be provided for by passing the flue gases when no water is being fed to the boiler through the economiser where it is not integral with boiler.

(h) **Explosion Doors**—To relieve the economisers of excessive pressure accumulation due to internal explosion doors preferably of horizontally hinged 'self-sealing' type shall be fitted.

(i) **Hydraulic Test**—All valves and mountings shell withstand satisfactorily a hydraulic test to the same pressure as will be applied to the economiser during its registration.

(j) **Feed Line**—Alternative means of feeding the boiler other than through the economiser shall be provided.

(k) **Non-Return Valve**—A valve shall be provided in the hot feed line between the economiser and the boiler to prevent the discharge of steam or water from the boiler into the economiser.

FEED PIPES

520. General

Feed pipes may be made of steel, cast iron or copper but cast iron pipes will not be accepted for a working pressure over 200 lbs. per sq. in. or 425°F. Copper feed pipes shall be solid drawn and not exceed 8" external diameter and may be used for a working pressure not exceeding 350 lbs. or 300°F.

Design Pressure for Feed Piping—The design pressure shall be the maximum pressure generated in overcoming friction and other losses in the feed piping under ordinary working conditions, or the maximum pressure which can be generated by the boiler feed pumps unless special provision is made to prevent that pressure being communicated to the pipeline.

Note: For boilers operating at working pressure 100 kg./sq.cm. and above, feed water discharge piping for feed water system without economizer inlet isolating valve can be designed based on boiler design pressure with provision of mechanical relief device, to prevent Boiler Feed Pump (BFP) shut off pressure being communicated to the piping system and with such a feed water system, boiler shall be hydro tested upto the last isolation valve in the feed water line.

521. Steel Feed Pipes

Steel feed pipes shall be in accordance with Chapter VIII.

522. Cast Iron Feed Pipes

(a) The standard conditions for material of construction and tests for cast iron pipes shall comply with Regulations 505 to 509.

(b) The maximum working pressure shall be determined by the following formula:

$$W.P. = \frac{130(t-6)}{d} \qquad \text{Eqn. (122)}$$

where, t = thickness in thirty-seconds of an inch.

d = the external diameter of the pipe in inches.

523. Copper Feed Pipes

(a) The standard conditions for material of construction and tests for copper pipes shall comply with Regulation 35.

(b) The maximum working pressure shall be determined by the following formula:

$$W.P. = \frac{60(t-3)}{d} \qquad \text{Eqn. (123)}$$

where, t = thickness in hundredths of an inch,

d = external diameter of the pipe in inches.

523A. Feed Heaters and Similar Vessels Fitted to Feed Pipes

(a) **Standard Requirements, Materials of Construction and Allowable Working Pressure**—These shall comply with the requirements of Chapters I, II and III for riveted construction. If so welded construction, such vessels shall comply with the requirements of Chapter XII, provided that radiographic examination of welds may be waived, for pressure not exceeding 17.5 kg./cm^2 (250 lbs./sq. in.). For parts of vessels of composite construction, the requirements of the appropriate regulations of the above Chapters shall be complied with as may be applicable to each such part.

(b) **Working Pressure**—Working pressures of all parts shall be determined by the appropriate formulae given in these regulations. Due consideration shall be given to the following additional points while calculating the stresses.

The stresses due to self-weight of vessels and its contents and any super-imposed vessel or other equipments, insulation and these due to static head, if any and pipes and other similar parts attached to the vessel.

(c) **Safety Valve Requirement in Feed Heaters and Similar Vessels**—Every such vessel shall be protected with a relieving device of sufficient capacity to avoid over-pressure in case of internal failure.

(d) **Inspection during Construction, Stamping and Testing**—These shall comply with the appropriate Regulation of Chapter I.

REGULATION FOR REGISTRATION AND INSPECTION OF ECONOMISERS AND FEED PIPES

524. Preparation for Inspection

(a) At each inspection the economiser shall be emptied and thoroughly cleaned internally and externally and in the flues. All mountings shall be opened up and all caps, doors and blank flanges removed to permit adequate inspection.

(b) The owner of an economiser to which this Regulation is applicable shall obtain the approval of the Chief Inspector in writing to the method of disconnection which he proposes to use and shall be responsible for ensuring that the method so approved is followed in practice.

525. Procedure for Regulation

(a) On receipt of an application for registration the Inspector shall after the economiser has been prepared for examination, take full particulars of the design and ascertain the working pressure allowed by the Regulations.

(b) The fitness of the economiser parts shall be determined as per the following formulae:

(i) **Cast iron smooth tube economisers with pressed socket joints—**

$$W.P. = \frac{AZ}{70a} + \frac{225N}{n} \qquad \text{Eqn. (124)}$$

where, WP = design pressure in pounds per square inch (gauge),

A = area of contact surface of a single socket, square inches,

a = cross-sectional area measured on the mean diameter of a socket-hole, in square inches,

Z = breakdown load of unreinforced socket joint in pounds,

N = number of stays per header,

n = number of sockets per header.

For existing standard designs the breakdown load of an unreinforced socket joint shall be taken as not greater than 13,500 lbs. For designs not already in use before the date of this standard the corresponding figure shall be taken as not greater than 75 per cent of the load as determined by experiment.

(ii) **Headers of approximately rectangular cross-section—**

$$W.P. = \frac{C(t-2)}{b^2} \qquad \text{Eqn. (125)}$$

where, t = thickness in thirty-seconds of an inch,

b = distance between the sides of header supporting the surface, in inches,

WP = design pressure, in pounds per square inch (gauge),

c = 11 where the water side surface is flat,

= 22 where the water side surface is curved, provided that the curvature is continued without interruption and the thickness at each end of the side is not less than that determined with C = 11.

In no case, however, shall the thickness of the side of a header be less than 16 thirty-seconds of an inch at any part.

(iii) **Headers of approximately circular cross-section—**

$$W.P. = \frac{0.6K\ (t-5)}{D} \qquad \text{Eqn. (126)}$$

where, t = thickness in thirty-seconds of an inch,

WP = design pressure, in pounds per square inch (gauge),

D = outside diameter of header in inches,

K = 265 for Grade 16.5 Iron,

= 240 for Grade 14 Iron,

= 220 for Grade 12 Iron.

The minimum thickness of plain cylindrical portions of a header in that part of the length which does not contain tube holes shall comply with the requirements of sub-clause (v).

In no case, however, shall the thickness at any point may be less than 16 thirty-seconds of an inch.

(iv) **Tubes—**

$$W.P. = \frac{K\ (t-c)}{D} \qquad \text{Eqn. (127)}$$

where, t = thickness in thirty-seconds of an inch,

WP = design pressure, in pounds per square inch (gauge),

D = outside diameter of tube in inches,

K = 265 for Grade 16.5 Iron,

= 240 for Grade 14 Iron,

= 220 for Grade 12 Iron,

C = 4 for portion where gills act as reinforcement,

= 5 for portion not reinforced.

In no case, however, shall the thickness at any point may be less than Il thirty-seconds of an inch.

(v) **Manifold pipes—**

$$W.P. = \frac{0.8K\,(t-5)}{D} \qquad \text{Eqn. (128)}$$

where, t = thickness in thirty-seconds of an inch,

WP = design pressure, in pounds per square inch (gauge),

D = outside diameter of pipes in inches,

K = 265 for Grade 16.5 Iron,

= 240 for Grade 14 Iron,

= 220 for Grade 12 Iron.

In no case, however, shall the thickness of a manifold pipe or branch be less than 14 thirty-seconds of an inch.

(vi) **Cast iron economisers with extended surface horizontal tubes, connector bends—**

$$W.P. = \frac{K\,(t-5)}{D} \qquad \text{Eqn. (129)}$$

where, t = thickness of bend in thirty-seconds of an inch,

WP = design pressure, in pounds per square inch (gauge),

D = outside diameter of bend in inches,

K = 265 for Grade 16.5 Iron,

= 240 for Grade 14 Iron,

= 220 for Grade 12 Iron.

In no case, however, shall the thickness of a connector bend be less than 10.3 mm (13 thirty-seconds of an inch) for 18.75 kg/cm^2 (12.0 tons/sq. in.) and 22.00 kg/cm^2, (14.0 tons/sq. in.) grade irons and 9.0 mm (11 thirty-seconds of an inch), for 26.00 kg/cm^2 (16.5 tons/sq. in.) grade iron.

TUBES

To comply with Equation 127.

MANIFOLD PIPES—

To comply with Equation 128.

(c) The Inspector shall enter full particulars of the economisers together with the required calculations of various parts in a Memorandum of the Inspection Book (Form IX) and submit it to the Chief Inspector.

(d) If no formula or co-efficient applicable to any part, other than what is mentioned above, is contained in the Regulations, the Chief Inspector shall at his discretion determine the fitness of the part.

(e) After inspecting the economiser and ascertaining, as prescribed, the maximum working pressure to which it may be worked, the Inspector shall witness the hydraulic test in accordance with Regulation No. 527 and may issue a Provisional Order in Form X.

526. Procedure at Subsequent Inspection

(a) After the economiser has been cleaned the Inspector shall make a thorough examination so far as its construction permits. The external condition of the tubes should be carefully noted for wasting especially at the feed inlet end and all accessible tubes should be calibered. The internal surfaces of cast iron tubes should be closely observed for graphitic wasting as far as it is possible and in the event of any tube failure these should be broken up for scrutiny so that the general internal condition of the other tubes may be estimated.

(b) Where tubes or other parts are wasted, the strength should be re-calculated.

(c) The scraper gear should be examined to note if any parts are missing if the length of travel is adequate and if the scrapers are correctly adjusted.

(d) All cap bolts are to be inspected, also the condition and position of the dampers and baffles.

(e) The record of each inspection and calculations will be entered in the Memorandum of Inspection Book.

527. Procedure for Hydraulic Test

Every economiser for registration shall be hydraulically tested in the presence of an Inspector to 1½ times the working pressure. Hydraulic tests of economisers at subsequent examination shall when required by the Inspector, be made after the inspection. The test pressure to be applied to economisers at subsequent examinations shall be from 1¼ to 1½ times the working pressure of the economisers. During the test, all parts externally and in the flues shall be noted for leakage.

528. Memorandum of Inspection Book

In this book the Inspector shall enter all particulars and dimensions of the economiser with the required calculations for the various parts together with details of hydraulic test. At subsequent inspection the Inspector shall enter all notes pertaining to the condition of the various parts.

529.

(a) **Registration Books**—Registration Books shall be maintained on the lines of Regulation 387.

(b) **Transfer of Memorandum of Inspection Book and Registration Books**—On an economiser passing from one State to another, the Memorandum of Inspection and Registration Book shall, on the request of the Chief Inspector of the State to which the economiser has been transferred, be forwarded to that Officer who shall take over their custody and maintain them as prescribed.

530. Grant of Certificate

A certificate for the use of an economiser shall be granted in Form XI.

531. Casual Visits

(a) The Inspector shall note if the economiser is working satisfactorily, and if the relief valves are correctly adjusted, if the scraper gear is operating and if the external brick work is free from cracks.

(b) He shall also ascertain that the maker's instructions for working are being strictly followed by the owner.

Note: It is recommended that the feed inlet temperature to the economiser should not be less than 100°F, to prevent sweating and consequent external corrosion of the tube and bottom headers.

532. Economiser Rating

The rating shall be equivalent to the area of the heatings surface in square metres which shall be computed from the tubes and the headers.

533. Registration Fee

An application for registration of economiser shall be accompanied by appropriate fee as specified below:

				Rs.
For Economiser rating not exceeding	50 sq. mtrs			600
For Economiser rating exceeding	50 sq. mtrs	but not exceeding	100 sq. mtrs	720
For Economiser rating exceeding	100 sq. mtrs	but not exceeding	150 sq. mtrs	840
For Economiser rating exceeding	150 sq. mtrs	but not exceeding	200 sq. mtrs	960
For Economiser rating exceeding	200 sq. mtrs	but not exceeding	250 sq. mtrs	1,080
For Economiser rating exceeding	250 sq. mtrs	but not exceeding	300 sq. mtrs	1,140
For Economiser rating exceeding	300 sq. mtrs	but not exceeding	350 sq. mtrs	1,200
For Economiser rating exceeding	350 sq. mtrs	but not exceeding	400 sq. mtrs	1,320
For Economiser rating exceeding	400 sq. mtrs	but not exceeding	450 sq. mtrs	1,440
For Economiser rating exceeding	450 sq. mtrs	but not exceeding	500 sq. mtrs	1,560
For Economiser rating exceeding	500 sq. mtrs	but not exceeding	600 sq. mtrs	1,680
For Economiser rating exceeding	600 sq. mtrs	but not exceeding	700 sq. mtrs	1,800
For Economiser rating exceeding	700 sq. mtrs	but not exceeding	800 sq. mtrs	1,920
For Economiser rating exceeding	800 sq. mtrs	but not exceeding	900 sq. mtrs	2,040
For Economiser rating exceeding	900 sq. mtrs	but not exceeding	1000 sq. mtrs	2,160

Above 1000 sq. metres for every 200 sq. metres or part thereof, an additional fee of Rs. 120 shall be charged.

534. Engraving of Registry Number

(a) Every economiser shall have a plate with its registry number engraved, secured in a conspicuous place and wherever practicable stamped for identification with that number in a prominent place. The engraving shall be done within a period of two months from the date of receipt of the registry number.

(b) A letter "E" shall be refixed to the registry number in the denominator of the appropriate device as shown in Regulation 382.

Example: $\frac{\text{UP}}{\text{E-53}}$

(c) The engraving shall be completed and ready for verification within thirty days from the date of receipt of the engraving slip from the Chief Inspector of the State.

(d) Economisers having registry devices different from those prescribed in clauses (a) and (b) shall have such devices crossed out or erased and engraved a new in conformity with those prescribed in the clauses aforesaid. The original numbers of such economisers shall be retained in the new device, provided that in case of economisers operating in an area which consequent upon the reorganisation of State forms part of another State, new numbers shall be given by the Chief Inspectors of the State. A number once allotted shall not be used again in another economiser.

534A.

(a) **Inspection of Feed Pipes**—Feed pipes shall be inspected and hydraulically tested before erection in place, and the hydraulic test pressure shall be not less than twice the working pressure of the economiser. A certificate from the recognised maker or Inspecting Authority that this has been done may be accepted. If the Inspector is satisfied with the test, the pipes may be erected. No separate certificate for feed pipes shall be issued, nor shall a separate fee be charged for their inspection. The engraving shall be done within a period of two months from the date of receipt of the registry number.

(b) At subsequent inspection or at any other time, the Inspector may make an external inspection of feed pipes and if found in an unsatisfactory condition he shall report the matter to the Chief Inspector who may require the pipes to be hydraulically tested.

534B. Submission of Plans of Feed Pipes

(a) The fees for the scrutiny of plans and particulars of the material, design and construction of feed pipes, before commencement of manufacture of the feed pipes shall be at the rate of Rs. 30 for 30 metres of piping or part thereof, subject to a minimum of Rs. 50, inclusive of all fittings excepting fittings like feed water heaters. For any such fittings like feed water heater, the fees shall be equal to the registration fees of the boiler to which feed pipe is attached subject to a maximum of Rs. 1,500.

(b) The fees for scrutiny of layout plans of feed pipes shall be Rs. 20 for 30 metres of piping or part thereof, subject to a minimum of Rs. 50, exclusive of fittings like feed water heater for any such fittings like feed water heater, the fee shall be Rs. 150.00 for each such fittings.

CHAPTER XII

SHELL TYPE BOILERS OF WELDED CONSTRUCTION

535. Application

These Regulations shall apply to all boilers of fusion welded construction other than Water Tube boilers and Electrode boilers referred to in Chapters V and X respectively.

Where the design of the boiler is of composite construction, viz., part fusion welded and part riveted, it shall comply with the relevent regulations governing that particular type of construction.

536. General Requirements

Where applicable the general requirements of Chapter I relating to Certificates from Makers, Inspecting Authorities, and the like and of Chapter III concerning construction, shall be followed.

536A. Equipment of Workshop

(a) The welding plant and equipment are to be of good quality and maintained in an efficient working condition. The welding apparatus is to be installed under cover and arranged so that welding work may be carried out in positions free from draughts and adverse weather conditions. The procedure is to be such that there is regular and systematic supervision of the welding works, and the welding operators are to be subjected by the works officials to periodic tests for quality of workmanship. Records of these tests are to be kept and are to be available to the Inspecting Officers for scrutiny.

(b) The works should be equipped with welding plant equipment and quality control personnel. However, the equipments for destructive, non-destructive testing and heat treatment is not necessary. The manufacturer can be tie-up for these facilities outside and a letter from the party with whom he makes a tie-up should be made available to the Chief Inspector of Boilers of the State Inspecting Authority or his representative should be allowed to inspect the material in the laboratory of the party during the test.

537. Materials of Construction

Plates, sections and bars used in the construction of these boilers shall comply in all respect with the requirements of Chapters II and V.

Where, however, the tensile strength exceeds 32 tons per square inch., the full details of the welding technique including pre-heating and post-heating, and the plate preparation to be used, shall be submitted to Inspecting Authority for approval before manufacture commences.

538. Covered Electrodes

Where covered electrodes are used they shall comply with the requirements of Regulations 94 to 98 save in the case of the weld metal as deposited, where the tensile strength shall not be less than the lower limit specified for the plate.

539. Plain and Stay Tubes

(a) Tubes shall comply so far as may be with the provisions of Regulations 36 to 63.

For plain tubes subjected to external pressure lap welded steel tubes as provided in the Regulations 64 to 67 may be used.

(b) **Seamless Steel Cross-tubes and Uptake Tubes**—Cross-tubes and uptake tubes shall comply with Regulations 127 and 128 respectively.

540. Construction and Workmanship

The manufacturer shall supply the Inspecting Authority with a fully dimensioned sectional drawing showing in full detail the construction of the boiler for approval before putting the work in hand.

Full details including dimensions of plates preparation for the longitudinal and circumferential seams shall also be shown on the drawing.

Fully dimensioned sketches showing in details the attachment for stand-pipes, branch pipes and seatings, the position of these attachments relative to the longitudinal and circumferential seams and other opening shall also be given in the drawing.

541. Preparation of Plates

The edges of all plates, shall be machined or flame-out by machine. Gusset plates may be sheared except on those edges, which are to be welded.

Plates which are to flame-out by machine without subsequent heat treatment, grinding or machining, shall not have a carbon content higher than 0.26 per cent. Where the carbon content exceeds 0.26 per cent, heat-treatment, grinding or machining shall be carried out.

The edges of all plates shall have a smooth finish.

The welding edges of all plates shall be cleaned to a smooth metallic surface and shall be free rust, oil or other foreign matter before welding is commenced.

The surfaces of the plates at the longitudinal and/or circumferential seams shall at no part be out of alignment with one another by more than 10 per cent of the plate thickness but in no case shall misalignment exceed 1/8 inch for longitudinal seams or 3/16 inch for circumferential seams.

542. Stress-Relieving

For the purpose of relieving internal stress all plates which have been dished, flanged or locally heated shall afterwards be, annealed unless during the last stage of manufacture they have been uniformly heated throughout.

543. Cylindrical Shells

Except where the design incorporates flat tube plates in the shell, each ring shall be formed from not more than two plates and bent to cylindrical form to the extreme ends of the plate. The bending shall be done entirely by machine. Local heating or hammering shall not be used.

The longitudinal seam or seams may be placed in any suitable position but the seams in successive rings shall not fall in line.

In the case of brick set boilers the seam or seams shall be kept as far as practicable clear of the brickwork.

544. Circularity

The difference between the maximum and minimum internal diameters of the shell measured at any one cross-section shall not exceed 1 per cent of the nominal internal diameter.

The profile as measured on the outside of the boiler by means of a gauge of the designed form of the exterior of the boiler, having a length equal to one quarter of the internal diameter, shall not depart from the designed form by more than the percentage given in Table XII/1.

TABLE XII/1: Maximum Percentage of Departure from Designed Form of Welded Boilers

Nominal internal diameter of boiler D	*Maximum departure from designed form*
Inches	Per cent
Upto and including 36	0.375
Over 36, upto and including 45	0.350
Over 45	0.300

There shall be no flats at the welded seams and any local departure from circularity shall be gradual.

545. End Plates, Crown Plates and Tube Plates

The end plate of welded Lancashire and Cornish boilers shall be flanged for attachment to shell plates:

(a) The dished end plates of boilers shall be in one piece made from one rolled plate. The flat end plates may be made from two pieces by fusion butt-welding (*see* Figures XII/1 and XII/2). In the latter case, the line of welding shall be parallel to the horizontal axis of the boiler and shall run through the centre line of furnace or furnaces of Lancashire and similar types of boilers. In the case of Marine type boilers, the weld shall be located preferably between two rows of bar stays or if there is only one row of bar stays, between this row and the top row of stay tubes and shall be subjected to a spot radiographic examination, otherwise it shall subjected to full radiographic examination.

(b) The segments for hemispherical shell crown plates shall be pressed in one heat to correct curvature and shall be butt-welded together in accordance with Figures XII/3, XII/4, XII/5 or XII/6. The cylindrical portion of the crown shall be tangential to the hemispherical portion.

Where hemispherical shell crowns are pressed from one plate the provisions of Regulation 547(b) shall apply.

(c) Flanging of plates shall be done by machine. Such flanging shall be done hot, preferably in one operation, but where this is impracticable, creep machine flanging may be used provided that the plate is worked at a suitable temperature and heated for an adequate distance beyond that portion of the plate under immediate treatment.

After completion of the flanging operation flanges shall be of true peripheral contour (either circular or straight as necessary to ensure accurate alignment with the connecting parts), and of good surface, free from bulges, grooves or other local irregularities; flat portions of the plate shall be free from set or distortion.

(cc) In the construction of unfired boilers when the dished ends do not form a part of the heating surface, cold spun dished ends conforming to IS: 2825 may be used.

(d) Where flats are pressed in dished end plates for the attachment of mountings they shall be formed with an ample radius at the junction of the flat and curved surfaces, and shall be free from sharp corners or tool marks, the plate shall not be unduly thinned.

(e) Plates which are flanged in accordance with Regulation 545(c), shall be welded to the parts to which they are to be connected as follows:

(i) to shells or cylindrical fireboxes as shown in Figures XII/7, XII/8, XII/9, XII/10 or XII/11;

(ii) to internal flue tubes as shown in Figures XII/13, XII/14 or XII/15;

(iii) to uptakes as shown in Figure XII/15;

(iv) to combustion chamber or firebox wrapper plates as shown in Figure XII/17.

Plates which are not flanged shall be welded to the parts to which they are to be connected as follows:

(v) to shells as shown in Figure XII/12 or XII/12A;

(vi) to internal flue tubes or uptakes as shown in Figure XII/16;

(vii) to combustion chamber or firebox wrapper plates as shown in Figures XII/18, XII/19 or XII/20.

Where dished ends or crowns are used they shall be flanged for connection to the shell or the cylindrical portion of the firebox. Flat shell and firebox crown plates of vertical boilers shall also be flanged for connection to the cylindrical portions of the shell or firebox.

The opening in the firebox crown plate of a vertical boiler for the uptake shall be flanged and the connection to the uptake made by means of a circumferential butt-weld (*see* Figures XII/3, XII/4, XII/5, XII/6).

546. Internal Flues

(a) Sections of internal flues shall each be made from one plate which shall be bent while cold to circular form. The longitudinal seam shall be forge lap-welded, or fusion butt-welded by the metal arc process.

(b) The maximum permissible variation in diameter of any cross-section shall not exceed 1/4 inch or half the thickness of the plate, whichever is the greater.

(c) The longitudinal welds shall be placed at the lower part of the furnace and shall break joint in successive sections at least by 150 mm.

(d) Where the flue sections are flanged for circumferential joints the flanging shall be carried out at one heat by suitable machinery.

(e) Edges of all flue flanges shall be machined or flame-cut by machine (*see* Regulation 541).

(f) Flanged circumferential seams shall be arranged so that they do not fall in line with those of the adjacent flue or with circumferential seams of the shell.

(g) The minimum mean internal diameter of furnaces shall not be less than those given in Figure XII/20A depending on the net heat input.

(gg) Where furnace flue is made up of plain or corrugated sections or both, they may be connected to each other by fusion butt-welded circumferential seams.

(ggg) (i) Plain furnaces shall not exceed 3 m in length except in the case of reverse flame boilers, which are considered to be inherently flexible or as provided in clause (ii). In all other cases flexibility shall be provided in the furnace by means of corrugations or bowling hoops or stepping of a minimum of 150 mm in the diameter of the furnace (*see* Figures XII/20B to XII/20F).

If corrugations are used to provide flexibility, at least one-third of the furnace length shall be corrugated.

Breathing spaces as per sub-regulation (i) of Regulation 590 shall be provided for boilers made as per this clause.

(ii) Notwithstanding the provisions of clause (i), plain furnaces longer than 3 m are allowed to be used in a boiler when the length between boiler end plates do not exceed 6.5 metres provided that breathing spaces used in this case are in accordance with sub-regulation (ii) of Regulation 590.

(h) Where a complete flue is constructed of short plain sections, the ends of each adjoining section shall either be swaged out to a radius to provide an adequate point of support and longitudinal flexibility and butt-welded together or be butt-welded to each side of a bowling hoop. The dimensions shall comply with Figures XII/23, XII/24 or XII/25.

(i) Stress-relieving by heat-treatment shall be carried out when the construction of a flue involves the use of a circumferential weld such stress-relieving being carried out on the completion of all welding in accordance with Regulation 562.

(j) The forms of flue connections to end plates shall be as shown in Figures XII/13, XII/14, XII/15, XII/16 and XII/16A or subject to the approval of the Inspecting Authority, be in any other form of welding groove.

547. Fireboxes and Combustion Chambers

(a) **Furnaces of Vertical Boilers**—The furnaces of vertical boilers may be constructed in one or more lengthwise sections, each section being rolled from one plate to a full circle. In such cases, the component sections may be jointed circumferentially by electrical butt-welding. The welding shall be stress-relieved in accordance with Regulation 562.

In the case of vertical boilers where tube plates form part of the firebox, the tube plate portion may be constructed in two vertical sections and the welding of the vertical seams when welded shall be stress-relieved.

The maximum permissible variation in diameter, at any cross-section shall not exceed ¼ inch for fireboxes upto 3 feet in diameter, or 3/8 inch for fireboxes over 3 feet in diameter, or half the thickness of the plate whichever is the greater.

Circular fireboxes shall preferably be tapered. A taper of 1½ inches in diameter per foot of height is recommended. The water space at the bottom between the firebox and the shell shall be not less than 2 inches for boilers upto and including 2 feet and 6 inches in diameter and shall be not less than 2½ inches for boilers over 2 feet and 6 inches in diameter.

The method of welding shall be in accordance with Regulation 558.

Flats formed in the firebox for the insertion of water tubes shall have an ample radius at the junction of the flat and the curved surfaces and shall be free from sharp corners or tool marks. The plate shall not be unduly thinned.

Ogee flanging, whether integral with the firebox or made as separate ring shall preferably be formed at one heat by suitable machinery and shall be allowed to cool gradually to avoid internal stresses.

Rings or firehole mouthpieces or foundation rings shall be made of mild steel. Z sections shall not be used for foundation rings.

Attachment of fireboxes to cylindrical shells shall be in accordance with Figures XII/26, XII/27, XII/28 or XII/29.

The method of attachment of firehole mouthpieces shall be in accordance with Figure XII/32 or XII/33.

(b) **Hemispherical Fireboxes**—Hemispherical fireboxes shall be pressed to form by machine in progressive stages without thinning and shall be annealed on completion.

Methods of attachment of firebox to the shell be in accordance with Figures XII/26, XII/27, XII/28 or XII/29.

The method of attachment of firehole mouthpieces and throatpieces shall be in accordance with Figures XII/32 or XII/33, XII/35 or XII/36.

(c) **Locotype Fireboxes**—Locotype firebox wrapper plate sides shall preferably be tapered. The water space at the bottom between the firebox and the shell shall be not less than 2½ inches.

Where the firebox tube plate or firehole plate is flanged for connection to the wrapper plate, the weld shall be located between the commencement of curvature of the flange and first row of screwed stays.

Rings for firehole mouthpieces of foundation rings shall be made of mild steel.

Z sections shall not be used for foundation rings. The attachment of the firebox to the outer casing shall be in accordance with Figure XII/29 or XII/30 or XII/31.

The method of attachment of firehole mouthpieces shall be in accordance with Figure XII/32 or, where the outer casing and the firebox plate are flanged towards the water side to form the firehole, a ring of screwed stays located at not more than half the average pitch of the stays distant from the commencement of the curvature of the flanging shall be provided (*see* Figure XII/37).

(d) **Water-Cooled Combustion Chambers**—The attachment of the combustion chambers tube plates and back plates to the wrapper plate shall be in accordance with Figures XII/17, XII/18, XII/19, XII/20 and where the tube plate is flanged for connection to the wrapper plate the weld shall be located between the commencement of curvature of the flange and the first row of screwed stays.

The method of attachment of furnace or flue tubes shall be in accordance with Figures XII/14, XII/15 or XII/16 and access openings shall be in accordance with Figure XII/32 or XII/38.

548. Uptakes

The uptakes shall be formed from seamless or electric resistance welded or fusion butt-welded pipes by electric arc process. The tolerances on these pipes shall comply with the requirements of Regulation 345. The uptakes shall be fusion butt-welded to the upward flange of the opening of the furnace crown plate in accordance with Figures XII/3 and XII/4. The depth of the flange of the firebox crown plate opening from the commencement of the curvature of flange shall be not less than twice the plate thickness with a minimum of 1 inch. Unless the whole boiler is to be subsequently stress-relieved the uptake and firebox crown plate shall be effectively stress-relieved after welding. Where the firebox crown plate is also fusion welded to the body of the firebox as in Figure XII/15 the firebox complete with the uptake shall be effectively stress relieved by heat treatment on completion of all welding.

The uptake may be attached to the shell crown as indicated on Figure XII/16 before the boiler is finally stress-relieved by heat treatment.

Where the vertical seam of the uptake is fusion welded the welding shall comply with Regulation 558 and the weld shall be so arranged that it is externally and internally (*see* Figure XII/34).

It is desirable that the uptake should be fitted with an internal cast iron liner extending below the low water level.

549. Cross-Tubes

Cross-tubes shall be made from weldless steel pipes or from plate or strip rolled and electric resistance welded or fusion butt-welded pipes by electric arc process. The fusion welding shall conform to the requirements of Chapter XII. Tolerances on these pipes shall conform to the requirements of Regulation 345.

The tubes shall be of sufficient length to project through the firebox plate not less than 1/4 inch or more than 5/8 inch at any part of the circumference of the tube. The tubes shall be fusion welded in position, the holes in the firebox plate shall be suitably chamfered, and the seams shall be welded externally and internally (*see* Figure XII/34).

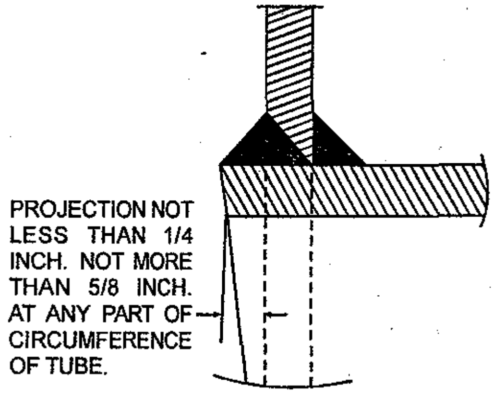


FIG. XII/34 — FUSION WELDS OF CROSS TUBES

550. Bar Stays and Firebox Stays

Each bar stay or firebox stay shall be made from a solid rolled bar without weld in its length, except where it is attached to the plate it supports.

Bar stays which have been worked in the fire shall be subsequently annealed.

It is preferred that when the stay is in position in the boiler, its axis shall be normal to the plate it supports, but where this cannot be so arranged, then, if the stay is fitted with nuts, bevelled washers shall be provided between the nuts and the plate.

Stays shall be secured to the plates they support by one of the following methods:—

(a) **Bar Stays—**

(i) Plain bars, passing through clearing holes in the plates and welded thereto (*see* Figure XII/42).

(ii) Plain bars passing through clearing holes in the plates and fitted with washers on the outside, the stay and washers being welded to the plates in accordance with any one of the methods shown in Figures XII/43(a), XIII/43(b), XII/44(a), XII/44(b), XII/45(a), XII/45(b), XII/46(a), and XII/46(b).

Note: Clearing hole for the purpose of this regulation mean a machined cylindrical hole having a diameter not exceeding that of bar stay by more than 2%.

(b) **Firebox Stays—**

(i) Screwed stays, screwed through the plates and riveted over at each end to form substantial heads, or fitted with nuts, or the projecting ends fillet-welded as indicated in Figures XII/39 and XII/40.

It is recommended that where the stays are screwed, this shall be with a fine thread and the stays and holes shall be screwed with a continuous thread.

The stays shall be screwed with fine threads of not less than 11 threads per inch.

The screw threads on the stays shall be clean, free from checks or imperfections, of full depth, or a correct standard form and a good fit in the holes.

The middle portion shall preferably be turned down to the bottom of the thread.

(ii) Plain stays shall be strength welded to the plates (*see* Figures XII/41 and XII/41A).

All screwed stays less than 14 inches long should preferably be drilled with a tell-tale hole 3/16 inch diameter to a depth of 1/2 inch beyond the inner face of the plate. Stays which are obscure on one side should preferably be made from hollow stay bar.

551. Girder Stays for Firebox and Combustion Chamber Crowns

Where girder stays are attached with stay bolts and nuts, they shall be bedded to the corners or ends of side plates.

The attachment of girder stays welded directly to the crown plates shall comply with Figures XII/47, XII/48, XII/49, XII/50 or XII/51. Such girders shall be welded to the crown plate prior to stress-relieving.

Each girder shall be of sufficient strength to support its due proportion of the load on the crown plate independently of the crown plate, and the bolts or weld attachments shall have sufficient cross-sectional area to carry the applied load.

The waterways between the underside of the girder and the crown plate shall be as large as practicable, but in no case less than 1½ inches deep.

552. Gusset Stays

Gusset stays shall be flat and perpendicular to the end plates. Gusset plates shall not be subjected to cranking or setting.

553. Access

At least one manhole or sight hole shall be provided in the upper part of the boiler, the dimensions being not less than those in Table XII/2 for the given size of boiler:

TABLE XII/2: Dimensions of Manholes or Sight Holes

Diameter of boiler	*Minimum size of hole inch*
Boilers not exceeding 2 feet and 6 inches	9 × 7
Boilers over 2 feet and 6 inches diameter and not exceeding 3 feet	12 × 9
Boilers over 3 feet diameter and not exceeding 3 feet and 6 inches	14 × 10
Boilers over 3 feet and 6 inches diameter and not exceeding 4 feet	15 × 11
Boilers over 4 feet	16 × 12

Where the size of construction of the boiler does not permit of entry for cleaning or inspection of all internal surfaces, cleaning holes sufficiently large and numerous shall be provided for this purpose. The cleaning holes shall be not less than 3½ inches × 2½ inches in size.

One cleaning hole shall be provided opposite at least one end of each cross-tube in a vertical cross-tube boiler. Where the water tubes are arranged in banks, an opening of sufficient size to permit to their replacement shall be provided.

At the bottom of the narrow water space in vertical boilers where internal access is not possible, mud holes shall be arranged at equal distances round the circumference of the boiler not less in number than as given in Table XII/3.

TABLE XII/3: Number of Lower Cleaning Holes or Mud Holes

Diameter of boiler	*No. of holes*
2 feet and over but not exceeding 3 feet	3
Over 3 feet and not exceeding 5 feet	4
Over 5 feet and not exceeding 6 feet	5
Over 6 feet and not exceeding 7 feet and 6 inches	6
Over 7 feet and 6 inches and not exceeding 8 feet and 6 inches	7
Over 8 feet and 6 inches and not exceeding 9 feet	8

Cleaning holes or mud holes in locotype boilers shall be provided at each bottom corner or as nearly as possible in the corners of the outer firebox casing and at the top corners above firehole opening and also at each corner of the saddle plate in line with the bottom of barrel smoke box tube shall be provided with a mud hole.

A manhole shall be provided in the lower part of front end plates of Lancashire boilers and in similar boilers with internal flues wherever practicable.

554. Manhole Frames, Mouthpieces and Doors

Manhole frames, mouthpieces, doors or cover plates shall be of mild steel. Frames shall be oval and where of the flanged type shall be formed to bed closely to the shell and provide a flat jointing surface to the door. Alternatively, raised circular mouthpieces may be fitted externally and where of the flanged type shall be bedded closely to the shell.

Wherever practicable, the frame shall be attached to the inside of the shell with the shorter axis parallel to the longitudinal centre line of the boiler. In all cases where the shell thickness exceeds 9/16 inch, oval frames or circular mouth-pieces shall be fitted.

Oval frames and externally raised circular mouthpieces shall be either:

(a) Formed in one piece without weld, or

(b) Formed from a suitable rolled section and forge-welded, or fabricated by fusion welding, provided they are stress-relieved by heat-treatment after welding and before attaching to the boiler unless the whole boiler is to be subjected to heat-treatment on completion.

Welds shall be positioned so that they are located on the transverse centre line of the boiler (*see* Regulation 556).

The joining flanges of mouthpieces and covers shall be machined on the face and edges and on the bearing surface for the bolts. Bolts and nuts shall be machined where in contact with the flanges and the joints should be formed inside and outside the pitch line or pitch circle of the bolts to preclude the possibility of flange distortion. Cover plates shall be dished outwards to a depth of approximately one-eighth of the internal diameter of the frame.

All edges shall be machined or flame-cut by machine (*see* Regulation 541).

Forms or manhole frames and attachments are shown in Figures XII/52, XII/53, XII/54, XII/55 and XII/56.

554A. Internal doors

Internal doors shall be of wrought steel in accordance with Chapter II and constructed in accordance with the following:—

(a) doors shall be formed to fit closely to the internal joint surface and should be fitted with studs, nuts and crossbars;

(b) doors for circular opening larger than 250 mm or elliptical/rectangular opening larger than 250 mm x 175 mm shall have two studs but for opening of 250 mm x 170 mm or less only one stud may be fitted. Doors for opening not larger than 123 mm x 90 mm may have the stud forged integrally with door;

(c) doors studs shall be of welding quality steel having a minimum specified tensile strength of not less than 360 N/mm^2 and those for manholes shall be not less than 30 mm;

They shall be fixed in any of the following way:—

(1) screwed through the plate and fillet welded on inside;

(2) fillet welded each side of the plate with a leg length of not less than 10 mm;

(3) attached to the door by an intermediate plate or legs so that the strength of the attachment is not less than the strength of the studs and the studs are prevented from turning; or

(4) provided with an integrated collar and be riveted or screwed on to the door plate and be prevented from turning in which case strength of the attachment shall be not less than the strength of the studs;

(d) door spigot when the door is in the central position shall have a clearance of approximately 105 mm all around and at no point shall the clearance exceed 3 mm. The spigot depth shall be sufficient to trap the gasket.

(e) the nuts shall be of appropriate material compatible to that of bolts and be placed on the seating surface;

(f) the cross-bars shall be of substantial proportions and of mild or wrought steel.

Note: Eye bolts of suitable legs on the door plate or headed bolts engaging with slotted sections on the door plate may be used instead of studs.

The minimum calculated thickness of the door of the flat plate construction (i.e. unstiffened made from one plate) shall be not less than that determined by the following formula:—

$$t = \sqrt{\frac{0.35P \times d^2 + W}{f}} \quad \text{for a circular door}$$

$$t = \sqrt{\frac{0.35P\left(2 - \frac{a}{b}\right) \times a^2 + W}{f}} \quad \text{for an elliptical door}$$

where,

t = is the minimum calculated thickness of the flat door (in mm),

P = is the working pressure of boiler (in N/mm^2),

d = is the diameter of the opening to which the door is fitted, if round (in mm),

a = is the minor axis of the opening to which the door is fitted if elliptical (in mm),

b = is the major axis of the opening to which the door is fitted, if elliptical (in mm),

W = is the full load capacity of one stud (effective stud area x design stress value at design temperature in (N),

f = is the maximum allowable stress of the plate at the design temperature (in N/mm^2).

Note: A design stress of value of $50 N/mm^2$ may be used for carbon steel bolts for design temperature not exceeding 300°C.

555. Seatings for Mountings

For pressures not exceeding 125 pounds per square inch mountings with screwed ends not exceeding 1 inch may be used; the screwed portion of any such mounting being an integral part thereof and the thickness at the bottom of the thread being not less than 3/16 inch.

The mountings may be screwed:—

Directly into the boiler shell plate, nuts being fitted on the water side, or into steel distance pieces the length of thread engaged being in no case less than the bore of the mounting plus ¼ inch.

The distance pieces shall be made from solid mild steel. They shall be screwed into the plate and fitted with nuts on the water side. The walls of the distance pieces shall be not less than ¼ inch thick at the bottom of the thread.

Mountings may be attached directly to any shell or end plate where the plate is of sufficient thickness to allow a suitable surface to be contained for the attachment of the boiler mounting.

The minimum thickness at the hole in the shell or end plate shall be not less than the thickness required for the maximum permissible working pressure considering the plate as being unpierced.

Where the boiler mountings are secured by studs, the studs, shall have a full thread holdings in the plate for at least one diameter. If the stud holes penetrate the whole thickness of the plate, the stud shall be screwed right through the plate and be fitted with a nut inside having a thickness equal to the diameter of the stud. Where bolts are used for securing mounting they shall be screwed right through the plate with their heads inside the shell or end plate.

(a) **Standpipes**—Where standpipes are used, the flanges shall be machined or flame-cut by machine on the edges. The bolting flanges shall be machined on the jointing and bolting surfaces.

(b) **Saddles**—Where saddles are used, the edges of the flanges shall be machined or flame-cut by machine. The joining surfaces shall be machined. The studs for the attachment of the mountings, if screwed through the saddle, shall be fitted on the inside with nuts of full thickness.

Where the stud holes do not penetrate through the saddles the length of the screwed portion of the stud in the plate shall be not less than the diameter of the stud.

(c) **Pads**—Where pads are used, the joining surfaces shall be machined. The pads shall have sufficient thickness to allow the drilling of the stud holes for mountings without the inner surface being pierced and the length of the screwed portion of the stud in the pad shall be not less than the diameter of the stud.

(d) **Attachment of Standpipes**—The following constructions as to standpipes attached to shells and end plates shall be permissible:

(i) When the internal diameter of the standpipe does not exceed 1 inch the standpipe may be screwed into the plate with a nut on the waterside.

(ii) Where the internal diameter of the standpipe exceeds one inch but does not exceed 2 inches, it may be screwed in and seal-welded.

(iii) Where the diameter of the standpipe exceeds 2 inches, it may be welded to the end plate.

The foregoing provisions as to the standpipe attachment shall regulated by the following conditions:

(i) When standpipes are screwed, the screwing shall be of standard pipe thread.

(ii) Standpipes shall be attached by one of the methods shown in Figures XII/84, XII/85 (A, B, C), XII/85D, XII/85E, XII/85F, XII/86, XII/87, XII/88, XII/89 and XII/93 or by any other method approved by the Inspecting Authority.

(iii) Where the standpipes are fabricated by fusion-welding they shall be stress-relieved by heat-treatment before attachment to the boiler unless the whole boiler is subject to heat-treatment on completion.

(iv) Where the bore of the standpipe does not exceed 5 inches or the diameter of the opening in the shell does not exceed 5 inches plus twice the thickness of the plate to which it is attached, the standpipe may be welded to the plate without subsequent heat-treatment of the weld so made. If these limits are exceeded the whole plate to which the standpipe is attached shall be stress-relieved by heat-treatment on completion of welding.

(e) **Attachment of Pads**—Pads welded to the shell or end plate shall be welded internally and externally.

Methods of attachment of pads shall be as shown in Figures XII/90, XII/91 or XII/92. Where the bore of the seating does not exceed 5 inches of diameter of the opening in the shell does not exceed 5 inches plus twice the thickness of the plate to which it is attached, the pad may be welded to the plate without subsequent heat-treatment of the weld so made. If these limits are exceeded the whole plate to which the pad is attached shall be stress-relieved by heat-treatment on completion of the welding.

(f) **Attachment of Water and Pressure Gauges**—Water gauges and pressure gauge syphons may be attached direct to the front end plate without the intervention of a pad or standpipe, provided they are flanged and secured by studs. If the studs are screwed through the plate, nuts of full thickness shall be fitted on the inside of the plate.

(g) **Bolts and Nuts**—All holes for bolts and studs shall be drilled and bolts and nuts shall be machined where in contact with the flanges.

556. Compensating Plates

Compensating plates shall be of mild steel and, before attachment, shall bed closely to the plates to which they are to be connected. Any welds therein shall be on the transverse centre line.

557. Definition of the Term 'Fusion Weld'

The term 'fusion weld' is, for the purpose of this Chapter applicable to all welded seams made by the metal arc process with covered electrodes or by any other electric arc process in which the arc stream and the deposited weld metal are shielded from atmospheric contamination.

The relevant provisions of this Chapter shall also apply to the single run or heavy run welding process and that welded boilers manufactured by that process shall comply with all Regulations of this Chapter excepting those in which divergence is necessary solely because of special requirements essential for the most efficient utilisation of that process. Thus all Regulations governing quality of material construction, workmanship, and testing (both non-destructive and otherwise) are applicable.

Where welded shells conforming to the Regulations of this Chapter are made by single or heavy run process it shall be understood that Regulations 557, 558 and 559 do not apply in their entirety. The method of making the welds shall be approved by the Inspecting Authority.

558. Methods of Welding

The seams shall be fusion-welded from both sides of the plates. The main weld may be on either side of the plate, whichever is most convenient to the manufacturer. Before the second side of the plate is welded, the weld metal at the bottom of the first side shall be removed by grinding, chipping, machining or other approved method:

Provided the requisite quality of welding is achieved the seams may be welded from both sides of the plates or from one side of the plate. Before the second side of the plate is welded, the metal at the bottom of the first side shall be removed by grinding, chipping, machining or other approved method.

Additional runs of metal shall be deposited at both surfaces of the welded seams to ensure that the weld metal at the level of the surfaces of the plate is refined as far as possible. The surfaces of the welds which are to be subsequently radiographed shall thereafter be machined or ground so as to provide smooth contours and to be flush with the respective surfaces of the plate. In the case of circumferential shell seams welded by submerged arc or any other approved automatic process producing a similar surface finish, such circumferential welds, need not be flush dressed, subject to their surface finish and shape being acceptable to the Inspecting Authority. There shall be no under-cutting of the junctions.

The positions of the welds shall be marked, compensation plates, doubling plates or manhole frames, not less than two runs or metal shall be deposited at each weld.

When affixing standpipes, branch pipes, seatings, compensation plates, doubling plates or manhole frames, not less than two runs or metal shall be deposited at each weld.

Each run of weld metal shall be thoroughly cleaned and freed from slag before the next run is deposited.

559. Types of Welded Shell Seams

The longitudinal and intermediate circumferential seams shall be made with butt joints of the single or double U or V type (*see* Figures XII/3, XII/4, XII/5, and XII/6) or of any other type approved by the Inspecting Authority. End circumferential seams shall be in accordance with Figures XII/7, XII/8, XII/9, XII/10, XII/11 or XII/12 or with any other form approved by the Inspecting Authority.

560. Repairs to Welded Seams

(a) Any repair to a weld carried out by the manufacturer shall first be agreed to by the Inspecting Authority.

(b) Where defects are distributed over the whole length of the seam the total length of the portions which may be cut out from any one longitudinal or circumferential seam to remove all defects shall not exceed 15 per cent of the total length of the seam.

When, however, the defects are all located in a single continuous length which may be cut out to remove all defects shall not exceed 10 per cent of the total length of the seam.

Circumferential Seams—Where the length of weld metal cut out for repair in a circumferential seam exceeds the amount stated above the whole of the weld metal shall be removed and the seam re-welded. Representative tests for a re-welded circumferential seam shall be provided when required by the Inspecting Authority.

Longitudinal Seams—Where the length of weld metal cut out for repair in any longitudinal seam exceeds the amount stated above, or the weld metal in any other way fails to comply with the requirements specified, the whole of the weld metal shall be removed and the seam re-welded, provided that the original test plates are treated similarly or new plates of the same thickness as the joint and of similar quality of material are attached to the ends of the seam and re-welded with it. In either case the plates are to be tested in accordance with the appropriate provision of Regulation 561 and the requirements for heat-treatment to be in accordance with Regulation 562.

(c) Defect shall be cut out by chipping, machining or other approved methods.

(d) Whenever a defective part has been cut out, Inspecting Authority shall be notified so that, if necessary, an examination may be made before re-welding.

(e) In the case of Class I boilers all repaired areas shall be subjected to radiographic examination.

(f) The boilers shall be heat-treated on completion of all welded repairs.

561. Tests on Welded Seams

(a) **Test Plates**—Test plates to represent all welded seams shall be attached at each end of each longitudinal seam in tension. These shall be of a size sufficient for the preparation of the test pieces specified. In the case of shell plates, the test plate may be located at one end only (*see* Figure XII/58). Where the shell is formed in two or more rings, the staggered longitudinal seam shall be regarded as a continuous longitudinal seam provided the welding be effected in one reasonably continuous operation and by the same operator or operators. The material for the test plates shall be cut from the respective plate or plates forming the appropriate seam.

In the case of insufficient material being available on the shell plate to permit the cutting of test pieces, these shall be acceptable if they are made from another plate provided it is made from the same cast. The test plates shall be stamped by the Inspecting Authority before being cut.

The weld groove in the test plates shall be similar to that adopted for the corresponding edges of the longitudinal seam, and the respective fusion faces shall be in continuous alignment. The test plates may be reinforced or supported during welding so that any relative displacement due to warping during welding does not exceed 5 degrees. The weld metal in the test plates and the seam shall be deposited continuously at the same operation.

The weld in any test plate shall not be repaired. If any defects are revealed in the weld metal of a test plate the position of this shall be clearly marked on the plate and the test pieces shall be selected from such parts of the test plates as may be decided by the Inspecting Authority.

Test plates warped during welding by not more than 5 degrees may be straightened before heat-treatment. For the heat-treatment of the test plates *see* Regulation 562.

Where there are circumferential seams only or where the method of welding the circumferential seams differ from that employed for the longitudinal seams, the method of providing the test plates shall be decided by the Inspecting Authority.

(b) **Test for Class I Boilers—**

(i) Specimens for the following tests shall be selected from the test plate or plates and stamped by the Inspecting Officer for identification (*see* Figures XII/58 and XII/59).

One tensile test specimen for the welded seam.

One all weld metal tensile test specimen.

Two bend test specimens.

Two impact test specimens.

One specimen from each test plate for macro and micro examinations.

The dimensions of the specimens shall be in accordance with the sketches in Figures XII/60, XII/62, XII/63 and XII/64. The remainder of the test plates shall be retained for re-tests if required. Any specimen for re-test shall be cut from the same test plate as the original specimen. Specimens representing welded seams shall, if necessary, be straightened cold before the commencement of machining. Tensile and bend specimens shall, if practicable, be of the full plate thickness. Surfaces of tensile, bend and Izod specimens corresponding with the outside or inside of the boiler shall be lightly dressed only so that the rolled surface of the parent metal is not wholly removed. Where the rolled surfaces of the abutting plates are not level with one another one plate may be machined at each face of the weld so long as the depth of the metal removed does not exceed 1/32 inch.

(ii) **Tensile Tests—**

(a) (i) *Welded Joint*—The dimensions of the reduced tensile section shall be as shown in Figure XII/60(a). The width of the reduced section shall be at least 25 millimetres.

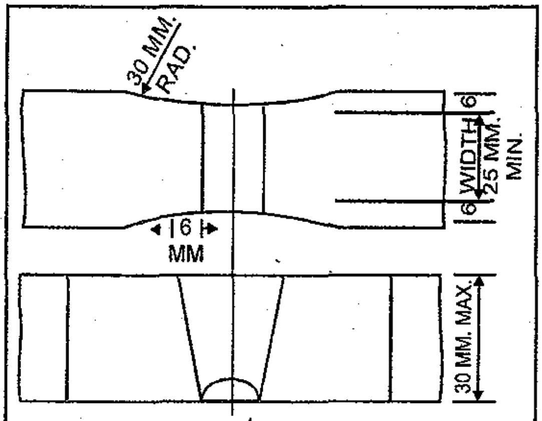


FIG. XII/60(A) — SPECIMEN 1A— REDUCED SECTION TENSILE SPECIMEN

(ii) If the thickness of the plate does not exceed 30 millimetres, the thickness of the specimen shall be equal to the plate thickness and the plate surface of the specimen shall be machined to take away the surface irregularities of the plate and the weld.

(iii) If the plate thickness exceeds 30 millimetres, the tensile test shall be carried out on several reduced section specimens, each having a thickness of at least 30 millimetres and width at the effective cross-section of at least 25 millimetres. These specimens shall be taken out of the test piece in such a way that the tensile test covers the whole thickness of the weld joints as shown in Figure XII/60(b). The tensile strength shall not be less than the lower limit specified for the plate.

(b) *All Weld Metal*—The dimensions of the all weld metal tensile test specimen shall be those given in Figure XII/63. The diameter shall be the maximum possible consistent with the cross-section of the weld but in no case more than 20 millimetres, the gauge length shall be equal to five times the diameter. The tensile strength shall not be less than the lower limit specified for the plate. The elongation shall not be less than 20 per cent on a gauge length of five times the diameter of the specimen or 5.65 times the square root of the cross-sectional area of the specimen, and the reduction in area not less than 35 per cent.

(iii) **Cold Bend Tests**—Two bend tests shall be made:

One specimen shall be tested with the outer surface of the weld in tension, and the other with the inner surface in tension. The specimens shall be rectangular in section and shall be cut out transversely to the weld so as to have a width not less than one and a half times the thickness of the plates. The sharp corners of the specimens shall be rounded to a radius not exceeding 10% of the thickness of the specimen.

Where the plate thickness does not exceed 1¼ inches, the thickness of the specimen shall be equal to the full thickness of the test plate. Where the plate thickness exceeds 1¼ inches, the specimen shall in all cases have a thickness of at least 1¼ inches. The specimen to be tested with the outer surface of the weld in tension shall be prepared by cutting to waste the metal local to the inner surface of the weld, so that the desired specimen thickness is obtained (*see* A, Figure XII/64).

The specimen to be tested with the inner surface in tension shall be prepared by cutting to waste the metal local to the outer surface of the weld so that the desired specimen thickness is obtained (*see* B, Figure XII/64). Where the thickness of the plate permits, both specimens may be cut from the same piece of plate, the specimens being located in the plate one above the other (*see* C, Figure XII/64). Each specimen shall be mounted with the weld midway between the supports set apart at a distance of not more than 5.2 times the thickness of the specimen and pushed through the supports with a former having a diameter equal to three times the thickness of the specimen.

On completion of the test no crack or defect at the outer surface of the specimen shall be greater than 1/16 inch measured cross the specimen or 1/8 inch measured along the length of the specimen. Premature failure at corners or the specimen shall not be considered cause for rejection.

(iv) **Impact Tests**—Two rectangular specimens shall be cut out transversely to the welded joint and they shall conform to the dimensions shown in Figure XII/62.

One specimen shall have the notch cut at the middle of the outer surface of the weld, and the other at the middle of the inner surface of the weld.

The tests shall show a minimum Izod impact test value of 20 foot pounds, the test being carried out at a temperature between 50°C (122°F) and 100°C (212°F).

(v) **Macro and Micro Examinations**—A specimen of the full thickness of the plate and not less than 13 millimetres wide shall be provided from each set of test plates for the purpose of macro and micro examinations.

Micro-etching of a complete cross-section of the weld injuding the heat affected zone, should show satisfactory penetration, fusion and absence of significant inclusions or other defects.

Should there be any doubt as to the condition of the weld as shown by macro-etching, the area concerned is to be microscopically examined for defect investigation.

(vi) **Additional Tests before Rejection**—Should any of the test specimens taken in accordance with this Regulation fail to meet the specified requirements, retests shall be allowed for each specimen that fails as follows:

Where any result of the tensile test is not less than 90% of the specified figures one retest shall be made. Where any result falls below 90% two retests shall be made.

Where a bend specimen fails to meet the specified requirements, two retests shall be made.

If an impact test fails to meet the specified requirements, two retests shall be taken from the test plate, one on each side of the final specimen and separate from it by not more than 5 millimetres.

If it be found there is insufficient metal to permit the preparation of specimens for retest from the remainder of the test plate from which the original specimen was taken, the specimen for retest may be cut from the test plate relating to the opposite end of the same longitudinal seam.

Should any of the additional tests fail to meet the specified requirements the welded seams represented by these tests shall be rejected.

(vii) **Specimens after Tests**—If required the specimens after test shall be at the disposal of the Inspecting Authority for examination.

(viii) **Radiographic Examinations**—Every portion of the longitudinal and circumferential butt-welded seams of the shell of the boiler shall be subjected to radiographic or ultrasonic examination. Where ultrasonic examination is used, it shall be demonstrated to the satisfaction of the Inspecting Authority that the equipment and the technique used are satisfactory. The manufacturer shall ensure that the operator employed is competent to use the equipment, apply the technique and interpret the results of the examination.

The methods employed in obtaining the radiographs shall be such as to show clearly differences equal to 2 per cent of the thickness at the welded joints. To determine whether this result is being attained an indicator of approved form which includes a portion equivalent to not more than 2 per cent of the joint thickness shall be placed in the vicinity of the weld so as to make a record on each radiograph. Each section of every weld shall be marked so that the radiographs can be easily corrected to the particular part of the same represented.

The examination shall be made from the original films and the acceptability of the welds shall be decided by the Inspecting Authority. The welds deemed unsatisfactory shall be rejected or dealt with under the condition of Regulation 560 and can be radiographed again. The films shall be retained by the manufacturer for a reasonable period for reference and be available to the Inspecting Authority, if required.

Note: (1) **Magnetic Particle Flaw Detection**—Magnetic methods of flaw detection shall be employed wherever possible for ferritic steel.

(2) **Dye-Penetrant Flaw Detection**—Dye-penetrant or equivalent methods of flaw detection shall be employed for Austenetic or other non-magnetic steel.

(3) All butt-welded joints shall be subjected to non-destructive examination by radiographic, radioscopy or other approved methods such as ultrasonic testing, magnetic particle inspection or liquid dye penetrant inspection. When radioscopic examination is to be performed in lieu of radiography on welded components, the following requirements shall be met, namely:—

(a) A written procedure shall be submitted for approval to the Inspecting Authority which shall contain the following:—

(i) material and the thickness range;

(ii) equipment qualifications;

(iii) test object scan plan;

(iv) radioscopic parameters;

(v) image processing parameters;

(vi) image display parameters;

(vii) image archiving requirements;

(viii) accept-reject criteria (Code reference);

(ix) performance evaluation;

(x) operator identification.

(b) The system shall be aided with an image processor to enhance the quality of the radioscopic images and system performance quality shall exhibit—

(i) a thin section contrast sensitivity of 3%;

(ii) a thick section contrast sensitivity of 2%;

(iii) a spatial resolution of 3 line pairs per mm;

(iv) IQI sensitivity—2% of the joint thickness when wire IQI's are to be used, the wire diameter axis shall be oriented along the axis of the least sensitivity of the system.

(c) Radioscopes are to be properly marked to co-relate with particular part of joint represented.

(d) The radioscopic examination data shall be recorded and stored on video tape, magnetic disk or optical disk at the maker's plant for a sufficient period after the date of radioscopic examination as specified by the Inspecting Authority, efficient radioscopic examination record recall shall be made available at any time over the record retention period and shall be traceable to the test objects.

(e) When repair has been performed as a result of radioscopic examination, the repaired areas shall be re-examined using the same radioscopic technique to evaluate the effectiveness of the repair.

(f) To aid in proper interpretation of the radioscopic examination data, the details of the technique used shall accompany the data. As a minimum, the information shall include the approved procedure requirements and system performance test data.

(c) **Test for Class II Boilers—**

(i) From each longitudinal seam test pieces shall be selected for the following tests and stamped by the Inspector for identification.

From the test plate or plates:

One tensile test specimen for welded seam.

One bend test specimen.

One reverse bend test specimen.

One nick-break test specimen.

The disposition of the specimen shall be in accordance with the sketches in Figure XII/65. The remainder of each test plate shall be retained for re-tests if required.

(ii) **Tensile Test**—The dimensions of the test specimen shall be in accordance with the sketch in Figure XII/60. Specimen 1a, and the specimen shall be cut out transversely to the welded seam. When the capacity of the available testing machine does not allow the full specimen to be tested, two narrower tensile specimens shall be substituted. These specimens shall be the full thickness of the plate at the welded joint and their breadth shall be as great as the testing machine will reasonably allow, provided the effective cross sectional area of the test piece is not less than 1½ square inches (*see* Figure XII/60 Specimen 1b). The tensile strength of the welded joint specimen shall be not less than the lower limit specified for the plate.

(iii) **Cold Bend Tests**—Two bend tests shall be made.

One specimen shall be tested with outer surface of the weld in tension, and the other with the inner surface in tension. The specimens shall be rectangular in section and shall be cut out transversely to the weld so as to have a width not less than one and a half times the thickness of the plate. The sharp corners of the specimens shall be rounded to a radius not exceeding 10 per cent of the thickness of the specimen.

The specimen to be tested with the outer surface of the weld in tension shall be prepared by cutting to waste the metal local to the inner surface of the weld, so that the desired specimen thickness is obtained (*see* A, Figure XII/64). The specimen to be tested with inner surface in tension shall be prepared by cutting to waste the metal local to the outer surface of the weld so that the desired specimen thickness is obtained (*see* B, Figure XII/64). Where the thickness of the plate permits both specimens may be cut from the same piece of plate, the specimens being located in the plate one above the other (*see* C, Figure XII/64).

Each specimen shall be mounted with the weld midway between the supports set apart at a distance of not more than 5.2 times the thickness of the specimen and pushed through the supports with a former having a diameter equal to three times the thickness of the specimen.

On completion of the test no crack or defect at the outer surface of the specimen shall be greater than 1/16 inch measured across the specimen, or 1/8 inch measured along the length of the specimen. Premature failure at corners of the specimen shall not be considered cause for rejection.

(iv) **Nick-Break Specimen**—This specimen shall have a width not less than one and a half times its thickness and the slot shall be cut in each side of the specimen through the centre of the weld and perpendicular to the outer face of the boiler.

The specimen shall then be broken in the weld and the fracture shall reveal a sound homogeneous weld substantially free from slag inclusions, porosity and coarse crystallinity.

(v) **Additional Tests before Rejection**—If any of the test specimens should fail, two retests shall be made and both shall meet the specified requirements.

(vi) **Specimen after Tests**—If required specimens after tests shall be at the disposal of the Inspecting Authority for examination.

(vii) **Radiographic or Ultrasonic Examination**—Each longitudinal and circumferential seams in Class II boiler (including shell to end plate) shall be subjected to spot radiographic or ultrasonic examination.

(d) **Test for Class III Boiler**—

(i) Specimens for the following tests shall be selected from the test plate or plates and stamped by the Inspecting Officer for identification:

1. One forward bend test.
2. One reverse bend test.

(ii) **Radiographic or Ultrasonic Examination**—Each longitudinal and circumferential seams in Class III boiler (including shell to end plate) shall be subjected to spot radiographic or ultrasonic examination.

562. Heat Treatment

(1) All boilers constructed to Class I or Class II requirements shall be stress-relieved by heat-treatment after completion of all welding and before hydraulical test if any plate is 20 mm thick or greater or carbon content of the steel exceeds 0.25% of the material used in the construction of boiler is alloy steel.

For carbon steel a stress relieving heat-treatment shall be performed by heating part to at least 600° + 20°C. When required by the characteristics of the material, different temperatures may be necessary to obtain proper stress-relieving. The part to be stress-relieved shall be brought slowly up to the specific temperature and held at that temperature for a period proportionate on the basis of at least 2½ minutes per millimetre of the maximum thickness of part (approximately one hour per 25 mm of thickness) and shall be left to cool in the furnace to a temperature which, for the parts with a thickness greater than 20 mm does not exceed 400°C. After withdrawal from a furnace the part shall be allowed to cool in a still atmosphere. A temperature time diagram of the stress-relieving process shall be provided for a welded shell or drum and a similar diagram for other welded pressure parts when the Inspecting Authority requires it.

During heat treatment the Official test plates shall be inside the boiler. Where the shell is subjected to a primary stress-relieving treatment identical to the final heat treatment to be given to the boiler, the test plates may be placed inside the shell during primary treatment and thereafter cut up and tested without waiting for the final treatment of the boiler.

Where the shell is not subject to primary stress-relieving treatment or is subjected to primary stress-relieving treatment which is not identical with the final heat-treatment, the test plates may be placed inside any other boiler of comparable dimensions which is to be heat treated in accordance with this Chapter.

Temperature charts shall be submitted to indicate that the test plates and boilers they represent have been subjected to identical heating, soaking and cooling treatment.

> **Note:** Other stress-relieving heat-treatment at a temperature as low as 550°C may be adopted, provided attention is given to the holding time in order to ensure a sufficient degree of stress-relieving.

(2) Where the welded joint connects parts that are of different thickness, the thickness to be considered in applying the limiting thickness of 20 mm for carbon steel shall be the following nominal thickness including corrosion allowance:

(i) the thinner of two adjacent butt-welded component including shell to end connection;

(ii) the thickness of the shell in connections to flat ends;

(iii) the thickness of the shell or end in nozzle attachment welds;

(iv) the thickness of the nozzle at the joint in nozzle to flange connections;

(v) the thickness of the pressure part at the point of attachment where a non-pressure part is welded to a pressure part, in case of butt-welds;

(vi) the thickness of the fillet weld at the point of attachment where a non-pressure part is welded to a pressure part, in case of fillet welds.

(3) Notwithstanding anything contained in sub-regulations (1) and (2), if the thickness of the small component of boiler exceeds 20 mm and the weld recess also exceeds 20 mm local stress-relieving to the satisfaction of the Inspecting Authority shall be permitted.

(4) Notwithstanding anything contained in sub-regulations (1) and (2), post-weld heat treatment in weld joints of such equipment in carbon steel and low alloy steel may be exempted when heat treatment is not practical in some of such equipment, where inside is lined with special Stainless Steel which cannot be heated beyond 400°C (due to the associated problem of reduction of corrosion properties of such lining during heating to the temperature), post-weld heat treatment may be avoided in the weld joints of such equipment in carbon steel and low alloy steel when all the following conditions are satisfied—

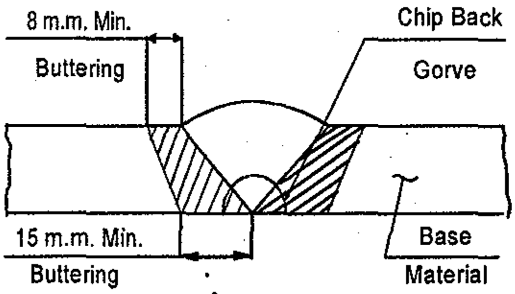
(a) Built-up overlay welding (buttering is performed on both the welding edge bevels of the parts of the closing joint to be welded together. The buttering can be of:

(i) With Carbon Steel Electrode with low carbon (C) = 0.1 per cent max. (Ex: E7018-1) in case of Carbon Steel parts,

(ii) With Stainless Steel Electrode E-309 or with Inconel electrode in case of low alloy steel parts,

(iii) With low alloy steel electrodes, having carbon (C) = 4.12 per cent max. (Ex: 9018G) or with Inconel electrode in case of high strength low alloy steel parts having UTS greater than 56 kg/mm^2 such as WB36, Sa533 Gr.B C 1.02;

(b) Buttering thickness shall be 15 mm minimum on the side where chip back is required to be done before re-welding and 8 mm minimum on the other side. Refer figure given below:



(c) Suitable pre-heat and other pass heating is applied during buttering;

(d) Individual parts shall be post-weld heat treated after buttering if required as per applicable regulations prior to welding the special stainless steel corrosion resistant liner plate or prior to applying final weld overlay of special corrosion resistant stainless steel lining;

(e) The final layer on the internal liner side shall be compatible with liner material and final weld (carbon steel welding in carbon steel base metal, low alloy steel Inconel welding in case of high strength low alloy steel base metal and E309 Inconel welding in case of other low alloy steel base metals) on the base metal side shell be compatible with base metal in respect of mechanical properties. The welding procedure shall be established taking care of adequate toughness and ductility and the procedure approved by IBR inspectors;

(f) Charpy - V Notch impact test shall be carried out at 0°C for:

(i) base metal and heat affected zone,

(ii) weld metal in case of Carbon Steel welding;

(g) Non-destructive testing as below is recommended:

(i) Magnetic particle test of weld bevels prior to buttering.

(ii) Dye-Penetrant test of buttering layer.

(iii) Dye-Penetrant test of rest of weld.

(iv) Dye-Penetrant test of final weld on internal liner side.

(v) Ultrasonic test of final weld after hydro test of the equipment with the closing seam.

563. Classification of Fusion-Welded Boilers

The boilers covered by this Chapter shall be classified in accordance with Table XII/3.

TABLE XII/3: Classification of Fusion-Welded Boilers

Classification	*Limits of application*	*Minimum thickness*
Class I	No limit	¼ inch
Class II	When the following limits are not exceeded: (a) Working pressure 105 pounds per sq. in. (b) Working pressure in pounds per sq. in. multiplied by internal diameter in inches—5250	Boilers upto and including 36 inches internal diameter 5/16 inch
Class III	When the following Limits are not exceeded: (a) Working pressure 30 lbs. per sq. in. (b) Working pressure multiplied by internal diameter in inches—3000	Boiler over 36 inches internal diameter 3/8 inch

564. Shells

(a) The working pressure of cylindrical shells for Class I boilers shall be determined in accordance with Regulations 270 and 271.

(b) The working pressure of cylindrical shells for Class II and Class III boilers shall be determined by the following formula:

$$W.P. = \frac{(t-1.5)SC}{0.7D} \qquad \text{Eqn. (XII/1)}$$

where, t = is minimum thickness of shell plate in mm,

WP = is working pressure in kg/cm^2,

D = is maximum internal diameter in mm,

S = is minimum tensile strength of plate in kg/mm^2,

C = is a constant, as given below.

In no case, however, shall the factor of safety of the shell be less than 4 or the plate thickness be less than specified in Table XII/3 given under Regulation 563,

C = 27 where Class II requirements are complied with,

C = 23 for Class III boilers when stress-relieved,

C = 21 for Class III boilers when no stress-relieved.

Where boilers have a nest or nests of horizontal tubes, so that there is a direct tension on the tube plates due to the vertical load on the boiler ends or to tube plates acting as horizontal ties across the shell:

(i) each alternate tube in the outer vertical row of tubes shall be a stay tube;

(ii) the thickness of the tube plates and the spacing of the tubes shall be such that the section of metal taking the load is sufficient to keep the stress within that allowed on the shell plate, as determined by the following formula:

$$W.P. = \frac{(t-2)SJ}{2D} \qquad \text{Eqn. (XII/2)}$$

where, T = is the thickness of the tube plate in mm,

WP = is working pressure in kg/cm^2,

S = is the minimum tensile strength in kg/mm^2,

D = is twice the radial distance of the centre of the outer row of tube holes from the axis of the shell in mm,

J = is the percentage strength of the plate through the tube holes, i.e.

$$\frac{100(p-d)}{p} \qquad \text{Eqn. (XII/3)}$$

p = is the vertical pitch of tubes in mm,

d = is the diameter of the tube holes in mm.

Note: The tube plates between the stay tubes shall comply with the requirements for tube plates (*see* Regulation 577).

565. Horizontal Shelves of Tube Plates Forming Part of the Shell

The number of gussets required to support the horizontal shelves of tube plates to withstand the vertical load due to the pressure on the boiler ends shall be determined in the following manner:

For combustion chamber tube plates the minimum number of the gusset shall be:

Where C exceeds 4560	1 gusset
Where C exceeds 6240	2 gussets
Where C exceeds 7440	3 gussets

For the smoke box tube plate the minimum number of gussets shall be:

Where C exceeds 4560	1 gusset
Where C exceeds 8400	2 gussets

$$\text{and } C = \frac{PAD}{t} \qquad \text{Eqn. (XII/4)}$$

where, A = is maximum horizontal dimension of the shell from the inside of the shell plate is to the outside of the tube plate in inches (*see* Figure XII/61),

D = is inside diameter of the boiler in inches,

P = is working pressure in pounds per square inch,

t = is thickness of tube plate in thirty-seconds of an inch.

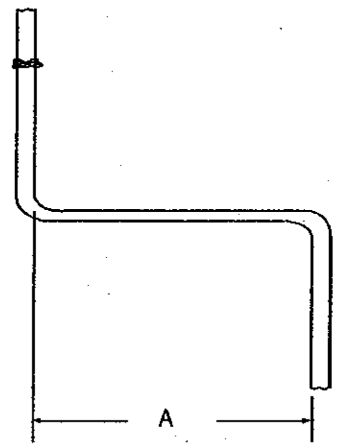


FIG. XII/61

The shell plates to which the sides of the tube plates are connected shall be not less than 1/16 inch thicker than is required by the formula applicable to shell plates with continuous circularity; and where gussets or other stays are not fitted to the shelves, the strength of the parts of the circumferential seams at the top and bottom of these plates from the outside of one tube plate to the outside of the other, shall be sufficient to withstand the whole load on the boiler end, with a factor of safety of not less than 4.5.

566. Dished End Plates for Lancashire and Cornish Boilers

For the dished ends of Lancashire and Cornish boilers without stays and subject to internal pressure the maximum working pressure shall be determined by the following formula:

$$W.P. = \frac{(t-8)30 \times S}{R} \qquad \text{Eqn. (XII/5)}$$

where, t = is minimum thickness of the end plate is thirty-seconds of an inch,

WP = is working pressure in pounds per square inch,

R = is the inner radius of curvature of the end plate in inches,

S = is minimum tensile strength of the plate in tons per square inch.

The inner radius of curvature of the end plate shall not exceed 1½ times the external diameter of the shell which it is attached.

The inner radius of flanging of the end plate shall be not less than 4 times the thickness of the plate but in no case less than 2½ inches.

Where the end plate has a manhole, compensation shall be obtained by flanging the edge of the opening or by providing a fabricated ring (*see* Figure XII/52).

In either case the depth of the flanging or ring measured at the minor axis shall not be less than that determined by the following formula:

$$D = \sqrt{TW} \qquad \text{Eqn. (XII/6)}$$

where, D = is depth of flange or ring in inches measured from the outside of the plate to the joint face,

T = is thickness of the plate in inches,

W = is width of the opening in inches, measured on the minor axis.

567. Dished Ends Subject to Internal Pressure

(a) For unstayed ends of shells and tops of vertical boilers and the like boiler parts, when dished to partial spherical form the maximum working pressure shall be determined by the following formula:

$$W.P. = \frac{15 \times s \times (t-1)}{R} \qquad \text{Eqn. (XII/7)}$$

W.P. = is the working pressure in pounds per square inch,

t = is thickness of the end plate in thirty-seconds of an inch but in no case this shall be less than the thickness of the shell to which it is attached,

R = is the inner radius of curvature of the end in inches, which shall not exceed the external diameter of the shell to which it is attached,

s = is the minimum tensile breaking strength of plate in tons per square inch, or whatever is allowed for it.

(b) The inside radius to which a crown plate is dished shall be not greater than the external diameter of the cylinder to which it is attached.

(c) The inside radius of curvature of the flanges to the shell shall be not less than 4 times the thickness of the crown plate and in no case less than 2½ inches.

(d) The inside radius of curvature of flanges to uptakes shall be not less than twice the thickness of the crown plate and in no case less than 1 inch.

(e) When the end has a manhole in it (t – 5), shall be substituted for (t – 1) in the formula.

(f) The total depth of flange of manhole from the outer surface in inches measured on the minor axis shall be at least equal to—

$$\sqrt{(T \times W)} \text{ depth of flange in inches} \qquad \text{Eqn. (XII/8)}$$

where, T = is the thickness of the plate in inches and W is the minor axis of the hole in inches.

(g) The depth of the crown plate opening from the commencement of the curvature of the flanging radius shall be not less than twice the plate thickness with a minimum of one inch.

567A.

Nothing in Regulation 567 shall preclude the use of dished ends in compliance with Regulations 275 to 278, where not fitted with an uptake.

568. Dished Ends Subject to External Pressure

In the case of unstayed dished ends for the co-efficient 15 in Equation XII/7, the co-efficient 12 shall be substituted, and R shall be the outer radius of the curvature of plate, which shall not exceed the external diameter of the shell to which it is attached.

For plates exposed to furnace-flame the co-efficient shall be 10.5.

In no case shall R/t exceed 2.75.

The inside radius of curvature at the flange shall be not less than 4 times the thickness of the end plate and in no case less than 2½ inches.

The inside radius of the curvature of the flange to uptake shall be not less than twice the thickness of the crown plate and in no case less than one inch.

569. Hemispherical Crowns

The maximum working pressure for hemispherical crowns subjected to internal pressure shall be determined by the following formula:

$$W.P. = \frac{(t-2)S \times C}{R} \qquad \text{Eqn. (XII/9)}$$

where, t = is thickiness of plate in thirty-seconds of an inch,

WP = is the working pressure in pounds per square inch,

R = is inner radius of curvature in inches,

S = is minimum tensile strength of the plate in tons per square inch,

C = is a constant, as given below.

In no case, however, shall the factor of safety of the crown plate be less than 4 nor the plate thickness be less than specified in Table given under Regulation 563,

C = 32 where Class I requirements are complied with,

C = 27 where Class II requirements are complied with,

C = 23 for Class III boilers when stress-relieved,

C = 21 for Class III boilers when not stress-relieved.

570. Manholes and other Openings in Shells

Manholes and other openings in shells shall be placed as far as possible from any seam. Wherever practicable oval openings shall be arranged with the minor axis parallel with the longitudinal centre line of the boiler. In no case shall the circumferential length of any opening exceed twice the longitudinal width of the opening.

571. Compensation for Openings in Shells

Where the width of any opening (measured in a direction parallel to the longitudinal axis of the boiler) exceeds two and a half times the thickness of the shell plate in inches plus 2¾ inches, compensation shall be provided.

(a) **Area to be Compensated**—The area to be compensated shall be the product of the maximum width of the opening cut in the shell and the thickness of an unpierced seamless shell of similar material calculated by Equation XII/1 with constant C = 35 for the same working pressure.

(b) **Compensating Area**—Compensation shall be considered adequate when the sum of the following areas is not less than the area to be compensated:

(i) The area obtained by multiplying the difference between the actual thickness of the shell and the thickness required for an equivalent unpierced seamless shell by a length 2 (3 inches + Ts), where Ts is the actual thickness of the shell plate in inches.

(ii) The net cross-sectional area of the frame or pad, or in the case of a branch the cross-sectional area of the wall of the branch minus the sectional area of a branch of the same bore having thickness equal to that calculated by Equation XII/1 for the same working pressure (with constant C=35) if seamless, plus the thickness required to withstand external loads. The area shall be measured within limits such that (a+b) in Figure XII/66 does not exceed 4 inches.

Where the material of a frame, pad or branch has a tensile strength which differs from that of the shell to which it is attached, the compensating area shall be multiplied by the ratio:

$$\frac{\text{Tensile strength of compensating part}}{\text{Tensile strength of shell plate}}$$

(iii) The cross-sectional areas of the welding fillets.

(c) **Compensating Plates**—In cases where the sum of (i), (ii) and (iii) is less than the area to be compensated a compensating plate shall be welded to the shell, its total cross-sectional area being equal to the amount of the deficit and due allowance being made as above when the tensile strength of the material of the plate differs from that of the shell.

Notwithstanding compliance with the requirements of paragraph (b) however, a reinforcing plate shall be fitted around all branches of 4 inches bore and over-welded to shell plates having a thickness of ½ inch or less.

The compensating plate may be fitted on the inside or outside of the shell plate as most convenient and its diameter shall not exceed twice the longitudinal width of the opening in the shell.

(d) Figure XI/66 shows a welded branch to which foregoing requirements apply where:

W = is width of the opening in the shell in inches,

T_s = is actual thickness of shell in inches,

T_1 = is thickness of an equivalent unpierced seamless shell calculated by Equation XII/1 with C=35 inches,

T_n = is actual thickness of branch in inches,

T_2 = is minimum thickness body of branch calculated by Equation XIII/1 (with C=35 if seamless) in inches,

T_3 = is thickness required to withstand external loads in inches=1/8 inch unless the loading is known to be such as to require a greater thickness and is=0 where there is no external loading,

T_c = is minimum thickness of compensating plate in inches,

S_1 = is minimum tensile strength of shell plate in tons per square inch,

S_2 = is minimum tensile strength of branch in tons per square inch,

S_3 = is minimum tensile strength of compensating plate in tons per square inch,

W = is width of compensating plate in inches measured in the same plate as the shell opening.

AREA TO BE COMPENSATED

$$A = W \times T_1$$

COMPENSATING AREA

(i) Portion of shell available for compensation:

$$B = 2\,(3 + T_s)\,(T_s - T_1)$$

(ii) Portion of branch available for compensation:

$$C = 2\,(4 + T_s)\,[T_n - (T_2 + T_3)]\,\frac{S_2}{S_4}$$

(iii) Portion of welds available for compensation:

D = Total cross-sectional area of the internal and external welding fillets.

If A is greater than (B+C+D), additional compensation is required to make up the difference. In the example shown in Figure XII/66 this is provided by means of a compensating plate, the total compensating area being such that (B+C+D)+Z is not less than A where:

$$Z = 2 \times W \times T_c \times \frac{S_3}{S_1}$$

572. Raised Manhole Frames, Cover Plates and Joint Bolts

Raised circular manhole frames not exceeding 16 inches in diameter shall not be less than 3/4 inch thick in all parts.

The circular over plates and joint flanges for such frames shall be not less than—

1 inch thick for pressures not exceeding 120 pounds per square inch.

1-7/8 inches thick for pressures exceeding 120 pounds per square inch but not exceeding 200 pounds per square inch.

1¼ inches thick for pressure exceeding 200 pounds but not exceeding 250 pounds per square inch.

For pressure exceeding 250 pounds per square inch, raised circular manhole frames shall not be fitted.

The cover plates shall be secured by at least sixteen steel bolts not less than 1 inch diameter, such that the stress in the bolts due to steam pressure shall not exceed—

5,000 pounds per square inch for 1 inch bolts.

6,000 pounds per square inch for 11/8 inches bolts.

6,500 pounds per square inch for 11/4 inches bolts.

For the purpose of calculation the pressure shall be assumed to act on the whole area within the pitch circle of the bolts and the bolt area at the bottom of the screw thread shall be taken.

573. Standpipes and Branches

(a) The thickness and bolting of all flanges for joining the mountings and fittings shall be in accordance with the dimensions as laid down in Appendix E to these regulations. In no case, however, shall the thickness of flanges be less than 13 mm.

(b) (i) The wall thickness of nozzles and other connections shall not be less than that specified for the applicable loading, namely, internal pressure, bending and static loads.

(ii) The pressure loading shall be determined by Regulation 564, but in no case shall the thickness be less than that calculated by the following formula:

$$t = .04D + 2.5 \text{ mm} \quad \text{(Eqn. XII/10)}$$

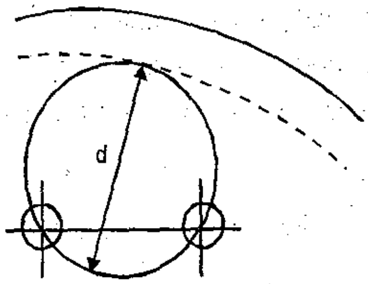
where, t is the thickness of standpipe and D is the outside diameter of connection. If the branch is connected by screwing, the thickness 't' shall be measured at the root of the thread.

(c) Where a double flanged steam pipe is tapered, the thickness of flange joining the boiler and fitting shall correspond to the bore of pipe at the flange connection in accordance with Appendix E to these Regulations.

574. Stayed Flat Surfaces (other than Crowns of Vertical Boilers)

Stayed Heads/Braced and Stayed Surfaces—For various braced and stayed flat plates and those which by these Regulations require staying as flat surfaces with braces or staybolts of uniform diameter symmetrically spaced, the thickness should be calculated by the following formula; namely:

$$e = Cd\sqrt{\frac{P}{f_1}} + e_1$$



where, P = design pressure in kgf/cm^2,

e = thickness, in mm,

d = diameter of the largest circle taken between staying points of the plate (in mm),

f_1 = 0.85 f (f as defined in Regulation 271), kgf/cm^2,

e_1 = additional thickness equal to 0.75 mm (0.03 in.),

C = co-efficient having the following values—

(1) C = 0.33 for flanged connections;

Note: d is the diameter of the largest circle taken from the commencement of the curvature of the flange.

(2) C = 0.40 for stays screwed in plate with nut or screwed and welded, or plain end strength welded on the outside;

(3) C = 0.33 for screwed bar stays with washer of not less than 3.5 times the diameter of bar stay;

(4) C = 0.31 for screwed bar stays with reinforcing plate, washer and nut on the outside.

Notes: 1. If the plate is stayed in any other way, average valued of C shall be taken into account.

2. If the plate is flame swept, the thickness shall be increased by 10%.

3. The welding materials used in the manufacture of these plates shall not have the ultimate tensile strength less than that of the plate used.

575. Flat Crown Plates for Vertical Boilers

(i) Flat crown plates shall be supported by the uptake and/or bar stays.

(ii) The inside radius of curvature of the flange to the shell or firebox shall be not less than four times the thickness of the plate and in no case less than 63 mm where the plate is flanged for attachment to the uptake, the inside radius of curvature of the flange shall be not less than twice the thickness of the plate and in no case less than 25 mm.

(iii) The thickness of flat crown plates shall be determined in accordance with Regulation 574.

576. Wide Water Spaces Between and Around Tube Nests

The thickness of plate at wide water spaces shall be calculated as per Regulation 574 taking

$$d = \sqrt{(A^2 + B^2)}$$

where, A = is width of the wide water space between the tube nests in mm measured from centre to centre of the tubes; and

B = is pitch of the tubes in the boundary rows of the wide water space in mm.

577. Flat Tube Plates and Tubes Nests

(a) Stay Tubes and Plain Tubes

(i) Stay tubes are tubes having a weld depth equal to the nominal tube thickness plus 3 mm as shown typically in Figures XII/68A(i) to (iv). These stay tubes are not required within tube nests except when the tube nests comprise tubes which are expanded only as shown typically in Figure XII/67A(iii).

(ii) If tube nests comprise plain tubes which are expanded and beaded, expanded and belled as shown typically in Figure XII/67A(iv) or expanded and welded [as shown typically in Figures XII/67A(i) and (ii)], welded stay tubes [as shown typically in Figures XII/67A(i) to (iv)] shall be used in boundary rows in sufficient numbers to carry the flat plate loadings outside the tube area.

(iii) For plain tubes and stay tubes exposed to flame or gas temperatures exceeding 600°C, the ends of welded tubes shall be dressed flush with the welds and the ends of the expanded tubes shall be as shown in Figures XII/67A(iii) and (iv). If not so exposed, the ends of welded tubes shall extend a maximum of 10 mm beyond the weld or, in the case of expanded tubes, the tubes shall project beyond the tube plate up to a maximum of 15 mm.

(iv) Each stay tube shall be designed to carry its due proportion for the load on the plates which it supports. The thickness of stay tubes welded into tube plates shall be such that the axial stress on the thinnest part of the tube does not exceed 70 N/mm^2.

(b) **Parts of Flat Plates within Tube Nests**—If stay tubes are used within tubes nests, the thickness of the tube plate shall be calculated in accordance with Regulation 574.

578. Manhole Openings in Flat Plates

Where manholes are located in flat plates, the openings shall be suitably compensated.

Compensation shall be obtained by flanging the edge of the opening, or by providing a fabricating ring (*see* Figures XII/52, XII/53, XII/54, XII/55 and XII/56).

The manhole in the lower portion of the flat front end plates shall be fitted with a flanged strengthening ring, the thickness of the flat portion of which shall be not less than (1.5 T + 1/8 inch).

where, T = the thickness of the end plate in inches, and in boilers of 7 feet and 6 inches diameter and over the manhole frame shall be fitted with a peak to reinforce the portion of the end plate between and below the furnaces and this peak shall be securely welded thereto.

In all cases the depth of the flanging or ring shall not be less than that determined by Equation XII/6.

Notes: Where the manhole is located in or between tube nests in Multi-tubular Boilers or below the furnaces of other Boilers the stay tubes in the boundary rows, or the gusset stays, as applicable, shall be arranged as closely as practicable to the manhole.

579. Plain Tubes

(a) **Attachment**—Plain tubes may be welded at both ends, welded at the inlet and expanded at the outlet end, or expanded at both ends.

Where the tubes are expanded only, the process shall be carried out with expanders having parallel rollers, and the expanded portion of the tube shall be parallel through the full thickness of the tube plate. In addition to expanding tubes may be bell-mouthed or beaded at the inlet end.

Where the tube is welded to the tube plate, the tube should be lightly expanded to grip the tube hole before welding.

(b) The thickness of tubes under external pressure shall be calculated as under:

$$t = \frac{WP'D}{1.6f} + C \qquad \text{Eqn. (XII/14)}$$

where, t = minimum thickness of tube in mm,

WP' = external working pressure in kg/cm^2 (g),

D = outside tube diameter in millimeters,

C = corrosion allowance to be taken as 0.75 millimetre but for stainless steel C =0.

Higher value may be adopted if desired by user;

f = allowable stress as per Regulation 338.

(c) In no case the thickness of straight tubes under external pressure shall be less than as specified below:

Tube outside diameter (mm)		*Minimum thickness (mm)*
Not exceeding	32	2.10
Exceeding 32 but not exceeding	39	2.28
Exceeding 39 but not exceeding	51	2.81
Exceeding 51 but not exceeding	70	3.12
Exceeding 70 but not exceeding	77	3.38
Exceeding 77 but not exceeding	87	3.96
Exceeding 87 but not exceeding	102	4.26

(d) **Internal Pressure**—The thickness of tubes under internal pressure shall be calculated as under:

$$t = \frac{WP.D}{WP + 2f} + C \qquad \text{Eqn. (XII/15)}$$

where, WP = internal working pressure, kg/cm^2 (g), and other symbols as per clarifications indicated at (a) above.

In no case the thickness of straight tubes under internal pressure shall be less than listed below:

Tube outside diameter (mm)				*Minimum thickness (mm)*
Not exceeding	39			1.75
Exceeding	39	but not exceeding	51	2.16
Exceeding	51	but not exceeding	70	2.40
Exceeding	70	but not exceeding	77	2.60
Exceeding	77	but not exceeding	96	3.05
Exceeding	96	but not exceeding	102	3.28
Exceeding	102	but not exceeding	127	3.50

580. Pitch of Tubes

The spacing of tube holes shall be such that the minimum width in inches of any ligament between the tube holes shall be not less than:

$$\frac{D}{8} + ½$$

alternatively,

the thickness and cross-section of the plate between the tube holes shall be not less than

$0.125D + 0.2$ = minimum thicknes in inches,

$0.17D + 0.025$ = minimum cross-section in square inches,

where, D is diameter of the tube hole in inches.

In no case shall the minimum thickness of any tube plate in the tube area be less than following limits:

$$T = \frac{1}{2}\text{inch},$$

where the diameter of the tube hole does not exceed 2 inches.

$$T = \frac{9}{16}\text{inch},$$

where the diameter of the tube hole is greater than 2 inches.

581. Stay Tubes

Stay tubes shall be of steel seamless or electrically resistance welded.

(a) **The Minimum Thickness of Stay Tubes**—The minimum thickness of stay tubes shall be as per Regulation 148.

(b) The maximum working pressure for screwed in stay tube shall be calculated by the following formula:

$$W.P. = \frac{5900}{A}\left[\left(D\frac{1.28}{N}\right)^2 - D_1^2\right] \qquad \text{Eqn. (XII/16)}$$

D = is diameter of the stay tube over threads in inches,

D_1 = is internal diameter of the tubes under the threads in inches,

N = is number of threads per inch,

A = is the area in square inches supported by one stay tube, measured from centre to centre of stay tubes. When the area contains tubes or parts of tubes their aggregate area, calculated from their smallest external diameter of body when in tension and smallest internal when in compression, shall be deducted from the area of the containing figure and the remainder used as A in the formula.

Where stay tubes have their thickness increased at the screwed, ends to provide for plus threads the increased thickness shall be obtained by upsetting and not by welding, and the tubes shall be subsequently annealed.

Stay tubes may be attached to the tube plates either by screwing or by metal arc welding.

Where stay tubes are screwed into the tube plates they shall be screwed with a continuous thread not finer than 11 threads per inch at both ends and shall be expanded into the tube plates, by roller expander and, if desired, may be seal-welded.

Welded attachment of stay tubes be as shown in Figures XII/67, XII/67A, XII/68, XII/68A and XII/69.

582. Compression of Tube Plates

(a) For firebox or combustion chamber tube plates which are subject to compression due to the pressure on the roof plate, the maximum working pressure shall be:

$$W.P. = \frac{C \times (P - D) \times t}{L \times P} \qquad \text{Eqn. (XII/17)}$$

where, t = is thickness of the tube plate in thirty-seconds of an inch,

P = is pitch of the tubes in inches, measured horizontally where the tubes are chain pitched or diagonally where the tubes are zig-zag pitched and the diagonal pitch is less than the horizontal,

D = is internal diameter of the plain tubes in inches,

L = is internal length of the firebox or combustion chamber in inches measured at top between tube plate and firehole plate or back plate, or between tube plates in double ended boilers with combustion chambers common to two opposite furnaces.

$$C = 875$$

Provided that the above formula shall not apply in the cases of fireboxes where the girders do not rest on the tube plate, or where the roof plate is stayed direct to the outer shell or to girders supported by the shell.

(b) Where girders rest on the side plates or the roof plate is so formed that the load is carried both by side and end plates, the compressive stress on the plates shall not in either case exceed 14,000 pounds per square inch.

583. Girders for Firebox and Combustion Chamber Crowns

(a) For girders supporting crown plates of rectangular fireboxes, where the ends of the girders are supported by the vertical end or side plates, their proportions shall be calculated by the following formula:

$$W.P. = \frac{C S T d^2}{L^2 Y} \qquad \text{Eqn. (XII/18)}$$

where, WP = is working pressure in pounds per square inch,

S = is minimum tensile stress of the material in tons per square inch,

T = is total thickness of the stay in thirty seconds of an inch,

d = is depth of the girder stay in inches,

L = is length of girder stay in inches measured between the inside of the tube plate and the firehole plate, or between the inside of the side plates, according to the method of support,

Y = is pitch of girder stays in inches,

C = 22 for steel plates or steel forgings,

= 19 for steel castings.

(b) Where girders are welded to the crown plate the dimensions of the welds shall be such that the stress calculated on an area equal to the sum of the effective lengths of the welds attaching each girder multiplied by the effective throat thickness shall not exceed 7,500 pounds per square inch multiplied by the appropriate weld factor in Table XII/17, ("Effective length" and "Effective throat thickness" are defined in Regulation 591). The load on the welds shall be taken as that due to the design pressure acting on the area LY: L and Y being as defined in Regulation 583.

584. Girder Sling Stays

For slung girders the proportion in slings, links, pins and connections to the shell shall be sufficient to carry the whole load that would otherwise be carried on the toes of the girders and for any of the above parts in tension a stress of 9,000 pounds per square inch of net section, and for parts in shear a stress of 8,000 pounds per square inch of net section shall not be exceeded. In the case of parts in double shear, the net area of the section should be taken as 1.875 times the single section.

585. Stays for Fireboxes and Circular Furnaces

(a) **Solid Screwed Stays**—For screw stays to combustion chambers and fireboxes and for longitudinal and cross-stays, the maximum working pressure for the stays is to be calculated from the appropriate one of the following two formulae:

$$\text{W.P.} = \frac{C}{A}\left(D - \frac{1.28}{N}\right)^2 \qquad \text{Eqn. (XII/19)}$$

$$\text{W.P.} = \frac{C \times D_1^2}{A} \qquad \text{Eqn. (XII/20)}$$

WP = is the working pressure in pounds per square inch,

D = is diameter of stays over threads in inches,

D_1 = is diameter of body of stay at its smallest part in inches,

N = is number of threads of stay per inch,

A = is area in square inches supported by one stay for area to be supported by stays near tubes in firebox tube plates of Locotype Boilers, [*see* Regulation 193(a)],

C = 7,100 for steel or special wrought iron screw stays to combustion chamber or fire-boxes,

C = 8,640 for steel longitudinal or cross-stays fitted with nuts,

= 4,700 for copper stays.

Where stays are made with enlarged ends and the body of the stay is smaller in diameter than at the bottom of the thread the working pressure shall be calculated from the second formula.

(b) **Circumferential Stays for Circular Furnaces and Fireboxes**—The diameter of the stay shall be not less than 3/4 inch or twice the thickness of the firebox plate, whichever is the greater. In the case of screwed threads the diameter shall be measured over the threads.

The pitch of the stays at the firebox shall not exceed 14 times the thickness of the firebox plate.

586. Firebox Crown Stays for Locotype Boilers

Where firebox crown stays are directly attached to a semi-cylindrical outer casing, and the firebox top is chambered and fitted with stays arranged as shown in Figure XII/78 the thickness of the outer casing shall be sufficient to provide not less than three engaging threads, of which not less than one shall be full thread in stays not normal to the stayed surface, but if the thickness of the plate is not sufficient to give one engaging full thread the plate shall be reinforced.

Where vertical stays only are used to take part of the load on the firebox top, boilers with shells 4 feet and 6 inches diameter and over shall be fitted with transverse stays (*see* Figure XII/79). Stays may be attached as shown in Figures XII/49, XII/40 and XII/41.

587. Longitudinal Bar Stays

The maximum working pressure for longitudinal bar stays is to be calculated from the appropriate one of the following two formulae:

$$\text{W.P.} = \frac{C}{A}\left(D - \frac{1.28}{N}\right)^2 \qquad \text{Eqn. (XII/21)}$$

$$\text{W.P.} = \frac{C \times D_1^2}{A} \qquad \text{Eqn. (XII/22)}$$

where, WP = is working pressure in pounds per square inch,

D = is diameter of stays over threads in inches,

D_1 = is diameter of body of stays at its smallest part in inches,

N = is the number of threads of stay per inch,

A = is area in square inches supported by one stay,

C = is values given in Table below.

TABLE XII/5: Stress on Longitudinal Bar Stays

Range of tensile strength of bar (Tons per square inch)	*Value of C (Pounds per square inch)*
26/30	7,850
28/32	8,640
30/34	9,320
32/36	10,200

Where bar stays are fitted in vertical boilers, not less than four bar stays shall be fitted to boilers of 4 feet and over but under 5 feet in diameter; five bar stays to boilers of 5 feet and over but under 6 feet in diameter; six bar stays to boilers of 6 feet and over in diameter.

In no case, shall the diameter of the stay at any part be less than 1 inch. Where joined stays are fitted, the strength of the knuckle joint employed shall be at least equal to the strength of the remainder of the bar stay.

588. Loads on Stay Tubes and Bar Stays

Stay tubes and bar stays shall be designed to carry the whole load due to the pressure on the area to be supported, the areas being calculated as follows:

(a) For a stay tube within the tube nest the net area to be supported shall be the product of the horizontal and vertical pitches, in inches, of the stay tubes less the area of the tube holes embraced. Where the pitch of the stay tubes is irregular the area shall be taken as the square of the mean pitch of the stay tubes (i.e., the square of ¼ of the sum of the four sides, of any quadrilateral bounded by four adjacent stay tubes), less the area of the tube holes embraced.

(b) For a stay tube in the boundary row, or for bar stay, the net area to be supported shall be the area, in square inches enclosed by lines passing midway between the stay and the adjacent points of support and by the boundary margin (*see* Regulation 589), less the area of any tubes or stays embraced.

(c) In the case of bar stay where there are no stay tubes in the tube nest the area to be supported shall extend to the tangential boundary of the tube nest.

589. Flat Plate Margins

The amount of support in relief of the stays which may be attributed to the shell, furnaces or flues to which flat plates are attached, shall not exceed that determined by the following formulae:

$$\text{Width of margin in inches} = \frac{C(t-1)}{\sqrt{WP}} \qquad \text{Eqn. (XII/23)}$$

where, t = is plate thickness in thirty-seconds in an inch,

WP = is working pressure in pounds per square inch,

C = 3.47 for plates exposed to flame,

C = 3.70 for plates not exposed to flame.

Where the plates are flanged, the margin shall be measured from the commencement of curvature of flanging, or from a line 3½ times the thickness of the plate measured from the outside of the plate, whichever is nearer to the flange. Where the flat plate is not flanged for attachment to the shell or flue tubes and is welded as shown in Figure XII/12 or XII/16 the width of the margin shall be measured from the inside of the shell or the outside of the flue tube, whichever is applicable.

In no case, however, shall the diameter D of the circle forming the boundary of the margin supported by the uptake of a vertical boiler be greater than that found by the following formula:

$$D = \sqrt{\frac{5000A}{W.P.}} + d^2 \qquad \text{Eqn. (XII/24)}$$

A = is cross-sectional area of the uptake tube in square inches,

W.P. = is working pressure in pounds per square inch,

d = is external diameter of uptake in inches.

590. Breathing Space

Breathing spaces as provided in clause (i), (ii) or (iii) shall be provided depending on the design of the boiler with special attention to the provisions of sub-regulation (ggg) of Regulation 546 regarding furnaces.

(i) For boilers as per clause (i) of sub-regulation (ggg) of Regulation 546—

(a) **Arrangement of stays**—Stays shall be arranged to give sufficient breathing space around the furnace connections and tube nests (*see* Figures XII/75 and XII/77), and shall divide the unstayed areas equally.

(b) **Multi-tubular boilers**—For both the front and rear attachment of furnaces, the breathing spaces between furnace and tube nests or between furnace and shell shall be a minimum of 50 mm or 5% of the shell inside diameter, whichever is larger, with a maximum requirement of 100 mm.

Clearances between the furnace and wet-back wrapper plates shall not require consideration as breathing spaces.

In the case of reverse flame boilers, the breathing space at the front end between furnace and tube nests shall be not less than 50 mm and the breathing space formed by the outer-annular area of the furnace rear plate shall be not less than 50 mm or 5% of the shell inside diameter, whichever is larger, with a maximum of 100 mm.

Breathing spaces between gusset or link stays and tube ends shall be not less than 100 mm. Clearances between the tubes and wet-back wrapper plates shall not require consideration as breathing spaces.

Breathing spaces between tubes and shells shall not be less than 40 mm.

Breathing spaces between gusset or link stays and furnaces shall be not less than 200 mm except that for shell outside diameters exceeding 1800 mm and furnace lengths exceeding 6000 mm they shall be not less than 250 mm and for shell outside diameter less than 1400 mm and furnace lengths less than 3000 mm they shall be not less than 150 mm.

All other breathing spaces shall be a minimum of 50 mm or 3% of the shell inside diameter, whichever is larger, with a maximum requirement of 100 mm.

(c) **Cornish and Lancashire boilers**—In Cornish boilers, the circle defining the breathing spaces shall be as shown in Figure XII/73 i.e. the distance AB between the centre of the stay circle and the centre of the flue shall be not less than 3e+63, where, e is the thickness of the end plate in millimetres.

Note: For Lancashire boilers, the proportions shown in Table XII/6A given below are recommended for the portion of the end plates above the furnaces and flues.

Table XII/6A: Breathing Space for Lancashire Boilers

Thickness of end plate (in mm)	13	14	16	18	20	over 20
Dimension L (in mm) (*see* Figure XII/70)	255	280	305	330	330	340

It is recommended that the breathing space below the flue be approximately one-half of the dimensions given in Table XII/6A.

(ii) **For boilers as per clause (ii) of sub-regulation (ggg) of Regulation 546**—Stays shall give breathing spaces around the furnace connections and tube nests (*see* Figures XII/70 to XII/77, XII/80, XII/80A, XII/80B, XII/80C and XII/80D) and equally divide the unstayed areas. Breathing spaces between furnaces and tube nests shall be a minimum of 50 mm or 5% of the shell outside diameter, whichever is larger, but need not be more than 100 mm.

Breathing spaces between furnaces and shells shall be as given in Table XII/6B or XII/6C as applicable, but shall be not less than 50 mm or, for bowling hoop furnaces, not less than 75 mm as measured from the outside diameter of the bowling hoop.

For the boilers having more than one furnace, breathing spaces between furnaces shall be not less than 120 mm.

Breathing spaces between gusset or link stays and furnaces shall be not less than 200 mm, except for;

Shell outside diameter or furnace length	> 1800 mm > 6000 mm	250 mm
Shell outside diameter or furnace length	< 1400 mm < 3000 mm	150 mm

Breathing spaces between gusset or link stays and tube nests shall be not less than 100 mm.

When unflanged flat end plates as used, the breathing spaces between gussets or link stays and furnaces shall be increased as follows:

Increase 200 mm to 220 mm

Increase 250 mm to 275 mm

Increase 150 mm to 165 mm

Increase 100 mm to 110 mm

All other breathing spaces shall be a minimum of 50 mm or 3% of the shell outside diameter whichever is larger but need not be more than 100 mm.

Table XII/6B: Breathing spaces between furnaces and shells when tube plate thickness does not exceed 25 mm (*see* Table XII/6C also)

Design	*Length between the boiler end plates*		*Breathing space*	
	L in m		*% of outside diameter (Note)*	*Maximum mm*
Inserted flat ends		≤ 5.5	5	100
	5.5 < L	≤ 6.0	5.5	110
	6.0 < L	≤ 6.5	6	120
Flanged ends	any length		5	100

Note: But not less than 50 mm or, for bowling hoop furnaces 75 mm.

When the actual thickness of the end plate exceeds 25 mm the breathing spaces in accordance with Table XII/6B shall be increased in accordance with Table XII/6C.

Table XII/6C: Breathing spaces between furnaces and shells when the thickness of the end plate exceeds 25 mm

Length of furnace m		*Breathing space*		
		% of d.	*Need not be more than mm*	*Minimum mm*
	≤ 5.5	6.5	130	65
5.5 < L	≤ 6.0	7.0	140	70
6.0 < L	≤ 6.5	8.0	150	75

(iii) **For boilers not covered under the above clauses of this regulation**—Gusset stays shall be arranged to give sufficient bearing space around the furnace connections and tube nests (*see* Figures XII/70 to XII/77, XII/80, XII/80A to XII/80D). The proportions shown in Table XII/6D are recommended for the portion of the end plates above the furnaces and the flues.

Table XII/6D: Breathing Space

Thickness of end plate mm	*Dimension 'L' mm*
< 13	255
≥ 13 ≤ 14	280
> 14 ≤ 16	305
> 16 ≤ 20	330
> 20	340

The breathing space below the flues shall be approximately one-half the dimensions given in Table XII/6.

For gusset stays above the tube nests, as fitted in multi-tubular waste heat boilers without internal furnaces, a breathing space of 20.3 mm from the centre line of the adjacent tubes to the toe of the gusset angle or plate, may be maintained. For the back end stays below the furnaces of multi-tubular dryback boilers, a breathing space of 152 mm may be maintained where the flues are constructed in accordance with Regulation 546.

Where the flues are constructed of corrugated sections welded together, a breathing space of 114 mm may be maintained.

591. Gusset Link, Brace and Similar Stays

For welded Lancashire, Cornish and Cylindrical Horizontal Multi-tubular type boilers, all-welded gusset stays shall not be used. To ensure flexibility, link stays, bar stays, brace stays and other similar stays or suitably designed gusset stays other than the all-welded type shall be used. All welded gusset stays, however, may be used in cylindrical horizontal waste heat and cylindrical vertical multi-tubular boilers.

Welded gusset stays and braces may be used for welded Lancashire, Cornish and Cylindrical Horizontal Multi-tubular boilers provided their method of attachment is approved by the Inspecting Authority.

(a) **Load on Each Stay**—Each gusset or link stay supporting the flat end plate of a boiler shall be designed to carry the whole load due to pressure on the area it supports. The areas supported by any one stay shall be obtained by considering the total area to be supported which lies within the limits of the flat plate margins and dividing this area by boundary lines drawn between the stays. These boundary lines shall be at all points equidistant from the adjacent points of support in the area under consideration.

The effective uniformly distributed load on a triangular gusset plate or on a diagonal link stay shall be assumed to be equal to the perpendicular load on the portion of the end plate to be supported (determined as above) multiplied by L/L_1 (*see* Figures XII/81, XII/82 and XII/83).

(b) **Gusset Plates**—Gusset plates shall be so proportioned that the angle "V" (*see* Figures XII/81 and XII/82), is not less than 60°.

The thickness of the gusset plate shall be such that the stress in the plate to withstand the effective uniformly distributed load (as defined above) calculated on the smallest cross-section on line XX or YY (Figure XII/81 and XII/82), shall not exceed one-seventh of the minimum tensile stress of the plate used but in no case shall the thickness be less than seven-eighths of the thickness of the shell, plate with a minimum of 7/16 inch.

Where all-welded gusset stays are used a stiffening plate shall be welded at the toe of the gusset where it is secured to the end plate i.e. where the maximum stress occurs (*see* Figure XII/81).

(c) **Link Stays**—Link stays shall be so arranged that the angle "V" (Figure XII/83) is not less than 60° and the dimensions shall be such that stress in the stay at its weakest part does not exceed one-seventh of the minimum tensile stress of the plate used.

(d) **Anchor Plates, Angles, Link Pins and the Like Members**—The strength of anchor plates, angles and link pins calculated at the weakest section shall be as follows:

(i) Link pins shall be so designed that the shear stress does not exceed 8,000 pounds per square inch, the strength of pins in double shear being taken as 1.875 times the strength of pins in single shear.

(ii) Anchor plates or angles shall be so designed that the calculated stress does not exceed one-seventh of the minimum tensile stress of the material used, but in no case shall the thickness be less than seven-eighth of the thickness of the shell plate with a minimum of ½ inch, nor the length of the portion attached to the end plate be less than the distance between the lines of end to shell flat margin and the breathing space line around the flues of tube nests.

(e) **Weld Attachment**—Where gusset plates, anchor plates or angles are welded to the shell and/or end plates, the attachment shall be by means of continuous fillet welds on each side or by butt-welds prepared in accordance with paragraph 2, details l, m, n or p or Appendix A of this Chapter.

The welds shall be of such dimensions that the stress calculated on an area equal to the effective length of the weld multiplied by the effective throat thickness shall not exceed that permitted for the parent metal multiplied by the appropriate weld factor in Table XII/7.

The effective length of a weld shall be taken as that length of weld which is of the specified size throughout.

For open-ended fillet welds the effective length shall be the overall length less twice the weld size.

For the purpose of stress calculation the effective throat thickness of a butt-weld shall be taken as the thickness of the gusset or another plate and the effective throat thickness of fillet weld shall be taken as 0.7 of the fillet size. For compound welds the effective thickness shall be the sum of those of the constituent parts.

Table XII/7: Weld attachments

Form of weld		*Weld factor*	
		Not stress-relieved	*Stress-relieved*
Single J or bevel butt-welds	Unsealed	0.35	0.45
(with or without superimposed fillet)	Sealed	0.60	0.70
Double J or bevel butt-welds	Unsealed	0.60	0.70
(with or without superimposed fillets)			
Double fillet welds		0.55	0.65

592. Furnaces, Furnace Components, Wet-back Reversal Chambers and Fireboxes of Cylindrical form subject to External Pressure

Furnaces:

(a) **Maximum Furnace Diameter**—The mean diameter of furnaces shall not exceed 1800 mm.

(b) **Notations**—

b = is the pitch of the furnace corrugations (in mm);

C = is the corrosion allowance = 0.75 mm;

d = is the mean diameter of furnace (in mm) (*see* Note 1);

d_{max} = is the maximum mean diameter of the furnace (in mm);

d_{min} = is the minimum mean diameter of the furnace (in mm);

e = is the furnace plate thickness (in mm);

E = is Young's modulus of elasticity (in kg/cm^2) at the design temperature;

E_t = is the specified minimum elevated temperature yield stress or the 0.2% proof stress at the design temperature (in kg/cm^2);

F = is the cross-sectional area of a longitudinal section of the corrugated furnace wall, of length b and thickness (e-c) (in mm^2) [*see* Figures XII/94(a) to (g)];

I = is the second moment of area of one complete corrugation about its neutral axis, excluding the corosion allowance (in mm^4);

I_s = is the second moment of area of plain stiffener section (*see* Figures XII/21 & XII/22) about its neutral axis, including a length of the furnace of $0.55\sqrt{(de)}$ on each side of the stiffener (in mm^4) (*see* Note 2);

L = is the distance between the centre of two effective points of support (in mm) (*see* Note 3);

P = is the design pressure (in kg/cm^2)

S_1 = is the factor of safety:

= 2.5 for furnaces in Class I and Class II boilers

= 3.5 for furnaces in Class III boilers

= 2.0 for furnaces and wrapper plates not exposed to flame;

S_2 = is the factor of safety:

= 3.0 for Class I and Class II boilers

= 3.9 for Class III boilers;

u = is the percentage out-of-roundness to be taken as 1.5 for plain furnaces and 1.0 for corrugated furnaces;

W = is the depth of corrugation (in mm).

Notes: 1. For corrugated furnaces, mean diameter is equal to inside diameter plus full depth of one corrugation referred to in Fig. XII/94 which is equal to the inside diameter +e+W.

2. When calculating Is, it is only necessary to take into account a corrosion allowance on the furnace gas side.

3. Stiffeners complying with Figures XII/21 and XII/22 boiler and reversal chamber end plates are considered to be effective points of support.

4. The design temperature of the furnace = Cs + 4e + 15 saturation temperature plus four times the thickness of the furnace plus 15.

(c) Evaluation of Young's modulus at the design temperature. Value of E shall be obtained from the following table (by linear interpolation if required):

Design temperature in °C	*Value of E in $kg/cm^2 \times 10^3$*
250	1987
300	1947
350	1896
400	1845
450	1814

(d) **Plain Furnaces**—The design pressure of plain furnaces shall be the lower of those obtained using Equations XII/25 and XII/25A as follows, but the thickness shall be not less than 7 mm and shall not exceed 22 mm:

$$P = \frac{2\,E_t\,(e - C)}{S_1\,d}\left[\frac{1 + \dfrac{d}{15L}}{1_{(e-C)} + \dfrac{0.03du}{\left(1 + \dfrac{d}{0.3L}\right)}}\right] \qquad \text{(Eqn. XII/25)}$$

$$P = \frac{1.73E\,(e - C)^{2.5}}{S_2\,L\,d^{1.5}} \qquad \text{(Eqn. XII/25A)}$$

Equations XII/25 and XII/25A may be expressed in terms of thickness using Equations XII/26 and XII/26A respectively as follows and the greater of the thickness obtained shall be used.

$$e = \frac{B}{2}\left(1 + \sqrt{\left\{1 + \frac{0.12\,du}{B\left(1 + \dfrac{d}{0.3\,L}\right)}\right\}}\right) + C \qquad \text{(Eqn. XII/26)}$$

$$\text{where, } B = \frac{PdS_1}{2E_t\left(1 + \dfrac{d}{15L}\right)}$$

$$e = d^{0.6}\left(\frac{LS_2P}{1.73E}\right)^{0.4} + C \qquad \text{(Eqn. XII/26A)}$$

If the furnace/combustion chamber has tubes radially to it. The thickness of that portion of the furnace is to be increased by the value of ligament efficiency.

(e) **Furnace Components**—The thickness of furnace components, e.g. ash drop-out tubes and fuel inlet connections, shall be calculated in accordance with sub-regulation (d) with a minimum thickness of 10 mm and a maximum thickness of 22 mm.

(f) **Corrugated Furnaces**—The design pressure of corrugated furnaces shall be determined using the Equation XII/28 but the thickness shall be not less than 10 mm and shall not exceed 22 mm. Calculated value of I and F for some of the corrugations are given in Figure XII/94 for other shapes and sizes calculations need to be made from basic principles.

$$P = \frac{2FE_t\left(1 + \dfrac{0.1d}{L}\right)}{S_1bd\left[1 + \dfrac{FWDu}{800I\left\{1 + \dfrac{5d(e - C)^3}{L(W)}\right\}}\right]} \qquad \text{(Eqn. XII/28)}$$

(g) **Tolerances and Allowances**—The calculated wall thickness contains a fixed allowance of 0.75 mm for corrosion and wear. For corrugated furnaces, the calculated wall thickness shall be the minimum thickness of the finished furnace. For plain furnaces and reversal chambers, allowance shall be made to take account of any minus tolerances on the plate thickness.

(h) **Out-of-roundness**—The percentage out-of-roundness is as follows:

$$u = \frac{200(d_{max} - d_{min})}{d_{max} + d_{min}}$$

This shall be included in the calculation as u=1.0 for corrugated furnaces and u=1.5 for plain furnaces.

(i) **Stiffeners**—

(i) Stiffeners shall have second moment of areas not less than that given by the following equation:

$$Is = \frac{Pd^3L}{1.35 \times 10^7}$$

(ii) If the stiffeners are made in sections from bar or plate, the abutting ends shall be prepared so as to ensure that full penetration welds are made.

The thickness of the stiffening ring shall be kept to the minimum required (for limiting dimensions *see* Figures XII/21 and XII/22).

(iii) Bowling hoops are considered as effective points of support. The minimum pitch of bowling hoop centres shall be not less than 500 mm. If bowling hoops are used, the furnace thickness shall be calculated from sub-regulation (d). The dimensions of bowling hoops shall be in accordance with Figures XII/95(a), (b) and (c) and their second moment of area determined from the tables given in these figures, shall be not less than required by sub-regulation (i).

(iv) If corrugated furnaces are equipped with several stiffeners, e.g. one on each corrugation or on each second corrugation, the cross-sectional area and the second moment of area of the stiffeners shall also be taken into consideration when using the Equation XII/28. A height of not more than four times the furnace thickness shall be used for the calculation.

(j) **Circular Reversal Chambers**—

(i) The thickness of wrapper plates of cylindrical reversal chambers of horizontal multi-tubular boilers shall be calculated in accordance with the equations given in sub-regulation (d). The thickness shall be not greater than 35 mm and shall be not less than 10 mm.

However, the design temperature for reversal chamber wrapper plates shall be determined in accordance with the following equations:—

t = $(ts + 2e_2)$ or $(ts + 50)$ whichever is greater.

where, t = Design temperature (in degree Centigrade)

ts = Saturation temperature of water (in degree Centrigrade) at the design pressure, for both steam or hot water boilers.

e_2 = nominal plate thickness (in mm).

(ii) The thickness of access tubes shall be calculated in accordance with sub-regulation (d) with a minimum thickness of 10 mm.

593. Plain Furnaces of Vertical Boilers

The maximum working pressure of Plain Furnaces of Vertical Boilers shall be the lesser of the two values obtained by Equations XII/25 and XII/26.

where, D = external diameter of the firebox in inches. Where the firebox is tapered the diameter taken shall be the mean of that at the top and at the bottom where it meets the substantial support from the flange or ring,

L = is length of the firebox in inches between points of substantial support measured from the commencement of flange curvature or from the foundation connection, or from a row of screwed stays which comply with Regulations 550(b), 585(b), whichever is applicable.

In no case, however, shall the thickness be more than 7/8 inch. For fireboxes under 2 feet and 6 inches in diameter, the thickness shall be not less than 5/16 inch and for fireboxes 2 feet and 6 inches in diameter and over the thickness shall be not less than 3/8 inch.

594. Corrugated Fireboxes of Vertical Boilers

For the semi-spirally corrugated fireboxes of 'Sentinel' standard motor wagon boilers the working pressure shall be determined by the following formula:

$$W.P. = \frac{C(t-1)}{D} \qquad \text{Eqn. (XII/29)}$$

where, $W.P.$ = working pressure in pounds per square inch,

t = thickness of the firebox plate in thirty-seconds of an inch,

D = mean of the external diameters of firebox measured over the plain part at each end at commencement of curvature of flange,

C = 390.

No corrugated furnace shall be less than 3/8 inch thick.

595. Hemispherical Furnaces of Vertical Boilers

When furnaces are hemispherical in form and subject to pressure on the convex side and are without support from stays of any kind the maximum working pressure shall be found by the following formula:

$$W.P. = \frac{275(t-1)}{R} \qquad \text{Eqn. (XII/30)}$$

where, W.P. = is working pressure in pounds per square inch,

t = is thickness of the top plate in thirty-seconds of an inch,

R = is outer radius of curvature of the furnace in inches.

The thickness of these furnaces shall in no case exceed 7/8 inch.

596. Foundations of Vertical Boiler Furnaces

When circular furnaces of fireboxes of vertical boilers are not connected to the shell crown by uptake tube, smoke tubes or bolt stays and the whole load on the firebox vertically is borne by the bottom part of the firebox where it is connected to the shell the working pressure for the part, if firebox is joggled out to meet the shell or if any ogee ring is fitted, shall not exceed that found by the following formula:

$$W.P. = \frac{C(t-1)^2}{D(D-D_1)} \qquad \text{Eqn. (XII/31)}$$

where, W.P. = is working pressure in pounds per square inch,

t = is thickness of the joggled firebox plate or ogee ring in thirty-seconds of an inch,

D = is inside diameter of the boiler shell in inches,

D_1 = is outside diameter of the joggled firebox at the commencement of curvature above joggled part or the outside diameter of the firebox where it joins the ogee ring,

C = 140 for ogee rings (*see* Figures XII/26 and XII/27).

597. Foundations of Locotype Boiler Fireboxes

Where the firebox roof in locotype boilers is not stayed direct to the external casing crown or to girders carried by the casing or if not connected to the casing by slings the working pressure for the parts, if plates are joggled out to meet the casing or if an ogee ring is fitted, shall not exceed that found by the following formula:

$$W.P. = 70\,\frac{(t-1)\times(L+W)}{L+W(W-W_1)} \qquad \text{Eqn. (XII/32)}$$

where, W.P. = is working pressure in pounds per square inch,

t = is thickness of the joggled firebox side plates of firehole plate (whichever is less) or ogee ring in thirty-seconds of an inch,

L = is length of firebox casing in inches measured between the water sides of front end plate and saddle plate at the foundation seam,

W = is width firebox casing in inches measured between the water side of casing side plates at the foundation seam,

W_1 = is width of firebox in inches measured between the water sides of firebox side plates at the commencement of curvature above joggled part of where it joins the ogee ring.

Where only a comparatively narrow strip of the firebox roof is stayed directly to the casing crown the area so stayed shall be deducted from the area represented by $L \times W$ in the bottom line of the formula thus:

$(L \times W - A)(W - W_1)$ and so used is Equation XII/32 in determining the working pressure for the parts. "A" being the area in square inches of the part of roof supported by the casing crown.

598. Uptakes of Vertical Boilers

The working pressure for uptake tubes of vertical boilers shall be determined by the following formula:

(i) When an internal liner is not fitted:

$$W.P. = \frac{100(t-2)}{D} \qquad \text{Eqn. (XII/33)}$$

(ii) When an internal liner is fitted extending below the low water level:

$$W.P. = \frac{725}{D} \times \frac{(t-1)^2}{(L+24)} \qquad \text{Eqn. (XII/34)}$$

where, W.P. = is working pressure in pounds per square inch,

t = is thickness of the uptake in thirty-seconds of an inch,

D = is external diameter in inches,

L = is length of the uptake in inches, measured between the circumferential seams.

In no case shall the thickness of an uptake tube be less than 3/8 inch.

599. Cross Tubes

Internal diameter of cross tubes shall not exceed 12 inches. The working pressure of the tubes shall be determined by the following formula:

$$W.P. = \frac{200(t-7)}{D} \qquad \text{Eqn. (XII/35)}$$

where, t = is thickness in thirty-seconds of an inch of the cross tube,

D = is internal diameter in inches of the cross tube.

In no case shall be thickness of a cross tube be less than 5/16 inch.

600. Pads Welded to Shell or the Attachment of Flanged Mountings

The size of outer peripheral fillet welds by which circular pads are attached to shell plates shall be determined by the following formula XII/36, but shall in no case be less than the inner welds or nor less than the minimum specified for plate thickness in Table XII/3:

$$Lo = \frac{2A - D_1 L_1}{D} \qquad \text{Eqn. (XII/36)}$$

where, Lo = is size of fillet weld around outer periphery of pad, in inches,

L_1 = is size fillet weld around inner periphery of pad, in inches,

A = is cross-sectional area of opening in shell (based on minimum thickness in square inches *see* Regulation 571),

Do = is outer diameter of pad, in inches,

D_1 = is inner diameter of pad, in inches.

601. Hydraulic and Hammer Tests

(a) (i) *Class I Boilers*—Each Class I Boiler shall, on completion of all welding and/or repairs and after heat-treatment, be subjected to a hydraulic test of 1.5 times the design pressure without any indication of weakness or defect.

(ii) *Class II and Class III Boilers*—Each Class II and Class III Boilers shall be tested to a pressure twice the design pressure.

(b) (i) The Test shall be witnessed by the Inspecting Authority or Inspecting Officer.

(ii) The test pressure shall be maintained for a period not less than 30 minutes.

It is important in the interest of safety that the boiler be properly vented, so as to prevent the formation of air pockets, before the test pressure as applied.

Notes: 1. It is recommended that the temperature of the water should not be less than 7°C during the hydraulic test.

2. It is further recommended that before the boiler is approached for close examination, the pressure shall be reduced to not less than 1.1 times the design pressure and not more than 0.9 times the hydraulic test pressure.

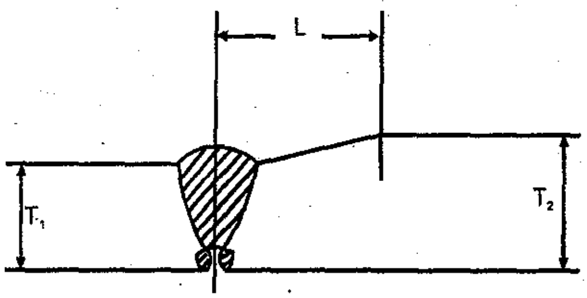
3. On completion of hydraulic test, release of pressure shall be gradual.

4. Deflection of different pressure parts shall be examined carefully and there shall not be any permanent set after release of pressure.

(c) If any repairs are found to be necessary during or subsequent to the hydraulic pressure test, the boiler shall again be subjected to the pressure test specified above after completion of the repairs and after any heat treatment.

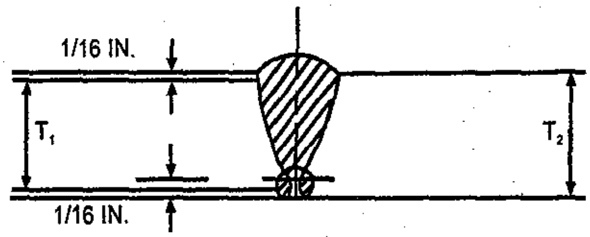
Note: Observations and remarks of Inspecting Officer/Inspecting Authority should be recorded for filming with maker's papers.

CROSS SEAMS IN END PLATES



L = 8 (T_2–T_1) BUT NOT LESS THAN 1½ IN.

FIG. XII/1



WHERE (T_2–T_1) DOES NOT EXCEED 1/8 IN.

FIG. XII/2

GOUGED OUT BEFORE APPLYING WELD FROM SECOND SIDE

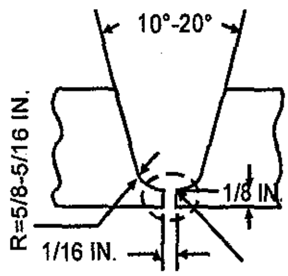


FIG. XII/3

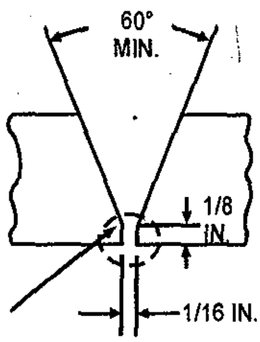


FIG. XII/4

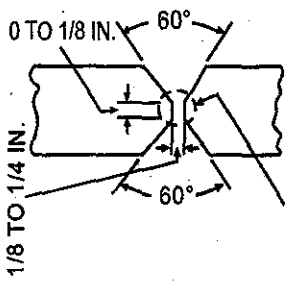


FIG. XII/5

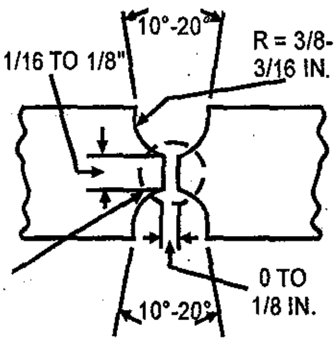


FIG. XII/6

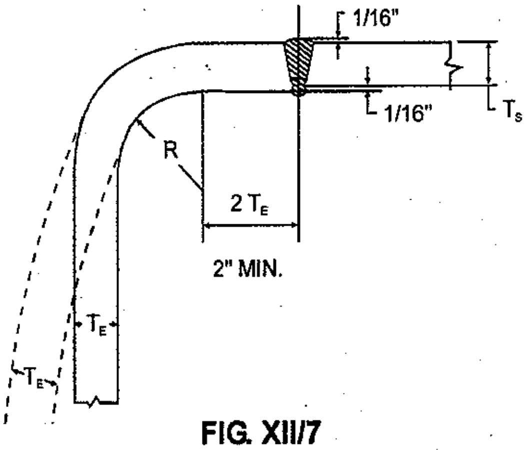


FIG. XII/7

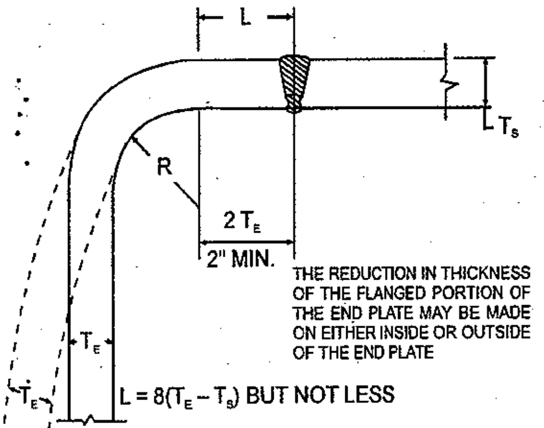


FIG. XII/8 — FLANGED END PLATES ENDS THICKER THAN SHELL

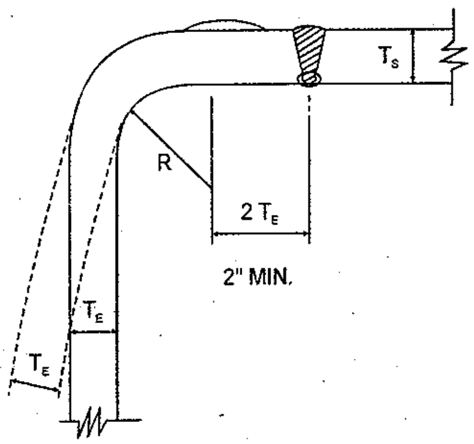


FIG. XII/9 — FLANGED END PLATES ENDS THICKER THAN SHELL

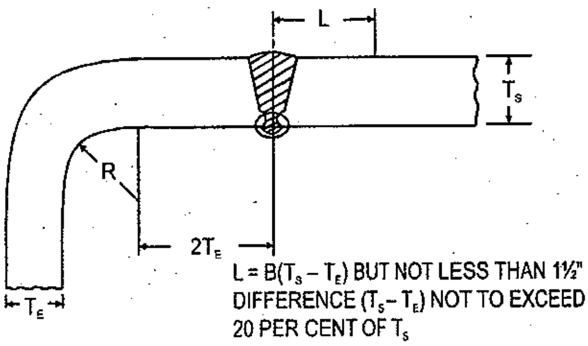


FIG. XII/10 — FLANGED FLAT END PLATES

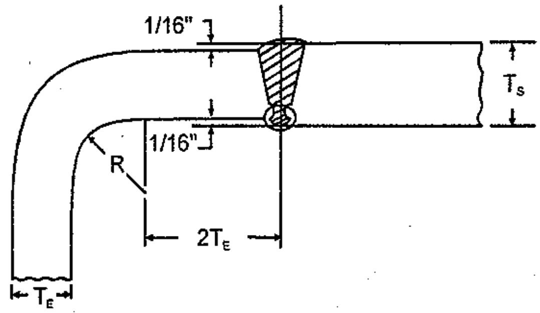


FIG. XII/11 — FLANGED FLAT END PLATES TO SHELL (SHELL THICKER THAN ENDS)

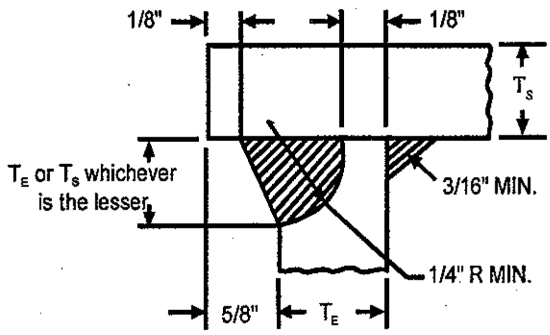
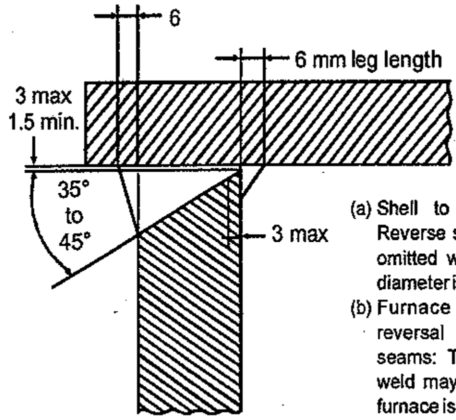


FIG. XII/12 — FLAT END

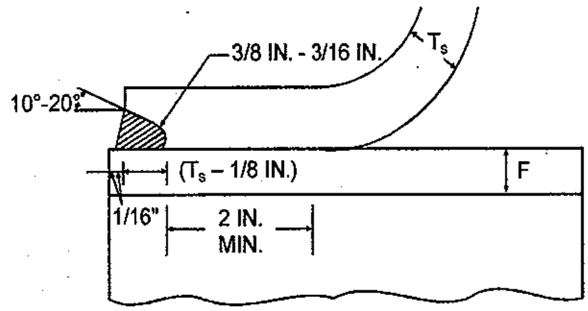


(a) Shell to end plate seams : Reverse side fillet weld may be omitted when the shell outside diameter is less than 1800 mm.

(b) Furnace to end plate and reversal chamber tube plate seams: The reverse side fillet weld may be omitted when the furnace is less than 750 mm. outside diameter and the seam is protected by a refractory lining.

Note : The above requirements for reverse side fillet welds are dictated by consideration of accessibility for welding but whenever it is generally practicable to insert a fillet weld of the requisite quality for full circumstances of the seam then the weld should be inserted. It is preferable to complete the fillet weld before welding from the other side whenever it is practicable to do so.

FIG. XII/12A



THE USE OF MIN. ANGLE SHOULD ASSOCIATED WITH MAX. RADIUS OF 3/8 IN. CONVERSELY THE MAX. ANGLE SHOULD BE ASSOCIATED WITH MIN. RADIUS R OF 3/16 IN.

FIG. XII/13 — ATTACHMENT OF FLUES TO END PLATES—DISHED OR FLAT

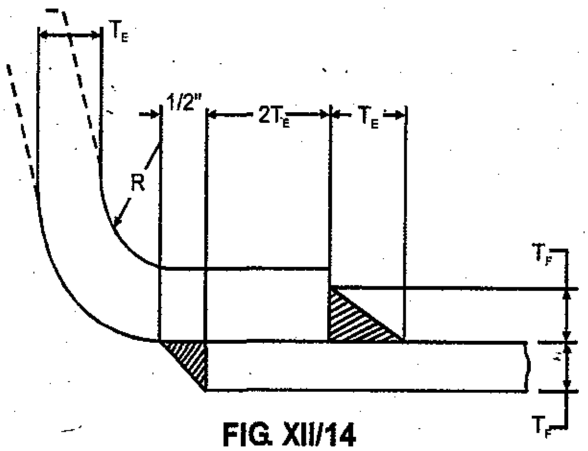


FIG. XII/14

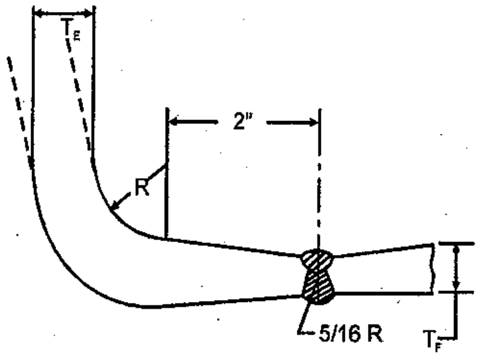


FIG. XII/15—FLUE CONNECTIONS TO END PLATES (DISHED OR FLAT)

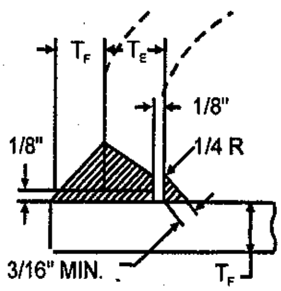
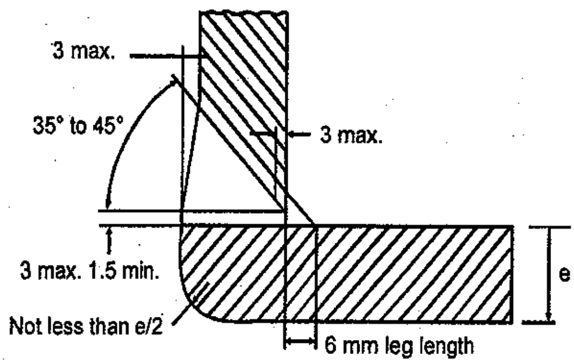


FIG. XII/16 — FLUE CONNECTIONS TO END PLATES (DISHED OR FLAT)



Note: 1. The plate edge radius of not less than e/2 is only required when furnace end is exposed to a flame or comparably high temperature, e.g., at the entry to the reversal chamber.

2. The front end of the furnace can protrude beyond the weld provided that the protrusion and the weld area are adequately insulated to prevent overheating. All dimensions are in millimeters. Attachment of furnace to end plate or reversal chamber.

FIG. XII/16A

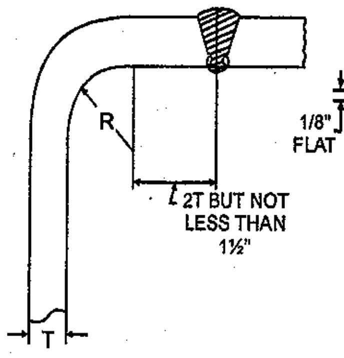


FIG. XII/17

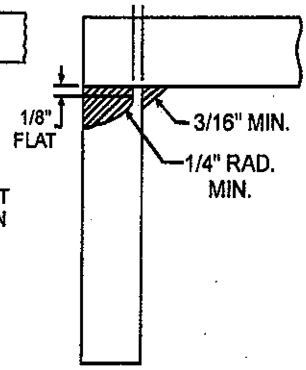
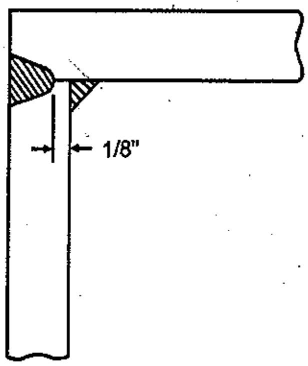


FIG. XII/18



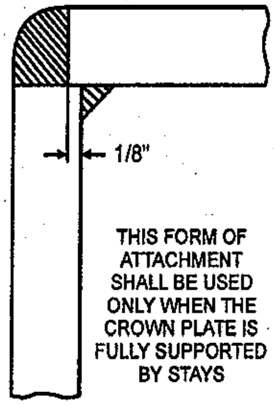


FIG. XII/19 **FIG. XII/20**

ATTACHMENT OF END PLATES TO COMBUSTION CHAMBER ENDS OR FIREBOX WRAPPER PLATES

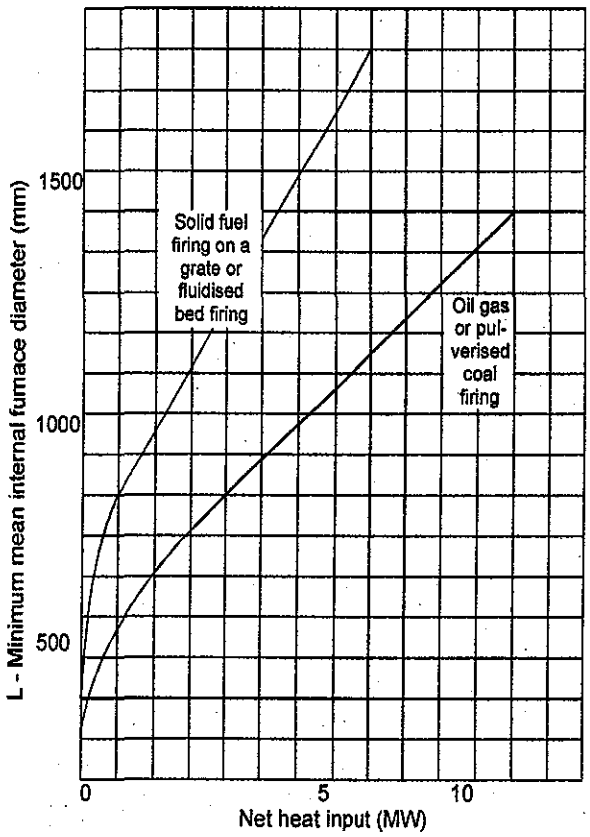


FIG. XII/20A — RELATIONSHIP BETWEEN FURNACE DIAMETER AND PERMISSIBLE HEAT INPUT

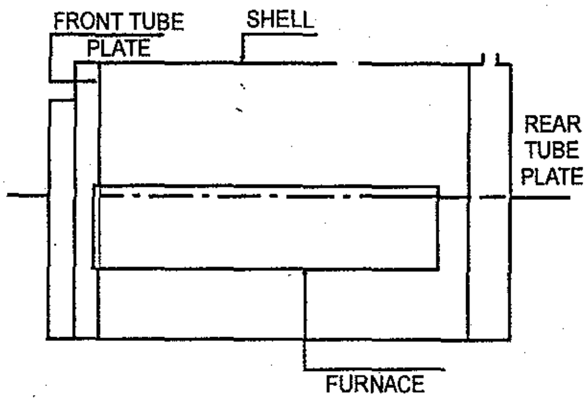


FIG. XII/20B — REVERSE FIRED BOILER

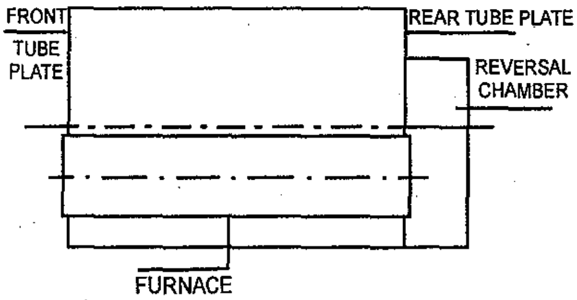


FIG. XII/20C — DRY BACK BOILER

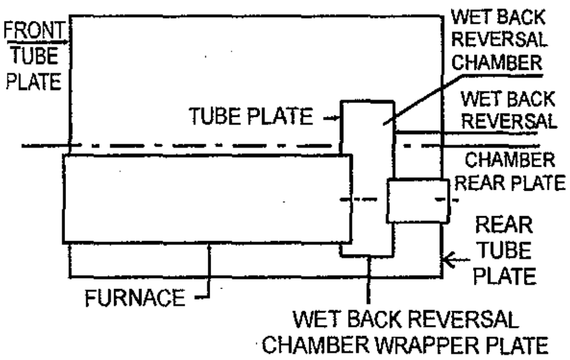
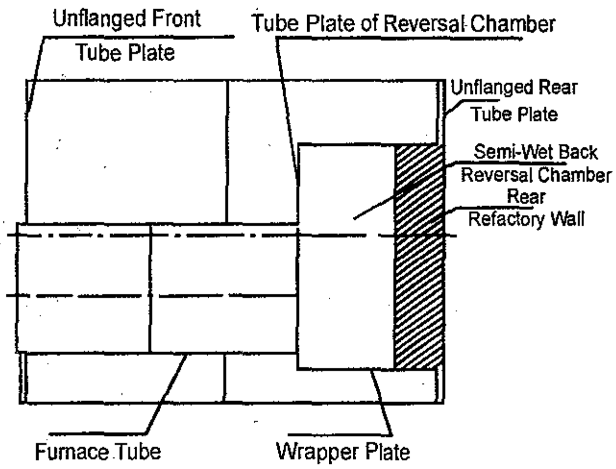


FIG. XII/20D — WET BACK BOILER



NOTE : RADIANT HEATING SURFACE COMPRISES FURNACE TUBE AND WRAPPER PLATE

FIG. XII/20E — SEMI-WET BACK BOILER

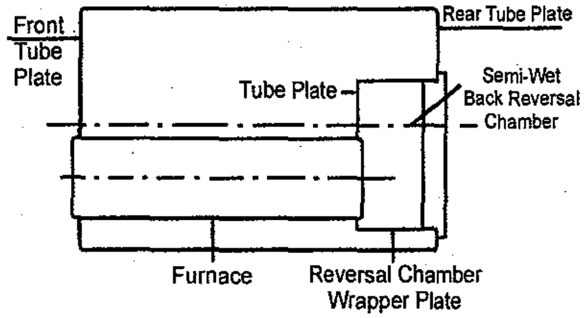


FIG. XII/20F — SEMI-WET BACK BOILER

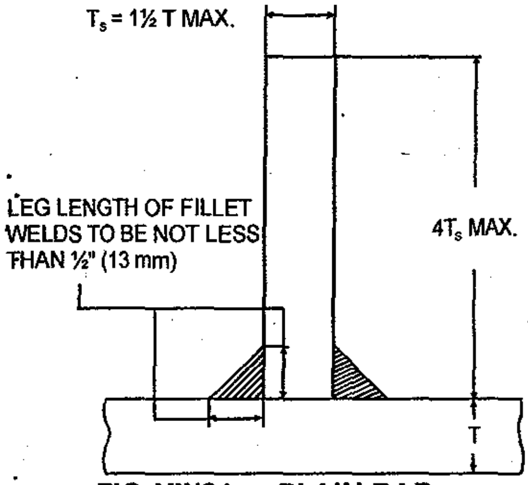


FIG. XII/21 — PLAIN BAR

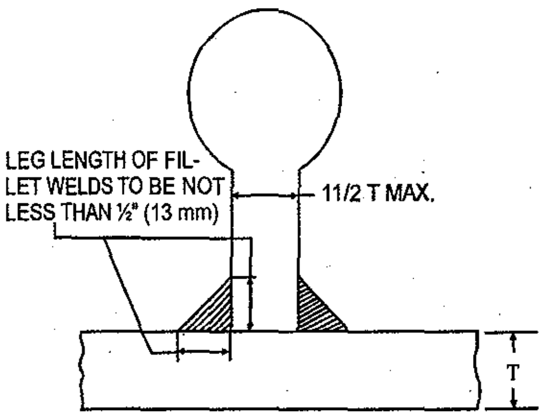


FIG. XII/22 — BULB BAR
STIFFENERS FOR HORIZONTAL FLUES

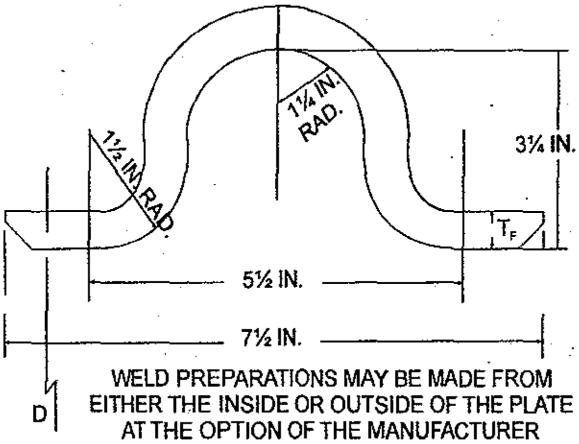
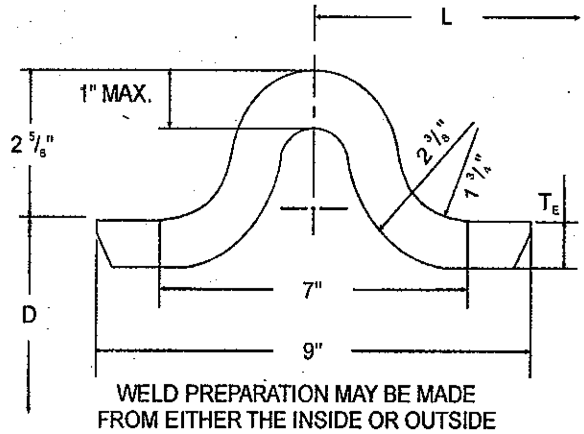


FIG. XII/23 — BOWLING HOOP



WELD PREPARATION MAY BE MADE FROM EITHER THE INSIDE OR OUTSIDE OF THE PLATE AT THE OPTION OF THE MANUFACTURER.

FIG. XII/24 — BOWLING HOOP

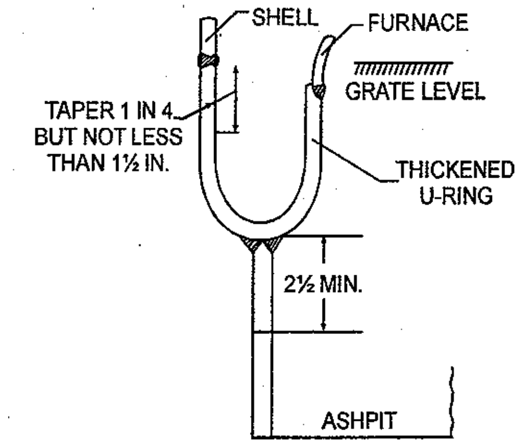


FIG. XII/28

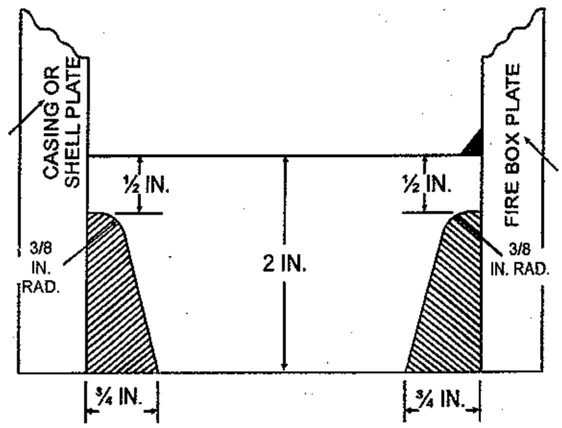
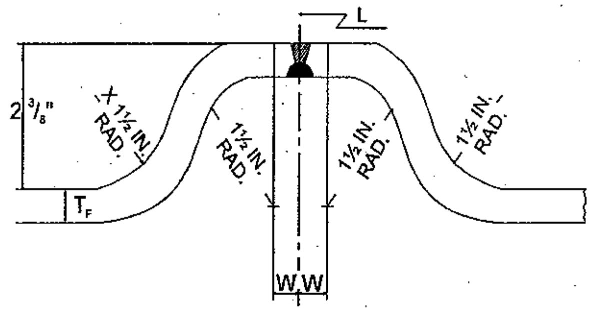
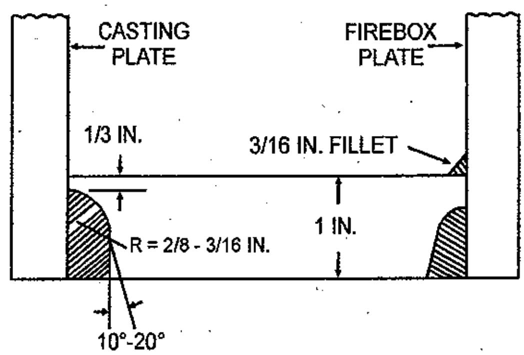


FIG. XII/29 — FOUNDATION RINGS



W=T - 1/8 IN. BUT NOT LESS THAN ½ IN

FIG. XII/25 — DETAIL FLUE JOINT



PERMITTED ONLY ON LOCOTYPE BOILERS WITH FULLY SUPPORTED FIREBOX SHOWN IN FIG. XII/78
THE USE OF MIN. ANGLE SHOULD BE ASSOCIATED WITH MAX. RADIUS R. OF 3/8 IN. CONVERSELY. THE MAX. ANGLE SHOULD BE ASSOCIATED WITH MIN. RADIUS R. OF 3/16 IN.

FIG. XII/30 — FOUNDATION RINGS

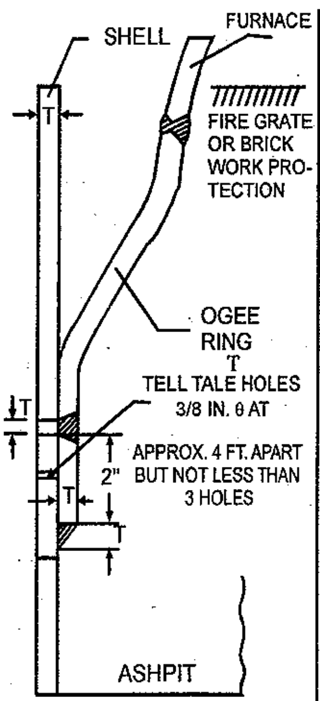


FIG. XII/26

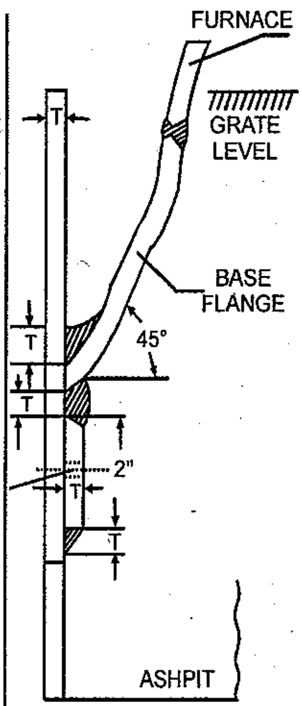
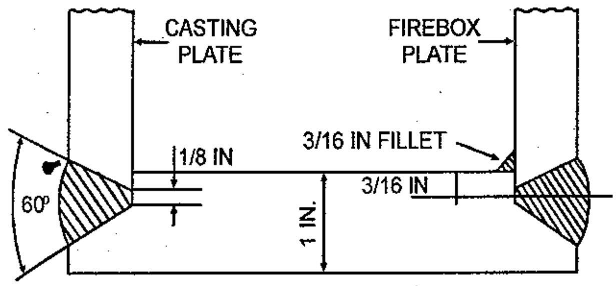


FIG. XII/27



PERMITTED ONLY ON LOCOTYPE BOILERS WITH FULLY SUPPORTED FIREBOX SHOWN IN FIG. XII/78

FIG. XII/31 — FOUNDATION RINGS

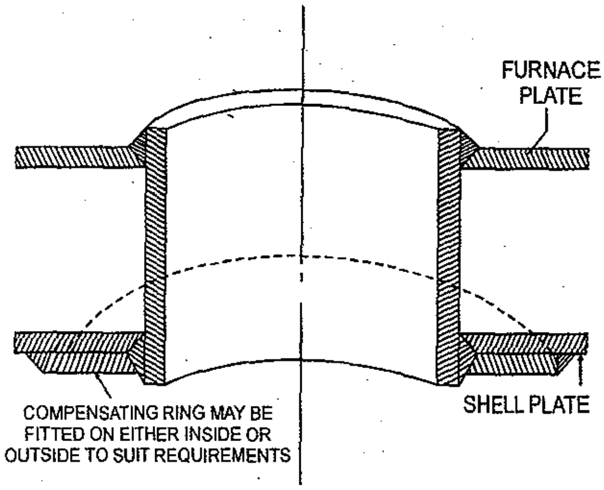


FIG. XII/ 32 — FIREHOLE MOUTHPIECE

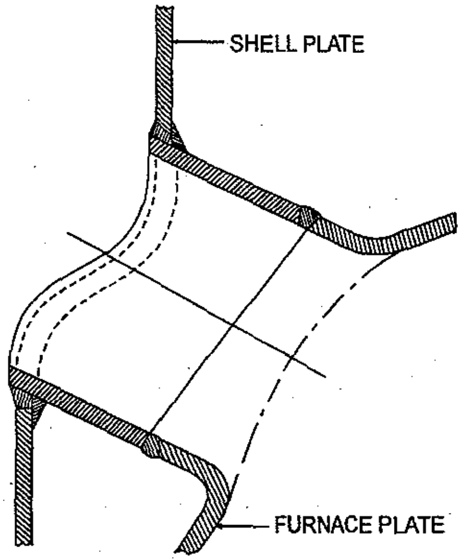


FIG. XII/36 — THROAT PIECE

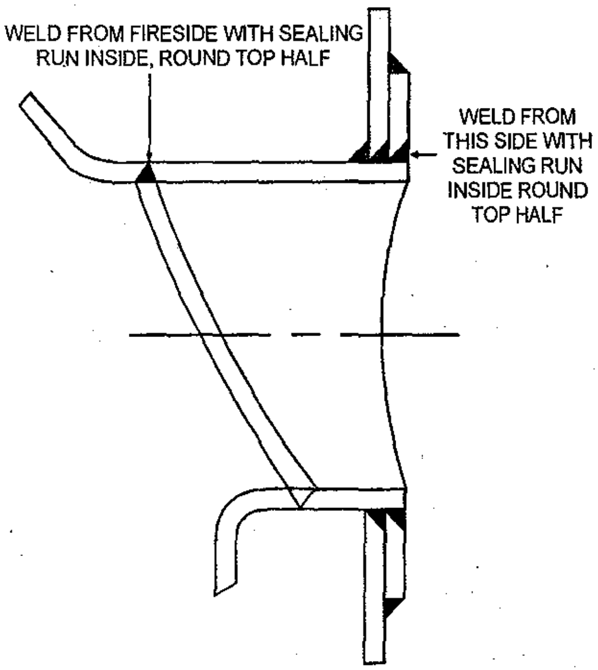
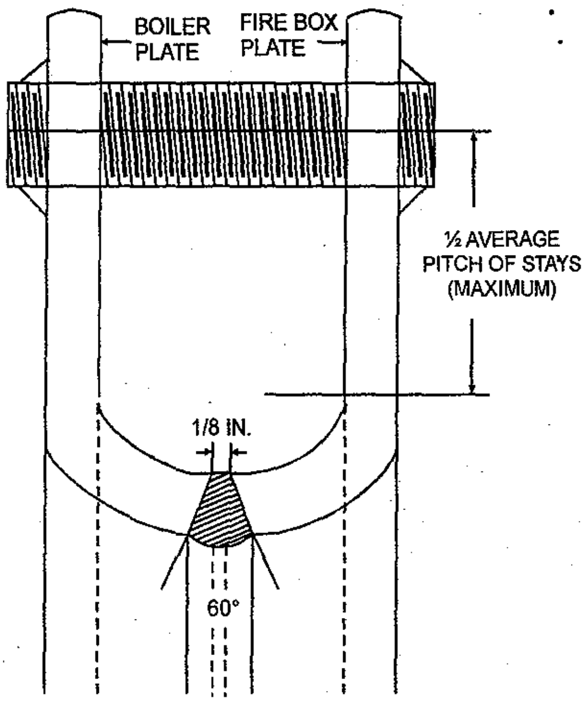


FIG. XII/33 — FIREHOLE MOUTHPIECE



CONNECTION BETWEEN FLAT PLATES TO FORM FIREHOLE AND ACCESS OPENINGS

FIG. XII/37

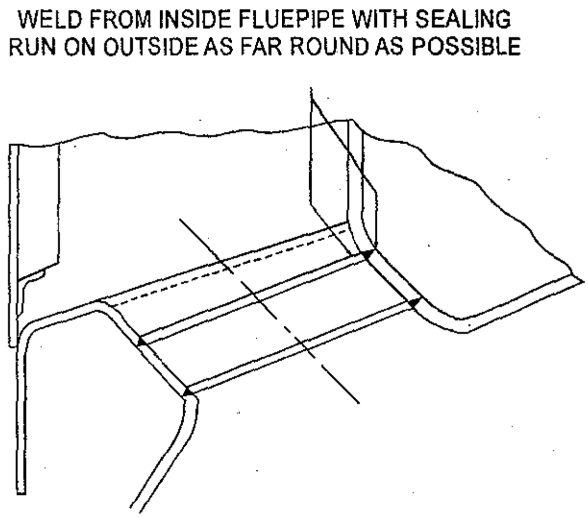
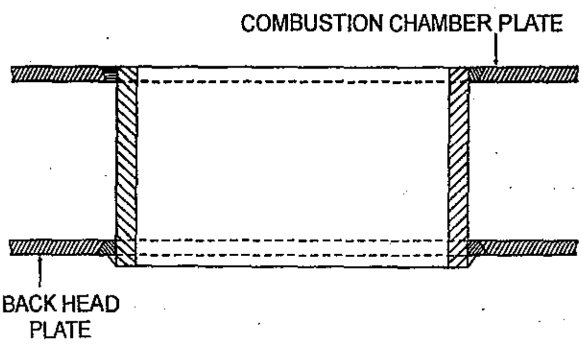


FIG. XII/35 — WELDING OF FLUE PIPES



ACCESS OPENING FOR WET-BACK BOILERS

FIG. XII/38

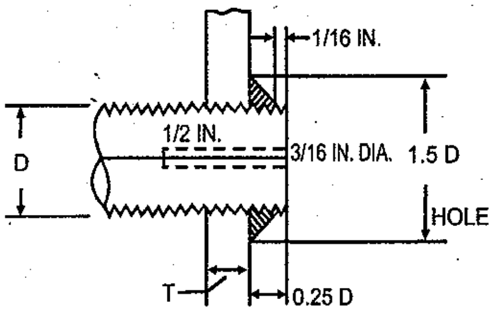


FIG. XII/39 — ATTACHMENT OF FIREBOX AND COMBUSTION CHAMBER STAYS

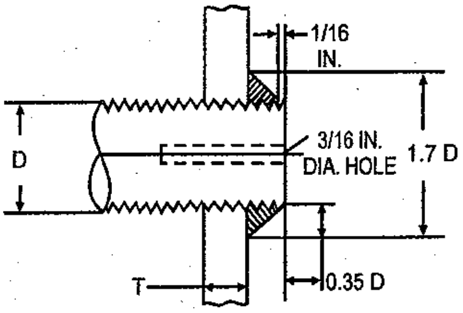


FIG. XII/40 — ATTACHMENT OF FIREBOX AND COMBUSTION CHAMBER STAYS

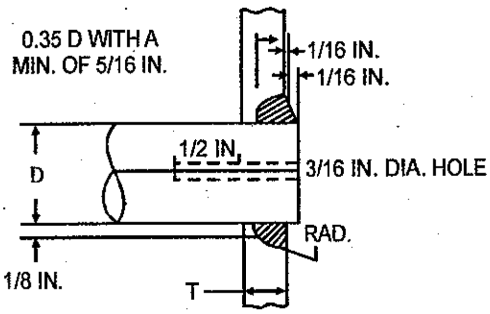


FIG. XII/41 — ATTACHMENT OF FIREBOX AND COMBUSTION CHAMBER STAYS

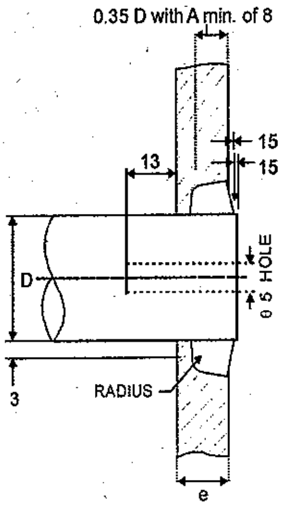


FIG. A

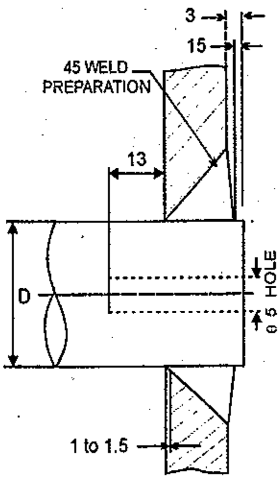


FIG. B

All dimensions are in mm

Note: This type of attachment is recommended for Plain Bar Stay.

FIG. XII/41A — ATTACHMENT OF FIREBOX AND REVERSAL CHAMBER

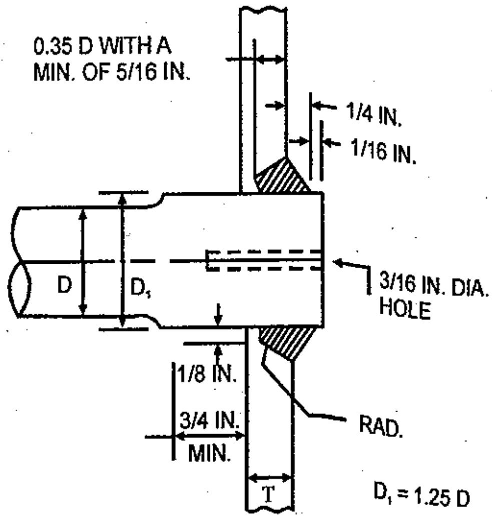


FIG. XII/42 — ATTACHMENT OF BAR STAYS

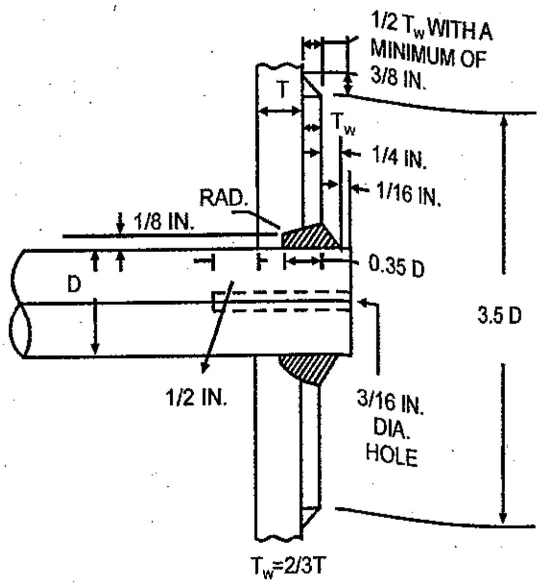


FIG. XII/43(a) — ATTACHMENT OF BAR STAYS

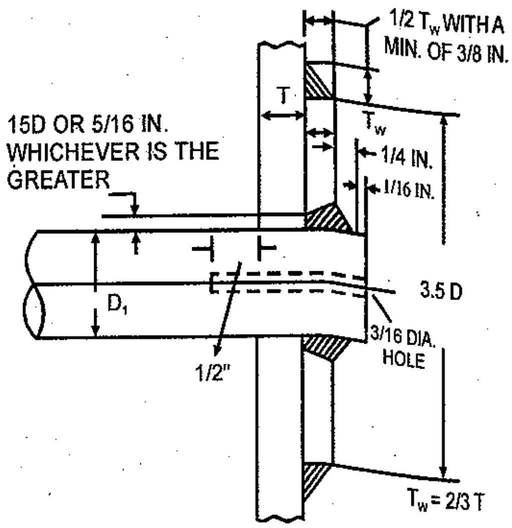


FIG. XII/43(b) — ATTACHMENT OF BAR STAYS

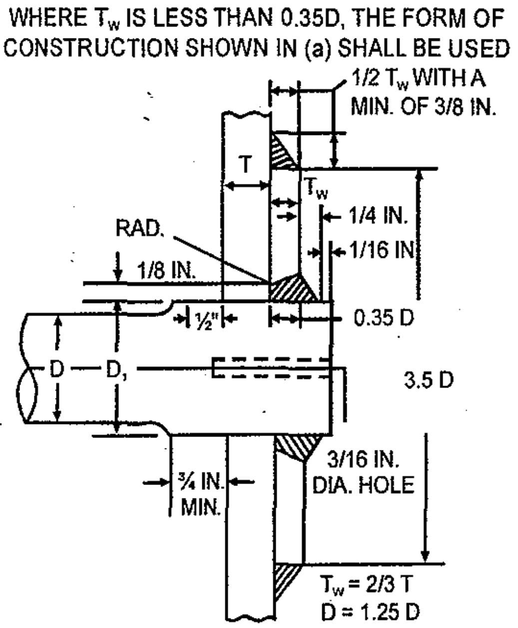


FIG. XII/44(a) — ATTACHMENT OF BAR STAYS

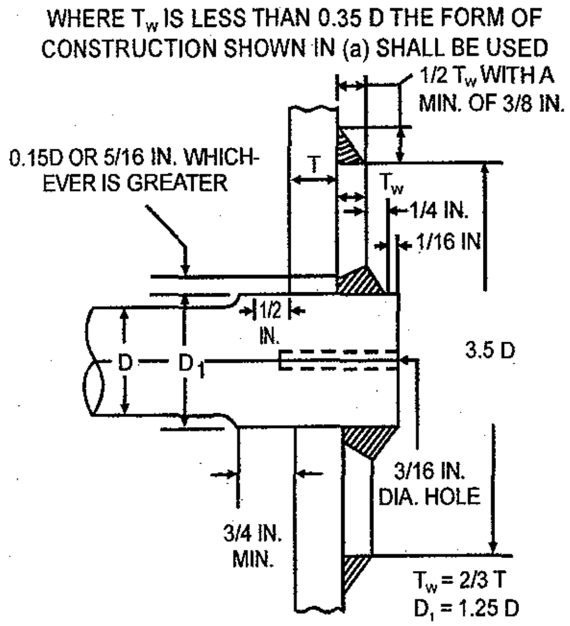


FIG. XII/44(b) — ATTACHMENT OF BAR STAYS

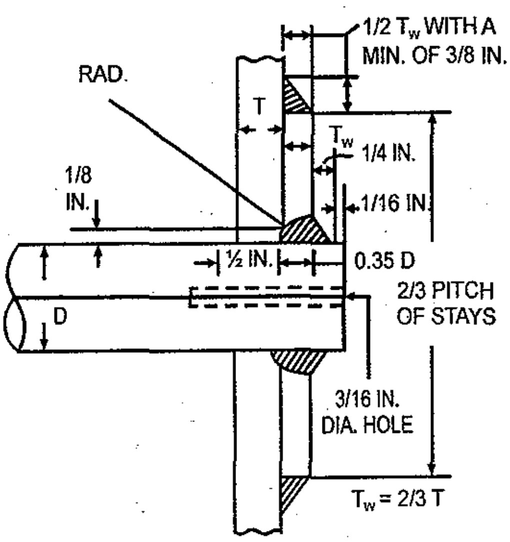


FIG. XII/45(a) — ATTACHMENT OF BAR STAYS

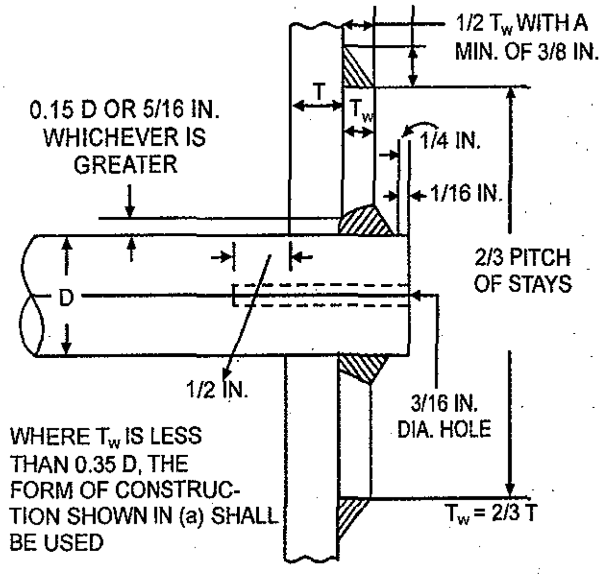


FIG. XII/45 (b) — ATTACHMENT OF BAR STAYS

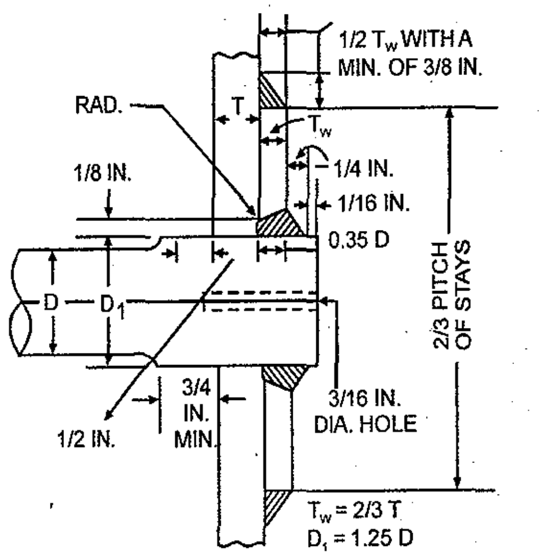


FIG. XII/46 (a) — ATTACHMENT OF BAR STAYS

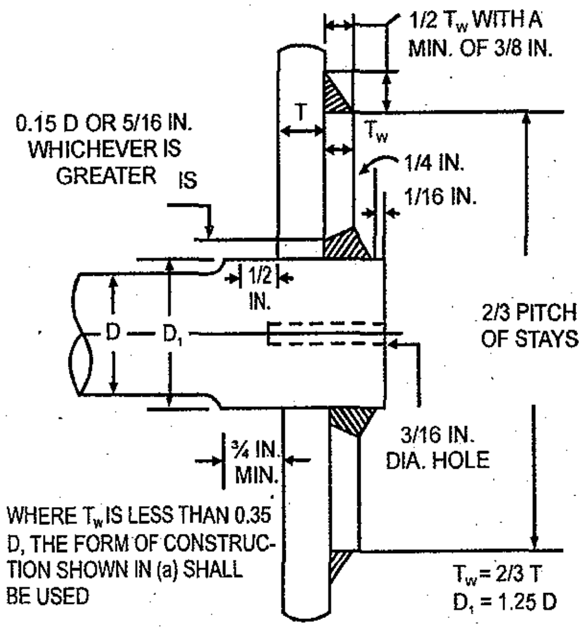


FIG. XII/46(b) — ATTACHMENT OF BAR STAYS

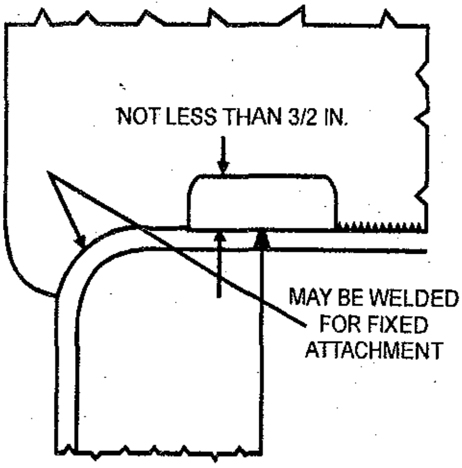


FIG. XII/47*

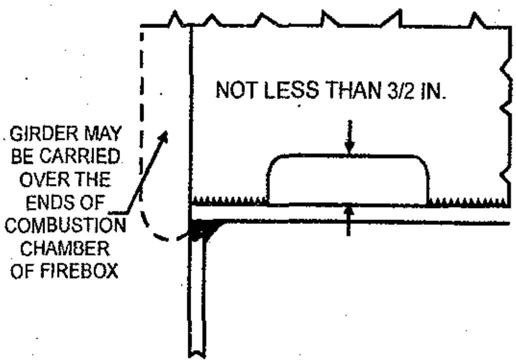


FIG. XII/48*

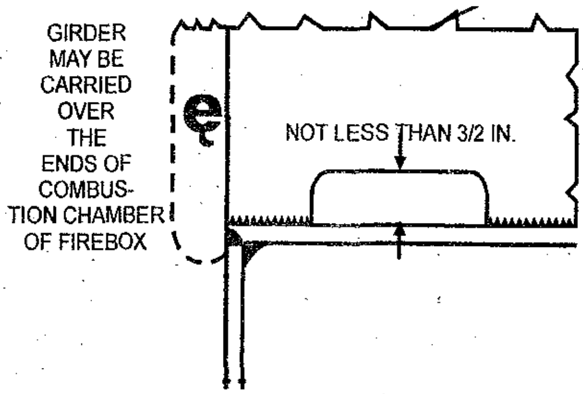


FIG. XII/49*

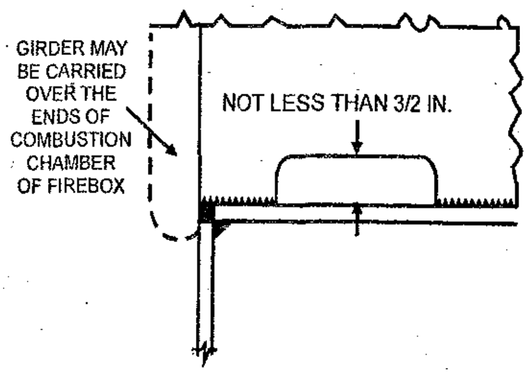


FIG. XII/50*

***TYPICAL METHODS OF FITTING WELDED GRINDERS TO WELDED COMBUSTION CHAMBERS AND FIREBOXES**

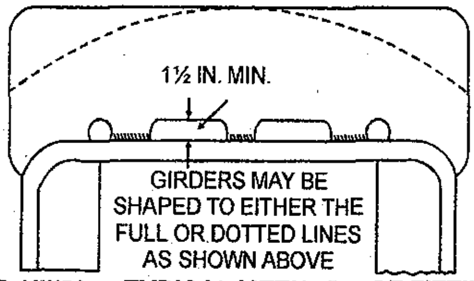


FIG. XII/51 — TYPICAL METHODS OF FITTING WELDED GRINDERS TO WELDED COMBUSTION CHAMBERS AND FIREBOXES

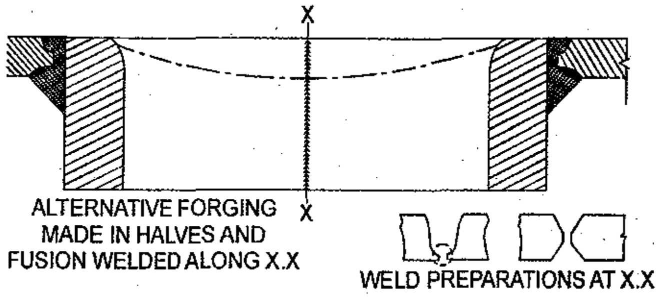


FIG. XII/52 — FUSION WELDED OVAL MANHOLE FRAME

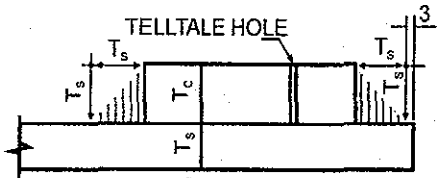


FIG. XII/53

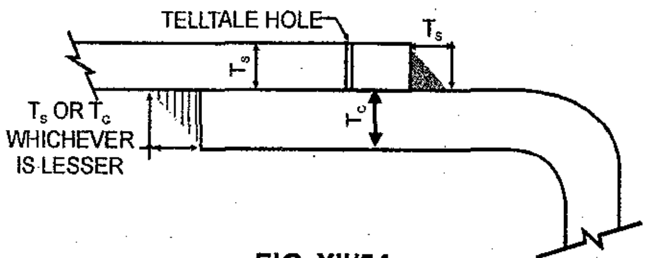


FIG. XII/54

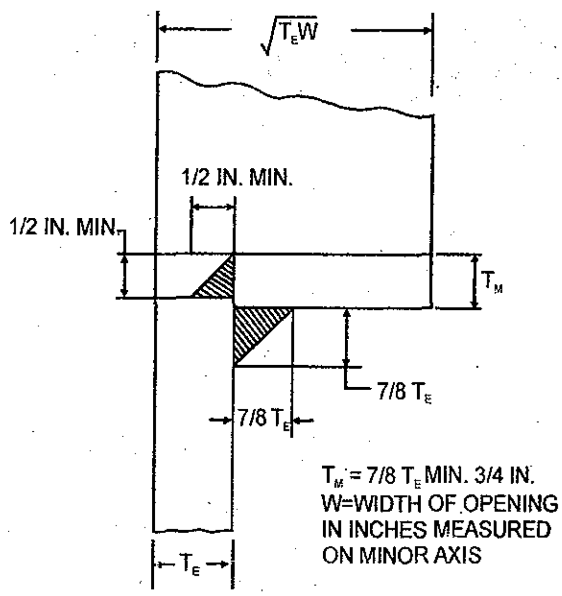


FIG. XII/55 — WELDING DETAIL FOR MANHOLE IN FLAT END PLATE

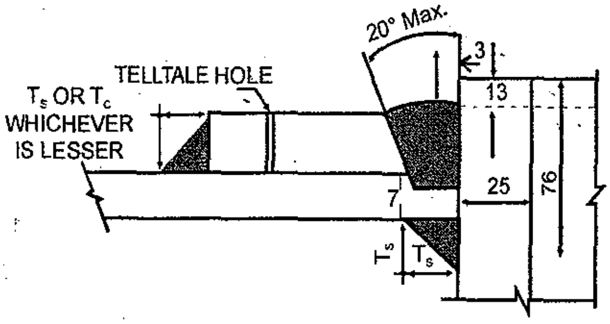


FIG. XII/56

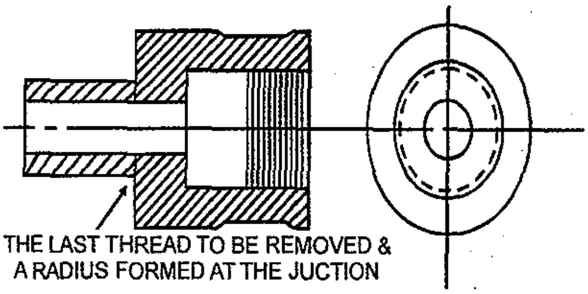
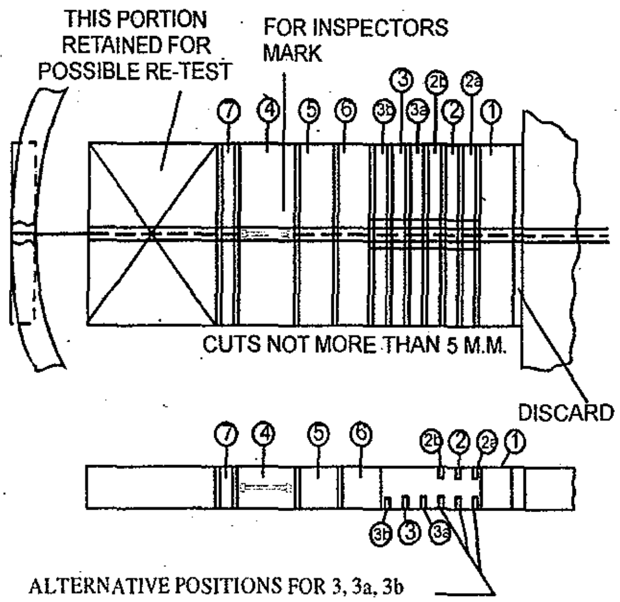


FIG. XII/57 — TYPICAL MILD STEEL DISTANCE PIECE FOR MOUNTINGS



1. TENSILE TEST FOR SEAM.
2. IMPACT TEST OUTER SURFACE OF PLATE.

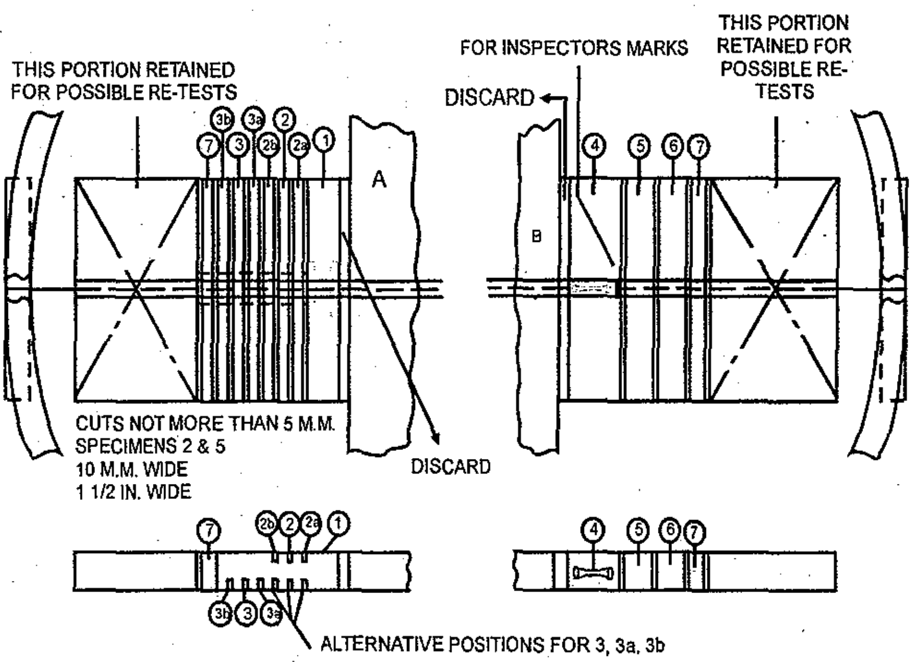
2a & 2b. IMPACT RE-TEST OUTER SURFACE OF PLATE.

3. IMPACT TEST INNER SURFACE OF PLATE.

3a & 3b. IMPACT RE-TEST INNER SURFACE OF PLATE.

4. TENSILE TEST FOR ALL-WELD METAL.
5. NORMAL BEND TEST—OUTER SURFACE IN TENSION.
6. REVERSE BEND TEST—INNER SURFACE IN TENSION.
7. MICRO AND MACRO TESTS.

FIG. XII/58 — DETAILS OF TEST PLATES



1. TENSILE TEST FOR SEAM.
2. IMPACT TEST OUTER SURFACE OF PLATE.

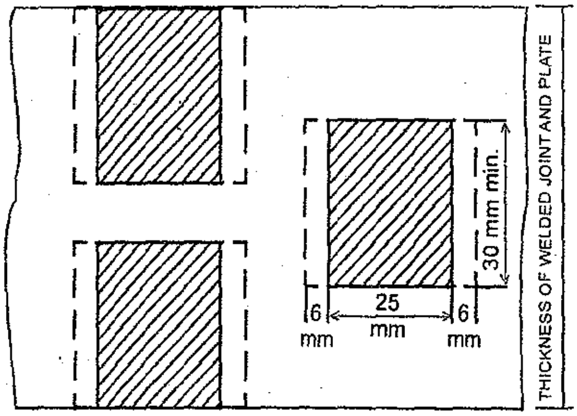
2a & 2b. IMPACT RE-TEST OUTER SURFACE OF PLATE.

3. IMPACT TEST INNER SURFACE OF PLATE.

3a&3b. IMPACT RE-TEST INNER SURFACE OF PLATE.

4. TENSILE TEST FOR ALL-WELD METAL.
5. NORMAL BEND TEST—OUTER SURFACE IN TENSION.
6. REVERSE BEND TEST—INNER SURFACE IN TENSION.
7. MICRO AND MACRO TESTS.

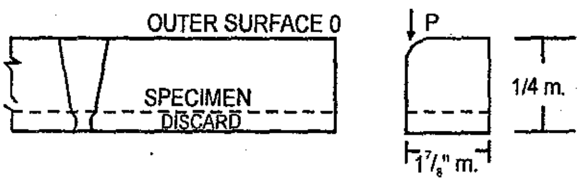
FIG. XII/59



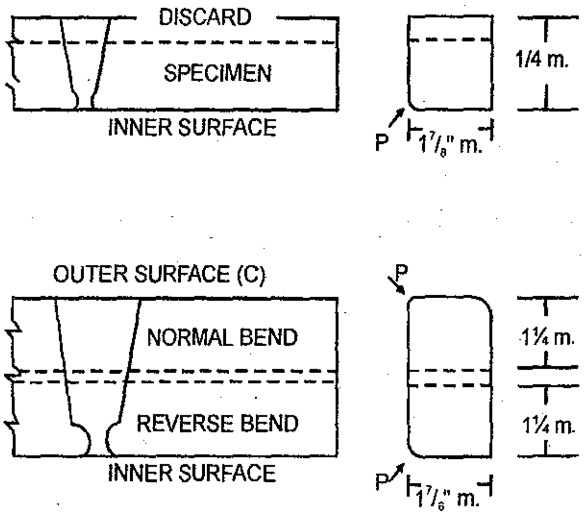
SPECIMEN 1B

FIG. XII/60(B) — REDUCED SECTION TENSILE SPECIMEN IN A THICK PLATE

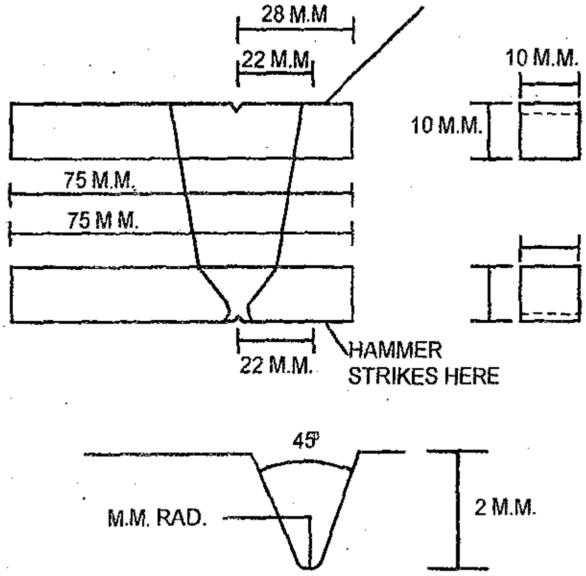
RADIUS 10% OF T (THICKNESS OF THE SPECIMEN)



A — NORMAL BEND SPECIMEN (C)



C = SPECIMEN (C) CUT SINGLE PIECE OF PLATE



ENLARGED VIEW OF NOTCH

SPECIMENS (2) AND (3) IMPACT TEST
FIG. XII/62 — IZOD IMPACT TEST PIECES

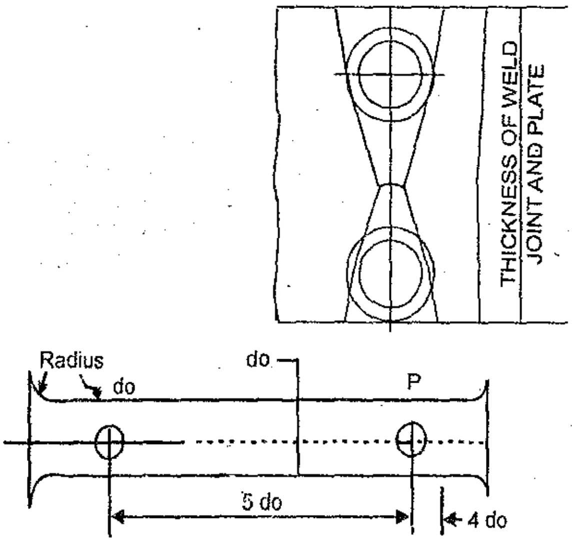
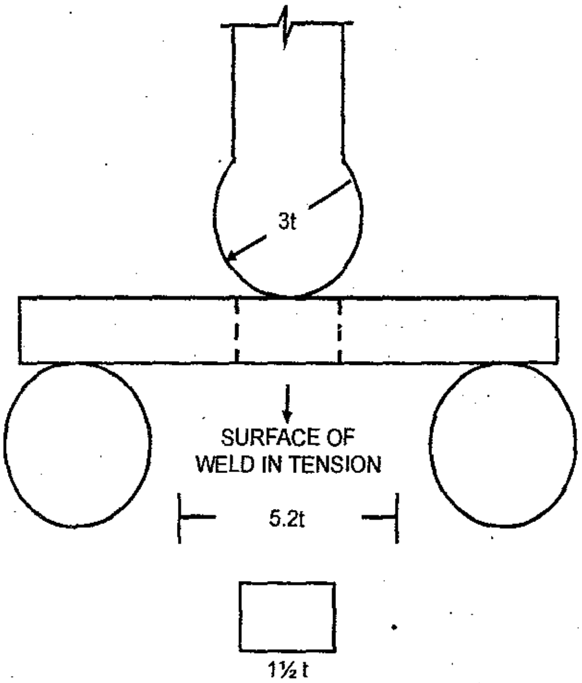
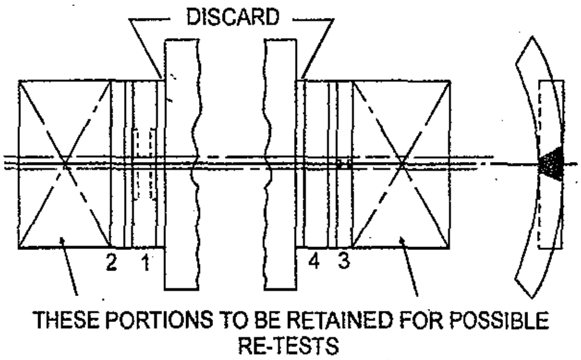


FIG. XII/63 — TENSILE TEST ALL-WELD METAL



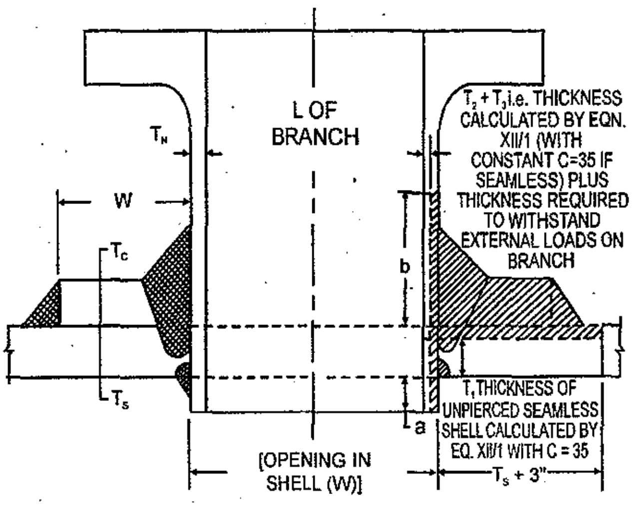
CORNERS ROUNDED TO RADIUS, NOT EXCEEDING 10% SPECIMEN MOUNTED

FIG. XII/64



1. TENSILE TEST FOR WELDED SEAM.
2. BEND TEST — OUTER SURFACE OF THE WELD IN TENSION.
3. BEND TEST — FOR INNER SURFACE.
4. NICK BREAK TEST.

FIG. XII/65 — DETAILS OF TEST PLATES



AREA AVAILABLE FOR COMPENSATION ON EACH SIDE (a+b) NOT GREATER THAN 4"

FIG. XII/66 — COMPENSATION FOR BRANCH

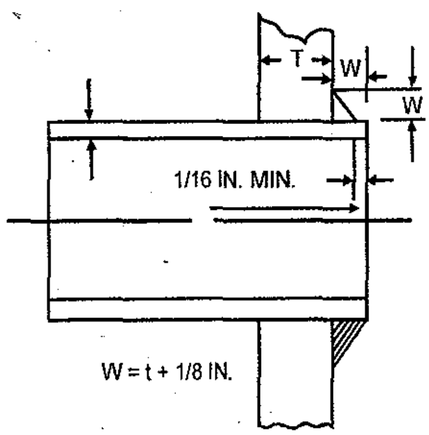
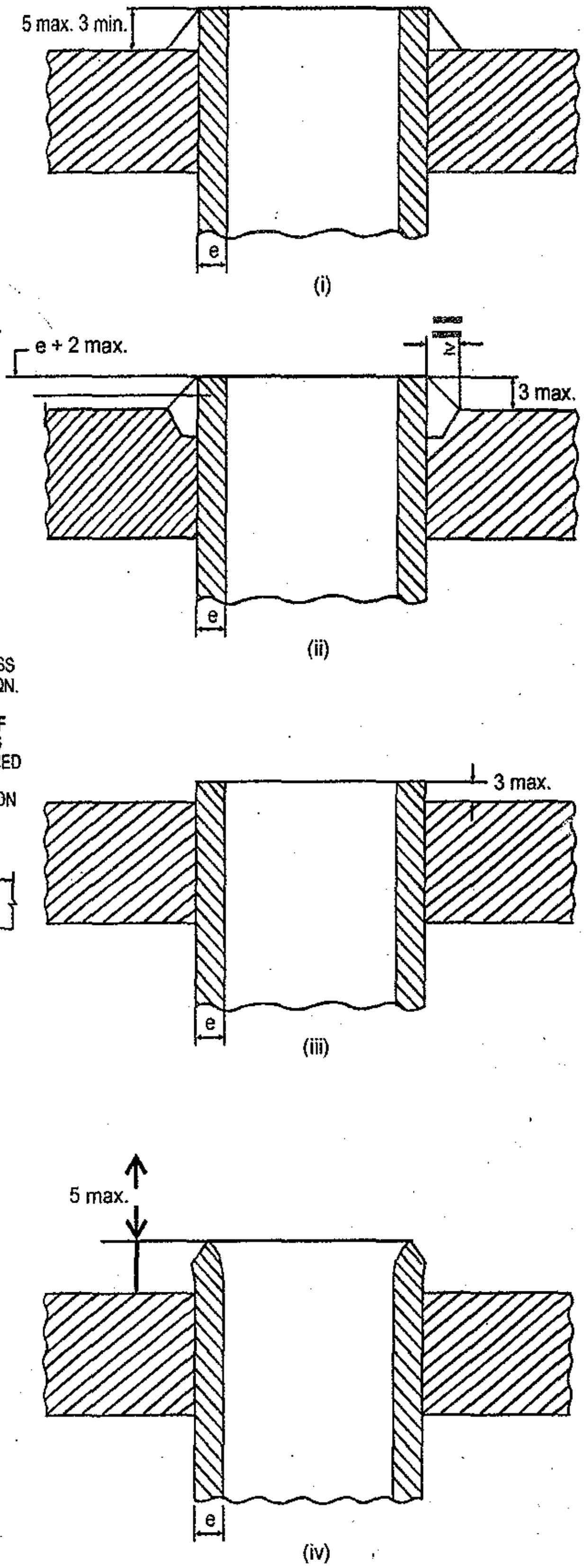


FIG. XII/67 — TUBES TO BE LIGHTLY EXPANDED INTO THE PLATE BEFORE WELDING



All dimensions are in millimetres

FIG. XII/67A — TYPICAL ATTACHMENT OF PLAIN TUBES

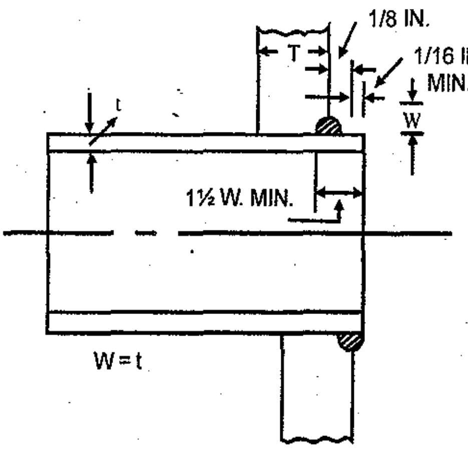
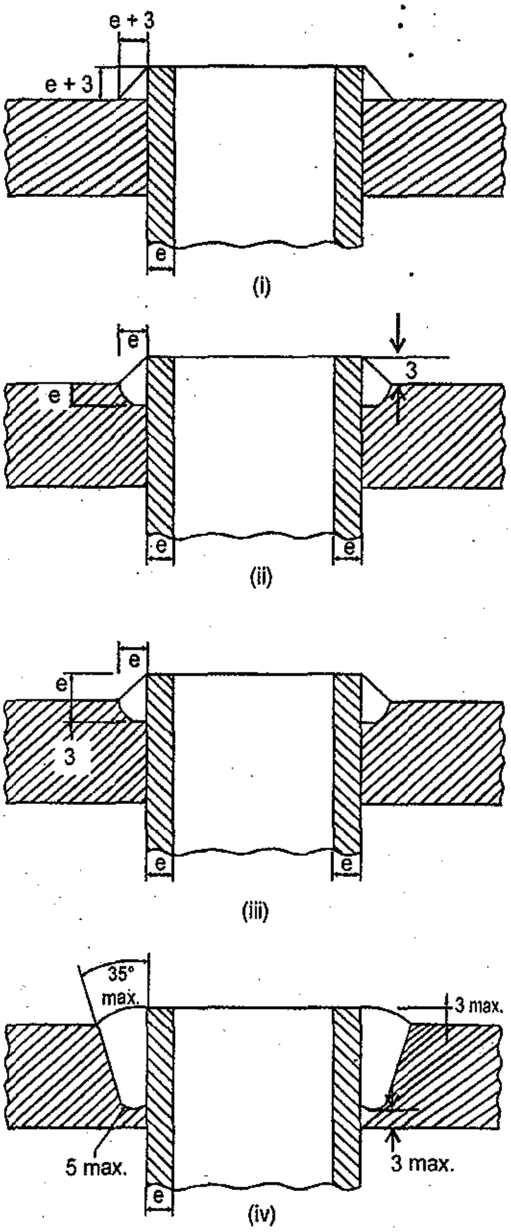
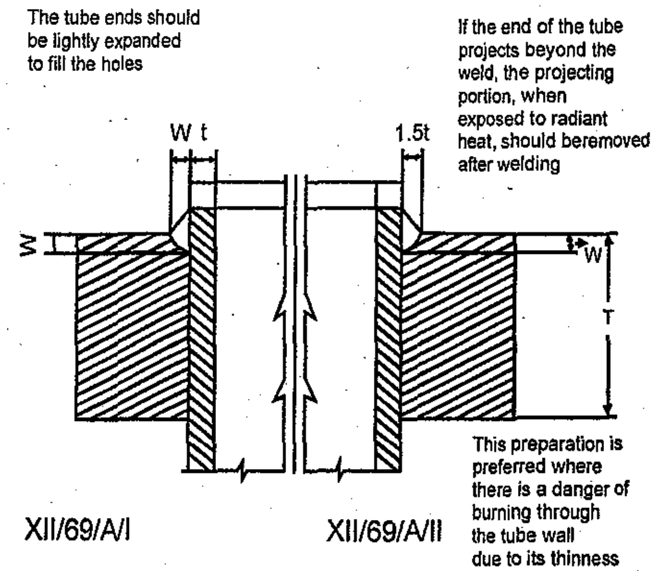


FIG. XII/68 — TUBES TO BE LIGHTLY EXPANDED INTO THE PLATE BEFORE WELDING

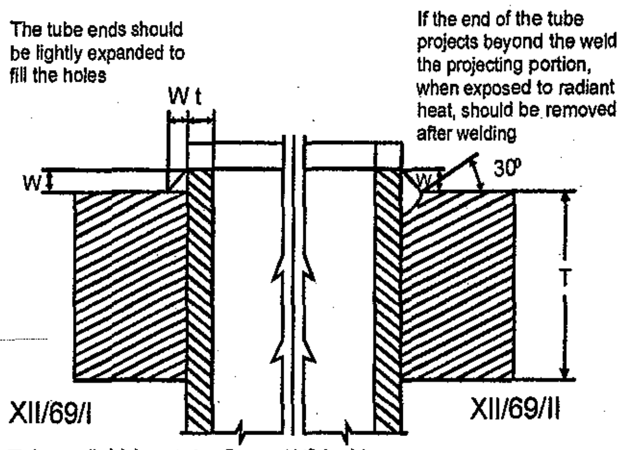


All dimensions are in millimetres

FIG. XII/68A — TYPICAL ATTACHMENT OF STAY TUBES

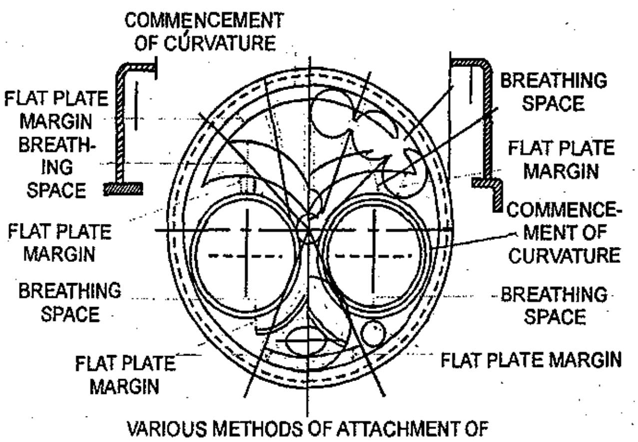


The ends of the tubes together with the reinforcing fillet welds may be removed flush with the surface of the plate, but in this case care must be taken to ensure that dimension W = t min. is maintained.



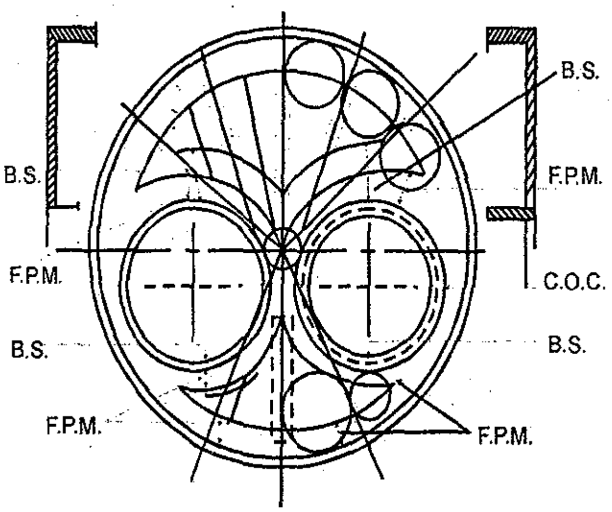
Tube wall thickness $t > 3$ mm (1/8 inch)
Weld size $W > t$ but ≥ 5 mm (3/16 inch). The minimum distance between tubes = 2.5 t or 9 mm (5/16 inch) whichever is lesser.
It may be necessary to deposit the weld in two runs to ensure a tight joint if the operating conditions are onerous.

FIG. XII/69



VARIOUS METHODS OF ATTACHMENT OF END PLATES TO SHELL AND FURNACE

FIG. XII/70 — TYPICAL ARRANGEMENT OF END PLATES ON LANCASHIRE BOILERS



SEE REG. 545 FOR VARIOUS METHODS OF ATTACHMENT OF END PLATES TO SHELL AND FURNACE

F.P.M. : FLAT PLATE MARGIN
B.S. : BREATHING SPACE
C.O.C. : COMMENCEMENT OF CURVATURE.

FIG. XII/71 — TYPICAL ARRANGEMENT OF END PLATES ON LANCASHIRE BOILERS

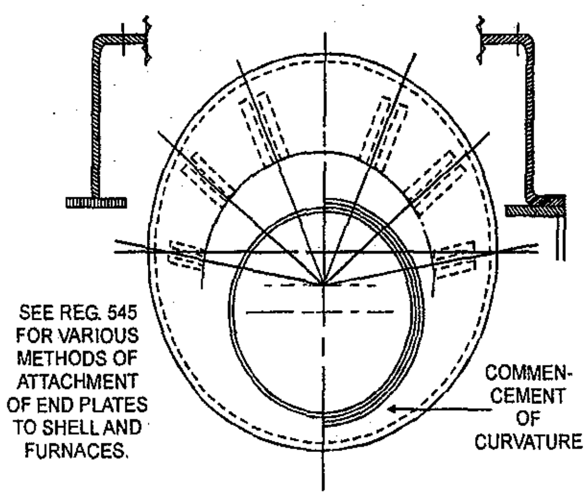


FIG. XII/72 — TYPICAL ARRANGEMENT OF END PLATES ON CORNISH BOILERS

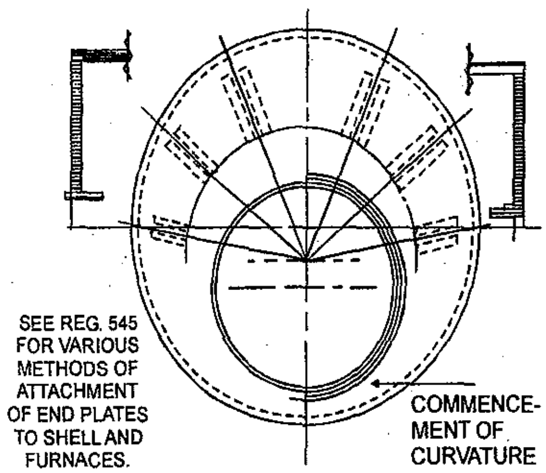
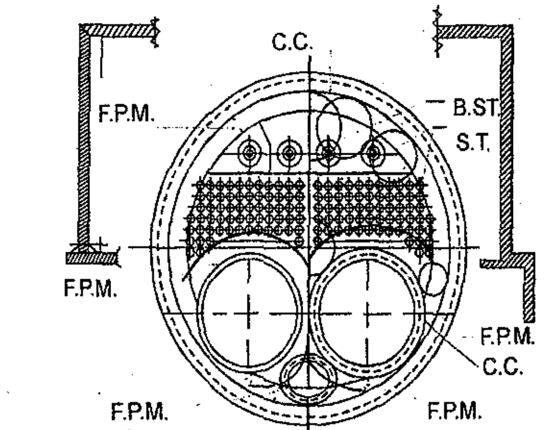
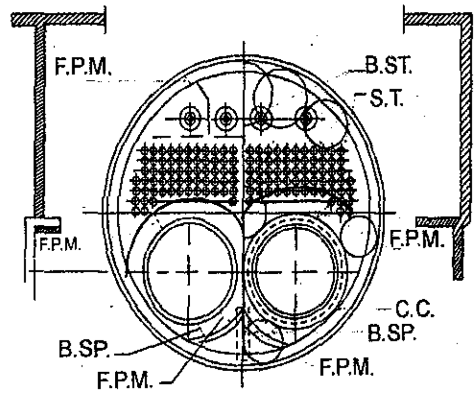


FIG. XII/73 — TYPICAL ARRANGEMENT OF END PLATES ON CORNISH BOILERS



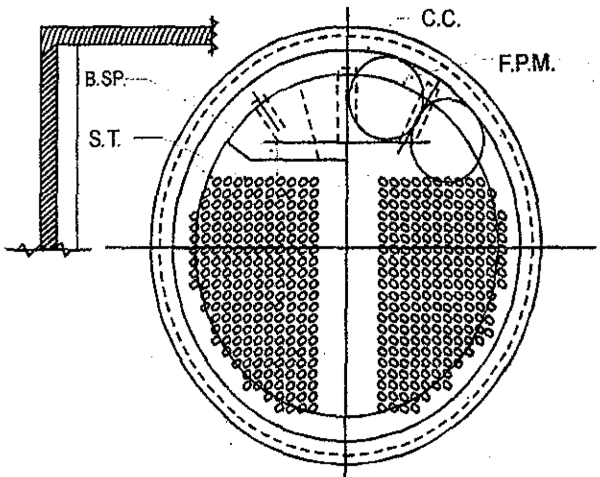
F.P.M. - FLAT PLATE MARGIN
C.C. - COMMENCEMENT OF CURVATURE
B.SP. - BREATHING SPACE
B.ST. - BAR STAY
S.T. - STAY TUBES

FIG. XII/74* — TYPICAL ARRANGEMENT OF END PLATES OF ECONOMIC BOILERS



F.P.M. - FLAT PLATE MARGIN
C.C. - COMMENCEMENT OF CURVATURE
B.SP. - BREATHING SPACE
S.T. - STAY TUBES
B.ST. - BAR STAYS

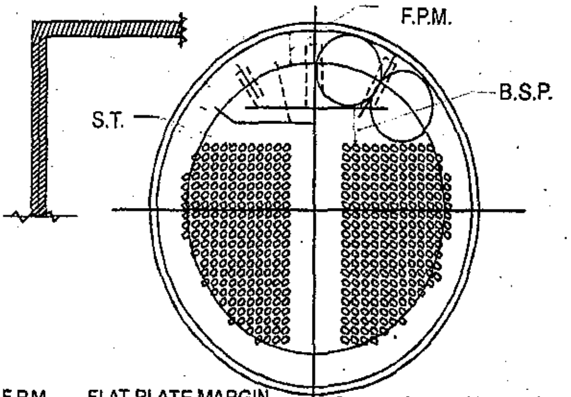
FIG. XII/75* — TYPICAL ARRANGEMENT OF END PLATES ON ECONOMIC BOILERS



F.P.M. - FLAT PLATE MARGIN
C.C. - COMMENCEMENT OF CURVATURE
B.SP. - BREATHING SPACE
S.T. - STAY TUBES

FIG. XII/76* — TYPICAL ARRANGEMENT OF END PLATES ON MULTI-TUBULAR BOILERS

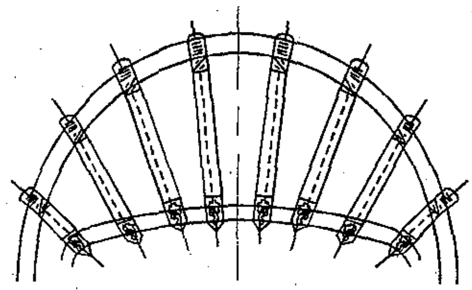
* See Reg. 545 for various methods of attachment of end plates to shell and furnaces



F.P.M. - FLAT PLATE MARGIN
B.S.P. - BREATHING SPACE
S.T. - STAY TUBES

SEE REG. 545 FOR VARIOUS METHODS OF ATTACHMENT OF END PLATES TO SHELL

FIG. XII/77 — TYPICAL ARRANGEMENT OF END PLATES ON MULTI-TUBULAR BOILERS



FOR OTHER METHOD OF ATTACHMENT SEE FIGS. XII/39, 40 & 41

FIG. XII/78 — ARRANGEMENT OF FIREBOX CROWN STAYS FOR LOCOTYPE BOILERS

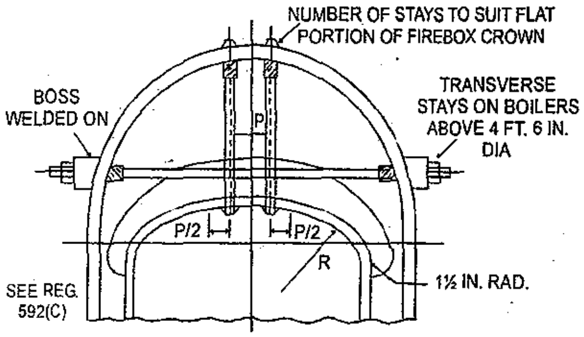
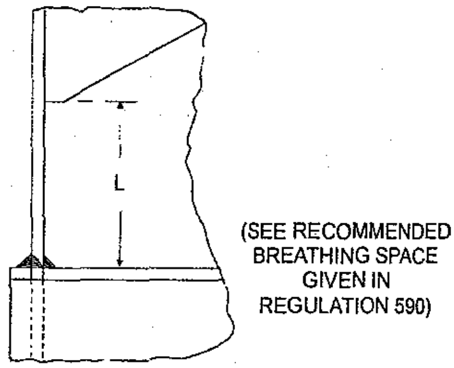


FIG. XII/79 — ARRANGEMENT OF FIREBOX CROWN AND TRANSVERSE STAYS FOR LOCOTYPE BOILERS



NOTE : THIS SKETCH IS DIAGRAMMATIC

FIG. XII/80 — BREATHING SPACE

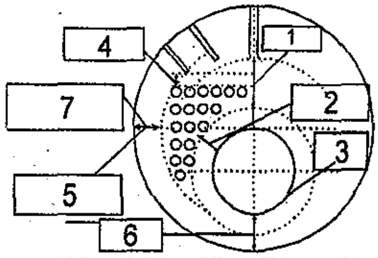


FIG. XII/80A — SOME OF THE BREATHING SPACES IN SMALL TYPE BOILERS

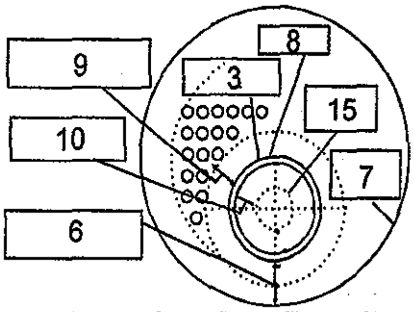


FIG. XII/80B — SOME OF THE BREATHING SPACES OF REVERSIBLE FLAME BOILERS

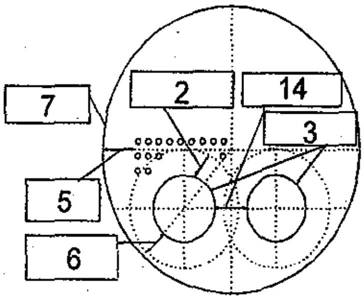


FIG. XII/80C — SOME OF THE BREATHING SPACES IN BOILERS WITH MORE THAN ONE FURNACE

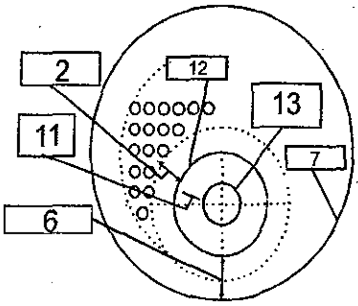


FIG. XII/80D — SOME OF THE BREATHING SPACES OF STEPPED FURNACE

1. B. Sp. between Gusset/Link Stays and Furnace.
2. B. Sp. between Furnace and Tubes/Tube Nest.
3. Outer Diameter of Furnace.
4. B. Sp. between Gusset/Link Stays and Tubes/Tube Nest.
5. B. Sp. between Shell and Tubes/Tube Nest.
6. B. Sp. between Furnace and Shell.
7. Inner Diameter of Shell.
8. Inner diameter of the furnace.
9. B. Sp. at the Front End between Furnace and Tubes/Tube Nest.
10. B. Sp. formed by the outer annular area of the Furnace Rear Plate.
11. Stepping in terms of radius.
12. Outer Dia. of the highest diameter portion of the Stepped Furnace.
13. Outer dia. of the lowest diameter portion of the Stepped Furnace.

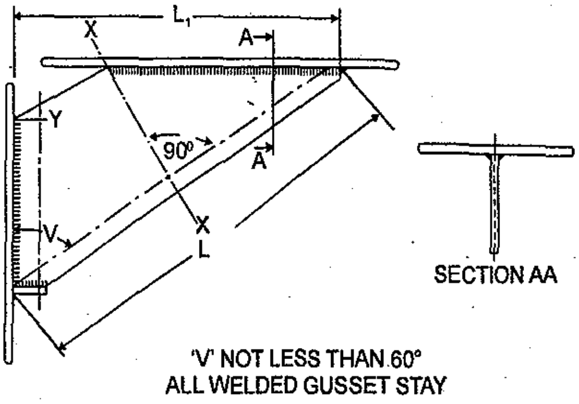


FIG. XII/81 — TYPICAL DETAILS FOR ALL-WELDED GUSSET STAY

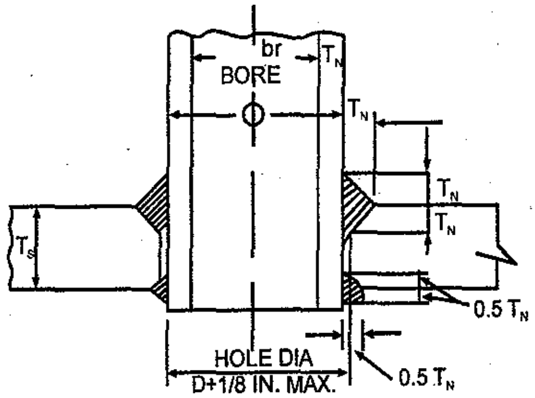


FIG. A.

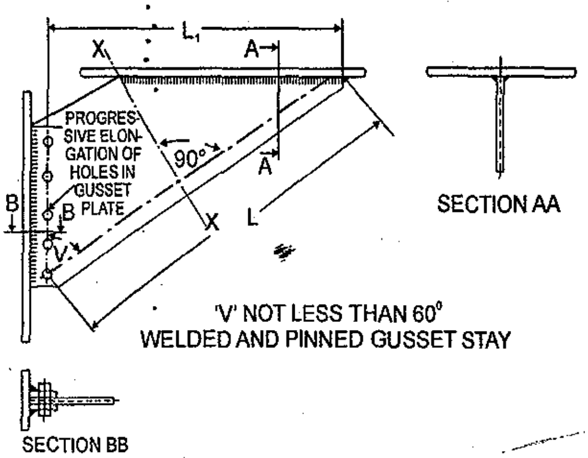


FIG. XII/82 — TYPICAL DETAILS FOR WELDED AND PINNED GUSSET STAY

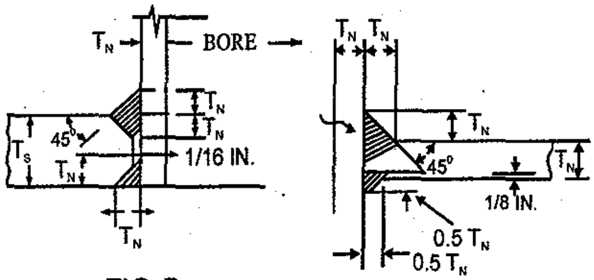


FIG. B. FIG. C.

MINIMUM WELD THICKNESS WHERE PLATE THICKNESS T_S IS LESS THAN 1.5 T_N

Note : THE TYPES IN 'A' AND 'B' ARE ONLY PERMITTED WHERE THE ELECTRODES AND TECHNIQUE TO BE USED HAVE BEEN SHOWN BY SEPARATELY PREPARED TEST SPECIMENS TO GIVE FULL PENETRATION WITH SOUND WELD METAL THE ROOT OF THE GROOVES.

FIG. XII/84 — MINIMUM WELD ATTACHMENT FOR STANDPIPES UP TO AND INCLUDING 5 IN. BORE NOT REQUIRING COMPENSATING PLATES

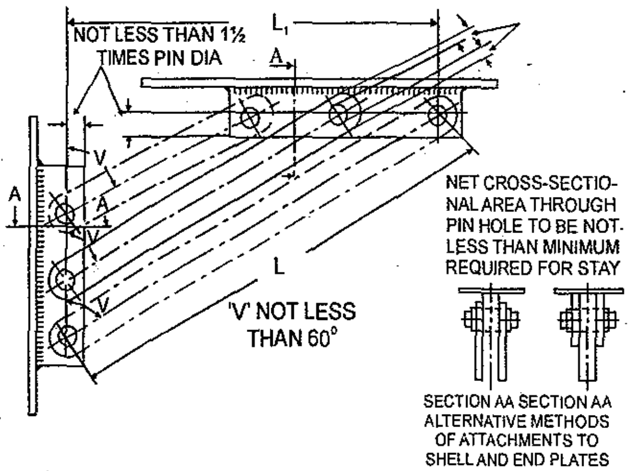


FIG. XII/83 — TYPICAL DETAILS FOR DIAGONAL STAYS (CHAIN LINES INDICATES STAY WITH MULTIPLE LINKS)

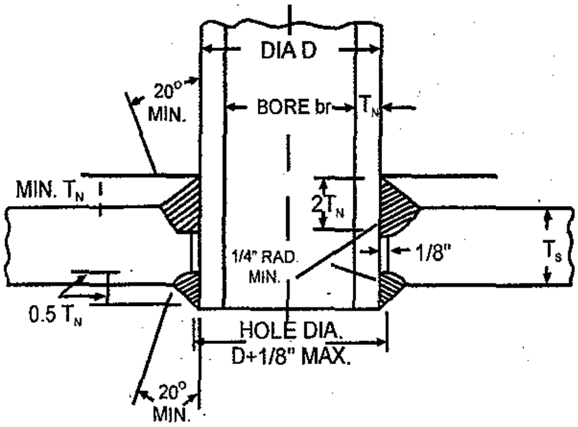


FIG. XII/85(A)

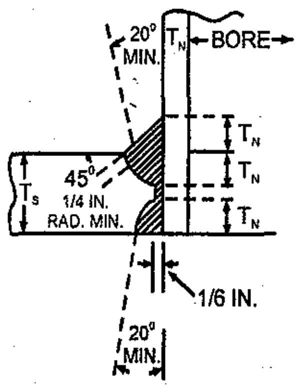


FIG. XII/85(B)

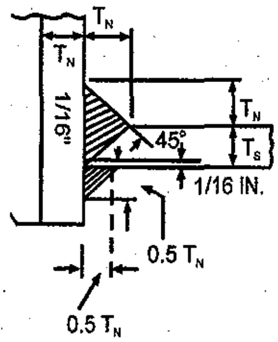
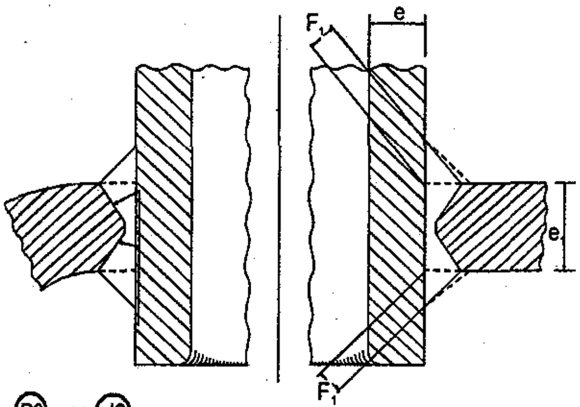


FIG. XII/85(C)

MINIMUM WELD DIMENSIONS WHERE PLATE THICKNESS T_S IS LESS THAN 1.5 T_N

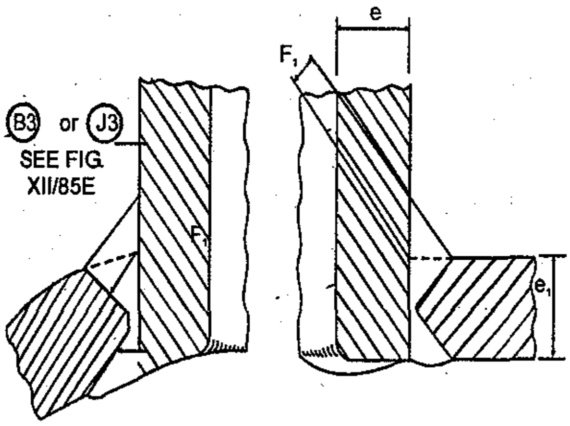
FIG. XII/85(A), XII/85(B) & XII/85(C)— MINIMUM WELD ATTACHMENTS FOR STANDPIPES OVER 5 BORE NOT REQUIRING COMPENSATING PLATES



B3 or J3
SEE FIG. XII/85E

F_1 = e/10 minimum or 6 mm whichever is larger.

FIG. A

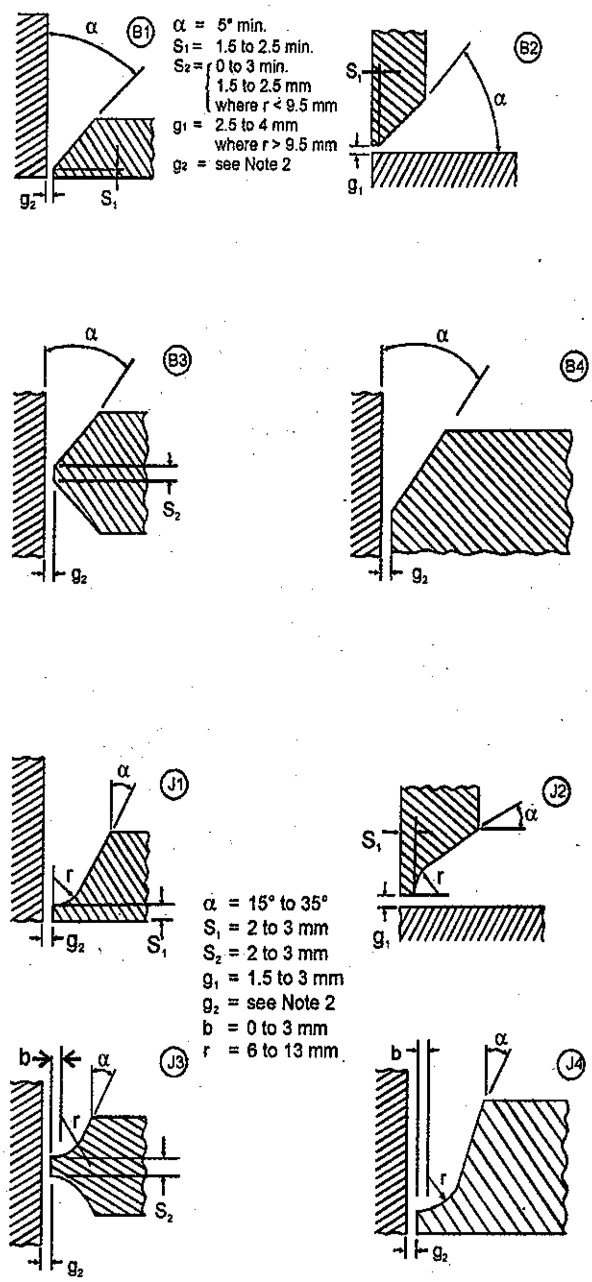


F_1 = e/5 minimum or 6mm whichever is larger

FIG. B

Note: These are generally used when e is greater than e½.

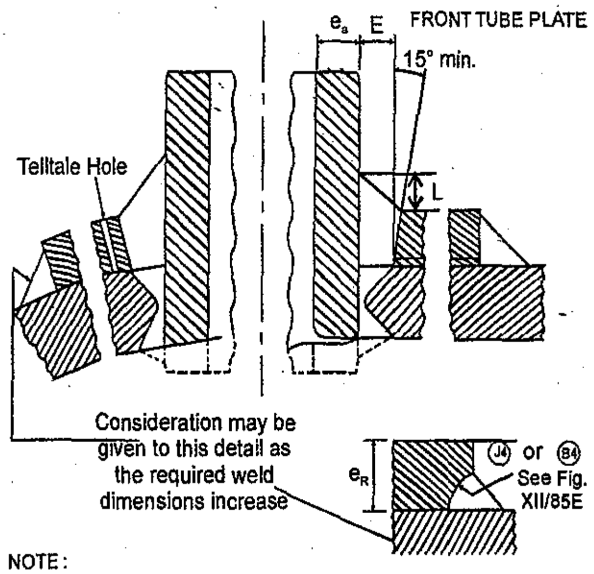
FIG. XII/85D — SET IN BRANCHES (Full Penetration Weld)



Note: 1. These recommendations have been included for general guidance discretion should be used in applying the maximum and minimum dimensions quoted which are subject to variation according to the welding procedure employed for example, size and type of electrodes the position in which the welding is carried out and the practicability of carrying out satisfactory non destructive testing, where necessary.

2. It is recommended that in no case should the gap between the branch and shell exceed 3 mm, wider gaps increase the tendency to spontaneous cracking during welding particularly as the thickness of the parts joined increases.

FIG. XII/85E — STANDARD WELD PREPARATION DETAIL



NOTE:
E = 10 MIN.
L = e3 BUT NOT LESS THAN 6
ALL DIMENSIONS ARE IN MILLIMETERS

FIG. XII/85F — SET IN BRANCHES WITH ADDED COMPENSATION RINGS

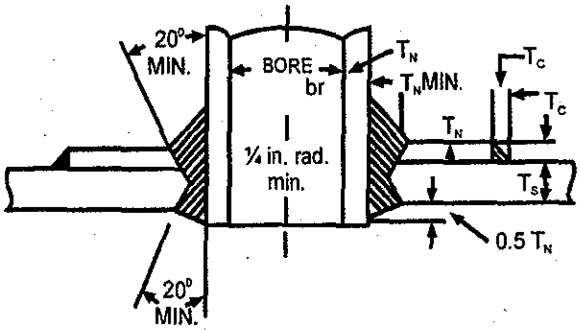


FIG. XII/86 — MINIMUM WELD ATTACHMENT FOR STANDPIPES OVER 5 IN. BORE REQUIRING COMPENSATION PLATES

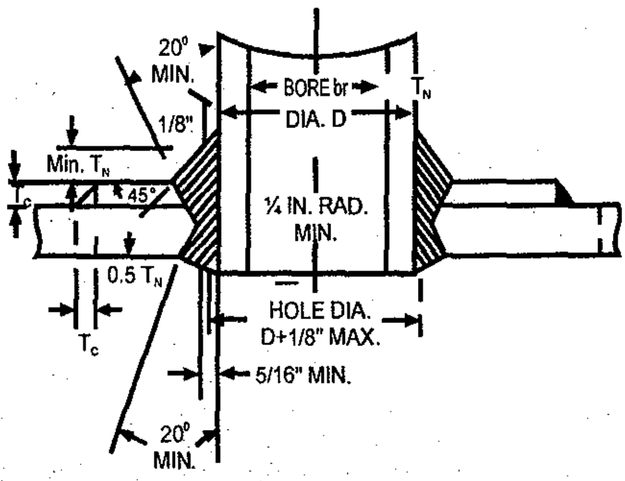


FIG. XII/87 — MINIMUM WELD ATTACHMENT FOR STANDPIPES OVER 5 IN. BORE REQUIRING COMPENSATION PLATES

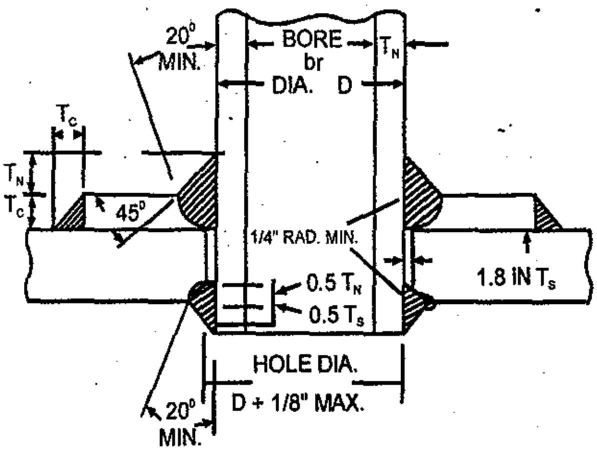


FIG. A

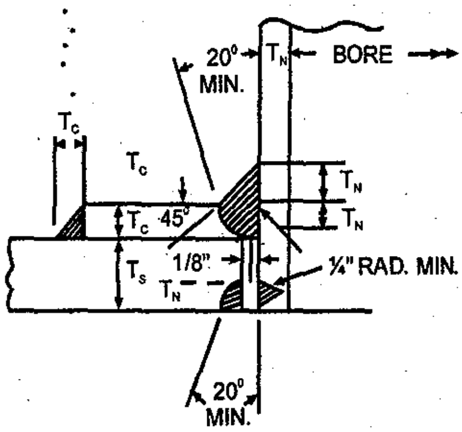
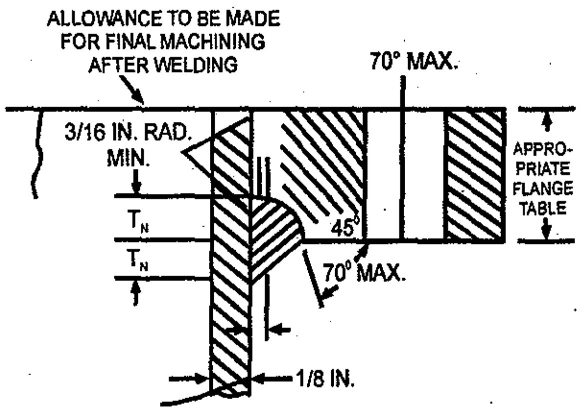


FIG. B

FIG. XII/88 — MINIMUM WELD ATTACHMENTS FOR STANDPIPES UPTO AND INCLUDING 5" BORE REQUIRING COMPENSATION PLATES



THE FLANGE SHALL NOT BE A TIGHT FIT ON TO THE PIPE. THE MAXIMUM CLEARANCE BETWEEN THE BORE OF THE FLANGE AND THE OUTSIDE DIAMETER OF THE PIPE SHALL BE 1/8 IN. AT ANY POINT AND THE SUM OF THE CLEARANCES DIAMETERICALLY OPPOSITE SHALL NOT EXCEED 3/16 IN.

FIG. XII/89 — WELDED ON GLANGE

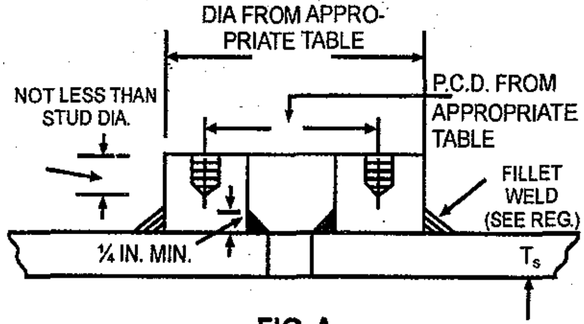


FIG. A

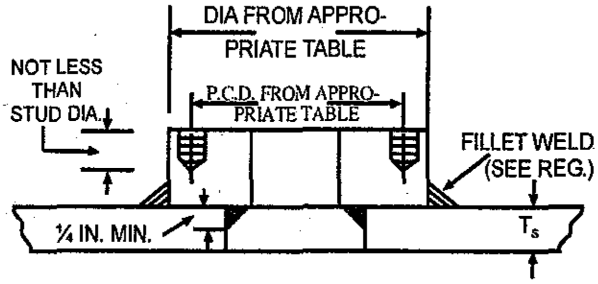
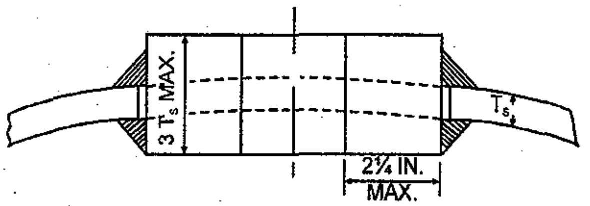


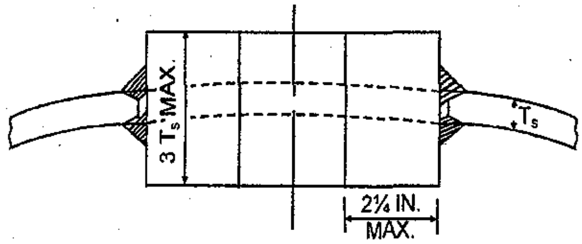
FIG. B

FIG. XII/90 — PADS WELDED ON FOR STUDS



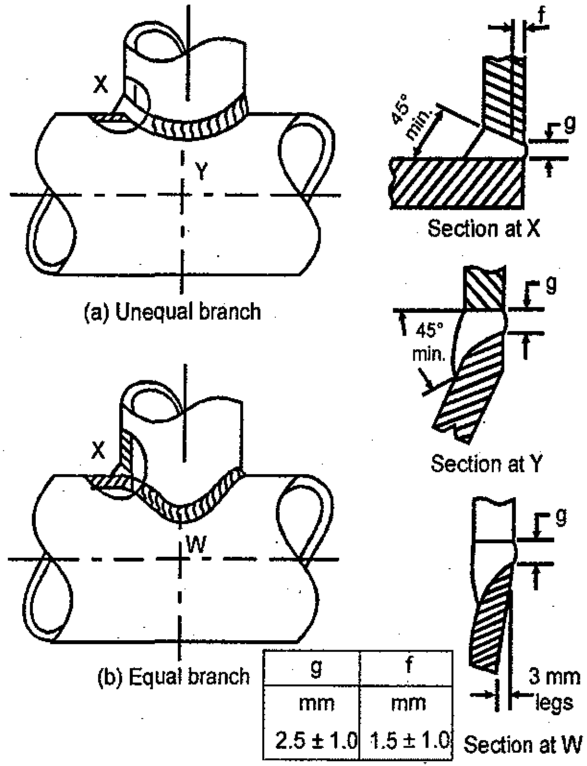
THE TYPE SHOWIN IN FIG. XII/91 SHALL NOT BE USED WHERE THICKNESS OF THE SHELL EXCEEDS ¾ IN.

FIG. XII/91



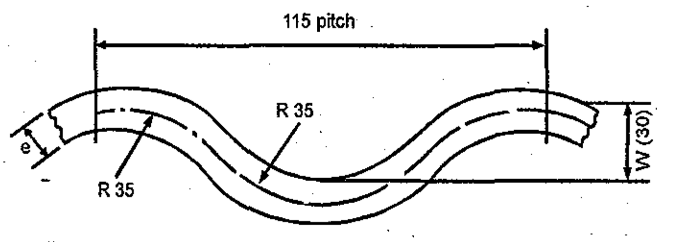
THE TYPE SHOWN IN FIG. XII/92 TO BE USED WHEN SHELL THICKNESS EXCEEDS ¾ IN.

FIG. XII/92



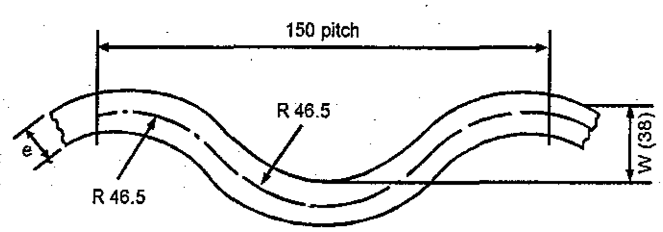
g	f
mm	mm
2.5 ± 1.0	1.5 ± 1.0

FIG. XII/93 — TYPICAL PREPARATION AND ASSEMBLY OF SET ON RIGHT ANGLE BRANCHES WITHOUT BACKING



e – C	I	F
	$mm^4 \times 10^4$	$mm^2 \times 10^2$
8.25	13.9	11.1
9.25	15.8	12.5
10.25	17.8	13.8
11.25	19.9	15.2
12.25	22.1	16.5
13.25	24.4	17.9

FIG. A — FOX TYPE FURNACES (115 CORRUGATION AND 30 MM DEPTH)



e – C	I	F
	$mm^4 \times 10^4$	$mm^2 \times 10^2$
9.25	31.9	16.1
10.25	35.7	17.9
11.25	39.6	19.6
12.25	43.6	21.4
13.25	47.8	23.1
14.25	52.1	24.9
15.25	56.6	26.6
16.25	61.2	28.4
17.25	66.0	30.1
18.25	71.0	31.8
19.25	76.2	33.6
20.25	81.6	35.3
21.25	87.3	37.1

ALL DIMENSIONS ARE IN MILLIMETERS

FIG. B — FOX TYPE FURNACES (150 MM CORRUGATION AND 38 MM DEPTH)

FIG. XII/94 — SECOND MOMENTS OF AREA AND CROSS-SECTIONAL AREA F *(Contd.)....*

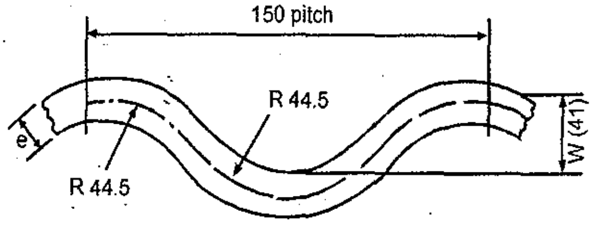


FIG. C — FOX TYPE FURNACES (150 MM CORRUGATION AND 41 MM DEPTH)

e – C	I	F
	mm⁴ × 10⁴	mm² × 10²
9.25	37.7	16.5
10.25	42.2	18.3
11.25	46.8	20.1
12.25	51.5	21.9
13.25	56.3	23.6
14.25	61.3	25.4
15.25	66.4	27.2
16.25	71.8	29.0
17.25	77.3	30.8
18.25	83.0	32.6
19.25	88.9	34.3
20.25	95.0	36.1
21.25	101.4	37.9

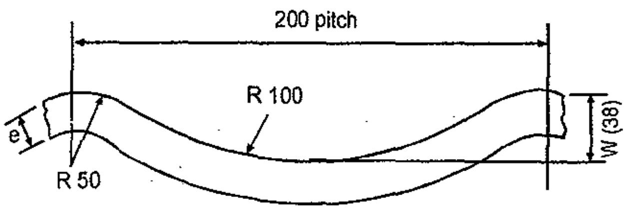


FIG. D — MORRISON TYPE FURNACES (200 MM CORRUGATION AND 38 MM DEPTH)

e – C	I	F
	mm⁴ × 10⁴	mm² × 10²
9.25	38.6	20.2
10.25	43.2	22.4
11.25	47.8	24.6
12.25	52.6	26.8
13.25	57.5	29.0
14.25	62.6	31.2
15.25	67.8	33.4
16.25	73.2	35.6
17.25	78.8	37.8
18.25	84.6	40.0
19.25	90.6	42.1
20.25	96.8	44.3
21.25	100.3	46.5

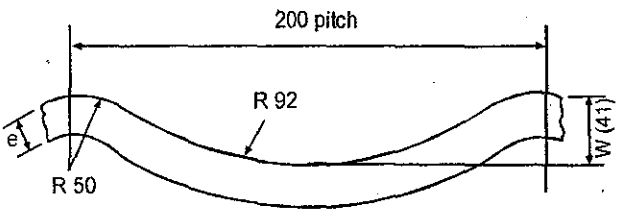


FIG. E — MORRISON TYPE FURNACES (200 MM CORRUGATION AND 41 MM DEPTH)

e – C	I	F
	mm⁴ × 10⁴	mm² × 10²
9.25	45.6	20.5
10.25	50.9	22.7
11.25	56.3	25.0
12.25	61.8	27.2
13.25	67.5	29.4
14.25	73.3	31.6
15.25	79.3	33.8
16.25	85.5	36.1
17.25	91.8	38.3
18.25	98.4	40.5
19.25	105.2	42.7
20.25	112.2	44.9
21.25	119.5	47.2

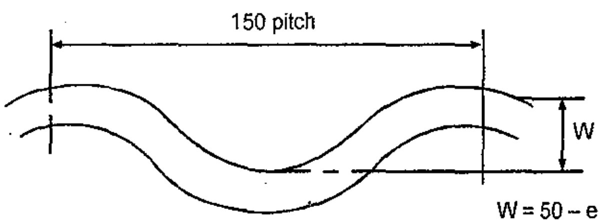


FIG. F — FOX TYPE FURNACES (150 MM CORRUGATION AND 50 MM DEPTH)

e – C	I	F
	mm⁴ × 10⁴	mm² × 10²
9.25	35.6	16.4
10.25	37.7	18.0
11.25	39.6	19.6
12.25	41.2	21.2
13.25	42.7	22.8
14.25	44.1	24.4
15.25	45.3	25.9
16.25	46.4	27.4
17.25	47.4	28.9
18.25	48.3	30.4
19.25	49.2	31.9
20.25	50.1	33.3
21.25	51.0	34.8

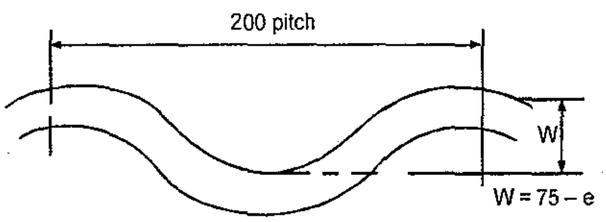
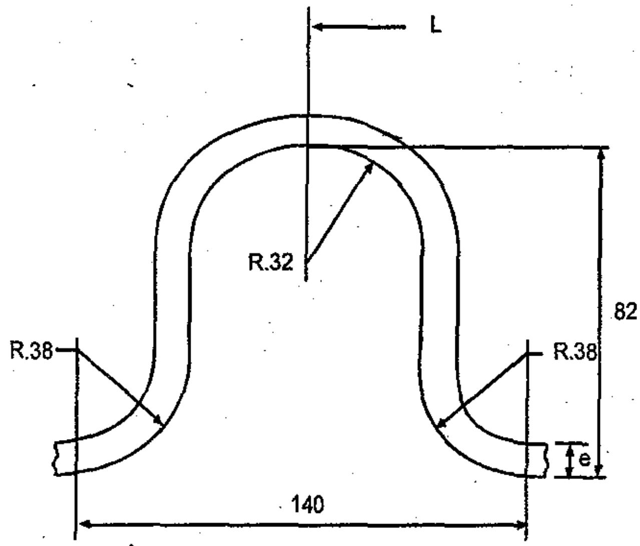


FIG. G — FOX TYPE FURNACES (200 MM CORRUGATION AND 75 MM DEPTH)

ALL DIMENSIONS ARE IN MILLIMETERS

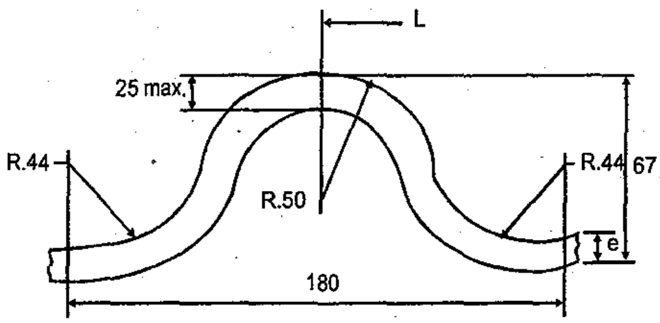
e – C	I	F
	mm⁴ × 10⁴	mm² × 10²
9.25	129.4	23.3
10.25	138.9	25.7
11.25	147.7	28.0
12.25	155.9	30.4
13.25	163.5	32.6
14.25	170.5	34.9
15.25	177.0	37.1
16.25	183.0	39.4
17.25	188.5	41.5
18.25	193.6	43.7
19.25	198.4	45.8
20.25	202.8	48.0
21.25	206.9	50.0

FIG. XII/94 — SECOND MOMENTS OF AREA AND CROSS-SECTIONAL AREA F *(Concluded)*



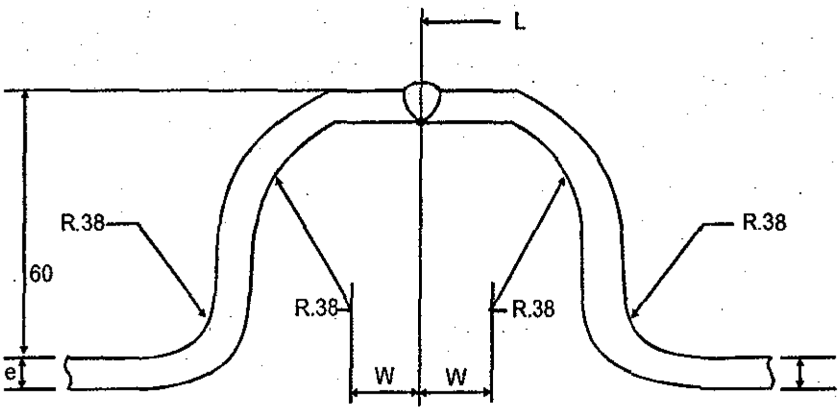
e – C	I
	$mm^4 \times 10^4$
9.25	1.9
10.25	2.11
11.25	2.32
12.25	2.53
13.25	2.74
14.25	2.96
15.25	3.18
16.25	3.40
17.25	3.62
18.25	3.85
19.25	4.08
20.25	4.31
21.25	4.55

FIG. A



e – C	I
	$mm^4 \times 10^6$
9.25	1.3
10.25	1.44
11.25	1.59
12.25	1.74
13.25	1.90
14.25	2.04
15.25	2.2
16.25	2.36
17.25	2.52
18.25	2.68
19.25	2.84
20.25	3.01
21.25	3.18

FIG. B



W = e – c but not less than 13

e – C	I
	$mm^4 \times 10^6$
9.25	1.14
10.25	1.28
11.25	1.41
12.25	1.55
13.25	1.7
14.25	1.86
15.25	2.04
16.25	2.22
17.25	2.41
18.25	2.6
19.25	2.8
20.25	3.01
21.25	3.22

FIG. C

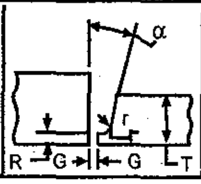
ALL DIMENSIONS ARE IN MILLIMETERS

FIG. XII/95

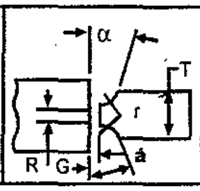
APPENDIX A

RECOMMENDED FORMS OF WELD PREPARATION (MODIFIED) DETAILS I-p INCLUSIVE ARE SUITABLE FOR MANUAL WELDING AND NORMAL AUTOMATIC WELDING WHERE THE AUTOMATIC DEEP PENETRATION TECHNIQUE IS EMPLOYED, SOME MODIFICATION MAY BE NECESSARY

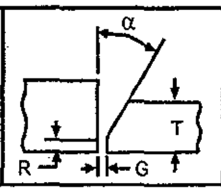
SINGLE J BUTT WELD

WELD DETAIL		WELDING POSITION	THICKNESS T	GAP G	ANGLE α°	RADIUS r	ROOT FACE R
WELDED FROM BOTH SIDES OR ONE SIDE ONLY		ALL POSITIONS	IN. OVER ½	IN. 0-18	10°-20°	IN. 3/16-3/8	IN. 1/16-1/8

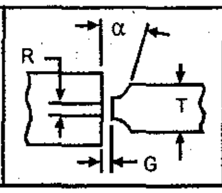
m DOUBLE J BUTT WELD

WELD DETAIL		WELDING POSITION	THICKNESS T	GAP G	ANGLE α°	RADIUS r	ROOT FACE R
WELDED FROM BOTH SIDES		ALL POSITIONS	IN. OVER 1	IN. 0-18	10°-20°	IN. 3/16-3/8	IN. 1/16-1/8

n SINGLE BEVEL BUTT WELD

WELD DETAIL		WELDING POSITION	THICKNESS T	GAP G	ANGLE α°	ROOT FACE R
WELDED FROM BOTH SIDES OR ONE SIDE ONLY		ALL POSITIONS	IN. 3/16-3/8	IN. 1/8-8/16	45°-50°	IN. 0-1/16
			OVER 3/8	3/16-5/16	45°-50°	0-1/16

p DOUBLE BEVEL BUTT WELD

WELD DETAIL		WELDING POSITION	THICKNESS T	GAP G	ANGLE α°	ROOT FACE R
WELDED FROM BOTH SIDES		ALL POSITIONS	IN. OVER ½	IN. 3/16-5/16	45°- 50°	IN. 0-1/16

THE USE OF MIN. GAP AND MIN. ANGLE SHOULD BE ASSOCIATED WITH THE MAX. RADIUS OF 3/8 IN. CONVERSELY THE MAX. GAP AND MAX. ANGLE SHOULD BE ASSOCIATED WITH THE MIN. RADIUS r OF 3/16 IN.

CHAPTER XIII

QUALIFICATION TESTS FOR WELDERS ENGAGED IN WELDING OF BOILERS AND STEAM-PIPES UNDER CONSTRUCTION, ERECTION AND FABRICATION AT SITE IN INDIA AND IN REPAIRING BOILERS AND STEAM-PIPES BY WELDING

602. Scope

These regulations shall apply to testing of welders engaged in the manufacture and site welding connected with erection and fabrication and repair of boilers and steam-pipes of ferrous material.

603. Definition

In this chapter "Welder" means a person engaged in manual welding (gas or electric).

604. Engaging of Certified Welders

No welder shall be engaged on welding of boilers or steam-pipes under construction, erection or fabrication at site or in the repair of boilers or steam-pipes, unless he possesses a certificate as required under the Regulations hereinafter contained.

605. Initial Qualification Test and Issue of Certificate

Every welder shall be duly tested and qualified to the satisfaction of the Competent Authority who shall assess his performance for qualifying for the certificate. The Competent Authority may, thereafter, issue a certificate in the Form XIII indicating the class and type of welding in which he has qualified.

605A. Issue of Duplicate Certificate

(i) In case of loss of a certificate issued to a welder in Form XIII a duplicate certificate may be issued by the Competent Authority who issued the original certificate provided that the Competent Authority is satisfied with the genuineness of the case.

(ii) Fee for issue of duplicate certificate shall be Rs. 25.00.

606. Production of Certificate

The holder of such certificate shall be bound to produce it when called upon to do so by the Inspecting Authority, Inspecting Officer or Inspector, as the case may be.

607.

(a) **Validity of Certificate**—A certificate issued to a welder under these regulations shall remain valid for a maximum period of twenty-four months from the date of issue, provided that the holder thereof has, subsequent to the test, been employed with reasonable continuity on the class and type of work for which he is qualified.

(b) **Revalidation of Certificate**—The certificate may be extended from time to time for a period not exceeding twenty-four months at a time on completion of a requalification test (*see* Regulation

610) to the satisfaction of the Competent Authority. In case the welder is employed in another State at the time of revalidation of a certificate, he may appear for a requalification test before the Competent Authority of the State for extension of his certificate.

(c) Notwithstanding anything contained in clauses (a) and (b) above, a welder shall appear for a requalification test consequent upon any of the following conditions, namely:

(i) An omission of backing strip in arc welding single welded butt joint or the addition of the backing strip in gas welding.

(ii) A change in class of electrode (Carbon or Alloy steel).

(iii) A change in the base metal to be welded.

(iv) If during the preceding three months or more the welder has not been engaged in welding of the type or class for which he is qualified.

(v) If there is some specific reason to question the welder's ability.

(vi) A change from one welding process to any other process.

(vii) A change from direct current to alternating current, and *vice versa.*

Note: However, a welder qualified for a type and process of higher grade of steel can be allowed to weld the lower grade of steel.

608. Age and Experience

A candidate who wishes to qualify for a certificate under these regulations shall not be less than 18 years of age and shall have undergone a regular apprenticeship from a recognized industrial training institute or one year regular apprenticeship from an industrial organization followed by at least one year regular on job experience as a welder in a workshop of industry.

*609. Tests for Initial Qualification of a Welder

(A) **Theoretical Examination**—A welder shall be required to answer questions on the following subjects, orally or otherwise—

1. Electric Welder—

(i) Weld preparation.

(ii) Elementary knowledge of the working of welding equipment.

(iii) Properties of material to be welded—cold and hot working, thermal conductivity, fusion point, oxidation (for welders engaged in alloy steel welding).

(iv) Elementary knowledge of electro-technical principles—kinds of current, striking arc voltage, welding-arc voltage.

* **Note:** Every welded test piece for the examination of welders shall be stamped with an identification mark on either side of the weld.

(v) Welding defects and their prevention—influence of length of electric arc, effect of excessive or too low amperage, slag inclusions, porosity finishing the surface of welding bead.

(vi) Electrodes for different types of welds and steels and joints in different positions.

2. Gas Welder—

(i) Weld preparation.

(ii) Working of welding equipment.

(iii) Elementary knowledge of properties of materials to be welded—cold and hot working, thermal conductivity, fusion point, oxidation (for welders engaged in alloy steel welding).

(iv) Elementary knowledge of fuel gas and flame adjustments for favourable welding condition.

(v) Kinds of welds, welding defects and their prevention, welding technique (right-ward and left-ward), welding with two torches on vertical surface, excess of gas or oxidation, pre-heating of base material and subsequent heat treatment.

(vi) Filler metals.

(B) A welder shall be required to undergo and pass the following practical tests—

1. Material for Tests—The material of plates, tubes, pipes and electrodes used for these tests shall conform to the requirements of appropriate Regulations as may be applicable in each case.

2. Test Welds for Initial Qualification (Electric or Gas)—

(a) **Plate Welding—**

(i) One groove welded joint of two pieces of plates with Double Vee or Double U grooves on boiler quality plates over a length of 300 mm in the following positions (size of plates to be welded being not less than 299 mm × 381 mm x 16 mm) (9" x 15" x 5/8" each)—

(1) Flat Position XIII/6—Plate in a horizontal plane with the weld metal deposited from above.

(2) Horizontal Position XIII/7—Plate in a vertical plane with the axis of the weld horizontal.

(3) Vertical Position XIII/8—Plate in a vertical plane with the axis of the weld partical.

(4) Overhead Position XIII/9—Plate in a horizontal plane with the weld metal deposited from underneath.

Qualification in position XIII/7 or XIII/8 shall qualify also for positions XIII/6, XIII/7 and XIII/8 also.

(ii) One fillet welded joint over a length of 381 mm (15 inches) using plates of not less than 16 mm (5/8 inches) in the following positions—

(1) Flat Position XIII/10—Plates so placed that the weld is deposited with its axis horizontal and its throat vertical.

(2) Horizontal Position XIII/11—Plates so placed that the weld is deposited with its axis horizontal on the upper side of the horizontal surface and against the vertical surface.

(3) Vertical Position XIII/12—Plates so placed that the weld is deposited with its axis vertical.

(4) Overhead Position XIII/13—Plates so placed that the weld is deposited with its axis horizontal on the under side of the horizontal surface and against the vertical surface.

Qualification in positions XIII/11, or XIII/12 shall qualify for position XIII/10.

Qualification in position. XIII/12 shall qualify for positions XIII/10, XIII/11 and XIII/12.

(b) **For Pipe Welding**—

(1) One test on groove weld joint for each of the following welding positions—

(i) **Horizontal Rolled**—Pipe with its axis horizontal and rolled during welding so that the weld metal is deposited from above with the axis of the weld horizontal.

(ii) **Horizontal Turned**—Pipe with its axis horizontal the upper half welded first, the pipe then being turned through 180 degree and the other half then welded.

(iii) **Vertically Fixed**—One test of groove welded joint with the axis of the pipe in a vertical position and the seam welded circumferentially in a horizontal position.

(iv) **Horizontal Fixed**—One test of groove welded joint with the axis of the pipe in a horizontal position and the seam welded without rotating the pipe.

Qualification in position (ii) or (iii) shall qualify also for position (i) Qualification in position (iv) shall qualify for position (i) or (ii).

(2) One weld of a branch to a pipe—

The size of pipe to be welded shall be not less than 127 mm (5 inches) in external diameter and 10 mm (3/8 inch) thick, and a branch pipe shall not be less than 89 mm (3½ inches) outside diameter and 6 mm (1/4 inch) thick.

(c) **For Tube Welding**—A butt-welded joint of two pieces of boiler tubes with the axis in a vertical position and tubes of same size fixed in adjoining positions. This test shall be in addition to the test for pipe welding under clause (b).

610. Tests for Requalification

At a requalification test a welder need not be examined in theoretical subjects, but he shall be required to qualify in the following practical tests:

(a) **Plate Welding**—A groove welded joint of two pieces of plates not less than 16 mm (5/8 inch) thick over a length of 152 mm (6 inches) in a position 45 degree to vertical, size of plates to be welded being 229 mm × 152 mm (9 inches × 6 inches). The main welding is to be carried from the underside only.

(b) **Pipe Welding**—The material of plates, tubes, pipes and electrodes used for these test shall conform to the requirements of appropriate Regulations as may be applicable in each case.

(i) A groove welded joint with the axis of the pipe in a horizontal position and without rotating the pipe.

(ii) One weld of a branch to a pipe, as prescribed in Regulation 609.

(c) **Tube Welding**—A butt-welded joint of two pieces boiler tubes with the axis in a vertical position, and tubes of same size fixed in adjoining positions. This test shall be in addition to the test for pipe welding under clause (b).

(d) When a welder is continuously engaged on production weld, test on the work in actual production to the satisfaction of the Competent Authority may be accepted as an alternative to the tests prescribed as above under clauses (a), (b) and (c).

611. Examination of Test Specimens for Initial Qualification Tests

(a) **Groove Welded Plate Specimens**—The groove welded plate specimens after welding may be lightly pressed cold to remove any distortion due to welding. The test specimen shall be similarly treated as required for the actual production weld.

After visual examination, the welded specimen shall be subjected to radiographic examination in the manner as provided in Regulation 265(b), provided that this requirement may be waived when the welder is to be engaged on production work where radiographic examination is not required under these Regulations.

Thereafter test pieces shall be marked and cut out in the order shown in Figure XIII/1.

The bend test specimens (B_1 & B_2) shall be prepared and tested as per Regulations 261 & 262. In the case of alloy steel specimen, the angle of the bend is to be decided by the Competent Authority, provided that the angle shall, in no case, be less than 120°.

Two each specimens (E_1 & E_2) shall be prepared, one for micro and the other for macro examination as per Regulation 265(a).

(b) **Fillet Welded Plate Specimens**—To dimensions and preparation of the fillet-weld test specimen shall conform to Figure XIII/2. The test specimen shall not contain any visible cracks. It shall be cut transversely to provide a centre section (254 mm) (10 inches) long and two end sections each approximately (22 mm) (1 inch) long.

The steam of the (254 mm) (10 inches) centre section shall be loaded laterally in such a way that the root of the weld is in tension. The load shall be steadily increased until the specimen fractures or bends flat upon itself. In order to pass the test—

(1) The specimen shall not fracture, or

(2) If it fractures, the fractured surface shall show no evidence of cracks or incomplete root penetration, and the sum of the lengths of inclusions and gas pockets visible on the fractured surface shall not exceed (51 mm) (2 inches).

The cut end of one of the end sections shall be polished and etched with a suitable reagent to give a clear definition of the structure of the weld.

In order to pass the test—

(i) Visual examination of the cross-section of the weld shall show complete fusion at the root and freedom from cracks;

(ii) The weld shall not have a concavity or convexity greater than (1.6 mm) (1/16 inch); and

(iii) There shall be not more than (1.6 mm) (1/16 inch) difference in the lengths of the legs of the fillet.

(c) **Groove and Fillet Welded Pipe and Tube Specimens**—The groove welded pipe and tubes specimens shall be marked and test pieces cut out as in Figure XIII/3. The test pieces shall be prepared for face bend, root bend and etch test.

The pipes shall not be flattened, but tested in their curved conditions. The penetration bead may be removed to 0.8 mm (1/32") proud of the surface of the material.

Fillet welded branches shall be tested for:

(i) **Visual Examination**—The test welds so obtained shall be visually examined for root penetration, freedom from undercut, disposition of runs, uniformity of surface, shape of profile, smoothness of joint, freedom from cavities and slag, dimensions of weld deposit, quality of weld metal (overheating, surface cracks, spongy surface, etc.). Any piece showing serious defects shall be rejected.

(ii) **Macro Examination**—Each branch weld test piece shall be sawn as shown in Figure XIII/4 and each portion so produced shall be prepared and etched. The sections shall then be examined for degree of fusion, degree of root penetration, absence of non-metallic (slag) inclusions and quality of weld metal. The joint should show good root fusion, complete freedom from basal cracking, and the absence of any butt very minor defects.

(d) **Welded Tube Joints**—A test length approximately 203 mm long shall be cut from the tube with the welded joint disposed approximately at the centre. After visual examination, one test piece not exceeding 13 mm, for tubes 6 mm in thickness and below and thrice the thickness of the tube for thickness of over 6 mm shall be cut longitudinally.

The test shall not be less than 76 mm in length on either side of the weld. The slight excess of internal bead may be filed until it is not more than 0.8 pround of the general surface. The test piece shall then be bent back with the root in tension through 90 degree round a former of diameter equal to three times the thickness of the tubes. With regard to alloy steel pipes and tubes, the bend test specimen shall be bent without being straightened, but after removal of the weld reinforcement down to the level of but not below the surface, round a former of diameter 4t and through an angle of 90 degree. The bending may be carried out by blows or by pressure. Care shall be taken to ensure that the former is so positioned that the weld is maintained at the crown of the bend. The test specimen shall be capable of being bent through 90 degree without signs of failure, although slight premature failure at the edges of a specimen need not be considered a cause for rejection. The opening out of a slight defect due to incomplete root penetration or lack of root fusion need not be considered a cause for rejection; provided the defect has sound metal at the back and on either side of it.

(e) **Additional Tests before Rejection**—Should any of the test pieces tested in accordance with the above sub-regulations fail to meet the specified requirements, one further strip may be cut from the specimen and subjected to the same test. If any test piece does not reach the required standard two further welds shall be made and the procedure in the above sub-regulation repeated. If any of these welds does not reach the required standard, the welder shall be deemed not to have qualified for a certificate.

612. Examination of Test Specimens for Requalification Tests

(a) **Groove Welded Plate Specimens**—The welded joint shall first be examined under X-ray and thereafter cut to appropriate dimensions for conducting the following tests:

Provided that the radiographic examination of the weld, may be waived when the welder is to be engaged on production work where radiographic examination is not required under these regulations.

One forward bend test, one reverse bend test, and two macro examinations.

The test piece shall be marked and cut out in the order shown in Figure XIII/5 and tested in accordance with the provisions of Regulation 611.

(b) **Fillet Plate Welded Specimen**—They shall be conducted as detailed in Regulation 611(b).

(c) **Pipe and Tube Welding**—Specimens shall be prepared and tested as prescribed in Regulation 611(c) or 611(d), as the case may be.

(d) **Additional Test before Rejection**—Should any of the test pieces tested in accordance with the above sub-regulations fail to meet the specified requirements, one further weld may be cut from the specimen and subjected to the same test.

If any test piece does not reach the required standard, two further welds shall be made and the procedure in the above regulations repeated. If any of these welds does not reach the required standard the welder shall be deemed not to have qualified for a certificate.

613. Awarding of Marks

Marks shall be awarded in accordance with the Form XII. Candidates obtaining marks not less than 60 per cent in the oral or written examination and not less than 75 per cent in the practical tests, shall be deemed to have qualified for a certificate provided that the bend tests are found to be satisfactory. Should a candidate fail in the oral or written examination but pass in the practical test, he may be re-examined in oral or written examination within a period of twelve weeks from the date of examination of practical test, and if he obtains not less than 60 per cent marks in the re-examination, he shall be deemed to have qualified for a certificate.

The Form shall be attested by the Competent Authority and filed in this office for future reference.

614. Award of Certificate

On successful completion of tests prescribed in Regulation 609(A) any of these prescribed in Regulation 609(B) the welder may be awarded a certificate in Form XIII to the extent of the tests passed by him.

Welder who pass the tests for groove welds in plates shall be considered as having qualified for making fillet welds in plates. Welders who pass the tests for fillet welds, shall be qualified to make fillet welds only. Any certificate issued for any purpose under the rules made by the State Government in this behalf shall be deemed to have been issued for that purpose under this Chapter and any action taken under the said rules, shall be deemed to have been taken under this Chapter.

615. Maintenance of Records

Every manufacturer or repairer of boilers and steam-pipes shall maintain a record of all welding personnel engaged on welding and repairing of boilers and steam-pipes, particulars of each welder and the work handled by him. Such record shall be produced to the Inspecting Authority, Inspecting Officer or an Inspector on demand.

In the case of welders who undertake welding under their own responsibility, the record as aforesaid shall be maintained by themselves.

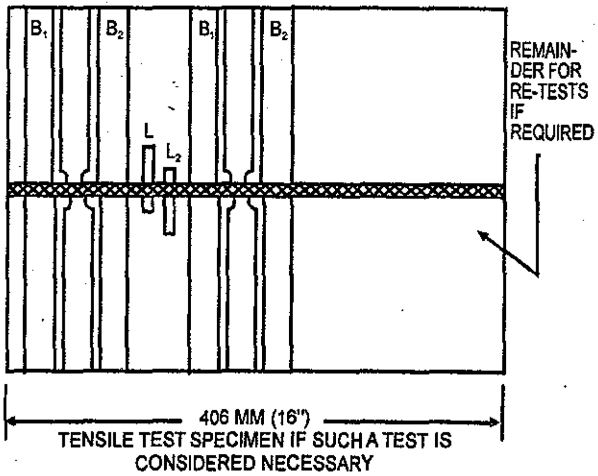
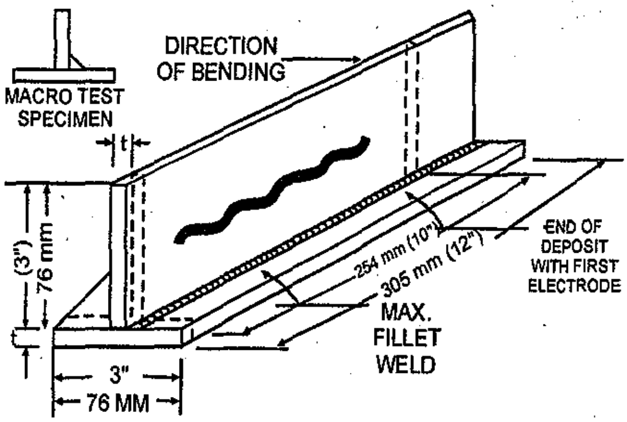


FIG. XIII/1— ORDER OF REMOVAL OF TEST SPECIMEN FROM TEST PLATE FOR INITIAL QUALIFICATION TEST



FILLET WELD SOUNDNESS TEST FOR PERFORMANCE QUALIFICATION OF WELDERS

FRACTURE TEST : MAXIMUM PERMISSIBLE DEFECTS SUCH AS SLAG. NON-FUSION ETC. 20 PER CENT OR 2 INCHES. EVIDENCE OF CRACKING OF FILLET SHALL CONSTITUTE GROUNDS FOR REJECTION.

MACRO TEST: THE FILLET SHALL SHOW FUSION TO THE ROOT CONVEXITY AND/OR CONCAVITY OF THE FILLET SHALL NOT EXCEED 1/16 INCH. BOTH LEGS OF THE FILLET SHALL BE EQUAL TO WITHIN 1/16 INCH.

FIG. XIII/2

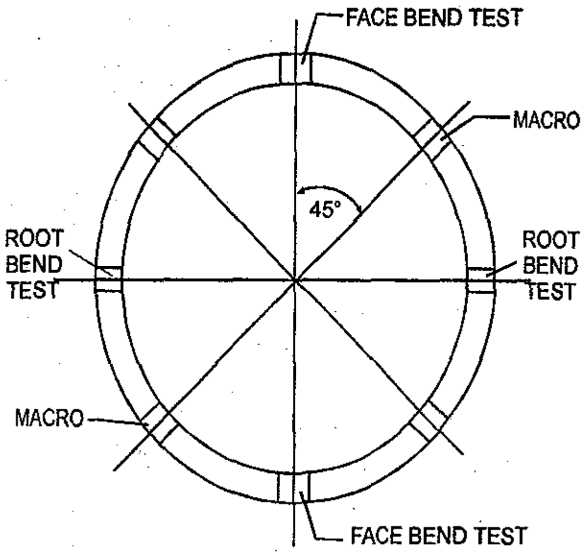


FIG. XIII/3— ORDER OF REMOVAL OF TEST SPECIMENS FROM WELDED PIPE

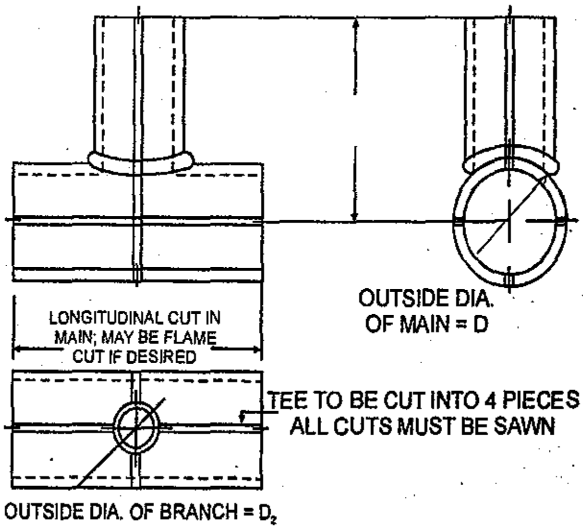


FIG. XIII/4— BRANCH WELD SPECIMEN FOR BRANCH PIPES

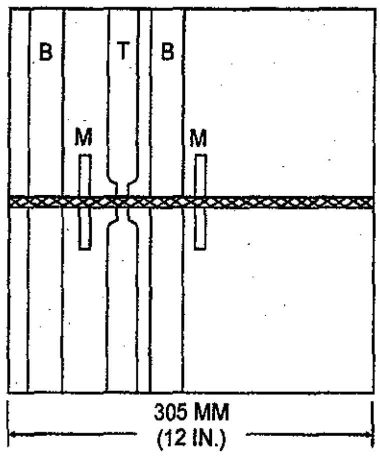
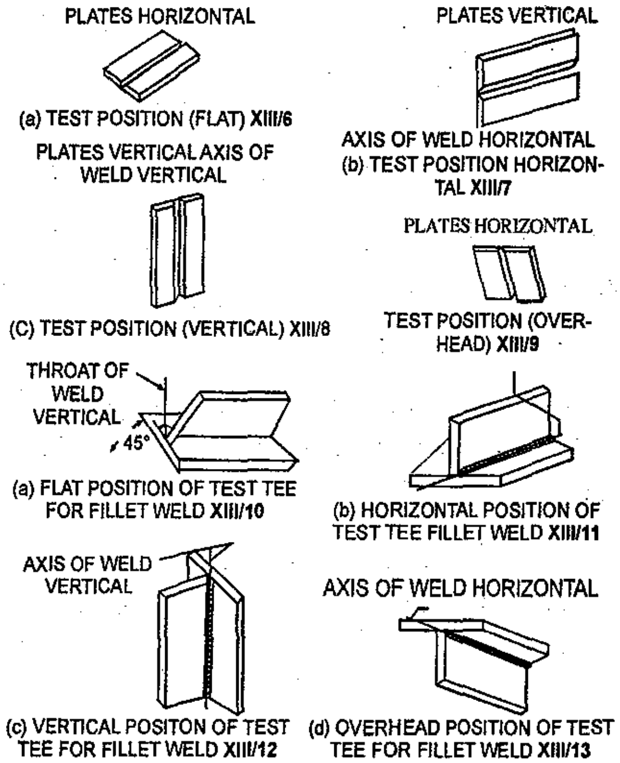


FIG. XIII/5— ORDER OF REMOVAL OF TEST SPECIMEN FROM TEST PLATE, FOR RE-QUALIFICATION TEST



616. Fees for Examination of Welders

Fees for examination of welders under these regulations shall be Rs. 100 and this shall be borne by the applicant/sponsor. In addition, the applicant/sponsor shall bear all other expenses like cost of material and workshop and testing facilities as fixed by the Competent Authority.

The fee for endorsement of welder's certificate shall be Rs. 100 and shall be borne by the applicant/sponsor.

617. Penalty

(1) Whoever employs a person in welding a boiler or steam-pipe in contravention of these Regulations shall be punishable with fine which may extend to Rs. 100.

(2) Any employer or welder who fails to maintain the records as required under Regulation 615 shall be punishable with fine which may extend to Rs. 100.

CHAPTER XIV

(Regulations made under clauses (a) and (aa) of Section 28 of the Act)

SMALL INDUSTRIAL BOILERS

GENERAL

618. Scope

This Chapter shall apply to the design, construction, inspection, registration, operation and maintenance of small industrial boilers.

619. Definition

In this Chapter, "Small Industrial Boiler" means—

(a) a shell type boiler generating steam for use external to itself under pressure up to 7 kg/cm^2 and having a volumetric capacity exceeding 22.75 litres, but not exceeding 500 litres including the volumetric capacity of all pressure parts being heated from the same heating source and connected to the boiler; or

(b) a coil type boiler or a once through boiler or a water tube boiler having the conditions specified in clause (a) above except that—

(i) the limitation of pressure shall be 12 kg/cm^2, and

(ii) the capacity shall be not exceeding 150 litres:

Provided that in case of boilers having combined features of clauses (a) and (b), the working pressure shall be restricted to 7 kg/cm^2 and the volumetric capacity of particular pressure parts shall not exceed the limits specified in the respective clauses above subject to an aggregate of 500 litres.

620. Extent to which Variation from the Standard Conditions laid down in the Preceding Chapters is Permissible

The following variations from the standard conditions laid down in the preceding Chapters shall be permitted, subject to the conditions specified below, with due regard to the safety of the boilers and personnel:—

(1) **Materials**—

(a) The materials used in the construction of Small Industrial Boilers shall, except as otherwise provided hereinafter, conform to the provisions made in Chapter II of these regulations.

(b) Steel plates used in the construction of the boilers shall be of IS: 2062 Grade B or C or equivalent and the plate for shell and heads shall be not less than 6 mm in thickness and the heads as tube sheets for tubes rolled in shall be at least 8 mm in thickness.

(c) (i) Heads of parts of boilers when not exposed to direct impact of flame may be made of cast iron or malleable iron provided they comply with other requirements of these regulations.

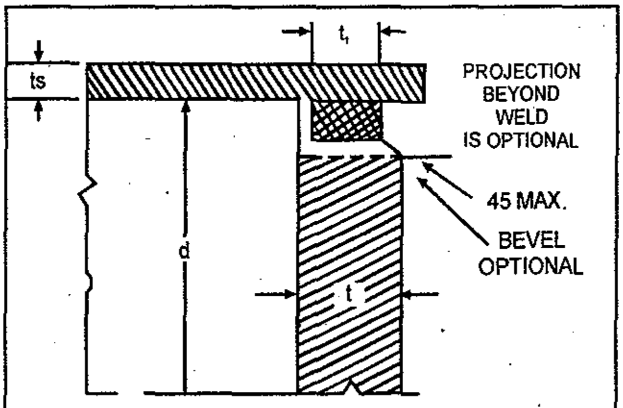
(ii) The allowable stress on cast iron or malleable iron shall be based on the tensile strength of material with a factor of safety of not less than 4.5.

(2) **Design, Construction, Workmanship and the Method of Computing the Maximum Allowable Working Pressure—**

(a) (i) The construction except where otherwise specified shall be the same as those prescribed in the relevant provisions of the preceding Chapters of these regulations.

(ii) In the case of fusion welded boiler neither stress-relieving nor radiography of welded joints is required.

(b) (i) In the Small Industrial Boilers unflanged steel tube plate may be inserted into the shell and welded for the entire thickness as shown in Figure XIV/1 below with a fillet weld having a throat not less than 1¼ times the thickness of the shell or tube sheet whichever is smaller.



t_1 : 2 TIMES REQUIRED THICKNESS OF A SEAMLESS SHELL BUT NEVER LESS THAN 1.25 t_s OR GREATER THAN t

FIG. XIV/1

(ii) The minimum thickness of unflanged welded tube sheets shall be 10 mm.

(iii) The temperature of the heating element of electrically heated steam boilers shall be so controlled that it shall not exceed 650°C.

(c) (i) The tubes shall be made of steel.

(ii) The tube holes shall be drilled full size with shells butt straps and ends bolted up in position or may be punched at least 13 mm smaller in diameter than full size and then drilled, reamed or finished full size with a rotating cutter. The sharpedges and chips removed, the plates and butt straps reassembled metal to metal with pins fittings the holes and with tack bolts.

(3) **Inspection and Testing**—The Small Industrial Boilers shall be subjected to inspection during construction and after completion by an Inspecting Authority. The inspection of the boilers shall be made at the following stages:

A. **Shell Type Boilers:**

(i) Material identification and inspection.

(ii) Inspection of each component after completing welding and drilling.

(iii) Assembly of boiler.

(iv) Hydraulic test:

(a) Every completed boiler of riveted construction shall be tested hydraulically at least twice the working pressure;

(b) In case of a boiler wholly or partly welded construction, the hydraulic test pressure shall be equal to two times the maximum allowable working pressure of the boiler.

(v) A test coupon shall be provided by the maker for conducting root and face bend tests.

B. **Coil Type Boilers, Once Through Boilers and Water Tube Boilers:**

(i) Identification of materials.

(ii) Hydraulic test—The pressure for hydraulic test shall be two times that of the working pressure of the boiler.

(4) **Certificates and Maker's Stamps**

(a) The certificate and maker's stamp shall be in conformity with the provisions of Chapter I of these regulations.

(b) If owing to small size of the boiler all information cannot be visibly stamped on the boiler plate, maker's certificate accompanying the boiler shall contain the necessary details, but in all cases name, works number and the year of the make must be stamped or exhibited on the boiler.

621. Valves, Gauges, Fittings and Feed Supply

(a) Washout Plugs, etc. for cleaning—

(i) Every boiler shall be fitted with at least 3 brass wash plugs of not less than 25 mm diameter which shall be screwed into the openings in the shells near the bottom. In the boilers of closed system type heated by removable internal electric heating elements, the opening for these elements when suitable for cleaning purposes may be substituted for wash out openings.

(ii) Boilers not exceeding 300 mm internal diameter may have two 25 mm openings for cleaning one of which may be used for the attachment of the blow off valve. The openings shall be opposite to each other, wherever possible. All threaded openings in the boiler shall be provided with rivetted or welded reinforcement, if necessary, to give four full threads therein.

(iii) Electric boilers of a design employing removable top cover flange for inspection and cleaning need not be fitted with washout openings and washout plug. Level gauges are not required for once through boilers.

(b) Every boiler shall be provided with at least one feed pump or other feeding device except where it is connected with a water main carrying pressure to feed the boiler or where the steam generator is operated with no extraction of steam (closed system). In the latter case, in lieu of the feeding device, a suitable connection or opening shall be provided to feed the boilers. Such connection shall be not less than 13 mm in diameter.

(c) Subject to the provisions of this sub-regulation every boiler shall be fitted with necessary mountings and fittings as provided in Chapter VI of these regulations, and they shall be of substantial construction suitable for 7 kg/cm^2. All these fittings except safety valves shall be certified by manufacturers of the fittings themselves.

(i) **Feed Pipe**—The feed pipe shall be provided with a check valve and a stop valve of a size not less than that of the pipe. The feed water may be delivered to the boiler through the openings of the same size in the shell as that of the blow off connection.

(ii) **Blow Off**—Each boiler shall be equipped with a blow off connection, not less than 18 mm in size located to drain the boiler water from the lowest water space practicable when the boiler is under pressure. Feed water shall not be introduced through the openings or connection needed for the water column, the water gauge glass or the gauge cock.

(iii) **Water Gauges**—Every boiler other than a coil type or a once through boiler shall be fitted with two gauge glasses not less than 150 mm long for determining the water level. The boiler shall have the lowest visible part of the water gauge located at least 25 mm above the lowest permissible water level.

The lowest permissible water level of vertical boilers shall be at a point one-third of the height of the shell above the bottom head or tube sheet. Where the boiler is equipped with internal furnace, the water level shall not be less than one-third of the length of the tubes above the top of the furnace tube sheet.

(iv) **Pressure Gauge**—The steam pressure gauge shall have its dial graduated to not less than twice the maximum allowable working pressure of the boiler. The diameter of the dial shall be at least 100 mm and the pipe connecting the pressure gauge shall be minimum 10 mm and the connection shall be through siphon.

(v) **Safety Valve**—Each boiler shall be equipped with two safety valves for relieving the steam pressure. The diameter of the valve shall not be less than 19 mm.

The minimum relieving capacity of the safety valve shall be sufficient to discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 10 per cent above maximum allowable working pressure. The safety valve shall be connected to the boiler independently of any other steam connections, without any unnecessary intervening pipe or fitting. Such intervening pipe or fitting if unavoidable shall be not longer than the corresponding face to face dimension of a tee fitting of the same diameter and the minimum opening there through shall be at least equal to the valve inlet.

No valve of any description shall be placed between safety valve and the boiler not on the discharge pipe from the safety valve to the atmosphere.

The electrically heated boilers shall be effectively earthed with a lead of substantial cross-section.

622. Registration, Operation and Maintenance

(a) (i) The fee required to accompany an application under sub-section (1) of Section 7 of the Act shall be five hundred rupees per boiler.

(ii) The annual inspection fee shall be five hundred rupees per boiler.

(b) The certificate of manufacture and test for small industrial boilers shall be furnished in Form XVII appended to these regulations.

(c) Operator for these boilers shall be a pass in Class X or equivalent.

CHAPTER XV

FEED WATER FOR BOILER

623. Scope

(a) This chapter lays down specifications for feed water and boiler water for low and medium pressure boilers (boilers operating up to 60 kg/cm^2).

(b) For boilers operating at pressures higher than 60 kg/cm^2, better quality of water to IS:10496-1983 may be adopted.

624. Requirements

The water shall comply with the requirements given in Table 1 when tested by the methods prescribed in Cols. 6 and 7 of the table.

625. Sampling

Sampling shall be done following general directions given in 2 of IS: 3025-1964*. In particular, the following points shall be observed:

(a) It is necessary that a stainless steel or monel metal coil is fitted on the sampling cock so that the temperature of the water sample will be well below the boiling point at atmospheric pressure and these is no risk of aeration and concentration due to flashing into steam; and

(b) Samples of feed water shall be collected from the delivery of the boiler feed pump, samples of boiler water from the top drum, and samples of condensate from the delivery of the condensate extraction pump.

626. Test Methods

Tests shall be carried out as prescribed in the appropriate clauses of IS: 3025-1964* and IS: 3550-1965+ as indicated against the characteristics in Table 1.

Table 1: Chemical Requirements of Feed Water and Boiler Water for Low and Medium Pressure Boilers

(Regulations 624 and 626)

Sl. No.	*Characteristic*	*Requirement for Boiler Pressure*			*Method of Test (Ref. to Cl. No. of)*	
		Up to 2.0 MN/m^2	*2.1 to 3.9 MN/m^2*	*4.0 to 5.9 MN/m^2*	*IS: 3550-1965**	*IS: 3025-1964⁺*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
(i)	Feed Water					
	(a) Total hardness (as $CaCO_2$), mg/l, max	10	10	0.5	—	16.1

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(b) pH value	8.5 to 9.5	8.5 to 9.5	8.5 to 9.5	—	8
	(c) Dissolved Oxygen, mg/l, max	0.1	0.02	0.01	25	—
	(d) Silica (as SiO_2), mg/l, max	—	5	0.5	16	—
(ii)	Boiler Water					
	(a) Total hardness (of filtered sample) (as $CaCO_3$), mg/l	—	Not detectable	—	—	16.1
	(b) Total alkalinity a (as $CaCO_3$), mg/l max	700	500	300	—	13
	(c) Caustic alkalinity (as $CaCO_3$) mg/l max	350	200	60	—	15
	(d) pH Value	11.0 to 12.0	11.0 to 12.0	10.5 to 11.0	—	8
	(e) bResidual sodium sulphite (as Na_2SO_3) mg/l	30 to 50	20 to 30	—	—	21
	(f) Residual hydrazine (as N_2H_4), mg/l	0.1 to 1 (if added)	0.1 to 0.5 (if added)	0.05 to 0.3	26	—
	(g) jRatio Na_2SO_4/Caustic alkalinity (as NaOH) or	—	above 2.5	—	—	20.2 and 15
	Ratio $NaNO_3$/total alkalinity (as NaOH)	—	above 0.4	—	—	48 and 13
	(h) Phosphates (as PO_4), mg/l (if added)	20 to 40	15 to 30	5 to 20	14	—
	(i) Total dissolved solids mg/l, max	3500s	2500	1500	9	12
	(k) Silica (as SiO_2), mg/l	Less than 0.4 of caustic alkalinity		15	16	30

Note:

1. *Recovery Boilers*: The boiler feed water used shall be completely de-mineralized and also the boiler feed water and boiler water shall be conditioned in accordance with high pressure boilers working at 60 kg/cm^2 and above (*see* IS: 4343-1967**).
2. When feed water heaters are of copper or copper alloy constructions, the pH of the feed water shall be maintained between 8.5 and 9.2 while when feed water heaters are of iron constructions, the pH of feed may be maintained between 8.5 and 9.5.
3. *Silica in Boiler Water*: Lower concentration of silica may be advisable for steam of turbines, which generally requires less than 0.02 mg/l silica in steam.

* Methods of test for routine control for water used in industry.
\+ Methods of sampling and test (physical and chemical) for water used in industry.
a Total alkalinity should preferably be about 20 per cent of total dissolved solids.
b Shall not apply if reducing agents other than sodium sulphite are used.
j For riveted boilers only.
s For shell type boilers depending on parameters, the limits can be relaxed.
** Code of practice for treatment of water for high pressure boilers (under revision).

FORM I

(Regulations 386 and 487)

INDIAN BOILERS ACT, 1923

BOILER INSPECTION DEPARTMENT

BOILER REGISTRY NUMBER

MEMORANDUM OF INSPECTION
OR
REGISTRATION BOOK

MISCELLANEOUS

District..

Owner..

Address of Factory....................................

Nearest Railway Station..........................

Factory is..

Work of Factory.. Miles by.. from station

Working Season ....

Boiler registered at.................................. on..

Register Book No. .... Page...

Registry Number...................................... verified on...

Approved Working Pressure

Boiler Rating.. Inspection Fee...

Registration Book Filed at......................... on...

Remarks on transfers, etc.

PROVISIONAL ORDER AND CERTIFICATE RECORD

Fee	*Date of Payment*	*Date of Inspection*	*Certificate No. and Date*	*Period of certificate*	*Working Pressure*	*Boiler Rating*	*Evaporation*	*Initials of Inspector*

PARTICULARS AND DIMENSIONS

Type of Boiler : Leading Dimensions :

Maker : Intended Working Pressure :

Place and Year of make : Maker's Number :

Description of Boiler :

Fascimile of Maker's stamp

Position of Stamp ....

MAKER'S CERTIFICATE

Boiler Maker	Name..........................	
	Manufacture, hydraulic test to .... lbs. Drawing No.	received..............
Inspecting Authority	Name..........................	
	Tests of material, construction, supervision, hydraulic test..................	received............
Steel Makers — Plates	Name..........................	received..............
	Process........................	
Steel Makers — Bars	Name..........................	received..............
	Process........................	
Steel Makers — Rivets	Name..........................	received..............
	Process........................	
Rolling Mill	Plates..........................	received..............
	Bars..........................	received..............
	Rivets..........................	received..............

TEST RESULTS

	Shell..........................	T	to	tons E	to	% in	ins.
	Gusset Stays................	T	to	tons E	to	% in	ins.
	Girders........................	T	to	tons E	to	% in	ins.
Plates	End and side................	T	to	tons E	to	% in	ins.
	Fire & flanged...............	T	to	tons E	to	% in	ins.
	....	T	to	tons E	to	% in	ins.
	....	T	to	tons E	to	% in	ins.
	Bar............................	T	to	tons E	to	% in	ins.
	Screw..........................	T	to	tons E	to	% in	ins.
Rivets	Bars..........................	T	to	tons E	to	% in	ins.
	Manufactured................						
Bends	Plates						
	Bars..........................						
Branding	Plates..........................						

Analysis

	Phos.	Sulph.
	%	%

CYLINDRICAL SHELL

	(a) *Shell or Fire box Casing Crown*	(b) *Barrel or Mud Drum*	(c) *Steam & Water Drum or Dome*
Name of parts			
Number and material of each			
Length between end plates			
Length between end plates seam			
Diameter inside largest belt			
Thickness of Plates			
Number of belts of plating			
First or top belt, inside or outside.			
Longitudinal seams			
Position (o'clock)			
Kind— L., S.B., D.B., W.			
Riveting— S., D., T., C, Z., H., M.			
No. of rivets per pitch			
Pitch of rivets			
Dia. of holes, outer rows			
Diar. of holes, inner rows			
Distance between rows, outer			
Distance between rows, inner			
Distance rivet centre to edge			
Outer butt strap, width × thickness			
Inner butt strap, width × thickness.			
Circumferential seams			
No. of seams (end and inner)			
Kind— L., S.B., D.B., W.F. & B.			
Riveting— S., D.T., C.Z., H., M.			
No. of rivets per pitch			
Pitch or rivets			
Dia. of holes			
Distance between rows			
Distance between rivet centre to edge			

SHELL END PLATES AND LONGITUDINAL STAYS

Parts and materials hereunder..

PLATES	Flat, dished, hemispherical (in.. pieces,) not stayed, not flanged			
	Diameter (outside), front........... back,...........	crown.....................	Largest circle	
	Radius of curvature front.................................	back, ...	crown	
	Radius of curvature, corner of flange,..............	shell, ...	furnace, ... uptake, ...	
	Plate, thickness, front .... back, ...	crown.....................	tubeplate F,........ B, ...	
	Attach. to shell, crown or front, ...			
	Attach. to shell, back end, ...			
	Attach. to uptake or furnace crown or front,.......			
	Attach. to furnace flue, back end.....................			
	Shell angle .... riveting, S.........., D.........,...	Pitch,.........................	holes, ...	
	Furnace or uptake riveting, pitch circle,...........	Pitch,.........................	holes,........................	
	Heml. end sectors, No.... riveting, S......., D....,	Pitch,......................		
	Steam space doubling plate, front,..................	back......................		
	Steam space stiffener or bulb, front, ...	back......................		

STAYS	Gusset Stay, No. F.E., top, ...	Bottom, ...	B.E., top, ...	bottom, ...
	Longtl. Stays No.	dia., ...	threads, ...	hutted, ...
	Longtl. Stays pitch, V	H	circle, ...	washers, ...
	Diagl. Do, ...			

MANHOLES, HAND AND SIGHT HOLES, DOORS AND STAND

Parts and materials hereunder ....

MANHOLES	No. and position			
	Framed or plate flanged			
	Boiler opening, length × width			
	Frame opening, length × width			
	Frame inside, outside, raised, pressed			
	Frame solid, welded, cast			
	Frame section on longtl. axis			
	Door, type and thickness			
	Door, if inside, spigot clearance			
	Bolts, No. dia., threads Nut			
	Bolts, pitch circle			
	Compensation ring, width x thickness			
	Riveting, S., D., T., No., rivets dia. holes			

SIGHT HOLES	No.	dimensions	positions ....
	Compensation rings fitted	section	
	Doors, type	bolts dia.,........ threads.........	spigot clearance..........
	Cleaning plugs, No	dia.	position ....

BLOCK ETC.	Height	dia. (outside), top,... bottom....	thickness ....
	Standpipe below stop valve, ...	height,...... dia. (outside)	thickness ....
	Flanges		

FIREBOX CASING

Parts and materials hereunder ....

PLATES	Length overall, bottom, ...	Width overall, bottom	....	
	Height, foundn., seam to inside of crown plate			
	Crown, arched or flat, riveted to or one piece with sides, dia., ...			
	Plate thickness, front, ...	sides, ...	saddle	crown ....
	Radius of corner of flanges, ...	saddle, ...	crown, ...	
	Riveting front to sides, S.,D., pitch	holes, ...	spacing, ...	
	Riveting, saddle to sides, S., D., pitch	holes, ...	spacing, ...	
	Cross stays, No. .... Dia., ...	threads, ...	nutted, riveted pitch......	

RECTANGULAR FIREBOX, COMBUSTION CHAMBER, GIRDERS SMOKE OR WATER TUBES AND SCREW STAYS

Parts and material hereunder ....

FIREBOX OF COMBUSTION CHAMBER	Length inside, bottom .... top	Width inside, bottom, ... top	
	Height, foundn., seam or chbr. bottom to roof	Rad. of curve, chbr. bottom, ... roof side	
	Roof, flat, curved, chambered, corrugated, stayed to shell or girders, type, ...		
	Plate thickness, firehole or chbr. back, ...	sides, ...	roof, ...
	Plate thickness, bottom .... tube plate, F, ... B, ... roof and sides in one, ...		
	Attacht. to firebox casing at bottom, ...		
	Attacht. to firebox casing at firehole, ...		
	Foundn., ring, section	riveting, pitch	holes, ...
	Firehole, ring, section	riveting, pitch	holes, ...
	Firehole, opening	distance of centre above foundn. seam, ...	
	Side seams, distance between	riveting, pitch	holes, ...

Firegrate dimensions .... type ....

GIRDERS

Type .... Section .... No .... lengthwise, crosswise, rest on ....

Distance apart .... Bolts., No. .... pitch, ... dia., ... threads, ...

nutted, screwed into girder

Slings No., ... distance apart .... X ...... Section .... X .... pins diar ....

Slings, attach. to shell ....

TUBES

No. plain, ... Stay .... length between tube plates ...... make ....

Plain, dia. (out) .... thickness, ... F.E., expd., bead, frld. S.E., Expd., bead, or .....

Stay, dia. (out) .... thickness, ... F.E., expd., bead, nutted, S.F., Expd., nutted,....

Stay, dia. (out) over threads, F.E., ... S.E., ... Threads .... buts, ...

Pitch of plain tubes, V .... H .... D .... C.Z. straight curved. Lie, ...

Pitch of stay tubes, V ..... X .... X .... X .... Marginal pitch, ...

SCREW STAYS

Tubes, plate No. of fows, V .... H, ... Pitch, V .... H., ...

F. hole or back do., V .... H, ... Pitch, V .... H., ...

Sides, do., V .... H, ... Pitch, V .... H., ...

Roof, do., L. wise., ... C. wise .... Pitch L., ... C., ...

Bottom, do., L. wise., ... C. wise .... Pitch L., ... C., ...

Ordinary stays dia., threads, ... nuts .... riveted, bodies turned to .... in ....

Marginal do., threads, ... nuts .... riveted, bodies turned to .... in ....

Roof, do., threads, ... nuts .... riveted, bodies turned to .... in ....

CIRCULAR FURNACE, CROWN AND UPTAKE

Parts and material hereunder ....

HORIZONTAL AND VERTICAL FURNACES

No. of Furnaces, ... Type ....

No. of rings in each .... Longtl. seams ....

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length between Centre	R															
	L															
Inside diameter	R															
	L															
Plate thickness	R															
	L															
Positions of cross tubes	R															
	L															

HORIZONTAL AND VERTICAL FURNACES	Flanges, type .... riveting, pitch, ... holes, ...
	Caulking ring, ... Radius of corner .... Flang, width ....
	Cross-tubes, No. each furnace, ... longtl. seam, ... riveted, welded to Flue ......
	Cross-tubes, No. each furnace, dia., (outside), top ...... bottom .... thickness ....
	Attacht. to shell at bottom ....
	Attacht. to shell at bottom fireholes
	Foundn. ring, section .... riveting pitch .... holes ....
	Fireholes ring, section .... riveting pitch .... holes ....
	Fireholes opening .... X .... distance of centre above foundn. seam ....
	Screw Stays, No. of rows, ... Pitch, V .... H., ... nearest row to foundn., seam ......
	Screw Stays, No. of dia. .... threads .... nuts, ... riveted, bodies turned to ... in ......

CROWN	Firegrate dimensions .... Type ....
	Flat, dished hemispherical, not stayed, not flanged, Dia., (outside ....
	Radious of curvature .... corner of flange, furnace .... uptake .... largest circle ....
	Plate thickness, crown .... ogee ring .... Bolt stay pitch circle, ...
	Attacht., to furnace or .... to uptake, ...
	Uptake riveting, pitch circle, ... pitch .... holes ....

UP-TAKE	Cylindrical, tapered, flanged .... Longtl. Seam .... Length between seams, ...
	Thickness, ... Dia., (outside), top .... bottom .... Liner not fitted ....

WATER TUBES, HEADERS, BOXES AND SUPERHEATERS

Parts and material hereunder ....

TUBE	Main tubes No. .... Make ....
	Dia. (outside) .... thickness .... Length between headers or plates ....
	Pitch V., ... H., ... D., ... C.Z. Straight, curved, Lie ....
	Ends expanded beaded, belled, to .... in. in ....
	Downtake tubes, No. .... dia. (outside) .... thickness .... Length (exposed) ....

BOXES HEADER	Headers, No. .... section (outside) .... X .... thickness .... solid, welded,
	Staggered or straight, Lie .... No. tubes in each ....
	Caps round, oval, square, inside, outside, Bolts, Dia. .... threads, ... nuts, ...
	Mudbox, length, ... section (outside), ... X .... thickness, ... solid welded,
	Cross boxes No. .... section (outside), ... X .... thickness, ... solid welded,

SUPERHEATER

Tubes No. .... dia. (outside) .... thickness, ... make ....

Straight, curved, Lie .... Position ....

Ends expanded, beaded belled to .... in. in ....

Description of superheating system ....

Firegrate dimensions, ... Type ....

DESCRIPTION OF INTEGRAL ECONOMISERS

MOUNTINGS AND FITTINGS

VALVES, ETC. CHESTS

	Number	*Diameter*	*Type*	*Material*	*Bolted to*
Safety					
Safety					
M. Stop					
A. Stop					
Feed					
Blow Down					
Scum					
Injector					

MISCELLANEOUS FITTINGS

Water gauges, No. .... type .... Test cocks No. ....

Water gauges, top of lower nut is .... inches above ....

Test cocks, bottom cock is .... inches above ....

Pressure gauge, Type .... dia., ... in range .... lbs.

Pressure gauge, Maker .... No. .... red line at .... lbs.

Tester attachment type .... screw .... position ....

Hose attachment type .... screw ....position ....

Fusible plug, type .... position ....

Blow down elbow, material .... waste pipe, separate, connected to ....

Centre of feed inlet is .... inches above .... on right, left, side ....

Feed apparatus ....

Additional fittings ....

CALCULATIONS

SHELL, BARREL, S. & W. DRUM, F.C. CROWN, DOME, M. DRUM RIVETED JOINTS

Parts	*Joint Fig. No.*	*Longitudinal*	*Joint Fig. No.*	*Circumferential*	
(A)	P...D...T N C S_1			P...D... N C S_1	
(B)					
(C)					
	Actual	Rules	Actual	Rules	
Max. Pitch					
Outer Rows					
Inner Rows					
Edges					
Wider Strap					
Narrow Strap					
Plate %	$\frac{100(P-D)}{P}=\%$		$\frac{100(P-D)}{P}=\%$		
Rivet %	$\frac{100\times A\times N\times C\times S_1}{P\times T\times S}=\%$		$\frac{100\times A\times N\times C\times S_1}{P\times T\times S}=\%$		
Combd.%	$\frac{100(P-2D)}{P}+\frac{100\times A\times C\times S}{P\times T\times S}=\%$				
Working Pressure	t...S...J...C...D...W.P.= $\frac{(t-2)\times S\times J}{C\times D}=\text{lbs.}$				Least Pressure .... lbs.

FLAT END PLATES AND GUSSET STAYS PLATE STIFFNESS

	Dimensions	Front	Back	Front End
THICKNESS	t....................................			$W.P.=\frac{(t-1)^2}{D^2}=\text{lbs.}$
	t_1....................................			Around Manhole
	I....................................			$S.P.=\frac{(t-1)^2+(t_1-1)^2}{D^2}=\text{lbs.}$
	I-II....................................			Back End
	II-III....................................			$W.P.=\frac{(t-1)^2}{D^2}=\text{lbs.}$
	III-IV....................................			
	IV-V			
	Over Furnaces			
	Below Furnaces			
	Manhole			

AREAS (A) SUPPORTED BY GUSSET STAYS FRONT END

	Dimensions	Front	Back	Gussets		Areas
LENGTH OF LINES	Mid			I	=	Sq. in.
	I			II	=	"
	II			III	=	"
	III			IV	=	"
	IV			V	=	"
	V or Mid				BACK END	
DISTANCE BETWEEN LINES	I-I			I	=	"
	I-II			II	=	"
	II-III			III	=	"
	III-Apex.			IV	=	"
	IV-Apex			V	=	"
	IV-V or Mid.					

PLATE MARGINS

W.P. ....

$\frac{3.7(t-1)}{\sqrt{W.P.}}$ = ins. $\frac{3.7(t-1)}{\sqrt{W.P.}}$ = ins.

LEAST PRESSURE lbs.

GUSSET STAYS PARTICULARS

Gusset Plate, thickness .... tons .... angles .... X .... X ....

NUMBER AND DIAMETER OF RIVETS AND SECTION & OF STAYS

Gusset			N_1	N_2	N_3	N_4	D_1	D_2	D_3	D_4	G	G_1	Toe Rivets
	I.	F.											
		B.											
	II.	F.											
		B.											
	III.	F.											
		B.											
	IV.	F.											
		B.											
	V.	F.											
		B.											

GUSSET STAY CALCULATIONS

			I	II	III	IV	V	
COEFFICIENT		F						
	$N_1 \times N_2$	B						
	$N_2 \times A_1 \times 1.875$	F						
		B						
	$N_3 \times A_3 \times 1.875$	F						
		B						
WORKING PRESSURE	$N_4 \times A_4$	F						
		B						
	$(G - N_2 D_2)(t - 2) .0.37$	F						
		B						
	$(G - D)(t - 2) .0.37$	F						
		B						Least Pressure ......lbs.
	$\frac{8500 \times C}{A}$	F						
		B						

SAFETY VALVES

LEVER AND WEIGHT VALVES

High Steam and Low Water Type

	(A)	(B)	(C)
No. of valves each chest			
Type			
Diameter of valve			
Diameter of Neck			
Diameter of outlet			
....			

		( )	( )
Weights	B		
	L		
	V		
Distances	B to F		
	G to F		
	V to F		

Balanced Lever ( )

$$\frac{[W.P.(A-a)-V]\ V\ to\ F}{B} = ins.$$

Unbalanced Lever ( )

$$\frac{[W.P.(A-a)-V]\ V\ to\ F-(G\ to\ F)\ L}{B} = ins.$$

Small Valve ( )

$$W.P. \times a\ (\ ) = lbs.$$

Ordinary Type Unbalanced (Lever) ( )

$$\frac{[W.P.\ (A-V)-V]\ V\ to\ F-(G\ to\ F)L}{B} = ins.$$

DEAD WEIGHT VALVE ( ) = W.P.×A lbs.

Weight
- Plates ....
- Casting ....
- Valves ....

SPRING LOADED VALVE

Range of compression .... inches. Load compression .... inches.

L = (A × W.P.) ; D = ; C ; K = ; d = inches.

B = ; H = ; W.P. ; A = ;

Round section	Square section	Rectangle section
$W.P. = \dfrac{10000\,\Omega \times d^3}{DACK}$	$W.P. = \dfrac{33333 \times d^3}{DACK}$	$W.P. = \dfrac{160000\,B^2 \times H^2}{DACK\,(3B + 1.8H)}$

REQUISITE AREA OF SAFETY VALVES

For Saturated steam	For Superheated steam
$A = \dfrac{E}{C.P.}$	$As = A\sqrt{\left(1 + \dfrac{1.5T}{1000}\right)}$

E = ; C = ; P = ; A =

As = ; T = ; A = ;

NOTES ON WORKING OF BOILER

Boiler is used for ....

Constant, intermittent or seasonal work ....

Is boiler relieved by square boiler ? ....

How long worked between cleanings ? ....

Most suitable time for inspection ....

Pump available for hydraulically testing boiler ? ....

Feed water used, town well, surface or jet condenser ....

Nature of water ....

Fuel used .... Are printed instructions kept near boiler ? ....

Period between cleanings approved by Inspector ....

HEATING SURFACE

Total Heating Surface .... Sq. ft.

Boiler Rating..

Calculations made by .... on .... submitted on ....

Calculations checked by .... on ....

Least pressure, that for.. lbs.

Approved working pressure.. lbs.

Chief Inspector's remarks and signature ....

HYDRAULIC TEST REGISTRATION

Inspector .... Date of test .... Test pressure ....lbs.

Duration of test .... mins. Boiler pressure, gauge No. .... use at test ....

Boiler pressure gauge compared with .... on .... found ....

Position of Boiler at test ....

Brick work .... Lagging ....

Condition of boiler under test ....

Condition of boiler mountings under test ....

RIGHT HAND

	Ring	Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FURNACE GAUGINGS	Before Test	V															
		H															
	During Test	V															
		H															
	After Test	V															
		H															
	Bulging	V															
		H															
	Permt. Set	V															
		H															

LEFT HAND

	Ring	Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FURNACE GAUGINGS	Before Test	V															
		H															
	During Test	V															
		H															
	After Test	V															
		H															
	Bulging	V															
		H															
	Permt. Set	V															
		H															

		FRONT END				BACK END				Sketch position of gauge points
END PLATE GAUGINGS	Gauge Points	A	B	C	D	A	B	C	D	
	Before Test									
	During Test									
	After Test									
	Bulging									
	Permt. Set									

STEAM TEST (REGISTRATION)

Inspector .... Date of Test ....

Approved working pressure .... lbs .... Test pressure .... lbs. ....

Inspector's pressure gauge .... Boiler pressure gauge No. ....

Boiler connections .... Condition of fire ....

Fuel used .... Draught ....

Safety Valve lifted at (A) .... lbs. (B) .... lbs. (C) .... lbs. ....

	Beginning	5 mins.	10 mins.	14 mins.	Difference
Timing of test.................................					
Height of water in glass....................					
Pressure by Inspector's gauge...........					
Pressure by Boiler gauge..................					

Accumulation of pressure, 100 (–) = % ....

Do safety valves efficiently relieve boiler ? ....

Condition of boiler under steam ....

Condition of mountings under steam ....

Loading of valves at blowing pressure (A) ....

Loading of valves at blowing pressure (B) ....

Loading of valves at blowing pressure (C) ....

Thickness of washers or ferrules ....

Feed pump or injector worked ....

Water gauge tested ....

Boiler Attendant ....

Limit of load on safety valves to be entered in Certificate ....

STEAM-PIPES

PLAN OF BOILERS AND MAIN STEAM-PIPES

PARTICULARS AND DIMENSIONS

Situation ....

Ry. Nos. of connected boilers ....

Main Steam-pipes include ....

Pipes, material .... Daimeter (outside) ....

Pipes, material thickness .... ins. Make ....

Pipes, material attachment of flanges ....

Pipes, material made by .... Installed in ....

Drainage ....

Pipe, covering ....

Provisions for disconnection from other boiler ....

Main Steam ....

Auxy. Steam ....

Blow down ....

Feed delivery ....

CALCULATIONS

....

....

RECORDS OF INSPECTIONS AND TESTS

First inspection inside and outside by .... on ....

First hydraulic test (to lbs.) .... by .... on ....

INSPECTOR'S NOTES

PARTICULARS OF BOILER ATTENDANTS

Grade	Name	No. and Year of Certificate	Date of Employment

FORM II

INSPECTING AUTHORITIES CERTIFICATE OF INSPECTION DURING CONSTRUCTION

[Regulation 4 (c) (1)]

Designation of Inspecting Authority

We hereby certify that the .... type, boilers; length .... feet .... inches; diameter, ... feet .... inches; working pressure; .... lbs. built by Messrs .... at .... under Shop Number .... was constructed under our supervision and inspected at various stages of construction by the Inspecting Officer and that the construction and workmanship were satisfactory and in accordance with the Standard Conditions for the design and construction of land boilers under the Indian Boilers Act, 1923.

The boiler is stamped on the front end plate with our stamp as shown hereunder:—

Maker's Name .... Year of Make..

Works number .... Tested to .... lbs .... on ....

W.P. .... lbs. Inspecting Officer's or Inspecting Authority's Official Stamp.

The boiler on completion was
—————————— subjected to a water pressure tests of .... lbs. per square inch
The drum and headers were
in the presence of the Inspecting Officer on .... 20 .... and satisfactorily withstood the test.

*Samples of materials used in the constructions of the boiler were tested in the presence of the Inspecting Officer and found to comply with the requirements. All welded seams were subjected to physical tests and radiographic examination wherever applicable and found satisfactory.

Note: Strike off this paragraph where no such tests has been carried out and the certificate in Form IV by a Well-known Maker is intended to be furnished.

* Strike out which is not applicable.

We have satisfied ourselves that the construction and dimensions of the boiler are as shown in the Maker's Drawing No. .... signed by us, and that the particulars entered in the Maker's certificate of manufacture in Form III countersigned by us, are correct to the best of our knowledge and belief.

Dated at .... this .... day of .... 20...... *Signature of Inspecting Authority*

FORM II-A

INSPECTING AUTHORITIES CERTIFICATE OF INSPECTION DURING CONSTRUCTION IN RESPECT OF A BOILER MADE TO FOREIGN CODE FOR EXPORT

[Regulation 3A]

Designation of Inspecting Authority

We hereby certify that the .... type boilers; length .... diameter .... working pressure .... built by Messrs .... under Shop No. .... was constructed under our supervision and inspected at various stages at construction by the Inspecting Officer and that the design, construction and workmanship were satisfactory and in every respect in accordance with .... Code Specification. The boiler is stamped as under :

The boiler on completion was tested to .... in the presence of the Inspecting Officer on .... and it satisfactorily withstood the test. Details of tests and inspections are furnished with this certificate.

We have satisfied ourselves that the design, construction and dimensions of the boiler are as shown in the Maker's Drawing No. .... approved and signed by us, and that the particulars entered in the Maker's Certificate of manufacture are correct to the best of our knowledge and belief. Maker's certificate, signed by them and countersigned by us, as required by the .... Code/Specification, is enclosed.

Signature of Inspecting Authority

FORM II-B

INSPECTING AUTHORITY CERTIFICATE OF INSPECTION DURING CONSTRUCTION OF BOILERS FOR WHICH VARIATIONS FROM STANDARD CONDITIONS HAVE BEEN PERMITTED

[Regulation 4(c)(1) Note]

Designation of Inspecting Authority

We hereby certify that the .... type boilers; length .... diameter .... working pressure .... built by Messrs .... at .... under Shop Number .... was constructed under our supervision and inspected at various stages of construction by the Inspecting Officer, and that the design, construction and workmanship were satisfactory and in accordance with the variations from the standard conditions laid down in the Indian Boiler Regulations, 1950, for material design and construction features have been permitted by the Board of Inspecting Authority under the Indian Boilers Act, 1923.

The Boiler is stamped on the front end plate with our stamp as shown hereunder :—

Maker's Name .... Year of Make .... Works Number .... Tested to .... on .... W.P. Inspecting Officer's or Inspecting Authority's official stamp.

$\frac{\text{The boiler on completion was}}{\text{The drum and header were}}$ subjected to a water pressure test of.............. in the presence of Inspecting Officer on .... 20 .... and satisfactorily withstood the test.

*Samples of materials used in the construction of the boiler were tested in the presence of the Inspecting Officer and found to comply with the requirements. All welded seams were subjected to physical tests and radiographic examination wherever applicable and found satisfactory.

Note: Strike off this paragraph where no such test have been carried out and the certificate in Form IV by a Well-Known Maker is intended to be furnished.

* Strike out which is not applicable.

We have satisfied ourselves that the constructions and dimensions of the boiler are as shown in the Maker's Drawing No. .... signed by us and that the particulars entered in the Maker's certificate of manufacture in Form III countersigned by us, are correct to the best of our knowledge and belief. Particulars of variations from the standard conditions laid down in the said regulations as permitted by the Board or Inspecting Authority are enclosed.

Signature of Inspecting Authority

Dated at .... this .... day of .... 20.........

FORM III

WORKS ADDRESS

Constructor's Certificate of Manufacturer and Test

[Regulation 4(c)(III)]

1. Description	Constructor's Name and address...
	Manufactured for/Stock purposes ....
	Contract No. ....
	Type of Boiler .... Length overall
	Diameter inside Largest belt ....
	Design pressure .... lbs/sq. in.
	Intended working pressure .... lbs./sq. in.
	Shop Number of boiler ....
	Year of Manufacture ....
	Total heating surface .... Sq. ft.
	Final Temperature of steam (Design) .... of
	Grate area .... sq. ft.
	Brief description of boiler ....
	Evaporation capacity ....
	(for calculation of relieving capacity of safety valves)

2. Parts manufactured at the contractor's works	Name of Part(s) .... Description .... Leading dimensions .... Manufactured by .... Identification marks .... Part(s) manufactured, inspected at all stages of construction by .... (Inspection Authority). Certificates furnished (Contractor's/Steel Maker's and Inspecting Authority's etc.) .... Part(s) hydraulically tested and internally inspected after test by ....
3. Parts manufactured outside the constructor's works	Name of Part(s) .... Description .... Leading dimensions .... Manufactured by .... Identification marks .... Part(s) manufactured, inspecting at all stages of construction by .... (Inspection Authority). Certificates furnished (Contractor's Steel maker's and Inspecting Authority's etc.) .... Part(s) hydraulically tested and internally inspected after test by ....

Note: Similar information is to be furnished for each part manufactured outside the Contractor's Works.

4. Construction

(a) Riveted/composite construction shells/drums/Miniature Boilers: The construction is in accordance with Chapter III/XIV of the Indian Boiler Regulations.

Number of longitudinal seams in shell/drum in each belt ....

Number of longitudinal seams in furnace in each ring ....

Number of circumferential seams in shell/drum ....

(including end seams) ....

Number of circumferential seams in the furnace ....

Details of repairs, if any, carried out in welded seams during construction ....

Details of heat treatment ....

The longitudinal seams are welded/riveted and have .... rows of rivets in inside strap and .... rows of rivets in outside strap.

Rivet holes are .... diameter and number .... per pitch of..............

Butt straps cut from plates and bent to required curvature in.....................................

The circumferential seams joining rings of shell are .... Jointed and single/double riveted/welded.

Rivet holes are .... diameter and number .... per pitch of...........

The shell end seams are .... Jointed and single/double riveted/welded.

Rivet holes are .... diameter and number .... per pitch of ....

Details of seams as in drawing No. ....

All welded seams were subjected to Radiographic examination to the satisfaction of the Inspecting Authority, where required.

(b) Shell type boilers of welded construction— The construction is in accordance with Chapter XII of the Indian Boiler Regulations.

Number of longitudinal seams in shell in each belt ....

Number of longitudinal seams in furnace ....

Number of circumferential seams in shell ....

Number of circumferential seams in furnace ....

Details of repairs, if any, carried out to welded seams during construction ....

Details of heat treatment ....

All welded seams were subjected to radiographic examination to the satisfaction of the Inspecting Authority, where required.

(c) Fusion welded Electrode Boilers— The construction is in accordance with Chapter X of the Indian Boiler Regulations, 1950.

Number of longitudinal seams in shell ....

Number of circumferential seams (including end seams) ....

Details of repairs, if any carried out to welded seams during construction ....

Details of heat treatment ....

All welded seams were subjected to radiographic examination to the satisfaction of the Inspecting Authority, where required.

(d) Fusion welded and seamless forged drums of water tube boilers— The construction is in accordance with Chapter V of the Indian Boiler Regulations, 1950.

Number of longitudinal seams in each ring ....

Number of circumferential seams ....

Details of repairs, if any, carried out to seams during construction ....

Details of heat treatment ....

All welded seams were subjected to radiographic examination to the satisfaction of the Inspecting Authority.

(e) Furnace seams— The longitudinal seams are welded/riveted. The cross seams joining rings are of .... type ....riveted/welded.

Boiler parts and fittings	*Material*	*Smelter*	*Make*	*Inspecting Officer*	*Remarks*
5. Material Manufacture Plates					
Plates					
Rivet bars					
Stay bars					
Angles					
Bolts					
Tubes					
Tubes					
Girders					
Tubes					
Boxes					
Headers					
Headers					
Manhole frames					
Manhole doors					
Manhole					
Sighthole doors					
Stand blocks					
Stand pipes					
Stop valve chests					
					Contd...

Contd...					
Safety valve chests					
Feed valve chests					
Blow down valve					
Blow down elbow pipe					
Water gauge mountings					

Note: Under "Material" enter against appropriate items "Steel Simens Martin Open Hearth acid (or basic) process", "Wrought Iron, Brand......", "Cast Steel Process" .... etc. etc. and under "Remarks" a brief explanation of process of manufacture where necessary e.g., "Solid drawn Lap welded", "Solid Pressed", tested by Makers .... lbs. per sq. inch etc.

Part of Boiler	*Thickness of plates 32nd or diameter in inches*	*Tensile strength limits to tons*	*Elonga-tion limits to %*	*Gauge length inches*	*Brand & No. on plate*
1	2	3	4	5	6
6. Thickness of Plates etc. and tensile test, Limit					
Cylindrical Shell Plates					
Shell					
Butt, straps					
Steam & Water Drums					
Wrapper plate (1)					
Tube plate (1)					
Wrapper plate (2)					
Tube plate (2)					
Wrapper plate (3)					
Tube plate (3)					
Cylindrical shell Plates					
Barrel					
Fire box casing crown Dome					
Mud of bottom drum (1)					
Mud of bottom drum (2)					
Mud of bottom drum (3)					
Shell end plate and drum Heads					
Front end shell					
Front end shell steam and water drum (1)					
Front end shell steam and water drum (2)					
Front end shell steam and water drum (3)					
Front end shell Mud drum (1)					

Front end shell Mud drum (2)					
Front end shell Mud drum (3)					
Back end shell					
Back end shell Steam and water drum (1)					
Back end shell Steam and water drum (2)					
Back end shell Steam and water drum (3)					
Back end shell Mud drum (1)					
Back end shell Mud drum (2)					
Back end shell Mud drum (3)					
Shell crown					
Dome end					
Saddle					
Fire box casing sides					
Doubling plate front					
Doubling plate back					
Flanged and fire exposed plates					
Furnace circular (Plain)					
Furnace circular					
Furnace circular (Corrugated)					
Fire box crown					
Fire box side					
Fire box front					
Fire box tube					
Uptake					
Smoke box tube					
Com. Chbr. wrapper					
Com. Chbr. back					

THICKNESS OF PLATES ETC. AND TENSILE TEST LIMITS

1	2	3	4	5	6
Tubes					
Cross tubes					
Smoke Tubes (Plain)					
Smoke Tubes (Stay)					
Water tubes (bottom or front bank)					
Water tubes (top or rear bank)					
Balancer tubes (Steam)					
Balancer tubes (Water)					
Superheater tubes					

Superheater tubes					
Superheater tubes					
Water wall tubes					
Water wall tubes					
Integral Economiser tubes					
Headers and Sectional Headers Cross Boxes					
Sectional headers					
Water wall headers (1)					
Water wall headers (2)					
Water wall headers (3)					
Water wall headers (4)					
Water wall headers (5)					
Water wall headers (6)					
Integral Economiser headers (1)					
Integral Economiser headers (2)					
Superheater headers (1)					
Superheater headers (2)					
Superheater headers (3)					
Superheater headers (4)					
Superheater headers (5)					
Superheater headers (6)					
Mud Boxes (1)					
Mud Boxes (2)					
Mud Boxes (3)					
Mud Boxes (4)					
Stays and Gusset Stay Plates Bolts					
Gusset Stay Plates					
Longitudinal					
Cross					
Screw					
Roof					
Firebox roof slings					
Firebox roof pins					
Girder bolts					
Shell angle bolts					
Uptake angle bolts					
Manhole bolts					
Sighthole bolts					

Miscellaneous					
Firebox girders					
End plate stiffeners					
Shell angle					
Furnace angle					
Uptake angle					
Gusset angle					
Manhole compensation ring					
Manhole frame					
Manhole cover					
Sighthole compensation ring					
Sighthole doors					
Stand blocks					
Stand pipes					

7. Details of Drums

No.	*Nomenclature*	*Nominal dia.*	*Length*	*Shell plate*		*Tube plate*		*Head*			*Manholes No. & Size*	*Hydrostatic test lbs./sp.in*
				Thickness in 32nds. In.	*Inside radius in.*	*Thickness in 32nds. In.*	*Inside radius in.*	*Thickness in 32nds. In.*	*Type**	*Radius of dish in.*		
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*

*Indicate (1) Flat (2) Dished (3) Ellipsoidal (4) Hemispherical.

8. Headers and Boxes

No.		*Size and shape*	*Thickness in 32nd in.*	*Head or end*		*Hydrostatic test lbs./sq. in.*
				Shape	*Thickness in 32nds in.*	
Water Wall	1					
Headers	2					
	3					
	4					
	5					
	6					

Integral	1					
Economiser Headers	2					
Superheaters	1					
Headers	2					
	3					
	4					
	5					
	6					
Mud Boxes	1					
	2					
	3					
	4					

9. Tubes

Sl. No.	*Nomenclature*	*Outside Diameter in inches*	*Thickness in 100ths in.*
1.	Cross tubes		
2.	Smoke tubes (Plain)		
3.	Smoke tubes (Stay)		
4.	Water tubes (bottom or front bank)		
5.	Water tubes (rear or top bank)		
6.	Balancer tubes (Steam)		
7.	Balancer tubes (Water)		
8.	Superheater tubes		
9.	Superheater tubes		
10.	Water wall tubes		
11.	Integral economiser tubes		

10. Mountings

No.	*Nomenclature*		*Material*	*Type*	*No.*	*Size*
1.	Main stop valve					
2.	Auxiliary stop valves					
3.	Safety valves	(a)				
		(b)				
		(c)				
4.	Blow down valves					
5.	Feed Check valves					

11. Details of the safety valves and test results

Manufacturer ....

Identification marks of valves ....

Maker's No. ....

Type ....

Life (mm) .... Drawings Nos. ....

Valves details :

Material ....

Valve Seat ....

Flat/Bevel ....

Diameter of valve seating ....

Valve Body :

Material ....

Opening at neck ....

Opening at outlet ....

Springs:

Material ....

Process of manufacture ....

Chemical composition ....

Dimensions :

Outside diameter of coil ....

Section of wire ....

Number of coils ....

Free length of coils ....

Test results :

Place of test .... Date ....

Closing down pressure ....

Remarks :

Does the valve chatter? ....

Does the valve seat leak? ....

Blow off pressure ....

Type of valve and extract of test results ....

Type of valve ....

Place of test .... date ....

Constant 'C' by test results ....

Capacity of the valve for the intended blow off pressure ....

Signature of Maker's representative *INSPECTION AUTHORITY witnessing tests*

12. Certified that the particulars entered herein in manuscript by us are correct and that parts and fittings in sections 2 to 11, against the names of which entries are made, have been used in the construction and fittings of the boiler.

The particulars shown against the various parts used are in accordance with the enclosed certificates from the respective Makers.

The design of the boiler is that as shown in Drawing Nos. ....

The boiler has been designed and constructed to comply with the Regulations under the Indian Boilers Act, 1923, for a working pressure of .... lbs. per square inch at our Works above-named and satisfactorily withstood a water test of .... lbs. per square inch on the .... day of .... 20 .... in the presence of our responsible representative whose signature is appended hereunder.

Maker
(*Signature of Maker*)
or
Secretary of Firm

Name and Signature of Engineer who witnessed test.

Designation

Dated .... the day of .... 20......

Official Seal *Name and Signature of Inspecting Authorities*

FORM III-A

CERTIFICATE OF MANUFACTURE AND TEST
[Regulation 4(e)]

Name of Part ....

Maker's name and address ....

Design pressure ....

Design temperature ....

Material

Process of manufacture ....

Fully killed/rimmed ....

Chemical composition ....

Pipes

Main dimensions ....

Tolerances ....

Mode of manufacture ....

Identification marks ....

Drawing numbers ....

Bend test on pipes ....

Bend test on weld ....

Flattening test ....

Tensile strength ....

Mode of attachment of flanges ....

Flange particulars ....

Size of branches ....

Mode of attachment of branches ....

Heat treatment ....

Final hydraulic test ....

Note: In addition, the following information in respect of the material shall be furnished in a tabular form in conformity with the requirements of Regulation 4(c)(vi) for the note thereto, as the case may be. The information may be given from the established test data or if the material is of standard quality an extract from the standard may be furnished instead.

Metal temperature upto °C	*250*	*275*	*300*	*325*	*350*	*375*	*400*	*425*	*450*	*475*	*500*	*525*	*550*	*575*	*600*
E_t															
S_c															
S_r															

Tensile strength at 20°C

where, E_t = Yield point at temperature (0.2% proof stress).

**S_c = Average stress to produce and elongation of 1% (creep) in 100,000 hours at the various working metal temperatures.

**S_r = Average and lowest stress to produce rupture in 100,000 hours at the various working metal temperatures.

Temperature range in the table may extend upto the limit of applicability of the material.

The values of S_c and S_r need be furnished only in respect of Pipes/Tubes intended to be used for working metal temperature above 454°C (850°F).

Certified that the particulars entered herein are correct.

The particulars of fabricated component are shown in drawing No. ....

The part has been designed and constructed to comply with the Indian Boiler Regulations for a working pressure of .... and temperature .... and satisfactorily withstood a water test of .... on the .... day of .... 20........ in the presence of our responsible representative whose signature is appended hereunder.

Maker's Representative *Maker* ....
(*Name and Signature*)

We have satisfied ourselves that the pipes have been constructed in accordance with Chapter VIII. The tests conducted on the samples taken from the finished pipes have been witnessed by us and the particulars entered herein are correct.

Place ....

Date .... *Name and Signature of Inspecting Authority*

Note : (1) This form is intended for the use of both pipe manufacturers and pipe fabricators. Only such of the columns or paragraphs that are applicable, or information that can be obtained and furnished from other certificates, need be filled or entered in this form.

(2) In the case of fabrications made from steel pipes obtained from elsewhere, particulars in regard to the "material" and "pipes" shall be taken from similar forms of certificates obtained in respect of pipes and noted in the appropriate columns or paragraphs.

In the case of pipes made from steel, made and tested by well known Steel Makers in India or other countries listed, particulars regarding the "material" as certified by them (in any form) shall be noted in the appropriate columns or paragraphs in this certificate.

FORM III-B

CERTIFICATE OF MANUFACTURE AND TEST
[Regulation 4 (f)]

Maker's Name ....

Design Pressure ....

Design Temperature ....

MATERIAL

Process of manufacture ....

Fully killed/rimmed ....

Chemical composition ....

TUBES

Process of manufacture ....

Main dimensions ....

Tolerances ....

Tensile strength ....

Elongation percentage ....

Bend test ....

Flattening test ....

Crushing test ....

Flare test ....

Flange test ....

Bend test on weld ....

Bulging test and drifting test (for copper and brass) ....

Head treatment ....

Hydraulic test ....

Note: In addition, the following information in respect of the material shall be furnished in a tabular form in conformity with the requirements of regulation 4(c)(vi) or the Note thereto, as the case may be. This information may be given from the established test data or if the material is of standard quality, as extract from the standard may be furnished instead.

Metal temperature upto °C.	*250*	*275*	*300*	*325*	*350*	*375*	*400*	*425*	*450*	*475*	*500*	*525*	*550*	*575*	*600*
E_t															
S_c															
S_r															

Tensile strength at 20°C

Where, E_t = Yield point at temperature (0.2% proof stress).

**S_c = Average stress to produce an elongation of 1% (creep) in 100,000 hours at the various working metal temperatures.

**S_r = Average and lowest stress to produce rupture in 100,000 hours at the various working metal temperatures.

Temperature range in the table may extend upto the limit of applicability of the material.

The value of S_c and S_r need be furnished only in respect of Pipes/Tubes intended to be used for working metal temperature above 454°C (850°F).

Certified that the particulars entered herein are correct.

The tubes have been manufactured to comply with the Indian Boiler Regulations for a maximum working pressure of .... and a maximum temperature of .... at our works above-named and satisfactorily withstood a water test of .... on the .... day of .... 20......, in the presence of our responsible representatives whose signature is appended hereunder.

Maker's Representative
(Name and Signature) *Maker* ....

We have satisfied ourselves that the tubes have been constructed in accordance with Chapter II. The tests conducted on the samples taken from the finished tubes have been witnessed by us and the particulars entered herein are correct.

Place ....

Date .... *Name and Signature of Inspecting Authority*

Note: (1) This form is intended for the use of both tube manufacturers and tube fabricators. Only such of the columns or paragraphs that are applicable, or information that can be obtained and furnished from other certificates, need be filled or entered in this form.

(2) In the case of fabrications made from tubes/pipes obtained from elsewhere, particulars in regard to the "material" and "tubes" shall be taken from similar forms of certificates obtained in respect of pipes and noted in the appropriate columns or paragraphs.

In the case of tubes made from steel, made and tested by well-known Steel Makers in India or other countries particulars regarding the "material" as certified by them (in any form) shall be noted in the appropriate columns or paragraphs in this "certificate".

FORM III-C

CERTIFICATE OF MANUFACTURE AND TEST OF BOILER MOUNTINGS AND FITTINGS

(Regulation 269)

Name of part ....

Maker's name and address ....

Intended working pressure .... kg./cm^2 .... (lb./sq.inch)

Hydraulic test pressure .... (kg/cm^2) .... (lb./sq.inch)

Main dimensions ....

Drawing Nos. ....

Identification Marks ....

Chemical composition ....

Physical test results ....

(i) tensile strength ....

(ii) transverse bend test ....

(iii) elongation ....

Certified that the particulars entered herein by us are correct.

The part has been designed and constructed to comply with the Indian Boiler Regulations for a working pressure of .... and satisfactorily withstood a hydraulic test using water or kerosene or any other suitable liquid to a pressure of .... on the .... day of .... 20...... in the presence of our responsible representative whose signature is appended hereunder.

Signature of Maker's representative *Signature of Inspecting Officer who witnessed the test*

Date at .... the day of .... 20......

Signature and seal of Inspecting Authority ....

Place ....

Date ....

Maker's Representative
(*Name and Signature*) *Maker's* ....

We have satisfied ourselves that the valve/fitting has been constructed and tested in accordance with the requirements of the Indian Boiler Regulations, 1950. We further certify that the particulars entered herein are correct.

Place .... *Name and signature of the Inspecting Officer who witnessed the tests*

Date ....20..... *Name and Signature of the Inspecting Authority*

Note: In the case of valve chest made and tested by well-known Foundries or Forges recognised by the Central Boilers Board in the manner as laid down in Regulations 4A to 4H, particulars regarding the material as certified by them, in any form, shall be noted in the appropriate columns or paragraphs in the certificate and in case of certificates from well-known Foundries or Forges is produced, such certificate may be accepted in lieu of the certificate from Inspecting Authority in so far as it relates to the testing of material specified in the Form.

* Strike out which is not applicable.

FORM III-D

CERTIFICATE OF MANUFACTURE AND TEST

[Regulation 4(c)]

Certificate No. ....

Date of Manufacture ....

Name of Part ....

Maker's Name and address ....

Code of Manufacture/Specifications ....

Material

Heat No. ....

Process of manufacture ....

Fully killed/rimmed/semi-killed ....

Chemical composition ....

Pipes

Main dimensions ....

Tolerances ....

Mode of manufacture ....

Identification marks ....

Bend Test ....

Bend test on weld ....

Flare test ....

Flattening test ....

Drift test ....

Tensile strength ....

Crushing test ....

Heat treatment ....

Flange test ....

Final hydraulic test ....

Non-destructive examination ....

Certified that the particulars entered herein are correct.

The part has been manufactured to comply with the Indian Boiler Regulations at our works above-named and satisfactorily withstood a water test of........... on the.............. day of................. 20...... in the presence of our responsible representative whose signature is appended hereunder.

Maker's Representative
(*Name and signature*) *Maker* ....

Note: In the case of pipes made from steel, made and certified by well-known Steel Makers in India or other countries, particulars regarding the 'material' as certified by them (in any form) shall be noted in the appropriate columns or paragraphs in this "certificate".

FORM III-E

CERTIFICATE OF MANUFACTURE AND TEST

[Regulation 4(f)]

Maker's Name ....

Code of Manufacture/Specifications ....

Material

Heat No. ....

Process of Manufacture ....

Fully killed/rimmed/semi-killed ....

Chemical composition ....

Tubes :

Process of manufacture ....

Main dimensions ....

Tolerances ....

Tensile strength ....

Elongation percentage ....

Bend test ....

Flattening test ....

Crushing test ....

Flare test ....

Flange test ....

Bond test on weld ....

Bulging test and drifting test (for copper and brass) ....

Heat treatment ....

Hydraulic test ....

Non-constructive examination ....

Certified that the particulars entered herein are correct.

The tubes have been manufactured to comply with the Indian Boiler Regulations at our works above-named and satisfactorily withstood a water test of........... on the........... day of.................. 20...... in the presence of our responsible representative whose signature is appended hereunder.

Maker's Representative
(*Name and signature*)

Maker ....

Note: In the case of tubes made from steel, made and certified by the well-known Steel Makers in India or other countries, particulars regarding the 'material' as certified by them (in any form) shall be noted in the appropriate columns or paragraphs in this "certificate".

FORM III-F

CERTIFICATE OF MANUFACTURE AND TEST OF CASTINGS AND FORGINGS

(Regulations 73 to 80 or 81 to 85 as applicable)

Certificate No. ....

Name of Part ....

Maker's name and address ....

Main dimensions ....

Drawing Nos. ....

Identification Marks ....

Chemical composition ....

Physical test results ....,

(i) Tensile strength ....

(ii) Transverse bend test ....

(iii) Elongation ....

Certified that the particulars entered herein by us are correct. This satisfies the requirements of Indian Boiler Regulations, 1950.

Maker's Representative	*Monogram/*	
(*Name and signature*)	*Seal*	*Makers*......................

FORM III-G

CERTIFICATE OF MANUFACTURE AND TEST OF FORGINGS/CASTINGS (SEMIS)

(Regulation 269 of the Indian Boiler Regulations, 1950)

Name of Part .... Quantity :
.... Serial Nos.

Maker's Name & Address

Intended Working Pressure (kg/cm^2)						
Corresponding maximum temperature (^oC)						

Drawing No. Description Quantity

1, 2, 3, 4, 5

Identification Marks :

Forgings/Casting Process :

6. RAW MATERIAL

Size : Specification :

Maker : Certificate No. : Heat No./Cast No.

7. FINISHED MATERIAL

Size : Pouring Heat No. :

Specification : Heat Treatment :

Process : Temperature Soaking

Cooling Media : Batch No.

8. CHEMICAL COMPOSITION :

%C	%Si	%Mn	%S	%P	%Cr	%Ni	%Mo	%V		

9. PHYSICAL TEST RESULTS

Y.S. (kg/mm^2)	U.T.S. (kg/mm^2)	%Elongation	Bend Test	Flow lines Macro	Hardness	Radiography	N.D.T.		
							D.P.T.	M.P.T.	U.T.

10. MICROSTRUCTURE

Strike out whichever is not applicable.

Certified that the particulars entered herein by us are correct.

The part/parts has/have been designed and constructed to comply with the Indian Boiler Regulations for a working pressure/working pressures of .... and finally inspected on the day of .... in presence of our responsible representative whose signature is appended hereunder :

Maker's Representative

Name :
Designation :

Maker :
Designation :
Office Seal :

We have satisfied ourselves that forgings/castings (Semis) have been constructed and tested in accordance with the requirements of the Indian Boiler Regulations, 1950. We further certify that the particulars entered herein are correct.

Name and Designation of the Inspecting Officer who Witnessed the test
Place :
Date :

Name and Signature of Inspecting Authority
Place :
Date :

FORM IV

STEEL MAKER'S CERTIFICATE OF MANUFACTURE AND RESULTS OF TESTS

[Regulation 4(c)(iv) & 4(f)]

Designation of rolling mill ....

We hereby certify that the material described below has been made by M/s. .... by the .... process, as per specifications .... and rolled by .... and has been satisfactorily tested in the presence of our Test House Manager or his representative in accordance with the stipulated tests and tolerances.

For gothic bars/scalps, billets and hot rolled strips which are to be processed further by the same manufacturer for making tubes/pipes, the physical properties are not required to be mentioned by the steel manufacturer.

Signature or Initials
Test House Manager

Date of tests .... 20......
Ordered by ....
Boiler Number ....

Date ....
Order Number ....

RESULTS OF TESTS

Charge Number	*Brand & Number*	*Part of Boiler*	*Size of plate and bar*			*Number of pieces*	*Tensile breaking strength in tons per sq. in.*	*Elongation in inches*	*Bend Tests*	*Remarks*
			Length Ft. in.	*Breadth Ft. in.*	*Thickness or diameter in 32nds in.*					

Chemical analysis..

Note: Where the steel is manufactured by a maker, who is not recognised as a Well-known Steel Maker, the certificate of test shall be signed by the Inspecting Authority.

FORM IV-A

CERTIFICATE OF MANUFACTURE AND RESULTS OF TESTS IN LIEU OF FORM IV

[Regulation 4(c)(iv)]

It is hereby certified that original Steel Maker's Certificate in Form IV contain following information in respect of the material used in the manufacture of the boiler or parts thereof bearing Makers Number .... Sample and according to Drawing Number :

Part of Boiler	*Quantity*	*Cast/Heat No. Plate No.*	*Steel Making Process*	*Specification*	*Deoxidation*
1	*2*	*3*	*4*	*5*	*6*

Name of Steel Maker/Part Maker	*Test Piece No.*	*Certificate No. & Date*	*Length Breadth/O.D. Thickness*	*Heat Treatment*
1	*2*	*3*	*4*	*5*

% Chemical Analysis CMnPSSi other alloying elements*	*Yield strength (Kg/mm^2)*	*U.T.S. (Kg/mm^2)*	*Elongation % Gauge Length*	*Bend Test*	*Remarks*
1	2	3	4	5	6

*(Carbon Maganese Phosphorus Sulphate Silicon).

Official Seal *Inspecting Authority*

Counter foil

No.

....

....

are hereby permitted to use the .... Boiler (Registry No. ....) Boiler Rating .... made by .... and bearing Maker's number .... at a maximum pressure of .... lbs. per square inch pending the issue of or refusal of a certificate within six months from the date thereof after which period this order will become void.

Date .... *Inspector of Boilers*

FORM V

[Regulation 381(c)]

PROVISIONAL ORDER UNDER SECTION 9 OF THE INDIAN BOILERS ACT OF 1923

.... are hereby permitted to use the .... Boiler (Registry No. ....) Boiler Rating .... made by .... and bearing Maker's number .... at a maximum pressure of .... lbs. per square inch pending the issue of or refusal of a certificate within six months from the date thereof after which period this order will become void.

Dated .... *Inspector of Boilers*

N.B.: This order must be produced on demand by any authorised person and surrendered to Chief Inspector on receipt of orders.

FORM VI

...............Boiler Inspection Department

CERTIFICATE FOR USE OF A BOILER

(Regulation 389)

Registry Number of Boiler	Type of Boiler
Boiler Rating	Place and year of manufacture
Maximum Continuous Evaporation	
Name of Owner	
Situation of Boiler	

Repairs		
Remarks		
Hydraulically Tested on	to	lbs. per sq. inch

I hereby certify that the above described boiler is permitted by me/the Chief Inspector under the provisions of Section 7/8 of the Indian Boilers Act, No. V of 1923, to be worked at a maximum pressure of .... lbs. to the square inch for the period from .... to ....

The loading of the .... safety valve is not to exceed ....

Fee Rs. .... paid on ....

Dated at .... this .... day of .... 20......

Inspector
Countersigned
Chief Inspector
See Reverse for "Conditions"

CONDITIONS
(REVERSE OF FORM VI)

(1) No structural alteration, addition of renewal shall be made to the boiler otherwise than in accordance with section 12 of the Act.

(2) Under the provisions of Section 8 of the Act this certificate shall cease to be in force:

(a) on the expiry of the period for which it was granted; or

(b) when any accident occurs to the boiler; or

(c) when the boiler is moved the boiler not being vertical boiler the heating surface of which is less than two hundred square feet, or a portable or vehicular boiler; or

(d) when any structural alteration, addition or renewal is made in or to the boiler; or

(e) if the Chief Inspector in any particular case so directs when any structural alteration, addition or renewal is made in or to any steam-pipe attached to the boiler; or

(f) on the communication to the owner of the boiler of an order of the Chief Inspector prohibiting its use on the ground that it or any steam-pipe attached thereto is in a dangerous condition.

Under Section 10 of the Act, when the period of a certificate relating to a boiler has expired, the owner shall, provided that he has applied before the expiry of that period for a renewal of the certificate be entitled to use the boiler at the maximum pressure entered in the former certificate, pending the issue of orders on the application but this shall not be deemed to authorise the use of a boiler in any of the cases referred to in clauses (b), (c), (d), (e) and (f) of sub-section (1) of section 8 occurring after the expiry of the period of the certificate.

(3) The boiler shall not be used at a pressure greater than the pressure entered in the certificate as the maximum pressure nor with the safety valve set to a pressure exceeding such maximum pressure.

(4) The boiler shall not be used otherwise than in a condition which the owner reasonably believes to be compatible with safe working.

Note: The particulars and dimensions regarding this boiler may be obtained by the owner on payment in the prescribed manner on application to the Chief Inspector.

FORM VII

INSPECTING AUTHORITY'S CERTIFICATE OF INSPECTION UNDER CONSTRUCTION DESIGNATION OF INSPECTION AUTHORITY

[Regulation 501(e)]

We hereby certify that .... type, ... Economiser, consisting of .... sections and tubes to each section was constructed for a working pressure of .... lbs. Messrs .... under our supervision and inspected at various stages of construction by the Inspecting Officer and that the construction and workmanship were satisfactory and in accordance with the standard conditions for the design and construction of Economiser laid down in Chapter XI of the Indian Boiler Regulations, 1950.

Identification Mark on each section.

Branch Pipe on other pressure part.

Position of same.

The sections on completion were subjected to a water pressure of .... lbs. per sq. in. for ten minutes in the presence of the Inspecting Officer on .... and satisfactorily withstood the test in accordance with Reg. 504.

Samples of the material used in the constructions of the Economiser were tested in the presence of the Inspecting Officer and were found to comply with the tests prescribed in Chapter XI of the Indian Boiler Regulations, 1950.

We have satisfied ourselves that the construction and dimensions of the Economiser are as shown in the Maker's Drawing No. .... signed by us and that the particulars entered in the maker's certificate of manufacture in Form VIII countersigned by us are correct to the best of our knowledge and belief.

Dated at .... this .... day of .... 20......

Signature of Inspecting Authority

FORM VIII

WORKS ADDRESS

Contractor's Certificate of Manufacture and Test

[Regulation 501(D)]

1. Description	Type of Economiser No. of Sections Intended working pressure Year of manufacture Description		No. of tubes lbs. Total heating Surface of tubes
2. Inspecting Authority	Economiser constructed under supervision of .... Sections hydraulically tested for .... minutes and inspected after test by		
3. Construction and Workmanship	Details are in Drawing No. .... All castings are well finished free from external defects, porous places and blow-holes and true to dimensions without warping. Where chapters are used, there is satisfactory fusion with the metal. Chapters properly tinned with metal free from lead. All screw threads are of Whitworth form. All components parts are manufactured to limit gauges to secure interchangeability throughout.		

4. Economisers and fittings	*Parts*	*Material*	*Maker*	*Inspecting Officer Remarks*
Particulars of material used	Headers Tubes and/or Pipes Valve Chest Bolt			

THICKNESS OF PARTS AND TENSILE TEST—LIMIT

5. Part of Economiser	*Thickness in 32nds*	*Tensile strength limits to tons*	*Elongation limits to %*	*Gauge Length*	*Brand and No.*
Headers					
Tubes					
Bolts					

Certified that the particulars entered herein are correct and that the parts and fittings mentioned above have been used in the construction and fittings of the Economiser.

The particulars shown against the various parts used are in accordance with the Maker's certificates in our possession.

The design of the economiser in section and end view with principal parts fully dimensioned is that shown in Drawing No. .... The Economiser has been designed and constructed to comply with the Indian Boiler Regulations for a working pressure of .... lbs. per sq. in. at our Works Regulations for a working pressure of .... lbs. per sq. in. at our Works above-mentioned and the sections satisfactorily withstood a water test of .... lbs. per sq. in. for .... minutes on .... day of ....20...... in the presence of our ....responsible representative whose signature is appended hereunder.

Signature of Engineer who witnessed the test *Designation of Maker*

Dated at .... this .... day of .... 20......

Signature of Inspecting Authority

Note: The drawing of the Economiser and Maker's certificate of manufacture showing results of tests for tensile strength and elongation must accompany this certificate and if the economiser has been built under the supervision of an Inspecting Authority their certificate in Form VII must accompany.

FORM IX

(Regulation 528)

INDIAN BOILERS ACT, 1923

BOILERS INSPECTION
DEPARTMENT
ECONOMISERS
REGISTRY NUMBER

MEMORANDUM OF INSPECTION
OR
REGISTRATION BOOK

MISCELLANEOUS

District ....

Owners ....

Address of Factory ....

Nearest Railway Station ....

Economiser Registered at .... on ....

Register Book No .... Page ....

Registry Number .... Verified on ....

Approved Working Pressure .... lbs ....

Economiser Rating .... Inspection fee ....

Registration Book filled at .... on ....

Remarks on transfer etc. ....

....

PROVISIONAL ORDER AND CERTIFICATE RECORD

Fee	*Date of payment*	*Date of Inspection*	*Certificate No. and Date*	*Period of Certificate*	*Working pressure*	*Economiser Rating*	*Remarks and Inspector's initial*

Type of Economiser ....

Maker ....

Intended Working Pressure ....

Place and year of make ....

Maker's No ....

Description of Economiser ....

No. of tubes .... length .... Dia. ....

Thickness ....

Internal dimensions ....

No. of Headers ....

Thickness of Headers .... Thickness ....

Length of Top Branch Pipe .... Thickness ....

Length of Bottom Branch Pipe ....

Dimensions of cap openings ....

Diameter of cap bolts ....

MOUNTINGS

No.	*Diameter*	*Type*	*Position*	*Material*
Relief Valve				
Stop Valve				
Blow Down				
Thermometers				
Pressure Gauge				

Additional Fittings ....

MAKER'S CERTIFICATE

Name of Maker ....

Maker's Hydraulic Test Pressure ....

Maker's Drawing No. ....

Name of Inspecting Authority ....

Name of Maker of Material ....

Process
Tubes ....
Headers ....
Bolts ....

Test Results

Tubes T E

Headers T E

Pipes T E

Bolts T

% Sulphur

% Phosphorus

Maker's Identification Mark

Position

CALCULATIONS

HEADERS

TUBES

BRANCH PIPES

BOLTS

HEATING SURFACE

Total Heating Surface ....

Economiser Ratings ....

Calculations made by	submitted on ....
Calculations checked by	on ....
Least pressure, that for	lbs. ....
Approved working pressure	lbs. ....
Chief Inspector's remarks and signature	

INSPECTOR'S NOTES

Counterfoil	**FORM X** [Regulation 525(e)]
No.	No. Provisional Order under the Indian Boilers Act, 1923 ________________________________
Name of the person or firm to which Provisional Order is granted. Description of Economiser Maker's No. Rating Pressure permitted Period Date	are hereby permitted to use the Economiser Ry. No. .... and .... Economiser Rating .... made by .... and bearing Maker's No. .... at a maximum pressure of .... lbs. per sq. in/maximum temperature of .... °F pending the issue or refusal of a certificate within six months from the date thereof after which period this order will become void. Dated at .... this .... day of .... 19.....
Inspector	*Inspector*

FORM XI

............Boiler Inspection Department

CERTIFICATE FOR THE USE OF AN ECONOMISER

(Regulation 530)

Registry Number of Economiser	Type
No. of tubes	
Number of Headers	
Economiser Rating	Place and year of manufacture
Name of owner	
Situation of Economiser	

Repairs		
Remarks		
Hydraulically tested on		kg. per sq. cm. to lbs. per sq. in.

I/We hereby certify that the above described Economiser is permitted by me/Chief Inspector under the provisions of Section .... of the Indian Boilers Act, 1923 (V of 1923) to be worked at a maximum pressure .... lbs. per sq. in./maximum temperature of °F or the period from ....to ....

This loading of the safety valve is not exceed, ... lbs.

Fee Rs. .... paid on ....

Dated at ....

This .... day of .... 20......,

Countersigned *Inspector* *Chief Inspector*

CONDITIONS

(REVERSE OF FORM XI)

(1) No structural alteration, addition or renewal shall be made to the Economiser without a written permission from the Chief Inspector.

(2) This certificate shall cease to be in force—

(a) on the expiry of the period for which it was granted, or

(b) when any accident occurs to the Economiser, or

(c) when any structural alteration, addition or renewal is made in or to the Economiser, or

(d) if the Chief Inspector in any particular case so directs when any structural alteration, addition or renewal is made in or to the Economiser, or

(e) on the communication to the owner of the Economiser of an order of the Chief Inspector or Inspector prohibiting its use on the ground that it is in a dangerous conditions.

(3) The Economiser shall not be used at a pressure greater than the pressure/temperature entered in the certificate as maximum pressure/temperature not with the relief valve set to pressure/temperature exceeding such maximum pressure/temperature.

(4) The Economiser shall not be used otherwise than in a condition which the owner reasonably believes to be compatible with safe working.

N.B.: Details regarding this Economiser are recorded in a Registration Book No. .... of which a copy may be obtained on payment on application to the Chief Inspector.

FORM XII

(Regulation 613)

Record of Welder's Qualifications/Requalifications Tests (Indian Boiler Regulations, 1950)

Place of Test ....

Date ....

Name of Welder ....

Father's name ....

Date of Birth ....

Address ....

....

Service of experience on Gas/Electric Arc .... years.................................

Signature of Welder ....

Names and addresses of the firms where trained ....

....

Tested on .... (Plate, pipe, tube)

Gas of electric A.C./D.C. ....

Kind of test .... (Groove/Gillet/Branch)

Position ....

Thickness of material used ....

Diameter and thickness of pipe, branch or tubes used ....

Quality of base material and electrode or filler rod ....

RESULTS OF OBSERVATIONS

	Marks	
	Maximum	*Awarded*
A. Procedure		
1. Preparation of specimen	3	
2. Size & Grade of electrode or filler rod	2	
3. Number of runs and manipulation of control	5	

B. Visual Inspection		
4.	Root penetration	10
5.	Freedom from undercut	5
6.	Disposition of runs	2
7.	Uniformity of surface	1
8.	Shape of profile	1
9.	Smoothness of joints	2
10.	Freedom from cavities & slags	5
11.	Dimensions of weld deposit	1
12.	Quality of weld metal (Overheating, surface cracks, spongy surface etc.)	3
C. Physical Test		
13.	Face bend test	10
14.	Root bend test	20
D. Etch Test		
15.	Disposition of runs	2
16.	Degree of fusion	5
17.	Root Penetration	11
18.	Slags inclusions and porosity	5
E. Fractured Surface		
19.	Quality of weld metal (Excessive oxidation, carburisation, overheating, roughness, porosity, appearance).	7
		100

Signature of Competent Authority

Observation on radiographic examination (if conducted) ....

Marks awarded .... %

Results of Oral or Written examination ....

Marks awarded .... %

GENERAL REMARKS OF COMPETENT AUTHORITY ....

TYPE AND CLASS OF WELDING QUALIFIED .... in Gas or Electric Arc welding.

PERIOD OF VALIDITY OF CERTIFICATE .... From .... To ....

Place ....

Date ....

Competent Authority

FORM XIII

QUALIFIED BOILER WELDER'S CERTIFICATE ISSUED UNDER THE INDIAN BOILER REGULATIONS, 1950

PHOTO Passport Size	(SEAL) and Signature of Competent Authority

Name of Welder ....

Father's Name ....

Date of Birth ....

Identification marks ....

Left Hand Thumb Impression ....

Signature of Welder ....

Address of Welder ....

Period of Validity

From	To
....	....
....	....
....	....
....	....

This is to certify that Shri .... son of Shri .... has been examined and tested in the prescribed manner in the presence of .... (Representative of Competent Authority) and is deemed to have satisfactorily proved his ability to make sound welds as per particulars given below and is hereby authorised to undertake such welds. He is authorised/not authorised to undertake welding where radiographic examination is necessary under the Regulations.

Granted this .... day of .... 20...... under the seal and authority of ....

SEAL

Representative of Competent Authority

*Particulars :—

*Particulars shall contain information on the following:

Tested on	Plate/Pipe/Tube with position
Date	
Material	Mild Steel or alloy steel
Process	
Class of welding	
Backing strip	
Electrode	Class (Carbon or alloy steel)

Filter rod Type

Test piece X-rayed or not.

Period of Validity

From	To
....	....
....	....
....	....
....	....

EMPLOYMENT PARTICULARS

From	*To*	*Name of employer*	*Work on which engaged*	*Signature of employer*

(COVER PAGE)

FORM XIV

[Regulation 394(C)]

INDIAN BOILERS ACT, 1923

Boiler Inspection Department
Steam Pipes and Connected Fittings
Identification Number

Memorandum of Inspection Book

FORM XIV

[Regulation 394(C)]

INDIAN BOILERS ACT, 1923

Boiler Inspection Department
Steam Pipes and Connected Fittings
Identification Number

Memorandum of Inspection Book

MISCELLANEOUS

District ....

Owner ....

Address ....

Work of Factory : ....

Registration Number of Boilers to which the pipes and fittings, particulars of which are given in this Memorandum are connected.

Remarks

Date	*Particulars of additions & alterations*
....	....
....	....
....	....
....	....

PLAN OF STEAM PIPES & THEIR CONNECTED FITTINGS

FEE AND APPROVAL TO PLAN RECORD

Drawing No.	*Total length of Steam Pipes*	*No. of Connected vessels*	*Fee*	*Date of Payment*	*No. & date of approval of Plan & Layout*	*W.P. approval Kg/cm²*	*Temp allowed °C*	*Remarks & initial of Inspector*

STEAM PIPES—PARTICULARS AND DIMENSIONS

Situation ....

Ry. No. of connected Boilers ....

Steam Piping System include ....

Pipes Material .... Diameter (outside) ....

Pipes Thickness .... Make ....

Attachment of Flanges ....

Elbows, Tees etc. ....

....

Support ....

Flexibility ....

Drainage ....

Feed pipes ....

Outside Dia. .... Thickness ....

Make ....

Max. Pressure .... Max. Temp ....

Connected Vessel ....

No. ....

Type .. ..

Max. Design Press .... Max. Design Temp. ....

Date of Installation..

First Inspection inside & ....

Outside ....

Feed Pipes Hydraulic Test to .... kg/cm^2 .... By .... on ....

Remarks ....

CALCULATIONS

Steam Pipes : ....

....

....

....

CALCULATIONS

Steam Pipes : ....

....

....

....

CALCULATIONS

Steam Pipes : ....

....

....

....

CALCULATIONS

....

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....

....

INSPECTOR'S NOTE

....

....

....

....

FORM XV-A

[Regulation 4A(2)]

Questionnaire to be Answered by Firms Seeking Recognition by the Central Boilers Board to become an Inspecting Authority under The Indian Boiler Regulations, 1950

1. The registered name and address of the association.
2. Address for correspondence.
3. The year in which the association was established.
4. Is your association recognised by the Government?
5. Have you any Branch or Associate Office? If so, please give their names and addresses.
6. How long has your Association been functioning as an Inspecting Authority? If it is a registered company, please give the date of registration.
7. Please give details of classes machinery which you have so far been authorised to examine and code under which this is being done.
8. Please state the types, size and the range of working pressure of boilers which you have so far inspected during construction as an Inspecting Authority, also state the classes of service you render, namely:
   (a) Please name the various stages of manufacture at which inspections are carried out.
   (b) Excluding inspection at the steel works.
   (c) Only hydraulic test after the manufacture of the boiler has been completed.
9. How many Inspecting Officers have you in your employment? Please give details of the qualifications held by those officers.
10. Have you any Testing Laboratory of your own to conduct all destructive and non-destructive tests required in connection with the manufacture of Boilers?
11. Are you prepared to conduct the work of inspection of boilers, economisers and their accessories strictly in conformity with the Indian Boiler Regulations, 1950?
12. Are you prepared to accept full responsibility for the certificate issued by you?
13. Has your request for recognition as an Inspecting Authority been rejected by any Authority? If so, please give details.
14. Are you prepared to issue certificates for the products, you inspect in the formats of the Indian Boiler Regulations?
15. Are you aware that the recognition is for a period of 3 years only, which is renewable after every 3 years on fresh assessment?

FORM XV-B
[Regulation 4A(2)]

Questionnaire for Eliciting Information Regarding the Competency of a Firm to be Recognised as "Competent Authority" Under Regulation 4A(2) of the Indian Boiler Regulations

1. Registered name and address of the firm.
2. Address for correspondence.
3. Year in which the Organisation was established.
4. Address of branch or associate office, if any.
5. Principal work of the organisation.
6. Does the organisation have any training section for the welders? If so, details of the scheme to be stated.
7. Does the organisation regularly conduct tests on welds done by its welders? If so, the code followed and the details of tests carried out may please be stated.
8. What are the facilities that can be provided or availed of by the organisation for conducting the tests?
9. Is the organisation prepared to undertake testing of welders employed by other organisation?
10. Whether the organisation is prepared to conduct test as per requirements of the IBR?
11. The amount of fee which the organisation would charge a candidate for conducting a test for the issue of certificate. Estimates under the following heads may be given:
    (a) For the supply of tests pieces, electrodes and/or filler rods.
    (b) For the use of welding machine.
    (c) For matching the test pieces and preparation of specimen.
    (d) For conducting mechanical tests (including specimens preparation).
    (e) For non-destructive testings.
12. Is the organisation prepared to examine and issue certificate to welders in accordance with the requirements of the IBR, 1950?
13. Is the organisation prepared to take full responsibility for certificates issued by it?
14. Are you aware that the recognition is for a period of 3 years only which is renewable after every 3 years on fresh assessment?

FORM XV-C

[Regulation 4A(2)]

Questionnaire to be Answered by Steel Makers seeking Recognition by Central Boilers Board to be Notified as "Well-known Steel Makers" under Regulation 4A(2) of the Indian Boiler Regulations, 1950

1. Registered Name and Address of the firm.
2. Works address.
3. The year in which the factory was established.
4. Capacity for production of Steel.
5. Process of Manufacture of Steel.
6. Variety of Steel Products.
7. Range of Steel produced in each variety.
8. Various National and International Standards to which the Steel products are manufactured.
9. Testing facilities available within the Works.
10. Types of tests conducted.
11. If so, by whom conducted?
12. Are the tests conducted by the firm acceptable to the other organisations of the Country? If so, by whom?
13. Is the firm prepared to conduct tests in accordance with the IBR?
14. Have they been recognised as "Well-known Steel Maker" in any other country?
15. Whether they manufacture steel from the ore itself or from ore and scrap or from scrap only?
16. Whether the firm is agreeable to show their manufacturing under the provision of IBR?
17. Whether the firm is agreeable to show their manufacturing process and in House testing facilities to a team consisting of three members appointed by the Board?
18. Are you aware that the recognition is for a period of 3 years only which is renewable after every 3 years on fresh assessment?

FORM XV-D

[Regulation 4A(2)]

Questionnaire to be Answered by Foundry/Forge Seeking Recognition by Central Boilers Board to be Notified as "Well-known Foundry/Forge" under Regulation 4A(2) of The Indian Boiler Regulations, 1950

1. The Registered name and address of the firm.
2. Works address.
3. The year in which the factory was established.
4. Capacity of the Foundry/Forge:
5. (i) Capacity for production of Forgings/Castings;

   (ii) Maximum weight and size of Forgings/Castings.
6. Detailed description of the type of job done by them.
7. Materials of Castings/Forgings (ferrous-plain or alloy steel, non-ferrous alloys).
8. Range of forgings/casting produced in each variety.
9. Testing facilities available within the works.
10. Details of testing facility, namely chemical and physical tests etc.
11. Types of tests conducted.
12. If so, by whom conducted?
13. Are the test conducted by the firm itself acceptable to the other organisations of the country? If so, by whom?
14. Is the firm prepared to conduct tests in accordance with the Indian Boiler Regulations, 1950?
15. Have they been recognised as "Well-known Foundry/Forge" in any other country?
16. Whether the firm is in a position to produce Forgings/Castings in accordance with any national/International specifications fulfilling the minimum requirements of IBR, 1950.
17. Whether the firm has any previous experience to produce Forgings/Castings in accordance with the provision of IBR under the inspection of any recognised Inspecting Authority.
18. Whether the firm is prepared to furnish Certificates under the provision of IBR, 1950?
19. Whether the firm is agreeable to show their process of manufacture in House testing facilities to a team of members appointed by Central Boilers Board?
20. Are you aware that the recognition is for a period of 3 years only, which is renewable after every 3 years on fresh assessment?

FORM XV-E

[Regulation 4A(2)]

Questionnaire to be Answered by Tube/Pipe Maker Seeking Recognition by Central Boilers Board as "Well-Known Tube/Pipe Maker" under Indian Boiler Regulations, 1950

1. Registered name and address of the firm.
2. Works address.
3. Registration No. and year of registration.
4. Capacity of production of Tube/Pipe and the tonnage details per year from the beginning.
5. Reasons for seeking recognition under IBR.
6. Steel grades of Tube/Pipes under production.
7. Size range of Tube/Pipes under production.
8. Process of manufacture of Tube/Pipes.
9. (a) Whether the firm is producing the raw material or purchasing the raw material?

   (b) If the raw material is purchased, give the details of purchase so far:

   (i) from well-known steel maker under I.B.R.,

   (ii) from non-recognised firm.
10. If purchase is as per 9(b)(ii) state whether the raw material is tested at Tube maker's/Pipe maker's premises under IBR.
11. If the firm is producing raw material, state whether the firm is recognized as well-known steel maker under IBR.
12. Major Manufacturing facilities available with the firm.
13. Testing facilities available with the works.
14. Types of tests conducted on Tubes/Pipes (enclose complete quality control plan from raw material stage to finished stage alongwith the quality control & inspection personnel of the firm).
15. The details of failure and rejection:

   (a) By NDT

   (b) By Destructive Testing.
16. Whether the firm is in a position to manufacture Tubes/Pipes and also provide for their necessary testing facilities in accordance with the provision of IBR, 1950?
17. The name of the firms to whom the firm has supplied Tubes/Pipes.
18. Whether the firm is agreeable to show their manufacturing process and in House facilities to a team consisting of three members appointed by the Board?
19. Whether the firm is aware of the fact that the recognition is for a period of three years only, which is renewable after every three years term on fresh assessment?

FORM XV-F

[*See* Regulation 4A(2)]

Questionnaire to be Answered by a Laboratory seeking recognition by Central Boilers Board as a Well-known Material Testing Laboratory under Sub-regulation (2) of Regulation 4A of the Indian Boiler Regulations, 1950

1. The Registered Name and Address of the Laboratory.
2. Address of the Laboratory.
3. The year in which the laboratory was established.
4. (a) Whether the Laboratory is recognised by the Central Government or by a State Government?

   (b) If so, please furnish particulars of recognition.
5. Name and address of branch or associate Laboratory, if any.
6. How long the Laboratory has been functioning for testing of the products?
7. Equipments or machines available in the laboratory for carrying out the non-destructive or destructive testing.
8. Type and range of tests carried out by the Laboratory.
9. Details of testing personnel and their qualifications or experience.
10. Are you prepared to conduct the testing of specimens strictly as per the requirements of the Indian Boiler Regulations, 1950?
11. Has your request for recognition as an approved Laboratory been rejected by any authority? If so, please give details.
12. Are you prepared to issue the certificates for the products you test in the formats of the Indian Boiler Regulations?

Note: The recognition is valid for a period of 3 years only, which is renewable for 3 years on fresh assessment.

FORM XV-G

[*See* Regulation 4A(2)]

Questionnaire to be answered by Firm seeking recognition by Central Boilers Board as Remanent Life Assessment Organisation under Regulation 391A of the Indian Boiler Regulations, 1950

1. The Registered Name and Address of the firm.
2. Address of the firm.
3. The year in which the firm was established.
4. (a) Whether the firm is recognised by the Central Government or by State Government;

   (b) If so, furnish particulars of recognition.

5. Name and address of branch or associate firm, if any.
6. How long your firm has been functioning for Remanent Life Assessment of Boilers and Boiler Parts?
7. Equipments or machines available in the Laboratory for carrying out the non-destructive or destructive testing.
8. Type and range of tests carried out by the firm.
9. Details of testing personnel and their qualifications and experience.
10. Are you prepared to conduct the testing of specimens strictly as per the requirements of the Indian Boiler Regulations, 1950?
11. Has your request for recognition as an approved organisation been rejected by any authority? If so, please give details.
12. Are you prepared to issue the certificates for the tests recommended in the formats of the Indian Boiler Regulations?

SIGNATURE & SEAL

Note : The recognition is valid for a period of three years only which is renewable for three years on fresh assessment.

FORM XVI-A

[Regulation 4C(2)]

Serial No. ....

Central Boilers Board

Certificate of Approval For Inspecting Authority

This is to certify that the Inspection and Quality Management System of :

M/s ....

....

has been evaluated by the Central Boilers Board and has been granted recognition under Regulation 4C(2) of the Indian Boiler Regulations, 1950, as an INSPECTING AUTHORITY.

This Certificate is valid for three years, i.e., upto .... Validity is subject to the adherence to the quality control prescribed under the provisions of the Indian Boiler Regulations.

....

Date of Issue.

Approval Certificate No. *Secretary*

....

FORM XVI-B
[Regulation 4C(2)]

Serial No. ....

Central Boilers Board

Certificate of Approval for Competent Authority

This is to certify that the Examination of Welder System of :

M/s ....

....

has been evaluated by the Central Boilers Board and has been granted recognition under Regulation 4C(2) of the Indian Boiler Regulations, 1950, as a competent authority.

This Certificate is valid for three years, i.e., upto ....

Validity is subject to the adherence to three quality control prescribed under the provisions of the Indian Boiler Regulations.

Date of Issue ....

Approval Certificate No. .... *Secretary* ....

FORM XVI-C
[Regulation 4C(2)]

Serial No. ....

Central Boilers Board

Certificate of Approval for Well-known Steel Maker

This is to certify that the Inspection and Quality Management System of :

M/s ....

....

has been evaluated by the Central Boilers Board and has been granted recognition under Regulation 4C(2) of the Indian Boiler Regulations, 1950, as a well-known steel maker, for the manufacture of ....

This Certificate is valid for three years, i.e., upto ....

Validity is subject to the adherence to the quality control prescribed under the provisions of the Indian Boiler Regulations.

Date of Issue ....

Approval Certificate No .... *Secretary* ....

FORM XVI-D

[Regulation 4C(2)]

Serial No. ....

Central Boilers Board

Certificate of Approval For Well-Known Foundry

This is to certify that the Inspection and Quality Management System of :

M/s ....

....

has been evaluated by the Central Boilers Board and has been granted recognition under Regulation 4C(2) of the Indian Boiler Regulations, 1950, as a WELL-KNOWN FOUNDRY.

This Certificate is valid for three years, i.e., upto ....

Validity is subject to the adherence to the quality control prescribed under the provisions of the Indian Boiler Regulations.

Date of Issue ....

Approval Certificate No. .... *Secretary* ....

FORM XVI-E

[Regulation 4C(2)]

Serial No. ....

Central Boilers Board

Certificate of Approval For Well-known Forge

This is to certify that the Inspection and Quality Management System of :

M/s ....

....

has been evaluated by the Central Boilers Board and has been granted recognition under Regulation 4C(2) of the Indian Boiler Regulations, 1950, as a WELL-KNOWN FORGE.

This Certificate is valid for three years, i.e., upto ....

Validity is subject to the adherence to the quality control prescribed under the provisions of the Indian Boiler Regulations.

Date of Issue ....

Approval Certificate No. .... *Secretary* ....

FORM XVI-F

[Regulation 4C(2)]

Serial No. ....

Central Boilers Board

Certificate of Approval for Well-known Tube Maker

This is to certify that the Inspection and Quality Management System of :

M/s ....

....

has been evaluated by the Central Boilers Board and has been granted recognition under Regulation 4C(2) of the Indian Boiler Regulations, 1950, as a WELL-KNOWN TUBE MAKER for the manufacture of Tubes of Sizes from .... to ....

This Certificate is valid for three years, i.e., upto ....

Validity is subject to the adherence to the quality control prescribed under the provisions of the Indian Boiler Regulations.

Date of Issue ....

Approval Certificate No. ....

Secretary ....

FORM XVI-G

[Regulation 4C(2)]

Serial No. ....

Central Boilers Board

Certificate of Approval for Well-known Pipe Maker

This is to certify that the Inspection and Quality Management System of :

M/s ....

....

has been evaluated by the Central Boilers Board and has been granted recognition under Regulation 4C(2) of the Indian Boiler Regulations, 1950, as a WELL-KNOWN PIPE MAKER for the manufacture of pipe of sizes from .... to ....

This Certificate is valid for three years, i.e., upto ....

Validity is subject to the adherence to the quality control prescribed under the provisions of the Indian Boiler Regulations.

Date of Issue ....

Approval Certificate No. ....

Secretary ....

FORM XVI-H

[*See* Regulation 4C(2)]

Serial No. ....

National Emblem

Central Boilers Board

Certificate of Approval as Well-known Material Testing Laboratory

This is to certify that after evaluation of the inspection and material testing system of the following laboratory, the Central Boilers Board has granted recognition to it under Sub-regulation (2) of Regulation 4C of the Indian Boiler Regulations, 1950, as a Well-known Material Testing Laboratory.

M/s ....

....

This certificate is valid for three years, i.e., upto ....

Note: The recognition will be as per standards specified under the provisions of Indian Boiler Regulations, 1950

Recognition Certificate No. ....

Date of Issue ....

Secretary ....

FORM XVI-I

[*See* Regulation 4C(2)]

Serial No. ....

National Emblem

Central Boilers Board

Certificate of approval as Well-known Remanent Life Assessment Organisation

This is to certify that after evaluation of the inspection and material testing system of the following firm, the Central Boilers Board has granted recognition to it under Sub-regulation (2) of Regulation 4C of the Indian Boiler Regulations, 1950 as a Well-known Remanent Life Assessment Organisation.

M/s ....

....

This certificate is valid for three years, i.e., upto ....

Date of Issue ....

Approval Certificate No. ....

Secretary ....

FORM XVII

CERTIFICATE OF MANUFACTURE AND TEST FOR SMALL INDUSTRIAL BOILERS

(Manufactured Under Chapter XIV)

1. Maker's Name .... Year of Make ....

2. Manufactured for ....

3. Location of Installation ....

4. Boiler Identification .... Inspecting officer's stamp ....

5. Drawing No. .... Alteration No. ....

5A. Design Code .... Working Pressure (kg/Cm^2) ....

6. Size of Boiler

Length (Meters)	*Width (Meters)*	*Height (Metres)*	*Diameter (Metres)*

7. Shell/Furnace/Tube Plates/Flange Details

Material Specification	CHEMICAL COMPOSITION					MECHANICAL PROPERTIES				
	C	*Si*	*Mn*	*P*	*S*	*Y*	*S*	*U.T.S.*	*%*	*EL.*

Shell ....

Furnance ....

Tube Plates ....

Flange ....

Boiler Tubes/Pipe/Pads Details ....

Diameter	*Thickness*	*Material Specification*	CHEMICAL COMPOSITION					MECHANICAL PROPERTIES				
			C	*Si*	*Mn*	*P*	*S*	*Y*	*S*	*U.T.S.*	*%*	*EL.*

Tube ....

Pipes ....

Pads ....

8. Volumetric Capacity

9. Heating Surface (Sq. Metres)

10. Nozzle connection

(a) Steam Outlet ....

(No. Size And Type of Nozzles)

(b) Safety Valve ....
(No. Size And Type of Nozzles)

(c) Auxiliary (Air vent) ....
(No. Size And Type of Nozzles)

(d) Blowoff Valve ....
(No. Size And Type of Nozzles)

(e) Feed Valve ....
(No. Size And Type of Nozzles)

11. Shop Hydro Test Pressure (Kg. Cm^2) .... Date ....

Signature of Manufacturer

We certify that the above boiler constructed under our supervision and inspected at various stages of construction by the inspecting officer and that the construction, workmanship were satisfactory as per Indian Boiler Regulations.

Inspecting Officer *Signature of Inspecting Authority*

Dated .... this .... Day of .... 19......

FORM XVIII

[*See* Regulation 392(4)]

QUESTIONNAIRE FORM FOR REPAIRER OF BOILERS/ECONOMISER/STEAM LINE/FEED WATER LINES ETC. UNDER THE INDIAN BOILER REGULATIONS, 1950

1. Registered name of the firm and its permanent address..

2. Year of establishment ....

3. Classification applied for—

(a) Special Class (Boiler Pressure > 125 kg./cm^2)

(b) Class I (Boiler Pressure > 40 kg/cm^2 and $\leq$ 125 kg.cm^2)

(c) Class II (Boiler Pressure > 17.5 kg/cm^2 and $\leq$ 40 kg./cm^2)

(d) Class III (Boiler Pressure $\leq$ 17.5 kg/cm^2)

Note: A higher Class repairer would be eligible to undertake lower class works/jobs.

4. Type of jobs executed by the firm earlier, with special reference to their maximum working pressure, temperature and the materials involved, with documentary evidence ....

5. Whether the firm has ever been approved by any Boilers' Directorate/Inspectorate? If so, give details ....

6. Whether having rectifier/generator, grinder, general tools and tackles, dye penetrant kit, expander and measuring instruments or any other tools and tackles under Regulation 392(5)(i). ....

7. Detailed list of technical personnel with Xerox copy of the Welders' current certificate issued under the Regulations who are permanently employed with the firm ....

8. How many working sites can be handled by the firm simultaneously? ....

9. Whether the firm is prepared to execute the job strictly in conformity with the regulations and maintain a high standard of work? ....

10. Whether the firm is prepared to accept full responsibility for the work done and is prepared to clarify any controversial issue, if required? ....

11. Whether the firm is in a position to supply materials to required specification with proper test certificates if asked for? ....

12. Whether the firm has an internal quality control system of their own? If so, give details ....

13. Qualification and experience of the personnel employed ....

Date ....   *Signature of the authorised signatory*
Place ....   *of the firm with stamp*

Note 1: The recognition of the firm as a repairer shall be for a period of two years, thereafter they shall apply for renewal of their recognition at least two months before the expiry of the said period.

Note 2: In case the repairer is found indulging in violating the provisions of the Act/Regulations knowingly or unknowingly, the firm shall be blacklisted under intimation to Chief Inspectors or Directors of Boilers of all the States/Union Territories and renewal shall not be done in any case.

FORM XIX

DETAILS TO BE FURNISHED ALONGWITH APPLICATION FOR INSPECTION OF BOILER AFTER TWELVE MONTHS OF THE CERTIFICATION UNDER APPENDIX 'JA' AND APPENDIX 'JB'

1. Name and address of the owner ....

2. Registry number of the boiler ....

3. Quality of steam and its temperature ....

4. Rate of steam generation ....

5. Heating surface ....

6. Year of make ....

7. Brief description of boiler ....

8. Type of construction (Whether riveted or welded) ....

9. Whether fired or waste heat boiler ....

10. Date of registration ....

11. Details of past exemption granted by the Government, if any ....

12. Last date of annual inspection ....

13. Expiry date of current certificates ....

14. Working pressure at which last certificate was issued ....

15. Details of past repairs (year-wise) ....

16. Remark as entered in the last certificate ....

17. Quality of boiler feed water ....

18. Whether requisite number of feed pumps are in satisfactory working condition at present? ....

19. Number of safety valves mounted on shell/drum and superheater ....

20. Total number of soot blowers provided in boiler ....

21. Number of soot blowers in working condition ....

22. Whether safety valves are blowing satisfactorily at or below design pressure? ....

23. Whether safety valve assemble is free from jamming as verified by operating casing lever? ....

24. Whether high and low water level alarm is in good condition? ....

25. Whether main steam stop valves, feed check valves, blow down valves and master pressure gauge in working condition? ....

26. Whether additional requirements for automatic boilers as per Regulation 281A are complied with? (If 'No', give details) ....

27. Latest date of calibration for master pressure gauge, temperature indicator/recorder for superheater, hot reheat, cold reheat and main steam line. ....

28. Latest date when boiler protection devices were satisfactorily tested. ....

29. Details of boiler tripping for last three months with reasons thereof. ....

30. Present irregularities in instruments and controls if any observed in control-room of boiler house. ....

31. Details of present boiler leakage. ....

32. Present operating pressure of the boiler ....

33. Date when boiler water sample tested last (enclose copy of test report showing TDS) ....

34. State at what intervals such test is carried out ....

35. When boiler was last opened for internal and/or external cleaning? ....

36. State at what intervals such cleaning is carried out..........

37. Whether there was any shut down since last inspection when the boiler could have been offered for inspection? ....

38. Whether working pressure of the boiler ever exceeded in the past beyond certified limit? If any, give details ....

39. Details of boiler accident which took place in the past, if any ....

40. Whether State Boilers Operation Engineer's/Attendant's Rules are complied with? ....

41. Irregularities, if any, noticed in the past in compliance of Indian Boilers Act, 1923. ....

42. Whether guidelines laid down by Central Boilers Board for granting exemption to the Waste heat boilers are fulfilled or not? ....

General Manager (Generation)

Remarks of the Inspector who verified correctness of above statement paying check visit to the Boiler House.

Inspector of Boilers

APPENDIX A

DIAGRAMS OF RIVETED JOINTS WITH FORMULAE

SINGLE RIVETED JOINTS

LAP JOINT—ONE RIVET PER PITCH

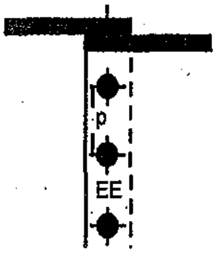


FIG. 1

Max Pitch	=	$1.31 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times S_1}{P \times T \times S}$	Eqn. (3)
E	=	$1.5 \times D$	Reg. 184

SINGLE BUTT STRAP—ONE RIVET PER PITCH

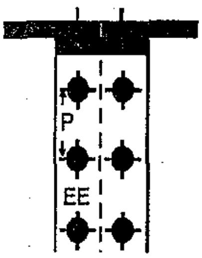


FIG. 2

Max. Pitch	=	$11.53 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times S_1}{P \times T \times S}$	Eqn. (3)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAP	=	$1.25 \times T$	Eqn. (5)

DOUBLE BUTT STRAP—ONE RIVET PER PITCH

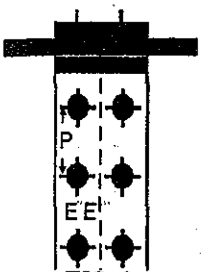


FIG. 3

Max. Pitch	=	$1.75 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAP	=	$.625 \times T$	Eqn. (7)

DOUBLE RIVETED JOINTS

LAP JOINTS—TWO RIVETS PER PITCH

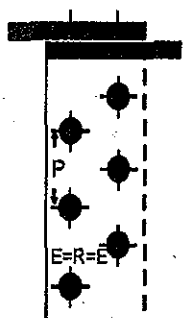


FIG. 4

Max. Pitch	=	$2.62 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 2 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$.33P + .67D$	Eqn. (12)
E	=	$1.5 \times D$	Reg. 184

LAP JOINTS—TWO RIVETS PER PITCH

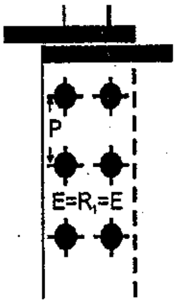


FIG. 5

Max. Pitch	=	$2.62 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 2 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$2 \times D$	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184

SINGLE BUTT STRAPS—TWO RIVETS PER PITCH

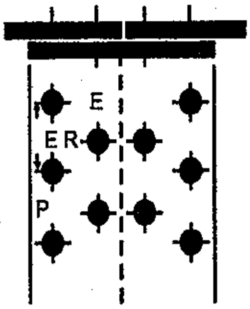


FIG. 6

Max. Pitch	=	$3.06 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 2 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$.33P + .67D$	Eqn. (12)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$1.125 \times T$	

DOUBLE RIVETED JOINTS
SINGLE BUTT STRAPS—TWO RIVETS PER PITCH

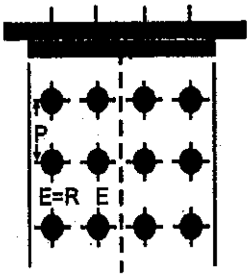


FIG. 7

Max. Pitch	=	$3.06 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 2 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$2 \times D$	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$1.125 \times T$	Eqn. (5)

SINGLE BUTT STRAPS—THREE RIVETS PER PITCH

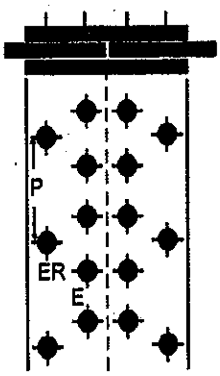


FIG. 8

Max. Pitch	=	$4.05 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 3 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\frac{100(P-2D)}{P} + \frac{200 \times A \times S}{P \times T \times S}$	Eqn. (4)
R	=	$.2P \times 1.15D$	Eqn. (14)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$1.125T \times \frac{(P-D)}{(2-2D)}$	Eqn. (6)

DOUBLE RIVETED JOINTS
SINGLE BUTT STRAPS—THREE RIVETS PER PITCH

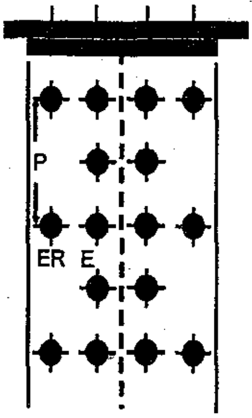


FIG. 9

Max. Pitch	=	$4.05 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 3 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\dfrac{100(P-2D)}{P} + \dfrac{200 \times A \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.33P \times .67$	Eqn. (12)
		or $2 \times D$ whichever is greater	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$1.125T \times \dfrac{(P-D)}{(2-2D)}$	Eqn. (6)

DOUBLE BUTT STRAPS—TWO RIVETS PER PITCH

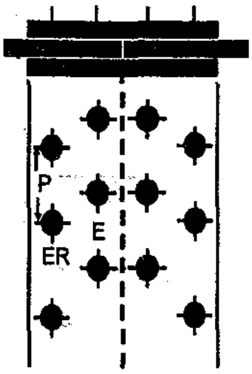


FIG. 10

Max. Pitch	=	$3.5 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 2 \times 1 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$.33P + .67D$	Eqn. (12)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625 \times T$	Eqn. (7)

DOUBLE RIVETED JOINTS

DOUBLE BUTT STRAPS—TWO RIVETS PER PITCH

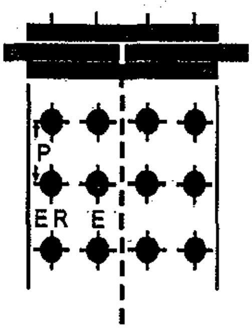


FIG. 11

Max. Pitch	=	$3.5 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 2 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$2 \times D$	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625 \times T$	Eqn. (7)

DOUBLE BUTT STRAPS—THREE RIVETS PER PITCH

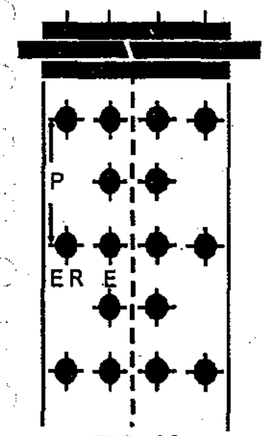


FIG. 12

Max. Pitch	=	$4.63 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 3 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\dfrac{100(P-D)}{P} + \dfrac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.2P \times 1.15D$	Eqn. (14)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625 \times \dfrac{(P-D)}{(P-2D)}$	Eqn. (8)

DOUBLE RIVETED JOINTS
DOUBLE BUTT STRAPS—THREE RIVETS PER PITCH

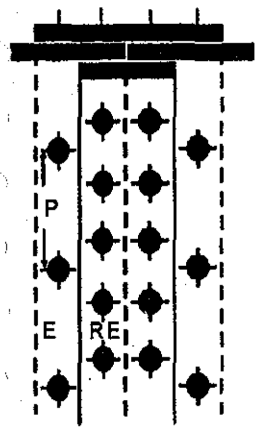


FIG. 13

Max. Pitch	=	$4.63 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 3 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\dfrac{100(P-D)}{P} + \dfrac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.33P \times .67D$	Eqn. (12)
		or $2 \times D$ whichever is greater	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625T \times \dfrac{(P-D)}{(2-2D)}$	Eqn. (8)

DOUBLE BUTT STRAPS OF UNEQUAL WIDTH—TWO RIVETS PER PITCH

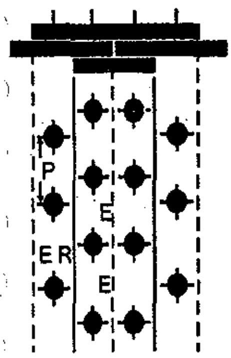


FIG. 14

Max. Pitch	=	$3.5 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$.33P + .67D$	Eqn. (12)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS (WIDE)	=	$.75T$	Eqn. (9)
BUTT STRAPS (NARROW)	=	$.625T$	Eqn. (10)

DOUBLE RIVETED JOINTS

DOUBLE BUTT STRAPS OF UNEQUAL WIDTH—TWO RIVETS PER PITCH

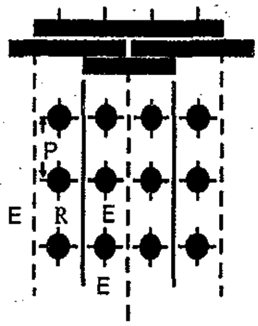


FIG. 15

Max. Pitch	=	$3.5 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$2 \times D$	Eqn. (14)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS (WIDE)	=	.75T	Eqn. (9)
BUTT STRAPS (NARROW)	=	.625T	Eqn. (10)

DOUBLE BUTT STRAPS OF UNEQUAL WIDTH—THREE RIVETS PER PITCH

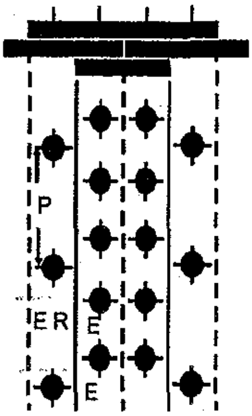


FIG. 16

Max. Pitch	=	$4.63 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 4.75 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\dfrac{100(P-2D)}{P} + \dfrac{100 \times A \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.2P \times 1.15D$	Eqn. (14)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS (WIDE)	=	.75T	Eqn. (9)
BUTT STRAPS (NARROW)	=	.625T	Eqn. (10)

DOUBLE RIVETED JOINTS

DOUBLE BUTT STRAPS OF UNEQUAL WIDTH—THREE RIVETS PER PITCH

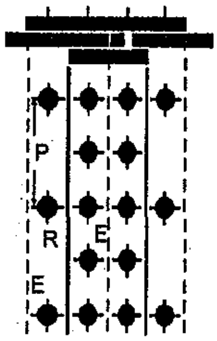


FIG. 17

Max. Pitch	=	$4.63 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 4.75 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\dfrac{100(P-2D)}{P} + \dfrac{100 \times A \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.33P \times 1.67D$	Eqn. (12)
		or $2 \times D$ whichever is greater	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS (WIDE)	=	.75T	Eqn. (9)
BUTT STRAPS (NARROW)	=	.625T	Eqn. (10)

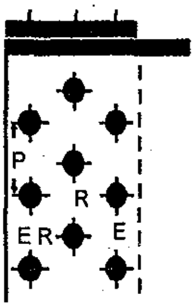


FIG. 18

TREBLE RIVETED JOINTS

LAP JOINTS—THREE RIVETS PER PITCH

Max. Pitch	=	$3.47 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 3 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$.33P \times .67D$	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184

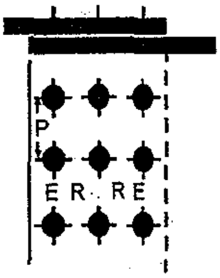


FIG. 19

TREBLE RIVETED JOINTS

LAP JOINTS—THREE RIVETS PER PITCH

Max. Pitch	=	$3.47 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 3 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$.2 \times D$	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184

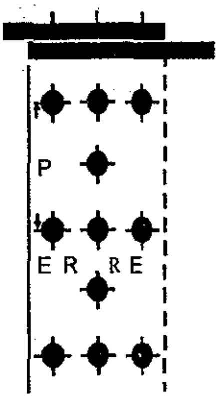


FIG. 20

LAP JOINTS—FOUR RIVETS PER PITCH

Max. Pitch	=	$4.14 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 4 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\frac{100(P-2D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.2P \times 1.15D$	Eqn. (14)
E	=	$1.5 \times D$	Reg. 184

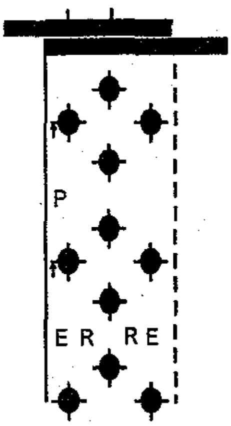


FIG. 21

TREBLE RIVETED JOINTS

LAP JOINTS—FOUR RIVETS PER PITCH

Max. Pitch	=	$4.14 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 4 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\frac{100(P-2D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.33P \times .67D$	Eqn. (12)
		or $2 \times D$ whichever is greater	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184

DOUBLE BUTT STRAPS—THREE RIVETS PER PITCH

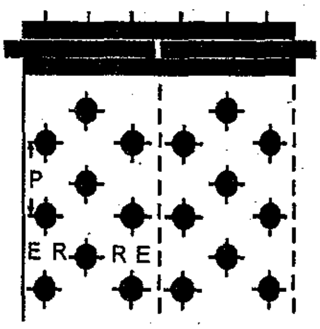


FIG. 22

Max. Pitch	=	$4.63 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 3 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$.33P \times .67D$	Eqn. (12)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625T$	Eqn. (7)

DOUBLE BUTT STRAPS—THREE RIVETS PER PITCH

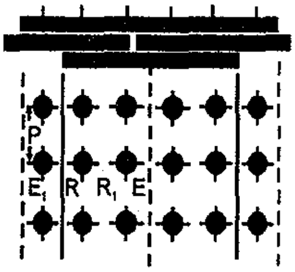


FIG. 23

Max. Pitch	=	$4.63 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 3 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$2 \times D$	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625T$	Eqn. (77)

TREBLE RIVETED JOINTS

DOUBLE BUTT STRAPS—FOUR RIVETS PER PITCH

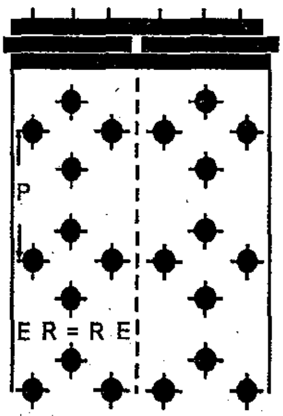


FIG. 24

Max. Pitch	=	$5.52 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 4 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\dfrac{100(P-2D)}{P} + \dfrac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.2P \times 1.15D$	Eqn. (14)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625T$	Eqn. (7)

DOUBLE BUTT STRAPS—FOUR RIVETS PER PITCH

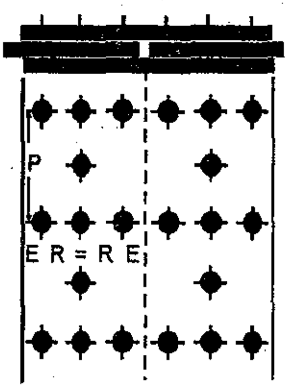


FIG. 25

Max. Pitch	=	$5.52 \times T + 1.625$	Eqn. (11)
Plate %	=	$\dfrac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\dfrac{100 \times A \times 4 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\dfrac{100(P-2D)}{P} + \dfrac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.33P \times .67D$	Eqn. (12)
		or $2 \times D$ whichever is greater	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625T$	Eqn. (7)

TREBLE RIVETED JOINTS
DOUBLE BUTT STRAPS—FIVE RIVETS PER PITCH

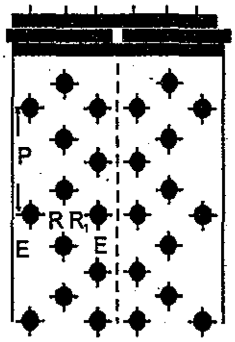


FIG. 26

Max. Pitch	=	$6 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 5 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\frac{100(P-2D)}{P} + \frac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.2P \times 1.15D$	Eqn. (14)
R_1	=	$0.165P + .67D$	Eqn. (15)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625 \times \frac{(P-D)}{(P-2D)}$	Eqn. (6)

DOUBLE BUTT STRAPS—FIVE RIVETS PER PITCH

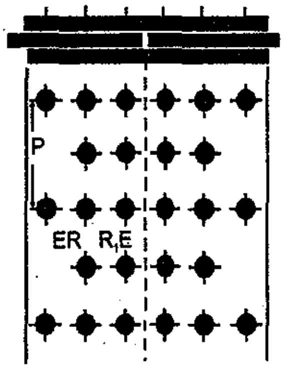


FIG. 27

Max. Pitch	=	$6 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 5 \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\frac{100(P-2D)}{P} + \frac{100 \times A \times 1.875 \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.33P \times .67D$	Eqn. (12)
		or $2 \times D$ whichever is greater	Eqn. (13)
R_1	=	$2 \times D$	Eqn. (15)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS	=	$.625 \times \frac{(P-D)}{(P-2D)}$	Eqn. (8)

TREBLE RIVETED JOINTS
DOUBLE BUTT STRAPS OF UNEQUAL WIDTH—THREE RIVETS PER PITCH

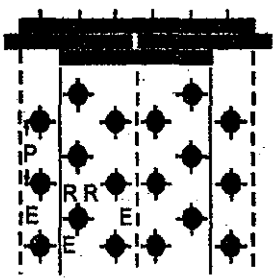


FIG. 28

Max. Pitch	=	$4.63 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 4.75 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$.33P \times .67D$	Eqn. (12)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS (WIDE)	=	$.75T$	Eqn. (9)
BUTT STRAPS (NARROW)	=	$.625T$	Eqn. (10)

DOUBLE BUTT STRAPS OF UNEQUAL WIDTH—THREE RIVETS PER PITCH

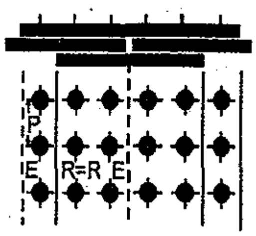


FIG. 29

Max. Pitch	=	$4.63 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 4.75 \times S_1}{P \times T \times S}$	Eqn. (3)
R	=	$2P \times D$	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS (WIDE)	=	.75T	Eqn. (9)
BUTT STRAPS (NARROW)	=	.625T	Eqn. (10)

TREBLE RIVETED JOINTS

DOUBLE BUTT STRAPS OF UNEQUAL WIDTH—FIVE RIVETS PER PITCH

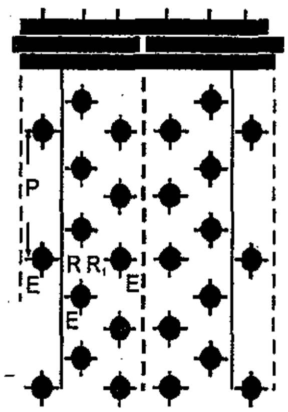


FIG. 30

Max. Pitch	=	$6 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 8.5 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\frac{100(P-2D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.2P \times 1.15D$	Eqn. (14)
R_1	=	$0.165P \times .67D$	Eqn. (15)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS (WIDE)	=	.75T	Eqn. (9)
BUTT STRAPS (NARROW)	=	.625T	Eqn. (10)

DOUBLE BUTT STRAPS OF UNEQUAL WIDTH—FIVE RIVETS PER PITCH

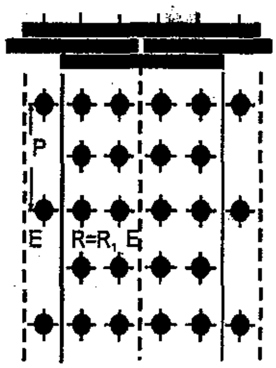


FIG. 31

Max. Pitch	=	$6 \times T + 1.625$	Eqn. (11)
Plate %	=	$\frac{100(P-D)}{P}$	Eqn. (2)
Rivet %	=	$\frac{100 \times A \times 8.5 \times S_1}{P \times T \times S}$	Eqn. (3)
Combined %	=	$\frac{100(P-2D)}{P} + \frac{100 \times A \times S_1}{P \times T \times S}$	Eqn. (4)
R	=	$.33P \times .67D$ or 2D whichever is greater	Eqn. (12)
R_1	=	$2 \times D$	Eqn. (13)
E	=	$1.5 \times D$	Reg. 184
BUTT STRAPS (WIDE)	=	.75T	Eqn. (9)
BUTT STRAPS (NARROW)	=	.625T	Eqn. (10)

APPENDIX B

FORMS OF STANDARD TENSILE TEST PIECES
STANDARD FLAT TEST PIECES

TEST PIECE A

1. Chief for sheets, plates, strips, flat bars, sections, etc.

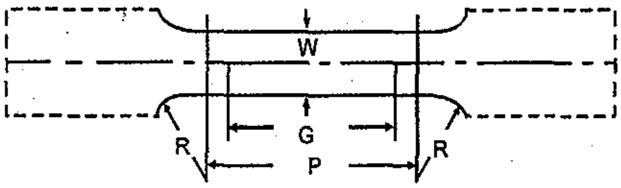


FIG. 1

Nominal thickness of test piece		*(i)*	*(ii)*	*(iii)* *(See note 3)*	*(iv)* *3/8 inch and thicker*
		Upto but not including 3/8 in.			
		in.	*in.*	*in.*	*in.*
Width	W	½	1	1½ (max,)	1½ (max,)
Gauge Length	L	2	4	8	8
Parallel Length	P	2½	4½	9	9
Radius as shoulder (Minimum)	R	1	1	1	1
Approximate total length		8	12	18	18

When the width of the material to be tested is insufficient to permit of the preparation of the standard tensile test pieces, a piece of the full width of the material may be used.

Notes:

(1) For some material it is convenient to use straight parallel test pieces.

(2) For certain non-ferrous metals it is sometimes convenient to use the standard test pieces that has a width of ½ in. and a gauge length of 2 in. for thickness exceeding ¼ in.

(3) A test piece of the dimensions given in Col. (iii) for material under 2/8 in. nominal thickness is intended for the ferrous metals only.

TEST PIECE A-1

2. In Tensile tests on special sheet and strip materials (e.g. steel used for deep pressing operations) the following alternative test piece may be used:—

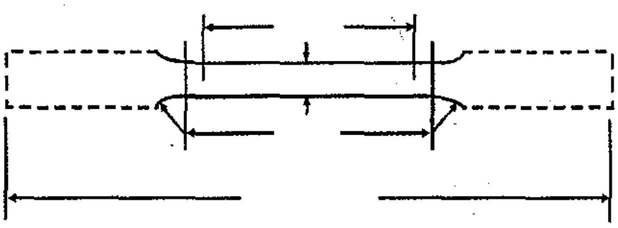
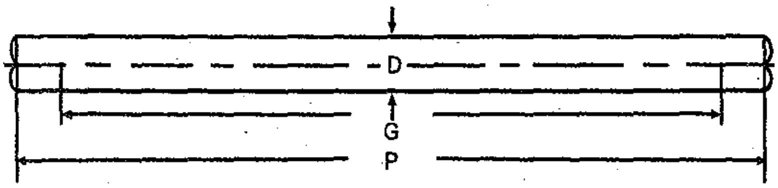


FIG. 2

STANDARD ROUND TEST PIECES

TEST PIECE B

3. Chiefly for unmachined rods and bars not exceeding 1 in. diameter (excluding cast metals).



Gauge Length G = 8; Length between grips P to be not less than 9D

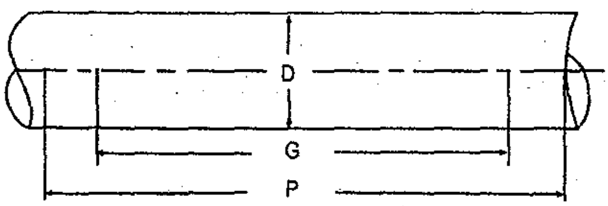
FIG. 3

All test pieces of form B are strictly similar and for the same material give the same percentage elongation. They give elongation figures nearly the same as those of standard flat test pieces 8 in. in gauge length 1½ in. wide and ½ in. thick.

Note: When tensile tests are made on unmachined square and hexagonal bars excluding cast metals the gauge length shall be 8 times the distance between the flats and the length between the grips shall be not less than 9 times the distance between the flats.

TEST PIECE B

4. For rods and bars over 1 in. diameter (excluding cast metals).

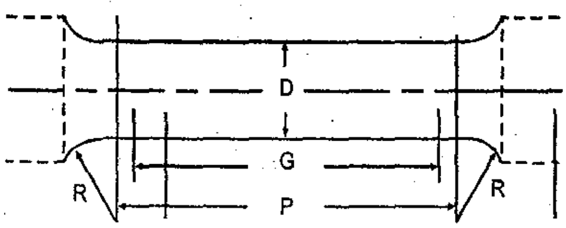


Gauge Length G = 4D; Length between grips P to be not less than 4.5D

FIG. 4

TEST PIECE C

5. Machined Round Test, Piece for general purposes.



Gauge Length G = 2 in.; Parallel length P to be not less than 2¼ in.

Diameter D = 0.564 in.; Cross-sectional area A = ¼ square in.

Radius at shoulder = ½ in. minimum for wrought metals and 2½ in. minimum for cast metals.

FIG. 5

SUBSIDIARY STANDARD ROUND TEST PIECES

6. Machined Test Pieces for general purposes (excluding cast iron).

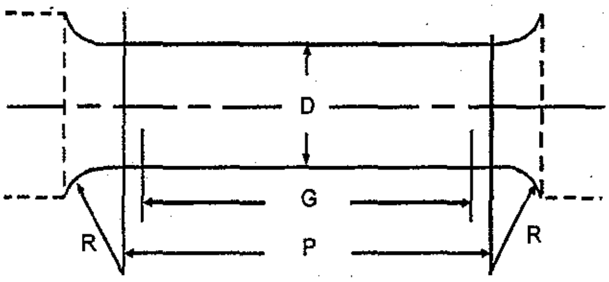


FIG. 6

Cross-sectional Area $A = \frac{D^2\pi}{4}$

Gauge length $G = 4\sqrt{A} = 3.54D$

Parallel length P = 9/8 G minimum = 3.98 D minimum

Radius at shoulder for wrought metals = G/4 minimum (0.88 D minimum).

Radius at shoulder for cast metals = G/4 minimum (4.40 D minimum).

All Test pieces conforming to the above dimensions are similar to Standard Test Piece C with corresponding shoulder radius, and give the same percentage elongation as Test Piece for the same material.

Recommended dimensions for Subsidiary Standard Round Test Pieces are tabulated below. Standard Test Piece C (0.564 in. diameter) is included for comparison. Any test piece, however, in which the diameter is not less than 0.125 in., and the dimensions of which conform to the subsidiary standard form, is recognised as a subsidiary standard test piece.

Diameter D	*Cross-sectional Area A*	*Gauge Length G*	*Parallel length P (minimum)*	*Radius at shoulder R*	
				Wrought Metal	*Cast Metal*
in.	*sq. in*	*in.*	*in.*	*in.*	*in.*
1. 128	1.0000	4.00	4.50	1.00	5.00
0.977	0.7500	3.46	3.89	0.86	4.30
0.798	0.5000	2.82	3.18	0.70	3.50
0.564	0.2500	2.00	2.25	0.50	2.50
0.424	0.1412	1.50	1.69	0.37	1.85
0.399	0.1250	1.41	1.58	0.35	1.75
0.357	0.1000	1.26	1.42	0.31	1.55
0.282	0.0625	1.00	1.12	0.25	1.25
0.226	0.0400	0.80	0.90	0.20	1.00
0.159	0.0200	0.56	0.63	0.14	0.70
0.125	0.0122	0.44	0.50	0.11	0.55

APPENDIX D

PROOF TEST FOR CREEP QUALITY OF CARBON STEEL PLATE OF BOILER PLATE QUALITY—SPECIFICATION

NATURE OF TEST

1. The test shall consist of a tensile creep test carried out over a period of at least 48 hours at a temperature of 450°C and with stress of 8 tons per sq. in. Under these conditions the slope of the chord to the creed curve between the 24th and 48th hour shall not exceed 50 × 10 = 4° strain per hour.

CONDITION OF MATERIAL

2. The test shall be made on the material in the normalised condition. The normalising temperature shall be between 875°C—925°C, and the plate sample shall be maintained at the normalising temperature for one hour per inch of thickness and cooled freely in still air.

TEMPERATURE OF TEST

3. (a) **Temperature Measurement**—The temperature of the specimen shall be measured by thermocouples suitable for the temperature specified. Two thermocouples situated one at each end of the gauge length shall be used in the case of test pieces having gauge lengths upto 2 in., and for longer gauge lengths and additional thermocouple situated at the middle of the gauge length shall be used.

Thermocouples shall make good thermal contact with the test piece and the protected from the direct heat of the furnace of being covered with asbestos tape or equivalent insulation.

The cold junction shall be maintained at a known temperature which shall be registered by a mercury thermometer. Alternatively, a suitable means shall be provided for correcting automatically errors in reading due to changes in temperature of the cold junction.

(b) **Temperature Control**—The two (or three) thermocouples specified in clause (a) shall agree with one another within 3°C and the average of these readings shall be taken as the test temperature which shall not vary from 450°C by more than ± 2°C throughout the test.

Either a continuous record of sufficient readings of the temperature shall be made to indicate that the temperature conditions have been satisfactory.

(c) **Heating period before loading**—The specimen shall be maintained at the specified temperature for atleast an hour prior to the application of the load.

STRESS

4. The load required to produce the specified stress shall be gradually applied without shock during a period not exceeding five minutes and the stress shall be accurate to ± 2½ per cent.

SENSITIVITY OF STRAIN-MEASURING EQUIPMENT

5. The sensitivity of the extensometer must be such that strains can be measured to the nearest 0.00002.

READINGS

6. A sufficient number of strain readings shall be taken clearly to define the creep curve upto 48 hours, and the chord slope shall be measured from a chord drawn between points on the curve at the 24th and 48th hours.

REPEAT TEST

7. If the materials fails to pass the test, but the chord slope does not exceed 60 × 10 = 6° strain per hour, a retest may be made at the request of the manufacturer and shall be accepted if satisfactory, or at the Inspector's discretion a pass test at a stress 5 per cent less than that specified may be accepted.

APPENDIX E

FLANGES FOR PIPES, VALVES AND FITTINGS

Table D: For Working Steam Pressures Upto 50 lbs.

(This table does not apply to boiler feed pipes, or to other water pipes subject to exceptional shocks.)

Table E: For Working Steam Pressures above 50 lbs. and upto 100 lbs. per square inch.

Nominal Intl. Dia. of Pipe	*Diameter of Flange*	*Diameter of Bolt Circle*	*Number and Diameter of Bolts (off Centre lines)*		*Thickness of Flange*				
					Cost Iron	*Cast Steel and Bronze*		*Stamped or Forged, Wrought Iron or Steel (See Nos.)*	
	Upto 50 lb. 100 lb.	*Upto 50 lb. 100 lb.*	*Upto 50 lb.*	*Upto 100 lb.*	*Upto 50 lb. 100 lb.*	*Upto 50 lb.*	*Upto 100 lb.*	*Upto 50 lb.*	*Upto 100 lb.*
in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
½	3¾	2-5/58	4½	4½	3/8	3/8	3/8	3/16	¼
¾	4	2-7/8	4½	4½	½	3/8	3/8	3/16	¼
1	4½	3¼	4½	4½	½	3/8	3/8	3/16	9/32
1¼	4¾	3-7/16	4½	4½	5/8	½	½	¼	5/16
1½	5¼	3-7/8	4½	4½	5/8	½	½	¼	11/32
2	6	4½	4-5/8	4-5/8	¾	9/16	9/16	5/16	3/89
2½	6½	5	4-5/8	4-5/8	¾	9/16	9/16	5/16	13/32
3	7¼	5¾	4-5/8	4-5/8	¾	9/16	9/16	3/8	7/16
3½	8	6½	4-5/8	8-5/8	¾	9/16	9/16	3/8	15/32
4	8½	7	4-5/8	8-5/8	7/8	11/16	11/16	3/8	½
*4½	9	7½	8-5/8	8-5/8	7/8	11/16	11/16	7/16	½
5	10	8½	8-5/8	8-5/8	7/8	11/16	11/16	½	9/16
6	11	9¼	8-5/8	8¾	7/8	11/16	11/16	½	11/16
7	12	10¼	8-5/8	8¾	1	¾	¾	½	¾
8	13¼	11½	8-5/8	8¾	1	¾	¾	½	¾
9	14½	12¾	8-5/8	12¾	1	¾	13/16	5/8	13/16
10	16	14	8¾	12¾	1	¾	7/8	5/8	7/8
*11	17	15	8¾	12¾	1-1/8	7/8	15/16	5/8	15/16
12	18	16	12¾	12-7/8	1-1/8	7/8	1	5/8	1
*13	19¼	17¼	12¾	12-7/8	1-1/8	7/8	1	¾	1
14	20¾	18½	12-7/8	12-7/8	1¼	1	1	¾	1
15	21¾	19½	12-7/8	12-7/8	1¼	1	1	¾	1

in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
16	22¾	20½	12-7/8	12-7/8	1¼	1	1	¾	1
*17	24	21¾	12-7/8	12-7/8	1-3/8	1-1/8	1-1/8	7/8	1-1/8
18	25¼	23	12-7/8	16-7/8	1-3/8	1-1/8	1-1/8	7/8	1-1/8
*19	26½	24	12-7/8	16-7	1-3/8	1-1/8	1¼	7/8	1¼
20	27¾	25¼	16-7/8	16-7	1½	1¼	1¼	1	1¼
21	29	26½	16-7/8	16-1	1½	1¼	1-3/8	1	1-3/8
*22	30	27½	16-1	16-1	1½	1¼	1-3/8	1	1-3/8
23	31	28½	16-1	16-1	1-5/8	1-3/8	1-3/8	1-1/8	1-3/8
24	32½	29¾	16-1	16-1	1-5/8	1-3/8	1½	1-1/8	1-1/8

*See notes at the end of Tables regarding these, also for other particulars.

Table F: For Working Steam Pressures above 100 lbs. and upto 350 lbs. per square inch.

Table H: For Working Steam Pressures above 150 lbs. and upto 250 lbs. per square inch.

Nominal Intl. Dia. of Pipe		*Diameter of Flange*	*Diameter of Bolt Circle*	*Number and Diameter of Bolts (off Centre lines)*		*Thickness of Flange*		
						Cast Iron	*Steel and Bronze Steel (Stamped or forged) (See Notes)*	
		Upto 150 lb. 250 lb.	*Upto 150 lb. 250 lb.*	*Upto 150 lb.*	*Upto 250 lb.*	*Upto 150 lb. only*	*Upto 150 lb.*	*Upto 250 lb.*
in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
150 lb Only	½	2¾	2-5/8	4½	4-5/8	½	3/8	—
	¾	4	2-7/8	4½	4-5/8	½	3/8	—
250 lb Only	½	4½	3¼	—	4-5/8	—	—	—
	¾	4½	3¼	—	4-5/8	—	—	½
1		4¾	3-7/16	4-5/8		½	3/8	9/16
1¼		5¼	3-7/8	4-5/8		5/8	7/16	11/16
2½		5½	4-1/8	4-5/8		5/8	½	11/16
2		6½	5	4-5/8		¾	5/8	¾
2½		7¼	5¾	8-5/8		¾	5/8	¾
3		8	6½	8-5/8		¾	5/8	7/8
3½		8½	7	8-5/8		7/8	¾	7/8
4		9	7½	8-5/8		7/8	¾	1
*4½		10	8¼	8¾		7/8	¾	1
5		11	9¼	8¾		1	7/8	1-1/8
6		12	10¼	12¾		1	7/8	1-1/8

in.	in.	in.	in.	in.	in.	in.	in.	in.
7		13¼	11½	12¾		1	7/8	1¼
8		14½	12¾	12¾		1-1/8	1	1¼
9		16	14	12-7/8		1-1/8	1	1-3/8
10		17	15	12-7/8		1-1/8	1	1-3/8
*11		18	16	16-7/8		1¼	1-1/8	1½
12		19¼	17¼	16-7/8		1¼	1-1/8	1½
*13		20¾	18½	16-1		1¼	1-1/8	1-5/8
14		21¾	19½	16-1		1-3/8	1¼	1-5/8
15		22¾	20½	16-1		1-3/8	1¼	1¾
16		24	21¾	20-1		1-3/8	1¼	1¾
*17		25¼	23	20-1		1½	1-3/8	1-7/8
18		26½	24	20-1-1/8		1½	1-3/8	1-7/8
*19		27¾	25¼	20-1-1/8		1½	1-3/8	2
20		29	26½	24-1-1/8		1-5/8	1½	2
21		30	27½	24-1-1/8		1-5/8	1½	2-1/8
*22		31	28½	24-1-1/8		1-5/8	1½	1-1/8
*23		32½	29¾	24-1-1/8		1¾	1-5/8	2¼
24		33½	30¾	24-1¼		1¾	1-5/8	2¼

*See Notes at the end of Tables regarding these also for flanges for pipe lines and other particulars.

Table J: For Working Steam Pressures above 250 lbs. and upto 350 lbs. per square inch.

Nominal Intl. Diameter of Pipes	*Actual External Diameter of Wrought Pipe*	*Diameter of Flange*	*Diameter of Bolt Circle*	*Number and Diameter of Bolts (off centre lines)*	*Thickness of Flange*
					Cast Steel and Bronze Steel (Stamped or forged) (see Notes)
in.	in.	in.	in.	in.	in.
½	27/32	4½	3¼	4-5/8	5/8
¾	1-1/6	4½	3¼	4-5/8	5/8
1	1-11/32	4¾	3-7/16	4-5/8	¾
1¼	1-11/16	5¼	3-7/8	4-5/8	¾
1½	1-29/32	5½	4-1/8	4-5/8	7/8
2	3-3/8	6½	5	4¾	1
2½	3	7¾	5¾	8¾	1

in.	in.	in.	in.	in.	in.
3	3½	8	6½	8¾	1¼
3¼	4	8½	7	8¾	1¼
4	4½	9	7½	8¾	1-3/8
4½	5	10	8¼	8-7/8	1-3/8
5	5½	11	9¼	8-7/8	1½
6	6½	12	10¼	12-7/8	1½
7	7½	13¼	11½	12-7/8	1-5/8
8	8½	14½	12¾	12-7/8	1-5/8
9	9½	16	14	12-1	1¾
10	10½	17	15	12-1	1-7/8
11*	11½	18	16	16-1	1-7/8
12	12½	19¼	17¾	16-1	2
13*	14	20¾	18¾	16-1-1/8	2
14	15	21¾	19¾	16-1-1/8	2-1/8
15	16	22¾	20¾	16-1-1/8	2-1/8
16	17	24	21¾	20-1-1/8	2¼
17*	18	25¼	23	20-1-1/8	2-3/8
18	19	26½	24	20-1¼	2-3/8
19*	20	27¾	25¼	20-1¼	2½
20	21	29	26½	24-1¼	2½
21	22	30	27½	24-1¼	2-5/8
22*	23	31	28½	24-1¼	2-5/8
23*	24	32½	29¾	24-1-3/8	2¾
24	25	33½	30¾	24-1-3/8	2¾

*See Notes at the end of Tables regarding these, also for flanges for pipe lines and other particulars. The actual external diameters of wrought pipes given above apply equally to all tables.

Table K: For Working Steam Pressures above 350 lbs. and upto 450 lbs. per square inch.

Nominal Intl. Diameter of Pipes	*Actual External Diameter of Wrought Pipe*	*Diameter of Flange*	*Diameter of Bolt Circle*	*Number and Diameter of Bolts (off centre lines)*	*Thickness of Flange*
					Cast Steel and Bronze Steel (Stamped or forged) (see Notes)
in.	*in.*	*in.*	*in.*	*in.*	*in.*
½	27/32	4½	3¼	4-5/8	¾
¾	1-1/16	4½	3¼	4-5/8	¾
1	1-11/32	5	3¾	4-5/8	7/8
1¼	1-11/16	5¼	3-7/8	4-5/8	1/8
1½	1-29/32	6	4½	4¾	1
2	2-3/8	6½	5	8-5/8	1
2½	3	7¼	5¾	8¾	1-1/8
3	3½	8	6½	8¾	1¼
3½	4	9	7¼	8-7/8	1¼
4	4½	9½	7¾	8-7/8	1-3/8
*4½	5	10	8¼	8-7/8	1½
5	5½	11	9¼	12-7/8	1-5/8
6	6½	12	10¼	12-7/8	1-5/8
7	7½	13½	11½	12-1	1¾
8	8½	14½	12½	12-1	1-7/8
9	9½	16	14	16-1	2
10	10½	17	15	16-1	2
*11	11½	18½	16¼	16-1-1/8	2-1/8
12	12½	19¼	17	16-1-1/8	2¼
*13	14	21½	19	16-1¼	2-3/8
14	15	22½	20	16-1¼	2-3/8
15	16	23¾	21¼	20-1¼	2½
16	17	24¾	22¼	20-1¼	3-5/8

Notes:

It is recommended that the use of sizes marked * should be avoided.

The thickness of flanges given in the tables include a raised face for not more than 1/16 in. high if such be used.

For ½ in. and 5/8 in. bolts the diameters of the holes to be 1/16 in. larger than the diameters of the bolts, and for larger sizes of bolts 1/8 in.

Iron or Steel flanges, (stamped or forged) may be screwed or riveted on with boss, or welded with fillet, the flanges being of steel for pressures above 150 lbs. per square inch.

Special welded-on flanges (stamped or forged) for pipe lines 2 in. nominal diameter of pipe and upwards (without valves of fittings) are made as stated below, the flange selected in all cases being, that given for the next smaller size of pipe in the corresponding table or as especially stated.

Table L: For Working Steam Pressures upto 150 lbs. per square inch corresponds with Table F, modified as above.

Table M: For Working Steam Pressures above 150 lbs. and upto 250 lbs. per square inch corresponds with Table H modified as above.

Table P: For Working Steam Pressures above 250 lbs. and upto 350 lbs. per square inch corresponds with Table I modified as above.

Table R: Flanges for pipes, Valves and Fittings.

For Working Steam Pressures above 450 lbs. and upto 600 lbs. per square inch.

Nominal Pipe Size	*Approximate Outside Diameter of Wrought Pipe*	*Diameter of Flange*	*Diameter of Bolt Circle*	*Number of Bolts*	*Diameter of Bolts*	*Thickness of Flange* *Cast Steel; Steel (Stamped or forged) screwed or riveted on with boss, or welded on with fillet*	*Diameter of Jointing Face*
1	*1(a)*	*2*	*3*	*4*	*5*	*6*	*7*
in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
½	27/32	4½	3¼	4	5/8	¾	2¼
¾	1-1/16	4½	3¼	4	5/8	¾	2¼
1	1-11/32	5	3¾	4	5/8	7/8	2½
1¼	1-11/16	5¼	3-7/8	4	5/8	7/8	2¾
1½	1-29/32	6	4½	4	¾	1	3
2	2-3/8	6½	5	8	5/8	1	3½
2½	3	7¼	5¾	8	¾	1-1/8	4
3	3½	8	6½	8	¾	1¼	4½
3½	4	9	7¼	8	7/8	1¼	5
4	4½	9½	7¾	8	7/8	1-3/8	5½
4½	5	10	8¼	8	7/8	1½	6
5	5½	11	9¼	12	7/8	1-5/8	6½
6	6½	12	10¼	12	7/8	1¾	7½
7	7½	13½	11½	12	1	1-7/8	8¾
8	8½	14½	12¾	12	1	2	9¾
9½	9½	16	14	16	1	2-1/8	10¾
10	10½	17	15¼	16	1	2¼	11¾
11	11½	19	17	16	1-1/8	2-3/8	12¾
12	12½	20	18	16	1-1/8	2½	13¾
13	14	21¾	19½	16	1¼	2-5/8	15
14	15	23	20¾	16	1¼	2¾	16
15	16	24	21¾	20	1¼	2-7/8	17
16	17	25¼	23	20	1¼	3	18

Table S: Steel Flanges for Pipes, Valves and Fittings.

For Working Steam Pressures above 600 lbs. and upto 900 lbs. per square in. and temperature upto 800°F (427°C).

Nominal Pipe Size	Actual Outside Diameter of Wrought Pipe	Diameter of Flange	Diameter of Bolt	Number of Bolts	Diameter of Bolts	Thickness of Flange	Diameter of Jointing Face
1	1(a)	2	3	4	5	6	7
in.	in.	in.	in.	in.	in.	in.	in.
½		5	3½	4	¾	7/8	2
¾	1-1/16	5	3½	4	¾	7/8	2
1	1-11/32	5½	4	4	¾	1	2¼
1¼	1-11/16	5¾	4¼	4	¾	1-1/8	2½
1½	1-29/32	6¼	5¾	4	¾	1-1/8	2¾
2	2-3/8	6¾	5¼	8	¾	1¼	3¼
2½	3	7¼	5¾	8	¾	1¼	3¾
3	3½	8	6½	8	7/8	1-3/8	4¼
3½	4	9¼	7½	8	7/8	1½	4¾
4	5	9¾	8	8	1	1-5/8	5¼
4½	5½	10½	8½	8	1	1-5/8	5¾
5	6	11¼	9¼	12	7/8	1¾	6¼
6	7	12¾	10¾	12	1	2	7¼
7	8½	14¾	12½	12	1-1/8	2¼	8½
8	9½	16¼	14	12	1¼	2½	9½
9	10½	17¼	15¼	16	1-1/8	2-5/8	10½
10	11½	19	16¾	16	1¼	2-7/8	11½
*10½	12½	21	18½	16	1-3/8	3-1/8	12¾
*11¾	14	22¾	20	16	1½	3¼	13¾
*12-5/8	15	24	21¼	16	1½	3½	14¾
*13½	16	25½	22¾	20	1½	3¾	16
*14-3/8	17	27½	24½	20	1-5/8	4	17
*15¼	18	29¼	26	20	1¾	4½	18

*The sizes shall be specified by the outside diameter dimensions given in column 1(a). The figures in column 1 (nominal bore) are approximate and are given for information only.

Table T: Steel Flanges for Pipes, Valves and Fittings.

(To be used in Conjunction with the Notes and Appendices)

For Working Steam Pressures above 900 lbs. and upto 1400 lbs. per square in. and temperature upto 800°F (427°C).

Nominal Pipe Size	*Maximum Outside Diameter of Wrought Pipe*	*Diameter of Flange*	*Diameter of Bolt*	*Number of Bolts*	*Diameter of Bolts*	*Thickness of Flange*	*Diameter of Jointing Face*
1	*1(a)*	*2*	*3*	*4*	*5*	*6*	*7*
in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
½	27/32	5½	4	4	¾	1	2¼
¾	1-1/16	5½	4	4	¾	1	2¼
1	1-11/32	5¾	4¼	4	¾	1-1/8	2½
1¼	1-11/16	6¼	4¾	4	7/8	1¼	2¾
1½	2-3/8	6¾	5¼	8	¾	1-3/8	3
2	3	7¼	5¾	8	¾	1-3/8	3½
2½	3	8	6½	8	7/8	1-5/8	4½
3	4	9¼	7½	8	1	1-7/8	5
3½	4	10½	8½	8	1-1/8	2-1/8	5½
4	5	11¼	9¼	8	1-1/8	2¼	6
4½	5½	11¾	10	12	1	2-3/8	6½
5	6½	12¾	10¾	12	1-1/8	2-5/8	7
6	7½	14¾	12½	12	1¼	2-7/8	8
7	9	17	14½	12	1-3/8	3¼	9¼
8	10½	18¾	16	12	1½	3½	10½
9	11½	20	17½	16	1-3/8	3¾	11¾
10	12½	22	19¼	16	1½	4¼	12¾

STANDARD PIPE FLANGES

The different tables of flange dimensions (Table F.T.) have been designed to suit pipes and vessels containing steam at a maximum temperature of 800°F.

If the temperature is higher than 800°F and does not exceed 900°F the following Table should be used for the next higher pressure.

Water pipes for a given pressure in which the water temperature does not exceed 450°F may be fitted with Flanges to the next lower Table than that required for steam at the stated pressure and a maximum temperature of 800°F.

In all cases the hydraulic test pressure should be twice the working pressure to which the pipes are subjected in use.

Table showing the permissible application of pipe flanges tables.

Pressure lb./sq. in.	*Steam at 900°F*	*Steam at 800°F*	*Water at 450°F*	*Hydraulic Test Pressure lb./sq. in.*
	Table	*Table*	*Table*	
1400	—	T	S	2800
900	T	S	R	1800
600	S	R	K	1200
450	R	K	J	900
350	K	J	H	700
250	J	H	F	500
150	H	F	-	300

APPENDIX F

TRANSVERSE RUPTURE STRESS (MODULUS OF RUPTURE)

The transverse strength of cast iron may be expressed by a figure known as the Transverse Rupture Stress; this figure is obtained by dividing the maximum bending moment at failure by the modulus of the section. Thus, the Transverse Rupture Stress is the maximum stress which would have existed if the material had behaved in accordance with the assumptions made in the ordinary theory of bending, and in that event it would be independent of the size and shape of the section. Bars fractured in transverse, however, are stressed beyond the elastic limit, and under these conditions the theory of bending no longer holds good. Furthermore, the influence of rate of cooling in cast metals is such that the Transverse Rupture Stress of a Thick Bar is less than that of a thinner bar of the same metal. The Transverse Rupture Stress, therefore, is not strictly independent of the size and metal. The Transverse Rupture Stress, therefore, is not strictly independent of the size and shape, of the section, but nevertheless forces a convenient way of expressing the result of transverse tests without the necessity for giving full details of bar dimensions. The formula required is obtained as follows:

A bar supported at both ends and centrally loaded with a load W is subject to a bending Moment WL/4, L being the distance between supports. The resistance offered by the bar may be expressed as fZ, f being the stress and Z the modulus of the section. At fracture, f becomes the breaking stress of Transverse Rupture Stress, and WL/4 = fZ, where f = (LW)/(4Z). If W is in tons and L in inches, f is in tons per square inch. For a round bar, $Z = 0.0982d^2$, where d diameter in inches.

Since for a standard round bar L and Z are constant, the value WL/4Z is fixed and hence the Transverse Rupture Stress f=KW, where K is a constant.

The factor K for converting actual breaking loads into Transverse Rupture Stress are given in the following tables both for the Standard test bars and the test bars varying within the limits of Regulation 88. In the same table are given factors for converting actual breaking loads into equivalent breaking loads on the bars of Standard diameter.

Factors X for converting Actual Breaking Loads into Equivalent Breaking Loads on Bars of Standard Diameter.

(Equivalent Breaking Load on Bar of Standard Diameter = X × Actual Breaking Load).

and

Factors K for converting Actual Breaking Loads into Transverse Rupture Stresses.

(Transverse Rupture Stress in tons per sq. in. = K × Actual Breaking Load in lb.)

0.6 in. Test Bar			*0.085 in. Test Bar*			*1.2 in. Test Bar*			*1.6 in. Test Bar*			*2.1 in. Test Bar*		
Dia.	*X*	*K*	*Dia.*	*X*	*K*	*Dia.*	*X*	*K*	*Dia.*	*X*	*K*	*Dia.*	*X*	*K*
in.			*in.*			*in.*			*in.*			*in.*		
—	—	—	—	—	—	—	—	—	1.50	1.214	0.00606	2.00	1.158	0.00341
—	—	—	—	—	—	1.11	1.264	0.0150	1.51	1.190	0.00594	2.01	1.140	0.00336
—	—	—	—	—	—	1.12	1.230	0.0146	1.52	1.666	0.00583	2.02	1.124	0.00331
—	—	—	0.81	1.261	0.0257	1.13	1.198	0.0142	1.53	1.444	0.00571	2.03	1.107	0.00326
—	—	—	0.82	1.215	0.0247	1.14	1.116	0.0138	1.54	1.121	0.00560	2.04	1.091	0.00321
—	—	—	0.83	1.172	0.0239	1.15	1.136	0.0135	1.55	1.100	0.00549	2.05	1.075	0.00317
0.56	1.230	0.0582	0.84	1.130	0.0230	1.16	1.107	0.0131	1.56	1.079	0.00539	2.06	1.059	0.00312
0.57	1.106	0.0552	0.85	1.091	0.0222	1.17	1.079	0.0128	1.57	1.058	0.00529	2.07	1.044	0.00308
0.58	1.107	0.0524	0.86	1.053	0.0214	1.18	1.052	0.0125	1.58	0.078	0.00419	2.08	1.029	0.00303
0.59	1.052	0.0498	0.87	1.017	0.0207	1.19	1.025	0.0121	1.59	1.019	0.00509	2.09	1.014	0.00299
0.60	1.000	0.0474	0.875	1.000	0.0204	1.20	1.000	0.0118	1.60	1.000	0.00499	2.10	1.000	0.00295
0.61	0.952	0.0451	0.88	0.983	0.0200	1.21	0.975	0.0115	1.61	0.981	0.00490	2.11	0.986	0.00290
0.62	0.906	0.0429	0.89	0.950	0.0193	1.22	0.952	0.0113	1.62	0.963	0.00481	2.12	0.972	0.00286
0.63	0.864	0.0409	0.90	0.919	0.0187	1.23	0.929	0.0110	1.63	0.946	0.00472	2.13	0.958	0.00282
0.64	0.824	0.0390	0.91	0.889	0.0181	1.24	0.906	0.0107	1.64	0.929	0.00464	2.14	0.945	0.00287
—	—	—	0.92	0.860	0.0175	1.25	0.885	0.0105	1.65	0.919	0.00455	2.15	0.932	0.00274
—	—	—	0.93	0.833	0.0170	1.26	0.864	0.0102	1.66	0.895	0.00447	2.16	0.919	0.00271
—	—	—	0.94	0.807	0.0164	1.27	0.844	0.0100	1.67	0.879	0.00439	2.17	0.906	0.00267
—	—	—	—	—	—	1.28	0.824	0.0098	1.68	0.864	0.00431	2.18	0.894	0.00260
—	—	—	—	—	—	1.29	0.805	0.0095	1.69	0.849	0.00424	2.19	0.882	0.00266
—	—	—	—	—	—	—	—	—	1.70	0.834	0.00416	2.20	0.870	0.00253

APPENDIX J

INSPECTION AND TESTING OF BOILERS DURING CONSTRUCTION

GENERAL

The Inspecting Authority shall have access to the works of the manufacturer at all reasonable times and shall inspect the manufacture of the boiler at least at the following stages and may reject any part that does not comply with the requirements of the Indian Boiler Regulations, 1950. In case of any doubt, the Inspecting Authority may examine at any stage other than the stages stipulated below. The manufacturer shall give at least 4 working days' notice to the Inspecting Authority/Inspecting Officer before reaching each stage. Before undertaking any of the stage inspections, the Inspecting Authority/Inspecting Officer shall satisfy himself that the testing equipment/instrument has been properly calibrated.

INSPECTION DURING CONSTRUCTION

Each boiler shall be inspected during construction by an Inspecting Officer nominated by the Inspecting Authority. Sufficient inspections shall be made to ensure that the materials, construction and testing conform to the requirements of these regulations.

Stages of Inspection During Construction

A. Shell Type Boilers

(a) (i) Check the identification markings on the plate with those recorded on the plate makers' certificates;

(ii) Check the reported result of the mechanical and chemical properties on the plate makers' certificates against the requirements of the Indian Boiler Regulations, 1950;

(iii) Witness the marking of the test plates for identification before they are cut from the parent plate or plates;

(b) When the Shell plate and end plates have been formed with plate edges prepared for welding and test plates are attached;

(c) When the welding of main cylindrical shell is completed and checked for circularity;

(d) To examine radiographs and/or reports of non-destructive testing;

(e) When openings have been prepared and stand pipes and similar connections including end plates have been tackwelded in position and subsequently on completion;

(f) When welding of drum or shell is completed and to check the records of heat-treatment when heat treatment is required under these regulations;

(g) When weld test specimens have been prepared from the test plate, previously selected to witness the required testing;

(h) During hydraulic test, followed by external and internal examination and stamping.

B. Water Tube Boilers

Welded drums and headers

(a) (i) When the plates are ready for identification with plate mill certificates at boiler maker's works and cut to size ready for forming to cylindrical shape;

(ii) In laying out and cutting the plates, the plate identification mark shall be located so as to be clearly visible after the boiler part is completed. If the plate's identification mark is unavoidably cut out, it shall be transferred by the manufacturer another part of the component to the satisfaction of the Inspecting Authority;

(iii) The Inspecting Authority shall identify weld test plate material if production weld tests are required;

(b) When the plates are formed to cylindrical shape with the edges prepared for welding and set up in readiness for commencement of welding and attachment of test plates;

(c) When the welding of the main cylindrical shell is completed, the shell checked for circularity and the radiographic or ultrasonic test reports, records are available for scrutiny;

(d) When the end plates are ready for identification with the mill certificate, formed to shape with weld edges prepared and set on to the cylindrical shell in readiness for the circumferential welding operation;

(e) When the welding of the end plates to the drum or the header is complete and the radiographs or ultrasonic examination records are available for scrutiny;

(f) When each drum or header is prepared to receive any compensation plates and attachments, and when at least 10% of each type of branch of tube stub is set up ready for welding;

(g) When all welding on each drum or header is complete, the Inspecting Authority will check the records of heat treatment, and mark off of specimens for preparation and testing from test plates;

(h) At hydraulic test followed by external and internal examination and testing and stamping. On alloy steel drums thicker than 50 millimetres and high carbon steel drums thicker than 100 millimetres further non-destructive examination shall be done on drums, nozzle and stub weld after stress relief;

(i) Any drum having tube holes drilled subsequently to the hydraulic test shall be further examined on completion of this work and prior to despatch from the manufacturers work.

C. Seamless Drums and Headers

(a) When material is ready for identification with the steel makers' Certificate of Manufacture and test, also when each cylinder is prepared for forming, or welding of separate end closures and to identify test plate material;

(b) When each plain shell drum or header is prepared to received compensation plates and attachments and a representative number of stand pipes, tubes or tube stubs, are set up ready for welding;

(c) When all welding on each drum is complete and the radiographs or ultrasonic test records are available the Inspecting Authority shall check the record of heat treatment and the marking off preparation and testing of specimens from test plates;

(d) At hydraulic test, followed by external and internal examination and stamping. On thick drums of high carbon or alloy material further non-destructive examination shall be done on drum nozzle and stub welds after stress relief.

D. Tubes and Internal Pipings

(a) When the tubes or pipes are ready for identification with the tube makers' certificate at the boiler makers' works and at least 10% of tubes and pipes are set up ready for welding;

(b) When all welding of tubes or pipes and their attachments are complete and the non-destructive examination report/records are available for scrutiny.

E. Inspections and tests to be carried out at Steel Makers' Works Foundry/Forging Units and the pipe and tube makers' works by the Inspecting Authority

1. Steel Makers Works

(a) When the billets, plates, angle, bars or any other parts to be used in the construction of the boilers:

(i) checking of the chemistry of steel as per regulation;

(ii) marking the test specimen for the mechanical test;

(iii) final testing.

Note: Notwithstanding anything specified above where the steel is made by the Well-known Steel Maker as recognised under the Indian Boiler Regulations, 1950 by the Central Boilers Board these tests will be carried out and certified by the Steel Makers themselves and the records maintained. The certificates so issued will be accepted by the Inspecting Authority of or further use.

2. *Foundry/Forging Units*—When billets, bars for forging are received and ready for identification:

(i) Chemical analysis of the castings/forging material;

(ii) Marking and mechanical testing of the test specimen of castings/forgings.

Note: Notwithstanding anything specified above, when the castings/forgings are made by well-known foundries/forging units as recognised under the Indian Boiler Regulations, 1950 by the Central Boilers Board then tests will be carried out and certified by the Foundries/Forges themselves and all records are maintained properly. The certificates so issued shall be accepted by the Inspecting Authority for further use.

3. Pipe and Tube Makers

(a) When billets, plates are ready for identification;

(b) When pipes/tubes are ready for examination; and selection of mechanical test after normalising;

(c) When the test specimens are ready for testing;

(d) When pipes/tubes are ready for hydraulic tests or the non-destructive examination.

Note: Notwithstanding anything specified above, when the pipes/tubes are manufactured by well-known pipes/tubes makers recognised under the Indian Boiler Regulations, 1950 by the Central Boilers Board, all the above stages of inspections shall be carried out and certified by the manufacturers of pipes and tubes themselves and records maintained. The certificates so issued by the manufacturers in the prescribed forms of Indian Boiler Regulations, 1950 shall be accepted by the Inspecting Authority for further use.

4. Inspection and tests to be carried out at the Fabricators' Works for fabrication of items

For parts manufactured from the tubes/pipes at the manufacturers' works either by manipulation or fabrication:

(a) Identification of materials;

(b) Checking of dimensions;

(c) Hydraulic test.

F. Valves and Mountings

(a) When pre-casting materials are ready for examination and selection for tests;

(b) When the test specimens are ready for test;

(c) Non-Destructive Testing as required under Indian Boiler Regulations.

(d) When the parts are machined and assembled and are ready for dimensional check in accordance with the drawings approved by the Inspecting Authority.

(e) Hydraulic test as per approved drawings.

Note: Notwithstanding anything specified above in case of Well-known Foundries/Forges, etc., the first two stages of inspection will be carried out by the Foundries/Forges themselves, and certified and record maintained. The certificates so issued shall be accepted by the Inspecting Authority for further use.

APPENDIX JA

[*See* regulation 376(ff)]

A. Power Utility Boilers working at a pressure 50 kg/cm^2 or more and upto 20 years of age

(1) The boilers working at a pressure 50 kg/cm^2 or more and up to 20 years of age, generating steam for power generation shall be inspected as detailed below after the expiry of twelve months from the date of inspection carried out in accordance with the procedure provided in regulation 390 and certification of fitness shall be issued by the concerned Inspector of Boilers in the State, through inspection of the following records which shall be made available to the concerned Inspector of Boilers at least thirty days before the expiry of the operating certificate, provided he is satisfied that the boiler can be allowed to be operated for a further period of twelve months.

(a) Operation data for superheater and reheater temperature excursions from the output of Data Acquisition System (DAS).

(b) History of shut downs during the previous year with their causes and actions taken.

(c) Records of any Non-Destructive test carried out on the boiler pressure parts during the year.

(d) Water quality to the boiler is maintained up to the requirement of such boilers and on line data of the quality be provided.

(e) Boiler tube failure record (location, number of tubes repaired/replaced).

(2) Inspection shall be carried out by the concernd Inspector of Boilers at the expiry of twenty-four months as provided in regulation 390. However, in case shutdown of fifteen days or more is planned any time before expiry of the certification period and after six months of the certification, the Inspector of Boilers shall be duly informed so that complete inspection can be scheduled during the said shut down period.

B. Boiler working at a pressure up to 50 kg/cm^2 and up to 20 years of age.

(1) The boilers working at a pressure up to 50 kg/cm^2 and up to 20 years of age generating steam for power generation shall be subjected to Hydraulic Test at pressure equivalent to the working pressure at the expiry of twelve months from the date of inspection carried out in accordance with the procedure provided in regulation 390 and certification of fitness by the concerned Inspector of Boilers in the State, and having satisfied with the operation records as at paragraph A, shall be allowed for running for another period of twelve months.

(2) Inspection shall be carried out by concerned Inspector of Boilers at the expiry of twenty-four months as provided in regulation 390. However, if shutdown of fifteen days or more is planned any time before expiry of the certification period and after six months of the certification, Inspector of Boilers shall be duly informed so that inspection can be scheduled during the said shut down period.

C. Boilers working at a pressure 50 kg/cm^2 or more, and more than 20 years of age

(1) Boiler working at a pressure 50 kg/cm^2 or more and more than 20 years of age, generating steam for power generation, shall be subjected to Hydraulic test at a pressure 1.25 times the working pressure at the expiry of twelve months from the date of inspection as provided in regulation 390 and certification of fitness by the concerned Inspector of Boilers in the State, and having satisfied the conditions and requirements as at paragraph A, shall be allowed running for another period of twelve months.

(2) Inspection shall be carried out by the concerned Inspector of Boilers at the expiry of twenty-four months as provided in regulation 390. However, if shut down of fifteen days or more is planned any time before expiry of the certification period and after six months of the certification, Inspector of Boilers shall be duly informed so that inspection can be scheduled during the said shut down period.

D. Boiler working at a pressure up to 50 kg/cm^2 and more than 20 years of age

Boiler working at a pressure up to 50 kg/cm^2 and more than 20 years of age shall continue to be subjected to inspection every year as provided in regulation 390.

APPENDIX JB

[*See* Regulation 376(fff)]

A. Waste Heat Boilers (Fired)/CO-Boilers working at a pressure up to 50 Kgs./sq.cm and upto 20 years of age used exclusively in continuous process plant.

(1) For Waste Heat Boilers (Fired)/CO-Boilers working at a pressure 50 Kgs/sq. cm or more and up to 20 years of age used exclusively in continuous process plant shall be subjected to Hydraulic Test at pressure equivalent to the working pressure at the expiry of twelve months from the date of inspection carrid out in accordance with the procedure provided in regulation 390 and certification of fitness by the concerned Inspector of Boilers in the State, and having satisfied with the operation records as given below, shall be allowed for running for another period of twelve months:—

(a) Operation data for superheater and reheater temperatue excursions from the output of Data Acquisition System (DAS);

(b) History of shut downs during the previous year with their causes and actions taken;

(c) Records of any Non-Destructive test carried out on the boiler pressure parts during the year;

(d) Water quality to the boiler is maintained as per the requirement of such boilers and on line data of the quality be provided through Data Acquisition System (DAS);

(e) Boiler tube failure record (location, number of tubes repaired/replaced).

(2) Inspection shall be carried out by the concerned Inspector of Boilers at the expiry of twenty-four months as provided in Regulation 390. However, if shutdown of fifteen days or more is planned any time before expiry of the certification period and after six months of the certification, Inspector of Boilers shall be duly informed so that inspection can be scheduled during the said shutdown period.

B. Waste Heat Boilers (Fire and Unfired)/CO-Boilers working at a pressure up to 50 Kgs./sq.cm and more than 20 years of age used exclusively in continuous process plant.

Boiler working at a pressure up to 50 Kgs/sq. cm and more than 20 years of age shall continue to be subjected to inspection as provided in regulation 390 every year to the satisfication of Boiler Inspector. However, if Remnant Life Assessment (RLA) as per the provisions of Indian Boiler Regulations, 1950 is carried out on the boiler, then procedure as given at paragraph 'A' above would be applicable.

C. Waste Heat Boilers (Unfired) working at a pressure up to 50 kgs./sq.cm and up to 20 years of age used exclusively in continuous process plant.

(1) For Waste Heat Boilers (Unfired) working at a pressure up to 50 kgs./sq. cm and up to 20 years of age used exclusively in continuous process plant shall be subjected to Hydraulic Test at pressure equivalent to the working pressure at the expiry of twenty four months from the date of inspection carried out in accordance with the procedure provided in regulation 390 and certification of fitness by the concerned Inspector of Boilers in the State, and having satisfied with the operation records as at paragraph A, shall be allowed for running for another period of twelve months.

(2) Inspection shall be carried out by the concerned Inspector of Boilers at the expiry of twenty-four months as provided in regulation 390. However, if shutdown of fifteen days or more is planned any time before expiry of the certification period and after six months of the certification, Inspector of Boilers shall be duly informed so that inspection can be scheduled during the said shutdown period.

D. Captive Boilers/Waste Heat Boilers (Fired)/HRSGs working at a pressure more than 50 kgs./sq.cm and up to 20 years of age used exclusively in continuius process plant.

(1) The Captive Boilers/Waste Heat Boilers (Fired)/HRSGs working at a pressure 50 Kgs./sq.cm or more and up to 20 years of age, used exclusively in continuous process plant shall be inspected as detailed below after the expiry of twelve months from the date of inspection carried out in accordance with the procedure provided in regulation 390 and certification of fitness shall be issued by the concerned Inspector of Boilers in State, through inspection of the following records which shall be made available to the Inspector of Boilers at least thirty days before the expiry of the operating certificate, provided he is satisfied that the boiler can be allowed to be operated for a further period of twelve months:

(a) Operation data for superheater and reheater temperature excursions from the output of Data Acquisition System (DAS);

(b) History of shut-downs during the previous year with their causes and actions taken;

(c) Records of any Non-Destructive test carried out on the boiler pressure parts during the year;

(d) Water quality to the boiler is maintained up to the requirement of such boilers and on line data of the quality be provided through Data Acquisition System (DAS);

(e) Boiler tube failure record (location, number of tubes repaired/replaced).

(2) Inspection shall be carried out by the Inspector of Boilers at the expiry of twenty four months as provided in regulation 390. However, in case shutdown of fifteen days or more is planned any time before expiry of the certification period and after six months of the certification, the Inspector of Boilers shall be duly informed so that complete inspection can be scheduled during the said shut-down period.

E. Captive Boilers/Waste Heat Boilers (Fired)/HRSGs working at a pressure more than 50 kgs./sq.cm and more than 20 years of age used exclusively in continuous process plant.

Boiler working at a pressure of more than 50 kg./sq.cm and more than 20 years of age shall continue to be subjected to inspection as provided in regulation 390 every year to the satisfaction of Boiler Inspector. However, if Remnant Life Assessment (RLA) as per the provisions of Indian Boiler Regulations, 1950 is carried out on the boiler, then procedure as given at paragraph 'A' above would be applicable.

APPENDIX L
SAFETY VALVE DISCHARGE EFFICIENCY TESTING

A. General

(i) The purpose and manner of testing shall be such as to provide suitable data from which a constant C may be determined in Equation 78. To this end the following information shall be supplied to the Inspecting Authority before testing is undertaken:

(a) Full particulars of the valves to be tested and range of valves and springs which they represent.

(b) Details of the test ring including instrumentation and proposed calibration procedure.

(c) Proposed sources, capacity, pressure, temperature of steam used for the test.

(ii) All testing shall be witnessed by the Inspecting Authority or the Inspecting Officer.

(iii) Tests shall be made to determine the operative characteristics of the safety valves for which a constant is to be determined and also to establish the discharge efficiency of the safety valve.

(iv) Where possible the tests to determine operating characteristic and discharge efficiency shall be carried out using the same steam, the same pressure conditions and at the same location. When the tests are carried out separately the valves in each case shall be complete and shall include all internals, e.g. blowdown adjustment rings.

(v) The set pressure at which the operating characteristics are determined shall be the minimum set pressure for which the spring used is designed. The test shall carried out using steam and shall determine the set pressure, the lift at the over pressure specified for the type of valve, as defined in Regulation 292.

(vi) The Inspecting Authority may dispense with the operating characteristic tests described in A(v).

(vii) Discharge efficiency tests shall be carried out using steam and shall be carried out relative to the operative characteristic tests described in A(v).

(viii) When the Inspecting Authority is satisfied that the design of valve will operate satisfactorily, it shall, if desired, be permissible to hold the valve head mechanically at the proven lift while carrying out the tests to ascertain the discharge efficiency.

B. VALVES USED IN THE TEST PROGRAMME

(i) The safety valves tested shall, as far as is practicable, be representative of the pressure and size range of valve manufactured.

(ii) The tests for operative characteristics and the discharge efficiency tests shall be carried out on the three sizes or half the number of sizes in the range, whichever is smaller, with a minimum of two sizes.

(iii) When the range is extended due consideration shall be given, in consultation with the Inspecting Authority, as to whether further witnessed tests are necessary.

(iv) The tests for operating characteristics shall be carried out at three significant different set pressure for each size of valve.

(v) The discharge efficiency tests shall be carried out relative to one set pressure for each size of valve.

(vi) Each test shall be carried out a minimum of three times to obtain acceptable average results.

(vii) For the case of valves of either novel or special design of which one size only is being manufactured, tests at one set pressure are permitted by the agreement with the Inspecting Authority. When the range of sizes or pressure is extended due consideration shall be given in consultation with the Inspecting Authority, as to whether further witnessed tests are necessary.

C. DETERMINATION OF CONSTANT C

Let

Et be the measured capacity, on test of saturated steam (Kg/h.)

Pt is the pressure at safety valve inlet at which the capacity was measured (bar gauge).

A be the area appropriate to the type of valve (mm²), [*see* Regulation 293(a)].

X be the allowable percentage over pressure for the type of valve under test (*See* Regulation 293).

Ct be the constant determined from test.

$$Ct = \frac{Et}{A\left(\dfrac{Pt}{1 + \dfrac{X}{100}}\right)}$$

To accommodate the permitted speed on test results, tolerance of valve parts and springs, this calculated valve of Ct shall be derated to 80% to obtain the value of C to be used in equation 78 of regulation 293(a). This is to ensure that all production valves will achieve their rated discharge capacity at not more than the over pressure allowed for the type of valve tested.

The Inspecting Authority may accept a more favourable derating factor of upto 90% of the calculated value of Ct where the performance of the valves under test and the manufacturing and spring tolerance applicable, ensure that the allowable overpressure for the type of valve under test will not be exceeded when a valve is discharging its rated capacity in service.

ANNEXURE II
CONVERSION TABLE

1 inch	25.4 mm
1 mm	0.03937 inch
1 foot	0.3048 meter
1 metre	3.2809 feet
1 lb./yd.	0.49605 Kg./m.
1 Kg./m	2.01591 lbs./yd.
1 lb.	0.45359 Kg.
1 Kg.	2.20462 lbs.
1 ton/sq.in	1.5749 Kg./sq. mm
1 Kg./sq.mm	0.6348 ton/sq.in.
1 lb./sq.in	0.07 Kg./sq.cm
1 Kg./sq.cm	14.22 lbs./sq.in.

THE BOILERS ACT, 1923

(5 of 1923)[1]

[*23rd February, 1923*]

An Act to consolidate and amend the law relating to steam boilers.

WHEREAS it is expedient to consolidate and amend the law relating to steam boilers; it is hereby enacted as follows:—

1. Short title, extent and commencement

(1) This Act may be called the [2][***] Boilers Act, 1923.

[3][(2) It extends to the whole of India [4][except the State of Jammu and Kashmir].]

(3) It shall come into force on such date[5] as the Central Government may, by notification in the Official Gazette, appoint.

2. Definitions

In this Act, unless there is anything repugnant in the subject or context,—

[6][(a) "accident" means an explosion of boiler, or boiler component, which is calculated to weaken the strength or an uncontrolled release of water or steam therefrom, liable to cause death or injury to any person or damage to any property;]

[7][(aa) "Board" means the Central Boilers Board constituted under section 27A;]

[8][(b) "boiler" means a pressure vessel in which steam is generated for use external to itself by application of heat which is wholly or partly under pressure when steam is shut off but does not include a pressure vessel,—

(i) with capacity less than 25 litres (such capacity being measured from the feed check valve to the main steam stop valve);

(ii) with less than one kilogram per centimetre square design gauge pressure and working gauge pressure; or

(iii) in which water is heated below one hundred degrees centigrade;

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1. For statement of Objects and Reasons, *see* Gazette of India, 1923, Pt. V, p. 249 an for Report of Joint Committee, see *ibid.*, p. 15. This Act has been extended to Berar by Act 4 of 1941; to Goa, Daman and Diu by Reg. 12 of 1962, S. 3 and Sch.; to Dadra and Nagar Haveli by Reg. 6 of 1963, S. 2 and Sch. I; to Loccadive, Minicoy and Amindivi Islands by Reg. 8 of 1965, S. 3 and Sch. and to Pondicherry by Act 26 of 1968, S. 3 and Sch.
2. The word "Indian" omitted by Act 49 of 2007, S. 2.
3. Subs. by the A.O. 1950, for sub-section (2).
4. Subs. by the Act 3 of 1951, S. 3 and Sch., for "except Part B States", w.e.f. 27.5.2008.
5. Came into force on 1.1.1924, *vide* Notification No. A-61, dated 4th December, 1923, *see* Gazette of India, 1923, Pt. I, p. 1695.
6. Subs. by Act 49 of 2007, S. 3(1) for:
   "(a) "accident" means an explosion of a boiler or steam-pipe or any damage to a boiler or steam-pipe which is calculated to weaken the strength thereof so as to render it liable to explode;", w.e.f. 27.5.2008.
7. Ins. by Act 11 of 1937, S. 3.
8. Subs. by Act 49 of 2007, S. 3(2) for:
   "(b) "boiler" means any closed vessel exceeding 22.75 litres in capacity which is used expressly for generating steam under pressure and includes any mounting or other fitting attached to such vessel, which is wholly or partly under pressure when steam is shut off;", w.e.f. 27.5.2008.

(ba) "boiler component" means steam piping, feed piping, economiser, superheater, any mounting or other fitting and any other external or internal part of a boiler which is subject to pressure exceeding one kilogram per centimetre square gauge;]

[1][(c) "Chief Inspector", "Deputy Chief Inspector", and "Inspector" mean, respectively, a person appointed to be a Chief Inspector, a Deputy Chief Inspector and an Inspector under this Act;]

[2][(ca) "Competent Authority" means an institution recognised in such manner as may be prescribed by regulations for issue of certificate to the welders for welding of boiler and boiler components;]

[3][(cb) "Competent Person" means a person recognised in such manner as may be prescribed by regulations for inspection and certification of boilers and boiler components during manufacture, erection and use;]

[4][(cc) "economiser" means any part of a feed-pipe that is wholly or partially exposed to the action of flue gases for the purpose of recovery of waste heat;

(ccc) "feed-pipe" means any pipe or connected fitting wholly or partly under pressure through which feed water passes directly to a boiler and which does not form an integral part thereof;]

[5][(ccd) "Inspecting Authority" means an institution recognised in such manner as may be prescribed by regulations for the inspection and certification of boilers and boiler components during manufacture. All Chief Inspectors of Boilers shall be ipso facto Inspecting Authorities;

(cce) "manufacture" means manufacture, construction and fabrication of boiler or boiler component, or both;

(ccf) "manufacture" means a person engaged in the manufacture;]

(d) "owner" [6][includes any person possessing or] using a boiler as agent of the owner thereof and any person using a boiler which he has hired or obtained on loan from the owner thereof;

(e) "prescribed" means prescribed by regulations or rules made under this Act;

[7][(f) "Steam-pipe" means any pipe through which steam passes, if—

(i) the pressure at which steam passes through such pipe exceeds 3.5 kilogram per square centimetres above atmospheric pressure; or

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1. Subs. by Act 18 of 1960, S. 2(b), for cl. (c) w.e.f. 6.5.1960.
2. Ins. by Act 49 of 2007, S. 3(3).
3. Ins. by Act 49 of 2007, S. 3(3).
4. Subs. by Act 34 of 1947, S. 2, as amended by Act 40 of 1949, S. 3 and Sch. II, for clause (cc).
5. Ins. by Act 49 of 2007, S. 3(4), clauses (cce) & (ccf) effective from 27.5.2008.
6. Subs. by Act 49 of 2007, S. 3(5), for "includes any person", w.e.f. 27.5.2008.
7. Subs. by Act 49 of 2007, S. 3(6), for:

"(f) "steam-pipe" means any pipe through which steam passes from a boiler to a prime-mover or other user or both, if—

(i) the pressure at which steam passes through such pipe exceeds 3.5 kilograms per square centimetre above atmospheric pressure; or

(ii) such pipe exceeds 254 millimetres in internal diameter;

and includes in either case any connected fitting of a steam-pipe;", w.e.f. 27.5.2008.

(ii) such pipe exceeds 254 millimetres in internal diameter and the pressure of steam exceeds 1 kilogram per square centimetres above the atmospheric pressure,

and includes in either case any connected fitting of a steam-pipe;]

[1][(g) "Structural alteration, addition or renewal" means,—

(i) any change in the design of a boiler or boiler component;

(ii) replacement of any part of boiler or boiler component by a part which does not conform to the same specification; or

(iii) any addition to any part of a boiler or boiler component;

(h) "superheater" means any equipment which is partly or wholly exposed to flue gases for the purpose of raising the temperature of steam beyond the saturation temperature at that pressure and includes a re-heater;

(i) "Technical Adviser" means the Technical Adviser appointed under sub-section (1) of section 4A.]

[2][2A. Application of Act to feed pipes

Every reference in this Act [except where the word "steam-pipe" is used in clause (f) of section 2], to a feed-pipe or steam-pipes shall be deemed to include also a reference to a feed-pipe or feed-pipes, respectively.]

[3][2B. Application of Act to economisers

Every reference in this Act to a boiler or boilers [except in clause (ccc) of section 2, [4][***] [5][***] shall be deemed to include also a reference to an economiser or economisers, respectively.]

[6][3. Limitation of application

Nothing in this Act shall apply to—

(a) locomotive boilers belonging to or under the control of the railways;

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1. Subs. by Act 49 of 2007, S. 3(7), for:
   "(g) "Structural alteration, addition or renewal" shall not be deemed to include any renewal or replacement of a petty nature when the part or fitting used for replacement is not inferior in strength, efficiency or otherwise to the replaced part or fitting", w.e.f. 27.5.2008.
2. Ins. by Act 17 of 1943, S. 3.
3. Ins. by Act 34 of 1947, S. 3.
4. The words "clause (e) of section 6, clauses (c) and (d) of section 11, clause (d) of section 29" omitted by Act 25 of 1952, S. 2, w.e.f. 6.3.1952.
5. The words and figures "and section 34" omitted by Act 18 of 1960, S. 3, w.e.f. 6.5.1960.
6. Subs. by Act 49 of 2007, S. 4, for:
   "3. Limitation of application.—(1) Nothing in this Act shall apply in the case of any boiler or steam-pipe—
   (a) in any steam-pipe as defined in section 3 of the Indian Steam-ships Act, 1884 (7 of 1884), or in any steam-vessel as defined in section 2 of the Inland Steam-vessels Act, 1917 (1 of 1917); or
   (b) belonging to, or under the control of, the Army, Navy or Air Force; or
   (c) appertaining to a sterilizer or disinfector of a type such as is commonly used in hospitals, if the boiler does not exceed ninety-one litres in capacity.
   (2) The Central Government may, by notification in the Official Gazette, declare that the provisions of this Act shall not apply in the case of boilers or steam-pipes, or any specified class of boilers or steam-pipes, belonging to or under the control of any railway administered by the Central Government or by any State Government or by any railway company as defined in clause (5) of section 3 of the Indian Railways Act, 1890 (9 of 1890)", w.e.f. 27.5.2008.

(b) any boiler or boiler component,—

(i) in any vessel propelled wholly or in part by the agency of steam;

(ii) belonging to, or under the control of, the Army, Navy or Air Force; or

(iii) appertaining to a sterilizer disinfector used in hospitals or nursing homes, if the boiler does not exceed one hundred litres in capacity.]

4. Power to limit extent

The [1][State Government] may, by notification in the Official Gazette, exclude any specified area from the operation of all or any specified provisions of this Act.

[2][4A. Technical Adviser

(1) The Central Government shall appoint a Technical Adviser from amongst the persons having such qualifications and experience as may be prescribed by rules.

(2) The terms and conditions of service of the Technical Adviser shall be such as may be prescribed by the Central Government.

(3) The Technical Adviser shall, in addition to exercising the powers and discharging the functions assigned to him under this Act or rules or regulations made thereunder, exercise such other powers and discharge such functions as the Central Government and the Board may delegate to him.

4B. Welders certificate

(1) Any person who proposes to undertake any welding work connected with or related to a boiler, or a boiler component or both shall apply to a Competent Authority for issue of a Welders certificate.

(2) On receipt of an application under sub-section (1), the Competent Authority shall follow such procedure for examination and grant of Welders certificate as may be prescribed by regulations.

(3) The Competent Authority may, if satisfied that the person applying for Welders certificate under sub-section (2) has compiled with the conditions precedent for issue of the Welders certificate, issue such certificate, to such person subject to the payment of such fee and such other conditions as may be prescribed by regulations:

Provided that the Competent Authority shall not refuse Welders certificate to any person unless such person is given an opportunity of being heard.

4C. Conditions precedent for manufacture of boiler and boiler component

(1) No person shall manufacture or cause to be manufactured any boiler or boiler component, or both unless—

(a) he has provided in the premises or precincts wherein such boiler or boiler component, or both are manufactured, such facilities for design and construction as may be prescribed by regulations;

1. The words "Governor-General in Council" have been successively amended by the A.O. 1937 and the A.O. 1950 to read the above.
2. Sec. 4A to 4F ins. by Act 49 of 2007, S. 5, w.e.f. 27.5.2008, so far it relates to Section 4A.

(b) the design and drawings of the boiler and boiler component have been approved by the Inspecting Authority under clause (a) of sub-section (2) of section 4D;

(c) the materials, mounting and fittings used in the construction of such boiler or boiler component, or both conform to the specifications prescribed by regulations; and

(d) the persons engaged for welding boiler or boiler component hold Welders certificate issued by a Competent Authority.

4D. Inspection during manufacture

(1) Every manufacturer, before commencing manufacture of a boiler or boiler component, shall engage an Inspecting Authority for carrying out inspection at such stages of manufacture as may be prescribed by regulations.

(2) The Inspecting Authority engaged under sub-section (1) shall follow such procedure for inspection and certification of boiler or boiler component as may be prescribed by regulations and after inspection, if it is—

(a) satisfied that the boiler or the boiler component conforms to the standards prescribed by regulations, it shall issue a certificate of inspection and stamp the boiler, or boiler component, or both; or

(b) of the opinion that the boiler, or boiler component, or both does not conform to the standards prescribed by regulations, it may for reasons to be recorded in writing refuse to issue such certificate:

Provided that no certificate shall be refused unless the Inspecting Authority had directed the manufacturer of the boiler or boiler component, or both in writing to carry out such modifications or rectifications as it deems necessary and the Inspecting Authority is of the opinion that inspite of such direction the manufacturer of the boiler or boiler component, or both did not carry out the direction.

(3) The Inspecting Authority may, for the purposes of inspection under this section, charge such fee as may be prescribed by regulations.

4E. Inspection during erection

(1) The owner who proposes to register a boiler under section 7, shall engage an Inspecting Authority for carrying out inspection at the stage of erection of the boiler.

(2) The Inspecting Authority shall follow such procedure for inspection and certification of a boiler or boiler component, or both as may be prescribed by regulations and after inspection if it is—

(a) satisfied that the erection of the boiler is in accordance with the regulations, it shall issue a certificate of inspection in such form as may be prescribed by regulations; or

(b) of the opinion that the boiler has not been erected in accordance with the regulations, it may for reasons to be recorded in writing, refuse to grant the certificate and shall communicate such refusal to the manufacturer of the boiler or boiler component forthwith:

Provided that no such certificate shall be refused unless the Inspecting Authority had directed the owner in writing to carry out such modifications or rectifications as it deems necessary and the Inspecting Authority is of the opinion that in spite of such direction the owner did not carry out the direction.

(3) The Inspecting Authority may, for the purposes of inspection under this section, charge such fee as may be prescribed by regulations.

4F. Conditions precedent for repairing boiler and boiler component

No person shall repair or cause to be repaired any boiler or boiler component or both, unless—

(a) he has provided in the premises or precincts, where in such boiler or boiler component or both are being used, such facilities for repairs as may be prescribed by regulations;

(b) the design and drawings of the boiler or boiler component, as the case may be, and the materials, mountings and fittings used in the repair of such boiler or boiler component conform to the regulations;

(c) persons engaged in welding, holds a Welders certificate issued by a Competent Authority;

(d) every user who does not have the in-house facilities for repair of boiler or boiler component shall engage a Boiler Repairer possessing a Boiler Repairer certificate for repair of a boiler or boiler component or both, as the case may be;

(e) every user shall engage a Competent Person for approval of repairs to be carried out in-house or by the repairers.]

[1][**5. Chief Inspector, Deputy Chief Inspectors and Inspectors**

(1) The State Government may appoint such persons as it thinks fit to be Inspectors for the State for the purposes of this Act, and may define the local limits within which each Inspector shall exercise the powers and perform the duties conferred and imposed on Inspectors by or under this Act.

(2) The State Government may appoint such persons as it thinks fit to be Deputy Chief Inspectors for the State and may define the local limits within which each Deputy Chief Inspector shall exercise his powers and perform his duties under this Act.

(3) Every Deputy Chief Inspector may exercise the powers and perform the duties conferred and imposed on Inspectors by or under this Act and, in addition thereto, may exercise such powers or perform such duties conferred or imposed on the Chief Inspector by or under this Act, as the State Government may assign to him.

(4) The State Government shall appoint a person to be Chief Inspector for the State who may, in addition to the powers and duties conferred and imposed on the Chief Inspector by or under this Act, exercise any power or perform any duty so conferred or imposed on Deputy Chief Inspectors or Inspectors.

[2][(4A) No person shall be appointed as the Chief Inspector, Deputy Chief Inspector or Inspector unless he possesses such qualifications and experience as may be prescribed by the Central Government.]

1. Subs. by Act 18 of 1960, S. 5, for S. 5, w.e.f. 6.5.1960.
2. Ins. by Act 49 of 2007, S. 6.

(5) Subject to the provisions of this Act, the Deputy Chief Inspectors and Inspectors shall exercise the powers and perform the duties conferred and imposed on them by or under this Act under the general superintendence and control of the Chief Inspector.

(6) The Chief Inspector, Deputy Chief Inspectors and Inspectors may offer such advice as they think fit to owners regarding the proper maintenance and safe working of boilers.

(7) The Chief Inspector and all Deputy Chief Inspectors and Inspectors shall be deemed to be public servants within the meaning of section 21 of the Indian Penal Code (45 of 1860).]

6. Prohibition of use of unregistered or uncertified boiler

Save as otherwise expressly provided in this Act, no owner of boiler shall use the boiler or permit it to be used—

(a) unless it has been registered in accordance with the provisions of this Act;

(b) in the case of any boiler which has been transferred from one State to another, until the transfer has been reported in the prescribed manner;

(c) unless a certificate or provisional order authorising the use of the boiler is for the time being in force under this Act;

(d) at a pressure higher than the maximum pressure recorded in such certificate or provisional order;

(e) where the [1][Central Government] has made rules requiring that boilers shall be in charge of persons holding [2][certificates of proficiency or competency], unless the boiler is in charge of a person holding the certificate required by such rules:

Provided that any boiler registered, or any boiler certified or licensed, under any Act hereby repealed shall be deemed to have been registered or certified, as the case may be, under this Act.

[3][***]

7. Registration

(1) The owner of any boiler which is not registered under the provisions of this Act [4][may apply to the Inspector along with such other documents as may be prescribed by regulations to have the boiler registered]. Every such application shall be accompanied by the prescribed fee.

(2) On receipt of an application under sub-section (1), the Inspector shall fix a date, within thirty days or such shorter period as may be prescribed from the date of the receipt, for the examination of the boiler and shall give the owner thereof not less than ten days' notice of the date so fixed.

[5][(3) On the said date the Inspector shall inspect the boiler with a view to satisfying himself that the boiler has not suffered any damage during its transit from the place or manufacture to the site of

1. Subs. by Act 49 of 2007, S. 7, for "State Government".
2. Subs. by Act 18 of 1960, S. 6, for "certificate of competency", w.e.f. 6.5.1960.
3. Proviso omitted by Act 34 of 1939, S. 3 and Sch. II.
4. Subs. by Act 49 of 2007, S. 8(a), for "may apply to the Inspector to have the boiler registered".
5. Subs. by Act 49 of 2007, S. 8(b), for:

"(3) On the said date the Inspector shall proceed to measure and examine the boiler and to determine in the prescribed manner the maximum pressure, if any, at which such boiler may be used, and shall report the result of the examination to the Chief Inspector in the prescribed form", w.e.f. 27.5.2008.

erection and forward a report of the inspection along with the documents to the Chief Inspector within seven days.]

(4) The Chief Inspector, on receipt of the report, may—

(a) register the boiler and assign a register number thereto either forthwith or after satisfying himself that any structural alteration, addition or renewal which he may deem necessary has been made in or to the boiler or any steam-pipe attached thereto, or

(b) refuse to register the boiler:

Provided that where the Chief Inspector refuses to register a boiler, he shall forthwith communicate his refusal to the owner of the boiler together with the reasons therefor.

(5) The Chief Inspector shall, on registering the boiler, order the issue to the owner of a certificate in the prescribed form authorising the use of the boiler for a period not exceeding twelve months at a pressure not exceeding such maximum pressure as he thinks fit and as is in accordance with the regulations made under this Act:

[1][Provided that a certificate issued under this sub-section in respect of an economiser [2][or of an unfired boiler which forms an integral part of a processing plant in which steam is generated solely by the use of oil, asphalt or bitumen as a heating medium] may authorise its use for a period not exceeding twenty-four months.]

(6) The Inspector shall forthwith convey to the owner of the boiler the orders of the Chief Inspector and shall in accordance therewith issue to the owner any certificate of which the issue has been ordered, and, where the boiler has been registered, the owner shall within the prescribed period cause the register number to be permanently marked thereon in the prescribed manner.

8. Renewal of certificate

(1) A certificate authorising the use of a boiler shall cease to be in force—

(a) on the expiry of the period for which it was granted; or

(b) when any accident occurs to the boiler; or

(c) when the boiler is moved, the boiler not being a vertical boiler the heating surface of which is less than [3][[4][20] square metres], or a portable or vehicular boiler; or

[5][(d) save as provided in section 12, when any structural alteration, addition or renewal is made in or to the boiler; or]

(e) if the Chief Inspector in any particular case so directs, when any structural alteration, addition or renewal is made in or to any steam-pipe attached to the boiler; or

(f) on the communication to the owner of the boiler of an order of the Chief Inspector or Inspector prohibiting its use on the ground that [6][it or any boiler component] attached thereto is in a dangerous condition.

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1. Added by Act 34 of 1947, S. 4.
2. Ins. by Act 18 of 1960, S. 7, w.e.f. 6.5.1960.
3. Subs. by Act 18 of 1960, S. 8(a), for "two hundred square feet" (w.e.f. 6.5.1960).
4. Subs. by Act 49 of 2007, S. 9(a)(i), for "18.58", w.e.f. 27.5.2008.
5. Subs. by Act 49 of 2007, S. 9(a)(ii), for:
   "(d) when any structural alteration, addition or renewal is made in or to the boiler; or", w.e.f. 27.5.2008.
6. Subs. by Act 49 of 2007, S. 9(a)(iii), for "it or any steam-pipe", w.e.f. 27.5.2008.

(2) Where an order is made under clause (f) of sub-section (1), the grounds on which the order is made shall be communicated to the owner with the order.

[1][(3) When a certificate ceases to be in force, the owner of the boiler may apply to the Competent Person for renewal thereof for such period as may be prescribed by regulations.]

[2][(4) On receipt of an application under sub-section (3), the Competent Person shall, within fifteen days from the date of such receipt, inspect the boiler in such manner as may be prescribed by regulations.]

[3][(5) If the Competent Person is—

(a) satisfied that the boiler and the boiler components attached thereto are in good condition he shall issue a certificate for such period as may be prescribed by regulations, or

(b) of the opinion that the boiler or boiler component, or both does not conform to the standards prescribed by regulations, it may, for reasons to be recorded in writing, refuse to issue such certificate:

Provided that no certificate shall be refused unless the Inspecting Authority had directed the owner of the boiler or the boiler component, or both in writing to carry out such modifications or rectifications as it deems necessary and the Competent Person is of the opinion that inspite of such direction the owner of the boiler or boiler component, or both did not carry out the direction:

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1. Subs. by Act 49 of 2007, S. 9(b), for:

"(3) When a certificate ceases to be in force, the owner of the boiler may apply to the Inspector for a renewal thereof for such period not exceeding twelve months as he may specify in the application:

Provided that where the certificate relates to an economiser or of an unfired boiler which forms an integral part of a processing plant in which steam is generated solely by the use of oil, asphalt or bitumen as a heating medium, the application for its renewal may be for a period not exceeding twenty-four months.".

2. Subs. by Act 49 of 2007, S. 9(c), for:

"(4) An application under sub-section (3) shall be accompanied by the prescribed fee and, on receipt thereof, the Inspector shall fix a date, within thirty days or such shorter period as may be prescribed from the date of the receipt, for the examination of the boiler and shall give the owner thereof not less than ten days' notice of the date so fixed:

Provided that, where the certificate has ceased to be in force owing to the making of any structural alteration, addition or renewal, the Chief Inspector may dispense with the payment of any fee:

Provided further that in the case of an economiser or of an unfired boiler which forms an integral part of a processing plant in which steam is generated solely by the use of oil, asphalt or bitumen as a heating medium, the date fixed for its examination shall be within sixty days from the date of receipt of the application and the owner shall be given not less than thirty days' notice of the date so fixed.".

3. Subs. by Act 49 of 2007, S. 9(c), for:

"(5) On the said date the Inspector shall examine the boiler in the prescribed manner, and if he is satisfied that the boiler and the steam-pipe or steam-pipes attached thereto are in good condition shall issue a renewed certificate authorising the use of the boiler for such period not exceeding twelve months and at a pressure not exceeding such maximum pressure as he thinks fit and as is in accordance with the regulations made under this Act:

Provided that renewed certificate issued under this sub-section in respect of an economiser or of an unfired boiler which forms an integral part of a processing plant in which steam is generated solely by the use of oil, asphalt or bitumen as heating medium may authorise its use for a period not exceeding twenty-four months:

Provided further that if the Inspector—

(a) proposes to issue any certificate—

(i) having validity for a less period than the period entered in the application, or

(ii) increasing or reducing the maximum pressure at which the boiler may be used, or

(b) proposes to order any structural alteration, addition or renewal to be made in or to the boiler or any steam-pipe attached thereto, or

(c) is of opinion that the boiler is not fit for use, the Inspector shall, within forty-eight hours of making the examination, inform the owner of the boiler in writing of his opinion and the reasons therefor, and shall forthwith report the case for orders to the Chief Inspector.".

Provided further that the Competent Person shall, within forty-eight hours of making the examination, inform the owner of the boiler or boiler component any defect in his opinion and the reasons therefor and shall forthwith report the case to the Chief Inspector.]

[1][(5A) The Competent Person may for the purpose of inspection under this section charge such fee as may be prescribed by regulations.]

(6) The Chief Inspector, on receipt of a report under sub-section (5), may, subject to the provisions of this Act and of the regulations made hereunder, order the renewal of the certificate in such terms and on such conditions, if any, as he thinks fit, or may refuse to renew it:

Provided that where the Chief Inspector refuses to renew a certificate, he shall forthwith communicate his refusal to the owner of the boiler, together with the reasons therefor.

(7) Nothing in this section shall be deemed to prevent an owner of a boiler from applying for a renewed certificate therefor at any time during the currency of a certificate.

9. Provisional orders

Where the Inspector reports the case of any boiler to the Chief Inspector under sub-section (3) of section 7 [2][***], he may, if the boiler is not a boiler the use of which has been prohibited under clause (f) of sub-section (1) of section 8, grant to the owner thereof a provisional order in writing permitting the boiler to be used at a pressure not exceeding such maximum pressure as he thinks fit and as is in accordance with the regulations made under this Act pending the receipt of the orders of the Chief Inspector. Such provisional order shall cease to be in force —

(a) on the expiry of six months from the date on which it is granted, or

(b) on receipt of the orders of the Chief Inspector, or

(c) in any of the cases referred to in clauses (b), (c), (d), (e) and (f) of sub-section (1) of section 8,

and on so ceasing to be in force shall be surrendered to the Inspector.

10. Use of boiler pending grant of certificate

(1) Notwithstanding anything hereinbefore contained, when the period of a certificate relating to a boiler has expired, the owner shall, provided that he has applied before the expiry of that period for a renewal of the certificate, be entitled to use the boiler at the maximum pressure entered in the former certificate pending the issue of orders on the application.

(2) Nothing in sub-section (1) shall be deemed to authorise the use of a boiler in any of the cases referred to in clauses (b), (c), (d), (e) and (f) of sub-section (1) of section 8 occurring after the expiry of the period of the certificate.

11. Revocation of certificate or provisional order

The Chief Inspector may at any time withdraw or revoke any certificate or provisional order on the report of an Inspector or otherwise—

(a) if there is reason to believe that the certificate or provisional order has been fraudulently obtained or has been granted erroneously or without sufficient examination; or

1. Ins. by Act 49 of 2007, S. 9(c) and Sl. No. corrected by corrigendum for "(6)".
2. The words "or sub-section (5) of section 8" omitted by Act 49 of 2007, S. 10. w.e.f. 27.5.2008.

(b) if the boiler in respect of which it has been granted has sustained injury or has ceased to be in good condition; or

(c) where the [1][Central Government] has made rules requiring that boilers shall be in charge of persons holding [2][certificates of proficiency or competency], if the boiler is in charge of a person not holding the certificate required by such rules; or

[3][***]

12. Alterations and renewals of boilers

No structural alteration, addition or renewal shall be made in or to any boiler registered under this Act unless such alteration, addition or renewal has been sanctioned in writing by the Chief Inspector:

[4][Provided that no such sanction is required where the structural alteration, addition or renewal is made under the supervision of a Competent Person.]

[5][**13. Alteration or renewal of boiler component**

(1) Before the owner of any boiler registered under this Act makes any structural alteration, addition or renewal in or to any boiler component attached to the boiler, he shall transmit to the Chief Inspector a report in writing of his intention and send therewith such particulars of proposed alteration, addition or renewal as may be prescribed by regulations.

(2) Any structural alteration, addition or renewal referred to in sub-section (1) shall be made by a person possessing a Boiler Repairer certificate under the supervision of the Competent Person.]

14. Duty of owner at examination

(1) On any date fixed under this Act for the examination of a boiler, the owner thereof shall be bound—

(a) to afford to the [6][Competent Person] all reasonable facilities for the examination and all such information as may reasonably be required of him;

(b) to have the boiler properly prepared and ready for examination in the [7][manner prescribed by regulations]; and

(c) in the case of an application for the registration of a boiler, to provide such drawings, specifications, certificates and other particulars as may [8][be prescribed by regulations].

1. Subs. by Act 49 of 2007, S. 11(a), for "State Government".
2. Subs. by Act 18 of 1960, S. 9, for "certificates of competency", w.e.f. 6.5.1960.
3. Clause (d) and the proviso omitted by Act 49 of 2007, S. 11(b). Clause (d) and the proviso, before omission, stood as under:

"(d) where no such rules have been made, if the boiler is in charge of a person who is not, having regard to the condition of the boiler in the opinion of the Chief Inspector competent to have charge thereof:

Provided that where the Chief Inspector withdraws or revokes a certificate or provisional order on the ground specified in clause (d), he shall communicate to the owner of the boiler his reasons in writing for the withdrawal or revocation and the order shall not take effect until the expiry of thirty days from the receipt of such communication."

4. Ins. by Act 49 of 2007, S. 12.
5. Subs. by Act 49 of 2007, S. 13, for section 13. Section 13 before substitution, stood as under:

"13. Alterations and renewals to steam-pipes.—Before the owner of any boiler registered under this Act makes any structural alteration, addition or renewal in or to any steam-pipe attached to the boiler, he shall transmit to the Chief Inspector a report in writing of his intention and shall send therewith such particulars of the purposed alteration, addition or renewal as may be prescribed.".

6. Subs. by Act 49 of 2007, S. 14(a)(i), for "Inspector".
7. Subs. by Act 49 of 2007, S. 14(a)(ii), for "prescribed manner".
8. Subs. by Act 49 of 2007, S. 14(a)(iii), for "be prescribed".

(2) If the owner fails, without reasonable cause to comply with the provisions of sub-section (1), the [1][Competent Person] shall refuse to make the examination and shall report the case to the Chief Inspector who shall, unless sufficient cause to the contrary is shown, require the owner to file a fresh application under section 7 or section 8, as the case may be, and may forbid him to use the boiler notwithstanding anything contained in section 10.

15. Production of certificates, etc

The owner of any boiler who holds a certificate or provisional order relating thereto shall, at all reasonable times during the period for which the certificate or order is in force be bound to produce the same when called upon to do so by a District Magistrate, Commissioner of Police or Magistrate of the first class having jurisdiction in the area in which the boiler is for the time being, or by the Chief Inspector or by an Inspector or by any Inspector appointed under [2][the Factories Act, 1948 (63 of 1948)], or by any person specially authorised in writing by a District Magistrate or Commissioner of Police..

16. Transfer of certificates, etc.

If any person becomes the owner of a boiler during the period for which a certificate or provisional order relating thereto is in force, the preceding owner shall be bound to make over to him the certificate or provisional order.

17. Power of entry

An Inspector may, for the purpose of inspecting or examining a boiler or any steam-pipe attached thereto or of seeing that any provision of this Act or of any regulation or rule made hereunder has been or is being observed, at all reasonable times enter any place or building within the limits of the area for which he has been appointed in which he has reason to believe that a boiler is in use.

18. Report of accidents

(1) If any accident occurs to a boiler or [3][boiler component], the owner or person in charge thereof shall within twenty-four hours of the accident, report the same in writing to the Inspector. Every such report shall contain a true description of the nature of the accident and of the injury, if any, caused thereby to the boiler or to the [3][boiler component] or to any person, and shall be in sufficient detail to enable the Inspector to judge of the gravity of the accident.

(2) Every person shall be bound to answer truly to the best of his knowledge and ability every question put to him in writing by the Inspector as to the cause, nature or extent of the accident.

[4][(3) Without prejudice to the provisions of sub-section (1), where any death has resulted due to any accident, an inquiry may be conducted by such person and in such manner as may be prescribed by the Central Government.]

19. Appeals to Chief Inspector

[5][(1)] Any person considering himself aggrieved by,—

(a) an order made or purporting to be made by an Inspector in the exercise of any power conferred by or under this Act, or

1. Subs. by Act 49 of 2007, S. 14(b), for "Inspector".
2. Subs. by Act 49 of 2007, S. 15, for "the Indian Factories Act, 1911 (12 of 1911), w.e.f. 27.5.2008.
3. Subs. by Act 49 of 2007, S. 16(a), for "steam-pipe", w.e.f. 27.5.2008.
4. Ins. by Act 49 of 2007, S. 16(b).
5. Section 19 renumbered as sub-section (1) by Act 49 of 2007, S. 17, w.e.f. 27.5.2008.

(b) a refusal of an Inspector to make any order or to issue any certificate which he is required or enabled by or under this Act to make or issue,

may, within thirty days from the date on which such order or refusal is communicated to him, appeal against the order or refusal to the Chief Inspector.

[1][(2) Every appeal under sub-section (1) shall be made in such manner as may be prescribed by the State Government.

(3) The procedure for disposing of an appeal shall be such as may be prescribed by the State Government.]

20. Appeals to appellate authority

[2][(1)] Any person considering himself aggrieved by an original or appellate order of the Chief Inspector—

(a) refusing to register a boiler or to grant or renew a certificate in respect of a boiler; or

(b) refusing to grant a certificate having validity for the full period applied for; or

(c) refusing to grant a certificate authorising the use of a boiler at the maximum pressure desired; or

(d) withdrawing or revoking a certificate or provisional order; or

(e) reducing the amount of pressure specified in any certificate or the period for which such certificate has been granted; or

(f) ordering any structural alteration, addition or renewal to be made in or to a boiler or steam-pipe, or refusing sanction to the making of any structural alteration, addition or renewal in or to a boiler,

may, within thirty days of the communication to him of such order, [3][prefer an appeal to the Central Government].

[4][(2) Any person considering himself aggrieved by the refusal of an Inspecting Authority to grant a certificate of inspection of manufacture or erection, as the case may be, may within thirty days from the date of communication of such refusal, prefer an appeal to the Central Government.

(3) Every appeal under sub-section (1) shall be made in such manner as may be prescribed by the Central Government.

(4) the procedure for disposing of an appeal shall be such as may be prescribed by the Central Government.

[20A. Power of Central Government to revise order of appellate authority

(1) Any person considering himself aggrieved by an order of the appellate authority refusing under section 20 to interfere with an order not to register a boiler or not to grant or renew a certificate in respect thereof on the ground that the boiler does not conform to the regulations made under

Ins. by Act 49 of 2007, S. 17, w.e.f. 27.5.2008.
Section 20 renumbered as sub-section (1) thereof by Act 49 of 2007, S. 18.
Subs. by Act 49 of 2007, S. 18(a), for "lodge with the Chief Inspector an appeal to an appellate authority to be constituted by the State Government under this Act".
Sub-sec. (2) to (4) ins. by Act 49 of 2007, S. 18(b).
Ins. by Act 18 of 1960, S. 10 (w.e.f. 6.5.1960).

this Act may, within two months of the communication to him of such order, make an application to the Central Government for a revision of that order on the ground that such boilers are in use in other countries.

(2) Upon the receipt of such an application, the Central Government may, after calling for relevant records and other information from the appellate authority and considering the observations, if any, of that authority on the application and after obtaining such technical advice as the Central Government may consider necessary, pass such order in relation to the application, as the Central Government thinks fit; and, where the revision is allowed, the order shall specify the terms and conditions on which any variations from the regulations made under this Act are to be dealt with during the examination of the boiler.]

[1][21. Finality of orders

[2][An order of the Central Government under sections 20 and 20A], or of the Chief Inspector, or of a Deputy Chief Inspector, or of an Inspector, shall be final and shall not be called in question in any court.]

22. Minor penalties

Any owner of a boiler who refuses or without reasonable excuse neglects—

(i) to surrender a provisional order as required by section 9, or

(ii) to produce a certificate or provisional order when duly called upon to do so under section 15, or

(iii) to make over to the new owner of a boiler a certificate or provisional order as required by section 16,

shall be punished with fine which may extend to [3][five thousand rupees].

23. Penalties for illegal use of boiler

Any owner of a boiler who, in any case in which a certificate or provisional order is required for the use of the boiler under this Act, uses the boiler either without any such certificate or order being in force or at a higher pressure than that allowed thereby, shall be punishable with fine which may extend to [4][one lakh rupees], and, in the case of a continuing offence, with an additional fine which may extend to [5][one thousand rupees] for each day after the first day in regard to which he is convicted of having persisted in the offence.

24. Other penalties

Any person who—

(a) uses or permits to be used a boiler of which he is the owner and which has been transferred from one [6][State] to another without such transfer having been reported as required by section 6, or

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1. Subs. by Act 18 of 1960, sec, 11, for section 21 (w.e.f. 6.5.1960).
2. Subs. by Act 49 of 2007, S. 19, for "An order of the Central Government under section 20A and, save as otherwise provided in sections 19, 20 and 20A, an order of an appellate authority".
3. Subs. by Act 49 of 2007, S. 20, for "one hundred rupees", w.e.f. 27.5.2008.
4. Subs. by Act 49 of 2007, S. 21(a), for "five hundred rupees", w.e.f. 27.5.2008.
5. Subs. by Act 49 of 2007, S. 21(b), for "one hundred rupees", w.e.f. 27.5.2008.
6. Subs. by the A.O. 1950, for "Province".

(b) being the owner of a boiler fails to cause the register number allotted to the boiler under this Act to be marked on the boiler as required by sub-section (6) of section 7, or

(c) makes any structural alteration, addition or renewal in or to a boiler without first obtaining the sanction of the Chief Inspector when so required by section 12, or to a steam-pipe without first informing the Chief Inspector, when so required by section 13, or

(d) fails to report an accident to a boiler or steam-pipe when so required by section 18, or

(e) tempers with a safety valve of a boiler so as to render it inoperative at the maximum pressure at which the use of the boiler is authorised under this Act, [1][or]

[2][(f) allows another person to go inside a boiler without effectively disconnecting the same in the prescribed manner from any steam or hot water connection with any other boiler or from fuel mains,]

shall be [3][punishable with imprisonment which may extend to two years or with fine which may extend to one lakh rupees, or with both].

25. Penalty for tampering with register mark

(1) Whoever removes, alters, defaces, renders invisible or otherwise tampers with the register number marked on a boiler in accordance with the provisions of this Act or any Act repealed hereby, shall be punishable with fine which may extend to [4][one lakh rupees].

(2) Whoever fraudulently marks upon a boiler a register number which has not been allotted to it under this Act or any Act repealed hereby, shall be punishable with imprisonment which may extend to two years, or with [5][which may extend to one lakh rupees, or with both].

26. Limitation and previous sanction for prosecutions

No prosecution for an offence made punishable by or under this Act shall be instituted except within [6][twenty-four months] from the date of the commission of the offence, and no such prosecution shall be instituted without the previous sanction of the Chief Inspector.

27. Trial of offences

No offence made punishable by or under this Act shall be tried by a Court inferior to that of a Presidency Magistrate or a Magistrate of the first class.

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1. Ins. by Act 18 of 1960, S. 12(a) (w.e.f. 6.5.1960).
2. Ins. by Act 18 of 1960, S. 12(b) (w.e.f. 6.5.1960).
3. Subs. by Act 49 of 2007, S. 22, for "punishable with fine which may extend to five hundred rupees", w.e.f. 27.5.2008.
4. Subs. by Act 49 of 2007, S. 23(a), for "five hundred rupees", w.e.f. 27.5.2008.
5. Subs. by Act 49 of 2007, S. 23(b), for "fine, or with both", w.e.f. 27.5.2008.
6. Subs. by Act 18 of 1960, S. 13, for "six months" (w.e.f. 6.5.1960).

[1] **[27A. Central Boilers Board**

(1) A Board to be called the Central Boilers Board shall be constituted to exercise the powers conferred by section 28.

[2][(2) The Board shall consist of the following members, namely:—

(a) the Secretary to the Government of India incharge of the Department of the Central Government having administrative control of the Board who shall be the Chairperson ex officio;

(b) a senior technical officer conversant with the inspection and examination of boilers, to be nominated by the Government of each State (other than a Union territory);

(c) equal number of other persons as in sub-section (b) above to represent —

(i) Central Government,

(ii) the Bureau of Indian Standards,

(iii) boiler and boiler component manufactures,

(iv) National laboratories,

(v) engineering consultancy agencies,

(vi) users of boilers, and

(vii) such other interests which in the opinion of the Central Government ought to be represented on the Board,

to be nominated by the Central Government;

(d) Technical Adviser, Member-Secretary ex officio.]

[3][(3) The term of office of the members nominated under clauses (b) and (c) of sub-section (2) shall be such as may be prescribed by the Central Government.]

[4][(4) The Board shall have full power to regulate by means of bye-laws or otherwise its own procedure and the conduct of all businesses to be transacted by it, the constitution of committees and sub-committees of members and the delegation to them of any of the powers and duties of the Board.]

(5) The powers of the Board may be exercised notwithstanding any vacancy in the Board.]

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1. Ins. by Act 11 of 1937, S. 4.
2. Subs. by Act 49 of 2007, S. 24, for
"(2) The Board shall consist of the following members, namely:—
(a) such number of members, including the Chairman, not exceeding fifteen, as the Central Government may nominate in the prescribed manner to represent that Government, the Union territories, the railways, the coal industry, the Indian Standards Institution, the boiler manufacturing industry, the users of boilers and, any other interests which, in the opinion of the Central Government, ought to be represented on the Board;
(b) a senior technical officer conversant with the inspection and examination of boilers, to be nominated by the Government of each State (other than a Union territory)", w.e.f. 27.5.2008.
3. Subs. by Act 49 of 2007, S. 24, for
"(3) Any vacancy occurring in the Board shall be filled as soon as may be by a nomination made by the authority by whom the member vacating office was nominated", w.e.f. 27.5.2008.
4. Subs. by Act 18 of 1960, S. 14(c), for sub-section (4) (w.e.f. 6.5.1960).

28. Power to make regulations

[1][(1)] The [2][Board] may, by notification in the Gazette of India, make regulations consistent with this Act for all or any of the following purposes, namely:—

[3][(a) for laying down the standard conditions in respect of material, design, construction, erection, operation and maintenance which shall be required for the purposes of enabling the registration and certification of boilers, boiler components, boiler mountings and fittings under this Act;]

[4][(aa) for prescribing the circumstances in which, the extent to which, and the conditions subject to which variation from the standard conditions laid down under clause (a) may be permitted;]

(b) for prescribing the method of determining the maximum pressure at which a boiler may be used;

(c) for regulating the registration of boilers, prescribing the fees payable therefor [5][and for the inspection and examination of boilers or parts thereof], the drawings, specifications certificates and particulars to be produced by the owner, the method of preparing a boiler for examination, the form of the Inspector's report thereon, the method of marking the register number, and the period within which such number is to be marked on the boiler;

(d) for regulating the inspection and examination of boilers and [6][boiler components, boiler mountings and fittings], and prescribing forms of certificates therefor;

(e) for ensuring the safety of persons working inside a boiler; and

[7][(ea) for prescribing the qualifications and experience subject to which the Inspecting Authorities, Competent Authorities and Competent Persons shall be recognised under this Act;

(eb) the conditions subject to which and the manner in which manufacturer of boiler components or material may be recognised;

(ec) facilities for design and construction which are required to be provided in the premises in which the manufacturing of any boiler or boiler component is carried out;

(ed) fee for the purposes of inspection or grant of recognition or any certificate under this Act;

(ef) procedure for examination and grant of Welders certificate;

(eg) powers and functions which the Board may delegate to the Technical Adviser;

(eh) documents to be enclosed alongwith the application for registration of boilers or renewal of a certificate authorising the use of boilers;

(ei) the manner of inspection of boilers;

(ej) the period for which a certificate authorising the use of a boiler may be renewed;

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1. Section 28 renumbered as sub-section (1) thereof by Act 40 of 1986, S. 2 and Sch. (w.e.f. 15.5.1986).
2. Subs. by Act 11 of 1937, S. 5. for "Governor-General in Council".
3. Subs. by Act 49 of 2007, S. 25(i), for
   "(a) for laying down the standard conditions in respect of material design and construction which shall be required for the purpose of enabling registration and certification of a boiler under this Act;", w.e.f. 27.5.2008.
4. Ins. by Act 11 of 1937, S. 5.
5. Ins. by Act 18 of 1960, S. 15 (w.e.f. 6.5.1960).
6. Subs. by Act 49 of 2007, S. 25(ii), for "steam pipes", w.e.f. 27.5.2008.
7. Cl. (ea) to (ep) ins. by Act 49 of 2007, S. 25(iii), w.e.f. 27.5.2008. **Note:** After clause (ed), instead of (ee), (ef) is published in Gazette.

(ek) the conditions subject to which and the form in which Competent Person shall renew a certificate authorising the use of boilers;

(el) the manner and the form in which a Repairer's certificate shall be issued;

(em) the manner in which the boiler shall be prepared for examination;

(en) drawings specification, documents and other particulars which owner of a boiler is required to make available to the Competent Person;

(eo) the manner in which a person may be authorised to conduct energy audit and the manner in which such audit shall be conducted;

(ep) the manner in which disputes between the States with respect to registration of boilers shall be resolved;]

(f) for providing for any other matter which is not, in the opinion of the [1][Board], a matter of merely local or State importance.

[2][(2) Every regulation made under this Act shall be laid, as soon as may be after it is made, before each House of Parliament, while it is in session, for a total period of thirty days which may be comprised in one session or in two or more successive sessions, and if, before the expiry of the session immediately following the session or the successive sessions aforesaid both Houses agree in making any modification in the regulation or both Houses agree that the regulation should not be made, the regulation shall thereafter have effect only in such modified form or be of no effect, as the case may be; so, however, that any such modification or annulment shall be without prejudice to the validity of anything previously done under that regulation.]

[3][28A. Power of Central Government to make rules

[4][(1) The Central Government may, by notification in the Official Gazette, make rules to carry out the provisions of this Act.

(1A) In particular, and without prejudice to the generality of the foregoing power, such rules may provide for all or any of the following matters, namely:—

(a) In procedure to be followed in making applications under section 20A and the fees payable in respect of such application;

(b) the qualifications and experience of persons to be appointed as Chief Inspectors, Deputy Chief Inspectors and Inspectors;

(c) the manner in which appeals may be preferred to the Board, the fees payable in respect of appeals and the procedure to be followed of disposing such appeals;

(d) the term of office of the members and the manner in which they shall be nominated under clauses (b) and (c) of sub-section (2) of section 27A;

(e) the qualifications and experience of the Technical Adviser;

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1. Subs. by Act 11 of 1937, S. 5, for "Governor-General in Council".
2. Ins. by Act 4 of 1986, S. 2 and Sch. (w.e.f. 15.5.1986).
3. Ins. by Act 18 of 1960, S. 16 (w.e.f. 6.5.1960).
4. Subs. by Act 49 of 2007, S. 26, for
   "(1) The Central Government may, by notification in the Official Gazette, make rules to provide for—
   (a) the procedure to be followed in making applications under section 20A and the fees payable in respect of such applications; and
   (b) any matter relating to the nomination of members under clause (a) of sub-section (2) of section 27A", w.e.f. 27.5.2008.

(f) for requiring boilers to be under the charge of persons holding certificate of proficiency or competency and for prescribing the conditions on which such certificate may be granted;

(g) the manner in which and the person who shall conduct inquiry into the accident.]

(2) Every rule made under sub-section (1) shall be laid as soon as may be after it is made before each House of Parliament while it is in session for a total period of thirty days which may be comprised in one session or [1][in two or more successive sessions, and if, before the expiry of the session immediately following the session or the successive sessions aforesaid], both Houses agree in making any modification in the rule or both Houses agree that the rule should not be made, the rule shall thereafter have effect only in such modified form or be of no effect, as the case may be, so however, that any such modification or annulment shall be without prejudice to the validity of anything previously done under that regulation.]

29. Power to make rules

[2][(1)] The State Government may, by notification in the Official Gazette, make rules consistent with this Act and the regulations made thereunder for all or any of the following purposes, namely:—

[3][(a) the powers and duties of the Chief Inspector, Deputy Chief Inspectors and Inspectors;]

(b) for regulating the transfer of boilers;

(c) for providing for the registration and certification of boilers in accordance with the regulations made under this Act;

[4][***]

(e) for prescribing the times within which Inspectors shall be required to examine boiler under section 7 or section 8;

[5][(f) fee payable for registration of boilers;]

(g) for regulating inquiries into accidents;

[6][(h) the manner in which appeals shall be preferred to the Chief Inspector and the procedure to be followed for hearing such appeals;]

(i) for determining the mode of disposal of fees, costs and penalties levied under this Act; and

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1. Subs. by Act 4 of 1986, S. 2 and Sch., for certain words (w.e.f. 15.5.1986).
2. Section 29 renumbered as sub-section (1) thereof by Act 4 of 1986, S. 2 and Sch. (w.e.f. 15.5.1986).
3. Subs. by Act 49 of 2007, S. 27(i), for
   "(a) for prescribing the qualifications and duties of the Chief Inspector, of Deputy Chief Inspectors and of Inspectors for prescribing or constituting authorities to which they shall respectively be subordinate, and the limits of the administrative control to be exercised by such authorities;".
4. Clause "(d) for requiring boilers to be in charge of persons holding certificates of proficiency or competency, and for prescribing the conditions on which such certificates may be granted;" omitted by Act 49 of 2007, S. 27(ii), w.e.f. 27.5.2008.
5. Subs. by Act 49 of 2007, S. 27(iii), for
   "(f) for prescribing the fees payable for the issue of renewed certificates, for the inspection and examination of boilers or parts thereof or drawings for steam-pipes, for the testing of welders or for any other matter which, in the opinion of the State Government, would involve time and labour and prescribing the method of determining the amount of such fees in each case;", w.e.f. 27.5.2008.
6. Subs. by Act 49 of 2007, S. 27(iv), for
   "(h) for constituting the appellate authority referred to in section 20, and for determining its powers and procedure;", w.e.f. 27.5.2008.

[1][***]

[2][***]

[3][(2) Every rule made by the State Government under this Act shall be laid, as soon as may be after it is made, before the State Legislature.]

30. Penalty for breach of rules

Any regulation or rule made under section 28 or section 29 [4][may direct that a person contravening such regulation or rule shall be punishable, in the case of a first offence, with fine which may extend to [5][one thousand rupees], and in the case of any subsequent offence, with fine which may extend to [6][one lakh rupees]].

31. Publication of regulations and rules

(1) The power to make regulations and rules conferred by sections 28 and 29 shall be subject to the condition of the regulations and rules being made after previous publication.

[7](2) Regulations and rules so made shall be published in the Gazette of India and the local Official Gazette, respectively, and, on such publication shall have effect as if enacted in this Act.

[8][31A. Power of Central Government to give directions

The Central Government may give such directions as it may deem necessary to a State Government regarding the carrying into execution of the provisions to this Act, and the State Government shall comply with such directions.]

32. Recovery of fees etc.

All fees, costs and penalties levied under this Act shall be recoverable as arrears of land-revenue.

33. Applicability to the Government

Save as otherwise expressly provided, this Act shall apply to boilers and [9][boiler components] belonging to Government.

34. Exemptions

[10][(l) The State Government may, by notification in the Official Gazette, exempt from the operation of this Act, subject to such conditions and restrictions as it thinks fit, any boilers or classes or types of boilers used exclusively for the heating of buildings or the supply of hot water.]

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1. Clause "(j) generally to provide for any matter which is, in the opinion of the State Government, a matter of merely local importance in the State;" omitted by Act 49 of 2007, S. 27(v), w.e.f. 27.5.2008.
2. Proviso omitted by the A.O. 1937.
3. Ins. by Act 4 of 1986, S. 2 and Sch. (w.e.f. 15.5.1986).
4. Subs. by Act 18 of 1960, S. 18, for certain words (w.e.f. 6.5.1960).
5. Subs. by Act 49 of 2007, S. 28(a), for "one hundred rupees", w.e.f. 27.5.2008.
6. Subs. by Act 49 of 2007, S. 28(b), for "one thousand rupees", w.e.f. 27.5.2008.
7. Sub-section (2) stands unmodified by the A.O. 1937.
8. Ins. by Act 18 of 1960, S. 19 (w.e.f. 6.5.1960).
9. Subs. by Act 49 of 2007, S. 29, for "steam-pipes", w.e.f. 27.5.2008.
10. Ins. by Act 9 of 1929, S. 3.

[1][2][(2)] In case of any emergency, the State Government may, by general or special order in writing exempt any boilers or steam-pipes or any class of boilers or steam-pipes or any boiler or steam-pipe from the operation of all or any of the provisions of this Act.]

[3][(3) If the State Government is satisfied that having regard to the material design or construction of boilers and to the need for the rapid industrialisation of the country, it is necessary so to do, it may, by notification in the Official Gazette and subject to such conditions as may be prescribed by regulations, exempt any boiler or boiler components in the whole or any part of the State from the operation of all or any of the provisions of this Act.]

35. Repeal of enactments

[Rep. by the Repealing Act, 1927 (12 of 1927), sec. 2 and Sch.]

THE SCHEDULE

Enactments repealed

[Rep. by the Repealing Act, 1927 (12 of 1927), sec. 2 and Sch.].

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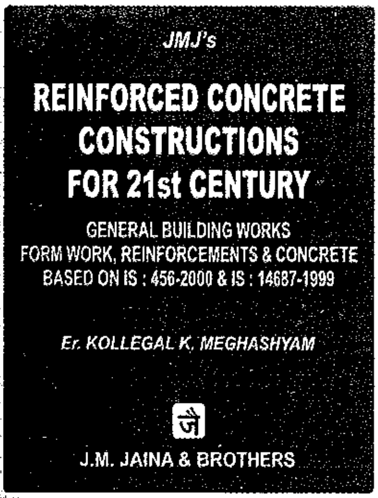
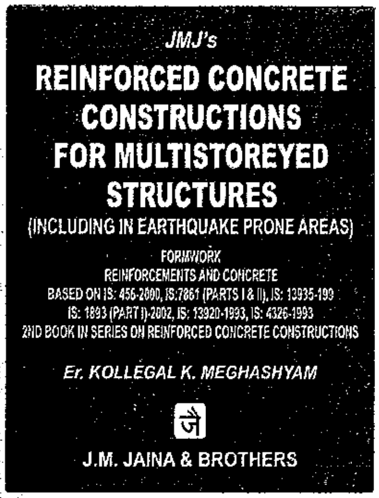
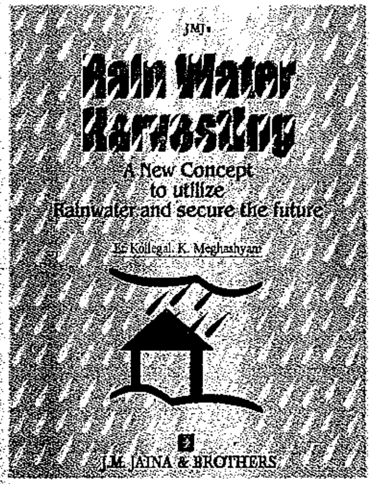
1. Section 34 re-numbered as sub-section (2) of that section by Act 9 of 1929, S. 3.
2. Subs. by Act 18 of 1960, S. 20, for sub-section (2) (w.e.f. 6.5.1960).
3. Subs. by Act 49 of 2007, S. 30, for

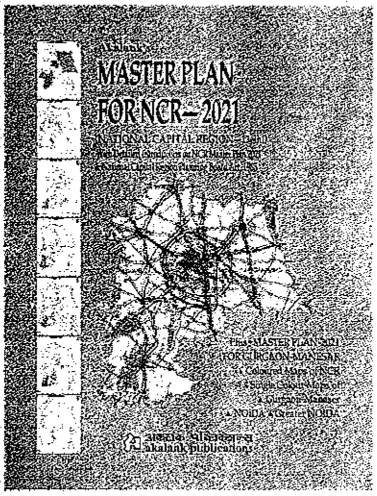
   "(3) If the State Government is satisfied that, having regard to the material design or construction of boilers and to the need for the rapid industrialisation of the country, it is necessary so to do, it may, by notification in the Official Gazette and subject to such conditions and restrictions as may be specified in the notification, exclude any specified class of boilers or steam-pipes in the whole or any part of the State, from the operation of all or any of the provisions of this Act.".

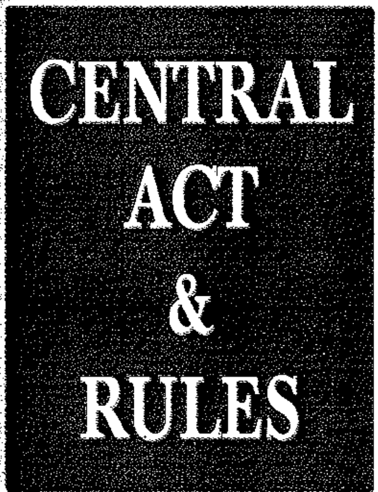
Best Sellers

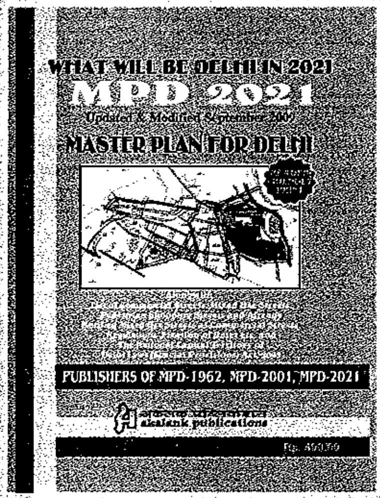












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