CHAPTER VIII

STEAM-PIPES AND FITTINGS

* **343. 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), lap welded, 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.

MATERIAL

* **344. Steel Pipes.**—(*a*) These pipes shall be made from steel made by the open hearth or an electric process acid or basic. Hot finished seamless and roll lap welded pipes, may, however, be made of basic Bessemer steel. Basic Bessemer steel shall not be used for pressures exceeding 21 Kg./cm.^{2} (300 lbs. per sq. in.) or temperature 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 steam temperature exceeding 399°C (750° F), the steel shall be of the non-segregated or fully killed type.

(*b*) Carbon and alloy steel pipes shall not be used for design temperatures exceeding those given in Table 2.

(*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 roll lap welded, hydraulic lap welded and butt welded pipes are to be made shall conform to the requirements of Table 1 under Regulation 347.

* (*e*)

345. Condition of Pipes.—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.

MECHANICAL TEST

346. Number of sets of tests.—The number of pipes on which mechanical tests shall be performed shall be as follows:—

Seamless pipes :

Up to and including 114 mm. (4-1/2 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 427°C (800°F) every pipe over 114 mm. (4-1/2 in.) outside diameter shall be tested.

* **347. (*a*) Flattening test [for pipes up to and including 102 mm.(4 in.) nominal bore].**—As per requirements of Chapter II.

(*b*) **Cold bend test [for pipes over 102 mm. (4 in.) nominal bore.]**—A strip not less than 38 mm. (1-1/2 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 up to 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. (1-1/2 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,

(*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 pipe 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.

TABLE I—CARBON STEELS

Roll Lap welded and Butt welded pipes

Kind of pipes	Ultimate tensile strength in Kg./Sq. mm. (tons per sq. in.)		Minimum elongation per cent.				Sulphur per cent. max.	Phosphorus per cent. max.
			On 203 mm. (8 in.)		On 51 mm. (2 in.)			
	Not less than	Not more than	6 mm. (1/4") thick and over	Less than 6 mm. (1/4") thick	6 mm. (1/4") thick and over	Less than 6 mm. (1/4") thick		
Strips cut from the pipes clear of the welds and tested in their curved condition	35 (22)	44 (28)	20	18	32	30	0.6	0.6
Test lengths taken from finished pipes (ends of pipes to be plugged for grips) . . .	35 (22)	44 (28)	25	23	—	—		

TABLE I—CARBON STEELS

Hydraulic (water gas) Lap welded pipes

Selected Samples cut transversely	Ultimate tensile stress in Kg./sq. mm. (Tons/ sq. in.)		Min. Elongation per cent. on 203 mm. (8")			Sulphur maximum %	Phosphorus maximum %
	Not less than	Not more than	13 mm. 1/2" thick and over	Less tnan 13 mm. thick and not less than 6 mm. (1/4") thick	Less than 6 n m. thick		
—	36 (23)	44 (28)	23	20	18	0.05	0·05

* **348. Method of manufacture, Heat treatment and Marking**—(*a*) The process of welding lap jointed seams shall be by hammering or rolling the joint. The pipe shall be carefully annealed, thereafter.

(*b*) 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.

(*c*) Cold drawn carbon pipes shall be carefully annealed throughout their lengths after the operation of drawing.

Cold drawn seamless alloy steel pipes shall be delivered in the normalised condition or hot drawn condition and hot finished pipes in the as rolled, or hot drawn in the normalised condition.

(*d*) **Marking**—Inspection and identification marks shall be stamped on end faces of pipes plain at ends. These marks shall be machined or ground off before erection. When flanges are fitted identification marks shall be stamped on the rims of flanges.

349. 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	482	900	Straights, bends or fittings.
	Hot finished seamless	Do.	482	900	Do.
*	Hydraulic lap welded ..	Do.	482	900	Do.
	Roll lap welded, butt welded [Max. nominal bore allowable 102 mm. (4 in.)].	21 Kg/Cm² (300 lb./sq. in.)	260	500	Do.
	Electric resistance welded [Max. nominal O.D. 114 mm. (4½ in.)] ..	No restriction	482	900	Straights
Cast steel	Castings ..	No restriction	482	900	Straights, bends or fittings.
Molybdenum steel	Cold drawn seamless and castings.	No restriction	524	975	Do.
Chromium molybdenum Steel	Cold drawn seamless and hot finished seamless .	No restriction	621	1150	Do.
Copper	Solid drawn up to and including 127 mm. (5 in.) dia.	12.6 Kg/Cm² (180 lbs./sq. in.)	Not allowed for superheated steam		Straights and bends.

WORKING PRESSURE OF STEAM-PIPES

* **350. Steel pipes.**—The maximum working pressure allowed on steel pipes shall be determined by the following formula:—

$$W.P. = \frac{2\,Sc\,(t-c)}{D} \quad .. \quad .. \quad .. \quad \text{Eqn 91}$$

t = minimum thickness.

W.P. = Maximum working pressure.

Where the total relieving capacity of the safety valve on the superheater is not less than 20 per cent. of the total evaporative capacity of the boiler, the steam-pipes may be designed for a pressure at which any superheater safety valve is to be set to lift provided that in no case shall these pressures be less than 91 per cent. of the design pressure of boiler.

D = Outside diameter of pipes.

S = Allowable stress as specified in Table 3.

c = Efficiency factor.

= 1 for seamless and electric resistance welded steel pipes.

= ·9 for welded steel pipes for values of t up to and including 22 mm.

= ·85 for welded steel pipes for values of t over 22 mm. (⅞") and up to and including 29 mm. (1⅛")

= ·8 for welded steel pipes for values of t over 29 mm. (1⅛")

c = 0·1 cm. (0·4 in.)

TABLE 3

Maximum permissible working stress for straights, bends or fittings

Material and method of manufacture	Up to and including 260°C (500°F)	Over 260°C (500°F) up to & including 288°C (550°F)	Over 288°C (550°F) up to & including 316°C (600°F)	Over 316°C (600°F) up to and including 343°C (650°F)	Over 343°C (650°F) up to and including 371°C (700°F)	Over 371°C (700°F) up to and including 399°C (750°F)	Over 399°C (750°F) up to and including 427°C (800°F)
Carbon steel							
* A. Roll lap welded and butt welded, and Bessemer hot finished seamless	865 kg./cm.² (12,300 lb./sq. in.)	Not used for these temperatures.....					
B. Castings	822 kg./cm.² (11,700 lb./sq. in.)	794 kg./cm.² (11,300 lbs./sq. in.)	745 kg./cm.² (10,600 lbs./sq. in.)	703 kg./cm.² (10,000 lbs./sq. in.)	654 kg./cm.² (9,300 lbs./sq. in)	605 kg./cm.² (8,600 lbs./sq. in.)	541 kg./cm.² (7,700 lbs./sq. in.)

Carbon steel		
* Seamless, hydraulic lap welded and Electric resistance welded	The lowest value obtained on the following basis from. For temperatures up to and including 350°C (662°F) ..	$\frac{T.S.}{3\cdot5}$ or $\frac{Et}{1\cdot6}$
Molybdenum steel seamless	For temperatures above 350°C (662°F).....	$\frac{Et}{1\cdot6}$ or $\frac{Sr}{1\cdot6}$ or Sc
Chromium Molybdenum Steel seamless		

where, T.S. = Minimum Tensile strength at 20°C (68°F)

Et = Yield point (0·2% proof stress) at the 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.

Sc = The average stress to produce an elongation of 1 % (creep) in 100,000 hours.

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:—

$$W.P. = \frac{2S\,(t - \cdot 015D - C)}{D} \quad \text{Eqn. (92)}$$

where, t = minimum thickness
W.P. = Working Pressure
D = External diameter of pipe
S = Allowable working stress as specified in table 4.
C = 0·64 cm (0·25 in.)

TABLE 4

Maximum Permissible Working Stress for Carbon and Alloy Cast Steel Pipes
(*See* Regulation 351)

Lowest value obtained in each case at the specified temperature calculated on the following basis:—

For service temperature at or below 350°C (662°F) .. .. $\frac{T.S.}{3 \cdot 5}$ or $\frac{Et.}{1 \cdot 6}$

For service temperature above 350°C (662°F) .. .. $\frac{Et}{1 \cdot 6}$ or $\frac{Sr}{1 \cdot 6}$ or Sc

T.S. = Minimum Tensile Strength of the material at room temperature.
Et = Warm yield point (0·2% proof stress) at temperature t.
Sr = The average stress at the service temperature to produce rupture in 100,000 hours and, in no case, more than 1·33 times the lowest stress to produce rupture at service temperature.
Sc = The average stress at service temperature to produce an elongation of 1% (creep) in 100,000 hours.

352. Copper Pipes.—(*a*) The material shall comply with Regulation 35.

(*b*) Copper pipes may be used for a working pressure not exceeding 180 lbs. per sq. inch. The external diameter shall not exceed 5 in.

(*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:—

$$W.P. = \frac{50\,(t - 3)}{d} \quad \text{Eqn. (93)}$$

where t = Minimum thickness in hundredth of an inch.
W.P. = Working pressure in lbs. per sq. in.
D = Outside diameter of pipe in inches.

FLANGES

* **353. Flanges of Steam-Pipes.**—Flanges of steam pipes shall be made of cast steel or wrought steel made without a weld. They may be secured to the pipes by screwing, riveting or welding.

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 pressures of 31·5 kg/cm²(450 lbs./sq. in.) and a maximum temperature of 399°C (750°F) and for feed for a maximum pressure of 42 kg/cm²(600 lbs./sq. in.)

355. Loose Flanges.—Loose flanges may be used where the joints are made by metal to 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:—

$$Sr = \left(\frac{A_o \times P}{AN}\right) \quad \text{Eqn. (94)}$$

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:—

$$Sp = \frac{(A_o \times P)}{(A_o - A_1) - (N \times d \times t)} \quad \text{Eqn. (95)}$$

where Sp = the stress in the pipe in lb. 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 34 of the following types:—

Type 1. Welding Neck flange. Figure 28.
2. 'Face and Back' welded—on flange for metal arc welding. Figure 29.
3. 'Bore and Back' welded—on flange for metal arc welding. Figures 30 and 30A.
4. 'Face and Fillet' welded—on flange for metal arc welding. Figure 31.
5. 'Bore and Fillet' welded—on flange for metal arc welding. Figures 32 and 32-A.
6. 'Slip on' welded—on flange for metal arc welding. Figure 33
7. 'Slip on' welded—on bossed flange for oxy-acetylene welding. Figure 34.

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 clearances 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 up to and including 42 kg/cm² (600 lbs./sq. in.) and design temperature not exceeding 399°C. (750°F.).

Types 6 and 7 flanges for all pressure conditions up to and including 17·6 kg./cm²(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 over 152 mm. (6″) in nominal bore.

(*c*) **Heat treatment after welding.**—Types 1, 2, 3, 4 and 5 carbon steel 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 13 mm. (1/2″).

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.**—The stress relieving temperature shall be:
for mild steel and carbon steel within the range 600/650°C. (1110/1200°F)
for alloy steels within the range 630/660°C (1170/1220°F).

The stress relieving temperature shall be maintained for approximately one hour per 25 mm. (1 inch) of weld throat with a minimum of half an hour.

Stress relieving shall be carried out by one of the following methods:—

(*a*) Local heating using a portable mufle furnace, induction coils or other suitable heating appliance. Particular care shall be taken to apply heat uniformly 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 peened, welded or otherwise suitably attached to the surface of the pipe and, where necessary, protected from frame impingement.

(*b*) Heating in a stationary industrial furnace. The temperature of the joint shall be measured by thermocouples 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 up to 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 up to 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 up to 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 up to 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 thermocouples 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 thermocouples 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*) Where pipe having a wall thickness exceeding 13 mm. ($\frac{1}{2}$ in.) are butt-welded together they shall be effectively stress relieved in accordance with the following:—

The stress relieving temperature shall be:

For mild steel and carbon steel within the range 600/650° C (1110/1200° F).

For alloy steels within the range 630/660° C (1170/1220° F).

The stress relieving temperature shall be maintained for approximately one hour per inch of pipe thickness with a minimum of half an hour.

Heat treatment shall be carried out by one of the following methods:

(*i*) Local heating using a portable muffle furnace induction coils, or other suitable heating appliance. Particular care shall be taken to apply heat uniformly over the area to be treated. The use of procedures that do not provide adequate control for this purpose such as manual operation of gas torches, is not permissible. The temperature shall be maintained symmetrically, over a peripheral band of metal of a minimum width of three times the width of the butt weld preparation. The temperature shall be measured by thermocouples peened, welded or otherwise suitably attached to the surface of the pipe and, where necessary, protected from flame impingement.

(*ii*) Heating in a stationary industrial furnace. The temperature of the joint shall be measured by thermocouples so disposed within the furnace as to give a true measure of the joint temperature.

(*c*) Such Butt-welded joints conform to fig. 28.

* (*d*)

STEAM-PIPE FITTINGS AND CONNECTIONS

361. Wrought Bends.—(*a*) Wherever practicable the radii of bends (on centre line) shall be not less than those given below:—

Bore up to and including 6″	.. ..	R=3×d
Bore over 6 in. up to and including 9″	..	R=3·5×d
Bore over 9 in. up to and including 12″	..	R=4×d
Bore over 12 in. up to and including 15″	..	R=4·5×d
Bore over 15 in. up to and including 18″	..	R=5×d
Bore over 18 in. up to and including 20″	..	R=5·5×d

where d=the bore of the pipe,

R=Radius of bend to centre line of pipe.

(*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:—

$$C = \frac{Dmax. - Dmin.}{D} \times 100$$

This deviation shall not exceed $\frac{20D}{R}$

where,

C =The percentage deviation of circularity.
Dmax. =maximum external diameter of the pipe as gauged at the bend.
Dmin. =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.

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 91-A external reinforcement shall be provided. Such reinforcement may take the form as given in Figure 32-A or other reinforcement approved by the Chief Inspector applied to or around the junction between branch and main. Gusset plates attached longitudinally to the surfaces of either pipe, shall not be used.

(*c*) **Thickness where no external reinforcements 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 91-A.

* $t_m = \frac{PD}{2 Sex} + C$ .. .. Equation (91-A.)

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where t_m = minimum thickness of the branch.

P = Working pressure.
D = Outside diameter of branch.
S = Maximum permissible stress as specified in Table 3.
e = factor given in regulation 350.
x = 1.—B (1—0·7 sin y) .. Equation (91-B.)
B = ratio of bore of branch to bore of main.
y = angle between branch and main, in degrees.
C = 0·1 cm (·04 in.)

The value of t_m derived from Equation 91-A is the minimum thickness and further provision shall be made for any minus tolerance.

No reinforcement is required if—

B is less than $\frac{Y}{Y+90}$ .. .. .. Equation (91-C.)

(*ii*) **A branch affected by one or more other branches.**—(*See* Figure 362/A.) Determine the 'X' values for each branch alone from Equation 91-B. Let 'X' be the value for the branch under consideration and Xa, Xb, etc, the value for the other branches

Then $X_1 = 1 - C(1 - Xa)$ .. .. .. Equation (91-D.)
$X_2 = 1 - C(1 - Xb)$
etc.

Where C is a factor the value of which is to be taken from Table 362/4.

The thickness of each branch which is a component of a multiple branch shall then be determined from Equation 91-E. Equation 91-C shall not apply:—

* $t_m = \left(\frac{PD}{2 Se_x}\right) \cdot \left(\frac{1}{X_1 \cdot X_2 \ldots}\right) + C$ ....Equation (91-E.)

Where C=1 mm. (·04 in.)

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:

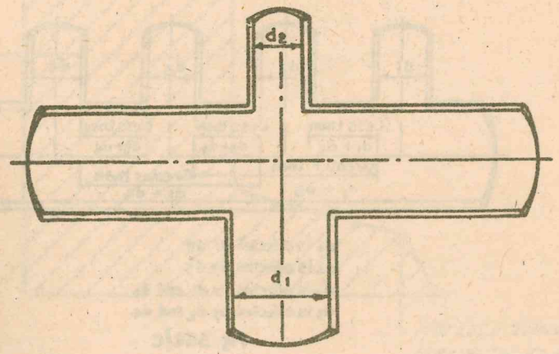
It is to be specially noted that a branch may form part of two distinct, multiple branches, when its thickness shall be the greater of the thickness calculated for it as a component of each multiple branch.

(*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.

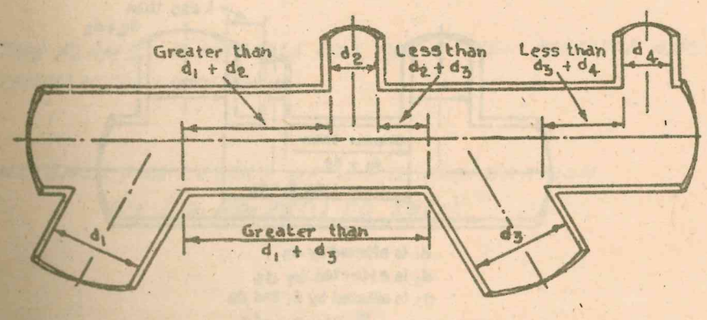
The additional thickness of a main for branch reinforcement shall extend over the length covered by the branch and beyond it for a distance not less than the bore of the branch on each side.

TYPICAL BRANCH PIECES



d_1 and d_2 form a pair affecting each other

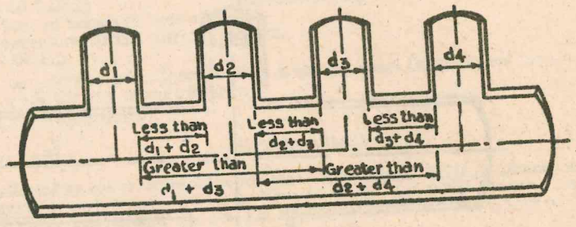
Fig. 362/A



d_1 is unaffected by the other branches
d_2 is affected by d_5
d_3 is affected by d_2 and d_4
d_4 is affected by d_3

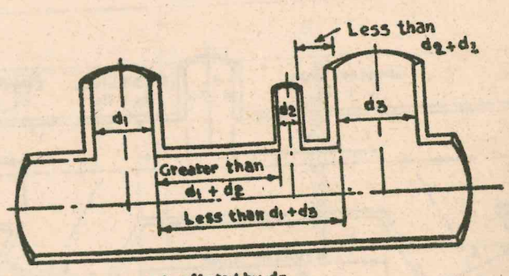
Fig. 362/B

TYPICAL BRANCH PIECES



d_1 is affected by d_2
d_4 is affected by d_3
d_2 is affected by d_1 and d_3
d_3 is affected by d_2 and d_4

Fig: 362/C



d_1 is affected by d_3
d_2 is affected by d_3
d_3 is affected by d_1 and d_2

Fig: 362/D

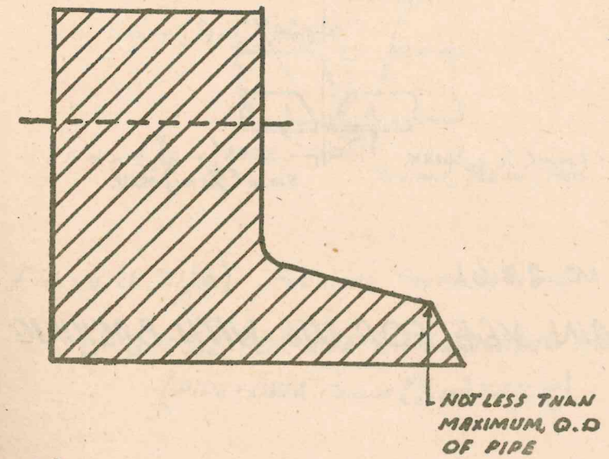


FIG.NO. 28.

THIS FLANGE IS SUITABLE FOR ALL DESIGN PRESSURE AND TEMPERATURE CONDITIONS

NOTE:— FOR DETAILS OF WELD PREPARATION SEE FIG. NO. 28(i) TO 28(x)

WELDING NECK FLANGE

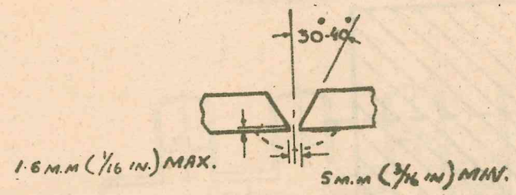


FIG. NO. 28 (i)

PLAIN VEE FOR USE WITH BACKING RING.

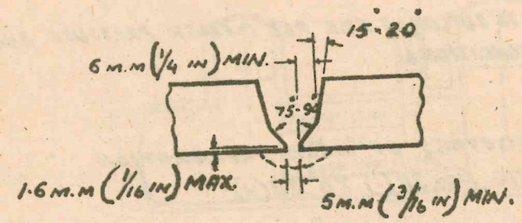


FIG. NO. 28 (ii)

DOUBLE ANGLE VEE FOR USE WITH BACKING RING
(PIPES OVER 13 M.M (1/2 IN) THICK)

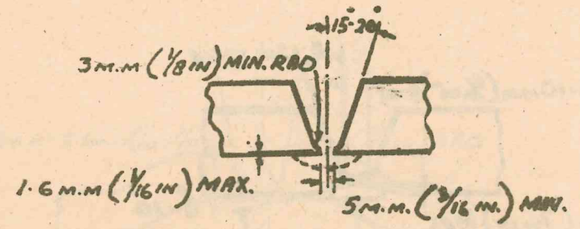


FIG. NO. 28 (iii)(a) NORMAL PREPARATION.

U-GROOVE FOR USE WITH BACKING RING
(PIPES OVER 13 M.M (1/2 IN) THICK)

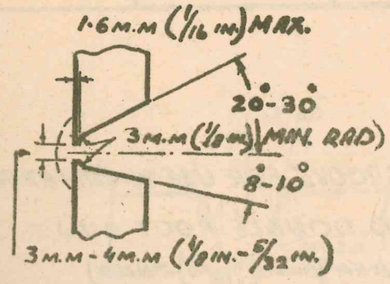
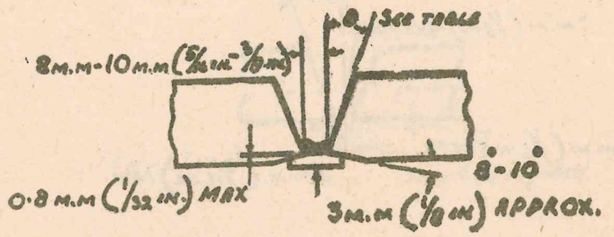


FIG. NO. 28 (iii)(b) PERMISSIBLE ALTERNATIVE PREPARATION FOR VERTICAL OR NEARLY VERTICAL PIPE

U-GROOVE FOR USE WITH BACKING RING
(PIPES OVER 13 M.M (1/2 IN.) THICK)



PIPE THICKNESS		θ
M.M.	IN	DEGREES.
≤25	≤1	16 - 20
>25≤38	>1≤1½	20 - 24
>38	>1½	23 - 27

FIG. No. 28 (iv)

PREPARATION OF GROOVE FOR USE WITH TAPER BACKING RING AND DOUBLE ROOT RUN.
(FOR PIPES OVER 8 M.M (5/16 IN) THICK)

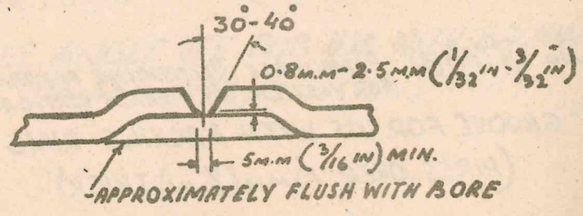


FIG. No. 28 (v)(a) FOR PIPES 13 M.M (1/2 IN) AND THINNER

GROOVE FOR USE WITH RECESSED BACKING RING

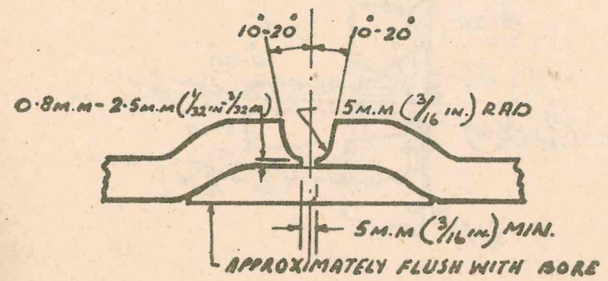


FIG. NO. 28 (v)(b) FOR PIPES THICKER THAN 13 M.M (1/2 IN.)

GROOVE FOR USE WITH RECESSED BACKING RING

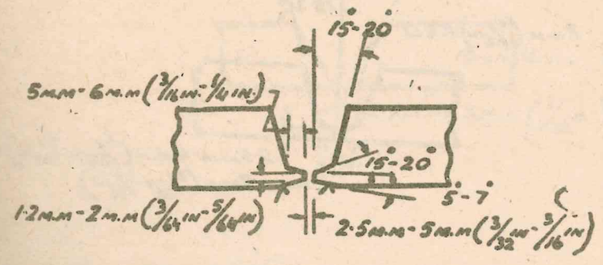


FIG. No. 28 (vi)(a) NORMAL PREPARATION

DOUBLE ANGLE VEE FOR USE WITH OXY-ACETYLENE BASE RUN

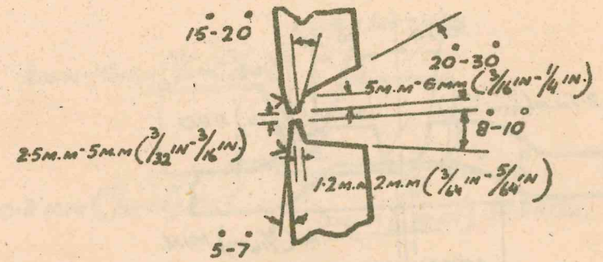


FIG. No. 28(VI)(b) PERMISSIBLE ALTERNATIVE PREPARATION FOR VERTICAL OR NEARLY VERTICAL PIPE.

DOUBLE ANGLE VEE FOR USE WITH OXY-ACETYLENE BASE RUN.

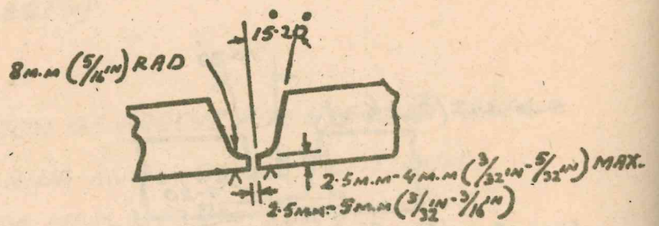


FIG. No. 28(VII)(a) NORMAL PREPARATION

U-GROOVE FOR USE WITH OXY-ACETTLENE BASE RUN.

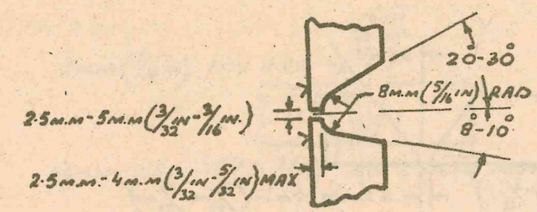


FIG. No. 28(VII)(b) PERMISSIBLE ALTERNATIVE PREPARATION FOR VERTICAL OR NEARLY VERTICAL PIPE.

U-GROOVE FOR USE WITH OXY-ACETYLENE BASE RUN.

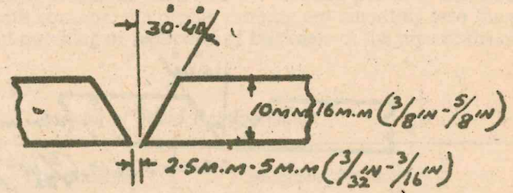


FIG. No. 28(VIII)

PLAIN VEE FOR USE WITH OXY-ACETYLENE BASE RUN (PIPES 10 TO 16 M.M (3/8 TO 5/8 IN) THICK INCLUSIVE)

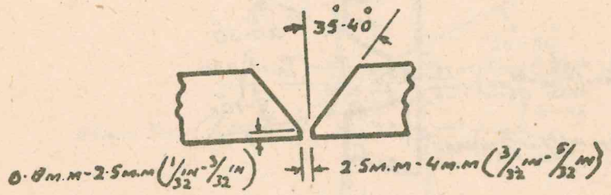


FIG. NO. 28 (IX)(a) NORMAL PREPARATION.

PLAIN VEE FOR USE WITHOUT BACKING RING

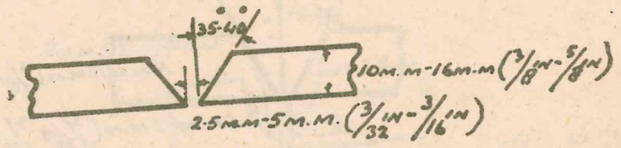


FIG. NO. 28 (IX)(b) FOR USE WITH SPECIAL WELDING TECHNIQUE

PLAIN VEE FOR USE WITHOUT BACKING RING

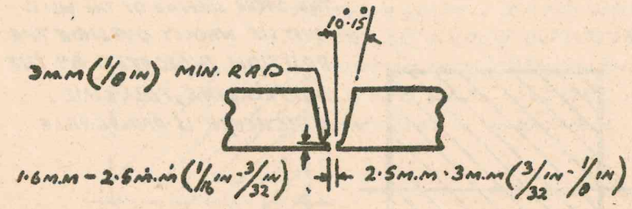


FIG. NO. 28 (X)

SINGLE U FOR USE WITHOUT BACKING RING

***Shape of profile.**—Unless the weld is dressed flush, there shall be external weld reinfrocement, 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 shall 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	3	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

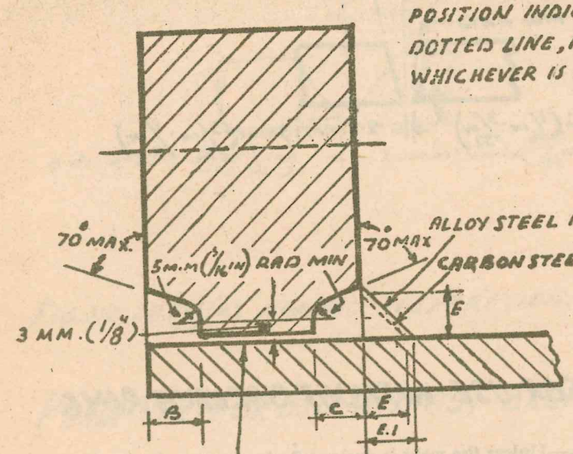


FIG. NO. 29.

CARBON STEEL PIPES	B = t BUT NOT LESS THAN 5m.m (3/16 IN).
ALLOY STEEL PIPES	B = t BUT NOT LESS THAN 5m.m (3/16 IN.)
CARBON STEEL PIPES.	C = E BUT NOTLESS THAN 6m.m (1/4 IN) FOR PIPES 13m.m (1/2 IN) AND 19m.m (3/4 IN) BORE; 8m.m (5/16 IN) FOR PIPES 25m.m (1 IN) TO 38m.m (1 1/2 m.m) BORE; 10m.m (3/8 IN) FOR PIPES 51m.m (2 IN) BORE AND OVER.
ALLOY STEEL PIPES	C = 2t BUT NOTLESS THAN 6m.m (1/4 IN) FOR PIPES 13m.m (1/2 IN) AND 19m.m (3/4 IN) BORE; 8m.m (5/16 IN) FOR PIPES 25m.m (1 IN) TO 38m.m (1 1/2 m.m) BORE; 10m.m (3/8 IN) FOR PIPES 51m.m (2 IN) BORE AND OVER.
CARBON STEEL PIPES	E = t BUT NOT LESS THAN 6m.m (1/4 IN)
ALLOY STEEL PIPES	E1 = 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.

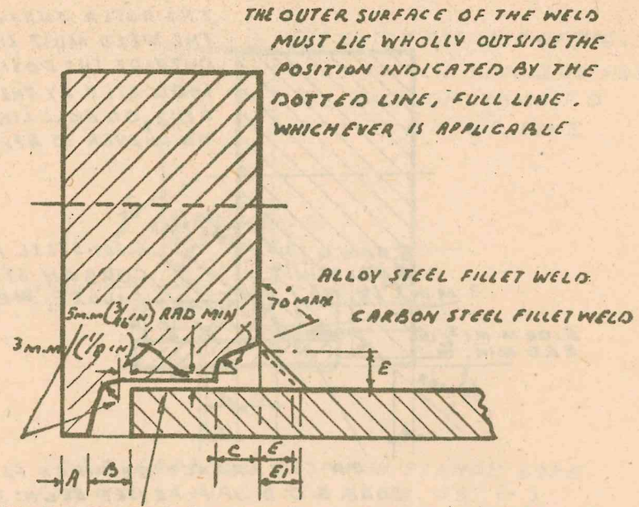


FIG. NO. 30.

CARBON STEEL AND ALLOY STEEL PIPES.	A = 1/2 t BUT NOT LESS THAN 5m.m (3/16 IN)
CARBON STEEL AND ALLOY STEEL PIPES.	B = 8m.m (5/16 IN) MIN. WHERE t IS NOT MORE THAN 8m.m (5/16 IN); = (t - 1.6m.m (1/16 IN)) WHERE t IS OVER 8m.m (5/16 IN) UPTO AND INCLUDING 14.5m.m (9/16 IN); = (t - 3m.m (1/8 IN)) WHERE t IS OVER 14.5m.m (9/16 IN) UP TO AND INCLUDING 22m.m (7/8 IN); = (t - 6m.m (1/4 IN)) WHERE t IS OVER 22m.m (7/8 IN)
CARBON STEEL PIPES	C = t BUT NOT LESS THAN 10m.m (3/8 IN)
ALLOY STEEL PIPES	C = 2t BUT NOT LESS THAN 10m.m. (3/8 IN)
CARBON STEEL PIPES	E = t BUT NOT LESS THAN 6m.m. (1/4 IN)
ALLOY STEEL PIPES.	E1 = 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 76m.m (3 IN) MIN. BORE.

'BORE AND BACK' WELDED-ON FLANGE FOR METAL-ARC WELDING

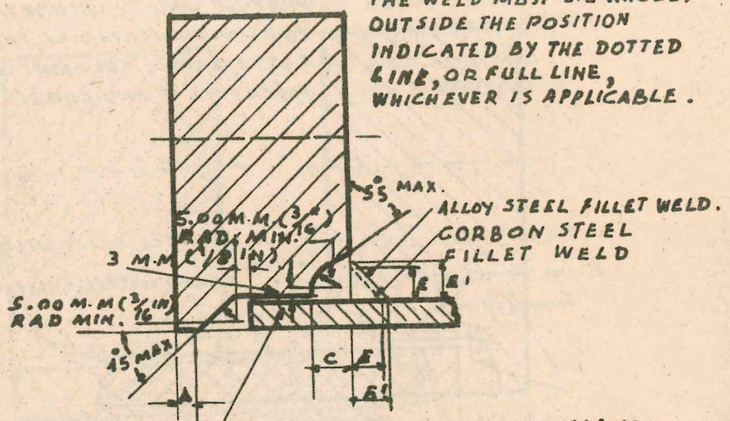


FIG. NO. 30-A.

CARBON STEEL AND ALLOY STEEL PIPES	$A = 1/2\,t$ BUT NOT LESS THAN 5.0 MM (3/16 IN)
CARBON STEEL PIPES	$C = t$ BUT NOT LESS THAN 10.0 M.M. (3/8 IN)
ALLOY STEEL PIPES	$C = 2t$ BUT NOT LESS THAN 10.0 M.M (3/8 IN)
CARBON STEEL PIPES	$E = t$ BUT NOT LESS THAN 6.0 M.M (1/4 IN)
ALLOY STEEL PIPES	$E' = 6.00$ M.M (1/4 IN) $+ 2/3\,t$ 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) MINIMUM BORE

WELD PREPARATION FOR USE ONLY WITH FLANGES POSITIONALLY WELDED ON.

BORE AND BACK' WELDED-ON FLANGE FOR METAL ARC WELDING

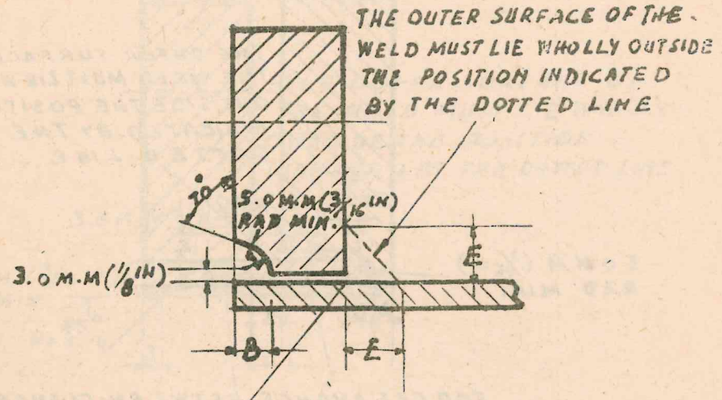


FIG. NO. 31.

$B = t$ BUT NOT LESS THAN 5.0 M.M. (3/16 IN.)

$E = 1\,1/2\,t$ 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.

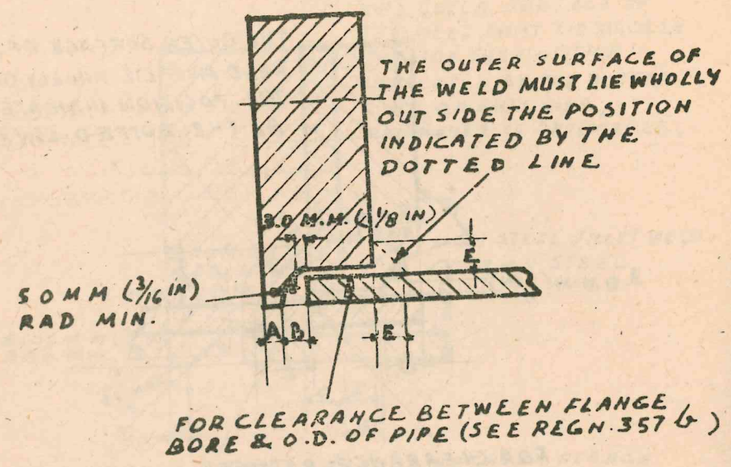


FIG. NO. 32.

A = ½ t 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") WHERE t IS OVER 8.0 M.M. (5/16") UP TO AND INCLUDING 14.50 M.M. (9/16 IN).
= (t - 3.0 M.M. (1/8") 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 22.0 M.M. (7/8 IN).

E = 1½ t 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

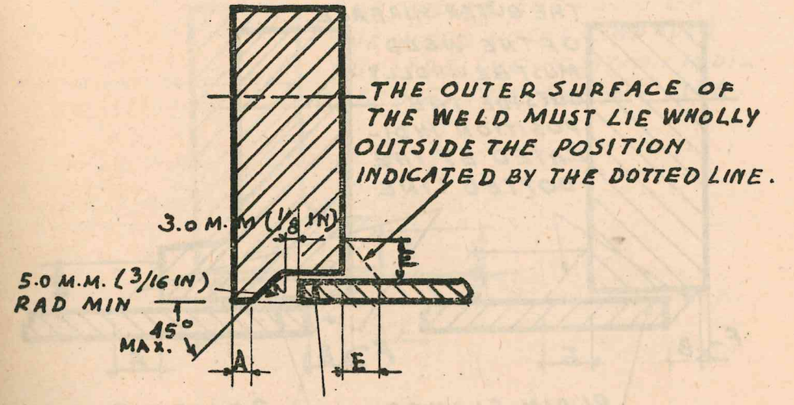


FIG. NO. 32-A

A = ½ t BUT NOT LESS THAN 5.0 M.M. (3/16 IN)
E = 1½ t 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

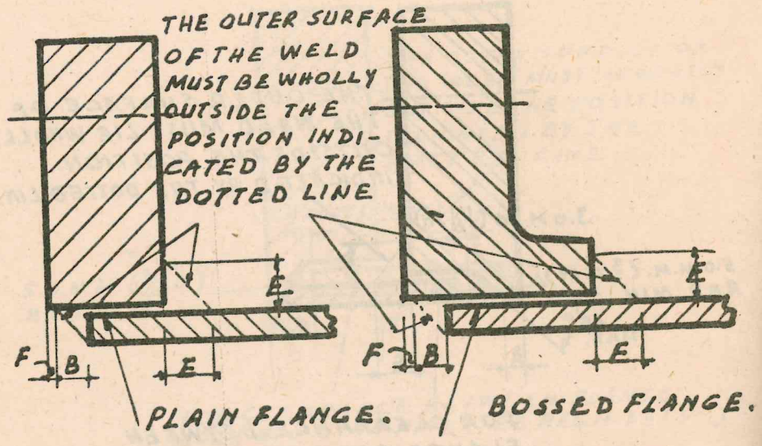


FIG. NO. 33.

B = t
E = 1½ t BUT NOT LESS THAN 5.0 M.M. (3/16 IN)
F = 1.6 M.M (1/16 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.

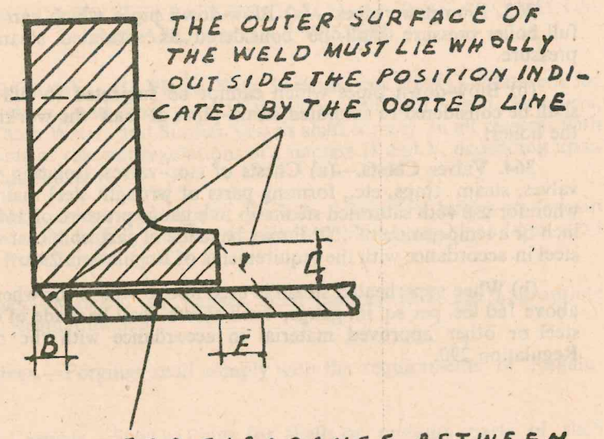


FIG. NO. 34.

B = t
E = 1½ t 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.

363. Blow-down pipes.—(a) Blow-down pipes which can 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 up to 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 relevent 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.**—Material 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 in one piece made from one plate and the shape shall conform to the requirements of Regulation 275. Dishing and 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.

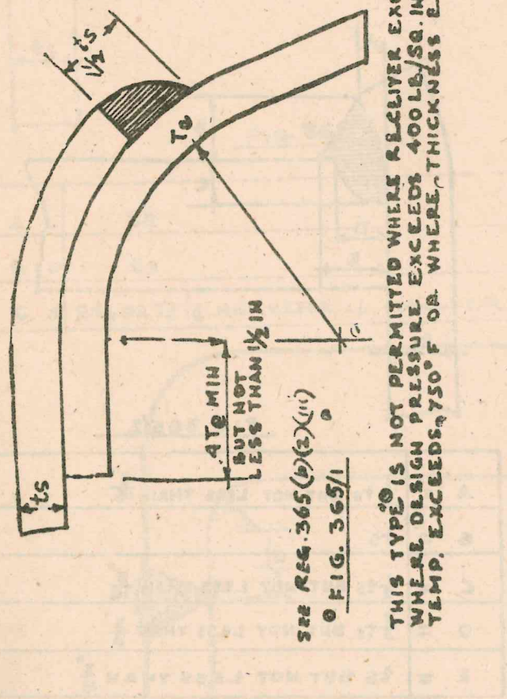
Dished ends shall be attached to the cylindrical part of the shell by one of the following methods:—

(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 in 24 ins. or over, the joints shall, 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) **Inserting, convex side outwards, into the cylindrical part of the shell which shall afterwards be hammered over at a forging temperature and welded round the periphery.**—The dished end shall be a tight fit in the cylindrical part of the shell and the length of the cylindrical portion of the dished end shall be not less than four times the thickness of the dished end but not less than 1-1/2 ins. This method may be used where the shell diameter does not exceed 36 ins. and the thickness of the cylindrical part of the shell does not exceed 1 in.; (*See* Figure No. 365/1), except that it shall not be permitted where the design pressure exceeds 400 lbs./sq. in. or where the design temperature exceeds 750° F.



Dished ends shall not be secured to the cylindrical part of the shell merely by Fillet Welding round periphery without any mechanical lock.

(3) **Flat Ends.**—Flat ends shall be of forged steel or plate seel 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 Figure Nos., 365/2, 365/3, 365/4 and 365/5.

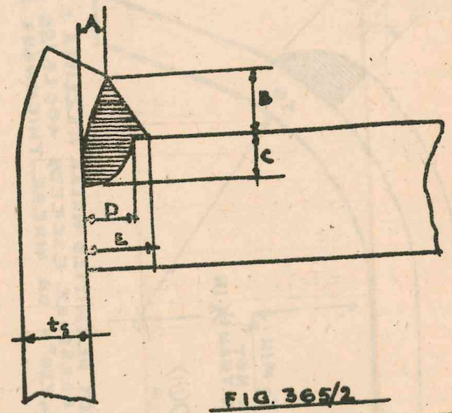


FIG. 365/2

A =	$\frac{1}{3}$ ts BUT NOT LESS THAN $\frac{3}{16}$"
B =	ts
C =	$\frac{1}{2}$ ts BUT NOT LESS THAN $\frac{5}{16}$"
D =	$\frac{2}{3}$ ts BUT NOT LESS THAN $\frac{3}{8}$"
E =	ts BUT NOT LESS THAN $\frac{3}{8}$"

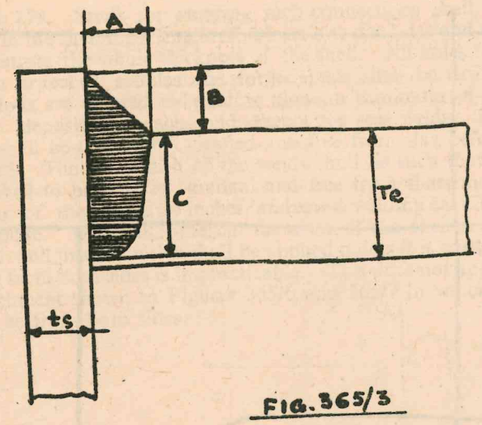


FIG. 365/3

A =	ts
B =	ts
C =	$2t_s$ OR Te $\frac{1}{16}$". WHICHEVER IS SMALLER.

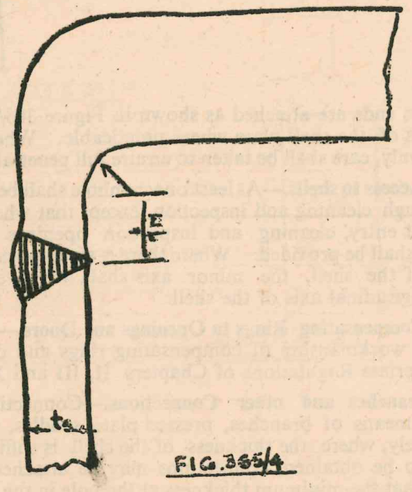


FIG. 365/4

TO BE WELDED FROM BOTH SIDES OF THE SHELL PLATE. BUT WHERE THIS IS IMPRACTICABLE CARE SHALL BE TAKEN TO ENSURE FULL PENETRATION AND BACKING STRIPS MAY BE USED

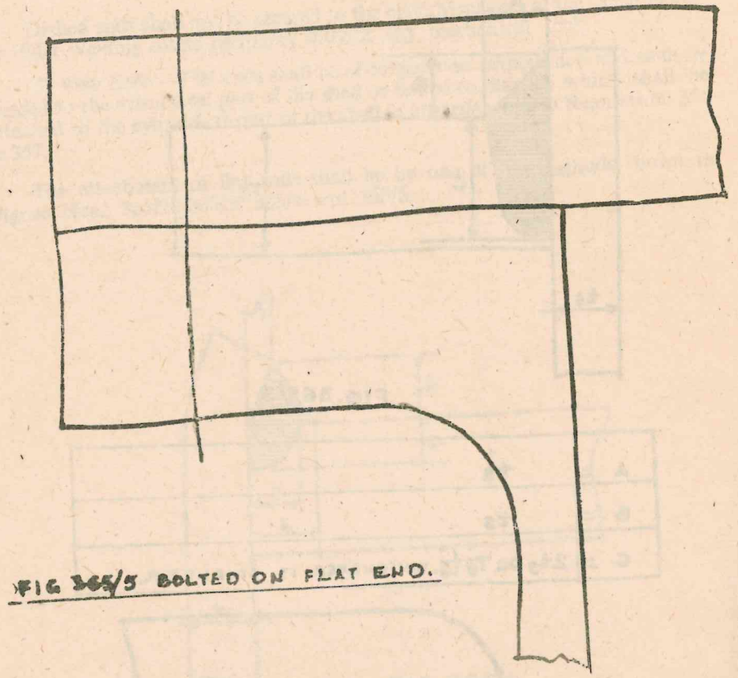


FIG 365/5 BOLTED ON FLAT END.

When ends are attached as shown in Figure 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.

(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 shall, 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 shells 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 Figures 365/6 and 365/7 in which the welding shall always be from both sides.

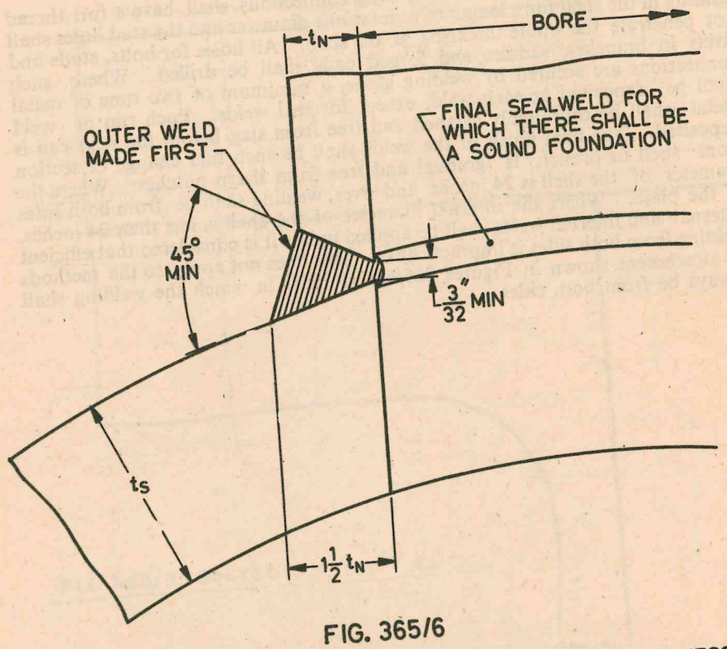


FIG. 365/6

HERE 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

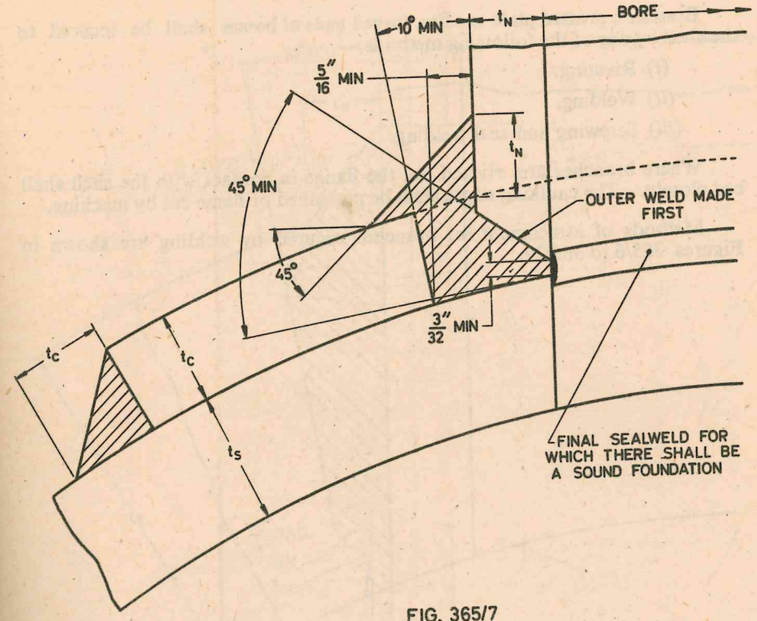


FIG. 365/7

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 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 LENGTH AND BRANCHES SHOULD BE AS SHORT AS POSSIBLE.

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 bed closely. The caulking edges shall be machined or flame cut by machine.

Methods of attachment for branches secured by welding are shown in Figures 365/6 to 365/29.

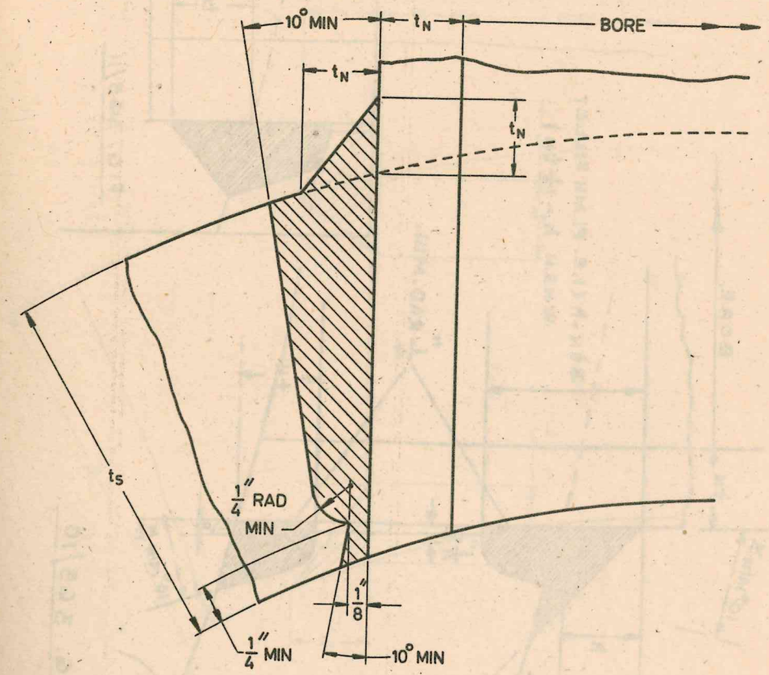


FIG. 365/8

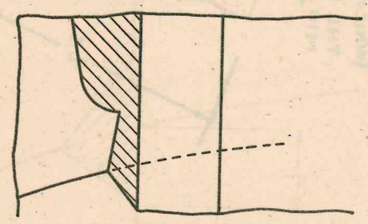


FIG. 365/9

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.

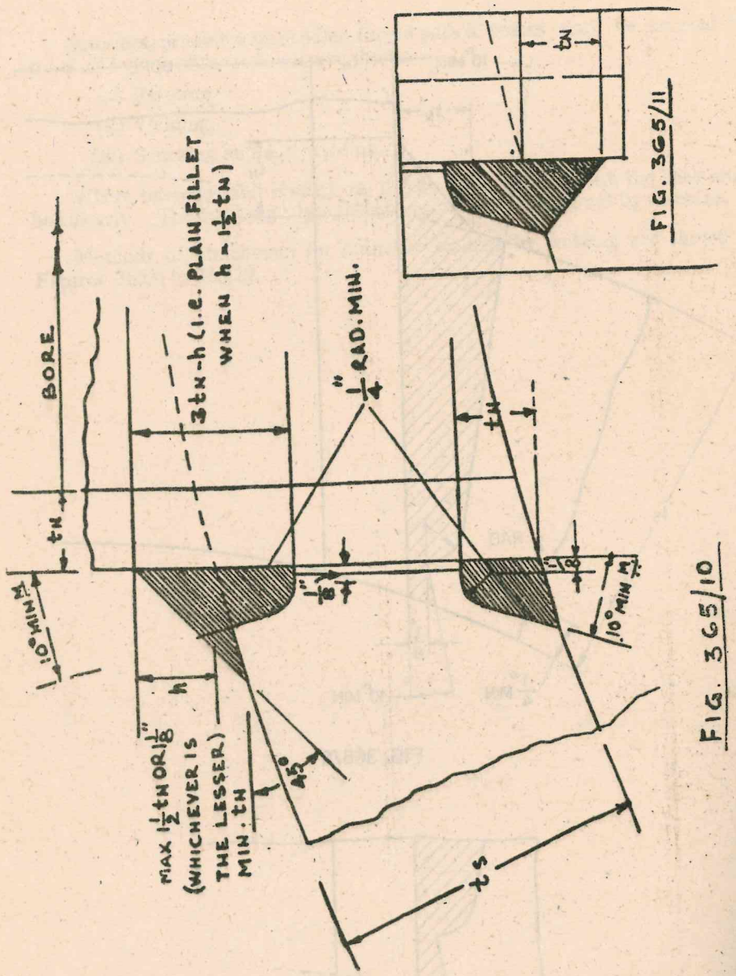


FIG. 365/11

FIG. 365/10

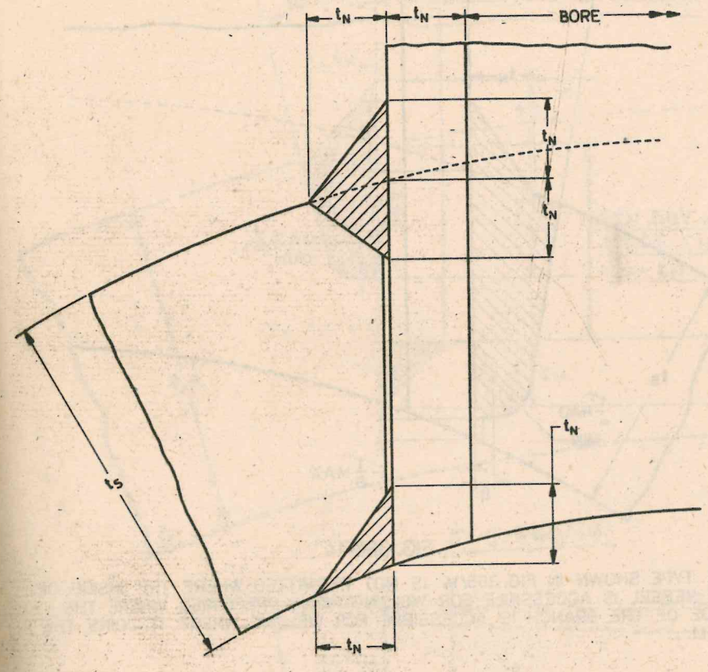


FIG. 365/12

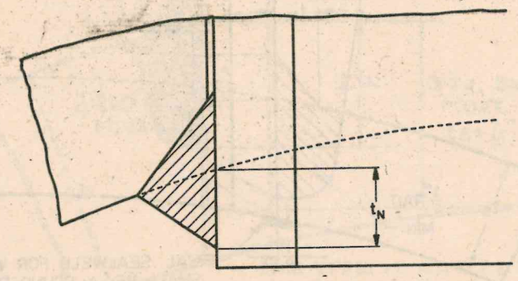


FIG. 365/13

THE TYPES SHOWN IN FIGS. 365/12 AND 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.

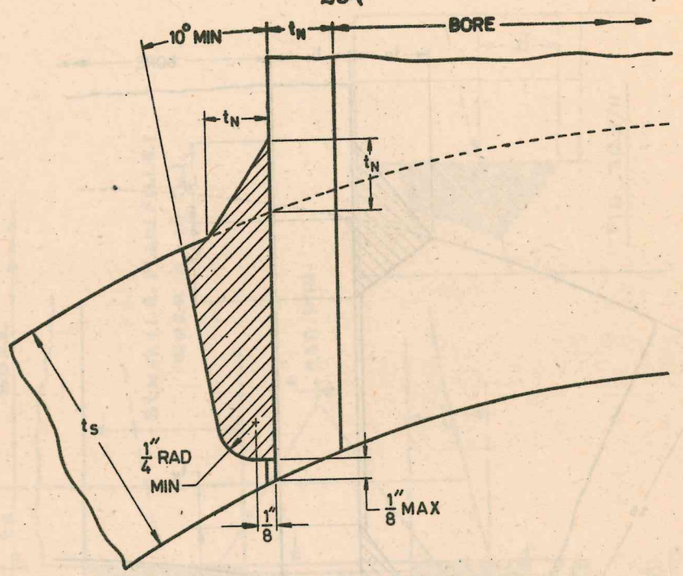


FIG. 365/14

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 ACCESSIBLE FOR WELDING, WHERE IT JOINS THE SHELL.

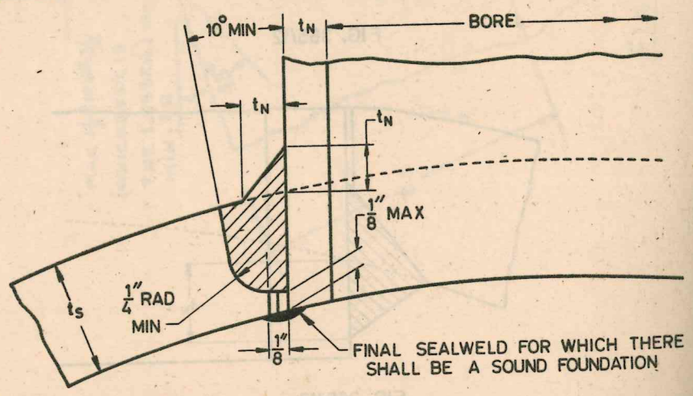


FIG. 365/15

THE TYPE SHOWN IN FIG. 365/15 IS NOT PERMITTED WHERE THE SHELL THICKNESS EXCEEDS 1 INCH.

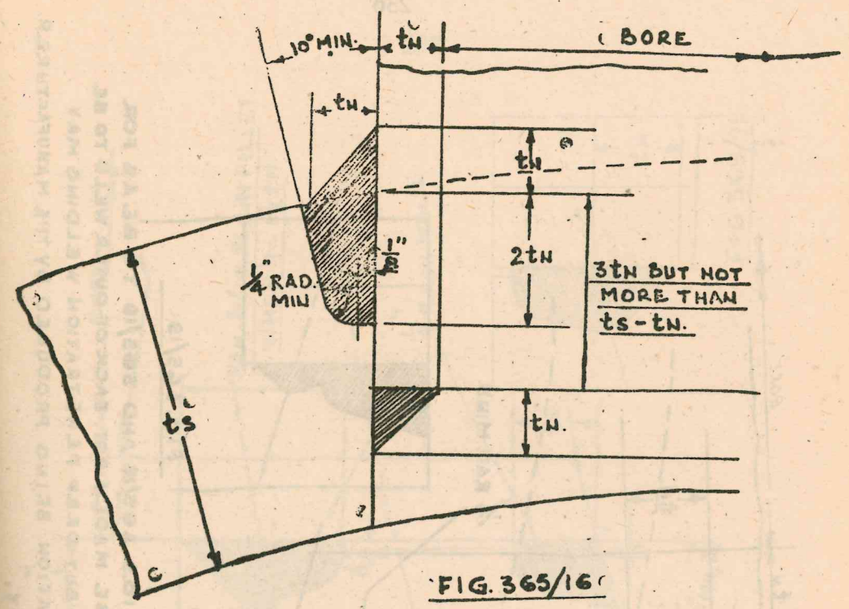
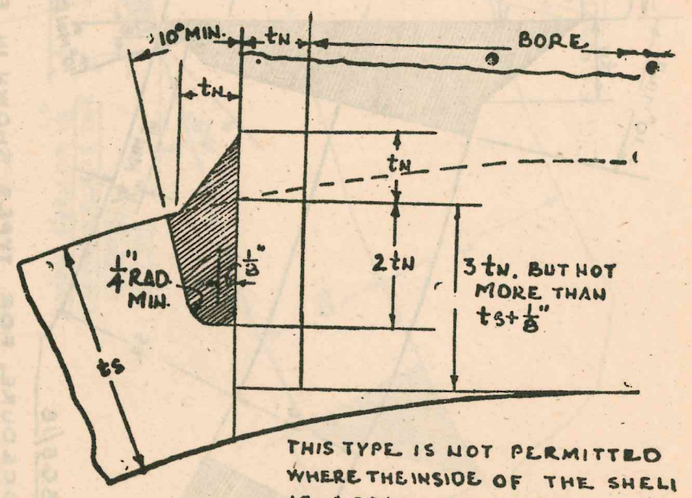


FIG. 365/16



THIS TYPE IS NOT PERMITTED WHERE THE INSIDE OF THE SHELL IS ACCESSIBLE FOR WELDING.

FIG. 365/17

THE TYPES SHOWN IN FIGS. 365/16 AND 365/17 ARE ONLY PERMITTED FOR DRAIN POCKETS AND LIKE CONNECTIONS WHERE THE STRESS OTHER THAN THAT DUE TO INTERNAL PRESSURE IS INSIGNIFICANT.

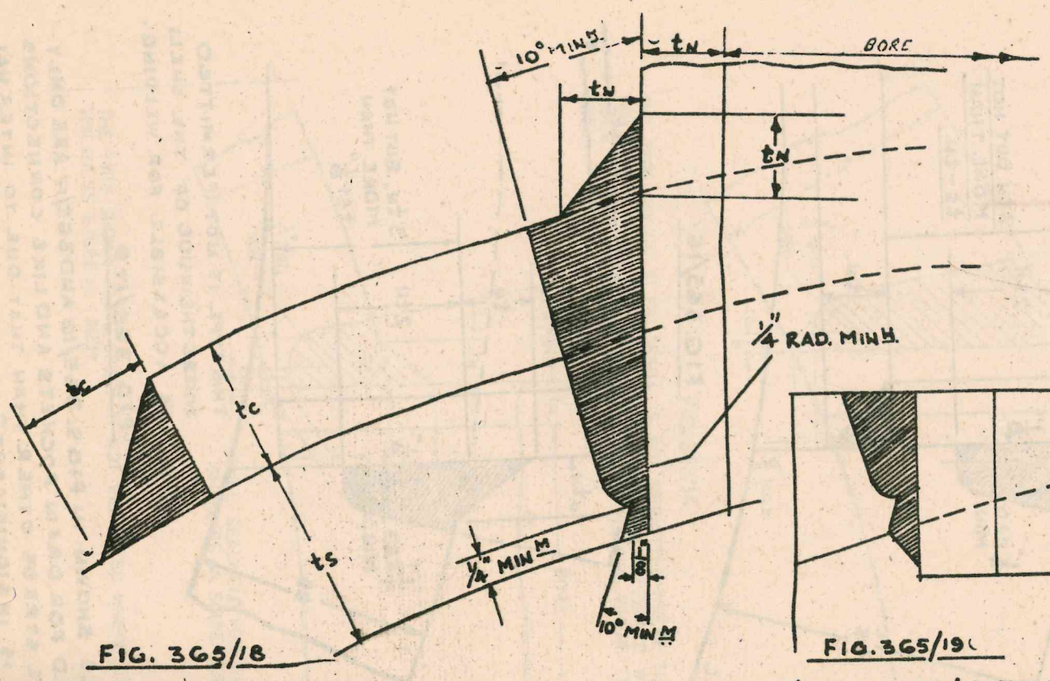


FIG. 365/18

FIG. 365/19

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 BE USED SUBJECT TO PROOF OF REQUISITE PENETRATION BEING PRODUCED BY THE MANUFACTURER WHERE CALLED FOR BY THE INSPECTING AUTHORITY."

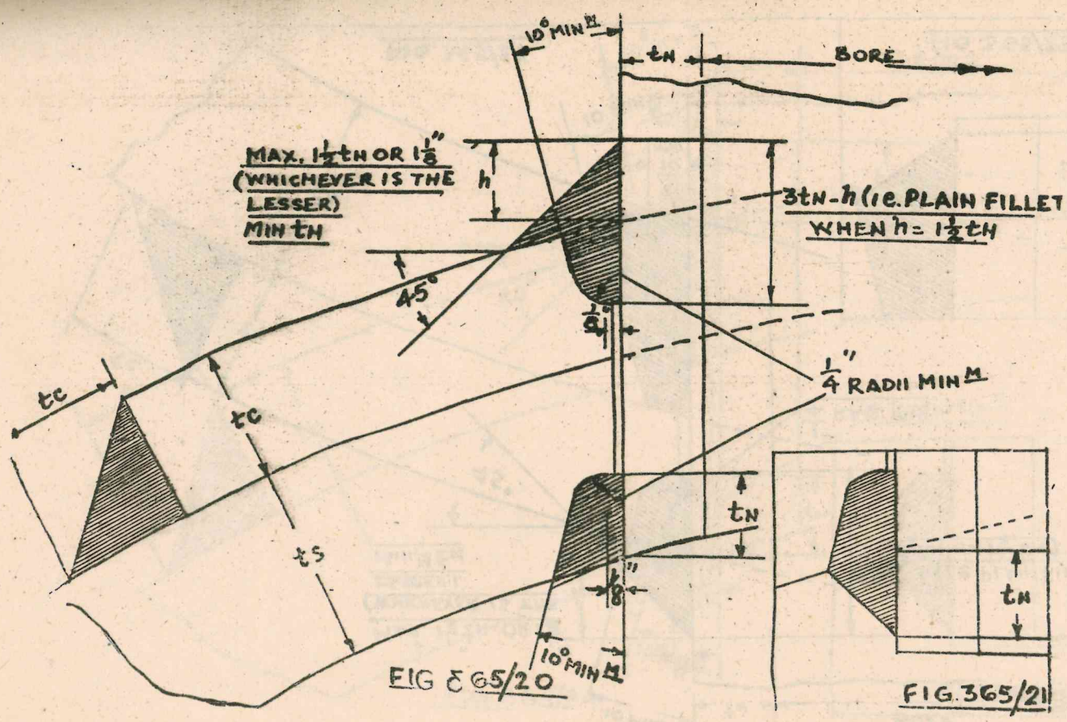


FIG 365/20

FIG. 365/21

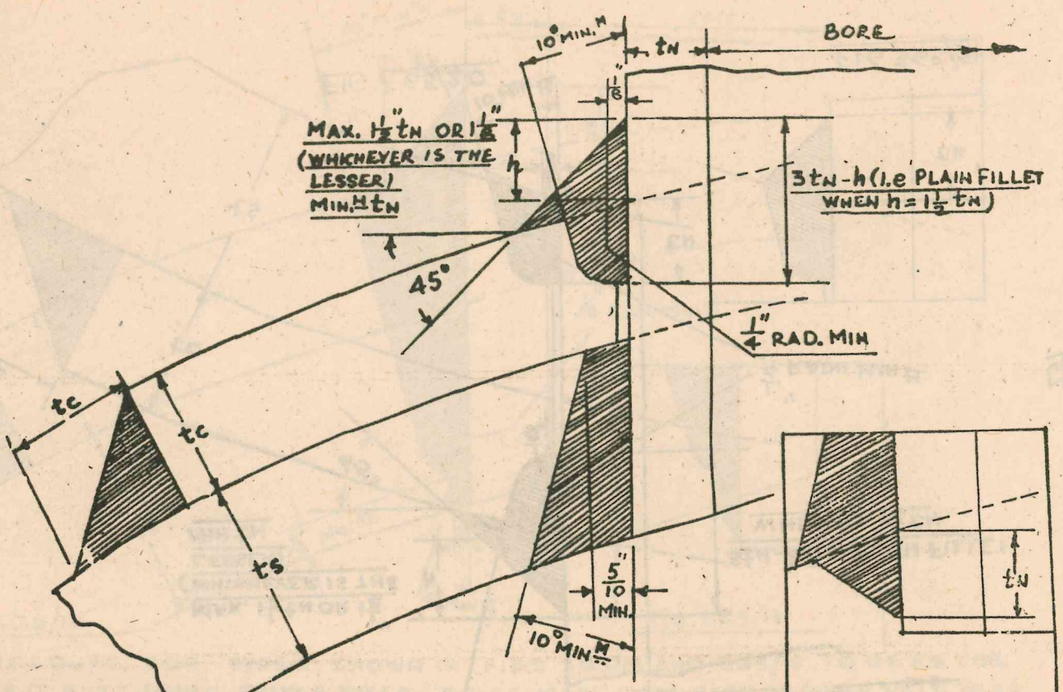


FIG. 365/22

FIG. 365/23

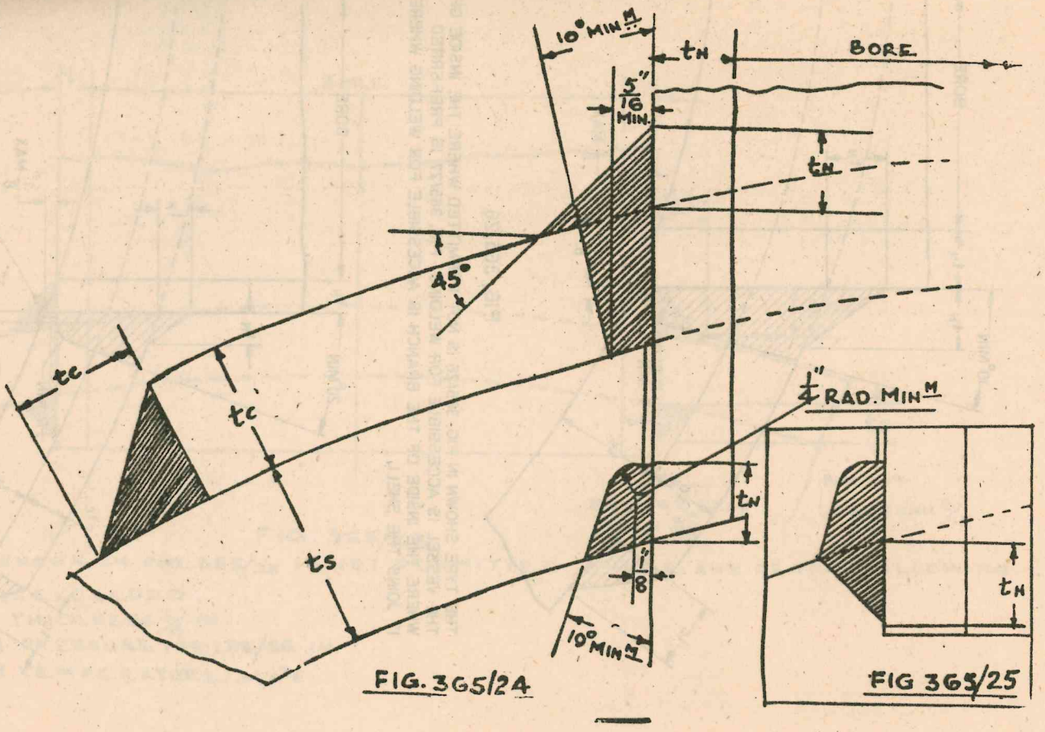


FIG. 365/24

FIG 365/25

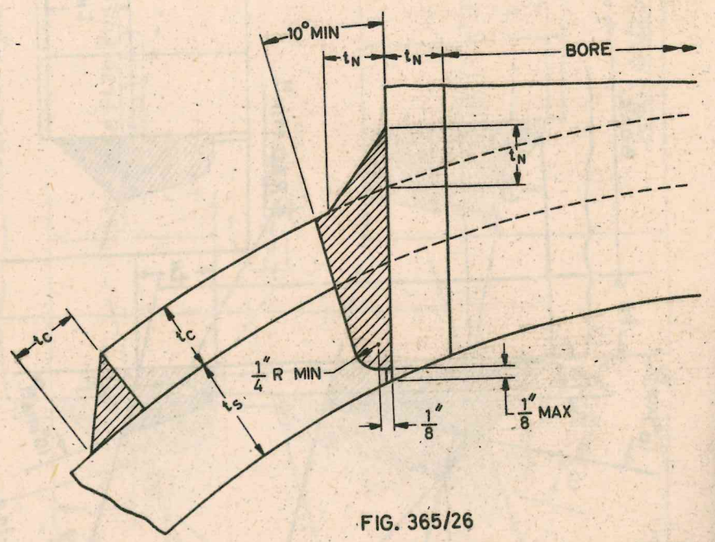


FIG. 365/26

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 JOINS THE SHELL

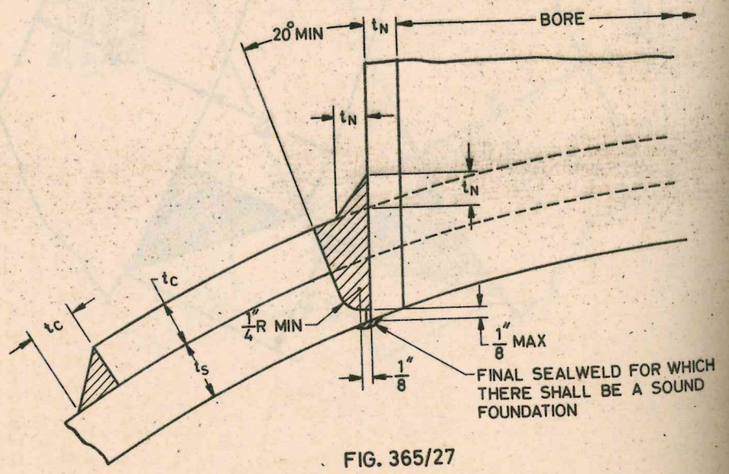


FIG. 365/27

THE TYPE SHOWN IN FIG. 365/27 IS NOT PERMITTED WHERE THE SHELL THICKNESS EXCEEDS 1 INCH.

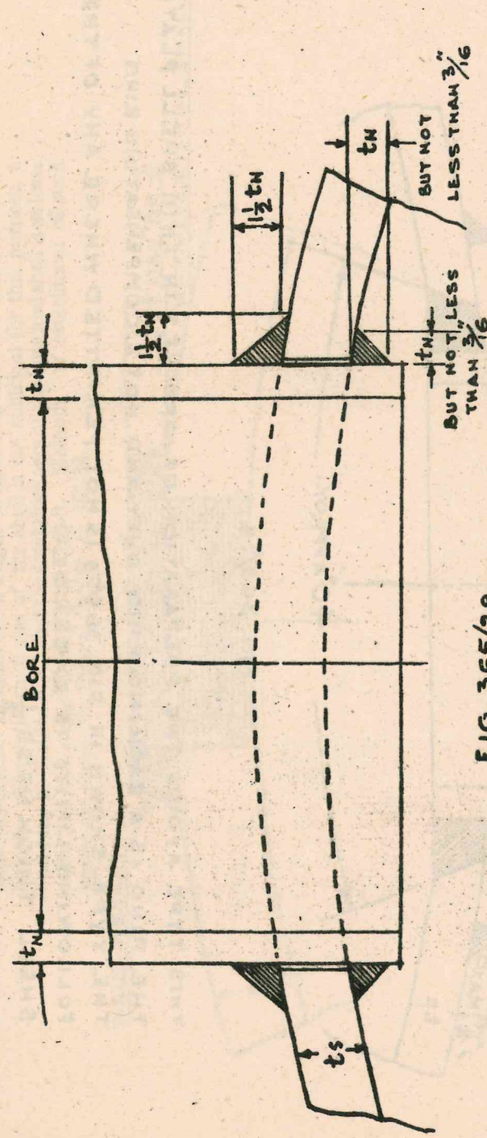


FIG. 365/28

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.

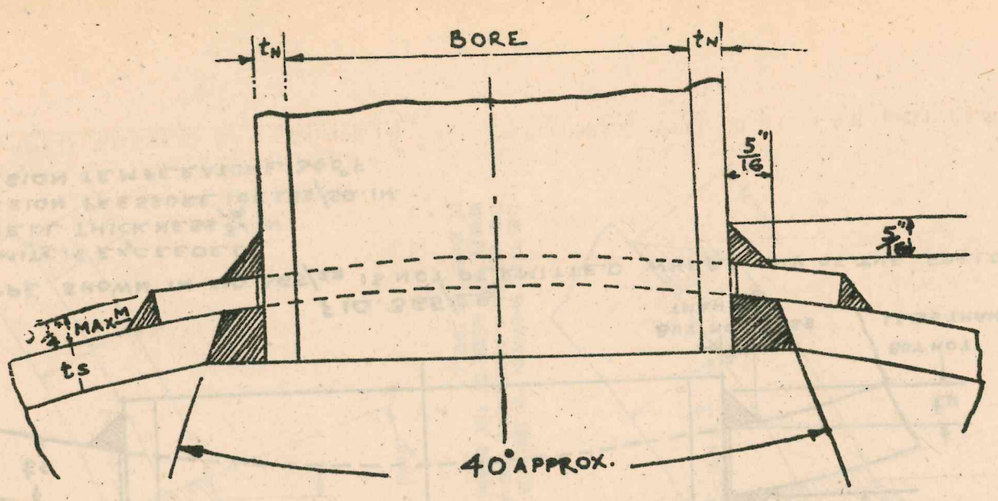


FIG. 365/29

THIS TYPE AVOIDS THE PREPARATION OF GROOVES IN THIN SHELL 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 $\frac{1}{2}$"
DESIGN PRESSURE 105 LBS/SQ.IN.
DESIGN TEMPERATURE 340°F.

Branches of not more than 1-1/2 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 at least equal to the required length of thread. Methods of attachment of such bosses are shown in Figures 365/30 to 365/34.

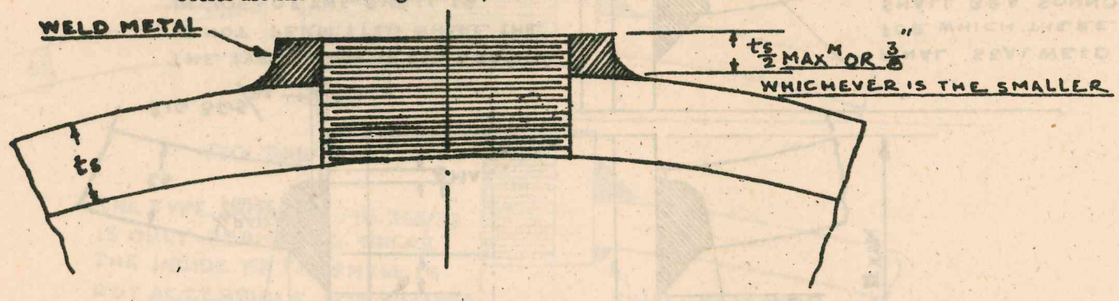
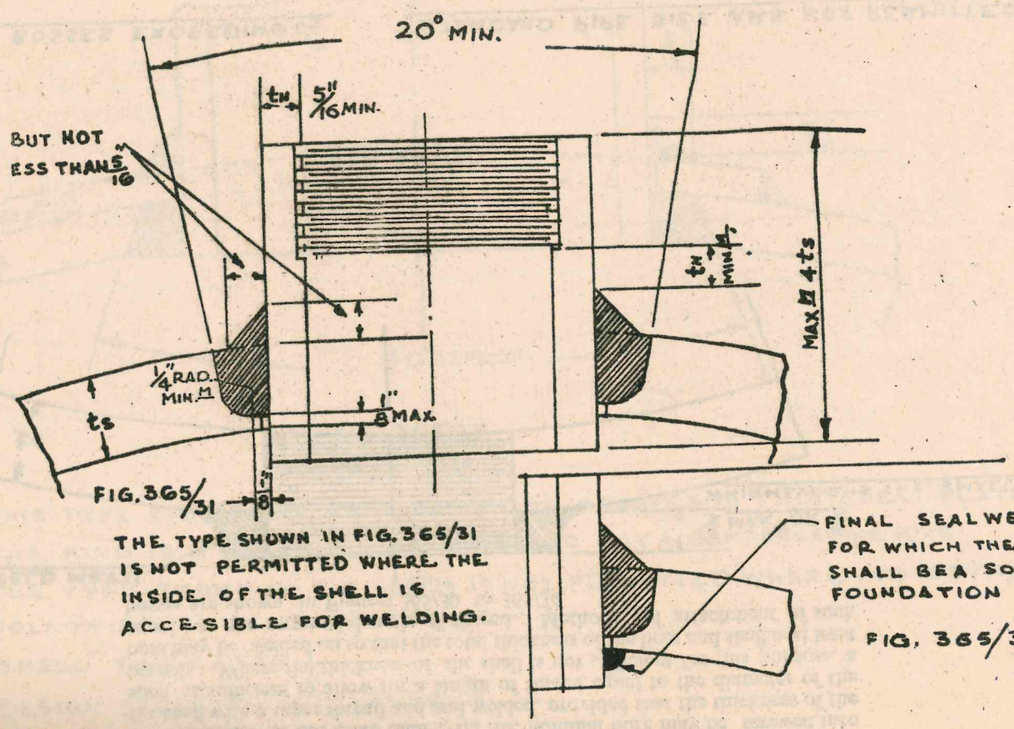


FIG. 365/30

TAPPED BOSSES EXCEEDING $1\frac{1}{2}$" STANDARD PIPE SIZE ARE NOT PERMITTED.



THE TYPE SHOWN IN FIG. 365/31 IS NOT PERMITTED WHERE THE INSIDE OF THE SHELL IS ACCESIBLE FOR WELDING.

FIG. 365/32

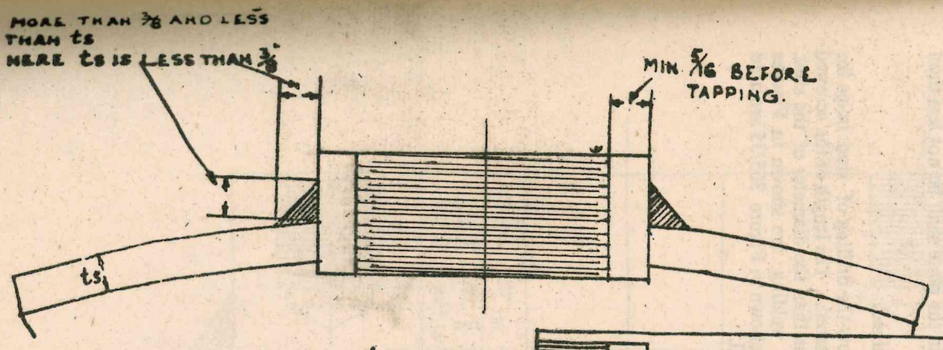


FIG. 365/33

THE TYPE SHOWN IN FIG. 365/33 IS ONLY PERMITTED WHERE THE INSIDE OF THE SHELL IS NOT ACCESSIBLE FOR WELDING

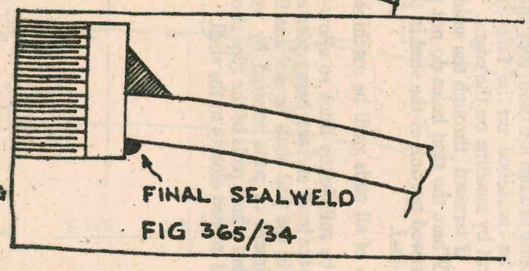


FIG 365/34

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" STANDARD PIPE SIZE ARE NOT PERMITTED

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 Regulation 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 joint 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 Figures 365/35 to 365/41, but where pads of the type shown in Figure 365/35 are used they shall be formed to bed closely to the shell.

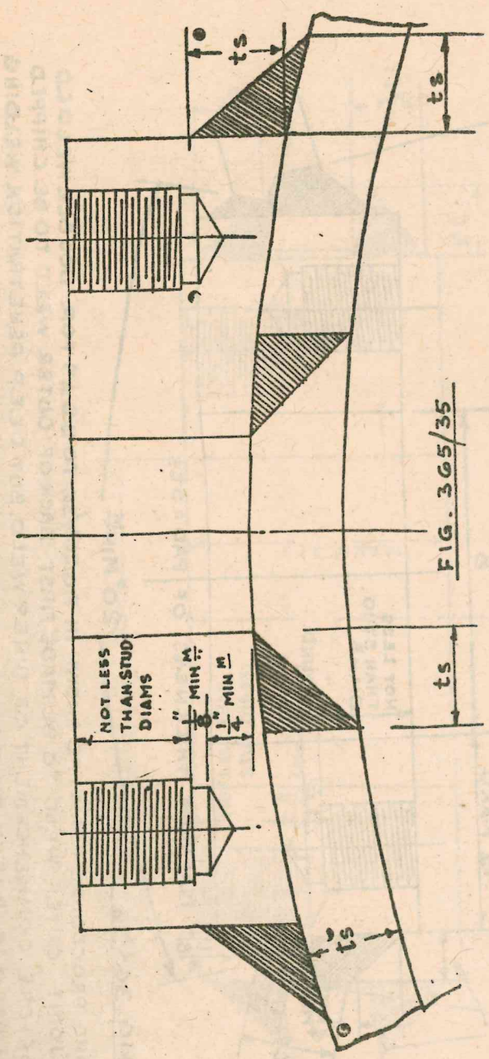


FIG. 365/35

THE TYPE SHOWN IN FIG. 365/35 IS NOT PERMITTED WHERE THE SHELL THICKNESS EXCEEDS 3/4 INCH.

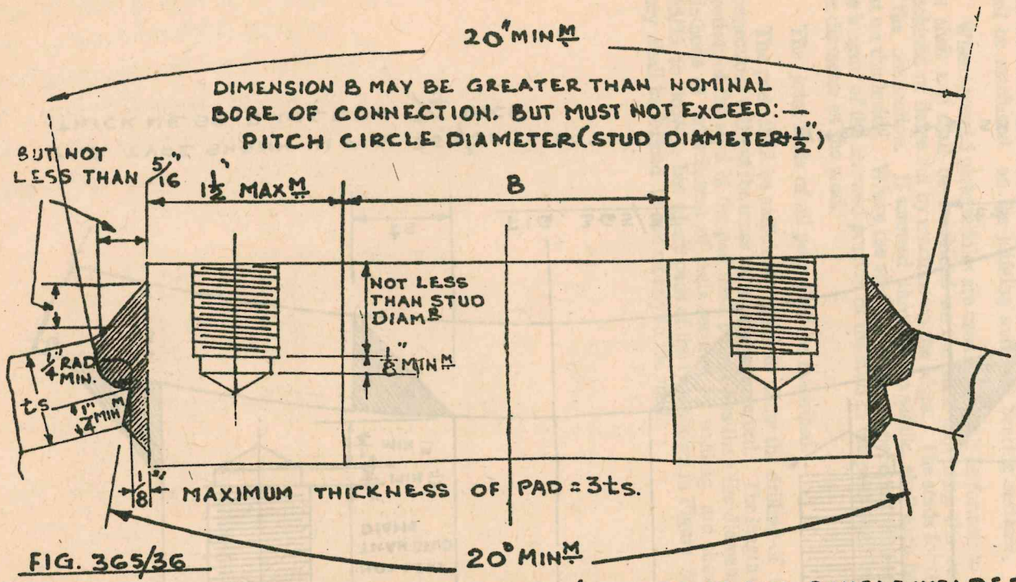


FIG. 365/36

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.

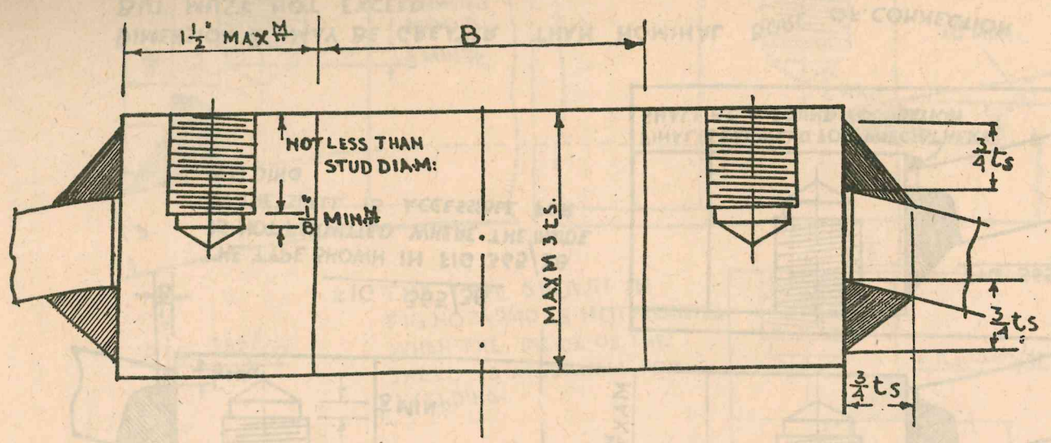


FIG 365/37.

Tapped bosses of not more than 1-1/2 ins. standard pipe size, 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 Figures 365/30, 365/34.

All welded attachments other than flang 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.

(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 butt 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.—All shells designed for a pressure exceeding 500 lbs./sq. in. or shells of which the product of the designed pressure in lbs./sq. in. and the internal diameter in inches exceeds 21,000 or the designed temperature exceeds 650°F.

Class II.—All shells designed for working below the limits specified for Class I.

Fusion welds, preparaion of seams, 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 all 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 up to a thickness 10 per cent greater than thickness of the late. 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.

* All shells shall be stress relieved by heat treatment after completion of all welding and before the hydraulic test. The heat treatment shall conform to the requirements of Chapter XII.

(3) *Seamless Forged Shells.*—These shall comply with the requirements of Regulations 235 to 243.

366. Determination of Working Pressure.—(a) Shells.—The maximum working pressure of shells shall be determined by the following formula:—

$$W.P. = \frac{2fE\,(T - \cdot 03)}{D + T - \cdot 03}$$

Where, T is Thickness in inches.

D is Maximum internal diameter in inches.

W.P. is Working pressure in lbs./sq. inch.

* f is Permissible working stress in lbs./sq. inch at the working metal temperature.

E is Efficiency of longitudinal riveted seam as given in Regulation 177.

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.

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 shells other than fusion welded shells.	Upto and including 24	1/4
	Over 24 and up to & including 36	5/16
	Over 36	3/8

* The maximum permissible stresses for cylindrical parts of seamless fusion welded and riveted shells shall not exceed those given below:—

Design Temperature F°	Tensile strength 28-32 tons/sq. in.	Tensile strength 32-36 tons/sq. in.	Tensile strength 36-38 tons/ sq. in.
	Seamless, fusion welded or riveted shells	Seamless shells	Seamless shells
	lbs./sq. in.	lbs./sq. in.	lbs./sq. in.
Upto 650	15,700	18,000	19,000
700	15,200	17,200	18,200
750	13,400	14,800	15,500
800	11,300	12,100	12,500
850	8,900	9,300	9,500
900	6,300	6,300	6,300

Intermediate values may be obtained by linear interpolation.

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 quality' as in Appendix D.

* The maximum permissible stress (f) for shells made from weldless pipes shall be those as given in table below:—

Design temperature		Cold drawn or Hot-finished weldless steel
	°F	lbs. /sq. in.
Upto	500	13,000
	550	12,500
	600	11,800
	650	11,100
	700	10,300
	750	9,500
	800	8,500
	850	7,500
	875	6,800
	900	5,600

Intermediate values may be obtained by linear interpolation.

The suitability of circumferential seams of riveted shells including the seams joining the ends of the cylindrical parts of the shell shall be verified by the following formula:—

$$W.P. = \frac{Ef\,(T - \cdot 06)}{CD}$$

Where E= Joint efficiency expressed as a fraction calculated by formuale in Regulation 177.

W.P.= Working pressure, in lbs./sq. in.

D= Inside diameter of the outer strake of plating of the cylindrical shell in inches.

T= Thickness of the plate, in inches.

f= Maximum permissible working stress in lbs./sq. in. at the working metal temperature given in column 1 of the table of stresses in sub-regulation (a) above.

C= 0·0257 where the seams are made with lap joints and treble riveted.
= 0·264 where the seams are made with lap joints and are double riveted.
= 0·300 where the seams are made with lap joints and are single riveted.

Compensation for openings in shells.—Where the major axis or diameter of any hole cut in cylinderical part of the shall is greater than 2½ times the thinckness of the shell plate plus 2½ 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 temperature.

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 279.

(b) End Plates.—(1) Dished End Plates.—The maximum working pressure of 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 Figur e No. 366/1.

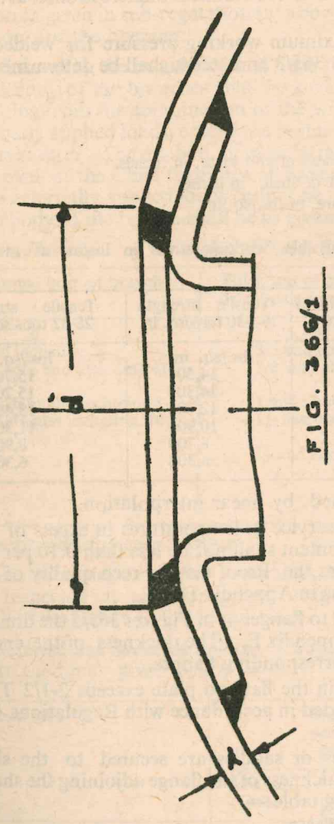


FIG. 366/1

ELLIPTICAL MANHOLE FRAME WELDED TO DISHED END PLATE.

NOTE: THE DIAMETER OF THE COMPENSATING PLATE SHALL NOT EXCEED TWICE OUTSIDE DIAMETER OF THE BRANCH

* The value of E= 1·00 where compesation is equal to or greater than required under Regulatisn 637.

$$\frac{\text{Diameteral cross sectional area of shell openings to be compensated}}{\text{Diameteral cross sectional area of frame and/or ring.}}$$

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 figures Nos. 365/2, 365/3 and 365/4, shall be determined by the following formula:—

$$W.P. = \frac{fT^2}{Cd^2}$$

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
* f = Maximum permissible working stress in lbs/in. as in the table below:—

Working metal temperature	Tensile strength 24—28 tons per sq. in	Tensile strength 26—30 tons/sq. in.	Tensile strength 28-32 tons.sq. in.
°F	lbs./sq. in.	lbs./sq. in.	lbs./sq. in.
Upto 650	13,400	14,500	15,700
700	13,200	14,300	15,200
750	12,000	12,700	13,400
800	10,500	10,900	11,300
850	8,500	8,700	8,900
900	6,300	6,300	6,300

Intermediate values may be obtained by linear interpolation.

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 reep quality of carbon steel plates of boiler plate quality' as in Appendix D.

Where flat end plates are bolted to flanges as in Figures 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 2-1/2 T+2-3/4 inches compensation shall be provided in accordance with Regulations 170 and 279.

(c) Branches.—Where branches or 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	Minimum thickness of flange
in.	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 flangers 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 ..	.. 3/4 and above	3/8
Over 2½ upto and including 4½	7/8 and above	7/16 — for thinner shells not less than one half the thickness of the cylinderical part of the shell.
Over 4½ upto and including 8	.. 1 and above	1/2
Over 8 upto and including. 10	.. 1¼ and above	5/8
Over 10	.. 1¼ and above	Subject to approval of the Chief 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. Screwed and socketed Joints.**—Couplings or sockets may be used on pipes within the limits given below:—

Nominal bore	Maximum permissible pressure		Maximum permissible temperature	
	Lbs./sq. inch.	Kg²/Cm	°C	°F
Upto and including 25mm (1 in.)	175	12·25	260	500
Over 25mm (1") upto and including 38 mm (1½"). ..	150	10·5	260	500
Over 38 mm (1½") upto and including 76mm (3").	125	8·75	260	500
Over 76mm (3") upto and including 102 mm (4").	100	7	260	500
Over 102 mm (4") upto and including 127 mm (5 in.).	120	8·5	177	350
	100	7	171	340

In all other cases, flanges, with bolts and nuts shall be used.

* **368. Other Fittings and Mountings.**—(a) Valve chests of bronze for stop valves up to 3 in. diameter of bore may be attached directly to steel pipes when pressures do not exceed 120 lbs. per sq. in. gauge and temperature not exceeding 425° F. The attachment may be by direct screwing to the steam pipe or by means of flanges.

(b) Drain cocks and valves may be attached to steam-pipes either by flange and bolts or be screwed into a boss formed on the pipe.

369. Reducing Valve.—Where a reducing valve is installed in a pipe line the pipe line 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.—The pipes shall be arranged so that the system is sufficiently flexible to absorb the whole of their expansion without the sum of the longitudinal pressure stress and the longitudinal bending stress exceeding the stress (S) given in Table 3, under the operating conditions within the limits of the working pressures and temperatures, except where the torsional stress is significant in which case the resultant combination of stress shall be taken into account. Where practicable, the requisite flexibility shall be provided in the layout of the pipes without having recourse to special expansion bends or expansion joints except for the safety valve discharge piping. The use of sliding expansion joints is prohibited. Additional stresses not specifically allowed for in the calculation such as circumferential being stress, or stress concentrations produced by abrupt changes of section should be kept to a a reasonable minimum.

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 warming 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 point.

(c) It is recommended that a by pass 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 pipe lines 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 to the test pressure H lbs./sq. in. determined from the following equation subject to a maximum test pressure of 316.3 kg/cm² (4500 lbs./sq. in.).

$$H = 1.7\ P \times \frac{S \text{ at } 260\ C\ (500\ ^\circ F)}{S \text{ at } T}$$

P = Maximum permissible pressure.

S = Maximum permissible working stress.

T = Design temperature.

(b) Pipes and fittings with flanges for steam pressures exceeding 7 kg/cm² (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 hydrualic pipes testing machine.

(c) Where the joints in a pipe system are of welded construction, the system shall, after erection, be tested hydraulically to twice the maximum permissible pressure, where the pressure does not exceed 35 kg/cm² (500 lbs./sq. in.) and to 1¼ times the maximum permisible pressure or 70 kg/cm² (1000 lbs./sq. in.), whichever is the greater where the maximum permissible pressure exceeds 35kg./cm² (500 lbs/sq. in.):

Provided that stress due to all causes including the stress due to the hydraulic test pressure shall not exceed 40 per cent of the minimum tensile strength of the material of pipes.

(d) Special arrangements shall be made, according to circumstances, for testing bends and other fittings which are not flanged.