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Local & Mun'l. (1898) Department.

MISCELLANEOUS.

G.O., No. 2180 M

DATED 16-12-98

INDEXED

[Despatch Abstract.]

Steam-boilers and Prime-movers Act, 1893.

Recording Ord. P.C. & D. approving & ordering to be published in the Nova Scotia Royal Gazette, the revised Rules under the ~~Act~~ Submitted by the Sanitary Engineer.

BACK PAPERS.

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BUILDINGS AND ROADS.
CIVIL WORKS.

# Government {1898} of Madras.

## PUBLIC WORKS.

LOCAL & MUNICIPAL DEPT.
CURRENT No. 3731 /98

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*Recd.* } 1898. *Enclosures*

*Regd.* *Spare copies*

**G.O., No. 3009 W., 24th November 1898.**

N
Misc Order
Recorded.

RP 14/12/98 ale 15/12/98

**NOVEMBER.**

**Steam-boilers and Prime-movers Act, 1893**

The revised rules under the —, submitted by the Sanitary Engineer, approved and ordered to be published in the *Fort St. George Gazette*.

14/12

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

**Buildings and Roads.**
**Civil Works.**

Read—again the following paper:—

G.O., No. 3104 W., dated 8th November 1897.

Read—also the following papers:—

From Messrs. BINNY and CO., dated 4th December 1897.

From A. S. RUSSELL, Esq., Acting Sanitary Engineer to Government, to the Secretary to Government, Public Works Department, dated Fort St. George, 9th March 1898, No. 319.

In reply to your endorsement No. 5333 C., dated 8th December 1897, on letter from Messrs. Binny & Co., I have the honour to forward copy of letter, No. 50, dated 8th instant, from the Inspector of Steam-Boilers.

2. Until a reply has been received to a reference which has been made to England for the Board of Trade rules, the query regarding F as a numerator cannot be properly answered, as there would appear to be some discrepancy between this formula and the formula commonly used. Pending receipt of a reply, the Boiler Inspector's recommendation to attach the sketches of the joints to the rules, and to publish both and allow an extension of time for criticisms, might be given effect to.

3. Rule 33 of the existing rules requires amending as follows:—

In the first line—

*For* "the area per square foot of fire grate surface of safety valves, or"
*Read* "the area of safety valves per square foot of fire grate surface, or".

From the Sanitary Engineer to Government, dated 23rd March 1898, No. 604.

From J. A. JONES, Esq., MEM. INST. C.E., F.R.S.E., Sanitary Engineer to Government, to the Secretary to Government, Public Works Department, dated Fort St. George, 12th July 1898, No. 1161.

With reference to your memo., No. 1758 C. of 22nd March 1898, and in continuation of my No. 319 of 9th March 1898, I have the honour now to submit, for the approval of Government, a draft of the proposed amendment to the Boiler Inspection rules.

2. The rules have been thoroughly revised with reference to the Boiler Inspector's letter enclosed in mine above quoted, and they now appear in a complete form, alterations and additions to existing rules being shown for convenient comparison in italics.

3. Omissions or substitutions cannot be shown in this way, but there is only one of importance, viz., the substitution of the rules sanctioned in G.O., No. 1018 W. of 10th April 1897, by the new rule numbered 22 (*b*), which not only covers the former rule, but is of more general application.

4. The rules are based on the Board of Trade rules.

5. The rules as now submitted include of course those published for receipt of suggestion in the *Fort St. George Gazette* of the 15th June and 30th November 1897, but which rules were not confirmed—it is in fact due to criticisms received in respe of the later issue of November 1897 that these present proposals are now subm



Order—No. 3009 W., dated 24th November 1898.

The revised rules under the Steam-boilers and Prime-movers Act, 1893, submitted by the Sanitary Engineer, with his letter No. 1161, dated 12th July 1898, are approved and will be published in the *Fort St. George Gazette*, with the following notification:—

NOTIFICATION.

In exercise of the powers conferred by section 23 of the Madras Steam-boilers and Prime-movers Act, 1893, His Excellency the Governor in Council proposes to issue the following revised rules under the said Act, in substitution of those already published. The Government will consider any suggestions made in respect of these rules which may be received within three months from date of publication hereof.

*A.—Preliminary.*

1. These rules may be called the Boiler Examination Rules.

2. In these Rules—
   (*a*) "The Act" means the Madras Steam-boilers and Prime-movers Act, 1893;
   (*b*) "Section" means a section of the said Act;
   (*c*) "Examination" means the examination of boilers under the Act, and "examination fees" means fees leviable on account of the examination of boilers.

*B.—The Inspector.*

3. The Inspector shall not undertake any professional work unconnected with his business under the Act except with the approval, or under the orders, of Government.

4. The Inspector shall receive such salary as Government may determine, all examination fees being credited to Government.

5. The Inspector shall have an office in which all records connected with the working of the Act shall be kept.

6. The Inspector shall keep the following records:—
   (*a*) a register of examination fee receipts;
   (*b*) a book containing counterfoils of licences;
   (*c*) a register of boilers in the following form which has been prescribed under section 9:—

| Name of owner. | Place where boiler is situated. | Registry number and description of boiler and age. | Nominal horse power. | When, where and by whom made. | When and where last repaired. | Date of grant of licence. | Maximum pressure at which boiler may be worked. | Time for which this licence is to be in force. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

   (*d*) a book containing a detailed account of every examination made by him;
   (*e*) a diary of the work done by him from day to day;
   (*f*) a register of licences suspended or revoked under section 11 (this register to be prepared upon information furnished to the Inspector by the suspending or revoking authority, *i.e.*, the Sanitary Engineer);
   (*g*) a register showing the result of appeals presented under section 12 (this register to be prepared upon information furnished to the Inspector by the Chief Presidency Magistrate).

7. The Inspector shall furnish to the Sanitary Engineer, on the third working day of every month, a copy of his diary for the preceding month.

8. All examination fees shall be paid into the Madras Bank by the owners of boilers, and no boiler shall be examined under section 5 unless the notice sent to the Inspector under that section is accompanied by a Bank receipt for the fee; and the Inspector, if he finds that the right fee has not been paid, may decline to examine the boiler until it has been paid.

9. An extract from the register of examination fee receipts which is compiled by the Inspector from the Bank receipts referred to in Rule 8 shall be forwarded by him, monthly, to the Accountant-General who shall verify it by reference to the amount actually received on account of examination fees during the month to which the extract relates and forward it to the Sanitary and C[illegible]ineer for record.

14/12

10. The Inspector shall be subordinate to the Sanitary Engineer and shall obey all lawful orders issued to him by that officer.

*C.—Examinations.*

11. Examination fees shall be paid in accordance with the following scale:—

| | | | | | | | | Rs. |
|---|---|---|---|---|---|---|---|---|
| (i) | For the examination of each boiler not exceeding | | | | 10 | N.H.P. | ... | |
| (ii) | ,, | ,, | ,, | ,, | 20 | ,, | ... | 12 |
| (iii) | ,, | ,, | ,, | ,, | 30 | ,, | ... | 16 |
| (iv) | ,, | ,, | ,, | ,, | 50 | ,, | ... | 24 |
| (v) | ,, | ,, | ,, | boiler exceeding | 50 | ,, | ... | 32 |
| | | | | | | | | 40 |

12. Examinations will not be made on Sundays except in cases of absolute necessity; in such cases the fees may be increased 25 per cent., the Inspector and his staff being allowed to divide the additional fee amongst them in proportion to their pay.

*Iron Boilers.*

13. The Inspector is required by the Act to fix the pressure to be allowed on boilers. In performing this very responsible and onerous duty he must be very careful, as in the event of accident it will be necessary for him to prove clearly that he used due caution. On the one hand he must be careful as regards safety, and on the other hand he must not unduly reduce the pressure on a boiler.

14. The Inspector should fix the working pressure for boilers by a series of calculations of the strength of the various parts, and according to the workmanship and material.

In the case of boilers made in India, the Inspector may receive and examine plans and particulars of boilers before the commencement of manufacture with the object of preventing questions arising after the boilers are finished.

When the Inspector has received plans and tracings of new boilers, or of alterations of boilers, and has approved of them, he will, of course, be careful in making his examination, when the boiler is ready for work, to see that they have been followed out. When he has not had the plans submitted, but is called in to inspect a boiler, he will, of course, measure the parts, note the details of construction, and, if necessary, bore the plates to ascertain their thickness, &c., before he gives his certificate.

The Inspector shall not declare a boiler to be safe unless (*a*) he is fully informed as to its construction, material and workmanship, or unless (*b*) he is furnished with a certificate from a Chief Engineer of a recognised boiler insurance company. He should therefore be very careful how he ventures to give a certificate.

15. In the case of new boilers the Inspector may allow a stress not exceeding 7,000 lb. per square inch of net section on solid iron screwed stays supporting flat surfaces, but the stress should not exceed 5,000 lb. when the stays have been welded or worked in the fire.

The areas of diagonal stays are found in the following way: Find the area of a direct stay needed to support the surface, multiply this area by the length of the diagonal stay, and divide the product by the length of a line drawn at right angles to the surface supported to the end of the diagonal stay; the quotient will be the area of the diagonal stay required.

When gusset stays are used, their area should be in excess of that found in the above way.

*A stress of 6,000 lb. may be allowed on the net section of iron stay tubes, providing that the net thickness is in no case less than $\frac{1}{4}$ inch. When screwed stays are used, and the threads are fine, the depth of the nuts should be at least $1\frac{1}{4}$ times the diameter of the stay.*

16. When the tops of combustion boxes or other parts of a boiler are supported by solid rectangular girders, the following formula should be used for finding the working pressure to be allowed on the girders, assuming that they are not subjected to a greater temperature than the ordinary heat of steam, and in the case of combustion chambers that the ends are fitted to the edges of the tube plate and the back plate of the combustion box.

$$\frac{C \times d^2 \times T}{(W-P)\, D \times L} = \text{Working Pressure.}$$

W = Width of combustion box in inches.
P = Pitch of supporting bolts in inches.
D = Distance between the girders from centre to centre in inches.
L = Length of girder in feet.
d = Depth of girder in inches.
T = Thickness of girder in inches.
*N = Number of supporting bolts.*

$C = \frac{N \times 1{,}000}{N+1}$ *when the number of bolts is odd.*

$C = \frac{(N+1)\ 1{,}000}{N+2}$ *when the number of bolts is even.*

The working pressure for the supporting bolts and for the plate between them should be determined by the rule for ordinary stays.



17. The pressure on plates forming flat surfaces is found by the following formula:—

$$\frac{C \times (T+1)^2}{S-6} = \text{Working Pressure.}$$

T = Thickness of the plate in sixteenths of an inch.
S = Surface supported in square inches.
C = Constant according to the following circumstances.

C = 100 when the plates are not exposed to the impact of heat or flame, and the stays are fitted with nuts and washers, the latter being at least three times the diameter of the stay and two-thirds the thickness of the plates they cover.*

C = 90 when the plates are not exposed to the impact of heat or flame, and the stays are fitted with nuts only.

C = 60 when the plates are exposed to the impact of heat or flame, and steam in contact with the plates, and the stays fitted with nuts and washers, the latter being at least three times the diameter of the stay and two-thirds the thickness of the plates they cover.

C = 54 when the plates are exposed to the impact of heat or flame, and steam in contact with the plates, and the stays fitted with nuts only.

C = 80 when the plates are exposed to the impact of heat or flame with water in contact with the plates, and the stays screwed into the plates and fitted with nuts.

C = 60 when the plates are exposed to the impact of heat or flame, with water in contact with the plates, and the stays screwed into the plates, having the ends riveted over to form substantial heads.

C = 36 when the plates are exposed to the impact of heat or flame, and steam in contact with the plates, with the stays screwed into the plates, and having the ends riveted over to form substantial heads.

*C = $67\frac{1}{2}$ when the plates are not exposed to the impact of heat or flame and the stays are screwed into the plates and riveted over.*

In cases where plates are stiffened by T or L irons, and a greater pressure is required for the plates than is allowed by the use of the above constants, the case should be submitted for the consideration of the Sanitary Engineer.

When the riveted ends of screwed stays are much worn or when the nuts are burned, the constants should be reduced, but the Inspector must act according to the circumstances that present themselves at the time of inspection, and it is expected that in cases where the riveted ends of screwed stays in the combustion boxes and furnaces are found in this state, it will be often necessary to reduce the constant 60 to about 36.

The Inspector should not in any case allow a greater compressive stress on the edge of the tube plates than 7,500 lb. per square inch, which is that used in the following formula:—

$$\frac{(D-d)\ T \times 15{,}000}{W \times D} = \text{Working Pressure.}$$

D = least horizontal distance between centres of tubes in inches.
d = inside diameter of ordinary tubes in inches.
T = thickness of tube plate in inches.
W = extreme width of combustion box in inches from front of tube plate to back of fire-box, or distance between combustion box tube plates when boiler is double ended and the box common to the furnaces at both ends.

18. The Inspector should take care that boilers, the outside of which cannot be seen, are cleared of all covering and fittings for inspection whenever the Inspector considers it necessary. It will often be found necessary to reduce the pressure, unless the boilers are partially cleared from their seats to enable the Inspector to judge of their condition. If the owners in any special case have any good reasons for not wishing to clear them when the Inspector requires it, the Inspector should submit the whole case in detail to the Sanitary Engineer for his consideration. The Inspector must recollect that he is not to certify as sufficient any boiler respecting which he cannot thoroughly satisfy himself.

The Inspector should record in his inspection book the dates on which boilers are inspected, when and to what extent cleared from brick work, and whether the boilers were set or not when examined, and if not set, where they were examined. Boilers which have been cleared should in all cases be subjected to the hydraulic test before the brick work is rebuilt.

19. Boilers well constructed, well designed, and made of good material, should have an advantage in the matter of working pressure over boilers inferior in any of the above respects, as unless this is done the superior boiler is placed at a disadvantage, and good workmanship and material will be discouraged. The following rules are therefore prescribed.

When cylindrical boilers are made of the best material with all the rivet holes drilled in place and all the seams fitted with double butt straps each of at least five-eighths the thickness of the plates they cover, and all the seams at least double riveted with rivets having an allowance of not

* If the diameter of riveted washers be at least two-thirds the pitch of the stays, and the thickness not less than the plates they cover, the constant may be increased to 150.

When doubling plates are fitted of the same thickness as the plates they cover and not less in width than two-thirds the pitch of the stays, the constant may be increased to 160.

*When doubling plates cover the whole of the flat surface, the case should be submitted for the consideration of the Sanitary Engineer.*

more than 75 per cent. over the single shear and provided that the boilers have been open to inspection during the whole period of construction, then 5 may be used as the factor of safety. The tensile strength of the iron is to be taken as equal to 47,000 lb. per square inch with the grain, and 40,000 lb. across the grain. But when the above conditions are not complied with, the additions in the following scale must be added to the factor 5, according to the circumstances of each case :—

| | | |
|---|---|---|
| A* | ·15 | To be added when all the holes are fair and good in the longitudinal seams, but drilled out of place after bending. |
| B* | ·3 | To be added when all the holes are fair and good in the longitudinal seams, but drilled out of place before bending. |
| C | ·3 | To be added when all the holes are fair and good in the longitudinal seams, but punched after bending instead of drilled. |
| D | ·5 | To be added when all the holes are fair and good in the longitudinal seams, but punched before bending. |
| E† | ·75 | To be added when all the holes are not fair and good in the longitudinal seams. |
| F | ·1 | To be added if the holes are all fair and good in the circumferential seams, but drilled out of place after bending. |
| G* | ·15 | To be added if the holes are fair and good in the circumferential seams, but drilled before bending. |
| H | ·15 | To be added if the holes are fair and good in the circumferential seams, but punched after bending. |
| I* | ·2 | To be added if the holes are fair and good in the circumferential seams, but punched before bending. |
| J† | ·2 | To be added if the holes are not fair and good in the circumferential seams. |
| K | ·2 | To be added if double butt straps are not fitted to the longitudinal seams, and the said seams are lap and double riveted. |
| L | ·1 | To be added if double butt straps are not fitted to the longitudinal seams, and the said seams are lap and treble riveted. |
| M | ·3 | To be added if only single butt straps are fitted to the longitudinal seams and the said seams are double riveted. |
| N | ·15 | To be added if only single butt straps are fitted to the longitudinal seams and the said seams are treble riveted. |
| O | 1·0 | To be added when any description of joint in the longitudinal seams is single riveted. |
| P | ·1 | To be added if the circumferential seams are fitted with single butt straps and are double riveted. |
| Q | ·2 | To be added if the circumferential seams are fitted with single butt straps and are single riveted. |
| R | ·1 | To be added if the circumferential seams are fitted with double butt straps and are single riveted. |
| S | ·1 | To be added if the circumferential seams are lap joints and are double riveted. |
| T | ·2 | To be added if the circumferential seams are lap joints and are single riveted. |
| U | ·25 | To be added when the circumferential seams are lap, and the strakes of plates are not entirely under or over. |
| V‡ | ·3 | To be added when the boiler is of such a length as to fire from both ends, or is of unusual length, as in the case of flue boilers; and the circumferential seams fitted as described opposite P, R, and S, but of course when the circumferential seams are as described opposite Q and T, V ·3 will become V ·4. |
| W† | ·4 | To be added if the seams are not properly crossed. |
| X† | ·4 | To be added when the iron is in any way doubtful, and the Inspector is not satisfied that it is of the best quality. |
| Y§ | 1·65 | To be added if no certificate is produced from a Chief Engineer of a recognized Boiler Insurance Company or if the boiler was not open to inspection during the whole period of its construction by the Inspectors of any recognized Boiler Insurance Company. |

* When the holes are to be rimered, or bored out in place, the case should be submitted to the Sanitary Engineer as to the reduction or omission of A, B, G, and I as heretofore.

*Note.*—If the iron be tested and the elongation measured in a length of 10 inches is not less than 14 per cent. with, and 8 per cent. across, the grain, and the Inspector is otherwise satisfied as to the quality of the plates and rivets, then 4·5 may be used instead of 5 in which case the minimum actual tensile strength of the plates shall be used in calculating the working pressure.

† Where marked † the factor of safety should be increased still further if the workmanship or material is very doubtful or is very unsatisfactory.

‡ When boilers are comparatively short, the cases should be submitted to the Sanitary Engineer for consideration as to the omission of V as heretofore.

*Welded seams in shells receivers, or domes of iron boilers shall be considered as having a strength not exceeding 70 per cent. of the solid plate.*

§ *The recognition of a certificate under this rule is limited to new boilers when first licensed and to boilers not more than 10 years old provided they have not shown any defect during that period; should the plates of a boiler have become pitted or unduly scaled when exposed to the impact of flame or should the material have become deteriorated or should the boiler be one which was not subject to periodical inspection or cannot be efficiently examined internally it will be in the discretion of the Inspector to increase the factor of safety as above.*



When the circumferential seams are double strapped and double riveted or lapped and treble riveted, and the calculated strength not less than 65 per cent. of the solid plate V, ·3 may be omitted as heretofore.

The strength of ordinary joints is found by the following method :—

$$\frac{(\text{Pitch} - \text{Diameter of rivet}) \times 100}{\text{Pitch}} = \left.\right\} \text{Percentage of strength of plate at joint as compared with the solid plate.}$$

*For the maximum pitch of rivets, see Appendix.*

$$\frac{(\text{Area of rivet} \times \text{No. of rows of rivets}) \times 100}{\text{Pitch} \times \text{thickness of plate}} = \left.\right\} \text{Percentage of strength of rivets as compared with the solid plate.*}$$

Then take iron as equal to 47,000 lb. per square inch and use the smaller of the two percentages as the strength of the joint, and adopt the factor of safety as found from the preceding scale.

$$\frac{(47{,}000 \times \text{percentage of strength of joint}) \times \text{twice the thickness of the plate in inches.}}{\text{Inside diameter of the boiler in inches} \times \text{factor of safety}} = \text{Pressure to be allowed per square inch on the safety-valves.}$$

In the case of ordinary zigzag riveting the strength through the plate diagonally between the rivets, when diagonal pitch $= \frac{6}{10}$ horizontal pitch $+ \frac{4}{10}$ diameter of rivet.

Plates that are drilled in place must have been taken apart and the burr taken off and the holes slightly countersunk from the outsides.

Butt straps must have been cut from plates and not from bars, and must be of as good a quality as the shell plates, and for the longitudinal seams must be cut across the fibre. The rivet holes may have been punched or drilled when the plates are punched or drilled out of place, but when drilled in place must have been taken apart and the burr taken off and slightly countersunk from the outside.

When single butt straps are used and the rivet holes in them punched, they must be one-eighth thicker than the plates they cover.

The diameter of the rivets must not be less than the thickness of the plates of which the shell is made, but it will be found when the plates are thin, or when lap joints or single butt straps are adopted, that the diameter of the rivets should be in excess of the thickness of the plates.

Dished ends must be stayed as flat surfaces; but when they are theoretically equal to the pressure needed, when considered as portions of spheres, the stays when solid may have a stress of 14,000 lb. per square inch of net section, but the stress should not exceed 10,000 lb. when the stays have been welded or worked in the fire.

Truly hemispherical ends subjected to internal pressure may be allowed double the pressure that is suitable for a cylinder of the same diameter and thickness.

All man-holes and openings must be stiffened with compensating rings of at least the same effective sectional area as the plates cut out, and in no case should the plate rings be less in thickness than the plates to which they are attached. The openings in the shells of cylindrical boilers should have their shorter axes placed longitudinally. It is very desirable that the compensating rings round openings in flat surfaces be made of L or T iron. Cast-iron doors are not to be passed.

The neutral part of boiler shells under steam domes must be efficiently stiffened and stayed, as serious accidents have arisen from the want of such precautions.

20. New boilers are to be tested by hydraulic pressure according to the following scale :—

Boilers intended to work up to 100 lb. pressure per square inch or any pressure below that are to be tested to double the working pressure.

| | | | | | |
|---|---|---|---|---|---|
| Above lb. | 100 | up to lb. | 125 | to be tested to lb. | 200. |
| ,, | 125 | ,, | 150 | ,, | 230. |
| ,, | 150 | ,, | 175 | ,, | 250. |
| ,, | 175 | ,, | 200 | ,, | 270. |
| ,, | 200 | ,, | 225 | ,, | 290. |
| ,, | 225 | ,, | 250 | ,, | 310. |
| ,, | 250 | ,, | 275 | ,, | 330. |
| ,, | 275 | ,, | 300 | ,, | 350. |

Any boilers intended for working pressure above these to be tested to not less than 50 lb. above such working pressure.

In the case of old boilers the Inspector must use his own judgment as to the necessary pressure to be applied.

21. Circular furnaces with the longitudinal joints welded or made with a butt strap *double riveted or double butt straps single riveted.*

$$\frac{90{,}000 \times \text{the square of the thickness of the plate in inches}}{(\text{Length in feet} + 1) \times \text{diameter in inches}}$$

= working pressure per square inch, provided it does not exceed that found by the following formula: —

$$\frac{9{,}000 \times \text{thickness in inches}}{\text{diameter in inches}} = \left.\right\} \text{Working pressure per square inch.}$$

* If the rivets are exposed to double shear multiply the percentage as found by 1·75.

The second formula limits the crushing stress on the material to 4,500 lb per square inch.

The length is to be measured between the rings if the furnace is made with rings.

If the longitudinal joints instead of being butted are lap-jointed in the ordinary way, then 75,000 is to be used instead of 90,000, excepting only where the lap is bevelled and so made as to give the flues the form of a *true* circle, when 80,000 may be used.

When the material or the workmanship is not of the best quality, the constants given above must be reduced, that is to say, the 90,000 will become 80,000, the 80,000 will become 70,000, the 70,000 will become 60,000; when neither the material nor the workmanship is of the best quality, such constants will require to be further reduced, according to circumstances and the judgment of the Inspector, as in the case of old boilers. One of the conditions of best workmanship is that the joints are double riveted with double butt straps, or single riveted with double butt straps, and the holes drilled after the bending is done and when in place and the plates afterwards taken apart, the burr on the holes taken off and the holes slightly countersunk from the outside.*

The working pressure for corrugated furnaces, practically circular and machine made, provided the plane parts at the ends do not exceed 6 inches in length, and the plates are not less than $\frac{5}{16}$ths of an inch thick, should not be greater than found by the following formula:—

$$\frac{9{,}000 \times \text{thickness in inches}}{\text{Mean diameter in inches}} = \text{Working pressure per square inch.}$$

*The strength of the joints of cylindrical superheaters and the factor of safety are found in a similar manner as for cylindrical boilers and steam receivers, but instead of using 47,000 lb. as the tensile strength of iron 30,000 lb. is adopted, unless where the heat or flame impinges at or nearly at right angles to the plate, then 22,400 lb. is substituted.*

*When a superheater is constructed with a tube subject to external pressure, the working pressure should be ascertained by the rules given for circular furnaces, but the constants should be reduced as 30 to 47.*

*In all cases the internal steam pipe should be so fitted that the steam in flowing to them will pass over all the plates which have steam in contact with them, and are exposed to the impact of the heat or flame. Superheaters should, as regards survey, be deemed to be the most important part of the boilers and must be inspected inside and outside; those that cannot be entered on account of their size or arrangement, must have a sufficient number of doors through which a thorough inspection of the whole of the interior can be made. Special attention should be paid to the survey of superheaters as with high pressures the plates may become dangerously weak and not give any sound to indicate their state when tested with a hammer; the plates should therefore be occasionally drilled. Drilling of furnace and the lower parts of combustion box plates, shell plates, &c., should of course be done when considered necessary in order to ascertain their actual thickness. If flaming is found to be of frequent occurrence in any boiler, extra care must be taken in the survey and in fixing the pressure as to be allowed as the tensile strength of plate when heated is often reduced to about 4 tons per square inch. Drain pipes must in all cases be fitted to superheaters in which a collection of water in the bottom is possible. Superheaters that can be shut off from the main boilers should be fitted with a parliamentary safety-valve of sufficient size, but the least size passed without special sanction of the Sanitary Engineer should be three inches in diameter.*

*The flat ends, &c., of all boilers, as far as the steam space extends and the ends of superheaters should be fitted with shield or baffle plates where exposed to the hot gases in the uptake.*

*As the uptakes of haystack boilers and others of similar type are especially liable to injury from overheating unless careful precautions are taken while steam is being raised, the Inspector must in all cases persuade makers and owners of such boilers to make the strength of uptakes considerably in excess of that required for ordinary superheaters subject to external pressures.*

---

* The following examples will serve to show the application of the constants for the different cases that may arise:—

Furnaces with butt joints and drilled rivet holes—
- 90,000 where the longitudinal seams are welded.
- 90,000 " " " double riveted and fitted with single butt straps.
- 80,000 " " " single " single "
- 90,000 " " " " double "

Furnaces with butt joints and punched rivet holes—
- 85,000 where the longitudinal seams are double riveted and fitted with single butt straps.
- 75,000 " " " single " single "
- 85,000 " " " " double "

Furnaces with lapped joints and drilled rivet holes—
- 80,000 where the longitudinal seams are double riveted and bevelled.
- 70,000 " " " " " and not bevelled.
- 70,000 " " " single " and bevelled.
- 65,000 " " " " " and not bevelled.

Furnaces with lapped joints and punched rivet holes—
- 75,000 where the longitudinal seams are double riveted and bevelled.
- 70,000 " " " " " and not bevelled.
- 65,000 " " " single " and bevelled.
- 60,000 " " " " " and not bevelled.

In the case of upright fireboxes of donkey or similar boilers 10 per cent. should be deducted from the constants given above, applicable to the respective classes of work.



*The employment of Bowling rings is beneficial by adding to the strength as well as allowing for expansion, but if there is a difficulty in getting these fitted, hoops riveted round, although not so desirable as Bowling rings, can be employed to increase the resistance of the tubes against collapse. The use of Bowling rings with a moderate thickness of plate is better than very thick plating. This applies to the uptakes of all boilers of this type including ordinary vertical donkey boilers. Bowling rings fitted to all such uptakes would be a decided advantage in allowing for expansion. When flaming coal is used extra care is required and extra strength absolutely necessary.*

*Steel Boilers.*

22. For steel boilers the rules for iron boilers may be *varied* as follows:—

The constants for flat surfaces when they are supported by stays screwed into the plate and riveted, 10 per cent. The constants for flat surfaces when they are supported by stays screwed into the plate and nutted, or when the stays are nutted in the steam space, 25 per cent. This is also applicable to the constants for flat surfaces stiffened by riveted washers or doubling strips, and supported by nutted stays.

The constants for combustion box girders, 10 per cent.

*The constants for plain furnaces, 10 per cent.*

*In cases where the Inspector is satisfied from tests made on the steel from which the boiler has been constructed that it is of a certain tensile strength per square inch, that strength may be substituted for the 47,000 lb. (allowed for iron plates) in the formula given in Rule 19, but in no case is a greater strength than 32 tons (71,680 lb.) to be allowed. In other cases, provided there is sufficient proof that the boiler is of steel, a minimum of 26 tons may be used.*

*Solid steel screwed stays which have not been welded or otherwise worked after heating may be allowed a working stress of 9,000 lb. per square inch of net section. Steel stays which have been welded or worked in the fire have been found to be unreliable; therefore, they should not be passed.*

Furnaces corrugated or ribbed and grooved.

22 (*a*). *When furnaces are machine-made by The Leeds Forge Company, of the Fox corrugated and Morison suspension types, or by Messrs. John Brown & Co., Sheffield, of the Purves ribbed and grooved type, if they are practically true circles, and the plates not less than $\frac{5}{16}$ths of an inch thick, the working pressure is found by the following formula:—*

$$\frac{C \times T}{D} = \text{working pressure.}$$

$C$ = 14,000 *for Fox's corrugated and Brown's ribbed and grooved furnaces.*
$C$ = 13,500 *for Morison's suspension furnace.*
$T$ = *thickness in inches.*
$D$ = *outside diameter in inches, measured at the bottom of the corrugations when the furnace is of the corrugated or suspension type, or over the plain parts when it is of the ribbed and grooved description.*

*In Fox's corrugated furnaces, the pitch of the corrugations and the length of the plain parts at the ends should not exceed 6 inches, and in Morison's suspension furnaces the pitch should not exceed 8 inches, and the length at the ends 5 inches. In both descriptions of furnaces the depth from top of corrugations outside to bottom of corrugations inside should not be less than 2 inches, and the plates at the ends should not be unduly thinned in the flanging.*

*The plates of ribbed and grooved furnaces should be formed by rolling, the ribs should not be less than $1\frac{5}{16}$ inches above the plain parts, and the depth of the grooves not more than $\frac{3}{4}$ inch, the length between the centres of the ribs not over 9 inches, and that of the plain parts at the ends not over 6 inches, and the ends rolled slightly thicker than the plain parts, and not reduced at any part by flanging, &c., below the thickness of the body of the furnace.*

*If the furnace is riveted in one or more lengths the case should be submitted for consideration of the Sanitary Engineer.*

Furnaces made up of flanged rings.

22 (*b*). *When horizontal furnaces of ordinary diameter are constructed of a series of rings welded longitudinally, and the ends of each ring flanged and the rings riveted together, and so forming the furnace, the working pressure is found by the following formula, provided the length in inches between the centres of the flanges of the rings is not greater than (120 $T$—12), and the flanging is performed at one heat by a suitable flanging machine, and also the conditions which follow the formula are complied with:—*

$$\frac{9{,}900 \times T}{3 \times D}\left(5 - \frac{l + 12}{60 \times T}\right) = \text{working pressure.}$$

$T$ = *thickness of plate in inches.*
$l$ = *length between centre of flanges in inches.*
$D$ = *outside diameter of furnace in inches.*

*The radii of the flanges on the fire side should be about $1\frac{1}{2}$ inches. The depth of the flanges from the fire side should be three times the diameter of the rivet plus $1\frac{1}{2}$ inches, and the thickness of the flanges should be as near the thickness of the body of the plate as practicable. The distance from the edge of the rivet holes to the edge of the flange should not be less than the diameter of the rivet, and the diameter of the rivets at least $\frac{3}{8}$ths of an inch greater than the thickness of the plate. The depth of*

*the ring between the flanges should be not less than three times the diameter of the rivets, the fire edge of the ring should be about the termination of the curve of flange, and the thickness not less than half the thickness of the furnace plate. Turned rings are such as may be considered a first-class method of construction.*

*The holes in the flanges and rings should be drilled in place if practicable, but if not drilled in place they should be drilled sufficiently small, and afterwards when in place rimered out until the holes are quite fair, the holes should be slightly tapered and the heads of the rivets of moderate size.*

*After all the welding, flanging and heating is completed, each ring should be efficiently annealed in one operation.*

*Compressive stress on tube plates.*

22 (*c*). *A greater compressive stress should not be allowed on tube plates than 10,000 lb., which is that used in the following formula :—*

$$\frac{(D - d)\ T \times 20{,}000}{W \times D} = \textit{working pressure.}$$

*D = least horizontal distance between centres of tubes in inches.*
*d = inside diameter of ordinary tubes in inches.*
*T = thickness of tube plate in inches.*
*W = extreme width of combustion-box in inches from front of tube plate to back of fire box, or distance between combustion-box tube plates when boiler is double-ended and the box common to the furnaces at both ends.*

22 (*d*). *When full allowance is wished the rivet section, if iron, in the longitudinal seams of cylindrical shells should, when those seams are lapped, be at least $1\frac{3}{8}$ times the net plate section, and if steel rivets are used, their section should be at least $\frac{28}{23}$ of the net section of the plate, if the tensile stress of the rivets is not less than 26 tons and not more than 32 tons per square inch. In calculating the working pressure, the percentage strength of the rivets may be found in the usual way by the Rules, but in the case of iron rivets the percentages found should be divided by $1\frac{3}{8}$, and in the case of steel rivets by $\frac{28}{23}$, the results being the percentages required. If the percentage strength of the rivets by calculation is less than the calculated percentage strength of the plate, calculate the working pressure by both percentages. When using the percentage strength of the plate 4·5 plus the additions suitable for the method of construction as per Rule 19 for iron boilers, may be used as the nominal factor of safety, but when using the percentage strength of the rivets 4·5 may be used as the factor of safety. The less of the two pressures so found is the working pressure to be allowed for the cylindrical portion of the shell. See formulæ in Appendix.*

*Plate and rivet section.*

*Boilers—General.*

23. Small boilers must be surveyed and be fitted the same way as the main boilers, and have a water and steam gauge, and all other fittings complete, and as regards safety-valves, must comply with the same regulations as the main boilers.

24. No boilers or steam chamber is to be so constructed, fitted, or arranged so that the escape of steam from it through the safety-valve can be wholly, or partially, intercepted by the action of any other valve.

A stop-valve must always be fitted between the boiler and the steam pipe, and, where two or more boilers are connected with a steam receiver or superheater, between each boiler and the superheater or steam receiver. The object of this is obvious, viz., to avoid the failure of all the boilers through the failure of one. The necks of stop-valves should be as short as practicable.

25. Each boiler must be fitted with a glass water-gauge, at least two test cocks, and steam-gauge, that is to say, each boiler must be fitted with all fittings as complete as if there were only one boiler. When a factory has more than one boiler, and these boilers are fitted with stop-valves, each boiler must be treated as a separate one, and have all the requisite fittings.

26. On every inspection of a steam boiler the Inspector shall, if the boiler is large enough, go inside it, and make a thorough examination of it.

When the boilers are not large enough for the Inspector to get into, he should see them tested by hydraulic pressure at every annual inspection at least. The hydraulic test should also be applied at every inspection if the Inspector considers it necessary.

Whenever it is only removable stays that prevent getting in, he must order their removal, and he must see them properly replaced before granting his declaration.

If any part of a main boiler near the uptake fire boxes or furnaces is so constructed that the Inspector cannot examine it, he is not to give a declaration, but shall report the case to the Sanitary Engineer.

If, for special reasons, and for special reasons only, the Inspector cannot go inside a small boiler, he must distinctly state on the face of his declaration his reasons for not being able to do so.

27. If the boiler is too hot for the Inspector to examine the inside efficiently, and with safety and convenience, he should decline to examine the boiler, and absolutely refuse to grant a certificate, until he can make an efficient internal examination.

28. Before testing a boiler the Inspector shall examine it, take the necessary measurements, and calculate what the working pressure should be in accordance with the regulations, and only test it with reference to that pressure in accordance with Rule 20. If the test is not satisfactory, the pressure must be proportionately reduced.



This course will enable any necessary alterations to be made by the owners and prevent delay or disappointment. The Inspector who grants the certificate should not increase the working pressure without first consulting the Sanitary Engineer.

The Inspector who grants the certificate must examine the boilers thoroughly, and, in the absence of special instructions from the Sanitary Engineer, will be held responsible for the pressure allowed.

29. The Inspector shall see all new boilers, and boilers that have been cleaned for a thorough repair, tested by hydraulic pressure, in accordance with Rule 20 previous to the boilers being set, and before they are covered in, to test the workmanship, &c.; but the working pressure is to be determined by the strength of stays, thickness of plates, and strength of riveting, &c., and not by the hydraulic test.

The hydraulic test should in no case exceed twice the calculated working pressure of the boiler, and it is never to be applied until the boiler has been examined and until the strength has been calculated from the necessary measurements taken from the boiler itself.

When the boilers are set the Inspector may, at any time he thinks it necessary, before he gives a certificate, have them tested by hydraulic pressure to satisfy himself as to any doubtful part, or of places not easy of access, care being taken in the case of old boilers not to overstrain them; but the test must always exceed the working pressure.

The hydraulic test should before a certificate is granted be applied to all boilers that have not previously had a working certificate.

When a boiler is partially inspected by one Inspector, and the inspection is completed and a certificate granted by another, if the Inspector, who witnesses the test of the boiler by hydraulic pressure, has an opportunity of examining it inside and outside after the test, such Inspector should determine the pressure to be allowed on the boiler in question, taking care to inform the makers, owners, or agents, and the Inspector who is ultimately to grant a certificate, what pressure should in his opinion be allowed on it. In the event of the original Inspectors having no opportunity to examine the boiler inside and out after the hydrostatic test, the Inspector must re-test the boiler by water and examine the boiler inside and out before determining the working pressure and granting a certificate.

The amount of the hydraulic pressure test, and the date on which it was last applied to the boiler, should be inserted in the Inspector's certificate, and recorded in the dimension sheet of that boiler.

Inspectors should pay particular attention to the examination and testing of steam pipes and economisers.

*The working pressure of well-made copper pipes when the joints are brazed is found by the following formula :—*

$$\frac{6{,}000 \times (T - \frac{1}{16})}{D} = \textit{working pressure.}$$

*T = thickness in inches.*
*D = inside diameter in inches.*

*When the pipes are solid drawn and not over 8 inches diameter substitute in the foregoing formula $\frac{1}{32}$ for $\frac{1}{16}$.*

*The internal pressure on wrought-iron pipes made of good material, and lap welded, may be determined by the following formula, provided that the thickness is not less than $\frac{1}{4}$ inch and the workmanship, by hydraulic test, &c., satisfactory :—*

$$\frac{6{,}000 \times T}{D} = \textit{working pressure.}$$

*T = thickness in inches.*
*D = diameter inside in inches.*

*Feed pipes should be made sufficient for a pressure 20 per cent. in excess of boiler pressure.*

In all cases in which a socket expansion joint is fitted to a bent steam pipe, the Inspector should require a fixed gland and bolts to be fitted, in order to prevent the end of the pipe being forced out of the socket. This regulation should be complied with in all cases of bent pipes fitted with socket expansion joints. Fixed glands and bolts should be fitted to the expansion joints of straight steam pipes, as cases have occurred, particularly with small straight pipes, in which the ends of the pipes have been forced out of the sockets.

30. In all boilers in which the Inspector finds that cast iron is employed in such a manner as to be subject to the pressure of steam or water, he shall report the circumstances to the Sanitary Engineer in order that he may obtain instructions how to act. Cast iron must not be used for stays, and the Inspector should discourage the use of cast-iron saddles for boilers.

31. A pressure once allowed on a boiler is not, *under any circumstances whatever*, to be increased unless the Inspector has previously written for and obtained the sanction of the Sanitary Engineer.

In case the Inspector is of opinion that an increased pressure may with safety be allowed, he shall communicate with the Inspector who last inspected the boiler; and if on learning the reasons why the existing pressure was formerly allowed, the Inspector is still of opinion that it may be increased, he should communicate all the facts of the case to the Sanitary Engineer; but, as above stated, the pressure shall not in any case be increased until the question has been decided by him.

*Safety-valves.*

32. The Inspector is instructed that in all *new boilers*, and whenever *alterations can be easily made*, the safety-valve and stop-valve should be placed directly on the boiler; and the neck, or part between the valve and the flange which is bolted on to the boiler, should be as short as possible.

The Inspector should note that it is not intended by this instruction that old boilers which have been previously passed with such an arrangement should be thrown out of work for the alterations to be carried out.

Of course in any case in which the Inspector is of opinion that it is positively dangerous to have a length of pipe between the boilers and the safety-valve, it is his duty at once to insist on the requisite alterations being made before granting a declaration.

The Inspector shall declare, amongst other things, the limits of the weight to be placed on the safety-valves, and that the safety-valves are such and in such condition as the circumstances of the case demand.

33. The area of safety-valves per square foot of fire grate surface or (when there is more than one safety-valve on the boiler) the combined area of the safety-valves should be not less than that given in the following tables opposite the boiler pressure intended, provided the valves are not less than two inches in diameter. This applies to new boilers which have not received a working certificate.

In ascertaining the fire grate area, the length of the grate should be measured from the inner edge of the dead plate to the front of the bridge, and the width from side to side of the furnace on the top of the bars at the middle of their length.

If there is only one safety-valve on a *main* boiler the Inspector should not grant a certificate without first referring the case to the Sanitary Engineer for special instructions.

In the case of small boilers, if it is wished to fit valves smaller than two inches diameter, the case should be submitted for the consideration of the Sanitary Engineer.

*Safety-Valve Areas.*

| Boiler pressure. | Area of valve per square foot of fire grate. | Boiler pressure. | Area of valve per square foot of fire grate. | Boiler pressure. | Area of valve per square foot of fire grate. |
|---|---|---|---|---|---|
| LB. | SQ. INCH. | LB. | SQ. INCH. | LB. | SQ. INCH. |
| 15 | 1·250 | 62 | ·487 | 109 | ·302 |
| 16 | 1·209 | 63 | ·480 | 110 | ·300 |
| 17 | 1·171 | 64 | ·474 | 111 | ·297 |
| 18 | 1·136 | 65 | ·468 | 112 | ·295 |
| 19 | 1·102 | 66 | ·462 | 113 | ·292 |
| 20 | 1·071 | 67 | ·457 | 114 | ·290 |
| 21 | 1·041 | 68 | ·451 | 115 | ·288 |
| 22 | 1·013 | 69 | ·446 | 116 | ·286 |
| 23 | ·986 | 70 | ·441 | 117 | ·284 |
| 24 | ·961 | 71 | ·436 | 118 | ·281 |
| 25 | ·937 | 72 | ·431 | 119 | ·279 |
| 26 | ·914 | 73 | ·426 | 120 | ·277 |
| 27 | ·892 | 74 | ·421 | 121 | ·275 |
| 28 | ·872 | 75 | ·416 | 122 | ·273 |
| 29 | ·852 | 76 | ·412 | 123 | ·271 |
| 30 | ·833 | 77 | ·407 | 124 | ·269 |
| 31 | ·815 | 78 | ·403 | 125 | ·267 |
| 32 | ·797 | 79 | ·398 | 126 | ·265 |
| 33 | ·781 | 80 | ·394 | 127 | ·264 |
| 34 | ·765 | 81 | ·390 | 128 | ·262 |
| 35 | ·750 | 82 | ·386 | 129 | ·260 |
| 36 | ·735 | 83 | ·382 | 130 | ·258 |
| 37 | ·721 | 84 | ·378 | 131 | ·256 |
| 38 | ·707 | 85 | ·375 | 132 | ·255 |
| 39 | ·694 | 86 | ·371 | 133 | ·253 |
| 40 | ·681 | 87 | ·367 | 134 | ·251 |
| 41 | ·669 | 88 | ·364 | 135 | ·250 |
| 42 | ·657 | 89 | ·360 | 136 | ·248 |
| 43 | ·646 | 90 | ·357 | 137 | ·246 |
| 44 | ·635 | 91 | ·353 | 138 | ·245 |
| 45 | ·625 | 92 | ·350 | 139 | ·243 |
| 46 | ·614 | 93 | ·347 | 140 | ·241 |
| 47 | ·604 | 94 | ·344 | 141 | ·240 |
| 48 | ·595 | 95 | ·340 | 142 | ·238 |
| 49 | ·585 | 96 | ·337 | 143 | ·237 |
| 50 | ·576 | 97 | ·334 | 144 | ·235 |
| 51 | ·568 | 98 | ·331 | 145 | ·234 |
| 52 | ·559 | 99 | ·328 | 146 | ·232 |
| 53 | ·551 | 100 | ·326 | 147 | ·231 |
| 54 | ·543 | 101 | ·323 | 148 | ·230 |
| 55 | ·535 | 102 | ·320 | 149 | ·228 |
| 56 | ·528 | 103 | ·317 | 150 | ·227 |
| 57 | ·520 | 104 | ·315 | 151 | ·225 |
| 58 | ·513 | 105 | ·312 | 152 | ·224 |
| 59 | ·506 | 106 | ·309 | 153 | ·223 |
| 60 | ·500 | 107 | ·307 | 154 | ·221 |
| 61 | ·493 | 108 | ·304 | 155 | ·220 |



*Safety-Valve Areas*—cont.

| Boiler pressure. | Area of valve per square foot of fire grate. | Boiler pressure. | Area of valve per square foot of fire grate. | Boiler pressure. | Area of valve per square foot of fire grate. |
|---|---|---|---|---|---|
| LB. | SQ. INCH. | LB. | SQ. INCH. | LB. | SQ. INCH. |
| 156 | ·219 | 171 | ·201 | 186 | ·186 |
| 157 | ·218 | 172 | ·200 | 187 | ·185 |
| 158 | ·216 | 173 | ·199 | 188 | ·184 |
| 159 | ·215 | 174 | ·198 | 189 | ·183 |
| 160 | ·214 | 175 | ·197 | 190 | ·182 |
| 161 | ·213 | 176 | ·196 | 191 | ·181 |
| 162 | ·211 | 177 | ·195 | 192 | ·181 |
| 163 | ·210 | 178 | ·194 | 193 | ·180 |
| 164 | ·209 | 179 | ·193 | 194 | ·179 |
| 165 | ·208 | 180 | ·192 | 195 | ·178 |
| 166 | ·207 | 181 | ·191 | 196 | ·177 |
| 167 | ·206 | 182 | ·190 | 197 | ·176 |
| 168 | ·204 | 183 | ·189 | 198 | ·176 |
| 169 | ·203 | 184 | ·188 | 199 | ·175 |
| 170 | ·202 | 185 | ·187 | 200 | ·174 |

34. The Inspector in his examination of the boilers and appurtenances is particularly to direct his attention to the safety-valves, and whenever he considers it necessary, he is to satisfy himself as to the pressure on the boiler by actual trial.

The Inspector is to fix the limits of the weight to be placed on the safety-valves, and the responsibility of issuing a certificate before he is fully satisfied on the point is very grave. The Inspector is to examine the whole of the valves, weights, and springs at every inspection.

The responsibility of seeing to the efficiency of the mode by which the valves are fitted so as to be as much as practicable under the control of the Engineer when steam is up, rests with the Inspector.

The safety-valve should be fitted with lifting gear, which should in all cases be arranged so that it can be worked by hand.

Care should be taken that the safety-valves have a lift equal to at least one-fourth their diameter; that the openings for the passage of steam to and from the valves, including the waste steam pipe, should each have an area not less than the area of valves required, and that each valve-box has a drain pipe fitted at its lower part. In the case of lever valves, if the lever is not bushed with brass, the pins must be of brass; iron and iron working together must not be passed. Too much care cannot be devoted to seeing that there is proper lift, and free means of escape of waste steam, as it is obvious that unless the lift and means for escape of waste steam are ample, the effect is the same as reducing the area of the valve or putting on an extra load. The valve seats should be secured by studs and nuts.

The Inspector shall, as far as is in his power, make these points generally known to the owners of steam boilers.

*Safety-valves that are spring loaded.—The size of the steel of which the springs are made must be in accordance with that found by the following formula:—*

$$\sqrt[3]{\frac{S \times D}{C}} = d$$

*S = the load on the spring in lbs.*
*D = the diameter of the spring (from centre to centre of wire) in inches.*
*d = the diameter, or side of square of the wire in inches.*
*C = 8,000 for round steel.*
*C = 11,000 for square steel.*

*The springs shall be protected from the steam and impurities issuing from the valves.*

*When valves are loaded by direct springs the compressing screws shall abut against metal stops or washers when the loads sanctioned by the Inspector are on the valves.*

*The springs shall have a sufficient number of coils to allow a compression under the working load of at least one quarter the diameter of the valve.*

35. When the Inspector has determined the amount of pressure, he is to see the valves weighted accordingly and the weights or springs fixed in such a manner as to preclude the possibility of their shifting or in any way increasing the pressure. The limits of the weight on the valves is to be inserted in the declaration, and should it at any time come to the Inspector's knowledge that the weights or the loading of the valves have been shifted, or otherwise altered, or that the valves have been in any way interfered with, so as to increase the pressure, without the sanction of the Sanitary Engineer, he is at once to report the facts.

## APPENDIX.

(*See last paragraph of Rule* 22.)

## CYLINDRICAL BOILER SHELLS.

### Joints with Drilled Holes.

*Formulæ for ordinary chain-riveted and ordinary zigzag-riveted joints, and for joints of these descriptions, when every alternate rivet in the outer or in the outer and inner rows has been omitted—*

*Let* $E$ = *distance from edge of plate to centre of rivet in inches.*
$V$ = *distance between rows of rivets in inches.*
$V_1$ = *distance between inner and middle row of rivets in inches for joints J and K* (*Figs.* 18 *and* 15).
$B$ = *boiler pressure in lb. per square inch.*
$C$ = 1 *for lap or single butt joints.*
$C$ = 1·75 *for double butt joints.*
$d$ = *diameter of rivets in inches.*
$D$ = *inside diameter of boiler in inches.*
$F$ = *factor of safety for shell plates, as by Rules* 19 *and* 22(*d*).
$n$ = *number of rivets in one pitch.*
$p_D$ = *diagonal pitch in inches.*
$P_D$ = *diagonal pitch in inches between inner and middle rows of rivets in inches for joint J.*
$p$ = *greatest pitch of rivets in inches.*
$r$ = *percentage of plate left between holes in greatest pitch.*
$R$ = *percentage value of rivet section.*
$R_1$ = *percentage of combined plate and rivet section.*
$S$ = *tensile strength of material in lb. per square inch of section.*
$T$ = *thickness of plate in inches.*
$T_1$ = *thickness of each butt-strap in inches.*
% = *least value of r, R, R*$_1$, *as the case may be, divided by* 100.

*When joints are used in boiler construction other than those shown in the attached sketches, or when any of the rivets are pitched less than two diameters apart, the particulars of such joints should be submitted for the consideration of the Sanitary Engineer.*

### Ordinary Chain and Zigzag Riveted Joints.

*Iron plates and iron rivets or steel plates and steel rivets :*

$$\frac{100\ (p - d)}{p} = r.$$

*Iron plates and iron rivets :*

$$\frac{100 \times d^2 \times \cdot7854 \times n \times C}{p \times T} = R.$$

*Steel plates and steel rivets :*

$$\frac{100 \times 23 \times d^2 \times \cdot7854 \times n \times C \times F}{4{\cdot}5 \times 28 \times p \times T} = R.$$

### Given C, *d*, F, *n*, T, to find *p*, so that *r* and *R* are equal.

*Iron plates and iron rivets :*

$$\frac{d^2 \times \cdot7854 \times n \times C}{T} + d = p.$$

*Steel plates and steel rivets :*

$$\frac{23 \times d^2 \times \cdot7854 \times n \times C \times F}{4{\cdot}5 \times 28 \times T} + d = p.$$

### Given C, F, *n*, T, *r*, to find *p* and *d*.

*Iron plates and iron rivets :*

$$\frac{r \times T}{(100 - r) \times \cdot7854 \times n \times C} = d.$$

$$\frac{100 \times r \times T}{(100 - r)^2 \times \cdot7854 \times n \times C} = p.$$

*Steel plates and steel rivets :*

$$\frac{4{\cdot}5 \times 28 \times r \times T}{23 \times (100 - r) \times \cdot7854 \times n \times C \times F} = d.$$

$$\frac{100 \times 4{\cdot}5 \times 28 \times r \times T}{23 \times (100 - r)^2 \times \cdot7854 \times n \times C \times F} = p.$$

*Iron plates and iron rivets or steel plates and steel rivets when d is found first, then :*

$$\frac{100d}{100 - r} = p.$$



### Butt-Straps.

*Iron plates and iron butt-straps or steel plates and steel butt-straps :*
*Double butt-straps :*

$$\frac{5 \times T}{8} = T_1$$

*Single butt-straps :*

$$\frac{9 \times T}{8} = T_1$$

### For Distance between Rows of Rivets, &c.

*Iron and steel :*

$$\frac{3 \times d}{2} = E.$$

*Chain-riveted joints* (*Figs.* 2, 4, 6, 9, 11), *not less than :*

$$2 \times d = V.$$

*See note at the end.*

*Zigzag-riveted joints* (*Figs.* 3, 5, 7, 10, 12) *:*

$$\frac{\sqrt{(11p + 4d)\ (p + 4d)}}{10} = V.$$

*Diagonal pitch* (*Figs.* 3, 5, 7, 10, 12) *:*

$$\frac{6p + 4d}{10} = p_D.$$

### To determine the working pressure.

$$\frac{S \times \% \times 2\,T}{F \times D} = B.$$

### Chain and Zigzag Riveted Joints in which every alternate Rivet has been omitted in the Outer Row, or in the Outer and the Inner Rows such as are shown by the following Sketches :—

*Iron plates and iron rivets or steel plates and steel rivets :*

$$\frac{100\ (p - d)}{p} = r.$$

*Iron plates and iron rivets :*

$$\frac{100 \times d^2 \times \cdot7854 \times n \times C}{p \times T} = R.$$

*Steel plates and steel rivets :*

$$\frac{100 \times 23 \times d^2 \times \cdot7854 \times n \times C \times F}{4{\cdot}5 \times 28 \times p \times T} = R.$$

*Iron plates and iron rivets or steel plates and steel rivets :*

$$\frac{100\ (p - 2d)}{p} + \frac{R}{n} = R_1.$$

### Butt-Straps.

*Where the number of rivets in the inner row is double the number in the outer row—*
*Iron plates and iron butt-straps or steel plates and steel butt-straps—*
*Double butt-straps :*

$$\frac{5 \times T\ (p - d)}{8 \times (p - 2d)} = T_1.$$

*Single butt-straps :*

$$\frac{9 \times T\ (p - d)}{8 \times (p - 2d)} = T_1.$$

*When the number of rivets in the inner row is the same as in the outer row—*
*Double butt-straps :*

$$\frac{5 \times T}{8} = T_1.$$

*Single butt-straps :*

$$\frac{9 \times T}{8} = T_1.$$

### For distance between Rows of Rivets, &c.

*Iron and steel :*

$$\frac{3 \times d}{2} = E.$$

*Chain-riveted joints* (*Figs.* 13, 14, 15, 19):

$$\sqrt{\frac{(11p + 4d)(p + 4d)}{10}} = V \quad \text{or} \quad 2 \times d = V$$

} *The greater of these two values of V to be used. See note at the end.*

*For joint K* (*Fig.* 15):

$2 \times d = V_1$. *See note at the end.*

*Zigzag riveted joints* (*Figs.* 16, 17, 18, 20):

$$\sqrt{(\tfrac{11}{20}p + d)(\tfrac{1}{20}p + d)} = V.$$

*Diagonal pitch* (*Figs.* 16, 17, 18, 20):

$$\tfrac{3}{10}p + d = p_D.$$

*For joint J* (*Fig.* 18):

$$\sqrt{\frac{(11p + 8d)(p + 8d)}{20}} = V_1$$

*Diagonal pitch* (*Fig.* 18):

$$\frac{3p + 4d}{10} = P_D.$$

To determine the Working Pressure—

$$\frac{S \times \% \times 2T}{F \times D} = B.$$

*Note.—The minimum value of V or $V_1$ for chain riveted joints is given as 2d, but* $\frac{4d + 1}{2}$ *is more desirable.*

Maximum Pitches for Riveted Joints.

*T = Thickness of plate in inches.*
*p = Maximum pitch of rivets in inches, provided it does not exceed 10 inches.*
*C = Constant applicable from the following table :—*

| Number of rivets in one pitch. | Constants for lap joints. | Constants for double butt-strap joints. |
|---|---|---|
| 1 | | |
| 2 | 1·31 | |
| 3 | 2·62 | 1·75 |
| 4 | 3·47 | 3·50 |
| 5 | 4·14 | 4·63 |
| | | 5·52 |
| | | 6·00 |

$$(C \times T) + 1\tfrac{5}{8} = p.$$

*When the work is first class, such pitches may be adopted so far as safety is concerned, yet in some cases it may be well not to adopt the greatest pitch found by the formula. The maximum pitch should not, however, exceed 10 inches with the thickest plates for boiler shells. If in any case the pitch is found to exceed that arrived at by the foregoing formula, for the particular description of joint and thickness of plate, such pitches should not be passed, but in all cases reported to the Sanitary Engineer.*

(True Extract.)

A. C. Russell.

Under Secretary to Government.

To the Superintendent, Government Press.
„ the Sanitary Engineer to Government.
„ the Local and Municipal Department.
„ the Judicial Department.
„ Messrs. Binny & Co.
„ Messrs. Richardson & Cruddas, Bombay.

Narayana Aiyangar.

Fig. 1.

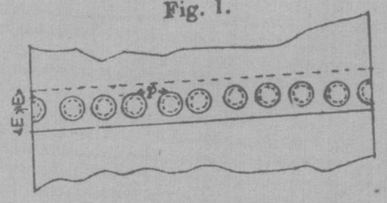


Fig. 2.

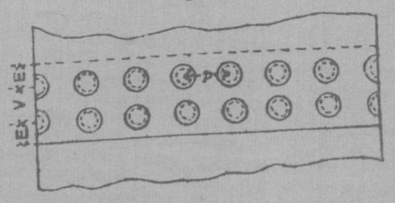


Fig. 3.

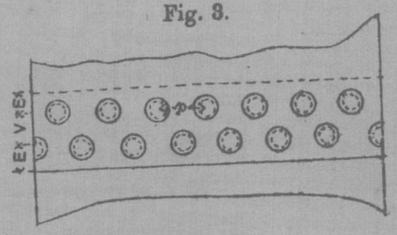


Fig. 4.

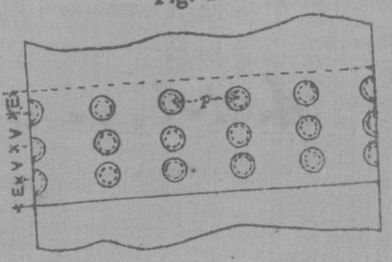


Fig. 5.

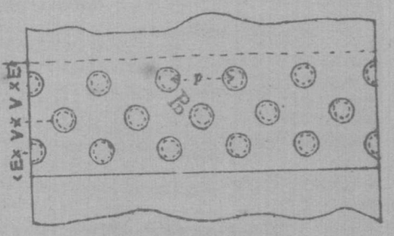


Fig. 6.

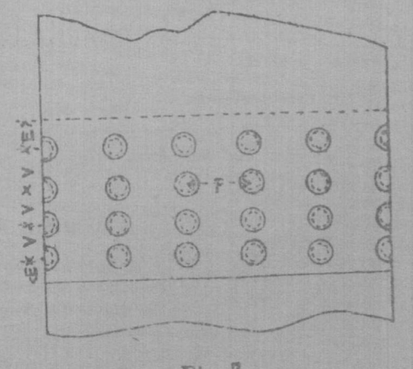


Fig. 7.

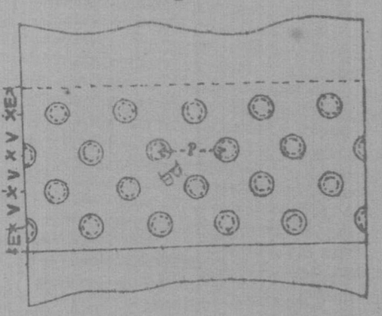


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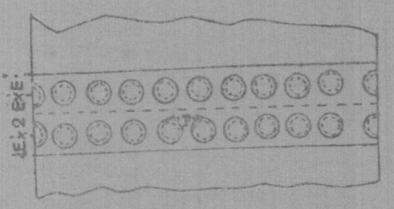


Fig. 9.

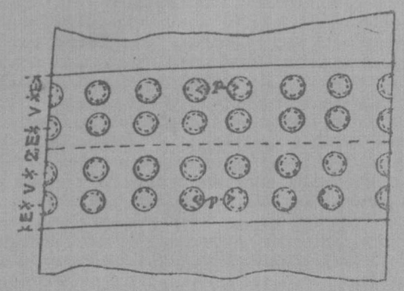


Fig. 12.

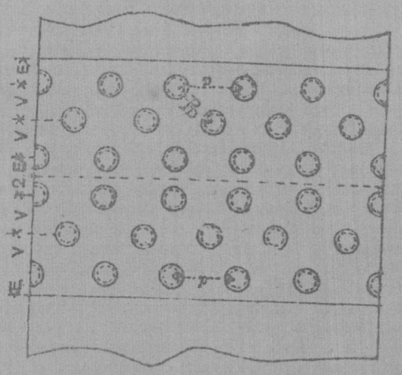


Fig. 10.

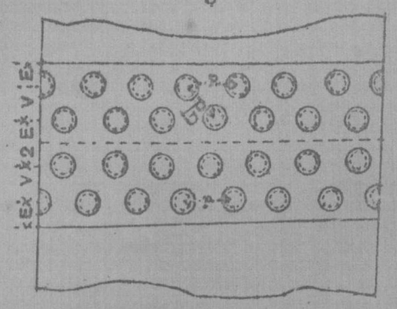


Fig. 13.

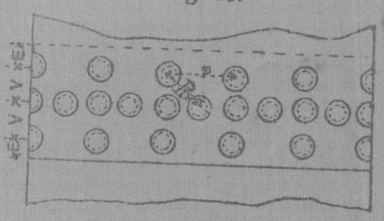


Fig. 11.

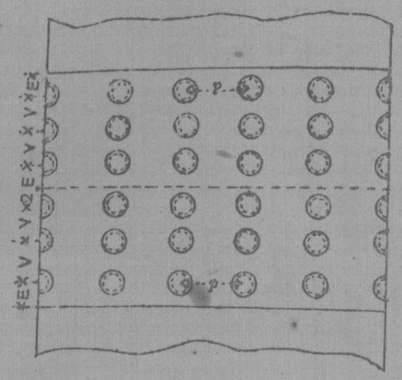
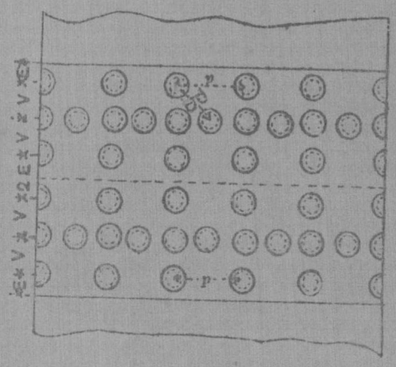


Fig. 14.



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