The Commonwealth of Massachusetts

DISTRICT POLICE

STEAM BOILER RULES

FORMULATED BY THE

BOARD OF BOILER RULES

ENFORCED BY THE BOILER INSPECTION DEPARTMENT
OF THE DISTRICT POLICE

BOSTON
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Publication of this Document
approved by the
Supervisor of Administration.

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BOARD OF BOILER RULES, STATE HOUSE, BOSTON.

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STEAM BOILER RULES

FORMULATED BY THE BOARD OF BOILER RULES.

[In accordance with the provisions of section 26, chapter 465, Acts of 1907, as amended by chapter 393, Acts of 1909, "An Act relative to the operation and inspection of steam boilers."]

The Rules previously issued and additions made thereto are arranged as follows: —

PART I. — These Rules, in addition to the Rules contained in Part II., apply to boilers installed on or **before** May 1, 1908.

PART II. — These Rules apply to **all boilers** now or hereafter installed, unless otherwise stated.

PART III. — These Rules, in addition to the Rules contained in Part II., apply to boilers installed **after** May 1, 1908.

Section 26 of the Acts of 1907, as amended by chapter 393 of the Acts of 1909, provides that "Changes made in the Rules which affect the construction of new boilers shall take effect six months after the approval of the same by the Governor."

The dates of previous editions of steam boiler rules formulated by this Board have been as follows: August 30, 1907; September 18, 1907; November 19, 1907; January 9, 1908; March 24, 1908; June 9, 1908; October 1, 1908; August 5, 1909; January 2, 1915; May 12, 1916.

PART I.

These Rules, in addition to the Rules contained in Part II., apply to boilers installed on or **before** May 1, 1908.

SECTION 1.

To determine maximum allowable pressure.

1. The maximum pressure to be allowed on a steel or wrought-iron shell or drum of a boiler shall be determined from the minimum thickness of the shell plates, the lowest tensile strength of the plates, the efficiency of the longitudinal joint, the inside diameter of the outside course and the lowest factor of safety allowed by these rules, the formula being: —

$$\frac{T.S. \times t \times \%}{R \times F.S.} = \text{maximum allowable working pressure per square inch, in pounds.}$$

T.S. = tensile strength of shell plates, in pounds.

t = minimum thickness of shell plates, in inches.

% = efficiency of longitudinal joint, method of determining which is given in section 7, Part II. of these Rules.

R = radius = one-half ($\frac{1}{2}$) the inside diameter of the outside course of the shell or drum.

F.S. = lowest factor of safety allowed by these Rules.

Tensile strength.

2. When the tensile strength of steel or wrought-iron shell plates is *not* known, it shall be taken as fifty-five thousand (55,000) pounds for steel and forty-five thousand (45,000) pounds for wrought iron.

Factor of safety.

3. The lowest factor of safety to be used for boilers, the longitudinal joints of which are of butt and double-strap construction, shall be four and five-tenths (4.5).

NOTE. — Factors of safety which also apply to boilers installed before May 1, 1908, are specified in paragraph 7, section 1, Part II. of these Rules.

Rivets.

4. When the diameter of the rivet holes in the longitudinal joints of a boiler is *not* known, the diameter and cross-sectional area of rivets, after driving, shall be taken as follows: —

Thickness of plate,	1/4" .25"	9/32" .28125"	5/16" .3125"	11/32" .34375"	3/8" .375"	3/8" .375"	13/32" .40625"
Diameter of rivet after driving,	11/16"	11/16"	3/4"	3/4"	3/4" up to and including 2" pitch.	13/16" over 2" pitch.	13/16"
Cross-sectional area of rivet after driving,	.3712 sq.in.	.3712 sq.in.	.4418 sq.in.	.4418 sq.in.	.4418 sq.in.	.5185 sq.in.	.5185 sq.in.

Thickness of plate,	7/16" .4375"	7/16" .4375"	15/32" .46875"	1/2" .5"	9/16" .5625"	5/8" .625"
Diameter of rivet after driving,	7/8" up to and including 2 1/4" pitch.	15/16" over 2 1/4" pitch.	15/16"	15/16"	1 1/16"	1 1/16"
Cross-sectional area of rivet after driving,	.6013 sq. in.	.6903 sq. in.	.6903 sq. in.	.6903 sq. in.	.8866 sq. in.	.8866 sq. in.

Size of safety valves, not spring-loaded.

5. The minimum size of a safety valve (other than a direct spring-loaded safety valve) shall be governed by the pressure allowed, as stated in the certificate of inspection, and by the grate area of the boiler, subject to the following conditions and as shown by the table in paragraph 6 of this section.

Single boilers, and boilers connected and allowed same pressure.

Condition A. — A single boiler, or two or more boilers connected to a common steam main and allowed the *same pressure:* the minimum size of safety valve for each boiler shall be governed by the pressure allowed, as stated in the certificate of inspection, and by the grate area of the boiler.

Boilers connected and allowed different pressures.

Condition B. — When two or more boilers, which are allowed *different pressures,* are connected to a common steam main, the minimum size of each safety valve shall be governed by the pressure allowed, as stated in the certificate of inspection, and by the grate area of the boiler; and all safety valves *shall be set* at a pressure not exceeding the lowest pressure allowed. The aggregate valve area shall not be less than that required for the aggregate grate area, based on the lowest pressure allowed, as shown by the table.

Condition C. — When two or more boilers, which are allowed *different pressures,* are connected to a common steam main, and all safety valves *are not set* at a pressure not exceeding the lowest pressure allowed, the boiler or boilers allowed the lower pressures shall each be protected by a safety valve or valves placed on the connecting pipe to the steam main; the area or combined area of the safety valve

or valves placed on the connecting pipe to the steam main shall not be less than the area of the connecting pipe, except when the steam main is smaller than the connecting pipe, when the area or combined area of safety valve or valves placed on the connecting pipe shall not be less than the area of the steam main. Each safety valve placed on the connecting pipe shall be set at a pressure not exceeding the pressure allowed on the boiler it protects.

6. A table of areas of grate surfaces, in square feet, for other than direct spring-loaded safety valves, follows: —

MAXIMUM PRESSURE ALLOWED PER SQUARE INCH ON THE BOILER.		ZERO TO 25 POUNDS.	OVER 25 TO 50 POUNDS.	OVER 50 TO 100 POUNDS.
Diameter of Valve, in Inches.	Area of Valve, in Square Inches.	Area of Grate, in Square Feet.		
1	.7854	1.50	1.75	2.00
1¼	1.2272	2.25	2.50	3.00
1½	1.7671	3.00	3.75	4.00
2	3.1416	5.50	6.50	7.25
2½	4.9087	8.25	10.00	11.00
3	7.0686	11.75	14.25	16.00
3½	9.6211	16.00	19.50	21.75
4	12.5660	21.00	25.50	28.25
4½	15.9040	26.75	32.50	36.00
5	19.6350	32.75	40.00	44.00

Bottom blow-off.

7. Each boiler shall have a bottom blow-off pipe, fitted with a valve or cock, in direct connection with the lowest water space practicable.

PART II.

These rules apply to **all boilers** now or hereafter installed, unless otherwise stated.

SECTION 1.

Maximum pressure.

1. The pressure allowed on a boiler constructed entirely of cast iron with the exception of the connecting bolts and nipples, and installed within this Commonwealth on or before July 2, 1915, shall not exceed twenty-five (25) pounds per square inch. The pressure allowed on such boilers installed after July 2, 1915, shall not exceed fifteen (15) pounds per square inch.

2. The pressure allowed on a boiler, the tubes of which are secured to cast-iron headers, shall not exceed one hundred and sixty (160) pounds per square inch.

3. The pressure allowed on a boiler fitted with a district police lock-pop safety valve shall not exceed fifteen (15) pounds per square inch. This special type of safety valve is provided for by section 1, chapter 259, General Acts of 1915 (Engineers' and Firemen's License Law), and applies to boilers used for heating purposes exclusively.

Crushing strength of mild steel.

4. The resistance to crushing of mild steel shall be taken at ninety-five thousand (95,000) pounds per square inch of cross-sectional area.

Shearing strength of rivets.

5. The maximum shearing strength of rivets per square inch of cross-sectional area shall be taken as follows: —

	Pounds.
Iron rivets in single shear, ...	38,000
Iron rivets in double shear, ...	70,000
Steel rivets in single shear, ...	42,000
Steel rivets in double shear, ...	78,000

6. The following table gives the allowable shearing strength of rivets from eleven-sixteenths ($\frac{11}{16}$) inch to one and one-sixteenth ($1\frac{1}{16}$) inches in diameter, in pounds: —

Diameter of rivet after driving,	11/16" .6875"	3/4" .75"	13/16" .8125"	7/8" .875"	15/16" .9375"	1 1/16" 1.0625"
Cross-sectional area of rivet after driving,	.3712 sq. in.	.4418 sq. in.	.5185 sq. in.	.6013 sq. in.	.6903 sq. in.	.8866 sq. in.
	Allowable Shearing Strength, in Pounds.					
Iron, single shear,	14,106	16,788	19,703	22,849	26,231	33,691
Iron, double shear,	25,984	30,926	36,295	42,091	48,321	62,062
Steel, single shear,	15,590	18,556	21,777	25,255	28,993	37,237
Steel, double shear,	28,954	34,460	40,443	46,901	53,843	69,155

PART II. — SECTION 2.

The shearing strength of the rivets, and the crushing strength of the plate in front of the rivets, shall be ample to take care of the pressure on the head.

Factors of safety.

7. The lowest factors of safety used for boilers, the shells or drums of which are exposed to the products of combustion and the longitudinal joints of which are of lap-riveted construction, shall be as follows: —

(*a*) Five (5) for boilers not over ten years old.

(*b*) Five and five-tenths (5.5) for boilers over ten and not over fifteen years old.

(*c*) Five and seventy-five hundredths (5.75) for boilers over fifteen and not over twenty years old.

(*d*) Six (6) for boilers over twenty years old.

(*e*) Five (5) for boilers, the longitudinal joints of which are of lap-riveted construction and the shells or drums of which are not exposed to the products of combustion.

SECTION 2.

Safety valves.

1. Each boiler shall have one (1) or more safety valves.

Size of safety valves, spring-loaded.

2. The minimum size of a direct spring-loaded safety valve shall be governed by the pressure allowed, as stated in the certificate of inspection, and by the grate area of the boiler, subject to the following conditions and as shown by the table in paragraph 3 of this section.

Single boilers, and boilers connected and allowed same pressure.

Condition A. — A single boiler, or two or more boilers connected to a common steam main and allowed the *same pres-*

sure: the minimum size of safety valve for each boiler shall be governed by the pressure allowed, as stated in the certificate of inspection, and by the grate area of the boiler.

Boilers connected and allowed different pressures.

Condition B. — When two or more boilers, which are allowed *different pressures*, are connected to a common steam main, the minimum size of each safety valve shall be governed by the pressure allowed, as stated in the certificate of inspection, and by the grate area of the boiler; and all safety valves *shall be set* at a pressure not exceeding the lowest pressure allowed. The aggregate valve area shall not be less than that required for the aggregate grate area, based on the lowest pressure allowed, as shown by the table.

Condition C. — When two or more boilers, which are allowed *different pressures*, are connected to a common steam main, and all safety valves *are not set* at a pressure not exceeding the lowest pressure allowed, the boiler or boilers allowed the lower pressures shall each be protected by a safety valve or valves placed on the connecting pipe to the steam main; the area or combined area of the safety valve or valves placed on the connecting pipe to the steam main shall not be less than the area of the connecting pipe, except when the steam main is smaller than the connecting pipe, when the area or combined area of safety valve or valves placed on the connecting pipe shall not be less than the area of the steam main. Each safety valve placed on the connecting pipe shall be set at a pressure not exceeding the pressure allowed on the boiler it protects.

3. A table of areas of grate surfaces, in square feet, for direct spring-loaded safety-valves with bevel seats, follows:—

Table for Spring-loaded Safety Valves (Bevel Seats).

		$W=\frac{75}{3600}$ P= 40 A=.401	$W=\frac{100}{3600}$ P= 65 A=.329	$W=\frac{160}{3600}$ P= 115 A=.297	$W=\frac{160}{3600}$ P= 140 A=.244	$W=\frac{200}{3600}$ P= 190 A=.224	$W=\frac{240}{3600}$ P= 240 A=.213
Maximum Pressure allowed per Square Inch on the Boiler.		Zero to 25 Pounds.	Over 25 to 50 Pounds.	Over 50 to 100 Pounds.	Over 100 to 150 Pounds.	Over 150 to 200 Pounds.	Over 200 Pounds.
Diameter of Valve, in Inches.	Area of Valve, in Square Inches.	Area of Grate, in Square Feet.					
1	.7854	2.00	2.50	2.75	3.25	3.5	3.75
1¼	1.2272	3.25	4.00	4.25	5.00	5.5	5.75
1½	1.7671	4.50	5.50	6.00	7.25	8.0	8.50
2	3.1416	8.00	9.75	10.75	13.00	14.0	15.00
2½	4.9087	12.50	15.00	16.50	20.00	22.0	23.00
3	7.0686	17.75	21.50	24.00	29.00	31.5	33.25
3½	9.6211	24.00	29.50	32.50	39.50	43.0	45.25
4	12.5660	31.50	38.25	42.50	51.50	56.0	59.00
4½	15.9040	40.00	48.50	53.50	65.00	71.0	74.25
5	19.6350	49.00	60.00	66.00	80.00	88.0	92.25

PART II. — SECTION 2.

3 (*a*) A table of areas of grate surfaces, in square feet, for direct spring-loaded safety valves, with flat seats, follows: —

Table for Spring-loaded Safety Valves (Flat Seats).

		$W=\frac{75}{3600}$ P= 40 A=.286	$W=\frac{100}{3600}$ P= 65 A=.235	$W=\frac{160}{3600}$ P= 115 A=.212	$W=\frac{160}{3600}$ P= 140 A=.171	$W=\frac{200}{3600}$ P= 190 A=.160	$W=\frac{240}{3600}$ P= 240 A=.152
Maximum Pressure allowed per Square Inch on the Boiler.		Zero to 25 Pounds.	Over 25 to 50 Pounds.	Over 50 to 100 Pounds.	Over 100 to 150 Pounds.	Over 150 to 200 Pounds.	Over 200 Pounds.
Diameter of Valve, in Inches.	Area of Valve, in Square Inches.	Area of Grate, in Square Feet.					
1	.7854	2.75	3.50	3.75	4.50	4.75	5.25
1¼	1.2272	4.50	5.50	6.00	7.00	7.75	8.00
1½	1.7671	6.25	7.50	8.25	10.00	11.25	11.75
2	3.1416	11.00	13.50	15.00	18.00	19.50	21.00
2½	4.9087	17.50	21.00	23.00	28.00	30.75	32.00
3	7.0686	24.75	30.00	33.50	40.50	44.00	46.50
3½	9.6211	33.50	41.25	45.50	55.25	60.00	63.25
4	12.5660	44.00	53.50	59.50	72.00	78.25	82.50
4½	15.9040	56.00	68.00	75.00	91.00	99.25	104.00
5	19.6350	68.50	84.00	92.00	112.00	123.00	129.00

PART II. — SECTION 2.

4. When the conditions exceed those on which the tables (paragraph 3) are based, the following formulas shall be used: —

$$A = \frac{W\,70}{P} \times 11, \text{ for valves with } 45^{c} \text{ bevel seats.}$$

$$A = \frac{W\,70}{P} \times 8, \text{ for valves with flat seats.}$$

Any valve manufacturer desiring to use this table shall plainly mark the valve FLAT SEAT. Any valve not so marked will be considered bevel seat.

A = area of direct spring-loaded safety valve in square inches per square foot of grate surface.

W = weight of water in pounds evaporated per square foot of grate surface per second.

P = pressure (absolute) at which the safety valve is set to blow.

5. A table of areas of grate surface, in square feet, for safety valves not direct spring-loaded, is given in paragraph 6, section 1, Part I. of these Rules.

6. If more than one (1) safety valve is used, the minimum combined area shall be in accordance with the table.

Safety valve connections.

7. Each safety valve shall have full-sized direct connection to the boiler, and when an escape pipe is used it shall be full-sized and fitted with an open drain, to prevent water lodging in the upper part of safety valve or escape pipe. When a boiler is fitted with two (2) safety valves on one (1) connection, this connection to the boiler shall have a cross-sectional area equal to or greater than the combined area of the two (2) safety valves. No valve of any description shall be placed between the safety valve and the boiler, nor on the escape pipe between the safety valve and the atmosphere. When an elbow is placed on a safety valve escape pipe it

shall be located close to the safety valve outlet, or the escape pipe shall be securely anchored and supported.

Safety valves on boilers installed after July 2, 1915, must be connected to a separate nozzle or opening in the boiler, independent of any other steam connection, and as close as possible to the boiler.

8. Safety valves having either the seat or disc of cast iron shall not be used.

Safety valves hereafter installed.

9. Safety valves hereafter installed on boilers shall not exceed five inches (5″) in diameter, and shall be the direct spring-loaded type, with seat and bearing surface of the disc inclined at an angle of about forty-five (45) degrees or about ninety (90) degrees to the center line of the spindle; designed with a substantial lifting device so that the disc can be lifted from its seat with the spindle, not less than one-eighth ($\frac{1}{8}$) the diameter of the valve, when the pressure on the boiler is seventy-five per cent. (75%) of that at which the safety valve is set to blow.

Fusible plugs.

10. Fusible plugs, as required by section 20, chapter 465, Acts of 1907, shall conform to the following specifications (see Fig. 1 on page 19): —

All fusible plugs shall consist of a bronze casing, holes in which shall be reamed and tinned before being filled, shall have an even taper from end to end not less than five-eighths of an inch ($\frac{5}{8}$″) to the foot, and shall be filled with ninety-nine per cent. (99%) pure tin.

11. All fusible plugs shall be stamped by the manufacturers with their names across the face of the plugs with letters not less than one-eighth of an inch ($\frac{1}{8}$″) in height, and the letters MASS STD.

The outside diameter of the plug is to be of the standard pipe threads.

No fusible plug shall be used for a longer period than one (1) year.

12. Each boiler shall have one (1) or more fusible plugs, located as follows: —

(*a*) In Horizontal Return Tubular Boilers — in the rear head, not less than two (2) inches above the upper row of tubes, measurement to be taken from the line of the upper surface of tubes to the center of the plug, as shown in Figs. 12 and 13 of these Rules, and projecting through the sheet not less than one (1) inch.

(*b*) In Horizontal Flue Boilers — in the rear head, on a line with the highest part of the boiler exposed to the products of combustion, and projecting through the sheet not less than one (1) inch.

(*c*) In Locomotive Type or Star Water Tube Boilers — in the highest part of the crown sheet, and projecting through the sheet not less than one (1) inch.

(*d*) In Vertical Fire-tube Boilers — in an outside tube, not less than one-third ($\frac{1}{3}$) the length of the tube above the lower tube sheet.

(*e*) In Vertical Fire-tube Boilers, Corliss Type — in a tube, not less than one-third ($\frac{1}{3}$) the length of the tube above the lower tube sheet.

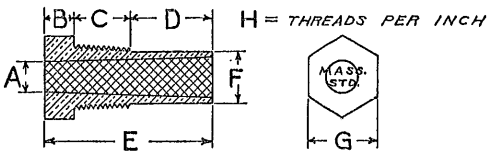
(*f*) In Vertical Submerged Tube Boilers — in the upper tube sheet.

(*g*) In Water-tube Boilers, Horizontal Drums, Babcock & Wilcox Type — in the upper drum, not less than six (6) inches above the bottom of the drum, over the first pass of the products of combustion, and projecting through the sheet not less than one (1) inch.

(*h*) In Stirling Boilers, Standard Type — in the front side of the middle drum, not less than four (4) inches above the

Part II. — Section 2.

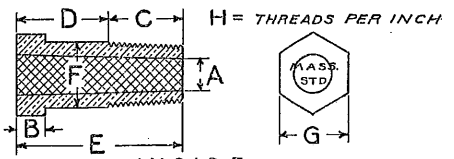
Fusible Plugs.



OUTSIDE

Size	A	B	C	D	E	F	G	H
1/2	1/2	3/8	3/4	1	2 1/8	11/16	15/16	14
3/4	1/2	3/8	7/8	1	2 1/4	3/4	1 3/16	14
1	1/2	3/8	15/16	1	2 5/16	25/32	1 3/8	11 1/2
1 1/4	1/2	3/8	1 3/16	1	2 7/16	13/16	1 13/16	11 1/2
1 1/2	1/2	7/16	1 5/16	1	2 3/4	7/8	2 1/8	11 1/2

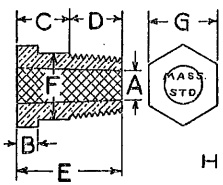
FOR ALL PRESSURES



INSIDE

Size	A	B	C	D	E	F	G	H
1/2	1/2	3/8	3/4	1	1 7/8	27/32	15/16	14
3/4	1/2	3/8	7/8	1	1 7/8	1 1/16	1 3/16	14
1	1/2	3/8	15/16	1	1 15/16	1 5/16	1 3/8	11 1/2
1 1/4	1/2	3/8	1 3/16	1	2 3/16	1 21/32	1 13/16	11 1/2
1 1/2	1/2	7/16	1 5/16	1	2 7/16	1 27/32	2 1/8	11 1/2

FOR ALL PRESSURES



TUBE PLUG

Size	A	B	C	D	E	F	G	H
3/8	3/8	1/4	3/4	11/16	1 1/16	11/16	13/16	18
1/2	3/8	3/8	3/4	3/4	1 1/2	27/32	15/16	14

FOR ALL PRESSURES

H = THREADS PER INCH

Fig. 1.

bottom of the drum, and projecting through the sheet not less than one (1) inch.

(*i*) In Stirling Boilers, Superheater Type — in the front drum, not less than six (6) inches above the bottom of the drum, exposed to the products of combustion, and projecting through the sheet not less than one (1) inch.

(*j*) In Water-tube Boilers, Heine Type — in the front course of the drum, not less than six (6) inches above the bottom of the drum, and projecting through the sheet not less than one (1) inch.

(*k*) In Robb-Mumford Boilers, Standard Type — in the bottom of the steam and water drum, twenty-four (24) inches from the center of the rear neck, and projecting through the sheet not less than one (1) inch.

(*l*) In Water-tube Boilers, Almy Type — in a tube or fitting exposed to the products of combustion, and extending not less than one (1) inch inside of boiler.

(*m*) In Vertical Boilers, Climax or Hazelton Type — in a tube or center drum not less than one-half ($\frac{1}{2}$) the height of the shell, measuring from the lowest circumferential seam, and extending not less than one (1) inch inside of boiler.

(*n*) In Cahall Vertical Water-tube Boilers — in the inner sheet of the top drum, not less than six (6) inches above the upper tube sheet, and projecting through the sheet not less than one (1) inch.

(*o*) In Scotch Marine Type Boilers — in combustion chamber top, and projecting through the sheet not less than one (1) inch.

(*p*) In Dry Back Scotch Type Boilers — in rear head, not less than two (2) inches above the upper row of tubes, and projecting through the sheet not less than one (1) inch.

(*q*) In Economic Type Boilers — in the rear head, above the upper row of tubes, and extending not less than one (1) inch inside of boiler.

(*r*) In Cast-iron Sectional Heating Boilers — in a section over and in direct contact with the products of combustion in the primary combustion chamber, and extending not less than one (1) inch inside of boiler.

(*s*) In Water-tube Boilers, Worthington Type — in the front side of the steam and water drum, not less than four (4) inches above the bottom of the drum, and projecting through the sheet not less than one (1) inch.

(*t*) For other types and new designs, fusible plugs shall be placed at the lowest permissible water level, in the direct path of the products of combustion, as near the primary combustion chamber as possible, and extending not less than one (1) inch inside of boiler.

Steam gage.

13. Each boiler shall have a steam gage connected to the steam space of the boiler by a brass syphon, or equivalent device, sufficiently large to fill the gage tube with water, and in such manner that the steam gage cannot be shut off from the boiler except by a cock with T or lever handle, which shall be placed on the pipe near the steam gage. Connection to gages shall be made of brass pipe and fittings from the boiler to the gage.

When the steam gage of a boiler is connected to water column pipe, there shall be brass pipe and fittings from the steam gage to water column connections.

Steam gage dial.

14. The dial of the steam gage shall be graduated to not less than one and one-half ($1\frac{1}{2}$) times the maximum pressure allowed on the boiler.

Attaching test gage.

15. Each boiler shall be provided with a one-fourth ($\frac{1}{4}$) inch pipe size connection for attaching inspector's test gage when boiler is in service, so that the accuracy of the boiler steam gage can be ascertained, as required by section 3, chapter 465, Acts of 1907.

Water glass.

16. Each boiler shall have at least one (1) water glass, the lowest visible part of which shall be above the fusible plug and lowest safe water line.

Gage cocks, 15 pounds' pressure, or less.

17. Each boiler shall have two (2) or more gage cocks, the center of which shall be located vertically within the range of the visible length of water glass, when the maximum pressure allowed does not exceed fifteen (15) pounds per square inch, except when such boiler has two (2) water glasses, located not less than three (3) feet apart, on the same horizontal line.

Gage cocks, over 15 pounds' pressure.

18. Each boiler shall have three (3) or more gage cocks, the center of which shall be located vertically within the range of the visible length of water glass when the maximum pressure allowed exceeds fifteen (15) pounds per square inch, except when such boiler has two (2) water glasses located not less than three (3) feet apart, on the same horizontal line.

Feed pipe.

19. Each boiler shall have a feed pipe fitted with a check valve, and also a stop valve or stop cock between the check

valve and the boiler, the feed water to discharge below the lowest safe water line. Means must be provided for feeding a boiler with water against the maximum pressure allowed on the boiler.

Stop valve.

20. Each steam outlet from a boiler (except safety valve connections) shall be fitted with a stop valve.

21. When a stop valve is so located that water can accumulate, ample drains shall be provided.

Damper regulator.

22. When a damper regulator is used, the boiler pressure pipe shall be fitted with a valve or cock, and shall be connected to the steam space of the boiler.

Lamphrey fronts.

23. Each boiler fitted with a Lamphrey Boiler Furnace Mouth Protector, or similar appendage, having valves on the pipes connecting the same with the boiler, shall have these valves locked or sealed *open*, so that the locks or seals will require to be removed or broken to shut the valves.

Valves on return pipes.

24. The main return pipe to a heating boiler (Gravity Return System) shall have a check valve, and also a stop valve between the check valve and the boiler.

25. When there are two (2) connected boilers (Gravity Return System), one (1) check valve and a stop valve shall be installed in the return pipe to each boiler.

Part II. — Section 3.

Feed piping.

26. The feed pipe of a boiler shall have open end or ends. When one or more globe valves are used on a feed pipe, the inlet shall be under the disc of the valve.

27. The feed water shall discharge about three-fifths ($\frac{3}{5}$) the length of a horizontal return tubular boiler from the front head (except a horizontal return tubular boiler equipped with an auxiliary feed water heating and circulating device), and at or about the central rows of tubes above the tubes, when the diameter of the boiler exceeds thirty-six inches (36″), and the pressure allowed exceeds fifteen (15) pounds per square inch. The feed pipe shall be carried through the head with a brass or steel boiler bushing, and securely fastened inside the shell above the tubes.

Blow-off on water column.

28. On each water connection to a water column, where there is a right angle turn, there shall be located at least one (1) gate valve and pipe of a diameter not less than one-half inch ($\frac{1}{2}$″) for the purpose of blowing out said water pipe. This shall not apply to a right angle turn inside of smoke box.

Boiler showing longitudinal lap crack.

29. A boiler in which a longitudinal crack is discovered in a shell plate at or near a longitudinal seam shall be immediately discontinued from further service.

Section 3.

Horse power rating.

1. A boiler having one square foot of grate surface shall be rated at three (3) horse power when the safety valve is

set to blow at over twenty-five (25) pounds pressure per square inch.

2. A boiler having two square feet of grate surface shall be rated at three (3) horse power when the safety valve is set to blow at twenty-five (25) pounds pressure per square inch, or less.

SECTION 4.

Annual internal inspections.

1. The owner or user of a boiler which requires annual inspection, internally and externally, by the boiler inspection department or by an insurance company, as provided by section 1, chapter 465, Acts of 1907, shall prepare the boiler for inspection by cooling it down (blanking off connections to adjacent boilers, if necessary), removing all soot and ashes from tubes, heads, shell, furnace and combustion chamber; drawing off the water; removing the handhole and manhole plates; removing the grate bars from internally fired boilers; and removing the steam gage for testing.

2. If a boiler has not been properly cooled down, or otherwise prepared for inspection, the boiler inspector shall decline to inspect it, and he shall not issue a certificate of inspection until efficient inspection has been made.

3. In making the annual internal and external inspection, as provided by sections 1 and 4, chapter 465, Acts of 1907, the boiler inspector shall apply the hammer test to all internal and external parts of a boiler that are accessible.

4. All proper measurements shall be taken by the boiler inspector, so that the maximum working pressure allowed on a boiler will conform to the rules relating to allowable pressures established by the Board of Boiler Rules; such measurements to be taken and calculations made before a hydrostatic pressure test is applied to a boiler.

PART II. — SECTIONS 5 AND 6.

5. The steam gage of a boiler shall be tested and its readings compared with an accurate test gage, and if, in the judgment of the boiler inspector, the gage is not reliable, he shall order it repaired or replaced.

SECTION 5.

Annual external inspections.

1. The annual external inspection of a boiler, as provided by section 3, chapter 465, Acts of 1907, should be made at or about six (6) months after the annual internal inspection, except in the case of a boiler that is in service a portion of the year only, in which case the annual external inspection shall be made during such period of service.

2. The boiler inspector shall attach an accurate test gage to a boiler, to note the pressure shown by said test gage, and compare it with that shown by the boiler gage, ordering the boiler gage repaired or replaced if necessary.

3. The boiler inspector shall see that the water glass, gage cocks, water-column connections and water blow-offs are free and clear; also, that the safety valve raises freely from its seat.

4. Fire doors, tube doors and doors in settings shall be opened, to view as far as possible the fire surface, settings, tube ends, blow-off pipes and fusible plug; the boiler inspector to note conditions and order changes or repairs if necessary.

SECTION 6.

Hydrostatic pressure tests.

1. When a boiler is tested by hydrostatic pressure, the pressure applied shall not be less than one and one-quarter ($1\frac{1}{4}$), nor more than one and one-half ($1\frac{1}{2}$) times the maximum

allowable working pressure; except that twice the maximum allowable working pressure may be applied on boilers permitted to carry not over fifteen (15) pounds pressure per square inch.

2. When making annual inspections on boilers constructed entirely of cast iron with the exception of the connecting bolts and nipples, a hydrostatic pressure test of not less than fifteen (15) pounds, and not more than twice the maximum allowable working pressure, shall be applied.

3. The boiler inspector, after applying a hydrostatic pressure test, shall thoroughly examine every accessible part of the boiler, both internal and external.

SECTION 7.

Efficiency of joint.

1. The efficiency that a unit of length of a riveted joint has to the same unit of length of solid plate shall be calculated as shown by the following examples: —

T. S. = tensile strength of plate, in pounds per square inch.
t = thickness of plate, in inches.
b = thickness of butt strap, in inches.
P = pitch of rivets, in inches, on row having greatest pitch.
d = diameter of rivet after driving, in inches.
a = cross-sectional area of rivet after driving, in square inches.
s = strength of rivet in single shear, as given in paragraph 5, section 1, Part II. of these Rules.
S = strength of rivet in double shear, as given in paragraph 5, section 1, Part II. of these Rules.
c = crushing strength of mild steel, as given in paragraph 4, section 1, Part II. of these Rules.

NOTE. — "c" applies only to boilers constructed after February 5, 1910.

n = number of rivets in single shear in a unit of length of joint.

N = number of rivets in double shear in a unit of length of joint.

Lap single-riveted.

2. *Example.* — Lap joint, longitudinal or circumferential, single-riveted.

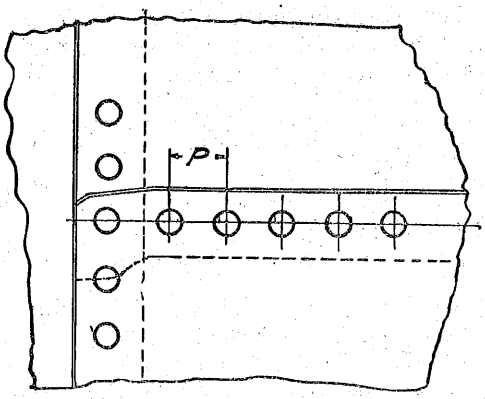


FIG. 2.

A = Strength of solid plate = P × t × T. S.
B = Strength of plate between rivet holes = (P—d) t × T. S.
C = Shearing strength of one rivet in single shear = n × s × a.
D = Crushing strength of plate in front of one (1) rivet = d × t × c.

Divide B, C or D (whichever is the least) by A, and the quotient will be the efficiency of a single-riveted lap joint, as shown in Fig. 2.

PART II. — SECTION 7.

T. S. = 55,000 pounds.

$t = \frac{1}{4}'' = .25''$.

$P = 1\frac{5}{8}'' = 1.625''$.

$d = \frac{11}{16}'' = .6875''$.

a = .3712 square inches.

s = 42,000 pounds.

c = 95,000 pounds.

$A = 1.625 \times .25 \times 55{,}000 = 22{,}343$..

$B = (1.625 - .6875)\ .25 \times 55{,}000 = 12{,}890$.

$C = 1 \times 42{,}000 \times .3712 = 15{,}590$.

$D = .6875 \times .25 \times 95{,}000 = 16{,}328$.

$\frac{12{,}890\ (B)}{22{,}343\ (A)} = .576$, Efficiency of joint.

Lap double-riveted.

3. *Example.* — Lap joint, longitudinal or circumferential, double-riveted.

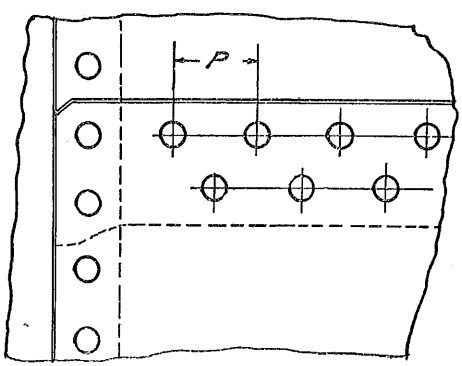


FIG. 3.

PART II. — SECTION 7.

A = Strength of solid plate = P × t × T. S.
B = Strength of plate between rivet holes = (P − d) t × T. S.
C = Shearing strength of two (2) rivets in single shear = n × s × a.
D = Crushing strength of plate in front of two (2) rivets = n × d × t × c.

Divide B, C or D (whichever is the least) by A, and the quotient will be the efficiency of a double-riveted lap joint, as shown in Fig. 3.

T. S. = 55,000 pounds.
t = $\frac{5}{16}$″ = .3125″.
P = $2\frac{7}{8}$″ = 2.875″.
d = $\frac{3}{4}$″ = .75″.
a = .4418 square inches.
s = 42,000 pounds.
c = 95,000 pounds.
A = 2.875 × .3125 × 55,000 = 49,414.
B = (2.875 − .75) .3125 × 55,000 = 36,523.
C = 2 × 42,000 × .4418 = 37,111.
D = 2 × .75 × .3125 × 95,000 = 44,531.

$\frac{36{,}523\ (B)}{49{,}414\ (A)}$ = .739, Efficiency of joint.

Butt double-riveted.

4. *Example.* — Butt and double strap joint, double-riveted.

A = Strength of solid plate = P × t × T. S.
B = Strength of plate between rivet holes in the outer row = (P − d) t × T. S.
C = Shearing strength of two (2) rivets in double shear, plus the shearing strength of one (1) rivet in single shear = N × S × a + n × s × a.

D = Strength of plate between rivet holes in the second row, plus the shearing strength of one (1) rivet in single shear in the outer row = (P − 2d) t × T. S. + n × s × a.

E = Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one (1) rivet in the outer row = (P − 2d) t × T. S. + d × b × c.

F = Crushing strength of plate in front of two (2) rivets, plus the crushing strength of butt strap in front of one (1) rivet = N × d × t × c + n × d × b × c.

G = Crushing strength of plate in front of two (2) rivets, plus the shearing strength of one (1) rivet in single shear = N × d × t × c + n × s × a.

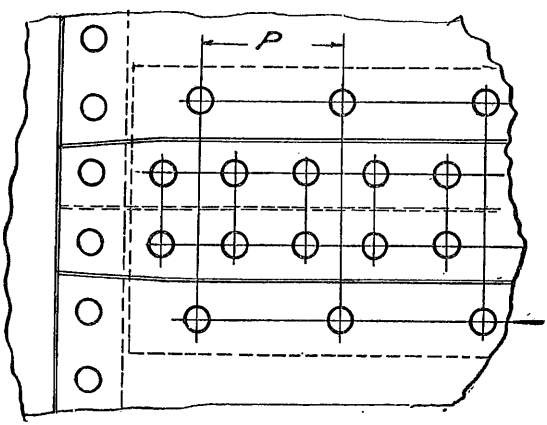


FIG. 4.

Divide B, C, D, E, F or G (whichever is the least) by A, and the quotient will be the efficiency of a butt and double strap joint, double-riveted, as shown in Fig. 4.

PART II. — SECTION 7.

T. S. = 55,000 pounds.
$t = \frac{3}{8}'' = .375''$.
$b = \frac{5}{16}'' = .3125''$.
$P = 4\frac{7}{8}'' = 4.875''$.
$d = \frac{7}{8}'' = .875''$.
a = .6013 square inches.
s = 42,000 pounds.
S = 78,000 pounds.
c = 95,000 pounds.

Number of rivets in single shear in a unit of length of joint = 1.

Number of rivets in double shear in a unit of length of joint = 2.

$A = 4.875 \times .375 \times 55{,}000 = 100{,}547.$

$B = (4.875 - .875)\ .375 \times 55{,}000 = 82{,}500.$

$C = 2 \times 78{,}000 \times .6013 + 1 \times 42{,}000 \times .6013 = 119{,}057.$

$D = (4.875 - 2 \times .875)\ .375 \times 55{,}000 + 1 \times 42{,}000 \times .6013 = 89{,}708.$

$E = (4.875 - 2 \times .875)\ .375 \times 55{,}000 + .875 \times .3125 \times 95{,}000 = 90{,}429.$

$F = 2 \times .875 \times .375 \times 95{,}000 + .875 \times .3125 \times 95{,}000 = 88{,}320.$

$G = 2 \times .875 \times .375 \times 95{,}000 + 1 \times 42{,}000 \times .6013 = 87{,}599.$

$\frac{82{,}500\ (B)}{100{,}547\ (A)} = .820$, Efficiency of joint.

Butt triple-riveted.

5. *Example.* — Butt and double strap joint, triple-riveted.

A = Strength of solid plate = P × t × T. S.

B = Strength of plate between rivet holes in the outer row = (P − d)t × T. S.

C = Shearing strength of four (4) rivets in double shear, plus the shearing strength of one (1) rivet in single shear = N × S × a + n × s × a.

PART II. — SECTION 7.

D = Strength of plate between rivet holes in the second row, plus the shearing strength of one (1) rivet in single shear in the outer row = (P − 2d) t × T. S + n × s × a.

E = Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one (1) rivet in the outer row = (P − 2d) t × T. S. + d × b × c.

F = Crushing strength of plate in front of four (4) rivets, plus the crushing strength of butt strap in front of one (1) rivet = N × d × t × c + n × d × b × c.

G = Crushing strength of plate in front of four (4) rivets, plus the shearing strength of one (1) rivet in single shear = N × d × t × c + n × s × a.

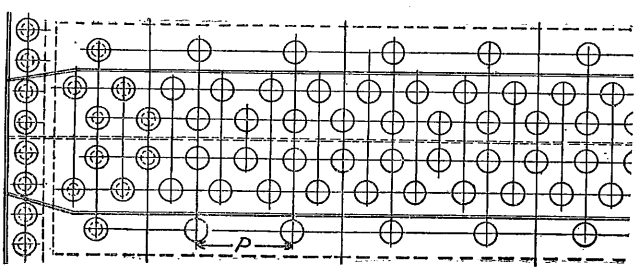


FIG. 5.

Divide B, C, D, E, F or G (whichever is the least) by A, and the quotient will be the efficiency of a butt and double strap joint, triple-riveted, as shown in Fig. 5.

T. S. = 55,000 pounds.
t = $\frac{3}{8}$″ = .375″.
b = $\frac{5}{16}$″ = .3125″.
P = 6$\frac{1}{2}$″ = 6.5″.
d = $\frac{13}{16}$″ = .8125″.
a = .5185 square inches.
s = 42,000 pounds.
S = 78,000 pounds.
c = 95,000 pounds.

PART II. — SECTION 7.

Number of rivets in single shear in a unit of length of joint = 1.

Number of rivets in double shear in a unit of length of joint = 4.

$A = 6.5 \times .375 \times 55{,}000 = 134{,}062.$

$B = (6.5 - .8125)\ .375 \times 55{,}000 = 117{,}304.$

$C = 4 \times 78{,}000 \times .5185 + 1 \times 42{,}000 \times .5185 = 183{,}549.$

$D = (6.5 - 2 \times .8125).375 \times 55{,}000 + 1 \times 42{,}000 \times .5185 = 122{,}323.$

$E = (6.5 - 2 \times .8125)\ .375 \times 55{,}000 + .8125 \times .3125 \times 95{,}000 = 124{,}667.$

$F = 4 \times .8125 \times .375 \times 95{,}000 + 1 \times .8125 \times .3125 \times 95{,}000 = 139{,}902.$

$G = 4 \times .8125 \times .375 \times 95{,}000 + 1 \times 42{,}000 \times .5185 = 137{,}558.$

$\frac{117{,}304\ (B)}{134{,}062\ (A)} = .875$, Efficiency of joint.

Butt quadruple-riveted.

6. *Example.* — Butt and double strap joint, quadruple-riveted.

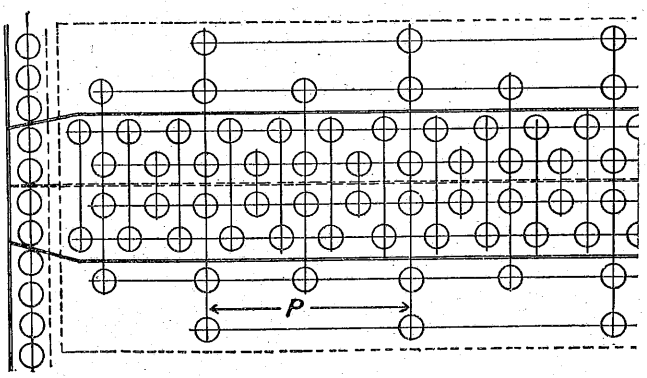


FIG. 6.

PART II. — SECTION 7.

A = Strength of solid plate = P × t × T. S.

B = Strength of plate between rivet holes in the outer row = (P − d) t × T. S.

C = Shearing strength of eight (8) rivets in double shear, plus the shearing strength of three (3) rivets in single shear = N × S × a + n × s × a.

D = Strength of plate between rivet holes in the second row, plus the shearing strength of one (1) rivet in single shear in the outer row = (P − 2d) t × T. S. + n × s × a.

E = Strength of plate between rivet holes in the third row, plus the shearing strength of two (2) rivets in the second row in single shear and one (1) rivet in single shear in the outer row = (P − 4d) t × T. S. + n × s × a.

F = Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one (1) rivet in the outer row = (P − 2d) t × T. S. + d × b × c.

G = Strength of plate between rivet holes in the third row, plus the crushing strength of butt strap in front of two (2) rivets in the second row and one (1) rivet in the outer row = (P − 4d) t × T. S. + n × d × b × c.

H = Crushing strength of plate in front of eight (8) rivets, plus the crushing strength of butt strap in front of three (3) rivets = N × d × t × c + n × d × b × c.

I = Crushing strength of plate in front of eight (8) rivets, plus the shearing strength of two (2) rivets in the second row and one (1) rivet in the outer row, in single shear = N × d × t × c + n × s × a.

Divide B, C, D, E, F, G, H or I (whichever is the least) by A, and the quotient will be the efficiency of a butt and double strap joint quadruple-riveted, as shown in Fig. 6.

PART II. — SECTION 8.

T. S. = 55,000 pounds.
$t = \frac{1}{2}'' = .5''$.
$b = \frac{7}{16}'' = .4375''$.
$P = 15''$.
$d = \frac{15}{16}'' = .9375''$.
a = .6903 square inches.
s = 42,000 pounds.
S = 78,000 pounds.
c = 95,000 pounds.

Number of rivets in single shear in a unit of length of joint = 3.

Number of rivets in double shear in a unit of length of joint = 8.

$A = 15 \times .5 \times 55{,}000 = 412{,}500.$

$B = (15 - .9375).5 \times 55{,}000 = 386{,}718.$

$C = 8 \times 78{,}000 \times .6903 + 3 \times 42{,}000 \times .6903 = 517{,}723.$

$D = (15 - 2 \times .9375).5 \times 55{,}000 + 1 \times 42{,}000 \times .6903 = 389{,}930.$

$E = (15 - 4 \times .9375).5 \times 55{,}000 + 3 \times 42{,}000 \times .6903 = 396{,}353.$

$F = (15 - 2 \times .9375)\ .5 \times 55{,}000 + .9375 \times .4375 \times 95{,}000 = 399{,}902.$

$G = (15 - 4 \times .9375).5 \times 55{,}000 + 3 \times .9375 \times .4375 \times 95{,}000 = 426{,}269.$

$H = 8 \times .9375 \times .5 \times 95{,}000 + 3 \times .9375 \times .4375 \times 95{,}000 = 473{,}145.$

$I = 8 \times .9375 \times .5 \times 95{,}000 + 3 \times 42{,}000 \times .6903 = 443{,}229.$

$\frac{386{,}718\ (B)}{412{,}500\ (A)} = .937$, Efficiency of joint.

SECTION 8.

Form of certificate.

1. The standard size of the certificate of inspection, as authorized by section 26, chapter 465, Acts of 1907, shall be eleven (11) inches in width and eight and one-half ($8\frac{1}{2}$)

inches in length, and shall be made up and worded in accordance with the following copy, space having been provided for the insertion of the State Boiler Inspection Department or the name of the insurance company using the same:

Commonwealth of Massachusetts

ANNUAL CERTIFICATE

OF

STEAM BOILER INSPECTION

As required by Chapter 465, Acts of 1907

[SPACE FOR COMPANY'S NAME OR STATE BOILER INSPECTION DEPARTMENT]

Boiler No.________ Date of Inspection________________, 19

This is to Certify that the herein-described steam boiler inspected by

[SPACE FOR COMPANY'S NAME OR STATE BOILER INSPECTION DEPARTMENT]

may be operated at a **Pressure not to exceed**________________**pounds per square inch.**

Name of owner________________ Type of boiler ________________

Location of boiler ________________________________

Age in years________________ Built by ________________

Length of shell or drum ________ft________in. Diameter of shell or drum ________________in.

Lowest tensile strength of shell plates________lbs. per sq. in. Number and size of tubes________________

Thickness of shell plates________________in. Thickness of heads________________in.

Style of longitudinal joint in shell or drum ________________________________

Percentage of strength of longitudinal joint________________ Location of fusible plug________________

[COMPANY'S NAME OR STATE BOILER INSPECTION DEPARTMENT]

Signature ________________________

Inspector of Boilers.

[FAC. SIM. OF EXECUTIVE OFFICER'S OR CHIEF INSPECTOR'S SIGNATURE]

[OFFICE]

In accordance with Section 21, Chapter 465, Acts of 1907, notify this department / company at once if any defect is discovered.

☞ POST UNDER GLASS IN CONSPICUOUS PLACE IN ENGINE OR BOILER ROOM. ☜

Certificate not to be removed.

2. The certificate of inspection shall be posted under glass in a conspicuous place in the engine or boiler room in which the boiler specified therein is located; and it shall not be removed therefrom unless the boiler or its appendages become defective, or a new certificate is issued, when it shall be removed by a member of the boiler inspection department of the district police, or an inspector holding a certificate of competency as an inspector of steam boilers, as provided by section 6, chapter 465, Acts of 1907.

PART III.

These Rules, in addition to the Rules contained in Part II., apply to boilers installed **after** May 1, 1908.

SECTION 1.

Open-Hearth Boiler-Plate and Rivet Steel.

Process.

1. Steel shall be made by the open-hearth process, and will be considered as manufactured by the basic method unless the report of test states that the acid method has been used.

Steel plates and rivets.

2. All plates and rivets used in the construction of steel shells or drums of boilers shall be as specified by the American Society for Testing Materials.

Chemical Properties.

Chemical properties.

3. There shall be two (2) classes of open-hearth boiler plate and rivet steel, namely, Firebox Steel and Extra Soft Steel, which shall conform to the following limits in chemical composition: —

	Firebox Steel (Per Cent.).	Extra Soft Steel (Per Cent.).
Phosphorus shall not exceed . . .	Acid, 0.04 Basic, 0.03	Acid, 0.04 Basic, 0.04
Sulphur shall not exceed	0.04	0.04
Manganese, ...	0.30 to 0.50	0.30 to 0.50

PART III. — SECTION 1.

Boiler rivet steel.

4. Steel for boiler rivets shall be of the Extra Soft class, as specified in paragraphs Nos. 3 and 5 of this section.

Physical Properties.

Physical properties.

5. The two classes of open-hearth boiler plate and rivet steel, — namely, Firebox Steel and Extra Soft Steel, — shall conform to the following physical qualities: —

	Firebox Steel.	Extra Soft Steel.
Tensile strength, pounds per square inch,	52,000 to 63,000	45,000 to 55,000
Yield point, in pounds per square inch, shall not be less than	½ T. S.	½ T. S.
Elongation, per cent. in 8 inches, shall not be less than	26	28

Modifications in elongation for thin and thick material.

6. For material less than five-sixteenths ($\frac{5}{16}$) inch and more than three-fourths ($\frac{3}{4}$) inch in thickness the following modifications shall be made in the requirements for elongation: —

(*a*) For each increase of one-eighth ($\frac{1}{8}$) inch in thickness above three-fourths ($\frac{3}{4}$) inch a deduction of one (1) per cent. shall be made from the specified elongation.

(*b*) For each decrease of one-sixteenth ($\frac{1}{16}$) inch in thickness below five-sixteenths ($\frac{5}{16}$) inch a deduction of two and one-half ($2\frac{1}{2}$) per cent. shall be made from the specified elongation.

Bending tests.

7. The two classes of open-hearth boiler plate and rivet steel shall conform to the following bending tests; and for this purpose the test specimen shall be one and one-half inches ($1\frac{1}{2}''$) wide, if possible, and for all material three-fourths inch ($\frac{3}{4}''$) or less in thickness the test specimen shall be of the same thickness as that of the finished material from which it is cut, but for material more than three-fourths inch ($\frac{3}{4}''$) thick the bending test specimen may be one-half inch ($\frac{1}{2}''$) thick.

Rivet rounds shall be tested of full size as rolled.

(*c*) Test specimens cut from the rolled material, as specified above, shall be subjected to a cold bending test and also to a quenched bending test. The cold bending test shall be made on the material in the condition in which it is to be used, and prior to the quenched bending test the specimen shall be heated to a light cherry red, as seen in the dark, and quenched in water, the temperature of which is between eighty degrees (80°) and ninety degrees (90°) Fahrenheit.

(*d*) Firebox steel and rivet steel, both before and after quenching, shall bend cold one hundred and eighty degrees (180°) flat on itself without fracture on the outside of the bent portion.

Homogeneity tests.

8. For fire-box steel a sample taken from a broken tensile test specimen shall not show any single seam or cavity more than one-fourth ($\frac{1}{4}$) inch long in either of the three fractures obtained on the test for homogeneity, as described in paragraph No. 13 of this section.

PART III. — SECTION 1.

Test Pieces and Methods of Testing.

Test specimen for tensile test.

9. The standard test specimen of eight (8) inch gaged length shall be used to determine the physical properties specified in paragraphs Nos. 5 and 6 of this section. The standard shape of the test specimen for sheared plates shall be as shown in Fig. 7.

For other material the test specimen may be the same as for sheared plates, or it may be planed or turned parallel throughout its entire length; and in all cases, where possible, two opposite sides of the test specimens shall be the rolled surfaces. Rivet rounds and small rolled bars shall be tested of full size as rolled.

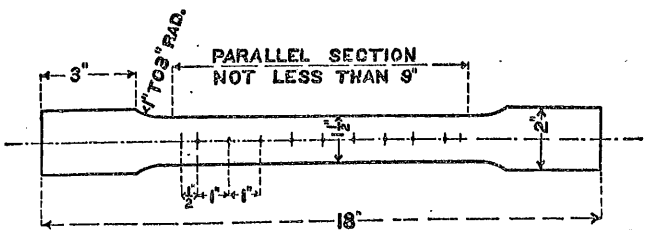
Number of tensile tests.

10. One tensile test specimen will be furnished from each plate as it is rolled, and two tensile test specimens will be furnished from each melt of rivet rounds. In case any of these develops flaws or breaks outside of the middle third of its gaged length, it may be discarded and another test specimen substituted therefor.

Test specimens for bending.

11. For material three-fourths ($\frac{3}{4}$) inch or less in thickness the bending test specimen shall have the natural rolled surface on two opposite sides. The bending test specimens cut from plates shall be one and one-half ($1\frac{1}{2}$) inches wide, and for material more than three-fourths ($\frac{3}{4}$) inch thick the bending test specimen may be one-half ($\frac{1}{2}$) inch thick. The sheared edges of bending test specimens may be milled or planed.

The bending test specimens for rivet rounds shall be of full size as rolled. The bending tests may be made by pressure or by blows.



Standard Test Specimen of 8" Gaged Length, Piece to be of Same Thickness as Plate.

FIG. 7.

Number of bending tests.

12. One cold bending specimen and one quenched bending specimen will be furnished from each plate as it is rolled. Two cold bending specimens and two quenched bending specimens will be furnished from each melt of rivet rounds. The homogeneity test for fire-box steel shall be made on one of the broken tensile test specimens.

Homogeneity tests for fire-box steel.

13. The homogeneity test for fire-box steel is made as follows: A portion of the broken tensile test specimen is either nicked with a chisel or grooved on a machine, transversely about one sixteenth ($\frac{1}{16}$) of an inch deep, in three places about two (2) inches apart. The first groove should be made on one side two (2) inches from the square end of

the specimen; the second, two (2) inches from it on the opposite side; the third, two (2) inches from the last, and on the opposite side from it. The test specimen is then put in a vise, with the first groove about one-fourth ($\frac{1}{4}$) of an inch above the jaws, care being taken to hold it firmly. The projecting end of the test specimen is then broken off by means of a hammer, a number of light blows being used, and the bending being away from the groove. The specimen is broken at the other two grooves in the same way. The object of this treatment is to open and render visible to the eye any seams due to failure to weld up, or to foreign interposed matter or cavities due to gas bubbles in the ingot. After rupture, one side of each fracture is examined, a pocket lens being used, if necessary, and the length of the seams and cavities is determined.

Yield point.

14. For the purposes of this specification the yield point shall be determined by the careful observation of the drop of the beam or halt in the gage of the testing machine.

Sample for chemical analysis.

15. In order to determine if the material conforms to the chemical limitations prescribed in paragraph No. 3 of this section, analysis shall be made of drillings taken from a small test ingot. An additional check analysis may be made from a tensile specimen of each melt used on an order, other than in locomotive fire-box steel. In the case of locomotive fire-box steel a check analysis may be made from the tensile specimen from each plate as rolled.

Part III. — Section 1.

Variation in Weight.

Variation in weight.

16. The variation in cross section of weight of more than $2\frac{1}{2}$ per cent. from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations: —

(*e*) Plates $12\frac{1}{2}$ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than $2\frac{1}{2}$ per cent. variation above or $2\frac{1}{2}$ per cent. below the theoretical weight; when 100 inches wide and over, 5 per cent. above or 5 per cent. below the theoretical weight.

(*f*) Plates under $12\frac{1}{2}$ pounds per square foot, when ordered to weight, shall not average a greater variation than the following: — Up to 75 inches wide, $2\frac{1}{2}$ per cent. below the theoretical weight; 75 inches wide up to 100 inches wide, 5 per cent. below the theoretical weight; when 100 inches wide and over, 10 per cent. above or 3 per cent. below the theoretical weight.

(*g*) For all plates ordered to gage there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in the following table: —

Table of Allowances for Overweight for Rectangular Plates when ordered to Gage.

[Plates will be considered up to gage if measuring not over 1-100 inch less than the ordered gage. The weight of 1 cubic inch of rolled steel is assumed to be .2833 pound.]

Plates 1–4 Inch and Over in Thickness.

Thickness of Plate (Inch).	Width of Plate.		
	Up to 75 Inches (Per Cent.).	75 to 100 Inches (Per Cent.).	Over 100 Inches (Per Cent.).
¼	10	14	18
5/16	8	12	16
⅜	7	10	13
7/16	6	8	10
½	5	7	9
9/16	4½	6½	8½
⅝	4	6	8
Over ⅝	3½	5	6½

Finish.

Finish.

17. All finished material shall be free from injurious surface defects and laminations, and must have a workmanlike finish.

Plate Manufacturer to stamp Plates and Heads.

Plates to be stamped.

18. Each plate shall be distinctly stamped by the manufacturer with the heat number.

19. Each plate shall be distinctly stamped by the manu-

facturer in at least five places in the following manner: At the four corners, at a distance of about twelve (12) inches from the edges, and at or near the center of the plate, with the name of the manufacturer, place where manufactured, brand and lowest tensile strength.

Heads to be stamped.

20. Each head shall be distinctly stamped by the manufacturer on each side with the name of the manufacturer, place where manufactured, brand and lowest tensile strength; stamps to be so located as to be plainly visible when the head is finished.

SECTION 2.

Material to be used.

Shell plates and heads.

1. Shells, drums, butt straps, heads, combustion chambers, furnaces, or any plates that require staying or flanging, shall be of Open-hearth Fire-box or Extra Soft Steel, as specified in paragraphs Nos. 3 and 5, section 1, Part III. of these Rules.

Steam domes.

2. Steam domes shall only be allowed on a locomotive type boiler, and shall be located on the barrel of the boiler when the top of the barrel is as high as or higher than any other portion of the boiler shell, and on the wagon top only when the wagon top is higher than the barrel.

Steam domes shall be made of the same quality of material as the boiler shell.

When the pressure desired does not exceed one hundred (100) pounds per square inch, the longitudinal joints of such steam domes may be of double riveted lap construction when

the diameter of the dome does not exceed thirty-six inches (36″), and the flange shall be double riveted to the boiler shell.

When a pressure greater than one hundred (100) pounds per square inch is desired, the longitudinal joints of such steam domes shall be of butt and double strap construction, and the flange shall be double riveted to the boiler shell.

Heads of steam domes shall be convex, curved outward from the shell.

When the opening in the shell to a steam dome is four inches (4″) in diameter or larger, the opening shall be reenforced to compensate for the metal removed along the longitudinal diameter of the opening.

At least two (2) drain holes, three-quarters of an inch ($\frac{3}{4}$″) in diameter, shall be located in the shell under a steam dome, at the lowest point where water can collect, for the purpose of draining.

Rivets.

3. Rivets shall be of Open-hearth Extra Soft Steel, as specified in paragraphs Nos. 3 and 5, section 1, Part III. of these Rules.

Cast steel.

4. Cast steel for use in boiler and steam superheater mountings, manhole frames, steam pipe, fittings, side lugs, or any other parts of boilers or superheaters where cast steel is used, shall not have less than fifty thousand (50,000) pounds tensile strength.

Cast iron.

5. Cast iron for use in boiler mountings, steam pipe fittings, side lugs, or any other parts of boilers where cast iron is

permitted to be used, shall not have less than eighteen thousand (18,000) pounds tensile strength.

Cross pipes and cross boxes.

6. Cross pipes connecting the steam and water drums of water-tube boilers, and cross boxes, shall be of wrought or cast steel when the working pressure exceeds one hundred and sixty (160) pounds per square inch.

Mud drums.

7. Mud drums of water-tube boilers shall be of wrought or cast steel when the working pressure exceeds one hundred and sixty (160) pounds per square inch.

Superheaters.

8. Pressure parts of superheaters, attached to boilers or separately fired, shall be of wrought or cast steel. Cast iron for superheat is prohibited.

9. Boiler and superheater mountings, such as nozzles, cross pipes, steam pipes, fittings, valves and their bonnets shall be of wrought or cast steel when exposed to steam which is superheated over 80° Fahrenheit.

10. Waterleg and door frame rings of vertical fire-tube and locomotive type boilers shall be of wrought or cast steel, or wrought iron.

SECTION 3.

Stamps to be visible.

1. In laying out shell plates, furnace sheets and heads in the boiler shop, care shall be taken to leave at least one of the stamps, specified in paragraphs 19 and 20, section 1, Part III. of these Rules, so located as to be plainly visible when the boiler is completed; except that the tube sheets

of a vertical fire-tube boiler shall have a portion, at least, of such stamps visible sufficient for identification when the boiler is completed.

Application for authority.

2. A manufacturer who desires to construct MASS STD boilers shall send a written application to the Board of Boiler Rules, and receive written authority from said Board before taking any steps toward the construction of a MASS STD boiler. A detailed list of shop equipment must accompany the manufacturer's application for such authority, also advice of the name of the insurance company authorized to inspect and insure steam boilers for this Commonwealth whose authorized inspector will examine during construction and stamp MASS STD upon completion, a boiler constructed in strict accordance with these Rules. Upon receipt of said application, the Board will designate the style of stamping which it will approve, after the following model:

MASS STD
1
(Designation by Board)

The manufacturer shall then submit a five inch by three inch (5″ x 3″) brass or copper plate showing exactly the style of stamping designated by the Board, for approval; the height of letters and figures to be not less than one-fourth inch ($\frac{1}{4}$″).

(*a*) Each boiler shall conform in every detail with the Rules formulated by this Board and shall be distinctly stamped with the words MASSACHUSETTS STANDARD, abbreviated to read MASS STD, by a member of the boiler

inspection department of the district police, or an inspector holding a certificate of competency as an inspector of steam boilers, as provided by section 6, chapter 465, Acts of 1907, and who is not, directly or indirectly, interested in the manufacture or sale of steam boilers, but in the employ of an insurance company authorized to insure boilers in this Commonwealth. Each boiler shall be stamped by the builder, in the presence of the inspector, with a serial number and with the style of stamping shown in fac-simile previously approved by this Board.

Boilers in process of construction.

(*b*) Any inspector holding a commission or certificate of competency as an inspector of steam boilers for this Commonwealth may make final inspection and test on a boiler built under rules of the Board of Boiler Rules of the Commonwealth of Massachusetts, provided the authorized manufacturer of said boiler, or his representative, makes affidavit under oath that said boiler has been so constructed, and furnishes the record of a properly authorized inspector who has followed the construction of the boiler.

(*c*) The age of a MASSACHUSETTS STANDARD boiler shall date from the time the final inspection is made; and the year of such final inspection shall be stamped by an authorized inspector underneath the MASS STD stamp.

Serial numbers.

3. In numbering serially, each builder shall commence with the number one (1) and continue numbering in consecutive order.

Data reports.

4. A data report, on forms to be furnished by the boiler inspection department of the district police, shall be for-

warded by the builder to the chief inspector of such department for each boiler stamped MASS STD, before the boiler is shipped from the boiler shop.

Location of stamps.

5. Location of stamps to be as follows: —

(*a*) On Horizontal Return Tubular Boilers — on the front head, above the central rows of tubes.

(*b*) On Horizontal Flue Boilers — on the front head, above the flues.

(*c*) On Locomotive Type or Star Water-tube Boilers — on the furnace end, above the handhole.

(*d*) On Vertical Fire and Vertical Submerged Tube Boilers — on the shell, above the furnace door.

(*e*) On Water-tube Boilers, Babcox & Wilcox, Stirling, Heine and Robb-Mumford Standard Types — on a head above the manhole opening, preferably on the flanging of the manhole opening.

(*f*) On Vertical Boilers, Climax or Hazelton Type — on the top head.

(*g*) On Cahall Vertical Water Tube Boilers — on the upper drum, above the manhole opening.

(*h*) On Scotch Marine Boilers — on the front head, above the centre or right-hand furnace.

(*i*) On Economic Boilers — on the rear head, above the central rows of tubes.

(*j*) For other types and new designs — in a location to be approved by this Board.

Stamps not to be covered.

6. The boiler builder's stamp shall not be covered by insulating or other material.

Construction inspection.

7. All boiler shops in which boilers are constructed for installation in this Commonwealth shall be open to the members of the boiler inspection department of the district police and inspectors holding certificates of competency as inspectors of steam boilers, as provided by section 6, chapter 465, Acts of 1907, at all reasonable hours, for inspection of material, methods of manufacture, workmanship and testing.

SECTION 4.

To determine maximum allowable pressure.

1. The maximum pressure to be allowed on a steel or wrought-iron shell or drum of a boiler shall be determined from the minimum thickness of the shell plates, the lowest tensile strength stamped on the plates by the plate manufacturer, the efficiency of the longitudinal joint or ligament between the tube holes, whichever is the least, the inside diameter of the outside course, and a factor of safety of not less than five (5), the formula being: —

$$\frac{\text{T. S.} \times t \times \%}{R \times \text{F. S.}} = \text{maximum allowable working pressure per square inch, in pounds.}$$

T. S. = tensile strength of shell plates, in pounds.

t = minimum thickness of shell plates, in inches.

$\%$ = efficiency of longitudinal joint or ligament between tube holes, whichever is the least.

R = radius = one-half ($\frac{1}{2}$) the inside diameter of the outside course of the shell or drum.

F. S. = 5, the lowest factor of safety allowed on boilers installed after May 1, 1908.

PART III. — SECTION 4.

When it is desired to construct a boiler of special material, the case shall be submitted to this Board for approval.

NOTE. — The method of determining the efficiency of longitudinal joint is given in section 7, Part II., and of determining the efficiency of ligament between tube holes in the following paragraphs.

Ligament between parallel tube holes.

2. Efficiency of ligament: when a shell or drum is drilled for tube holes in a line parallel to the axis of the shell or drum, the efficiency of the ligament between the tube holes shall be determined as follows: —

(*a*) When the pitch of tube holes on every row is equal, the formula is: —

$$\frac{p-d}{p} = \text{Efficiency of ligament.}$$

p = pitch of tube holes, in inches.
d = diameter of tube holes, in inches.

Example.

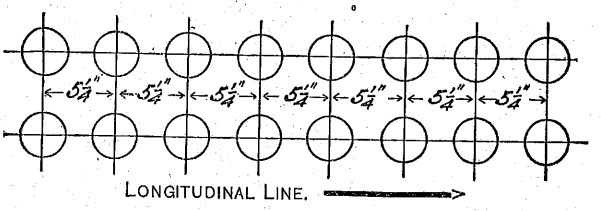


FIG. 8.

Pitch of tube holes in the drum of a water-tube boiler = $5\frac{1}{4}'' = 5.25''$.

Diameter of tube holes = $3\frac{1}{4}'' = 3.25''$.

$$\frac{p-d}{p} = \frac{5.25-3.25}{5.25} = .38, \text{ Efficiency of ligament.}$$

(*b*) When the pitch of tube holes on any one row is unequal, the formula is: —

$$\frac{P-nd}{P} = \text{Efficiency of ligament.}$$

P = unit length of ligament, in inches.
n = number of tube holes in length, P.
d = diameter of tube holes, in inches.

Example.

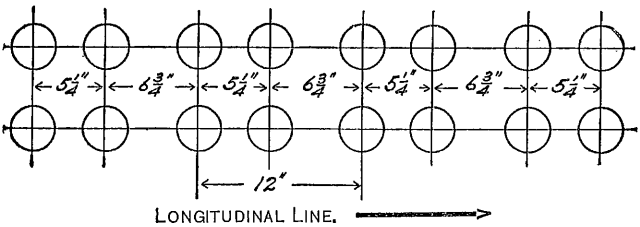


FIG. 9.

$$\frac{P-nd}{P} = \frac{12-2\times3.25}{12} = .458, \text{ Efficiency of ligament.}$$

Example.

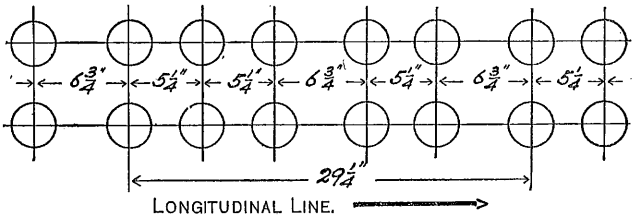


FIG. 10.

$$\frac{P-nd}{P} = \frac{29.25-5\times3.25}{29.25} = .444, \text{ Efficiency of ligament.}$$

Ligament between diagonal tube holes.

3. When a shell or drum is drilled for tube holes in a line diagonal with the axis of the shell or drum, the efficiency of the ligament between the tube holes shall be determined as follows: —

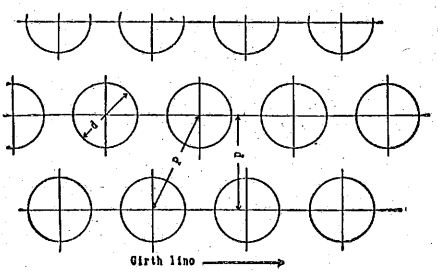


FIG. 11.

$\frac{P-d}{P}$ = Efficiency of ligament.

P = diagonal pitch of tube holes, in inches.
d = diameter of tube holes, in inches.
p = distance between rows of tubes, longitudinally.

Example.

Diagonal pitch of tube holes in the drum of a water-tube boiler = 6.42″.
Diameter of tube holes = 4″.
Distance between rows of tubes, longitudinally = 5.75″.

$$\frac{6.42-4}{5.75} = .42, \text{ Efficiency of ligament.}$$

PART III. — SECTION 4.

Staying heads H. T. boiler by steel angles. Pressure not to exceed 100 pounds.

4. When the shell of a horizontal return tubular boiler does not exceed thirty-six (36) inches in diameter, and is designed for a maximum working pressure not to exceed one hundred (100) pounds per square inch, the segment of head above the tubes *may* be stayed by steel angles, or Tee bars, the formula being: —

$$\frac{fI}{y} = M.$$

f = fiber stress = 16,000 pounds.

I = moment of inertia = $\frac{bh^3}{12}$.

h = height of beam, in inches.
b = thickness of beam, in inches.

y = distance of most strained fiber = h ÷ 2.

M = bending moment of beam.

Maximum bending moment for uniform load = $\frac{WL}{8.}$

W = weight to be supported, in pounds.
L = length of beam, in inches.

Staying heads 30″ H. T. boiler.

Example A. — When steel angles are used, the head of a horizontal return tubular boiler, thirty (30) inches in diameter, designed for one hundred (100) pounds working pressure, shall be stayed by two (2) four and one-half by three by three-eighths ($4\frac{1}{2} \times 3 \times \frac{3}{8}$) inch steel angles, as shown in Fig. 12, or by other sized commercial steel angles the resistance of which shall be equal to or greater than the maximum bending moment.

PART III. — SECTION 4.

Distance from tubes to shell = $13\frac{1}{2}$".
Area to be stayed = 143 square inches.
Load at 100 pounds pressure = 14,300 pounds.

$$\frac{WL}{8} = \frac{14{,}300 \times 21}{8} = 37{,}540 \text{ pounds.}$$

Moment of inertia = $I = \frac{1}{12} \times 4.5^3 \times \frac{3}{8} = 2.85$.
$y = 4.5 \div 2 = 2.25$.

$$\frac{fI}{y} = M = \frac{16{,}000 \times 2.85}{2.25} = 20{,}266 \text{ pounds for one angle.}$$

Resistance of one angle = 20,266 pounds.
Resistance of two angles = 40,532 pounds.

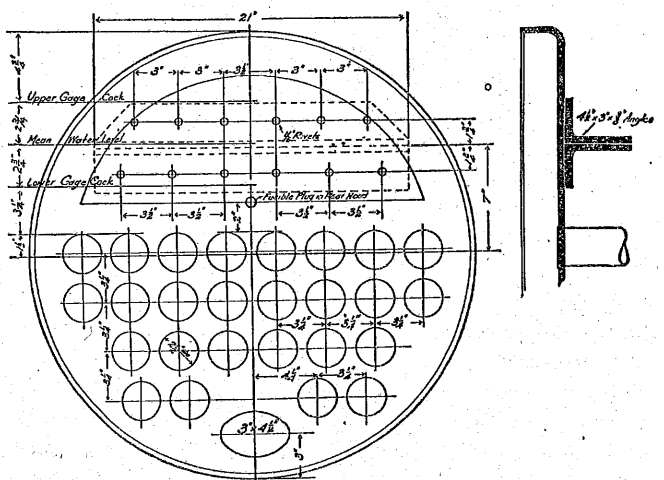


FIG. 12.

Staying heads 36″ H. T. boiler.

Example B. — When steel angles are used, the head of a horizontal return tubular boiler, thirty-six (36) inches in diameter, designed for one hundred (100) pounds working pressure, shall be stayed by two (2) six by three and one-half by one-half ($6 \times 3\frac{1}{2} \times \frac{1}{2}$) inch steel angles, as shown in Fig. 13, or by other sized commercial steel angles the resistance of which shall be equal to or greater than the maximum bending moment.

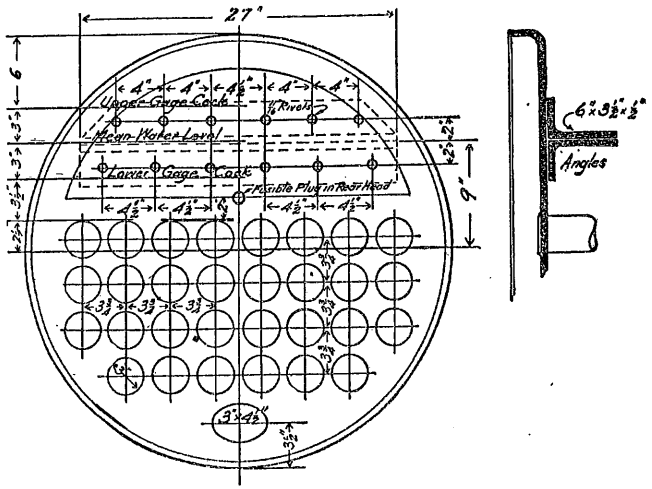


FIG. 13.

Distance from tubes to shell = $15\frac{1}{2}''$.
Area to be stayed = 220 square inches.
Load at 100 pounds pressure = 22,000 pounds.

$$\frac{WL}{8} = \frac{22{,}000 \times 27}{8} = 74{,}250 \text{ pounds.}$$

Moment of inertia = $I = \frac{1}{12} \times 6^3 \times \frac{1}{2} = 9.$
$y = 6 \div 2 = 3.$

$$\frac{fI}{y} = M = \frac{16{,}000 \times 9}{3} = 48{,}000 \text{ pounds for one angle.}$$

Resistance of one angle = 48,000 pounds.
Resistance of two angles = 96,000 pounds.

Longitudinal joints.

5. The longitudinal joints of a boiler, the shell or drum of which *exceeds* thirty-six (36) inches in diameter, shall be of butt and double strap construction.

6. The longitudinal joints of a boiler, the shell or drum of which *does not exceed* thirty-six (36) inches in diameter, *may* be of lap-riveted construction; and the maximum pressure allowed on such shells or drums shall not exceed one hundred (100) pounds per square inch.

7. Any form of longitudinal joint, other than specified in paragraphs 5 and 6 of this section, shall be submitted to this Board for approval.

8. The longitudinal joints of horizontal return tubular boilers shall be located above the fire-line of the setting.

9. A horizontal return tubular, vertical tubular, or locomotive type boiler shall not have a continuous longitudinal joint over twelve (12) feet in length.

Longitudinal joints welded by forging process.

10. The efficiency of longitudinal joint of a shell or drum, when welded by the forging process, shall not exceed the following: —

55.0% when the shell plates are stamped 52,000 T. S.
54.0% when the shell plates are stamped 53,000 T. S.
53.0% when the shell plates are stamped 54,000 T. S.
52.0% when the shell plates are stamped 55,000 T. S.
51.1% when the shell plates are stamped 56,000 T. S.

NOTE. — 56,000 pounds will be the highest tensile strength used in calculating the maximum allowable working pressure on a shell or drum, the longitudinal joints of which are welded by the forging process, this being irrespective of a higher tensile strength than 56,000 which may be stamped on the plates. The formula for calculating the working pressure is given in paragraph 1, section 4, Part III. of these Rules.

Thickness of shell plates.

11. The minimum thickness of plates used in the construction of a boiler shall be one-fourth ($\frac{1}{4}$) inch.

12. The minimum thickness of shell plates shall be as follows: —

WHEN THE DIAMETER OF SHELL IS —			
36" or Under.	Over 36" to 54" Inclusive.	Over 54" to 72" Inclusive.	Over 72".
¼"	5/16"	⅜"	½"

Thickness of butt straps.

13. The minimum thickness of butt straps shall be as follows: —

Thickness of Shell Plates.	Minimum Thickness of Butt Straps.	Thickness of Shell Plates.	Minimum Thickness of Butt Straps.
1/4"	1/4"	17/32"	7/16"
9/32"	1/4"	9/16"	7/16"
5/16"	1/4"	5/8"	1/2"
11/32"	1/4"	3/4"	1/2"
3/8"	5/16"	7/8"	5/8"
13/32"	5/16"	1"	3/4"
7/16"	3/8"	1 1/8"	3/4"
15/32"	3/8"	1 1/4"	7/8"
1/2"	7/16"		

Butt straps.

14. Butt straps shall be rolled or formed to the proper curvature on forms made for that purpose.

Thickness of tube sheets.

15. The minimum thickness of tube sheets shall be as follows: —

WHEN THE DIAMETER OF TUBE SHEET IS —			
42" or Under.	Over 42" to 54" Inclusive.	Over 54" to 72" Inclusive.	Over 72".
3/8"	7/16"	1/2"	9/16"

Dished heads.

16. The minimum thickness of a convex head curved outward from the shell shall be determined by the following

formula, excepting that said thickness shall not be less than one-fourth inch ($\frac{1}{4}''$): —

$$\frac{8.33\ R \times P}{T.\ S.} = t.$$

The minimum thickness of a concave head curved inward to the shell shall be determined by the following formula, excepting that said thickness shall not be less than one-fourth inch ($\frac{1}{4}''$): —

$$\frac{8.33\ R \times P}{0.6\ (T.\ S.)} = t.$$

R = one-half the radius to which the head is dished.
8.33 = factor of safety.
P = working pressure, in pounds per square inch, for which the boiler is designed.
T. S. = tensile strength, in pounds per square inch, stamped on the head by the manufacturer.
t = thickness of head, in inches.

The radius to which the head is dished shall not be greater than the diameter of the shell to which the head is attached.

The radius to which the curve shall be made close to the flange on a concave or convex head shall not be less than three (3) times the thickness of the material in the head, and shall be measured on the concave side of head.

17. When a convex or concave head has a manhole opening, the thickness as found by the formula in paragraph 16 of this section shall be increased by not less than one-eighth ($\frac{1}{8}$) inch.

18. When a convex or concave head has a manhole opening, the flange shall be turned inward, and to a depth of not less than three (3) times the thickness of the head, measured from the outside of the boiler.

Stayed flat surfaces.

19. The minimum thickness of plates in stayed flat surface construction shall be five-sixteenths ($\frac{5}{16}$) inch.

Ends of stay-bolts.

20. The ends of stay-bolts shall be riveted over or upset by equivalent process.

Pitch of stay-bolts.

21. The pitch allowed for stay-bolts on a flat surface and on the furnace sheet of an internally fired boiler in which the external diameter of the furnace is over thirty-eight (38) inches, except a corrugated furnace or a furnace strengthened by an Adamson ring or equivalent, shall not exceed that given in the following table: —

Part III. — Section 4.

Table of Maximum Allowable Pitch, in Inches, of Screwed Stay-bolts, Ends Riveted Over.

Pressure, in Pounds per Square Inch.	Thickness of Plate.						
	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"
	Maximum Pitch of Stay-bolts, in Inches.						
100, . . .	5½	6¼	7	7¾	8½	–	–
110, . . .	5¼	6	6¾	7⅜	8⅛	–	–
120, . . .	5⅛	5¾	6½	7⅛	7⅞	8½	–
125, . . .	5	5⅝	6⅜	7	7¾	8⅜	–
130, . . .	5	5⅝	6¼	6⅞	7⅝	8¼	–
140, . . .	4¾	5½	6	6⅝	7⅜	8	–
150, . . .	4¾	5¼	5⅞	6½	7⅛	7¾	8⅜
160, . . .	4⅝	5⅛	5¾	6¼	6⅞	7½	8
170, . . .	4½	5	5⅝	6⅛	6¾	7¼	7⅞
180, . . .	4⅜	4⅞	5½	6	6½	7⅛	7¾
190, . . .	4⅜	4⅞	5⅜	5⅞	6⅜	7	7½
200, . . .	4¼	4¾	5¼	5¾	6¼	6¾	7⅜
225, . . .	4⅛	4½	5	5½	6	6½	7
250, . . .	4	4⅜	4¾	5¼	5¾	6¼	6⅝
300, . . .	3¾	4⅛	4½	4⅞	5⅜	5¾	6⅛

When the maximum allowable pitch is five and one-half ($5\frac{1}{2}$) inches or less, the stay-bolts adjacent to a furnace door or other boiler fitting, handhole or other opening, may have an increased pitch of not over one (1) inch.

When a pitch not exceeding eight and one-half ($8\frac{1}{2}$) inches

is required and is not given in the table, the following formula shall be used: —

$$S=\sqrt{\frac{C\times(t+1)^2}{P}}+6, \quad P=\frac{C(t+1)^2}{S^2-6}, \quad t=\sqrt{\frac{P(S^2-6)}{C}}-1.$$

S = maximum pitch of stay-bolts, in inches.
C = a constant = 66.
t = thickness of plate, in *sixteenths* of an inch.
P = working pressure per square inch, in pounds.

Hollow stay-bolts.

When hollow stay-bolts are used, having the hole one-half ($\frac{1}{2}$) inch in diameter or over, the maximum allowable pitch given in the above table may be increased by the mean diameter of the stay-bolt: —

$$\text{Mean diameter of stay-bolt} = \frac{\text{least outside diameter of stay-bolt} + \text{diameter of hole in stay-bolt}}{2}.$$

Pitch of stay-bolts, V. T. boilers.

22. An internally fired boiler, in which the external diameter of the furnace is thirty-eight (38) inches or less, except a corrugated furnace or a furnace strengthened by an Adamson ring or equivalent, shall have the furnace sheet supported by one row of stay-bolts, or more, the circumferential pitch not to exceed that given in the following table, and the minimum outside diameter of stay-bolts to be as given in tables, paragraph 23 of this section.

THICKNESS OF FURNACE SHEET.	Pressure, in Pounds per Square Inch.							
	100	110	120	125	130	140	150	175
	Circumferential Pitch of Stay-bolts, in Inches, not to exceed —							
1/4", . . .	4 3/4	4 5/8	4 1/2	4 3/8	4 3/8	4 1/4	4 1/8	3 7/8
5/16", . . .	5 1/2	5 1/4	5 1/8	5	5	4 3/4	4 3/4	4 1/2

23. The longitudinal pitch between stay-bolts on the furnace sheet of an internally fired boiler, in which the external diameter of the furnace is thirty-eight (38) inches or less, except a corrugated furnace or a furnace strengthened by an Adamson ring or equivalent, shall not exceed that given in the following tables, the formula being: —

$$L=\left(\frac{Ct^2}{Pd}\right)^2, \quad t=\sqrt{\frac{Pd\sqrt{L}}{C}}, \quad P=\frac{Ct^2}{d\sqrt{L}}, \quad d=\frac{Ct^2}{P\sqrt{L}}.$$

L = longitudinal pitch of stay-bolts, in inches, or one-half the height of furnace when only one circumferential row of stay-bolts is required.

C = a constant = 110.

t = thickness of furnace sheet, in *thirty-seconds* of an inch.

P = working pressure per square inch, in pounds.

d = external diameter of furnace, in inches.

External diameter of furnace not exceeding 20″.	Pressure, in Pounds per Square Inch.							
	100	110	120	125	130	140	150	175
	Longitudinal Pitch of Stay-bolts, in Inches, not to exceed —							
Thickness of furnace sheet ¼″.	12⅜	10¼	8⅝	7⅞	7¼	6⅜	5½	4
	Diameter of stay-bolts over threads shall not be less than three-fourths (¾) inch.							

External diameter of furnace not exceeding 26″.	Pressure, in Pounds per Square Inch.							
	100	110	120	125	130	140	150	175
	Longitudinal Pitch of Stay-bolts, in Inches, not to exceed —							
Thickness of furnace sheet ¼″.	7¼	6	5⅛	4⅝	4⅜	–	–	–
	Diameter of stay-bolts over threads shall not be less than three-fourths (¾) inch.							
Thickness of furnace sheet 5/16″.	15⅞	14¾	12⅜	11⅜	10⅝	9	8	5¾
	Diameter of stay-bolts over threads shall not be less than seven-eighths (⅞) inch.							

External diameter of furnace not exceeding 32″.	Pressure, in Pounds per Square Inch.					
	100	110	120	125	130	140
	Longitudinal Pitch of Stay-bolts, in Inches, not to exceed —					
Thickness of furnace sheet 5/16″.	11¾	9¾	8⅛	7⅝	7	6
	Diameter of stay-bolts over threads shall not be less than seven-eighths (⅞) inch.					

External diameter of furnace not exceeding 38″.	Pressure, in Pounds per Square Inch.				
	100	110	120	125	130
	Longitudinal Pitch of Stay-bolts, in Inches, not to exceed —				
Thickness of furnace sheet 5/16″.	8 3/8	7	5 7/8	5 3/8	5
	Diameter of stay-bolts over threads shall not be less than seven-eighths (7/8) inch.				

24. When a pitch of stay-bolts is required for a pressure higher than given in the tables, paragraph 23 of this section, the furnace sheet shall be stay-bolted as a flat surface, as shown in the table, paragraph 21 of this section.

Measurement of height of furnace, V. T. boilers.

25. In a vertical fire-tube boiler the height of furnace shall be measured from the center of rivets at the bottom of the waterleg to the center of rivets in lower tube sheet; and the pitch of stay-bolts shall be measured at the furnace sheet. The vertical pitch of stay-bolts, measured from the rivets in the lower tube sheet to the first row of stay-bolts, shall not be greater than the maximum allowable pitch of stay-bolts.

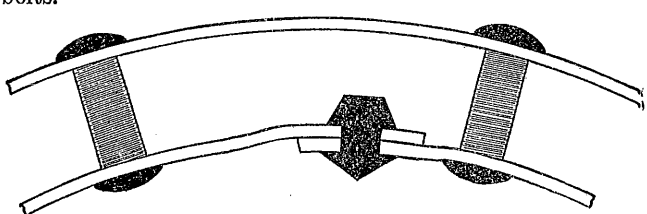


FIG. 14.

Longitudinal joint of furnace sheet, V. T. boilers.

26. When the longitudinal joint of the furnace sheet of a vertical fire-tube boiler is of lap-riveted construction, a stay-bolt in each row shall be located near the longitudinal joint, as shown in Fig. 14.

Staying segments of heads.

27. A segment of a head of a horizontal return tubular, locomotive, Scotch or similar type boiler shall be stayed by welded or weldless mild steel or wrought iron, head to head or through, diagonal or crow-foot stays, except a horizontal return tubular boiler, as provided in paragraph 4 of this section.

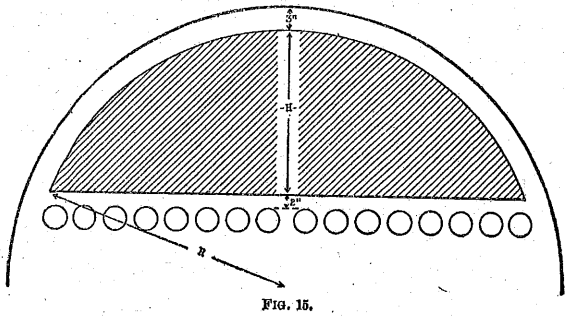


FIG. 15.

Areas of segments of heads to be stayed.

28. The area of a segment of a head to be stayed shall be the area enclosed by lines drawn three (3) inches from the shell and two (2) inches from the tubes, as shown in Figs. 15 and 16 of these Rules.

Table of areas of segments.

29. The following table gives the net area, in square inches, of any segment of a head to be stayed, as shown in Fig. 15.

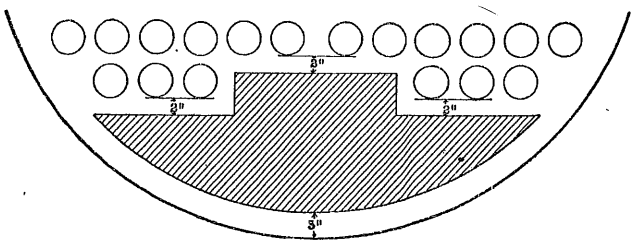


FIG. 16.

HEIGHT FROM TUBES TO SHELL.	Diameter of Boiler.												
	24″	30″	36″	42″	48″	54″	60″	66″	72″	78″	84″	90″	96″
	Area to be stayed, in Square Inches.												
8″	28	33	37	40	43	47	51	53	55	58	60	63	65
8½″	35	41	46	51	55	59	63	66	70	74	76	80	82
9″	42	49	56	62	67	72	76	82	86	90	92	95	98
9½″	50	58	66	70	80	86	91	96	101	105	111	116	119
10″	57	68	77	85	93	99	106	112	117	123	129	132	137
10½″	66	78	89	98	107	114	123	131	135	142	147	153	160
11″	74	88	100	111	121	130	138	147	155	161	169	174	183
11½″	83	99	112	124	137	146	156	165	173	181	189	196	204
12″	91	109	125	139	151	163	174	184	194	203	213	219	230
12½″		120	138	153	167	180	193	204	216	224	234	243	252
13″	—	132	151	168	183	197	211	224	235	247	256	267	279
13½″		143	164	183	200	216	230	246	258	270	282	293	302
14″	—	155	178	199	217	234	250	266	280	294	305	319	331
14½″		167	192	215	235	254	271	287	303	318	333	345	360
15″	—	178	206	231	252	273	291	309	326	343	357	372	386
15½″			220	247	271	291	312	332	350	368	382	400	417
16″	—	—	235	263	289	312	334	355	374	394	411	423	443
16½″			249	281	308	332	357	380	399	420	436	457	475
17″	—	—	264	297	326	353	378	402	425	447	467	486	502
17½″				314	345	374	400	426	449	471	494	516	536
18″	—	—	—	331	365	396	424	450	476	500	520	543	564
18½″				349	384	417	448	476	501	526	552	577	598
19″	—	—	—	366	404	439	470	500	529	555	580	604	631
19½″				384	424	461	496	528	558	584	613	641	663
20″	—	—	—	401	444	483	519	552	583	613	642	667	699

20½",	—	—	—	—	464	505	543	578	613	643	675	706	729
21",	—	—	—	—	485	528	568	604	640	673	705	733	766
21½",	—	—	—	—	505	551	594	632	669	703	739	766	797
22",	—	—	—	—	526	574	618	658	697	734	769	800	835
22½",	—	—	—	—	—	597	643	687	726	765	800	835	867
23",	—	—	—	—	—	620	668	713	754	796	830	869	906
23½",	—	—	—	—	—	642	695	740	784	827	866	904	945
24",	—	—	—	—	—	667	719	768	814	859	897	939	978
24½",	—	—	—	—	—	689	745	797	843	892	934	975	1,018
25",	—	—	—	—	—	714	771	825	875	922	966	1,010	1,051
25½",	—	—	—	—	—	737	798	855	907	956	1,003	1,047	1,092
26",	—	—	—	—	—	761	824	882	936	987	1,035	1,083	1,126
26½",	—	—	—	—	—		850	909	968	1,024	1,073	1,120	1,167
27",	—	—	—	—	—	—	877	939	998	1,053	1,106	1,157	1,202
27½",	—	—	—	—	—		904	968	1,030	1,089	1,145	1,195	1,243
28",	—	—	—	—	—	—	930	997	1,060	1,120	1,177	1,232	1,279
28½",	—	—	—	—	—			1,028	1,092	1,157	1,211	1,270	1,321
29",	—	—	—	—	—	—	—	1,056	1,123	1,187	1,248	1,305	1,360
29½",	—	—	—	—	—			1,084	1,155	1,221	1,284	1,347	1,400
30",	—	—	—	—	—	—	—	1,115	1,187	1,255	1,321	1,382	1,442
30½",	—	—	—	—	—				1,218	1,290	1,358	1,424	1,480
31",	—	—	—	—	—	—	—	—	1,252	1,324	1,394	1,459	1,523
31½",	—	—	—	—	—				1,286	1,359	1,433	1,496	1,561
32",	—	—	—	—	—	—	—	—	1,317	1,394	1,467	1,538	1,605
32½",	—	—	—	—	—					1,430	1,508	1,575	1,650
33",	—	—	—	—	—	—	—	—	—	1,465	1,542	1,617	1,687
33½",	—	—	—	—	—					1,500	1,578	1,655	1,733
34",	—	—	—	—	—	—	—	—	—	1,536	1,617	1,695	1,770
34½",	—	—	—	—	—						1,654	1,735	1,816
35",	—	—	—	—	—	—	—	—	—	—	1,692	1,775	1,856
35½",	—	—	—	—	—							1,810	1,900
36",	—	—	—	—	—	—	—	—	—	—	—	1,857	1,941
36½",													1,984
37",	—	—	—	—	—	—	—	—	—	—	—	—	2,026

Formula to find area of segment.

30. When an area is required that is not given in the table (paragraph 29), the following formula shall be used: —

$$\frac{4\,H^2}{3}\sqrt{\frac{2\,R}{H}-.608}=\text{Area of segment to be stayed, in square inches.}$$

H = distance from tubes to shell, minus five inches.
R = radius of boiler, minus three inches.

31. When a flat head has a manhole opening, the flange of which is formed from the solid sheet and turned inward to a depth of not less than three (3) times the thickness of the head, measured from the outside of the boiler, an area two inches (2″) wide all around the manhole opening, as shown in Fig. 17, may be deducted from the total area of head, including manhole opening, to be stayed.

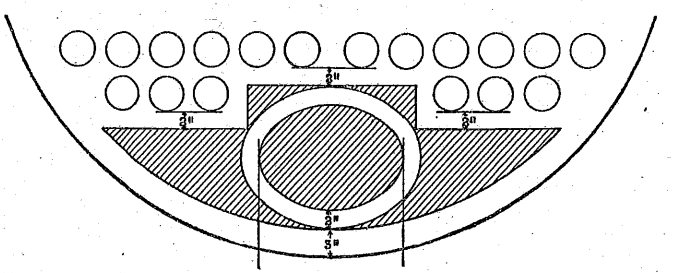


FIG. 17.

Example. — To find an area 2″ wide all around a 11″×15″ manhole,

15″×19″×.7854=224 (nearly) square inches.
11″×15″×.7854=130 (nearly) square inches.
And 224−130=94 square inches.

Therefore, if the area to be stayed on the *rear* head, below the tubes, of a seventy-two (72) inch horizontal return tubular boiler is 374 square inches, the area to be stayed on the *front* head, below the tubes, of this boiler, would be 374 − 94 = 280 square inches.

32. A horizontal return tubular boiler, having a manhole below the tubes, shall have one or more stays on each side of the manhole, the rear ends of which shall be attached to the rear head of the boiler, and the front ends shall pass through the front head and shall be secured with nuts, inside and out. The center line of such stays at the front head shall not be below the center line of the manhole.

33. Stay rods shall not exceed three (3) feet in length when screwed through the sheets and riveted over. Stay rods longer than three (3) feet, such as are used for bracing the segment of a circle, shall not have less than .7854 square inch cross-sectional area.

34. Flat surfaces other than segments of heads, and curved surfaces other than as provided in paragraphs 22 and 23 of this section shall be stay-bolted, or stayed by welded or weldless mild steel or wrought-iron, head to head or through, diagonal or crow-foot stays.

Load allowed on stay-bolts.

Example. — To determine the maximum allowable working pressure per square inch on *stay-bolted* flat surface, or *stay-bolted* curved surface on furnace sheet over thirty-eight (38) inches in diameter: —

Divide the load in pounds allowed on a given *stay-bolt* by the net area supported by the *stay-bolt*, in square inches: —

Pitch of stay-bolts = 5″ × 5″.
Outside diameter of stay-bolt = $\frac{7}{8}$″.
Area of a $\frac{7}{8}$″ stay-bolt at bottom of thread = .419 square inches.
Load allowed on a $\frac{7}{8}$″ stay-bolt at 6,500 pounds per square inch = 2,724 pounds.
Net area supported by one stay-bolt = 5″ × 5″ = 25 − .419 (net area of stay-bolt) = 24.581 square inches.
2,724 ÷ 24.581 = maximum allowable pressure per square inch = 110 pounds.

Stays and stay-bolts.

35. The maximum allowable stress per square inch net cross-sectional area of stays and stay-bolts shall be as follows: —

MATERIAL AND TYPE.	Size up to and including 1¼″ Diameter or Equivalent Area.	Size over 1¼″ Diameter or Equivalent Area.
Weldless mild steel head to head or through stays.	8,000 lbs.	9,000 lbs.
Weldless mild steel diagonal or crow-foot stays.	7,500 lbs.	8,000 lbs.
Weldless wrought-iron head to head or through stays.	7,000 lbs.	7,500 lbs.
Weldless wrought-iron diagonal or crow-foot stays.	6,500 lbs.	7,000 lbs.
Welded mild steel or wrought-iron stays.	6,000 lbs.	6,000 lbs.
Mild steel or wrought-iron stay-bolts,	6,500 lbs.	7,000 lbs.

Specifications for stays and stay-bolts, tested material.

36. When a greater allowable stress per square inch on stays and stay-bolts is required than that allowed in paragraph 35 of this section, the material shall conform to the following physical qualities: —

Tensile strength, pounds per square inch, shall not exceed .	62,000
Yield point, in pounds per square inch, shall not be less than	½ T. S.
Elongation per cent. in 8 inches shall not be less than . .	28

and a certified report of test of such material shall be filed with the data report required by paragraph 4, section 3, Part III. of these Rules; and the maximum allowable stress on such stays or stay-bolts shall be based on a factor of safety of not less than six and five-tenths (6.5).

Allowable load on stay-bolts.

37. Table of allowable loads on net cross-sectional area of stay-bolts, V threads, twelve (12) threads per inch: —

Outside Diameter of Stay-bolts, in Inches.		Diameter at Bottom of Thread, in Inches.	Net Cross-sectional Area (at Bottom of Thread), in Square Inches.	Allowable Load at 6,500 Pounds Stress, per Square Inch.	Allowable Load at 7,000 Pounds Stress, per Square Inch.
¾	.7500	.6057	.288	1,872	2,016
13/16	.8125	.6682	.351	2,282	2,457
⅞	.8750	.7307	.419	2,724	2,933
15/16	.9375	.7932	.494	3,211	3,458
1	1.0000	.8557	.575	3,738	4,025
1 1/16	1.0625	.9182	.662	4,303	4,634
1⅛	1.1250	.9807	.755	4,908	5,285
1 3/16	1.1875	1.0432	.855	5,558	5,985
1¼	1.2500	1.1057	.960	6,240	6,720
1 5/16	1.3125	1.1682	1.072	6,968	7,504
1⅜	1.3750	1.2307	1.190	7,735	8,330
1 7/16	1.4375	1.2932	1.313	8,535	9,191
1½	1.5000	1.3557	1.444	9,386	10,108

The formula for diameter of stay-bolt at bottom of thread being: —

$D-(P\times 1.732)=d$, or for 12 threads per inch,
$D-(.08333\times 1.732)=d$, then
$D-.1443=d$.

D = diameter of stay-bolt over the threads.
P = pitch of threads = $\frac{1}{12}$ = .08333.
d = diameter of stay-bolt at bottom of threads.
1.732 = a constant.

When U. S. threads are used, the formula becomes: —

$$D-(P\times 1.732\times .75)=d.$$

PART III. — SECTION 4.

38. Table of allowable loads on net cross-sectional area of stay-bolts, V threads, ten (10) threads per inch: —

Outside Diameter of Stay-bolts, in Inches.		Diameter at Bottom of Thread, in Inches.	Net Cross-sectional Area (at Bottom of Thread), in Square Inches.	Allowable Load at 6,500 Pounds Stress, per Square Inch.	Allowable Load at 7,000 Pounds Stress, per Square Inch.
1¼	1.2500	1.0768	.911	5,921	6,377
1 5/16	1.3125	1.1393	1.019	6,623	7,133
1⅜	1.3750	1.2018	1.134	7,371	7,938
1 7/16	1.4375	1.2643	1.255	8,157	8,785
1½	1.5000	1.3268	1.382	8,983	9,674
1 9/16	1.5625	1.3893	1.515	9,847	10,605
1⅝	1.6250	1.4518	1.655	10,757	11,585

39. Table of allowable loads on net cross-sectional area of circular stays or rectangular stays of equal cross-sectional area: —

Minimum Diameter of Circular Stay, in Inches.		Net Cross-sectional Area of Stay, in Square Inches.	Allowable Stress, in Pounds per Square Inch, Net Cross-sectional Area.					
			6,000	6,500	7,000	7,500	8,000	9,000
			Allowable Load, in Pounds, on Net Cross-sectional Area.					
1	1.0000	.7854	4,712	5,105	5,498	5,891	6,283	–
1 1/16	1.0625	.8866	5,320	5,763	6,206	6,650	7,093	–
1 1/8	1.1250	.9940	5,964	6,461	6,958	7,455	7,952	–
1 3/16	1.1875	1.1075	6,645	7,199	7,753	8,306	8,860	–
1 1/4	1.2500	1.2272	7,363	7,977	8,590	9,204	9,818	–
1 5/16	1.3125	1.3530	8,118	8,795	9,471	10,148	10,824	12,177
1 3/8	1.3750	1.4849	8,909	9,652	10,394	11,137	11,879	13,364
1 7/16	1.4375	1.6230	9,738	10,550	11,361	12,173	12,984	14,607
1 1/2	1.5000	1.7671	10,603	11,486	12,370	13,253	14,137	15,904
1 9/16	1.5625	1.9175	11,505	12,464	13,423	14,381	15,340	17,258
1 5/8	1.6250	2.0739	12,443	13,480	14,517	15,554	16,591	18,665
1 11/16	1.6875	2.2365	13,419	14,537	15,655	16,744	17,892	20,129
1 3/4	1.7500	2.4053	14,432	15,634	16,837	18,040	19,242	21,648
1 13/16	1.8125	2.5802	15,481	16,771	18,061	19,352	20,642	23,222
1 7/8	1.8750	2.7612	16,567	17,948	19,328	20,709	22,090	24,851
1 15/16	1.9375	2.9483	17,690	19,164	20,638	22,112	23,586	26,535
2	2.0000	3.1416	18,850	20,420	21,991	23,562	25,133	28,274
2 1/8	2.1250	3.5466	21,280	23,053	24,826	26,600	28,373	31,919
2 1/4	2.2500	3.9761	23,857	25,845	27,833	29,821	31,809	35,785
2 3/8	2.3750	4.4301	26,580	28,796	31,011	33,226	35,441	39,871
2 1/2	2.5000	4.9087	29,452	31,907	34,361	36,815	39,270	44,178
2 5/8	2.6250	5.4119	32,471	35,177	37,883	40,589	43,295	48,707
2 3/4	2.7500	5.9396	35,638	38,607	41,577	44,547	47,517	53,456
2 7/8	2.8750	6.4918	38,951	42,197	45,443	48,689	51,934	58,426
3	3.0000	7.0686	42,412	45,946	49,480	53,015	56,549	63,617

Drilling of stay-bolts.

(*a*) All stay-bolts, except those in vertical boilers having furnaces not exceeding forty-four inches (44″) in diameter, shall be drilled from the outside end to a depth of not less than one-half inch ($\frac{1}{2}$″) inside the boiler plate, and drilled to a diameter not smaller than three-sixteenths inch ($\frac{3}{16}$″).

(*b*) Hollow stay-bolts with a hole not less than three-sixteenths inch ($\frac{3}{16}$″) diameter, and undrilled flexible stay-bolts of a design approved by this Board, may be used. If a hole larger than three-sixteenths inch ($\frac{3}{16}$″) is used, this hole shall be deducted from the cross-sectional area of the stay-bolt at the base of the thread, in computing the allowable load on stay-bolts.

Cast-iron nozzles.

40. The minimum thickness of cast-iron nozzles shall be determined by the following formula: —

$$\frac{Pdf}{2S} + .5 = t.$$

P = working pressure, in pounds per square inch.
d = inside diameter of nozzle, in inches.
f = factor of safety = 12.
S = ultimate tensile strength of cast-iron, not less than eighteen thousand (18,000) pounds per square inch, as required by paragraph 5, section 2, Part III. of these Rules.
.5 = a constant.
t = thickness of nozzle in inches.

Example. — Find the required thickness of a cast-iron steam nozzle six (6) inches in diameter for a working pressure of one hundred and fifty (150) pounds.

$$\frac{150\times6\times12}{2\times18{,}000}+.5=.8'', \text{ Thickness of nozzle.}$$

Cast-iron blank flanges.

41. The thickness of cast-iron blank flanges shall not be less than specified by the manufacturers' standard for high pressure.

Riveting.

42. On longitudinal joints, the distance from the center of rivet hole to the edge of the plate, except rivet holes in the ends of butt straps, shall not be less than one and one-half ($1\frac{1}{2}$) times the diameter of the rivet hole.

43. Rivet holes, except for attaching stays or angle bars to heads, shall be drilled full size with plates, butt straps and heads bolted up in position; or they may be punched not to exceed one-fourth ($\frac{1}{4}$) inch less than full size for plates over five-sixteenths ($\frac{5}{16}$) of an inch in thickness, and one-eighth ($\frac{1}{8}$) of an inch less than full size for plates not exceeding five-sixteenths ($\frac{5}{16}$) of an inch in thickness, and then drilled or reamed to full size with plates, butt straps and heads bolted up in position.

44. Rivets shall be of sufficient length to completely fill the rivet holes and form a head equal in strength to the body of the rivet.

45. Rivets shall be machine driven, wherever possible, with sufficient pressure to fill the rivet holes, and shall be allowed to cool and shrink under pressure.

Calking.

46. The calking edges of plates and butt straps shall be beveled. Calking shall be done with a round-nosed tool.

Planing of plates.

46*a*. The calking edges of plates and butt straps shall be planed not less than one-eighth of an inch ($\frac{1}{8}''$), to remove the distorted edges of the plates.

Tube holes.

47. Tube holes shall be drilled full size, or they may be punched not to exceed one-half ($\frac{1}{2}$) inch less than full size, and then drilled, reamed or finished full size with rotating cutter.

48. The edges of tube holes shall be chamfered to a radius of about one-sixteenth ($\frac{1}{16}$) inch.

Tube ends fire-tube boilers.

49. A fire-tube boiler shall have the ends of the tubes substantially beaded.

Tube ends water-tube boilers and superheaters.

50. The ends of all tubes, suspension tubes and nipples shall be flared not less than one-eighth ($\frac{1}{8}$) inch over the diameter of the tube hole on all water-tube boilers and superheaters.

51. The ends of all tubes, suspension tubes and nipples of water-tube boilers and superheaters shall not project through the tube sheets or headers less than one-fourth ($\frac{1}{4}$) inch nor more than one-half ($\frac{1}{2}$) inch. Separately fired superheaters shall have the tube ends protected by refractory material where they connect with drums or headers.

Fusible plug in a tube.

52. When it is necessary to place a fusible plug in a tube, an extra thick tube shall be provided for that purpose, which shall not be less than three-sixteenths of an inch ($\frac{3}{16}$"), or number nine (No. 9) gage.

Opening in shells, drums or heads to be re-enforced.

53. An opening in a boiler for a threaded pipe connection one inch in diameter or over (except water column connections) shall not have less than the minimum number of threads in such opening, as shown in the following table: —

Size of pipe connection, in inches, . .	1 and 1¼	1½ and 2	2½ to 4 inclusive	4½ to 6 inclusive	7 and 8	9 and 10	12
Number of threads per inch, . . .	11½	11½	8	8	8	8	8
Minimum number of threads required in opening.	4	5	7	8	10	12	13
Minimum thickness of material required to give above number of threads.	.348″ (.375″=⅜″)	.435″ (.4375″=7/16″)	.875″	1″	1.25″	1.5″	1.625″

If the thickness of the material in the boiler is not sufficient to give such number of threads, there shall be a standard commercial pressed steel flange, cast steel flange or steel plate, substantially riveted to the boiler, so as to give the required number of threads. A feed pipe connection may be fitted with a brass or steel boiler bushing.

Cast steel.

53*a*. Steel castings shall conform to the CLASS—B specifications of the AMERICAN SOCIETY FOR TESTING MATERIALS.

Manholes and sizes.

54. An elliptical manhole opening shall not be less than eleven by fifteen (11×15) inches in size.

A circular manhole opening shall not be less than fifteen (15) inches in diameter.

A variation of one-half ($\frac{1}{2}$) inch in the above dimensions will be allowed.

55. There shall be a manhole in the upper part of the shell or head of a fire-tube boiler over forty (40) inches in diameter, except a vertical fire-tube boiler.

Manhole frames.

56. A manhole frame shall be of wrought or cast steel, and have a net cross-sectional area, on a line parallel to the axis of the shell, not less than the cross-sectional area of shell plate removed on the same line.

57. Manhole frames on shells or drums shall have the proper curvature, and on boilers over forty-eight (48) inches in diameter shall be riveted to the shell or drum with two rows of rivets, which may be pitched as shown in Fig. 18.

The strength of the rivets in shear shall not be less than the tensile strength of the shell plate removed, on a line parallel to the axis of the shell, through the center of the manhole.

Bearing surface for manhole gasket.

57*a*. There shall not be less than eleven-sixteenths of an inch ($\frac{11}{16}$″) bearing surface for manhole gasket.

58. The strength of manhole plates, yokes and bolts shall be in proportion to the strength of the manhole frames.

59. Manhole plates shall be of wrought or cast steel.

Location of manholes and handholes.

60. A manhole shall be located in the front head, below the tubes, of a horizontal return tubular boiler sixty (60) inches or over in diameter.

61. A manhole or handhole shall be located in the front head, below the tubes, of a horizontal return tubular boiler less than sixty (60) inches in diameter.

62. A handhole shall be located in the rear head of a horizontal return tubular boiler, below the tubes, except one which has a manhole in the front head, below the tubes.

63. A locomotive type boiler shall not have less than six (6) handholes, located as follows: —

One (1) in the rear head, below the tubes.

One (1) in the front head, at or about the line of the crown sheet.

Four (4) in the lower part of the waterleg.

Also, where possible, one (1) near the throat sheet.

64. A vertical fire-tube boiler, except the boiler of a steam fire-engine, shall not have less than seven (7) handholes, located as follows: —

Two (2) in the shell, at or about the line of the crown sheet, nd equally spaced.

One (1) in the shell, at or about the line of the fusible plug, except a vertical fire-tube boiler having a manhole in the shell or head, through which the fusible plug is accessible.

Two (2) in the shell, at the lower part of the waterleg, and equally spaced.

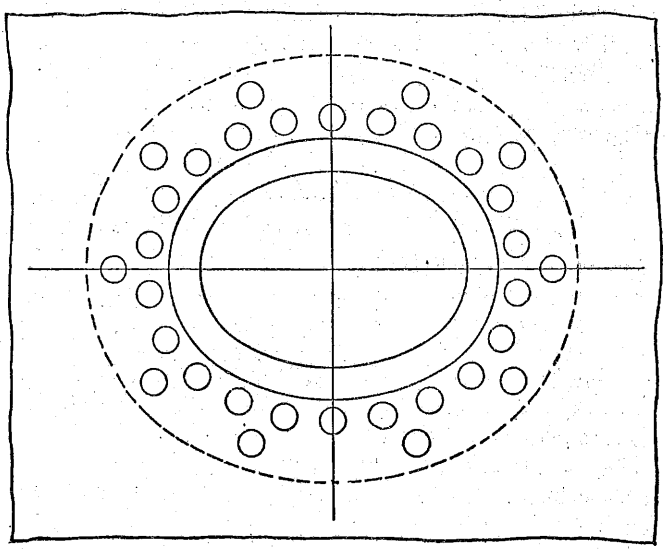


FIG. 18.

Two (2) located at or about the waterline of the boiler, and equally spaced, except a vertical fire-tube boiler having a manhole.

65. A vertical fire-tube boiler of a steam fire-engine shall not have less than three (3) brass washout plugs of not less than one (1) inch pipe size, screwed into the shell and located as follows:—

One (1) at or about the line of the crown sheet.

Two (2) at the lower part of the waterleg.

66. There shall not be less than one (1) inch of solid plate in the clear, inside and out, around a handhole opening in a boiler; except that on a stay-bolted surface seven-sixteenths ($\frac{7}{16}$) inch thick or over, there shall not be less than one-half ($\frac{1}{2}$) inch of solid plate in the clear, inside and out, around a handhole opening.

Method of supporting H. T. boilers.

67. A horizontal return tubular boiler over seventy-eight (78) inches in diameter shall be supported, independent of the boiler side-walls, from steel lugs by the outside suspended type of setting; where three (3) supports are necessary on each side of a boiler, an equalizer shall be used.

68. A horizontal return tubular boiler over fifty-four (54) inches in diameter, and up to and including seventy-eight (78) inches in diameter, shall be supported by the outside suspended type of setting, or by not less than four (4) steel or cast-iron brackets on each side, set in pairs.

69. A horizontal return tubular boiler up to and including fifty-four (54) inches in diameter shall be supported by the outside suspended type of setting, or by not less than two (2) steel or cast-iron brackets on each side.

Supporting lugs or brackets.

70. Supporting lugs or brackets shall have the proper curvature and be securely riveted to the shell; the shearing stress on the rivets not to exceed eight (8) per cent. of the allowable shearing strength given in paragraph 5, section 1, Part II. of these Rules.

Re-enforcing plates where brackets are attached.

70*a*. In all cases where brackets or other fixtures subjected to any working strain are attached to a portable boiler, the plates to which these brackets are attached may be re-enforced with plates of the same thickness as the outer plates of the boiler, and securely riveted together. The outer rows of rivets attaching re-enforcing plates to boiler must be at least three inches (3″) outside of the bracket. All brackets shall be properly fitted to the plates, flat or curved, with stud holes drilled to suit the holes in the brackets, which must be drilled to templates; and the studs attaching same shall be tapped through both plates where re-enforced. No tap bolts will be allowed. When shell plates are not less than one-half inch (½″) in thickness throughout, the re-enforcing plates referred to may be omitted.

Height of grate.

71. The upper surface of the fire-grate of an internally fired boiler of the open bottom locomotive, vertical fire-tube or similar type, shall not be below the water space in the water-leg, except where the rivets at the bottom of the waterleg are protected from the action of the fire and products of combustion.

Wet-bottom boilers.

72. Wet-bottom boilers shall have a clear space of not less than twelve (12) inches between the bottom of the boiler and the floor line.

SECTION 5.

Safety valves on steam pipes.

1. A safety valve shall not be connected to an internal pipe placed in the steam space of a boiler.

Safety valves on superheaters.

2. When a superheater can be shut off from the boiler, whether attached or separately fired, it shall have an ample safety valve at or near the steam inlet.

Stop valves.

3. Each steam outlet from a boiler which is over two (2) inches in diameter (except a safety valve connection) shall be fitted with a stop valve or valves of the outside screw and yoke type, located as near the boiler as practicable.

4. The stop valve or valves on the main steam pipe of a boiler shall be extra heavy when the pressure allowed exceeds one hundred (100) pounds. The fittings from boiler up to the valves shall be extra heavy, made to the manufacturers' standard for high pressures.

5. Two (2) stop valves of the outside screw and yoke type, with an ample valved drain between them, having an open discharge, shall be placed on the main steam pipe of a boiler set in battery, when the pressure allowed on any boiler in the battery exceeds fifteen (15) pounds.

Pipe threads.

6. The minimum number of threads that a pipe or nipple shall screw into a fitting is given in the following table: —

Size of pipe connection, in inches, . .	1 and 1¼	1½ and 2	2½ to 4 inclusive	4½ to 6 inclusive	7 and 8	9 and 10	12
Number of threads per inch, . . .	11½	11½	8	8	8	8	8
Minimum number of threads into fitting,	4	5	7	8	10	12	13

Feed pipe of H. R. T. boiler without manhole opening.

7. When a horizontal return tubular boiler, the diameter of which does not exceed thirty-six inches (36″), has no manhole opening, and the pressure desired is greater than fifteen (15) pounds per square inch, the feed pipe shall enter the front tube sheet above the tubes, and below the water line of the boiler, through a bushing, and an internal feed pipe, not less than three feet (3′) in length, screwed into said bushing, the end of said pipe being open.

Superheater drains.

8. All superheaters shall be fitted with drains from headers or drums where water of condensation can collect.

Cast-iron sections.

9. The sections for a cast-iron boiler shall be tested by hydrostatic pressure to not less than sixty (60) pounds per square inch before being assembled.

Feed-water discharge.

10. Feed water shall not discharge in a boiler in close proximity to riveted joints in shell or furnace sheets.

Valves on feed piping.

11. When boilers of fifty (50) horse power or over are set in battery, each boiler shall have two (2) stop valves, or a stop valve and stop cock, on the feed pipe, one (1) on each side of the check valve.

Feed-water appliances.

12. When a pump, inspirator or injector is required to supply feed water to a boiler of over fifty (50) horse power, more than one such mechanical appliance shall be provided.

Temperature of feed.

13. The temperature of the usual feed water entering a boiler, except the boiler of a steam fire-engine, shall not be less than one hundred and twenty degrees (120°), when the pressure allowed exceeds fifteen (15) pounds per square inch.

Surface blow-off.

14. The maximum size of a surface blow-off pipe shall not exceed one and one-half ($1\frac{1}{2}$) inches, and it shall be carried through the shell or head with a brass or steel boiler bushing, or the opening re-enforced.

Bottom blow-off and fittings.

15. Each boiler shall have a bottom blow-off pipe, fitted with a valve or cock, in direct connection with the lowest water space practicable; the minimum size of pipe and fittings shall be one (1) inch and the maximum size shall be two and one-half ($2\frac{1}{2}$) inches. Globe valves shall not be used.

16. A bottom blow-off cock shall have the plug held in place by a guard or gland. The end of the plug shall be distinctly marked in line with its passage.

17. When the pressure allowed on a boiler exceeds fifteen (15) pounds per square inch, the bottom blow-off pipe and fittings, from the boiler to the valve or valves, shall be extra heavy.

18. When the pressure allowed on a boiler exceeds one hundred (100) pounds per square inch, the bottom blow-off

pipe shall have two (2) valves, or a valve and a cock; and such valves, or valve and cock, shall be extra heavy.

19. A bottom blow-off pipe shall be protected from the products of combustion by a fire-brick casing, substantial cast-iron removable sleeve, or covering of non-conducting material.

20. An opening in brickwork for a blow-off pipe shall be fitted with an ample cast or wrought iron sleeve, to provide for free expansion and contraction.

Clean-out doors.

21. The minimum size of a clean-out door and opening to be placed in a boiler setting shall be twelve by sixteen inches (12″×16″), or equivalent area, twelve inches (12″) to be the least dimension in any case.

Water column pipes.

22. The minimum size of pipes connecting the water column of a boiler shall be one (1) inch.

23. The water connection to the water column of a boiler shall be of brass, when the allowable pressure exceeds fifteen (15) pounds per square inch.

24. The steam connection to the water column of a horizontal return tubular boiler shall be taken from the top of shell or the upper part of head; the water connection shall be taken from a point not less than six (6) inches below the center line of the shell.

25. No connections, except for damper regulator, feed-water regulator, drains or steam gages, shall be placed on the pipes connecting a water column to a boiler.

26. When shut-off valves are placed on the pipes connecting a water column to a boiler, these valves shall be of the straight-

way outside screw and yoke type, and shall be locked or sealed *open*.

27. No water glass connection shall be fitted with an automatic shut-off valve.

Steam mains.

28. Provision shall be made for the expansion and contraction of steam mains connected to all boilers, with substantial anchorage at suitable points, that there may be no perceptible vibration on the boiler shell plates.

29. Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration on the boiler shell plates.

SECTION 6.

Ogee form of construction.

1. The ogee form of construction at the lower end of furnace sheet, is hereby prohibited.

Portable boilers.

2. A portable boiler which has been used in this Commonwealth and removed therefrom, which does not conform in every detail with the rules of construction formulated by this Board, and has been previously inspected by a member of the boiler inspection department of the district police, or by an inspector of an insurance company authorized to insure steam boilers in this Commonwealth, may be inspected and a certificate of inspection issued if relocated in this Commonwealth.

Boilers in State on or before May 14, 1909, can be reinstalled.

Section 1, chapter 393, Acts of 1909, provides that: "A boiler in this Commonwealth at the time of the passage of this act, which does not conform to the rules of construction formulated by the board of boiler rules may be installed after a thorough internal and external inspection and hydrostatic pressure test by a member of the boiler inspection department of the district police, or by an inspector holding a certificate of competency as an inspector of steam boilers, as provided by section six of chapter four hundred and sixty-five of the acts of the year nineteen hundred and seven, and employed by the company insuring the boiler. The pressure allowed on such boilers is to be ascertained by rules formulated by the board of boiler rules." (*Approved May 14, 1909.*)

Factors of safety.

3. The lowest factors of safety to be used in calculating the maximum allowable pressure on boilers which were in this Commonwealth on or before May 14, 1909, and which are not MASSACHUSETTS STANDARD, or which have not been inspected, if hereafter installed, shall be as follows: —

(*a*) Six (6) for boilers, the longitudinal joints of which are of lap-riveted construction, diameters up to and including thirty-six inches (36″).

(*b*) Eight (8) for boilers, the longitudinal joints of which are of lap-riveted construction, diameters over thirty-six inches (36″).

(*c*) Five (5) for boilers, the longitudinal joints of which are of butt and double strap construction, age not exceeding ten (10) years.

(*d*) Five and five-tenths (5.5) for boilers, the longitudinal joints of which are of butt and double strap construction, age over ten (10) years.

PART III. — SECTION 6.

The hydrostatic pressure test on such boilers shall be one and one-half ($1\frac{1}{2}$) times the maximum allowable pressure obtained by using the above factors of safety.

All rules and parts of rules inconsistent herewith are hereby repealed.

George A. Luck
Frederick A. Wallace
Henry H. Lynch
Robert J. Dunkle
Edward D. Mullane

Approved.

SAMUEL W. McCALL,
Governor.

JULY 11, 1917.

INDEX.

INDEX TO STEAM BOILER RULES.

C.

D.

E.

F.

I.

J.

V.