Ind 41, 42

Filed Jan 31, 1961
11:10 am

STATE OF WISCONSIN }
DEPT. OF INDUSTRIAL COMMISSION } SS.

TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETINGS:

I, Helen E. Gill, Secretary of the Industrial Commission, and custodian of the official records of said commission, do hereby certify that the attached amendments regarding Wisconsin Administrative Code Chapters 41 and 42, Boiler and Unfired Pressure Vessel, were duly adopted by this commission on January 30, 1961.

I further certify that said copy has been compared by me with the original on file in this commission and that the same is a true copy thereof, and of the whole of such original.

IN TESTIMONY WHEREOF, I have hereunto set my hand and affixed the official seal of the department at the Capitol, in the city of Madison, this 30th day of January, A. D., 1961.

Helen E. Gill

Secretary

Pursuant to authority vested in the Industrial Commission of Wisconsin by Section 101.01-101.29 Wisconsin Statutes, the Industrial Commission on January 30, 1961 voted to repeal orders Ind 41.001, 41.01 to 41.11 inclusive, 41.50, 41.51, 41.52, 42.001, 42.005 to 42.40 inclusive, 42.50 to 42.56 inclusive, 42.59 to 42.66 inclusive, 42.69, 42.74, 42.75, 42.76, 42.78, 42.79 and 42.80 all known collectively as Chapters Ind 41 and 42 Boiler and Unfired Pressure Vessel Code and to adopt new orders Ind 41.01 to 41.06 inclusive, Ind 41.08, 41.11, 41.12, 41.20 to 41.28 inclusive, 41.50 to 41.54 inclusive, 41.60 to 41.99 inclusive to 42.01 to 42.22 inclusive, 42.25 to 42.33 inclusive, 42.35 to 42.63 inclusive to be known collectively as the Boilers and Unfired Pressure Vessels Code.

The newly created orders read as follows:

The new orders shall take effect on the first day of the month following their publication in the Administrative Code as provided in Sec. 227.

INDUSTRIAL COMMISSION OF WISCONSIN

Helen E. Gill

Helen E. Gill, Secretary

BOILERS AND UNFIRED PRESSURE VESSELS

PART I

S C O P E

Ind 41.01 Scope. (1) The provisions of this code apply to boilers and unfired pressure vessels in use at places of employment and in public buildings.

Note. Section 101.01 (1) Wisconsin Statutes provides that the phrase "place of employment" means and includes every place, whether indoors or out or underground and the premises appurtenant thereto where either temporarily or permanently any industry, trade or business is carried on or where any process or operation directly or indirectly related to any industry, trade or business is carried on and where any person is directly or indirectly employed by another for direct or indirect gain or profit but shall not include any place where persons are employed in (a) private domestic service which does not involve the use of mechanical power or, (b) farming. The term "farming" includes those activities specified in Section 102.04 (4) and also includes the transportation of farm products, supplies or equipment directly to the farm by the operator of said farm or his employees for use thereon if such activities are directly or indirectly for the purpose of producing commodities for market or as an accessory to such production.

(2) Vessels used for the storage and transportation of liquefied petroleum gas, anhydrous ammonia, and refrigerants shall be subject only to the provisions of this code found under Part V "New Installations", Part VII "Repairs, Additions, Alterations, and Special Rules", and Part VIII "Second Hand Boilers and Second Hand Unfired Pressure Vessels."

(3) The provisions of this code do not apply to air eliminators, scraper traps, and similar devices on the pumping and dispensing equipment or systems used in the transportation, storage, or distribution of flammable liquids.

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PART II

DEFINITIONS

Ind 41.02 Definitions. (1) A.S.M.E. BOILER AND UNFIRED PRESSURE VESSEL CODES are those published by the American Society of Mechanical Engineers.

(2) BOILER - A closed vessel intended for use in heating water or for the application of heat to generate steam or other vapor to be used externally to itself.

(a) LOW PRESSURE BOILER - A boiler on which the safety valves are set at pressures not exceeding 15 psig.

(b) MINIATURE BOILER - A boiler on which the safety valve is set at over 15 psig and that does not exceed the following limits:

16 inch inside diameter of shell;
42 inches overall length of outside to outside of heads at center;
20 square feet water heating surface;
100 psi maximum allowable working pressure.

(c) PORTABLE BOILER - An internally fired boiler primarily intended for temporary location and whose construction and usage is obviously of a portable nature.

(d) POWER BOILER - A boiler on which the safety valves are set at a pressure of more than 15 psig and that exceeds the dimensions of a miniature boiler.

(3) CERTIFICATE OF COMPETENCY - A certificate issued to a boiler or pressure vessel inspector who has passed a prescribed industrial commission examination.

(4) EXISTING INSTALLATION - Boiler and unfired pressure vessels placed in operation or contracted for prior to January 1, 1957.

(5) EXTERNAL INSPECTION - One made while boiler or vessel is in operation.

(6) FUSION WELDING - The melting together of filler metal and base metal, or of base metal only, which results in coalescence.

(7) HOT WATER HEATING BOILER AND HOT WATER SUPPLY BOILER - A boiler completely filled with water that furnishes hot water to be used externally to itself at pressures not exceeding 160 psig and at temperatures not exceeding 250 F. (A boiler exceeding these limits shall be classified as a power boiler.)

(8) INSPECTOR, AUTHORIZED OR QUALIFIED - (a) FIELD INSPECTOR - A boiler or unfired pressure vessel inspector who holds a valid certificate of competency.

(b) SHOP INSPECTOR - A boiler or unfired pressure vessel inspector who is employed by a city or state which has adopted the A.S.M.E. Boiler and Pressure Vessel Code, or who is employed by an insurance company, and who when performing shop inspections in Wisconsin holds a Wisconsin Certificate of Competency.

(9) INTERNAL INSPECTION - One made when the boiler or unfired pressure vessel is shut down and handholes and manholes or other inspection openings are opened or removed for inspection of the interior.

(10) MAJOR REPAIR - One upon which the strength of the boiler or vessel depends.

(11) NEW INSTALLATION, BOILER OR UNFIRED PRESSURE VESSEL - One placed in operation or contracted for after January 1, 1957.

(12) NON-STANDARD BOILER OR NON-STANDARD UNFIRED PRESSURE VESSEL - One not bearing a valid Wisconsin stamping, nor the A.S.M.E. stamping, nor the National Board stamping, nor the Interstate Commerce Commission stamping, nor the stamping of the A.P.I. - A.S.M.E., nor any stamping authorized by other applicable codes.

(13) OWNER or USER - Any person, firm, or corporation owning or operating a boiler or unfired pressure vessel.

(14) SECOND HAND VESSEL - A boiler or unfired pressure vessel when both location and ownership have been changed subsequent to the original installation.

(15) UNFIRED PRESSURE VESSEL - A vessel that obtains its pressure from an external source or from an indirect application of heat.

PART III

GENERAL RULES

Ind 41.03 Safety Regulations. (1) No boiler or unfired pressure vessel shall be operated at a pressure in excess of the allowable working pressure stated on its current inspection certificate.

(2) No unauthorized person shall remove or tamper with any connected safety device nor shall any person adjust a connected safety valve to a greater relieving pressure than that allowed for the vessel as stated on its current certificate of inspection.

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(3) Boiler and unfired pressure vessels shall be so installed that there will be sufficient room between the vessel and any ceiling, wall, partition, or floor to facilitate the connection and operation of valves, pipes, and other appurtenances.

Ind 41.04 Reporting of Accidents and Major Repairs. (1) Whenever a boiler or unfired pressure vessel fails and causes injury to any person, the owner or user shall report the facts involved to the industrial commission within the following 24 hours. The owner or user shall not remove or disturb the vessel or any of its parts nor permit any such removal or disturbance prior to receiving authorization from the industrial commission, **except for the purpose of saving human life or further property damage.**

(2) The owner, user, or his agent shall report any major repairs of a boiler or unfired pressure vessel as provided in Part VII - "Repairs, Additions, Alterations and Special Rules."

Ind 41.05 Reporting Boiler and Unfired Pressure Vessel Locations. (1) The owner or user of any boiler or unfired pressure vessel shall report the location of such vessels unless either of the following conditions are met:

(a) The vessels are exempt from periodic inspections. See section Ind 41.21.
(b) The vessels are subjected to periodic inspection by the industrial commission, a city, an insurance company, or a company authorized to make its own inspections.

Ind 41.06 Identification of Boilers and Unfired Pressure Vessels. (1) The owner or user of a boiler or unfired pressure vessel shall number each vessel in some permanent manner and in an accessible location.

Ind 41.08 Certificate of Competency as Inspector. (1) Certificate required. An inspection report covering a boiler or unfired pressure vessel may be recognized and accepted only when the inspector holds a valid certificate of competency issued by the industrial commission.

(2) Eligibility.
(a) The applicant for a certificate of competency as a boiler or unfired pressure vessel inspector shall be an employee of the state, a municipality, an insurance company, or a corporation or company authorized to make its own inspections.

(b) The applicant shall be at least 25 years of age. He shall have had at least 3 years of experience in one or more of the following endeavors: construction, repairing, inspecting, operating engineer in charge of high pressure steam boilers or unfired pressure vessels.

(c) A degree in mechanical engineering may be accepted as the equivalent of two years practical experience.

(d) The applicant's employer shall certify that applicant's statement of experience is correct.

(3) Applications and Renewals.
Fees for examination and reciprocal certificates of competency
(a) ~~Examination Fees~~ shall be submitted with applications and in the amount specified in Chapter Ind 69, Wisconsin Administrative Code.

(b) Renewal fees shall be submitted with the request for renewal and in the amount specified in Chapter Ind 69, Wisconsin Administrative Code.

(c) A request for renewal shall be filed with the industrial commission on or before January 1 of the calendar year for which the certificate is to be valid.

(d) Applications for examination and applications for renewals by employees of the state and employees of the City of Milwaukee require no fee.

(4) Examinations. (a) Certificates of competency for a boiler or unfired pressure vessel inspector may be issued by the industrial commission to eligible applicants passing the examinations prescribed by and conducted by the commission.

(b) Holders of certificates, who do not apply for renewal in any 3 year period may be required to pass a scheduled examination.

(5) Annulments and Revocations. (a) A certificate becomes invalid when the holder terminates his employment with the employer of record at the time of issue. A renewal may be obtained under the provisions of this section provided applicant meets eligibility requirements.

(b) A certificate may be annulled or revoked when incompetency or negligence is determined after investigation.

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(6) Reciprocal Commissions.

(a) A reciprocal certificate of competency may be granted by the industrial commission to a boiler or unfired pressure vessel inspector under the following conditions:

1. The inspector shall be employed by a boiler insurance company licensed to do business in Wisconsin. The boiler insurance company shall make the application for a reciprocal commission to the industrial commission.

2. The inspector shall hold a commission issued by the National Board of Boiler and Pressure Vessel Inspectors or a certificate of competency from a city or state which has adopted the A.S.M.E. Boiler and Pressure Vessel Code and which holds a written examination similar to that required by Wisconsin.

3. The inspector shall appear before an examining board appointed by the industrial commission to review his qualifications as an inspector.

Ind 41.11 Boiler Blow-Down Equipment. (1) The blow-down from a boiler or boilers that enters a sewer system or blow-down which is considered a hazard to life or property shall pass through some form of blow-off equipment that will reduce pressure and temperature as required hereinafter.

(2) The temperature of the water leaving the blow-off equipment shall not exceed 140 F.

(3) The pressure of the blow-down leaving any type of blow-off equipment shall not exceed 5 psi.

(4) The blow-off piping and fittings between the boiler and the blow-off tank shall comply with sections Ind 41.50 and Ind 41.51 of this code.

(5) The tank shall be designed in accordance with sections Ind 41.50 and Ind 41.51 of this code for a working pressure of at least one-fourth the maximum working pressure of the boiler to which it is connected.

(6) All blow-off equipment, except centrifugal blow-down separators, shall be fitted with openings to facilitate cleaning and inspection.

NOTE.

~~(7)~~ Blow-off equipment designed in accordance with the boiler blow-off equipment code issued by the national board of boiler and pressure vessel inspectors, 1957 edition, will meet the requirements of this section. Other methods of designing blow-off equipment may be used if approved by the industrial commission.

(Available for inspection at the office of the industrial commission and the secretary of state's office and the office of the revisor of statutes or may be procured for personal use from the National Board of Boiler and Pressure Vessel Inspectors, 1155 N. High Street, Columbus, Ohio.)

Ind 41.12 Vessels Supplied Through Pressure Reducing Valves. (1) The following formula shall be used for determining the sizes of safety and relief valves on unfired pressure vessels such as pressure cookers, indirect hot water heaters, equipment in heating systems, etc., which are supplied through pressure reducing valves from boilers carrying a higher steam pressure:

RVC = 1/3 x OC x VSPA

Where RVC = relief valve capacity, lbs. of steam per hour.

OC = orifice capacity, lbs. of steam per hour per square inch. (See Table 1)

VSPA = valve size pipe area, sq.in. (See Table 2)

Note. Most pressure reducing valves are arranged with a valved by-pass which also acts as a potential steam source hazard in case the by-pass is left open. Where such valved by-pass is used, the following formula shall be used to determine the steam flow rate through the by-pass:

RVC = $\frac{1}{2}$ x OC x BPA

Where RVC = relief valve capacity, lbs. of steam per hour.

OC = orifice capacity, lbs. of steam per hour per square inch. (See Table 1)

BPA = By-pass pipe area, sq. inch. (See Table 2)

The larger of the relief valve capacities calculated by the above two formulas shall be used for selecting the relief valve for the vessel.

Example:

Suppose a high pressure boiler operating at 125 psi distributes steam to a series of 40 psi A.S.M.E. constructed retorts through a $1\frac{1}{2}$ inch size pressure reducing valve provided with a glove-valved 1 inch by-pass. Determine the proper A.S.M.E. relief valve protection for the retorts. Utilizing data in Tables and the first of the two formulas above:

W = 1/3 x 7200 x 2.04 = 4896 lbs. steam per hour

Checking the by-pass steam flow according to the second formula gives:

W = $\frac{1}{2}$ x 7200 x 0.86 = 3100 lbs. steam per hour

The potential steam flow through the pressure reducing valve is 4896 lbs. per hour rated capacity or 4896 x 1000 or 4,896,000 Btu per hour.

TABLE 1

ORIFICE RELIEVING CAPACITIES, LB. PER HR. PER SQ. IN., FOR DETERMINING THE PROPER SIZE OF RELIEF VALVES USED ON LOW PRESSURE SIDE OF REDUCING VALVES

Outlet Pressure, psi	Pressure-reducing valve inlet pressure, psi								
	125	100	85	75	60	50	40	30	25
110	4550								
100	5630								
85	6640	4070							
75	7050	4980	3150						
60	7200	5750	4540	3520					
50	7200	5920	5000	4230	2680				
40	7200	5920	5140	4630	3480	2470			
30	7200	5920	5140	4630	3860	3140	2210		
25	7200	5920	5140	4630	3860	3340	2580	1485	
15	7200	5920	5140	4630	3860	3340	2830	2320	1800
10	7200	5920	5140	4630	3860	3340	2830	2320	2060
5	7200	5920	5140	4630	3860	3340	2830	2320	2060

TABLE 2
INTERNAL PIPE AREA

Nominal pipe size, inches	STANDARD		
	Actual external diameter, inches	Approx. internal diameter, inches	Approx. internal area square inches
3/8	0.675	0.49	0.19
½	0.840	0.62	0.30
3/4	1.050	0.82	0.53
1	1.315	1.05	0.86
1¼	1.660	1.38	1.50
1½	1.900	1.61	2.04
2	2.375	2.07	3.36
2½	2.875	2.47	4.78
3	3.5	3.07	7.39
3½	4.0	3.55	9.89
4	4.5	4.03	12.73
5	5.563	5.05	19.99
6	6.625	6.07	28.89
8	8.625	8.07	51.15
10	10.750	10.19	81.55
12	12.750	12.09	114.80

Note. In applying these rules, the area of the pipe is always based upon standard weight pipe and the inlet size of the pressure-reducing valve.

PART IV
INSPECTIONS

Ind 41.20 Periodic Inspections Required. (1) Inspection of Boilers. Except as regulated in Ind 41.21, boilers shall be subjected to either a regular internal ~~and~~ or external inspection at least once every 12 months by a qualified inspector.

(2) Inspection of Unfired Pressure Vessels. Except as regulated in Ind 41.21, unfired pressure vessels shall be subjected to a regular internal or external inspection at least once every 24 months by a qualified inspector.

(3) Where an internal inspection is not possible because of the construction of the boiler or pressure vessel, an external inspection will be acceptable.

(4) Extension of Period Between Inspections. If operating conditions require, longer periods between inspections of boilers and unfired pressure vessels may be approved by the industrial commission upon a written request for an extension.

Ind 41.21 Vessels Exempt from Periodic Inspections. The following boilers and unfired pressure vessels will not be subject to periodic inspection, but in individual cases any such vessel will be subject to inspection by or on order of the commission upon complaint of any person or upon initiative of the commission when there is reasonable cause to suspect that the construction, installation, maintenance or operation of the vessel is not in keeping with the general purpose and intent of this code:

(1) Boilers or unfired pressure vessels which receive regular inspections by United States Government inspectors.

(2) Steam boilers or unfired pressure vessels having an internal or external operating pressure not exceeding 15 psi with no limitations to size. Hot water boilers and their expansion tanks having an internal operating pressure not exceeding 30 psi with no limitations to size.

(3) Boilers used exclusively for agricultural purposes.

(4) Miniature boilers.

(5) Unfired pressure vessels having an inside diameter not exceeding 6 inches with no limitation to pressure.

(6) Unfired pressure vessels having a volume of less than 5 cubic feet and an operating pressure of less than 250 psi.

(7) Unfired pressure vessels with a volume of less than $1\frac{1}{2}$ cubic feet with no limit on pressure.

(8) Unfired pressure vessels which are used in accordance with the regulations of the interstate commerce commission.

(9) Air receivers having a volume not to exceed 12 cubic feet and an operating pressure of less than 225 psi.

(10) Hot water supply boilers and hot water storage tanks.

(11) Vessels used for the storage or processing of cold water including those with air cushions.

Ind 41.22 Preparation for Internal Inspections. The owner or user of a boiler or an unfired pressure vessel subject to inspection shall prepare the vessel

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for internal inspection after due notice from the inspector. To prepare a vessel for an internal inspection, all handhole, manhole plates and washout plugs shall be removed. The shell and heads shall be thoroughly cleaned and exposed when so requested. Each steam boiler shall be thoroughly drained of hot water and the combustion chamber and furnace cleaned out before an internal inspection is made.

Ind 41.23 Insurance Company Inspections. Periodic inspections of boilers and unfired pressure vessels by insurance companies may be accepted by the industrial commission under the following conditions:

(1) The boiler and pressure vessel inspectors employed by the insurance company shall hold certificates of competency issued by the industrial commission.

(2) The insurance company shall report inspections of boilers and unfired pressure vessels to the industrial commission as required in section Ind 41.26.

(3) The inspection procedures used by the insurance company shall conform to the regulations of this code.

(4) The insurance company shall report to the Industrial Commission within 30 days when insurance coverage is started or discontinued on a boiler or unfired pressure vessel. The reason for discontinuing the coverage shall be given on the report.

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the report.

Ind 41.24 Inspections by Cities. Periodic inspections of boiler and unfired pressure vessels by cities of the first class may be accepted by the industrial commission under the following conditions:

(1) The boiler and pressure vessel inspectors employed by the city shall hold certificates of competency issued by the industrial commission.

(2) The city shall keep a record of such periodic inspections.

(3) The inspection procedures used by the city shall conform to the regulations of this code.

Ind 41.25 Companies or Corporations Allowed to Make Inspections. Periodic inspections by companies or corporations of boilers or unfired pressure vessels which they own or operate may be accepted by the industrial commission under the following conditions:

(1) The boiler and pressure vessel inspectors employed by the company or corporation shall hold certificates of competency issued by the industrial commission.

(2) The company or corporation shall report inspections of boilers and unfired pressure vessels to the industrial commission as required in Ind 41.26.

(3) The inspection procedures used by the company or corporation shall conform to the regulations of this code.

Ind 41.26 Reporting of Inspections. (1) Reports of periodic internal inspections shall be sent to the industrial commission within 30 days from the date of the inspection.

(2) External inspections shall be reported only when either of the following conditions is found:

(a) An internal inspection is not possible because of the construction of the vessel. In such cases the first inspection shall be reported to the commission in the same manner as an internal inspection. The report shall be marked "external" and the reason for making an external inspection instead of an internal shall be given.

(b) When violations of this code or unsafe conditions involving the safety of the vessel are found. This report shall be made on A.S.M.E. Form P-6 and shall explain the violation or unsafe condition with references to code section numbers. A copy of the recommendations to the owner or user of the vessel shall accompany the report to the commission.

Ind 41.27 Inspection Report Forms. (1) First Internal Inspection. The first internal inspection (or external if internal is not possible) of a boiler or pressure vessel which conforms to the A.S.M.E. Code shall be reported on A.S.M.E. Form P-6. If the boiler or pressure vessel does not conform to the A.S.M.E. Code Form P-5 shall be used. The first inspection report shall be as complete as possible and shall contain the maximum allowable working pressure, number of safety valves and their settings and capacities, and the known violations of this code.

(2) Subsequent Inspections. After the report of the first internal or external inspection has been sent to the commission, the subsequent reports may be

copies of the report of inspection made to the owner or user of the vessel. Such reports shall show the location identifying number or description, safe working pressure, and safety or relief valve setting of the boiler or unfired pressure vessel. Such report shall give recommendations for correction of known violations of this code.

(3) Multiple Vessels on a Single Report. A group of unfired pressure vessels of the same design and use that are interconnected or are operated so as to form a unit, machine, or apparatus may be included in a single report. The report shall contain the number, description, and use of the vessels.

Ind 41.28 Inspection Certificates. (1) After each periodic internal inspection, the city, insurance company, or company or corporation shall issue an inspection certificate to the owner or user of the boiler or unfired pressure vessel.

(2) The inspection certificate shall give the maximum allowable working pressure for the vessel. Such pressure shall be determined using the regulations of the code.

(3) The inspection certificate shall be valid until the next required periodic inspection.

(4) The inspection certificate shall be kept on file by the owner or user of the boiler or unfired pressure vessel and shall be available when called for by a deputy of the industrial commission.

(5) For unfired pressure vessels, the inspection report made to owner or user may be used as the inspection certificate if the report is so marked.

PART V
NEW INSTALLATIONS
ORIGINAL CONSTRUCTION

Ind 41.50 A.S.M.E. Code Vessels. (1) Except as regulated in sections Ind 41.51, 41.52, and 41.53, boilers and unfired pressure vessels installed after the effective date of this section (Ind 41.50) shall be constructed and installed in accordance with the following sections of the A.S.M.E. Boiler and Pressure Vessel Code:

(a) Section I	Power Boilers	1959 Edition		As amended to ~~July 1, 1960~~ Jan. 1, 1961
(b) Section II	Material Specifications	"	"	"
(c) Section IV	Low Pressure Heating Boilers	"	"	"
(d) Section V	Miniature Boilers	"	"	"
(e) Section VIII	Unfired Pressure Vessels	"	"	"
(f) Section IX	Welding Qualifications	"	"	"

Note 1. Copies of the above publications are available for inspection at the office of the industrial commission, secretary of state's office, and the office of the revisor of statutes or they may be procured for personal use from the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N.Y.

Note 2. Because the A.S.M.E. references are subject to revision and amendment, this section of the code will be amended at intervals. It is recommended that holders of this code subscribe to the upkeep service available from the revisor of statutes, State Capitol, Madison, Wisconsin.

Ind 41.51 Wisconsin Special Vessels. (1) Where it is not possible or practical to construct a boiler or unfired pressure vessel in strict compliance with the A.S.M.E. codes listed in section Ind 41.50, the industrial commission may grant a modification to the owner or user to permit the installation of the vessel as a Wisconsin Special within the State of Wisconsin under the following conditions:

(a) When the method of designing or constructing the vessel is not covered by the A.S.M.E. codes, the commission may approve the installation of the vessel if adequate proof of comparable safety of the design or construction is shown.

1. Complete plans, calculations, and specifications in duplicate shall be submitted to and approved by the commission before the vessel is installed.

2. The vessel shall be stamped "Wisconsin Special".

3. All other applicable requirements of the A.S.M.E. codes listed in section Ind 41.50 shall be met.

(b) When the vessel is to be built by an owner for his own use, the commission may waive the stamping required by the A.S.M.E. codes listed in section Ind 41.50.

1. Complete plans, calculations, and specifications in duplicate shall be

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submitted to and approved by the commission before the vessel is installed.

2. The vessel shall be stamped "Wisconsin Special".

3. All other applicable requirements of the A.S.M.E. codes listed in section Ind 41.50 shall be met.

(c) When a small number of vessels is to be built by a manufacturer, the commission may waive the stamping required by the A.S.M.E. codes listed in section Ind 41.50.

1. Complete plans, calculations, and specifications in duplicate shall be submitted to and approved by the commission before the vessel is installed.

2. The vessel shall be stamped "Wisconsin Special".

3. All other applicable requirements of the A.S.M.E. codes listed in section Ind 41.50 shall be met.

(2) The provisions of this section shall not apply to Wisconsin Special vessels accepted by the industrial commission before the effective date of this section.

Ind 41.52 Interstate Commerce Commission Vessels. (1) Unfired pressure vessels carrying the stamping of the I.C.C. will be considered comparable to a vessel meeting the requirements of section Ind 41.50. When such vessels are used in the State of Wisconsin, it shall be the responsibility of the owner of the vessels to have the construction records of the vessels available for inspection by the industrial commission.

Ind 41.53 Non-Code Vessels. (1) The following vessels will only be required to meet the pressure-relief device requirements of the A.S.M.E. codes listed in section Ind 41.50.

(a) Water heating apparatus, such as range boilers or tanks having a self-contained gas, oil, or electric heating unit used exclusively for hot water service provided such apparatus carries a seal of approval from a testing agency recognized nationally and by the commission. The term "hot water service" shall be construed to mean a system in which the hot water is used for general cleaning purposes as in the bath, the laundry, and in the kitchen.

1. This exception shall not apply when the apparatus is used ~~to produce~~ as a heating boiler.

hot water ~~for heating purposes.~~

(b) Vessels for containing water under pressure for domestic supply including those having an air space for expansion.

(c) Hot water storage tanks, when heated indirectly by circulating either steam at or below 15 psig, or by hot water at or below 30 psig through a coil or heat exchanger, and the storage water temperature does not exceed 200 F.

(d) Pressure vessels used for water conditioning and filtration.

(e) The vessels listed in paragraphs (b), (c) and (d) of this section ~~above~~ shall be identified by stamping showing the manufacturer's name, a serial number, the allowable working pressure, and the year fabricated.

Ind 41.54 Low Water Fuel Cut-off for Hot Water Heating Boilers.

Every automatically fired hot water heating boiler installed after the effective date of this section with a heat input of more than 200,000 Btu ~~BTU~~ per hour shall be provided with an automatic low-water fuel cut-off so located as to automatically cut off the fuel supply when the surface of the water falls to the lowest safe water line. The lowest safe water line shall be at or above the height required on a corresponding steam boiler.

PART VI
EXISTING INSTALLATIONS

Ind 41.60 Application. (1) The provisions of sections Ind 41.60 through Ind 41.99 shall apply to boilers installed prior to January 1, 1957.

(2) Unfired pressure vessels installed prior to January 1, 1957 shall meet the requirements of section Ind 41.99, Pressure Relief Devices for Unfired Pressure Vessels.

Ind 41.61 Maximum Allowable Working Pressures. (1) The maximum allowable working pressure on a boiler is the safe pressure at which the boiler may be operated as determined by the provisions of sections Ind 41.60-41.99, inclusive, of this code.

(2) No boiler shall be operated at a pressure in excess of the maximum allowable working pressure for such boiler.

Ind 41.62 Code Constructed Vessels. Any boiler that has been constructed and stamped in accordance with the rules and regulations of the A.S.M.E. Boiler and Pressure Vessel Code, or other recognized codes, or has the standard stamping of another statethat has adopted the standard of construction of the A.S.M.E. Boiler and Pressure Vessel Code, shall be allowed and may be operated at the maximum working pressure stamped on its shell providing the vessel is unaltered, in good working order, and not deteriorated by age or corrosion. For unstamped boilers, the operating pressure shall be determined by using sections Ind 41.63 through Ind 41.76, inclusive.

(over)

Ind 41.63 Pressure Calculations for Shells. The maximum allowable working pressure to be allowed on the shell of a boiler shall be determined from the following formula:

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

where P = maximum allowable working pressure, pounds per square inch,

T.S. = tensile strength of shell plate, pounds per square inch,

t = minimum thickness of shell plates, inches

E = efficiency of longitudinal joint - method of determining which is given in section Ind 41.73.

R = Inside radius of the outside course of the shell,

F. S. = lowest factor of safety allowed by section Ind 41.70.

Ind 41.64 Pressure Calculations for Flat Heads and Flat Surfaces. The maximum allowable working pressure on flat surfaces of boilers shall be determined by the following formula:

$$P = \frac{T.S. \times t^2}{0.5 \times d^2 \times F.S.}$$

where P = Maximum allowable working pressure, pounds per square inch,

T.S. = tensile strength of plate, pounds per square inch,

t = thickness of plate, inches,

d = diameter of head or shortest unsupported span of head or maximum pitch between stays, inches,

F.S. = lowest factor of safety allowed by section Ind 41.70.

Note. No allowance will be made for the holding power of flanges.

Ind 41.65 Pressure Calculations for Dished Heads. The maximum allowable working pressure on unstayed dished heads shall be determined by the following formula:

Pressure on concave side (plus head)

$$P = \frac{2 \times T.S. \times E \times t}{8.33 \times L}$$

Pressure on convex side (minus head)

$$P = \frac{2 \times T.S. \times E \times t \times 0.6}{8.33 \times L}$$

where t = thickness of plate, inches

P = maximum allowable working pressure pounds per square inch

T.S. = tensile strength pounds per square inch

L = radius to which the head is dished, measure on the concave side of the head, inches

E = efficiency of weakest joint used in forming the head (exclusive of the joint to the shell) for seamless heads E = 1.00.

Ind 41.66 Dished Head Restrictions. Dished heads without skirts or flanges shall not be used for any pressure.

Ind 41.67 Pressure Calculation for Furnaces and Circular Flues. The maximum allowable working pressure on furnaces of vertical boilers and circular flues shall be determined as indicated in sections Ind 41.50 and Ind 41.51 of this code.

Ind 41.68 Boiler Plate Thickness. (1) The minimum thickness of any boiler plate under pressure shall be $\frac{1}{4}$ inch except that boiler plate in stayed surfaces shall be 5/16 inch thick minimum.

(2) Seamless shells for miniature boilers may be constructed of 3/16 inch boiler plate.

Ind 41.69 Other Methods of Installing Safety Devices and Other Appliances. Where the A.S.M.E. codes listed in Ind 41.50 permit other methods of installing safety devices and other appliances on boilers, these methods may be used on existing boilers.

Ind 41.70 Factor of Safety. Maximum allowable working pressure shall be determined by using a factor of safety of at least 5 except as provided in section Ind 41.62.

(over)

Ind 41.71 Strength of Materials. When the tensile strength of materials is not known, it shall be taken as 55,000 pounds per square inch for steel and 45,000 pounds per square inch for wrought iron, 30,000 pounds per square inch for copper and 18,000 pounds per square inch for cast iron. The resistance to crushing of mild steel shall be taken as 95,000 pounds per square inch of cross sectional area.

Ind 41.72 Shearing Strength of Rivets. (1) The maximum shearing strength of rivets per square inch of cross-sectional area shall be taken as follows:

	Ultimate Strength Pounds per square inch
Iron rivets in single shear	38,000
Iron rivets in double shear	76,000
Steel rivets in single shear	44,000
Steel rivets in double shear	88,000

(2) Rivet Dimensions after Driving. 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 from Table 3.

TABLE 3

Thickness of Plate	1/4" 0.25"	9/32" 0.2812"	5/16" 0.3125"	11/32" 0.34375"	3/8" 0.375"	3/8" 0.375"	13/32" 0.40625"
Diameter of Rivet after Driving	11/16"	11/16"	3/4"	3/4"	3/4" up to & including 2" pitch	13/16" Over 2" pitch	13/16"
Cross sectional area of rivet after driving	0.3712 sq.in.	0.3712 sq.in.	0.4418 sq.in.	0.4418 sq.in.	0.4418 sq.in.	0.5185 sq.in.	0.5185 sq.in.

TABLE 3 (continued)

Thickness of Plate	7/16" 0.4375"	7/16" 0.4375"	15/32" 0.46875"	1/2" 0.5"	9/16" 0.5625"	5/8" 0.625"	
Diameter of Rivet after Driving	7/8" up to & 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	0.6013 sq.in.	0.6903 sq.in.	0.6903 sq.in.	0.6903 sq.in.	0.8866 sq.in.	0.8866 sq.in.	

Ind 41.73 Efficiency of Joint. The efficiency of a joint is the ratio which the strength of the joint bears to strength of the solid plate, and shall be determined as follows:

(1) For riveted joints, calculate according to sections Ind 41.50 and Ind 41.51 of this code using the values stated in sections Ind 41.71 and Ind 41.72.

(2) For welded joints, calculate by reference to Table 4.

TABLE 4
MAXIMUM ALLOWABLE EFFICIENCIES FOR FUSION WELDED JOINTS

Type of Joint	Limitations	Maximum Joint Efficiency Per Cent
Double-Welded Butt Joint	None	80
Single-Welded Butt Joint with Backing Strip	Longitudinal joints not over $1\frac{1}{4}$" thick. No thickness limitations on circumferential joints.	80
Single-Welded Butt Joint without Backing Strip	Circumferential joints only not over 5/8" thick.	70
Double-Welded Full-Fillet Lap Joint	Longitudinal joints not over 3/8" thick. Circumferential joints not over 5/8" thick.	60
Single-Welded Full-Fillet Joints with Plug Welds	Circumferential joints only not over 5/8" thick and for attachments of heads not over 24" outside diameter to shells not over 5/8" thick.	50
Single-Full Fillet Joint without Plug Welds	For attachments to heads convex to pressure to shell not over 5/8" thick, only with use of fillet weld on inside shell; for attachments to heads having pressure on either side, with fillet weld on outside of head flange only, to shells not over 24" inside diameter and not over $\frac{1}{4}$" required thickness.	50
Forged Weld	None	70
Brazed Steel	None	80
Brazed Copper	None	90

Ind 41.74 Ligament Between Parallel Tube Holes. 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 shown in sections Ind 41.50 and Ind 41.51 of this code.

Ind 41.75 Ligaments Between Diagonal Tube Holes. 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 shown in sections Ind 41.50 and Ind 41.51 of this code.

(over)

Ind 41.76 Maximum Pressure for Cast Iron Boilers. (1) The maximum allowable working pressure on a steam boiler constructed wholly or principally of cast iron shall not exceed 15 pounds per square inch.

(2) The maximum allowable working pressure on boilers, the tubes of which are secured to cast iron headers, shall not exceed 160 pounds per square inch.

Ind 41.77 Safety or Relief Valves Required on Boilers. Every boiler shall have one or more safety or relief valves set at or below the maximum allowable working pressure. On power boilers the remaining valves may be set at a higher pressure in accordance with section Ind 41.78.

Ind 41.78 Safety Valves for Low Pressure Steam, Miniature and Power Boilers. (1) Every boiler shall be provided with safety valve capacity sufficient to discharge all the steam that can be generated without an increase over the maximum allowable working pressure or to which the valve is set, except a 6% increase while the valve is discharging for power and miniature boilers, and a 5 pound per square inch increase while the valve is discharging for low pressure steam boilers.

(2) The steam generating capacity of a boiler in pounds of steam per hour may be determined by one of the following:

(a) Manufacturer's maximum output rating.

(b) Pounds of steam

$$\text{per hour} = \frac{\text{Maximum Btu input per hour} \times 0.75}{1000}$$

(c) Actual evaporation test.

(d) On the basis of boiler heating surface or waterwall heating surface as given in Table 5.

TABLE 5

MINIMUM POUNDS OF STEAM PER HOUR PER SQUARE FOOT OF SURFACE

Type of Boilers	Surface	Firetube Boilers	Watertube Boilers
Power Boilers	Boiler heating surface		
	Hand-fired	5	6
	Stoker-fired	7	8
	Oil, gas, or pulverized fuel fired	8	10
	Waterwall heating surface		
	Hand-fired	8	8
	Stoker-fired	10	12
	Oil, gas, and pulverized fuel fired	14	16
Low Pressure Steam and Miniature Boilers	Boiler heating surface any method of firing	5	5*

* Shall include cast iron boilers.

Note. Compliance with section Ind 41.78 (1) will be required in every case.

(3) On power boilers one or more safety valves on the boiler proper shall be set at or below the maximum allowable working pressure. The remaining valves may be set within a range of 3% above the maximum allowable working pressure, but the range of setting of all of the valves on a boiler shall not exceed 10% of the highest pressure to which any valve is set.

(4) Safety valves which are constructed in accordance with the standards as specified in sections Ind 41.50 and Ind 41.51 of this code are acceptable. Safety valves constructed to other standards may be used if approved by the industrial commission. Dead-weight or weighted-lever safety valves shall not be used.

(5) When 2 or more safety valves are used on a boiler, they may be mounted either separately or as twin valves made by placing individual valves on Y-bases, or duplex, triplex, or multiplex valves having 2 or more valves in the same body casing. The valves shall be made of equal sizes, if possible, and in any event if not of the same size, the smaller of the two valves shall have a relieving capacity of at least 50% of that of the larger valve.

(6) The safety valve or valves shall be connected to the boiler independent of any other steam connection, and attached as close as practical to the boiler, without any unnecessary intervening pipe or fitting. Every safety valve shall be connected so as to stand in an upright position, with spindle vertical, when possible.

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(7) The opening or connection between the boiler and the safety valve or valves shall have at least the area of the inlet of the valve or valves. No valve of any description shall be placed between the required safety valve or valves and the boiler, nor on the discharge pipe between the safety valve and the atmosphere. When a discharge pipe is used, the cross-sectional area shall be not less than the full area of the valve outlet or of the total of the areas of the valve outlets discharging thereinto, and shall be as short and straight as possible and so arranged to avoid undue stresses on the valve or valves.

(a) All safety-valve discharges shall be so located or piped as to be carried clear from running boards, platforms, or otherwise carried to a safe location.

(b) Provision for gravity drain shall be made in the discharge pipe, at or near each safety valve, and where water or condensation may collect.

(8) (a) The spring in a safety valve in service for pressures up to and including 250 pounds shall not be used for any pressure more than 10% above or 10% below that for which it was designed. For higher pressures, the spring shall not be used for any pressure more than 5% above or 5% below that for which it was designed.

(b) If the operating conditions of a valve are changed so as to require a new spring for a different pressure, the valve shall be adjusted by the manufacturer or his authorized representative who shall furnish and install a new name plate.

(9) Every superheater shall have one or more safety valves near the outlet. The discharge capacity of the safety valve or valves on an attached superheater may be included in determining the number and size of the safety valves for the boiler, provided there are no intervening valves between the superheater safety valve and the boiler, and provided the discharge capacity of the safety valve or valves on the boiler, as distinct from the superheater, is at least 75% of the aggregate valve capacity required. A soot-blower connection may be attached to the same outlet from the superheater that is used for the safety valve connection.

(10) (a) Every boiler shall have outlet connections for the required safety valve or valves, independent of any other outside steam connection. The area

of the boiler opening or openings shall be at least equal to the aggregate areas of inlet connections of all of the safety valves to be attached thereto. An internal collecting pipe, splash plate, or pan may be used, provided the total area for inlet of steam thereto is not less than twice the aggregate areas of the inlet connections of the attached safety valves. The holes in such collection pipes shall be at least $\frac{1}{4}$" in diameter and the least dimension in any other form of opening for inlet of steam shall be $\frac{1}{4}$".

(b) If safety valves are attached to a separate steam drum or dome, the opening between the boiler proper and the steam drum or dome shall be not less than required by section Ind 41.78 (10) (a).

(c) When boilers allowed different pressures are connected to a common steam main and all safety valves are not set at the lowest pressure allowed, no safety valve shall be set to exceed by more than 50% the lowest pressure allowed.

(d) For conditions exceeding those specified in the above paragraph, the case shall be referred to the industrial commission for decision.

Ind 41.79 Water-relief Valves for hot Water Boilers. (1) Each hot water boiler shall have one or more relief valves of the spring loaded type, without disc guides on the pressure side of the valve. The valves shall be set to relieve at a pressure at or below the maximum allowable working pressure of the boiler.

(2) Relief valves which are constructed in accordance with sections Ind 41.50 and Ind 41.51 of this code are acceptable. Relief valves constructed to other standards may be used if approved by the industrial commission.

(3) Water-relief valves shall be attached directly or as close as possible to the boiler without any unnecessary intervening pipe or fitting. A water-relief valve shall not be connected to an internal pipe in the boiler. Water-relief valve shall be connected so as to stand upright with the spindle vertical when possible.

(4)No shut-off of any description shall be placed between the water-relief valve and the boiler, nor on discharge pipes between such valve and the atmosphere.

(5) When a discharge pipe is used its area shall be not less than the area of the valve or aggregate area based on the nominal diameters of the valves with

(over)

which it connects. The discharge pipe shall be pitched away from the valve to prevent water from lodging in the upper part of the valve or in the pipe. The water-relief valve shall be so located and piped that there will be no danger of scalding attendants.

(6) The required water-relief valve capacity for any hot water boiler shall be equal to the maximum Btu output at the boiler nozzle or shall be equal to the boiler heating surface multiplied by 5000.

(7) The water-relief valve capacity for each hot water boiler shall be such that the valve or valves will relieve all the pressure that can be generated by the boiler without allowing the pressure to rise more than 3 pounds above the maximum allowable working pressure of the boiler.

(8) Every boiler shall have proper outlet connections for the required water-relief valves, independent of any other connection outside the boiler. The area of the opening or openings shall be at least equal to the aggregate area based on the nominal diameters of all of the water-relief valves with which it connects.

Ind 41.80 Thermometers for Hot Water Boilers. Every hot-water boiler shall have a thermometer so located and connected that it shall be easily readable when observing the water pressure or altitude. The thermometer shall be so located that it shall at all times indicate the temperature in degrees Fahrenheit of the water in the boiler, at or near the outlet.

Ind 41.81 Water Glass. Every low pressure steam, miniature and power boiler shall have at least one water glass, equipped with a valved drain, the lowest visible part of which shall be at or above the following location except that in all cases it shall be so placed as to give adequate protection to those parts of a boiler proper subject to the heat of the products of combustion:

(1) Horizontal return tubular boilers - not less than 4 inches above the upper surface of the upper row of tubes except when the distance between the uppermost surface of the tubes and the top of the steam space is 13 inches or less the distance may be reduced to 2 inches.

(2) Locomotive type boilers - 3 inches above the highest part of the crown sheet.

(3) Vertical fire tube boilers - not less than 1/3 the length of the tube above the lower tube sheets.

(4) Water tube boilers - as specified by the manufacturer.

(5) Scotch marine type boilers - 3 inches above the combustion chamber top.
Note. For Dry Back see section Ind 41.81 (1).

(6) Cast iron boilers - as specified by the manufacturer.

(7) Other types and designs - for other types and new designs the location shall be fixed by the manufacturer subject to approval by the industrial commission.

Ind 41.82 Gage Cocks. (1) Every steam boiler, except those exempted below, shall have 3 gage cocks located within the range of the visible portion of the water glass.

(2) The following boilers shall not be required to have gage cocks:

(a) Boilers which do not have a definite water level.

(b) Boilers which have 2 water glasses spaced not less than 2 feet apart on the same horizontal line.

(c) Boilers which have 2 remote water level indicators in addition to the required water glass.

(d) Miniature boilers.

(3) The following boilers shall be required to have only 2 gage cocks:

(a) Low pressure steam boilers.

(b) Locomotive type boilers not over 36 inches in diameter.

(c) Firebox or water leg boilers in which the water heating surface does not exceed 50 square feet.

Ind 41.83 Water Column Piping. (1) No connections shall be placed on pipes connecting the water column to the boiler except connections for damper regulator, feed water regulator, steam gage or drains.

(2) The minimum size of the pipes connecting the water column to a boiler shall be 1 inch. Water-glass fittings or gage cocks may be connected direct to the boiler.

(over)

(3) The water connections to the water column of a boiler, when practicable, shall be provided with a cross at each right-angle turn to facilitate cleaning. The water column shall be fitted with a drain cock or drain valve with a suitable connection to the ashpit or other safe point of waste, and if the water connection thereto has a rising bend or pocket which cannot be drained by means of the water column drain, an additional drain shall be placed in this connection in order that it may be blown off to clear any sediment from the pipe.

(4) The steam connection to the water column of a horizontal-return tubular boiler shall be taken from the top of the shell or the upper part of the head; the water connection shall be taken from the fro nt head at a point not less than 6 inches below the center line of the shell. For the firebox types of boilers, the water connection to the water column shall be taken at a point not less than 6 inches below the lowest water line or as near thereto as possible, and in no case less than 18 inches above the mud ring.

(5) When shut-offs are used on the connections to a water column, they shall be either outside-screw-and-yoke type valves or stop cocks with levers permanently fastened thereto and marked in line with their passage. Where stop cocks are used they shall be of a type with the plug held in place by a guard or gland.

Ind 41.84 Pressure Gages. (1) (a) Every boiler shall be provided with a pressure gage connected to the upper part of the boiler and so arranged that the gage cannot be shut off from the boiler except that a shut-off valve or cock shall be placed close to the gage or a second shut-off valve or cock close to the boiler to permit removal for testing while the boiler is in operation.

(b) For steam boilers, the gage may also be connected to the water column or water column steam connection. For steam boilers, a siphon or equivalent device of sufficient capacity to keep the gage tube filled with water shall be provided.

(2) The dial of the pressure gage shall be graduated to at least one and one-half times the pressure at which the safety or relief valve is set except as follows:

(a) On low pressure steam boilers the gage shall be graduated to at least 30 pounds per square inch.

(b) On hot water boilers the pressure or altitude gage shall be graduated to at least one and one-half times the maximum allowable working pressure.

(3) (a) For low pressure steam boilers, the travel of the pointer from zero to 30 pounds per square inch shall be at least 4 inches.

(b) Effective stops shall be provided for the indicating pointer at the lowest and highest pressure points.

(4) The pressure gage dial shall at all times be protected by a transparent cover and shall be kept clear at all times. This gage should be so located as to be readily visible to the operator.

Ind 41.85 Stop Valves on Pressure Discharge Outlets. (1) Each pressure discharge outlet on miniature and power boilers, except safety or relief valve outlets, shall be fitted with one or more stop valves located as near to the boiler as practicable. When 2 or more low pressure steam boilers are connected to a common header, a stop valve shall be provided in the steam outlet of each boiler as near to the boiler as practicable.

(2) When 2 stop valves are placed in the steam connection between a power boiler and the steam main there shall be a free blow drain between them. The discharge of this drain valve shall be visible to the operator while manipulating the valve.

(3) (a) When a stop valve is so located that water can accumulate, drains shall be provided.

(b) Each dry pipe or similar apparatus shall have two holes drilled into it. These holes shall be not less than $\frac{1}{2}$" diameter each and shall be kept open so that the condensation can escape.

(4) Each superheater shall be equipped with at least one drain so located as will most effectively provide for the proper operation of the apparatus.

Ind 41.86 Steam Mains. Provision shall be made for the expansion and contraction of steam mains connected to boilers by providing substantial anchorage at suitable points so that there shall be no undue strain transmitted to the boiler. Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration of the boiler shell plates.

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Ind 41.87 Bottom Blow-off or Drain. (1) Connected to the lowest space practicable of each boiler, there shall be a bottom blow-off pipe fitted with a valve or cock. The valves shall be of straightway or angle construction and cocks shall have the plugs held in place with a gland or guard. Straightway globe valves of the ordinary type or valves of such type that dams or pockets can exist for the collection of sediment, shall not be used on such connections.

(2) A surface blow-off shall not exceed $2\frac{1}{2}$ inch pipe size and the internal and external pipes, when used, shall form a continuous passage, but with clearance between their ends and arranged so that the removal of either will not disturb the other. A properly designed steel bushing or a flanged connection shall be used.

(3) (a) 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 maximum size of pipe and fittings shall be $2\frac{1}{2}$ inches and the minimum size shall be 1 inch except that for boilers with 100 square feet of water heating surface or less and low pressure steam boilers the minimum size of pipe and fittings may be 3/4 inch. Straightway globe valves of the ordinary type or valves of such type that damsor pocketscan exist for the collection of sediment, shall not be used on such connections.

(b) The bottom blow-off pipe for low pressure steam, miniature, and hot water boilers may be connected to return connections which are the same size or larger than the size herein specified. In such case, the blow-off shall be so located that the connection may be completely drained.

(4) 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 the passage.

(5) (a) For power boilers, the bottom blow-off pipe or pipes shall be of wrought iron or steel and shall be at least extra heavy.

(b) The fittings between a power boiler and the required bottom blow-off valve or valves shall be of steel, cast steel or malleable iron and shall be not less than extra heavy construction for pressures not exceeding 150 pounds per square inch.

(c) For pressures exceeding 150 pounds per square inch such fitting shall be of steel construction and not less than extra heavy.

(d) Cast iron pipe and fittings shall not be used in the bottom blow-off pipe between the boiler and the bottom blow-off valve or valves.

(6) (a) On all boilers except those used for traction and portable purposes, when the maximum allowable working pressure exceeds 125 pounds per square inch, each bottom blow-off pipe shall have 2 slow-opening valves, or one slow-opening valve and a cock, and such valves, or valve and cock, shall be at least extra heavy construction. On a boiler having multiple blow-off pipes a single master valve may be placed on the common blow-off pipe from the boiler, in which case only one valve on each individual blow-off is required. Two independent valves, or a valve and a cock may be combined in one body provided the combined fitting is the equivalent of 2 independent valves, or a valve and a cock, so that the failure of one to operate could not affect the operation of the other.

(b) Every traction and portable boiler shall have a bottom blow-off valve; when the maximum allowable working pressure exceeds 125 pounds per square inch, the blow-off valve shall be at least extra heavy.

(c) For pressures exceeding 200 pounds per square inch the valves or cocks shall be of steel construction.

(d) The blow-off valve or valves shall be the full size of the blow-off pipe.

(7) A bottom blow- off pipe when exposed to direct furnace heat shall be protected by fire brick or other heat resisting material so arranged that the pipe may be inspected.

(8) An opening in the boiler setting for a blow-off pipe shall be arranged to provide for free expansion and contraction.

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(9) See section Ind 41.11 for required boiler blow-down equipment.

Ind 41.88 Feed Pipe. (1) (a) Each low pressure steam, miniature and power boiler shall have the feed pipe fitted with a check valve near the boiler and a stop valve between the check valve and the boiler. Single low pressure steam boiler installations of the gravity return type which do not have a stop valve in the steam outlet line will not be required to have a stop valve in the return pipe.

(b) On low pressure steam boilers, the return pipe loop connection shown in Fig. 1 may be used in place of the check valve.

(2) (a) The feed water shall be introduced into a boiler in such a manner that the water will not be discharged directly against surfaces exposed to gases of high temperature, or to direct radiation from the fire, or close to riveted joints of shell or furnace sheets.

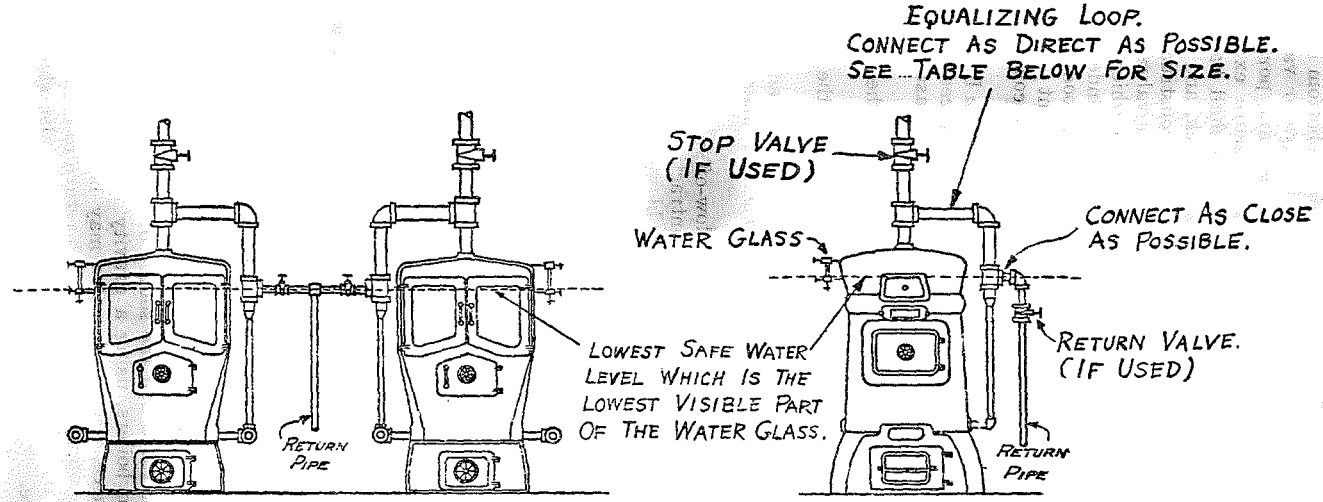
(b) Where horizontal return tubular boilers are fed through the front, a boiler bushing or its equivalent shall be used and the feed water shall discharge at about three-fifths the length of the boiler from the front head, and above the second row of tubes from the top.

(3) When 2 or more power boilers are fed from a common source, there shall be a globe or regulating valve on the branch to each boiler, between the check valve and the source of supply. When 2 or more low pressure steam boilers, using a gravity return system are fed from a common source, one check valve may be placed on the main return pipe with a stop valve on the branch return to each boiler. Wherever globe valves are used on feed piping, the inlet shall be under the disc of the valve.

(4) (a) Means shall be provided for feeding a boiler against the maximum allowable working pressure or the pressure at which the safety valve is set to blow.

(b) Where a source of feed is available at a sufficient pressure to feed the boiler against a pressure 6% higher than that at which the safety valve is set to blow, this may be considered one of the means.

(5) Every boiler and its piping system shall be provided with a water supply line from an outside source of water supply in order to replace the water leaving



GRATE AREA, OR Sq. FT.	SAFETY VALVE CAP., LBS/HR	EQUALIZING LOOP SIZE, INCHES
4 OR LESS	250 OR LESS	1 1/2
OVER 4 TO 15	251 TO 2000 INC.	2 1/2
OVER 15	OVER 2000	4

Fig. 1

RETURN PIPE LOOP CONNECTION

the system through leakage, process work, or other reasons.

(a) A stop and check valve shall be provided in the water supply line with the stop valve closest to the boiler.

(b) On low pressure steam and hot water boilers, the water supply line shall be connected to the boiler return or feed piping system and not directly to the boiler.

(c) On low pressure steam, miniature, and hot water boilers, the water supply line pressure shall be high enough to feed the boiler or the system against the maximum allowable working pressure of the boiler.

(6) A heater for oil or other liquid harmful to boiler operation shall not be installed directly in the steam or water space within a boiler. Where an external type heater for such service is used, positive means such as double-transfer heaters or indicators such as fuel-oil indicators or sight glasses shall be provided to prevent the introduction into the boiler of oil or other liquid harmful to boiler operation. > Insert Figure 1 <

Ind 41.89 Combustion Regulators for Boilers. (1) A temperature combustion regulator, which will control the rate of combustion to prevent the temperature of the water from rising above 250 F. at or near the outlet, or a thermostatic device which will relieve the pressure on the boiler when the temperature exceeds 250 F. shall be used on all hot water boilers.

(2) When a pressure combustion regulator is used on a steam boiler, it shall operate to prevent the steam pressure from rising above the maximum allowable working pressure for the boiler.

Ind 41.90 Flanged Connections. Openings in boilers having flanged connections shall have the flanges conform to the A.S.A. (American Standards Association) for the corresponding drilling for bolts or studs. Steel outlet nozzles and flanges may be riveted or welded to the shell. Cast iron outlet nozzles or flanges will be permitted only on low pressure steam or hot water boilers and can be attached to the shell only by riveting.

Ind 41.91 Washout and Inspection Openings. (1) All boilers shall be provid

(2) All horizontal fire tube boilers shall be required to have the following manhole or handhole openings:

(a) A manhole in the front head below the tubes for:
1. Horizontal return tubular power boilers over 54 inches in diameter.
2. Horizontal return tubular low pressure steam or hot water boilers over 60 inches in diameter.
3. For smaller boilers a handole may be used in place of the manhole.

(b) A manhole in the upper part of the shell or head for:
1. Horizontal return tubular, fire box and locomotive power boilers over 48 inches.
2. Scotch marine power boilers over 54 inches in diameter.
3. Low pressure steam boilers over 60 inches in diameter.
4. For smaller boilers a handhole may be used in place of the manhole.

(c) Locomotive and fire box boilers shall also have the following handhole or washout openings:
1. One at each of the 4 corners of the lower portion of the water leg.
2. One in the front head at or about the line of the crown sheet.
3. One near the throat sheet of power boilers where possible.
4. One in the rear head of power boilers below the tubes.

(3) (a) A vertical fire tube boiler, except boilers 24 inches or less in diameter shall have not less than 4 handholes located as follows: 2 in the shell at or about the line of the crown sheet or lower tube sheet; 2 in the shell at the lower part of the water leg.

(b) Vertical fire tube boilers 24 inches or less in diameter shall have 3 one-inch diameter washout plugs except that boilers not exceeding 12 inches internal diameter having less than 10 square feet of water heating surface need not have more than 2 such washout plugs, one of which may be used for the attachment of the bottom blow-off valve. The threads of the washout plugs shall be of non-ferrous material.

(4) Where handholes are provided, such handholes shall not be less than $2\frac{1}{2}$ inches by $3\frac{1}{2}$ inches in size.

(5) Washout plugs, except for vertical fire tube boilers, shall be not less than $1\frac{1}{2}$ inch pipe size and shall have threads of non-ferrous materials.

(6) Every cast iron boiler shall be provided with washout openings to permit the removal of any sediment that may accumulate therein. Washout openings may be used for return pipe connection if the washout plug is placed in a tee so that the plug is directly opposite and as close as possible to the opening in the boiler.

Ind 41.92 Manholes. Where manholes are provided, such manholes shall be not less than 11 inches by 15 inches, or 10 inches by 16 inches in size. A circular manhole opening shall be not less than 15 inches in diameter.

Ind 41.93 Maintenance. (1) All boilers shall be installed and maintained in such a manner as to prevent excessive corrosion or deterioration.

(2) The inspector shall note conditions during the internal inspection, external inspection or hydrostatic pressure test and order such changes or repairs as will place the boiler in a safe working condition.

Ind 41.94 Threaded Openings. (1) All pipe threads shall conform to the American Pipe Thread standard and all connection one inch pipe size or over shall have not less than the number of threads given in Table 6. For smaller pipe connections there shall be at least 4 threads in the opening.

(2) If the thickness of the shell of the boiler is not sufficient to give such number of threads a construction shall be employed which will provide at least the required number of threads.

TABLE 6
MINIMUM NUMBER OF PIPE THREADS FOR CONNECTIONS TO BOILERS

Size of pipe connections, inches	1 & 1¼	1½ & 2	2½ to 4 incl	4½ to 6 incl	7 & 8	9 & 10	12
Number of threads per inch	11½	11½	8	8	8	8	8
Minimum number of threads required for opening	4	5	7	8	10	12	13
Minimum thickness of material required to give above number of threads, inches	0.348	0.435	0.875	1	1.25	1.5	1.6265

Ind 41.95 Boiler Setting and Installation. (1) A horizontal return tubular boiler over 72 inches in diameter shall be supported from steel hangers by the outside suspension type of setting, independent of the boiler side walls. The hangers shall be so designed that the load is properly distributed between the rivets attaching them to the shell and so that no more than 2 of these rivets come in the same longitudinal line on each hanger. The distance girthwise of the boiler

(over)

from the centers of the bottom rivets to the center of the top rivets attaching the hangers shall be not less than 12 inches. The other rivets used shall be spaced evenly between these points. If more than 4 hangers are used they shall be set in 4 pairs.

(2) A horizontal return tubular boiler over 54 inches and up to and including 72 inches in diameter, shall be supported by the outside suspension type of setting, or at 4 points by not less than 8 steel or cast iron brackets, set in pairs. A horizontal return tubular boiler up to and including 54 inches in diameter shall be supported by the outside suspension type of setting, or by not less than 2 steel or cast iron brackets on each side.

(3) Lugs or hangers, when used to support a boiler of any type shall be properly fitted to the surfaces to which they are attached. If riveted, the shearing and crushing stresses on the rivets used for attaching the lugs or hangers shall not exceed 8% of the strength given in section Ind 41.72. Where it is impractical to use rivets, studs with not less than 10 threads per inch may be used. In computing the shearing stress, the area at the bottom of the thread shall be used. Strength welding may be used, if done in accordance with sections Ind 41.50 and Ind 41.51 of this code.

(4) Wet bottom stationary boilers shall have a space of not less than 12 inches between the bottom of the boiler and the floor line, with access for inspection.

(5) 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 water leg are protected from the action of the fire and products of combustion.

Ind 41.96 Access and Firing Doors. The minimum size of an access door to be placed in a boiler setting shall be 12 inches by 16 inches or equivalent area, 11 inches to be the least dimension in any case.

Ind 41.97 Water Tube Boiler Doors. A water tube boiler shall have the firing doors, furnace inspection doors and clinker doors of the inward opening

type, unless such doors are provided with latching or fastening devices or otherwise so constructed as to prevent them, when closed, from being blown open by pressure on the furnace side.

Ind 41.98 Low-water cut-off and water feeder. (1) ~~Every automatically fired~~ Every automatically fired power boiler which does not have a full time attendant and every automatically fired low ~~low pressure steam boiler and every automatically fired power boiler which does not have a full time attendant~~ pressure steam boiler shall be equipped with an automatic low-water fuel cut-off or other device which will perform a similar function, so located as to automatically cut off the fuel supply when the surface of the water falls to the lowest safe water line. If a water feeding device is installed, it shall be so constructed that the water inlet valve cannot feed water into the boiler through the float chamber and so located as to supply requisite feed water. The lowest safe water line shall be not lower than the lowest visible part of the water glass.

(2) Such a fuel or feed water control device may be attached direct to a boiler or to the tapped openings provided for attaching a water glass direct to a boiler, provided that such connections from the boiler are non-ferrous tees or Y's not less than $\frac{1}{2}$ inch pipe size between the boiler and the water glass so that the water glass is attached direct and as close as possible to the boiler; the straight-way tapping of the Y or tee to take the water glass fittings, the side outlet of the Y or tee to take the fuel cut-off or water-feeding device. The ends of all nipples shall be reamed to full size diameter.

(3) Designs embodying a float and float bowl, or prob e controls installed in a bowl or chamber externally to the boiler shall have a vertical straightway valved dr valved drain pipe at the lowest point in the water by which equalizing pipe connections by which the bowl or chamber and the equalizing pipe can be flushed and the device tested. vertical straightway ipe connections e device tested.

Ind 41.99 Pressure Relief Devices Required for Unfired Pressure Vessels.

(1) Every unfired pressure vessel shall be provided with or protected by a pressure relief device.

(2) The relieving capacity of the pressure relief device shall be equal to or greater than the input to the vessel or shall be great enough to prevent the pressure in the vessel from rising more than 10% above the maximum allowable working pressure of the vessel.

(over)

(3) Safety valves which are constructed in accordance with the standards of sections Ind 41.50 and Ind 41.51 of this code are acceptable. Safety valves constructed to other standards may be used if approved by the industrial commission.

(4) Rupture disks may be used in lieu of safety valves on vessels containing substances that may render a safety valve inoperative, or where a loss of valuable material by leakage should be avoided, or contamination of the atmosphere by leakage of noxious gases must be avoided. Such rupture disks shall be tested, marked, and installed in accordance with the A.S.M.E. codes listed in section Ind 41.50.

(5) When hot water supply is heated indirectly by steam in a coil or pipe a water relief valve of at least one inch in diameter, set to relieve at or below the maximum allowable working pressure of the tank shall be used.

~~the pressu~~ ~~hot water~~ ~~relieve at or below the maximum allowable working pressure of the tank, shall be used.~~

(6) Each safety or relief valve shall have a full size direct connection to the pressure vessel. When an escape pipe is used it shall be full sized and fitted with an open drain, to prevent water lodgingin the upper part of the safety or valve or escape pipe. When a pressure vessel is fitted with 2 safety or relief relief/valves on one connection, this connection to the pressure vessel shall have a cross-sectional area equal to or greater than the combined area of the 2 safety or relief valves. No valve of any description shall be placed between the safety or relief valve and the pressure vessel, nor on the escape pipe between the safety or relief valve and the atmosphere.

(7) When an elbow is placed on a safety or relief valve escape pipe it shall be located close to the safety or relief valve outlet, or the escape pipe shall be securely anchored and supported.

(8) When the capacity of the safety valve on an existing tank for containing gases is not known, the relieving capacity of such safety valve shall be determined from Table 7. Such safety valves shall not exceed 4 inches in diameter.

TABLE 7

MAXIMUM FREE AIR SUPPLIED IN CUBIC FEET PER MINUTE FOR DIFFERENT SIZES OF SAFETY VALVES AT STATED PRESSURES

Diameter of Valve (inches)	Gage pressure, pounds							
	50	100	150	200	250	300	350	400
1/4	———	———	———	———	———	———	———	53
1/2	20	32	42	51	59	67	74	111
3/4	37	59	78	96	112	127	141	176
1	58	94	124	152	178	202	224	248
1 1/4	84	135	180	221	259	293	325	———
1 1/2	114	186	248	302	354	400	444	———
2	189	306	410	501	592	668	741	———
2 1/2	282	457	613	750	880	998	1114	———
3	393	638	856	1050	1230	1398	1557	———

Diameter of Valve (inches)	Gage Pressure, Pounds							
	500	600	800	1000	1200	1600	2000	2400
1/4	61	70	84	97	109	128	147	167
1/2	129	147	177	205	230	270	304	330
3/4	224	232	242	346	386	423	474	518
1	286	324	390	450	500	586	———	———
1 1/4	374	———	509	———	———	———	———	———
1 1/2	472	———	634	———	———	———	———	———
2	———	———	———	———	———	———	———	———
2 1/2	———	———	———	———	———	———	———	———
3	———	———	———	———	———	———	———	———

PART VII
REPAIRS, ADDITIONS, ALTERATIONS

Ind 42.01 Rules and Reports. (1) Repairs, additions, or alterations to any boiler or pressure vessel or their fittings, settings, or appurtenances shall be made in accordance with sections Ind 42.01 through Ind 42.22 except that other methods may be used if submitted to and approved by the industrial commission. In the absence of specific rules, the rules for new construction shall apply.

(2) Manufacturers, owners, or contractors who make major repairs* in accord-

ance with these rules shall furnish the industrial commission with a report of every such major repair within 30 days after completion thereof. The report shall be signed by the authorized inspector who inspected the repair. The owner of the equipment on which major repairs were made shall retain a copy of the report in his files for review by an authorized inspector. The form to be used for the report shall contain the information shown in the following example:
* See section Ind 41.02 (10).

Record of Riveted or Welded Major Repairs

This is to certify that the major repair made by or under the direction of the undersigned on _____ (date of repair) and consisting of _____ (description of repair)

_____

_____ (On Boiler No.) (On Unfired Pressure Vessel No.)

located in the plant of _____ (Name of Pressure Vessel Owner)

_____ (Address of Plant)

was made in accordance with the requirements of the Wisconsin industrial commission for repairs by riveting or fusion welding to power or miniature boilers and unfired pressure vessels. The welding was done by

_____ (Fill in only if a fusion welded repair)

who has made the test reuirements of said rules.

Signed _____

Dated at _____ On _____

_____ Employed by

_____ Authorized Inspector

History: Cr.Register, December, 1956, No. 12, eff. 1-1-57

Ind 42.02 Hydrostatic Test. Upon completion of repairs, a hydrostatic test of 150% of the maximum allowable working pressure shall be applied and the patch seams should be tight at this pressure.
History: Cr. Register, December, 1956, Nov. 12, eff. 1-1-57

Ind 42.03 Design of Riveted Patches. It is the purpose of sections Ind 42.03 through Ind 42.07 covering the application of riveted patches,

(over)

to restore to the weakened portion of the shell or head enough of its initial strength to permit the boiler to operate at its original working pressure. This involves calculations of the patch joints based on the shape and location of the patch. The rules herein given enable the efficiency of the patch joints to be readily determined. It is required that when riveted patches are considered necessary or desirable, they shall be applied under the following rules.

(1) The first thing that shall be taken into consideration when proceeding with the design of a patch is whether or not all of the end stress is to be carried by the patch; in other words, whether the heads are supported or unsupported. In drums of water tube boilers, the full end wise stress has to be carried by the shell plates and the patch seams, whereas in shells of horizontal tubular boilers some of the end wise stress is carried by the through rods, tube or flues, and consequently there is less stress on the shell and patch seams. It is evident then that a patch in the one case need not have the same width for a given length as in the other case. In other words, different constants may be used in determining the width. Tables 8 and 9 take into account these 2 different conditions.

(2)The angle of a patch when laid out in the flat does not change when formed to the curvature of the boiler, therefore, the diameter of the boiler does not need to be taken into consideration in the design when the provisions of item (3) are met.

(3) (a) A patch shall be laid out in the flat and then carefully formed to accurately fit the contour of the boiler where it is to be applied.

(b) Patches shall be of the same thickness as the original thickness of the plate they replace.

(4) (a) Seams exposed to the products of combustion shall be single riveted lap construction.

(b) Seams not exposed to the products of combustion shall be double riveted or constructed similar to the original seams of the boiler.

(5) (a) Patches exceeding 24 inches in length shall have the proper width as determined by the rules herewith.

(b) Patches 24" or less in length shall be triangular, crescent, diamond or oval in form and the width shall be at least twice the length.

(6) (a) If it is found that a patch would extend extremely high it may be shortened in width to the extent that no more than 4 rivets will be in a longitudinal line, as shown in Figure 3.

(b) Likewise, to avoid the necessity of calking in sharp corners, a patch may be shortened in width to the extent that no more than 4 rivets will be in a longitudinal line, as shown in Figure 3.

(7) (a) If it is found that a patch would have to be 60 inches or more in length consideration shall be given to the use of a sheet having a width equivalent to 5/8 of the circumference of the boiler and the longitudinal seam shall be of a design similar to the design of the original seam of the boiler.

(b) In designing patches, it is not necessary to deal with angles in the term of degrees, but merely with the dimensions of the triangles forming a patch. The relation between the length and width provides certain fixed constants that have been tabulated and designated as Tables 8 and 9. The constant is the figure by which the length shall be multiplied to determine the width.

(c) If a patch is diamond in shape, it is considered equivalent to 2 triangular patches and half the total length is used in determining the width.

(d) As the angle of a patch as laid out when flat does not change when formed to the curvature of the boiler, the diameter of the boiler does not have to be taken into consideration in the design.

(8) (a) In laying out new patches over 24 inches long, it is recommended that they be triangular or diamond in shape, as may be required for the particular job, with definite straight line sides, but with the corners properly rounded out to permit proper calking, as illustrated in Figures 2, 3, 4, and 5.

(b) Where the length des ignated as "L" and the width designated as "W" is measured is also shown in Figures 2, 3, 4, and 5.

(9) (a) Rivets, patch bolts or staybolts may be used in "riveted" seams surfaces that are stayed or braced, provided at least one rivet or patch bolt is used between adjacent staybolts. The riveting shall be completed first. (over)

Fig. 2

TRIANGULAR PATCH

At girth seam on bottom of boiler (insde) as viewed from outside of boiler

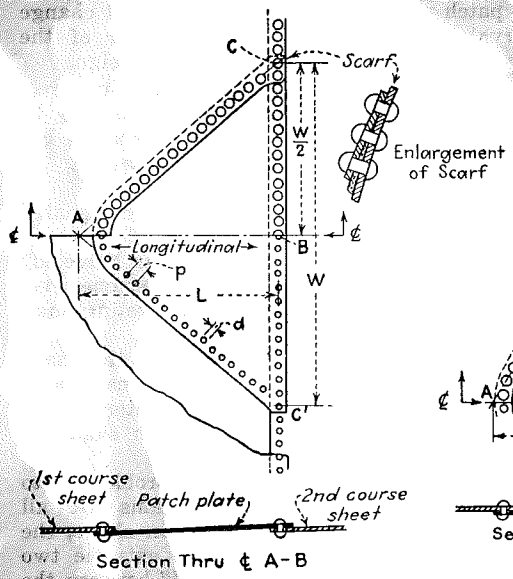


Fig. 3

Showing how patch may be shortened girthwise provided no more than 4 rivets are in a line parallel with the longitudinal seam.

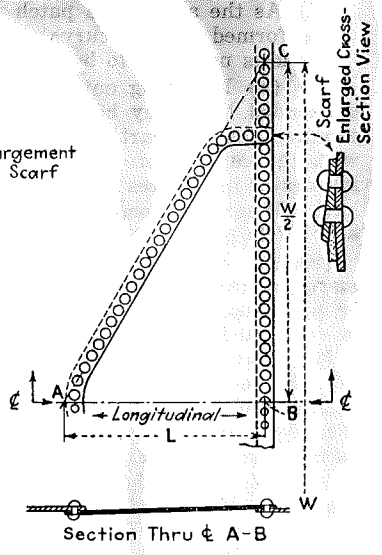


Fig. 4

DIAMOND SHAPE PATCH

At centre of sheet (inside)

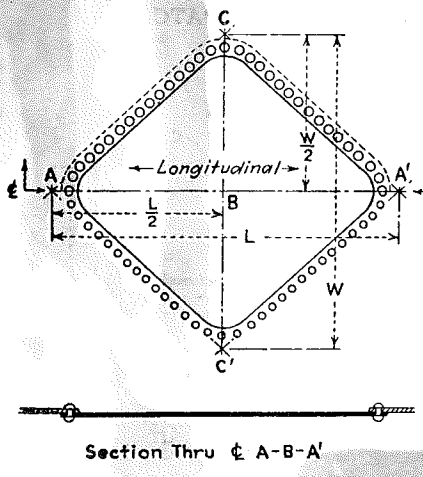


Fig. 5

TRIANGULAR PATCH

At head seam and blow-off on bottom of boiler (outside)

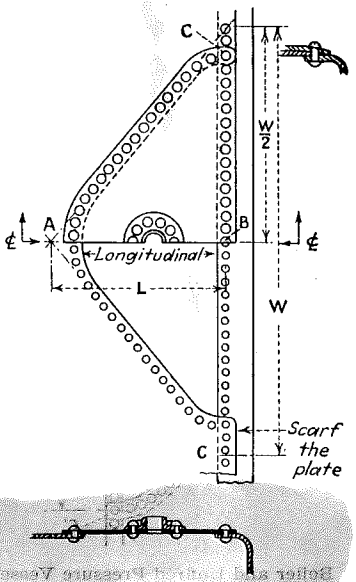


Fig. 6
CRESCENT PATCH
At Girth Seam

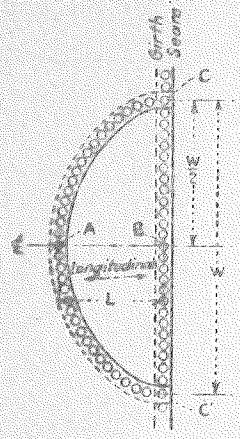
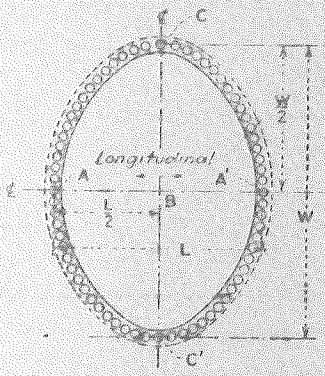


Fig. 7
OVAL PATCH



(b) Rivet holes may be countersunk in patches on shells that have braced heads, if desired, without materially affecting the calculated strength of the patch. The angle of the chamfer with center line of the rivet hole shall not exceed 45^{o} and the depth shall not exceed half the thickness of the plate.

(10) Where patches have already been applied the problem is to determine the effective diagonal efficiency. If the seams are all rounded, that is to say, the patch is crescent or oval in shape, the length "L" shall be taken between the center of the extreme two rivets on the longitudinal center line and the width "W" between the center of the extreme two rivets on the girthwise center line, as illustrated in Figures 6 and 7.

History: Cr. Register, December, 1956, No. 12, eff. 1-1-57

> Insert figures 2-3-4-5-6 and 7 <

Ind 42.04 Material for Riveted Patches. (1) Patch material shall be either fire box or flange steel. Structural steel shall not be used. The repair shop shall produce a copy of the manufacturer's mill test report of the material to be used.

(2) The material shall contain the steelmaker's brand. If only part of a plate is required and this part does not contain the brand, the brand shall be transferred to the patch plate in the presence of an authorized boiler inspector or a representative of the plate manufacturer, before the plate is cut. Rivets, patch bolts, or staybolts shall be of material of standard quality.

Hisotry: Cr. Register, December, 1956, No. 12, eff. 1-1-57

Ind 42.05 Workmanship on Riveted Patches. (1) All patch plates shall be placed inside a boiler shell or drum where exposed to the products of combustion and where deposits would be pocketed. Where a patch plate includes the part to which the blow-off is attached, the patch shall be placed on the outside.

(2) All defective material exposed to the products of combustion shall be removed and properly trimmed to provide for neat workmanship in attaching the patch. Defects not exposed to the products of bombustion need not be removed unless necessary to insure a workmanlike job.

(3) A distorted sheet which is to be patched shall first be set back straight as much as possible before proceeding with the cutting out of the plate so that the patch may be kept as small as possible.

(4) The edge of a patch shall be beveled by planing, chipping, or gas cutting before applying it to the boiler. Rivets shall be driven by gun, if at all possible.

(5) All rivet holes shall be drilled full size or the holes may be punched not to exceed $\frac{1}{4}$ inch less than full size for plates over 5/16 inch, and 1/8 inch less for plates 5/16 inch or less in thickness, and then reamed to full size with patch in place. Rivet holes are usually 1/16 inch greater in diameter than the normal diameter of the rivet but a 1/32 inch difference is preferable when the rivets are of uniform size.

(6) If seal welding is used, it shall be laid in a single bead with a throat thickness not less than 3/16 inch, nor more than 5/16 inch. The patch shall be tight before seal welding under a hydrostatic test equal to the operating pressure.

(7) Where 3 plates have to be lapped at the corners of a patch, the middle plate shall be carefully scarfed to a feather edge the entire width of the lap, as shown in Figure 2.

History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.06 Calculations for Riveted Patches. (1) First the length L of the patch shall be determined. The dimension is, of course, governed by the area of the defect. Next, the normal efficiency, e, of the single-riveted seam that is to be used in the patch shall be determined from Table 7. This is governed by the thickness of plate and diameter of rivet holes.

(2) After determining the length that a patch shall be, the next step is to determine what the width girthwise shall be. This is found by multiplying the length by the constant, C, as shown in Table 8 or 9, depending upon the type of boiler to be repaired. These tables give a constant C for a given efficiency, e, of patch and efficiency, E, of longitudinal seam.

(3) To determine the longitudinal efficiency of an existing patch, L and W shall be measured, also the pitch, p, and diameter of rivet, d. W divided by L will give the constant C. Table 7 will give e. Then under e in Table 8 or 9, depending upon the type of boiler to be repaired, find the constant C. Then whatever E at the left is found is the longitudinal or allowed efficiency of the patch seam (See section Ind 42.07).

(over)

TABLE X8

EFFICIENCIES OF SINGLE-RIVETED SEAMS

Plate Thickness, t	Rivet Hole Diameter, d	Pitch of Rivets, p	Efficiency of Seam, e
1/4	11/16	1-7/8	63.3
9/32	3/4	1-7/8	60.0
5/16	3/4	1-7/8	60.0
11/32	13/16	1-15/16	58.0
3/8	13/16	1-15/16	57.0
13/32	7/8	2-1/16	57.5
7/16	15/16	2-1/4	56.0
15/32	15/16	2-1/8	55.5
1/2	1	2-1/4	55.7
9/16	1-1/16	2-3/8	53.0
19/32	1-1/16	2-1/4	52.8
5/8	1-1/16	2-1/4	50.5
21/32	1-1/8	2-5/16	51.4
11/16	1-1/8	2-5/16	51.4

Tensile strength assumed at 55,000 psi and shearing strength at 44,000 psi.
History: Cr.Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.07 Examples of Calculations for Riveted Patches. (1) DESIGN OF PATCH FOR HORIZONTAL-TUBULAR BOILER. (a) A patch is to be placed in the fire sheet of a horizontal-return tubular boiler having shell plate 7/16 inch thick, a longitudinal seam efficiency of 74%, and a length of patch of 36 inches. Find the width W of patch to be applied so that there will not be any reduction in pressure, using a single-riveted seam of normal design.

(b) Referring to Table 7, it is found that a 7/16 inch plate with 15/16 inch diameter rivet holes, pitch 2-3/4 inch, gives a seam efficiency of 56%.

(c) Referring to Table 8, E-74 and e-56 give a constant C-1/75; then width W = L x C = 36 x 1.75 = 63 inches.

(2) PRESSURE ALLOWANCE ON AN EXISTING PATCH FOR HORIZONTAL-TUBULAR BOILER. (a) A crescent shape patch has already been installed on a horizontal-tubular boiler. It is found to be 30 inches long and 48 inches wide. The seam is noted to be single-riveted with 13/16 inch riveted holes pitch 1-15/16 inch. The boiler shell plate is 3/8 inch thick. The longitudinal seam is of the double-riveted butt-strap type having an efficiency of 82%. The safety valve is set for 125 pounds presure. What maximum pressure should be allowed on the boiler?

(b) Referring to Table 7, it shows that the normal efficiency of the patch seam is 57%.

TABLE 8

TABLE OF CONSTANTS FOR USE IN COMPUTING PATCH SEAMS WHEN HEADS ARE SUPPORTED

Efficiency of longitudinal Seams or diagonal efficiency - E	"e" efficiency of patch seams															
	.50	.51	.52	.53	.54	.55	.56	.57	.58	.59	.60	.61	.62	.63	.64	.65
.65	1.68	1.60	1.51	1.43	1.36	1.28	1.20	1.13	---	---	---	---	---	---	---	---
.66	1.75	1.67	1.58	1.50	1.42	1.35	1.27	1.19	---	---	---	---	---	---	---	---
.67	1.82	1.73	1.65	1.57	1.49	1.41	1.33	1.26	1.18	---	---	---	---	---	---	---
.68	1.88	1.79	1.70	1.63	1.55	1.47	1.40	1.32	1.24	1.16	---	---	---	---	---	---
.69	1.94	1.86	1.77	1.69	1.61	1.53	1.45	1.38	1.30	1.23	1.15	---	---	---	---	---
.70	2.01	1.91	1.83	1.75	1.67	1.59	1.52	1.44	1.36	1.30	1.22	1.15	---	---	---	---
.71	2.06	1.97	1.89	1.81	1.73	1.65	1.57	1.50	1.43	1.35	1.28	1.21	1.15	---	---	---
.72	2.12	2.03	1.95	1.86	1.79	1.71	1.63	1.56	1.48	1.41	1.34	1.27	1.20	1.14	---	---
.73	2.17	2.09	2.00	1.93	1.85	1.77	1.69	1.62	1.54	1.47	1.40	1.33	1.26	1.19	1.13	---
.74	2.22	2.14	2.06	1.98	1.91	1.83	1.75	1.67	1.60	1.52	1.45	1.39	1.32	1.25	1.18	---
.75	2.28	2.20	2.12	2.04	1.96	1.88	1.81	1.73	1.66	1.58	1.51	1.44	1.37	1.31	1.24	1.17
.76	2.34	2.25	2.17	2.09	2.02	1.93	1.86	1.79	1.71	1.64	1.57	1.50	1.43	1.36	1.30	1.23
.77	2.39	2.31	2.22	2.15	2.07	2.00	1.92	1.84	1.76	1.69	1.62	1.55	1.48	1.42	1.35	1.29
.78	2.44	2.36	2.28	2.20	2.13	2.05	1.97	1.89	1.82	1.75	1.67	1.61	1.54	1.47	1.41	1.35
.79	2.50	2.42	2.33	2.25	2.18	2.10	2.03	1.95	1.87	1.81	1.73	1.66	1.59	1.52	1.46	1.40
.80	2.55	2.46	2.39	2.30	2.23	2.15	2.08	2.00	1.93	1.86	1.79	1.72	1.64	1.58	1.48	1.45
.81	2.60	2.51	2.43	2.36	2.28	2.20	2.13	2.05	1.98	1.91	1.84	1.77	1.69	1.63	1.57	1.50
.82	2.65	2.56	2.48	2.40	2.33	2.25	2.18	2.11	2.03	1.97	1.89	1.82	1.75	1.68	1.62	1.55
.83	2.70	2.62	2.53	2.45	2.38	2.30	2.22	2.15	2.08	2.01	1.94	1.87	1.80	1.73	1.67	1.60
.84	2.75	2.66	2.59	2.51	2.43	2.35	2.27	2.20	2.13	2.06	1.99	1.92	1.85	1.78	1.72	1.65
.85	2.80	2.71	2.63	2.56	2.48	2.40	2.32	2.25	2.18	2.11	2.04	1.97	1.90	1.84	1.77	1.70
.86	2.85	2.77	2.68	2.60	2.52	2.45	2.37	2.30	2.23	2.16	2.09	2.02	1.95	1.89	1.82	1.75
.87	2.90	2.82	2.74	2.65	2.57	2.49	2.42	2.34	2.28	2.21	2.14	2.07	2.00	1.93	1.87	1.81
.88	2.96	2.87	2.78	2.71	2.62	2.54	2.474	2.40	2.32	2.25	2.19	2.12	2.05	1.98	1.92	1.85
.89	3.01	2.92	2.83	2.75	2.68	2.59	2.52	2.44	2.37	2.30	2.23	2.16	2.10	2.03	1.96	1.90
.90	---	2.97	2.89	2.80	2.71	2.65	2.57	2.50	2.42	2.34	2.27	2.21	2.14	2.08	2.01	1.95
.91	---	---	2.94	2.86	2.77	2.69	2.62	2.54	2.47	2.39	2.32	2.25	2.19	2.12	2.06	2.00
.92	---	---	2.99	2.90	2.82	2.74	2.66	2.59	2.51	2.44	2.36	2.30	2.23	2.17	2.10	2.04
.93	---	---	---	2.95	2.87	2.78	2.70	2.63	2.56	2.48	2.42	2.34	2.28	2.21	2.15	2.08
.94	---	---	---	---	2.91	2.83	2.75	2.67	2.60	2.53	2.45	2.39	2.32	2.25	2.19	2.13
.95	---	---	---	---	---	2.87	2.79	2.72	2.64	2.57	2.50	2.43	2.36	2.29	2.23	2.17

Constant "C" Triangle or crescent shape patches $C = W \div L$ $W = C \times L$ $L = W \div C$

Diamond or oval shape patches $C = 2W \div L$ $W = C \times L \div 2$ $L = 2W \div C$

(over)

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TABLE 9

TABLE OF CONSTANTS FOR USE IN COMPUTING PATCH SEAMS WHEN HEADS ARE UNSUPPORTED

Efficiency of longitudinal seams or diagonal efficiency - E	"e" efficiency of patch seams														
	.50	.51	.52	.53	.54	.55	.56	.57	.58	.59	.60	.61	.62	.63	.64	.65
.65	2.20	2.06	1.93	1.80	1.69	1.56	1.45	1.35	1.24	1.14	---	---	---	---	---	---
.66	2.30	2.16	2.03	1.90	1.78	1.66	1.55	1.45	1.34	1.22	1.12	---	---	---	---	---
.67	2.40	2.26	2.13	2.00	1.88	1.75	1.64	1.52	1.43	1.32	1.21	---	---	---	---	---
.68	2.50	2.36	2.23	2.10	1.98	1.86	1.73	1.63	1.52	1.42	1.31	1.19	---	---	---	---
.69	2.62	2.46	2.33	2.20	2.07	1.95	1.84	1.71	1.61	1.50	1.40	1.30	1.17	---	---	---
.70	2.75	2.57	2.43	2.30	2.16	2.04	1.93	1.80	1.69	1.59	1.49	1.37	1.28	1.16	---	---
.71	2.87	2.70	2.53	2.40	2.26	2.14	2.02	1.90	1.79	1.67	1.57	1.47	1.37	1.26	1.15	---
.72	3.00	2.81	2.65	2.48	2.36	2.23	2.11	1.99	1.88	1.78	1.66	1.56	1.45	1.36	1.26	1.14
.73	3.14	2.93	2.76	2.60	2.46	2.33	2.20	2.09	1.97	1.87	1.75	1.64	1.54	1.44	1.35	1.24
.74	3.28	3.07	2.87	2.71	2.56	2.42	2.30	2.19	2.06	1.93	1.83	1.73	1.62	1.52	1.43	1.34
.75	3.38	3.19	3.00	2.83	2.66	2.52	2.40	2.27	2.15	2.05	1.92	1.81	1.71	1.61	1.51	1.42
.76	3.52	3.32	3.14	2.96	2.78	2.62	2.49	2.36	2.24	2.12	2.01	1.90	1.79	1.69	1.60	1.50
.77	---	3.46	3.28	3.07	2.90	2.74	2.58	2.45	2.32	2.22	2.10	1.98	1.88	1.77	1.67	1.58
.78	---	---	3.40	3.19	3.03	2.85	2.69	2.55	2.42	2.30	2.19	2.07	1.96	1.86	1.75	1.66
.79	---	---	---	3.32	3.16	2.97	2.80	2.65	2.51	2.39	2.27	2.16	2.05	1.94	1.84	1.74
.80	---	---	---	3.46	3.28	3.10	2.92	2.75	2.61	2.48	2.36	2.24	2.14	2.03	1.92	1.83
.81	---	---	---	---	3.40	3.20	3.03	2.87	2.71	2.57	2.45	2.33	2.21	2.11	2.00	1.90
.82	---	---	---	---	---	3.34	3.16	2.97	2.82	2.67	2.53	2.42	2.30	2.19	2.09	1.98
.83	---	---	---	---	---	3.46	3.29	3.10	2.93	2.78	2.63	2.50	2.39	2.27	2.17	2.06
.84	---	---	---	---	---	---	3.39	3.22	3.05	2.87	2.75	2.59	2.47	2.37	2.25	2.15
.85	---	---	---	---	---	---	---	3.32	3.17	2.99	2.83	2.69	2.55	2.44	2.34	2.23
.86	---	---	---	---	---	---	---	3.45	3.29	3.13	2.96	2.78	2.65	2.54	2.42	2.32
.87	---	---	---	---	---	---	---	---	3.40	3.24	3.07	2.90	2.76	2.62	2.50	2.40
.88	---	---	---	---	---	---	---	---	---	3.32	3.17	3.00	2.86	2.71	2.59	2.47
.89	---	---	---	---	---	---	---	---	---	3.46	3.29	3.14	2.97	2.81	2.68	2.56
.90	---	---	---	---	---	---	---	---	---	---	3.40	3.24	3.07	2.93	2.78	2.65
.91	---	---	---	---	---	---	---	---	---	---	---	3.35	3.19	3.03	2.87	2.75
.92	---	---	---	---	---	---	---	---	---	---	---	3.45	3.29	3.14	2.97	2.83
.93	---	---	---	---	---	---	---	---	---	---	---	---	3.39	3.24	3.09	2.93
.94	---	---	---	---	---	---	---	---	---	---	---	---	---	3.32	3.19	3.03
.95	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3.43	3.28

Constant "C" Triangle or crescent shape patches $C = W \div L$ $W = C \times L$ $L = W \div C$

Diamond or oval shape patches $C = 2W \div L$ $W = C \times L \div 2$ $L = 2W \div C$

History: Cr. Register, December, 1956, No. 12, eff. 1-1-57

(c) If the efficiency is not found in the table, refer to any other available table or determine it in the customary manner described in sections Ind 41.50 and Ind 41.51 of this code.

(d) Divide the width of the patch W = 48 inches by the length L = 30 inches to find the constant C = 48/30 = 1.60

(e) Follow down column e = 0.57 of Table 8 until 1.60 is found. It will be noted that this is somewhere between 1.56 and 1.62 representing E somewhere between 0.72 and 0.73. As the difference between 1.56 and 1.62 is 6, and the difference between 1.56 and 1.60 is 4, E will be 0.72 plus 4/6 of 0.001 which is 0.7266.

(f) The pressure approved varies directly as the seam efficiency. Accordingly P = 0.7266/0.82 x 125 = 110 pounds per square inch.

(g) If this allowance interferes with the operation of the plant, the patch will have to be replaced by a new one with proper dimensions giving a diagonal efficiency of 82%.

(3) DESIGN OF PATCH FOR WATER-TUBE BOILER. (a) Sections of the plate having a total length of 36 inches (measured at the pitch line) are to be removed on each side of a girth seam. The patch is to be diamond or oval shape. The shell plate is 7/16 inches thick and the longitudinal seam is double-riveted butt strap construction, having an efficiency of 82%. What should be the width of the patch for maintaining the same pressure allowance?

(b) Referring to Table 7, it shows that a single-riveted lap seam with 7/16 inch plate, 15/16 inch diameter rivet holes, and $2\frac{1}{2}$ inch pitch has a normal efficiency of 56%.

(c) Referring to Table 9, it shows for E = 0.82 and e = 0.56, the constant C is 3.16.

(d) Then width W = C x L ÷ 2
W = 3.16 x 36 ÷ 2 = 56.88, say 57 inches.

History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.08 Welding Procedure. Manufacturers, owners or contractors undertaking repairs under these rules shall have available for the inspector a written welding procedure specification that shall be followed in making the necessary repair and

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also a record of procedure qualification tests. Welding procedure specifications shall have been prepared and qualified in accordance with the requirements of sections Ind 41.50 and Ind 41.51 of this code under Welding Qualifications, section Ind 41.50 (6).

Repairs by fusion welding on low pressure steam and hot water boilers shall be exempt from the provisions of sections Ind 42.01 through Ind 42.21, except that a qualified welder shall be required for such repairs and the repairs shall conform to sections Ind 42.10, Ind 42.11, Ind 42.12, Ind 42.13 and Ind 42.20.

History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.09 Welders. (1) WELDER QUALIFICATION. Manufacturers, owners or contractors shall have available for the inspector records of welder qualification tests showing that each welder to be employed on the work has satisfactorily passed tests as prescribed in sections Ind 41.50 and Ind 41.51 of this code under Welding Qualifications for the type of filler metal to be used and for each position in which he will be called upon to operate in making the repair.

(2) WELDING TESTS, MANUFACTURER'S, OWNER'S or CONTRACTOR'S RESPONSIBILITY, INSPECTOR'S DUTY. Preparation of welding procedure specifications and the conducting of tests of procedures and welders shall be the responsibility of the manufacturer, owner or contractor. Before repairs are started, it shall be the duty of the inspector to satisfy himself by examination of the written welding procedure and records of qualification tests that procedures and welders have been properly qualified as required in section Ind 41.50 (6). Witnessing of the tests by the inspector shall not be mandatory but he shall have the right to witness such tests when he deems it necessary. The inspector shall also have the right to call for and witness the making of test plates by any welder, at any time, and to observe the physical testing of such plates.

History: Cr.Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.10 Rules for Welding. The repairs that may be made under these rules are limited to steels of flange or fire box quality having known weldable quality and further limited to carbon steels having a carbon content of not more than 0.35%.

Structural steel shall not be used. The welding of high alloy material and non-ferrous material shall be done in accordance with the requirements of sections Ind 41.50 and Ind 41.51 of this code for boilers and unfired pressure vessels.
History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.11 Prohibited Repairs. A welder shall not make repairs in a plate thickness in excess of that permitted under sections Ind 41.50 and Ind 41.51 of this code for Welding Qualifications. A welder shall not make repairs on a material that is not covered within his qualification tests.
History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.12 Procedure. Groove welds shall completely penetrate the thickness of the material being welded. If possible, welding shall be applied from both sides of the plate or a backing strip or ring may be used to insure complete penetration. Manually applied welds shall have a convex surface on both sides if applied on both sides of the plates being joined, or on one side if welding is applied from one side only. Valleys and undercutting at edges of welded joints shall not be permitted. The reinforcement may be chipped, ground, or machined off flush with the base metal, if so desired, after the welding has been completed.
History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.13 Defective Weld. In making a repair to a weld that has failed in service, the defective weld shall be removed by chipping, grinding or gouging until sound metal is reached on all sides. The resulting groove shall be filled as required by the applicable welding procedure.
History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.14 Stress Relieving Operations. (1) In repairing carbon or low alloy steels, when required by these rules and considered necessary by the authorized inspector, thermal stress relieving shall be applied to the completed work. The heat may be applied by any means that will raise the temperature of the material being heated gradually and uniformly to approximately 1,200 F. (In the absence of more accurate means of determining temperature, a dull red glow in daylight will suffice.) This temperature shall be maintained for a period of one hour per inch of thickness of material. For circumferential joints, the area heated shall

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comprise a band extending completely around the cylinder and having a width on each side of the center line of the weld not less than 3 times the greatest width of the finished weld. For nozzles, the heated area shall comprise a circumferential band extending around the entire vessel, including the nozzle or welded attachment and shall extend at least 6 times the plate thickness beyond the welding which connects the nozzle or other attachment to the vessel. Under certain conditions other methods of thermal stress relieving acceptable to the authorized inspector may be used. Under certain conditions preheating may be necessary.

(2) Upon completion of the stress relieving operation, the plate shall be allowed to cool at a rate not greater than 500 F. per hour divided by the maximum thickness of the welded part in inches, but in no case more than 500 F. per hour. This rate of cooling shall be maintained until a temperature of approximately 600 F. is reached, after which normal cooling by exposure in a still atmosphere may be permitted.

(3) Thermal stress relieving of austenitic steels is a controversial subject. It shall not be attempted except in accordance with the recommendations of the manufacturer of the material or the requirements of sections Ind 41.50 and Ind 41.51 of this code.

(4) In lieu of thermal stress relieving of carbon steels, peening or other methods acceptable to the authorized inspector may be employed.

History: Cr. Register, December, 1956, No. 12, Eff. 1-1-57.

Ind 42.15 Cracks, Permissible Welded Repairs. CAUTION. Before making welded repairs, care should be taken to investigate the cause of the cracks. Where circumstances indicate that welding cracks is likely to result in recurrence, consideration should be given to cutting out the cracked area and installing a patch.

(1) Cracks in unstayed shells, drums or headers of boilers or pressure vessels may be repaired by welding, providing the cracks do not extend between rivet holes in a longitudinal seam or parallel to a rivet seam within 8 inches, measured from nearest calking edge. The total length of any one such crack shall not exceed 8 inches. Cracks of a greater length may be welded, provided the complete repair is radiographed and stress relieved in accordance with section Ind 42.14. See

Figures 8 and 8(a) for acceptable methods.

(2) Cracks of any length in unstayed furnaces may be welded, provided the welds are thermally stress relieved in accordance with section Ind 42.14. Welds applied from both sides of the plate shall be used where possible. Welds applied from one side only shall be subject to the approval of the authorized inspector. Field repair of cracks at knuckle or turn of flange of furnace opening are prohibited unless specifically approved by the industrial commission. See Figure 9 for acceptable methods.

(3) Cracks of any length in stayed areas may be repaired by fusion welding except that multiple or star cracks radiating from rivet or staybolt holes shall not be welded. See Figure 10 for acceptable methods.

Ind 42.16 Corroded Surfaces and Seal Welding. (1) Corroded areas in stayed surfaces may be built up by fusion welding, provided the remaining plate has an average thickness of not less than 50% of the original thickness, and further provided that the areas so affected are not sufficiently extensive to impair the safety of the object. See Figure 11 for Acceptable Methods.

(2) Corroded areas around manhole or handhole openings in either stayed or unstayed plates may be built up by fusion welding, provided the average loss of thickness does not exceed 50% of the original plate thickness and also provided the area to be so repaired does not extend more than 3 inches from the edge of the hole.

(3) Corroded areas in unstayed shells, drums or headers may be built up by fusion welding provided that in the judgment of the authorized inspector, the strength of the structure has not been impaired. See Figure 12 for Acceptable Methods.

(4) Edges of butt straps or of plate laps and nozzles or connections attached by riveting may be restored to original dimensions by welding. Seal welding shall not be used except with the special approval of the authorized inspector, and in no case where cracks are present in riveted areas. See Figure 13 for Acceptable Methods.

(5) The ends of tubes in fire tube and water tube boilers may be seal welded provided they have not been reduced more than 10% in thickness, and requirements of sections Ind 41.50 and Ind 41.51 of this code are satisfied. See Figure 14 for

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Acceptable Methods.
History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.17 Re-ending and Piecing Tubes. Re-ending or piecing of tubes or pipes in either fire tube or water tube boilers is permitted provided the thickness of the tube or pipe has not been reduced by more than 10% from that required by sections Ind 41.50 and Ind 41.51 of this code for the pressure to be carried. In all cases the requirements of sections Ind 41.50 and Ind 41.51 of this code shall be met.
History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.18 Patches, Material. The material used for patches shall be of the same general quality and have at least the minimum physical properties of the plate to be patched. The thickness of any patch shall be at least equal to, but not more than, 1/8 inch greater than the plate being patched.
History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.19 Flush or Butt Welded Patches. (1) Flush or butt welded patches in unstayed shells, drums or headers shall be radiographed and stress relieved to conform to the requirements of sections Ind 41.50 and Ind 41.51 of this code for new construction. Subject to the approval of an authorized inspector, peening or other methods of stress relieving may be substituted for thermal stress relieving. Subject to compliance with this requirement , no limit is placed on dimensions or location of such patches or on the thickness of the material. When the longest dimension of a patch does not exceed 16 times the plate thickness or a maximum of 8 inches, radiographing and stress relieving is not required. See Figure 15 for Acceptable Methods.

(2) Flush or butt welded patches or new sections may be applied to stayed plates without limitation of size or plate thickness. See Figure 16 for Acceptable Methods.
History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.20 Lapped and Fillet Welded Patches. Lapped and fillet welded patches may be applied to stayed plates provided they are not exposed to radiant heat. Lapped and fillet welded patches may be applied on the pressure side of the sheet in unstayed areas, provided the maximum diameter of the opening so repaired does not exceed 16 times the thickness of the plate, but in no case larger than 8 inches in diameter. See Figure 17 for Acceptable Methods.
History: Dr. Register, December, 1956, No. 12, eff. 1-1-57.

Ind 42.21 Stays. (1) Threaded stays may be replaced by welded-in stays provided that in the judgment of the inspector the plate adjacent to the stay bolt has not been materially weakened by deterioration or wasting away. All requirements of the applicable section of sections Ind 41.50 and Ind 41.51 of this code governing welded-in stays shall be met, except that stress relieving other than thermal may be used as provided in section Ind 42.14.

History: Cr. Register, December, 1956, No. 12, eff. 1-1-57.

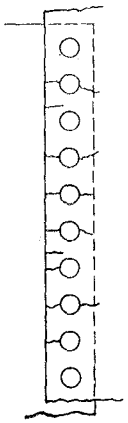
Ind 42.22 Additional Acceptable Repair Methods. Repairs and repair methods not discussed in the chapter shall comply with methods illustrated in Figures 18, 19, 20 and 21.

History: Cr. Register, December, 1956, No. 12, eff. 1-1-57

FIGURES 8, 8a, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21 to remain as in current code. FIGURE 20 is new.

Fig. 8

CRACKS IN UNSTAYED SHELLS, DRUMS AND HEADERS



Fire Cracks at Girth Seams

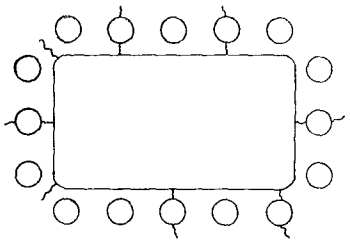
Prior to repairing fire cracks by welding, the rivets to which such cracks may extend and the rivets on each side of them shall be removed.

Tack bolts shall be placed in alternate holes to hold the plate laps firmly.

Cracks shall then be chipped, ground or gouged to produce required welding groove.

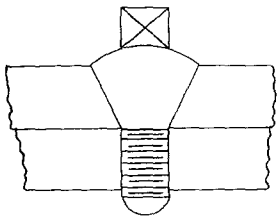
CRACKS WHICH EXTEND PAST THE INNER EDGE OF THE PLATE LAP SHALL BE WELDED FROM BOTH SIDES.

Rivet holes shall be reamed before new rivets are driven.



Fire Cracks at Door Openings

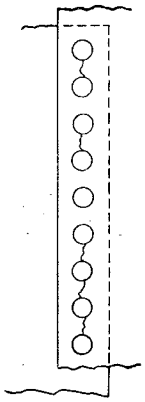
Repairs shall be made as for fire cracks at girth seams. Patch bolts may be used where it is not possible to redrive rivets.



Patch Bolt

Fig. 8a

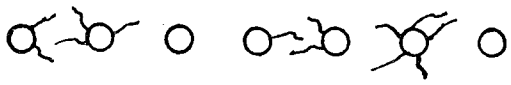
CRACKS IN UNSTAYED SHELLS, DRUMS AND HEADERS



Circumferential Cracks at Girth Seams

Caution: Before attempting repairs care shall be taken to investigate the cause of cracks of this type. Welding shall not be used if "caustic embrittlement" is indicated. Multiple or star cracks shall not be welded.

If repair by welding is authorized, method for repairing fire cracks at girth seams shall be used.

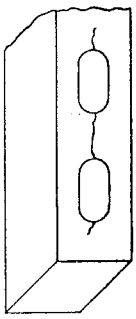


Example of Multiple or Star Cracking

Cracks Between Tube Holes

In repairing cracks of this type, welding shall be applied from both sides of the plate if possible.

The tubes to which the cracks extend and the tubes on each side of them shall be removed and the cracks chipped, ground or gouged to provide the required welding groove. Tube holes shall be reamed before new tubes are installed.

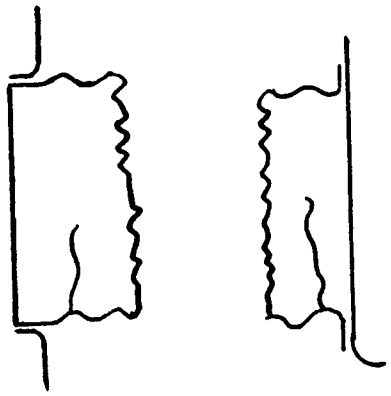


Cracks in Headers

In repairing cracks of this type, welding may be applied from one side. A backing strip shall be used if possible to insure complete penetration at bottom of welding groove.

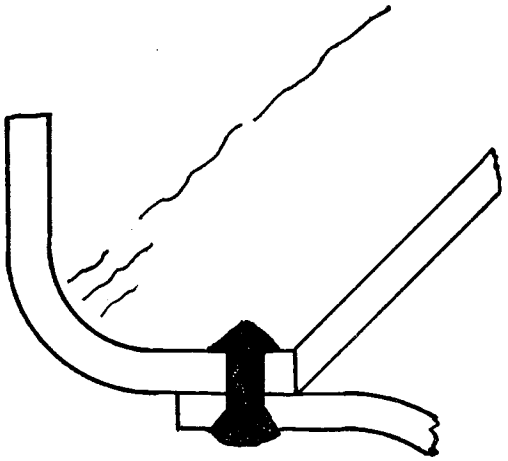
Fig. 9

CRACKS IN UNSTAYED FURNACES



Caution: Successful performance of this repair requires a ductile weld free from slag inclusions, voids, cracks or other defects.

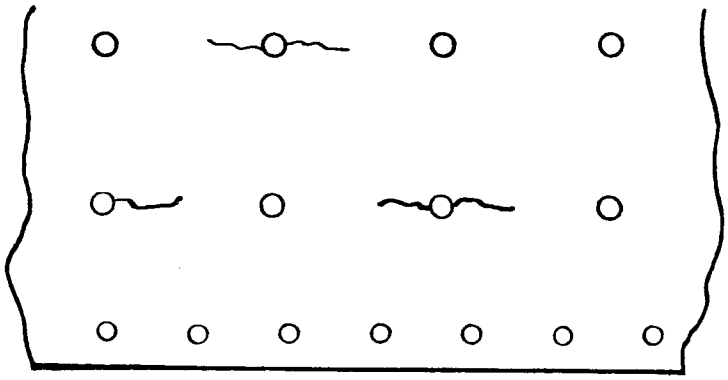
Cracks shall be chipped, ground or gouged to provide required welding groove; root of weld shall be cleaned by chipping or flame gouging and welding applied from both sides of the plate. Thermal stress relieving is recommended.



Field repair of cracks at knuckle or turn of flange of furnace opening is difficult. It is recommended that this repair be made in a well equipped shop.

Fig 10

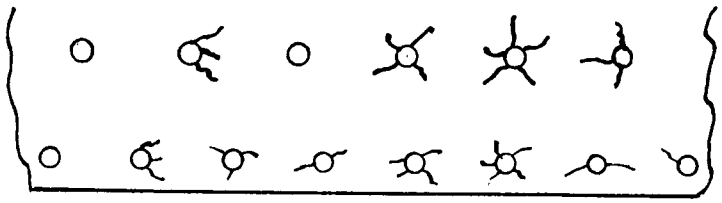
CRACKS IN STAYED PLATES



Caution: Before attempting repairs to cracks of this type the inner surface of the plate shall be carefully examined for possible excessive corrosion or grooving.

Staybolts to which cracks may extend shall be removed and the cracks then chipped, ground or gouged to provide the required welding groove.

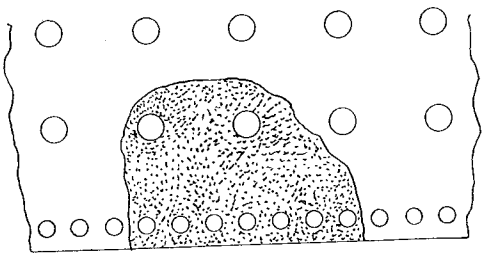
After welding, threaded staybolt holes shall be retapped and new staybolts properly driven and headed.



Multiple or star cracks radiating from staybolts or rivet holes shall not be repaired by welding.

Fig. 11

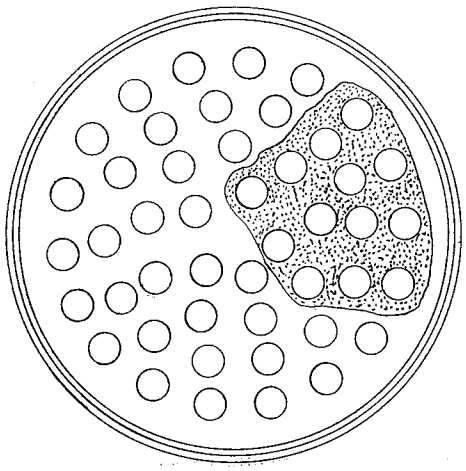
REINFORCING OF CORRODED AREAS IN STAYED PLATES



If corroded area includes rivets or staybolts, these shall be removed before welding is applied.

Threaded staybolt holes shall be retapped and rivet holes reamed before new staybolts are installed or rivets are driven.

Note: Welding shall not cover rivets or staybolt heads.



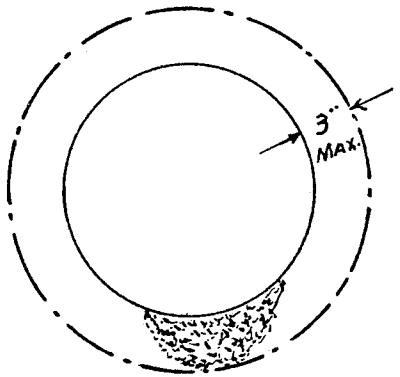
Corroded areas of tube sheets may be built up by welding where tubes act as stays.

All tubes in such corroded areas shall be removed before welding is applied.

After welding the tube holes shall be reamed before new tubes are installed.

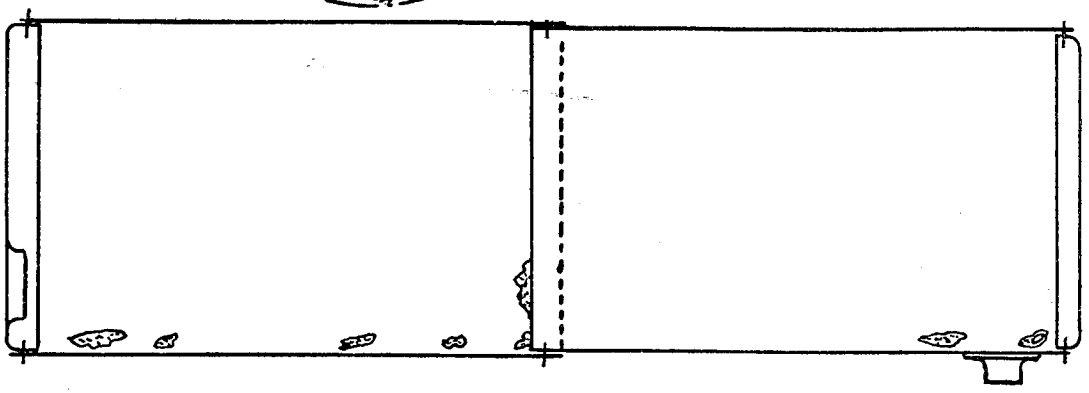
Fig. 12

CORRODED AREAS



Corroded Area around manhole or handhole openings.

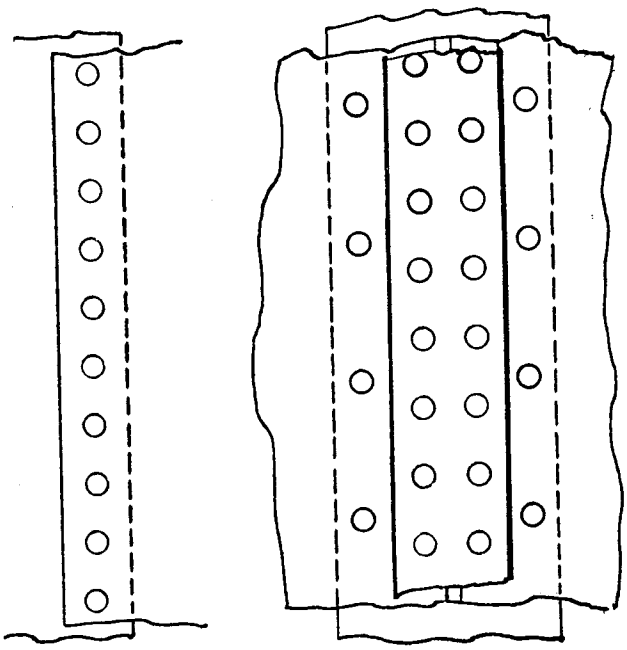
Corroded area shall be thoroughly cleaned before welding.



No corroded area which is shown in this sketch and which exceeds in size the permissible area of an unreinforced opening or exceeding in average depth 50% of the plate required thickness shall be "built up" by welding. Larger areas in vessels which are subject to internal corrosion or erosion but where the required thickness would be satisfactory for the pressure, can be built up under this rule.

Fig 13

SEAL WELDING OF CAULKING EDGES



Caution.—Seal welding shall not be applied if cracks are present in riveted areas.

Indications of persistent or recurring leakage may be a sign of cracking. No welding shall be applied until a careful examination—including removal of rivets if necessary—has been made of such areas.

Seal welding shall be applied in one light layer if practicable but not more than two layers shall be used.

Throat approx. ¼"

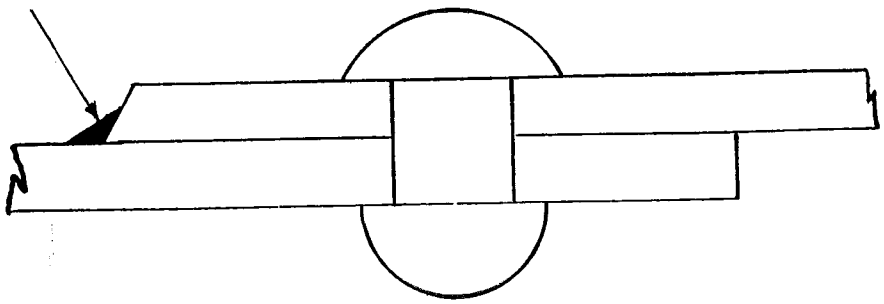
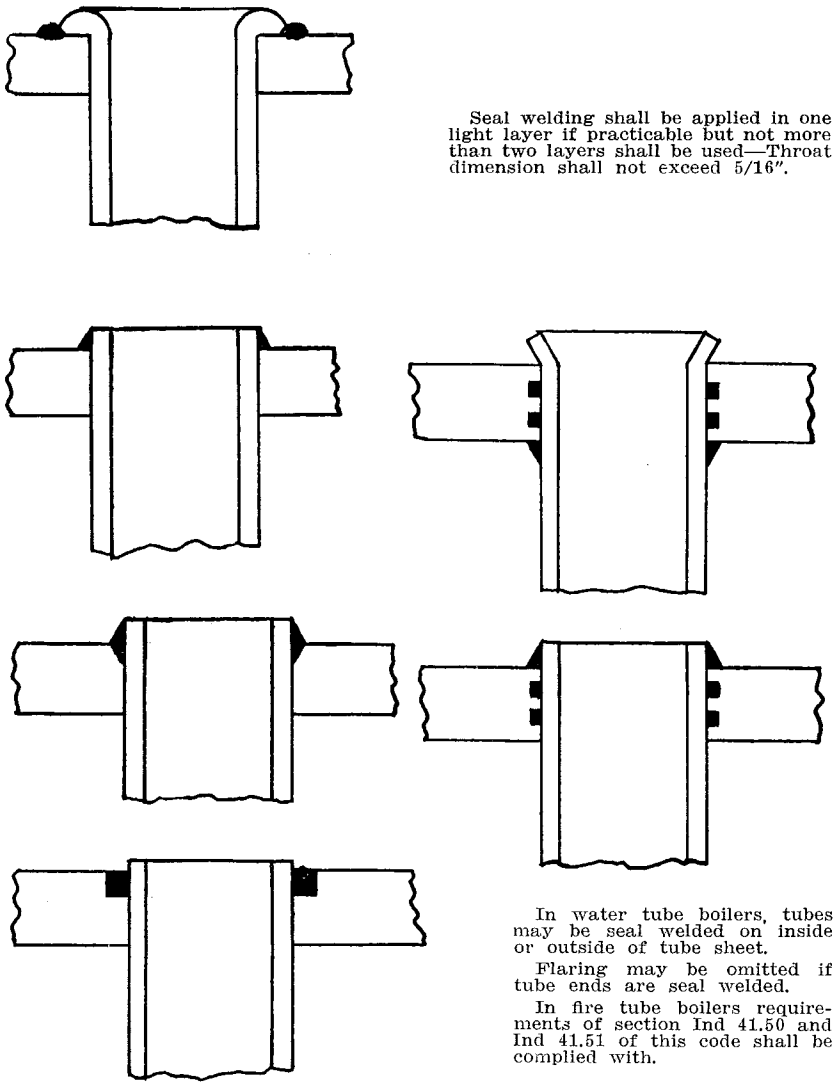


Fig 14

SEAL WELDING OF TUBE ENDS



Seal welding shall be applied in one light layer if practicable but not more than two layers shall be used—Throat dimension shall not exceed 5/16".

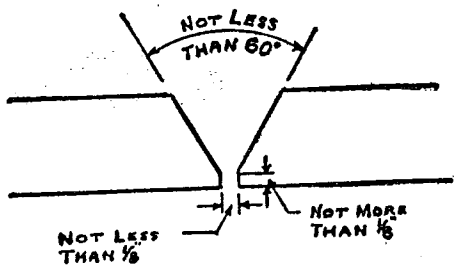
In water tube boilers, tubes may be seal welded on inside or outside of tube sheet.

Flaring may be omitted if tube ends are seal welded.

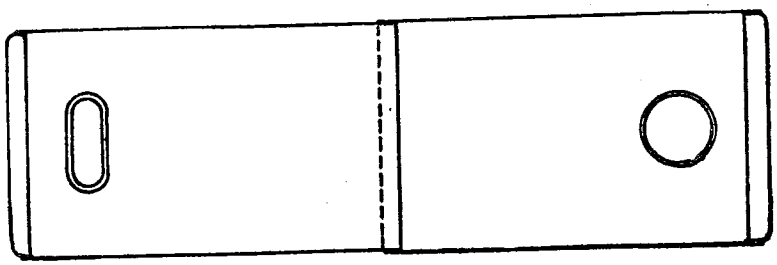
In fire tube boilers requirements of section Ind 41.50 and Ind 41.51 of this code shall be complied with.

Fig 15

FLUSH OR BUTT WELDED PATCHES IN UNSTAYED AREAS



Accepted Detail of Weld



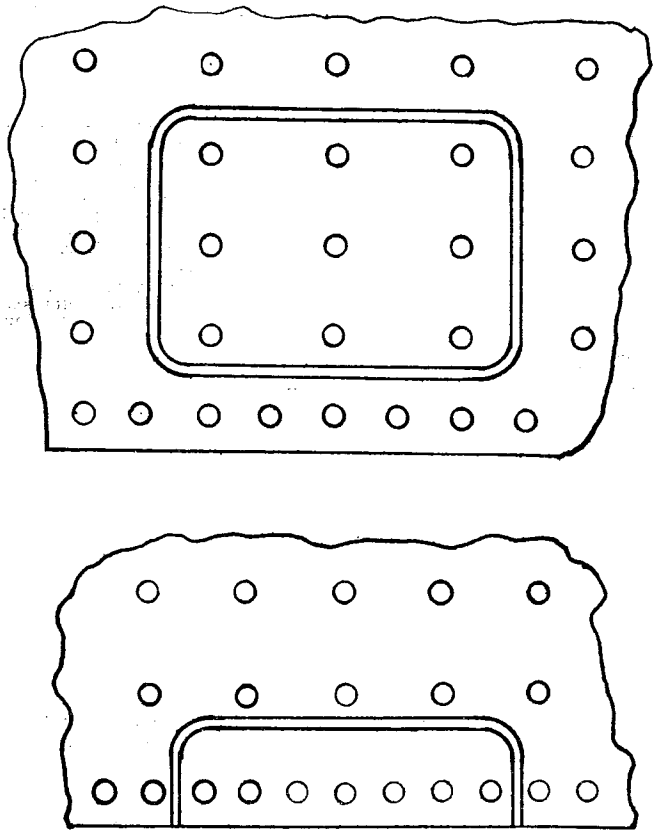
Before any effort is made to patch a bagged or deformed area the original shape or curvature shall be restored as far as possible. Patch shall be rolled or pressed to proper shape or curvature. Edges shall align without overlap.

Flush or butt welded patches may be of any shape, an adequate radius shall however be provided at corners if patch is rectangular. Sharp corners shall be avoided.

Note: Patches shall be of material equal to the original construction in thickness and quality.

Fig. 16

FLUSH OR BUTT WELDED PATCHES IN STAYED AREAS



Patches shall be of material equal to the original in quality and thickness.

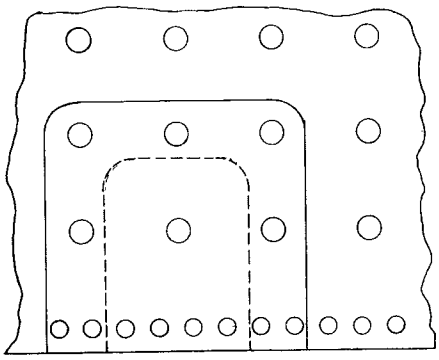
Before applying patches of this type, defective metal shall be cut away until sound material is reached.

Patch seams shall come between staybolt rows or riveted seams.

In applying patches of this type, square corners shall be avoided. Ample radius shall be provided at corners.

Fig. 17

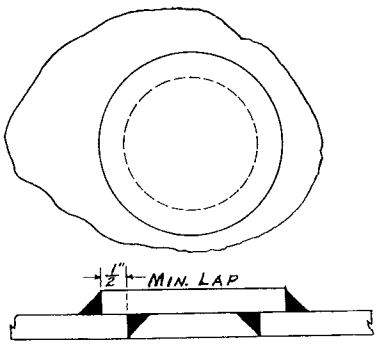
LAP-FILLET WELDED PATCHES



Patches shall be of material equal to the original in quality and thickness.

If area to be patched includes a riveted seam rivets shall be removed before patch is applied and new rivets driven before patch is welded at edges.

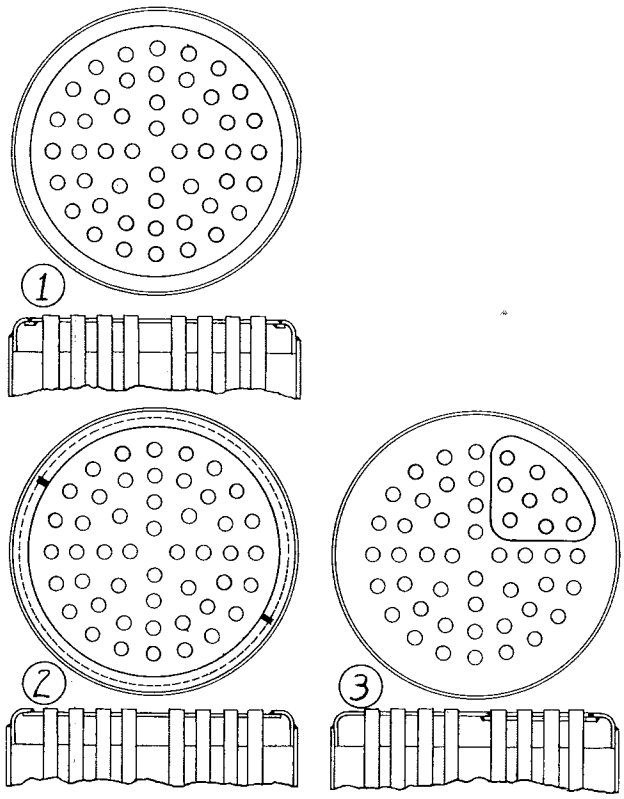
New staybolts shall be installed in patched area, the heads of staybolts shall not be covered by welding.



Lap Fillet Welded Patch in Unstayed Area

Fig. 18

ACCEPTABLE REPAIRS FOR CORRODED OR WORN HEADS OF VERTICAL TUBE OR SIMILAR TYPE BOILERS



1. Flush Butt Welded Head

With this repair the old head is cut close to the point of tangency of the knuckle of the flange and the new head, previously drilled for tube holes and beveled for adequate welding groove is butt welded to flanged section of old head. Pack up ring, inserted in sections if necessary, shall be used to insure weld penetration for full head thickness.

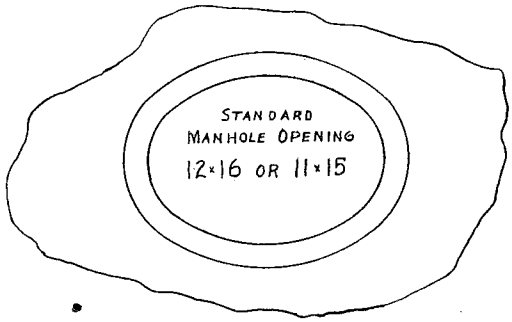
2. Lapped and Fillet Welded Head

With this repair, the new head is lapped under the flange knuckle of old head, previously slotted as shown to admit new head, then fillet welded at edge.

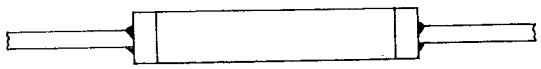
3. Segmental or Pie-Shaped Butt Welded Patch

Fig. 19

ACCEPTED REPAIRS FOR INSPECTION OPENINGS



A badly corroded manhole flange may be repaired by cutting out flanged section and inserting a ring type frame as shown. Dimensions shall comply with requirements of sections Ind 41.50 and Ind 41.51 of this code.



Ring type frame may be fabricated and stress relieved in shop then welded in place.

Rules for flush patches shall be complied with.

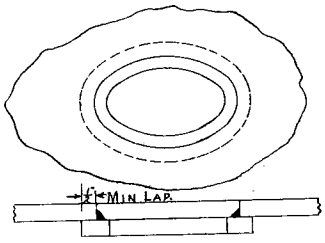
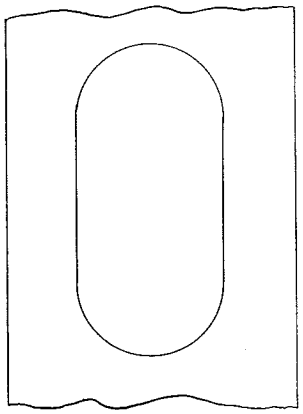


Plate lap should not be less than ½".

When corrosion has reduced thickness of plate around handhole opening by more than 50% (average) a reinforcing ring shall be used as shown placed on the inside.

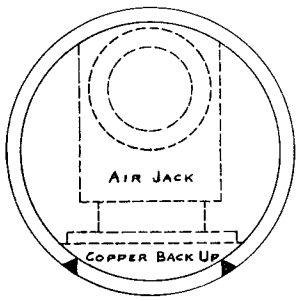
Fig. 21

ACCEPTED "WINDOW" PATCH FOR WATER TUBE BOILER TUBES



This type of patch may be used if necessary to seal a hole cut in a water wall tube to provide access for welding the back side of a circum. joint or to replace a small sharp bag.

Window patches shall comply with provisions of sections Ind 41.50 and Ind 41.51 of this code. Patch shall be cut from tube of same size and thickness as the one being repaired.



When practicable, a removable copper backup recessed as shown to provide complete weld penetration through the tube wall and held in place by a removable air jack shall be used during the welding operation.

Suggested Furnace Renewal

Longitudinal seam in furnace double butt-welded and thermally stress-relieved. For repair, final joint to each head may be stress-relieved by peening. Furnace may be welded into a riveted boiler by using adaptable end closures. Ringed furnace shall be thermally stress-relieved after longitudinal seam and rings have been applied.

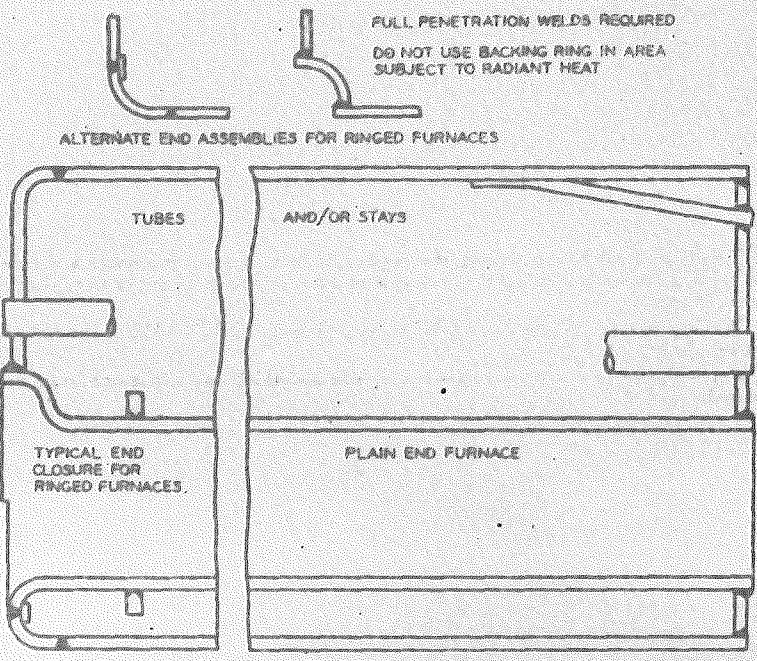


FIG. ~~19~~ 20 SUGGESTED FURNACE RENEWAL

PART VIII
SECOND HAND BOILERS - SECOND HAND UNFIRED PRESSURE VESSELS PORTABLE BOILERS

Ind 42.25 Application. Sections Ind 42.25 through Ind 42.33 shall apply to second hand boilers, second hand unfired pressure vessels installed after July 1, 1960 on which both the ownership and location were changed, and shall also apply to portable boilers (See Ind 42.33).

Ind 42.26 Code Constructed Vessels. Second hand pressure vessels which were constructed and stamped according to some edition of the A.S.M.E. Boiler and Unfired Pressure Vessel Code or other recognized pressure vessel codes may be installed with the working pressure stamped on the vessel.

Ind 42.27 Existing Vessels. Second hand boilers which were constructed and installed in Wisconsin under the provisions of sections Ind 41.60 through Ind 41.99 may be reinstalled if the working pressure is recalculated with a factor of safety of ~~six~~ 6. Second hand ~~unfired~~ unfired pressure vessels which do not meet the requirements of Ind 42.26 may be reinstalled if the working pressure is recalculated with a factor of safety of 6, using Ind 41.63 through Ind 41.65 and Ind 41.71 through Ind 41.75 for such calculations.

Ind 42.28 Vessels From Other States. Second hand pressure vessels previously operated in other states shall meet the requirements of section Ind 42.26.

Ind 42.29 Lap Seam Boilers. Second hand boilers which have lap seam construction and which are larger than 36 inches in diameter shall be limited to a maximum allowable working pressure of not more than 15 pounds per square inch.

Ind 42.30 Prohibited Boilers. The installation of second hand boilers which have the longitudinal joint exposed to the intense heat of the furnace is prohibited.

Note. The locomotive or inside welt strap will not be considered as strengthening or changing the original type of boiler joint.

Ind 42.31 Inspection and Testing. (1) Each second hand boiler and unfired pressure vessel exclusive of vessels used for the storage and transportation of

containing vessels of less than 2,000 gallons water capacity shall be inspected and given a hydrostatic pressure test by an authorized inspector at its new location before it is put into operation. The hydrostatic test pressure shall be at least $1\frac{1}{2}$ times the working pressure of the vessel.

(2) The vessels excluded in section Ind 42.31 (1) may be acceptable for use provided a copy of the manufacturer's data sheet is furnished to the industrial commission for each vessel indicating that it was manufactured originally to the requirements of section Ind 41.50. If a vessel has been repaired since its fabrication, a copy of the new manufacturer's data report shall be furnished to the industrial commission.

(3) For unfired pressure vessels where a hydrostatic test, in the opinion of the industrial commission, is not possible or desirable, the industrial commission may accept alternate means to determine the safety of the vessel for its intended use.

Ind 42.32 Installation. All second hand pressure vessels exclusive of vessels used for the storage and transportation of liquefied petroleum gases, anhydrous ammonia, and all refrigerant containing vessels when re-installed shall comply with the A.S.M.E. codes listed in section Ind 41.50 in regard to fittings, appliances, valves, connections, settings and supports. (The excluded vessels are subject to the provisions of other applicable administrative codes.)

Ind 42.33 Portable Boilers. A portable boiler, when brought into this state for use, shall be given the inspection and test specified in section Ind 42.31 and the allowable working pressure shall be calculated using sections Ind 41.60 through Ind 41.99 unless it meets either of the following requirements:

(1) The boiler was constructed and stamped according to section Ind 42.26 code constructed vessels.

(2) The boiler is insured by a boiler insurance company.

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PART IX
INSPECTION AND REPAIR OF UNFIRED PRESSURE VESSELS IN PETROLEUM REFINERIES

Ind 42.35 Application. Sections Ind 42.35 through Ind 42.63 shall apply to the inspection, repair, evaluation for continued use, and the methods for computing the maximum allowable working pressure of unfired pressure vessels in petroleum refineries.

Ind 42.36 Inspection - General. (1) Vessels that are inspected in accordance with the procedures described herein will be acceptable, however, other procedures approved by the industrial commission may be used.

(2) New vessels shall be permitted to operate within the conditions for which they were constructed as determined in section Ind 42.40 or, in cases where the provisions of section Ind 42.39 (1) (c) apply, for an initial period during which corrosion rates are determined as specified in section Ind 42.39 (1) (c).

(3) If the vessel is to be kept in service the allowable conditions of service and the length of time before the next inspection shall be based on the condition of the vessel, as determined by the inspection.

(4) If the allowable working pressure and temperature are changed, the period of operation until the next inspection shall be established for this new service.

(5) If both the ownership and location of any vessel are changed, the vessel shall be inspected before it is re-used and the allowable conditions of service and the next period of inspection shall be established for the new service.

Ind 42.37 Qualifications of Inspectors. Inspectors shall be at least 25 years of age and shall have at least 3 years experience in boiler or unfired pressure vessel construction or repair or operating engineer in charge of high pressure boilers, or an inspector of steam boilers or unfired pressure vessels. Technical education with a recognized degree of mechanical engineering shall be allowed 2 years as the equivalent of practical experience.

Ind 42.38 Inspection Records. (1) A permanent and progressive record shall be maintained for each vessel. This record shall include the following:

(a) Manufacturer's and owner's serial numbers.

(b) Location and thickness for critical points at all inspections.

(c) Limiting metal temperature and location on vessel, if such temperature is below -20 F., or is a factor in establishing the allowable working pressure or other service conditions for the vessel.

(d) Computed maximum allowable working pressure at the time of the next inspection and coincident temperature,* and, in addition, if the vessel is rated by a code other than the one to which it was constructed, computations showing method of determining the maximum allowable working pressure with reference to the specific edition of the code or codes used.

(e) Hydrostatic test pressure if so tested at the time of inspection.

(f) Scheduled (approximate) date of next inspection.

(g) Date of installation and of any significant change in service conditions (pressure, temperature, character of contents, or rates of corrosion), for any vessels of the types mentioned in section Ind 42.38 (2) (b).

(2) In addition to the progressive vessel record described in section Ind 42.38 (1), a file which contains the following information shall be maintained:

(a) Complete safety valve data, including spring data, and date of latest inspection.

(b) For all vessels used in process operations and others subject to corrosive conditions, drawings giving sufficient details to permit calculation of service rating of all components.

*For a vessel designed for more than one combination of operating conditions, i.e., having more than one maximum allowable working pressure with coincident temperatures, or for a vessel in which different zones are subjected to different temperatures (see section Ind 41.50), all conditions should be recorded.

Ind 42.39 Determination of Probable Corrosion Rate. (1) On new vessels and on vessels for which service conditions are being changed, one of the following methods shall be employed to determine the probable rate of corrosion from which the remaining wall thickness at the time of the next inspection can be estimated:

(a) The corrosion rate as established by accurate data collected by the owner or user on vessels in the same or similar service.

(b) If accurate data for the same or similar service are not available, the probable corrosion rate as estimated from the inspector's knowledge and experience on vessels in similar service.

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(c) If the probable corrosion rate cannot be determined by either of the above mentioned methods, thickness determinations shall be made after approximately 1,000 hours of service, or one normal run if longer than this; subsequent sets of thickness measurements shall be taken after additional similar intervals until the corrosion rate is established. If the probable corrosion rate is determined by this method, the corrosion data indicated by the first inspection may be used as a first approximation of the corrosion rate, but shall be excluded from all subsequent computations of the corrosion rate, since attack on the initial surfaces may not be indicative of subsequent attack on corroded surfaces.

Ind 42.40 Maximum Period Between Inspections. (1) When the contents of a vessel are known to be, or expected to be, corrosive, the maximum period between internal inspections shall not exceed $\frac{1}{2}$ of the estimated remaining safe operating life of the vessel, or 5 years, whichever is less; except in cases where an adequate inspection history extending over a period of at least 5 years has established that the corrosion rate is reasonably uniform and predictable, the interval between the current inspection and the next subsequent one may be established as the projected full remaining safe operating life of the vessel, provided this projected period does not exceed one year.

(2) In cases where part or all of the vessel wall has a protective lining, the frequency of inspections for the portions of the vessel so protected shall be determined from a consideration of records of previous experience with the protection afforded by the lining during similar operations (and the corrosion allowance for the protected metal if there is any likelihood that the lining will fail), but the maximum period between internal inspections shall not exceed 5 years.

(3) When a vessel has 2 or more zones of considerable extent and the net discarding thicknesses, corrosion allowances, or corrosion rates for each differ so much that the foregoing provisions give significant differences in maximum periods between inspections for the respective zones (e.g., the upper and lower portions of some fractionating towers), the periods between inspections may be established individually for each zone on the basis of the conditions applicable thereto,

instead of being established for the entire vessel on the basis of the zone which requires the more frequent internal inspection.

(4) The "net discarding thickness" for a vessel or zone, as referred to above, shall be understood to mean the large of the following:

(a) The net wall thickness, exclusive of any corrosion allowance, required for the safety valve setting and operating temperature for the service in which the vessel is being used, or

(b) The minimum practical thickness permitted by the provisions of section Ind 41.50.

(5) When the contents of a vessel are known to be non-corrosive, the vessel need not be inspected internally as long as it remains in the same service and provided all the following conditions are met:

(a) The non-corrosive character of the contents (including the effect of trace components) shall have been established by at least 5 years comparable service experience with the fluid which is being handled.

(b) No questionable condition is disclosed by the annual external examinations required by section Ind 42.40 (7).

(c) The operating temperature of the vessel contents does not exceed 500 F. for ferrous metals, or 250 F. for non-ferrous metals.

(d) The vessel is so installed that the contents are not subject to inadvertent contamination by corrosives.

(6) When the contents of a vessel are expected to be non-corrosive, but one or more of the conditions of section Ind 42.40 (5) is not met, the maximum period between inspections shall not exceed 5 years, or such shorter interval as may be deemed necessary if some kind of deterioration other than corrosion is anticipated or suspected.

(7) In addition, all vessels aboveground shall be given a visual external examination at least once every 12 months, preferably while in operation, to determine the readily apparent condition of the vessel, its supports, and exterior insulation, as well as the general alignment of the vessel on its supports, which might indicate external loadings affecting the vessel's condition.

(over)

(8) The safety and relief valve equipment shall be inspected and tested at intervals as necessary to maintain the equipment in a safe operating condition. The intervals between inspections should be determined by experience in the particular service concerned. Other pressure relieving devices, such as rupture disks, shall be given a thorough examination at intervals determined on the same basis.

(9) The periods for inspection referred to in this section assume that the vessel is in continuous operation, interrupted only by normal shutdown intervals. If the vessel is out of service for an extended interval, the effect of such a non-operating period shall be considered in revising the date of the next inspection which was established and reported at the time of the previous inspection. If the vessel is out of service for a continuous period of one year or more, it shall be given an inspection before again being placed in service.

Ind 42.41 Inspection for Corrosion. (1) The minimum thickness and maximum corrosion rate for any part of the vessel shall be determined at each inspection specified in section Ind 42.40 by methods such as described in the following paragraphs:

(a) The depth of corrosion in vessels subjected to corrosion service may be determined by gaging from uncorroded surfaces within the vessel, when such surfaces are available and suitably located with respect to the area in question. These surfaces may be obtained by either of two methods:

1. protecting the normal surface with welded corrosion-resistant strips or buttons which can be removed during inspection; or,

2. by using such strips or buttons as reference levels from which to measure if the strips or buttons are fully corrosion-resistant and if accelerated corrosion does not occur adjacent to the strips or buttons.

(b) When corrosion-resistant strips or buttons cannot be used, it may be practical to drill small holes from the corrosion-susceptible surfaces, before corrosion starts, at suitable intervals to a depth equal to the metal thickness allowed for corrosion, and to plug these holes with protective material that can be readily removed to determine from time to time the loss in metal thickness as measured from the bottom of these holes.

(c) When the depth of corrosion cannot be readily determined otherwise, holes may be drilled through the portions of the wall where corrosion appears to be a maximum, and the thickness determined by taking thickness-gage measurements through these holes. If suitably located existing openings are available, such measurements may be taken through these openings.

(d) Any other suitable method (such as ultrasonic or gamma-ray instruments) that will not affect the safety of the vessel may be used provided it will assure minimum thickness determinations accurate within the following tolerances:

Wall Thickness, t	Permissible Tolerance
5/16 in. and less	0.10t
Over 5/16 in.	1/32 in., or 0.05t, whichever is greater.

(2) for a corroded area of considerable size in which the circumferential stresses govern, the least thicknesses along the most critical element of such area may be averaged over a length not exceeding:

(a) the lesser of $\frac{1}{2}$ the vessel diameter, or 20 in., in the case of vessels with inside diameters of 60 in. or less; or

(b) The lesser of 1/3 the vessel diameter, or 40 in., in the case of vessels with inside diameters greater than 60 inches - except that if the area contains an opening, the distance within which thicknesses are averaged on either side of such opening shall not extend beyond the limits of reinforcement as referred to in section Ind 41.50. If, because of wind loads or other factors, the longitudinal stresses would be of importance, the least thicknesses in a similarly determined length of arc in the most critical plans perpendicular to the axis of the vessel also shall be averaged for computation of the longitudinal stresses. The thicknesses used for determining corrosion rates at the respective locations shall be the average thicknesses determined as aforesaid; and for the purposes of section Ind 42.48 "the actual thickness as determined by inspection" shall be understood to mean the most critical value of average thickness so determined.

(3) Widely scattered pits may be ignored provided their depth is not more than $\frac{1}{2}$ the net thickness of the vessel wall (exclusive of corrosion allowance), the total area of the pits does not exceed 7 sq.in. within any 8-in. diameter circle, and the sum of their dimensions along any straight line within this circle does not exceed 2 inches.

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Ind 42.42 Correction of Corrosion Rate. If, upon measuring the wall thickness at any inspection, it is found that an inaccurate rate of corrosion has been assumed, the rate to be used for the next period shall be increased or may be decreased to conform with the actual rate found.

Ind 42.43 Inspection for Defects. (1) The parts of a vessel which should be inspected most carefully depend upon the type of vessel and the operating conditions to which it is subjected. The inspector should be familiar with the operating conditions of the vessel and with the causes and character of defects and deterioration that may result therefrom.

(2) Among the many ways of inspecting a vessel for defects, careful visual examination is by far the most important and the most universally applicable. Other means that may be very useful from time to time include magnetic-particle inspection (for cracks and other elongated discontinuities in magnetic materials), fluorescent or dye penetrants (for disclosing porosity, pinholes, etc., which extend to the surface of the material and for outlining other surface manifestations, especially in non-magnetic materials), hammer testing, pressure testing, exploratory chipping, etc. All of these methods should be considered as auxiliary to careful visual examination. The extent to which one or more of them should be used in any given case can be determined only by the exercise of mature judgment based upon the details of circumstances encountered. Adequate surface preparation is frequently of paramount importance to proper visual examination and to the satisfactory application of any auxiliary procedure such as those mentioned above. The extent to which special surface preparation may be required is dependent upon the individual circumstances involved, but may require wire brushing, sandblasting, chipping, or grinding, or a combination of these operations in addition to routine cleanings.

(3) If it is found that external or internal coverings, such as insulation, refractory protective linings, corrosion-resistant linings, etc., where they exist are in good condition and there is no reason to suspect any unsafe condition behind them, usually it is not necessary to remove them for inspection of the vessel. In such cases, however, it sometimes may be advisable to remove small portions of the

coverings in order to investigate their condition and effectiveness and the condition of the metal back of them. Where operating deposits, such as coke, normally are permitted to remain on a vessel surface, it is particularly important to determine whether such deposits adequately protect the vessel surface from deterioration; this may require thorough removal of the deposit in selected critical areas for spot-check examination. Where vessels are equipped with removable internals, these internals need not be completely removed provided reasonable assurance exists that deterioration in regions rendered inaccessible by them is not occurring to an extent that might constitute a hazard or to an extent beyond that found in more readily accessible parts of the vessel.

(4) The items that normally shall be examined during an inspection, subject in each case to the provisions of section Ind 42.43 (3) and various suggestions concerning some of the things to be looked for, or procedures that may be used, are as follows:

(a) Shells and heads. Examine surfaces carefully for possible cracks, blisters, bulges, and other evidences of deterioration giving particular attention to the knuckle regions of the heads. If ev idence of distortion is found, it may be advisable to make a detailed check of the actual contour against the design shape even though this may require removal of insulation or internal protective linings. On vessels with torispherical (dished) heads, if no record exists as to the crown radius and knuckle radius of the heads, these dimensions should be ascertained and recorded even though no evidence of distortion is observed.

(b) Joints. Examine inner and outer surfaces of welded joints carefully for possible cracks and for other defects such as may have been uncovered by the progress of corrosion. Magnetic-particle inspection is suggested as a useful means for doing this either throughout the lengths of the welds or as a supplement to visual inspection on selected lengths which may appear to need more than a visual inspection. Examine riveted joints inside and outside of the vessel for the condition of rivet heads, butt straps, and plates, and for the condition of the calked edges.

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(c) Manways, nozzles, and other openings. Examine the surfaces of all manways, nozzles, and other openings carefully for distortion, cracks, and other defects giving particular attention to all welding or riveting used for attaching such parts and their reinforcements. If drawings are not available which show details of opening reinforcements and their attachments, take such measurements on these components as may be needed for computing the adequacy thereof. If any question exists as to the condition of any threaded connections, the threaded parts should be disassembled to permit a careful check of the number of threads that remain effective and in good condition. Examine accessible flange faces for distortion and for the condition of gasket seating surfaces.

(5) The inspection items given above are not presumed to be complete for every vessel, but include those features common to most vessels and in general those of greatest importance. Inspectors must supplement this list with any additional items necessary for the particular vessel or vessels involved.

Ind 42.44 Check of Dimensions. The vessels shall be examined for visible indication of distortion; if any such distortion is suspected or observed, the overall dimensions of the vessels shall be checked to determine the extent and seriousness of the distortion.

Ind 42.45 Pressure relief devices. The safety valves and other protective devices, such as rupture disks and vacuum valves, where used, should be checked to see that they are in proper condition. This inspection, in the case of valves, will normally include a check on their operation at the set pressure, a check that the proper spring is installed for the service, and an examination to determine that inlets, outlets, and discharge piping are free of corrosion products or other stoppage.

Ind 42.46 Temperature Measuring Devices. Temperature measuring devices used for determining metal temperatures shall be checked for accuracy and general condition.

Ind 42.47 Allowable Operation Based on Inspection Data. Defects or damage discovered during the inspection shall be repaired in accordance with section Ind 42.50 through section Ind 42.63, or shall constitute a basis for reducing the allowable working pressure in accordance with section Ind 42.48, or, as a final resort, for retiring the vessel from service.

Ind 42.48 Allowable Working Pressure. (1) The allowable working pressure for the continued use of a vessel may be established by the code to which the vessel was built or by computation using the appropriate formulas in the latest edition of the A.S.M.E. Code listed in section Ind 41.50 if all essential details (such as quality of materials and workmanship, knuckle radii of heads, reinforcement of openings,etc.) definitely are known to comply with the latter. In corrosive service the actual thickness as determined by inspection minus twice the estimated corrosion loss before the date of the next inspection shall be used, except as modified in section Ind 42.40 (1). Suitable allowance shall be made for the other loadings in accordance with section Ind 41.50.

(2) For vessels with riveted joints, in which the strength of one or more of the joints is a governing factor in establishing the maximum allowable working pressure, consideration shall be given to whether, and to what extent, corrosion will change the possible modes of failure through such joints. Also, even though no additional thickness may have originally been provided for corrosion allowance at such joints, credit may be taken where computations show this to be justified, for the corrosion allowance inherent in the joint design.

(3) The allowable working pressure of vessels with one or more openings, for which the closures are auxiliary equipment not part of the pressure vessel, shall be determined only after due consideration of any pressure limitations imposed by such auxiliary equipment.

Ind 42.49 Pressure Test. (1) Unless required by section Ind 42.49 (2), a pressure test normally need not be made as a part of a periodic inspection. However, one shall be made when unusual, hard-to-evaluate forms of deterioration possibly

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affecting the safety of the vessel are disclosed by inspection (and after certain repairs, see section Ind 42.63.) When a pressure test is made for this purpose, it shall be conducted at a pressure determined in accordance with the provisions of section Ind 41.50.

(2) Any vessel that has not previously been given a hydrostatic test at a pressure of 1.50 times its maximum allowable pressure as referred to in section Ind 41.50, or a pneumatic test at a pressure of 1.10 times the maximum allowable pressure, shall be given a hydrostatic pressure test at the time of each inspection at a pressure not less than 1.50 times its design pressure, or a pneumatic test not less than 1.10 times the design pressure, suitable correction being made in either case for differences in temperature between design and test conditions. Vessels whose main joints are 100% radiographed are exempted from this requirement.

Ind 42.50 Field Repairs - General. No repairs, additions, or alterations shall be made until the proposed methods of execution have been considered and approved by the inspector. Other methods may be used if submitted to and approved by the industrial commission. All such work shall be of the highest quality of workmanship, and shall be executed in a manner and by practices acceptable in applicable fabrication sections of section Ind 41.50, with code approved materials, and under proper supervision. Complete records of all such work shall be made and filed.

Ind 42.51 Defects in Welded Joints and Plates. Repairs to cracks found in welded joints and to minor defects found in plates may be made, after preparing a U or V-shaped groove the full depth and length of the crack, by filling this groove with weld metal deposited in accordance with the requirements of section Ind 42.57, or by riveting a reinforcing plate which meets the requirements of section Ind 41.50 for a hole equal in diameter to the full length of the crack after chipping out or drilling the ends.

Ind 42.52. Corrosion Pits. Isolated corrosion pits may be filled with weld metal deposited in accordance with the requirements of section Ind 42.57. Such pits shall be cleaned to sound metal before welding.

Ind 42.53 Thickness Gage Holes. (1) In corroded vessels subject to rapid stress fluctuations, the holes drilled through the vessel wall for measuring thickness in accordance with section Ind 42.41 shall be closed by welding which complies with section Ind 42.57 and provides complete penetration and fusion for the full depth of the hole.

(2) For vessels in other service, these holes may be treated as unreinforced openings and may be closed by any method permitted under the rules of the A.S.M.E. code.

Ind 42.54 Corroded or Distorted Flange Faces. (1) Corroded flange faces may be cleaned thoroughly and built up with weld metal deposited in accordance with the requirements of section Ind 42.57 and re-machined in place, if possible, to a thickness not less than that of the original flange or that required by calculations in accordance with the rules in section Ind 41.50. Corroded flanges may also be re-machined in place, without building up with weld metal, provided the metal removed in the process does not reduce the thickness of the flange below that calculated as above.

(2) Warped flanges which cannot be re-machined, or flanges which have become distorted because of excessive tightening of bolts, shall be replaced with new flanges which have at least the dimensions conforming to section Ind 41.50, welded on in accordance with the requirements of section Ind 42.57.

Ind 42.55 Cracks at Tapped Openings. (1) It is not recommended to repair a crack at a tapped opening by chipping, welding, and re-tapping.

(2) Instead of making a repair as mentioned in (1) a fully reinforced flanged nozzle may be installed, or if a tapped connection is required, it may be provided by welding in a heavy-wall, 3000# minimum threaded coupling by one of the methods permitted in section Ind 41.50.

Ind 42.56 Inadequate Bolting Material. Defective bolting material shall be replaced with suitable material which meets the requirements of section Ind 41.50.

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Ind 42.57 Field Welding. (1) Strength welding shall be done by qualified welders and shall meet all other requirements of section Ind 41.50.

(2) Preheating to not less than 300 F. may be considered as an alternative to thermal stress relief for minor alterations or repairs of initially stress relieved vessels constructed of the P-1 carbon steels listed in section Ind 41.50 and for the P-3 alloy steels preheat sometimes can be considered as an alternative, especially when the operating temperature is high enough to assure reasonable ductility of the weldment during operation, and there is no excessive hazard during hydrostatic tests. Vessels constructed of other steels, which initially were required to be stress-relieved normally, shall be stress-relieved if alterations or repairs involving strength welding are performed. Any stress relieving shall be performed in accordance with section Ind 41.50. When preheat is used as an alternative for thermal stress relief as provided above, the stress relief factor may be continued.

Ind 42.58 Applying Patches to Vessels by Welding. (1) Patches to be welded to vessel walls shall be made of material equivalent to the material of the plate to be repaired. If a flush patch is to be installed in a vessel with welded longitudinal joints, a type of joint shall be used which has a joint factor (efficiency) as high as the original longitudinal joint. If a flush patch is to be installed in a seamless section, a double welded butt joint shall be made.

(2) If a lap patch is applied, welding shall be performed in the same manner as for a reinforcing plate around an opening, and the proportions of the patch shall be determined as outlined in section Ind 41.50. The application of patch plates to both the outside and inside of the vessel wall sometimes is preferred to a single lap plate. (Such double patch plates should be avoided in high temperature service; in hydrogen blistering service a weep hole should be provided in one of the patch plates.) Lap patches attached by welding should not be applied to wall thicknesses over 5/8 inch.

(3) If a welded patch is applied to a riveted vessel, the type of welded joint used shall have at least as high an efficiency as the riveted longitudinal joint.

Ind 42.59 Riveting. All field riveting shall meet the requirements of section Ind 41.50.

Ind 42.60 Applying Patches to Vessels by Riveting. The application of a riveted patch shall be made in conformity with the rules given in section Ind 41.50 for reinforcing plates attached by riveting.

Ind 42.61 New Connections. (1) New connections may be installed on vessels provided the design, location, and method of attachment meet the construction requirements of the A.S.M.E. code.

(2) Welding shall conform to the requirements of section Ind 42.57 and riveting to the requirements of section Ind 42.59.

Ind 42.62 Calking Riveted Vessels. Riveted joints may be made tight either by mechanical calking or by metallic arc seal welding in accordance with Ind 41.50 after carefully cleaning the seam and cleaning around the rivet heads.

Ind 42.63 Pressure Test After Repairs. A vessel, which has had repairs or alterations, shall be given a pressure test in accordance with section Ind 42.49 (2), provided the inspector deems it necessary.

The new orders shall take effect on the first day of the month following their publication in the Administrative Code as provided in Sec. 227.

INDUSTRIAL COMMISSION OF WISCONSIN

Helen E. Gill

Helen E. Gill, Secretary