The Ohio Historical Boilers Licensing Board
Standard Operating Procedures to Attain
Maximum Allowable Working Pressure (MAWP)
for Historical Boilers

Maximum Working Pressure for Historical Boilers with Manufacturer's Data:

- At the first inspection period, the owner will supply documented proof of the working pressure, in the form of a copy or original manufacturing data that was produced by the company that manufactured the engine (example. Catalog).
  **** This information must be noted and collected at the time of the inspection****

- From the data given in the manufacturer's specification on working pressure, the historical boiler will be inspected based on the historical boiler's own merits. This will be done by performing a hydrostatic test and a visual inspection of the historical boiler, which will be done to the Historical Boilers Licensing Board's current set of standards for inspecting historical boilers as set forth in Ohio Revised Code §§ 4104.34 and 4104.36 and in Ohio Administrative Code §§ 1301:3-4-02 through 1301:3-4-05 and 1301:3-4-08.

- If the historical boiler passes the inspection of the hydrostatic and visual test conducted by an Ohio Department of Commerce historical boiler inspector, the historical boiler will be certified to the original working pressure of the manufacturer specifications.

- The maximum working pressure will be determined from the manufacturer data specification, which will follow the historical boiler for its functional life in the State of Ohio. The historical boiler can be operated at its designed MAWP as long as the historical boiler can pass the State of Ohio's current set of standards for inspecting historical boilers.

- The information collected from inspections will be maintained by the Division of Industrial Compliance. Upon request, the information maintained by the state will be made available for review.

- Any questions and concerns about the process of the inspection or during the inspection process can be submitted to be reviewed by the Ohio Historical Boilers Licensing Board upon the next meeting. Questions that concern a fast and immediate response can be directed to the State of Ohio's Chief Boiler Inspector.

Maximum Working Pressure for Historical Boiler with No Manufacture Data:

- In the absence of manufacturer specifications, the maximum allowable working pressure of historical boilers with similar design and specifications may be used in the determination of the maximum allowable working pressure for the historical boiler in question.

- At the first inspection period, the owner will supply documented proof of the working pressure, in the form of a copy or original manufacturing data that was produced by the company that manufactured the engine (example. Catalog).

  **** This information must be noted and collected at the time of the inspection****

- From the data given in the manufacturer's specification on working pressure, the historical boiler will be inspected based on the historical boiler's own merits. This will be done by performing a hydrostatic test and a visual inspection of the historical boiler, which will be done to the Historical Boilers Licensing Board's current set of standards for inspecting historical boilers.

- If the historical boiler passes the inspection of the hydrostatic and visual test conducted by an Ohio Department of Commerce historical boiler inspector, the engine will be certified to the original working pressure of the manufacturer specifications.

- The maximum working pressure will be determined from the manufacturer data specification, which will follow the historical antique boiler for its functional life in the State of Ohio. The historical boiler can be operated at its designed MAWP as long as the historical boiler can pass the State of Ohio's current set of standards for inspecting historical boilers.

- The information collected from inspections will be maintained by the state of Ohio Division of Industrial Compliance. Upon request, the information maintained by the state will be made available for review.

- Any questions and concerns about the process of the inspection or during the inspection process can be submitted to be reviewed by the Ohio Historical Boilers Licensing Board upon the next meeting. Questions that concern a fast and immediate response can be directed to the State of Ohio's Chief Boiler Inspector.

Criteria for historical boilers that do not meet Ohio's current historical boiler inspection standards:

- Two options can be taken if deemed necessary based on the information presented to the members of the State of Ohio's Historical Boilers Licensing Board.

  - Following the completion and inspection of the repair(s), the historical boiler will then be inspected for the maximum allowable working pressure based on the manufacturer's original specifications.

  - Second is to use the following calculations for MAWP to determine a safe maximum allowable working pressure for the historical boiler. These calculations will use the current thickness of material in question to find the new MAWP. Thickness readings will be obtained by taking measurements. The process on how the boiler plate will be measured will be determined by the owner and inspector.

- Method to determine the thickness of boiler plate.

  Thickness can be determined either by drilling holes, ultrasonic thickness testing, or a combination of both. A minimum of ten readings will be taken in a ten by ten area where possible.

  - Results

    If the readings are over the minimal allowable thickness for the MAWP specified, then you are done taking readings.

    If any of the readings in the questionable areas are lower than the minimal allowable thickness for the MAWP specified, an average of the readings will be used for an average thickness of the boiler plate for the MAWP. More documentation and readings should be taken where grooving or large areas of corrosion are apparent. More readings may be requested by the historical boiler inspector or owner after analyzing the data that was collected.

  - Ultrasonic Testing.

    - The tester must be calibrated to a test block at the time thickness readings are taken. If the owner does not feel competent to take their own readings, a third party could be provided by the owner.

All historical boilers in the state of Ohio that are inspected and deemed unacceptable or have the working pressure reduced under the manufacturer's specifications can be repaired, re-inspected and recertified to the original working pressure.

Formulas for Finding Working Pressure of a Historical Boiler

General Information

Joint Percent Efficiency's = E

Single Riveted Lap	58%
Double Riveted Lap	74%
Triple Riveted Lap	78%
Double Riveted Butt Strap	82%
Triple Riveted Butt Strap	88%
Quadruple Riveted Butt Strap`	94%

The owner may and can specify a more accurate Joint Percent Efficiency, for this accommodation the Machinery's Handbook and/or the manufacturer's specification and ASME code at the time the boiler was manufactured can be used to calculate the accurate Joint Percent Efficiency.

Tensile Strength (TS) of different Boiler Plate:
Wrought Iron = 45,000 - 55,000 PSI
Steel = 55,000 – 65,000 PSI
Avg. TS most found for steel = 55,000 PSI

Tensile Strength (TS) of rivets should be the same as the Boiler Plate

Tensile Strength (S) in Staybolts:
TS = 11,300

MAWP: Maximum Allowable Working Pressure
This information is found in Manufacture information or from the Historical Boiler Data Base.

FS: Factor of Safety = 4

Joint Percent Efficiency's From: Boiler Types & Designs: Section 2, Steam – Boiler Design, pg 8. 1908
Tensile Strengths for Boiler Sheets, From: Boiler Types & Designs: Boiler Materials and details of Construction, pg 10. 1908
Tensile Strengths for Staybolts, From: 2007 NBIC, Part 2, Section 6, S2.10.4.1

The above are default values. The owner can specify different values with additional documentation.

Determining Minimum Allowable Thickness of Boiler Plate in a Barrel based on MAWP

The efficiency of a riveted joint increases if thinning occurs in the plate, other than at the joint. When the efficiency reaches 100%, the mode of potential failure changes from the joint to the plate.

$$Tp = \frac{MAWP \times R \times FS}{TS}$$

Tp = Thickness of boiler plate in a Barrel
MAWP = Max Allowable Working Pressure
R = is ½ the inside diameter of the barrel
FS = 4
TS = 55,000 PSI

MAWP Determined by the Thickness of the Barrel Plate

The efficiency of the plate in the barrel of a boiler, regardless of the amount of thinning, is considered to be 100 %.

$$MAWP = \frac{TS \times T_p \times E}{R \times FS}$$

Tp = Thickness of boiler plate in a Barrel
MAWP = Max Allowable Working Pressure
R = is ½ the inside diameter of the barrel
FS = 4
TS = 55,000 PSI
E = 100%

Finding MAWP Based on the Barrel Joint Efficiency and the Thickness of the Joint

$$MAWP = \frac{TS \times T_j \times E}{R \times FS}$$

Tp = Thickness of boiler plate in a Barrel
Tj = Thickness of plate in joint. (Plate should be the same thickness as the original thickness)
MAWP = Max Allowable Working Pressure
R = is ½ the inside diameter of the barrel
FS = 4
TS = 55,000 PSI
E = Joint Efficiency

TABLE B-I

Minimum Number Threads Required in Plates (Flat or Curved)
And Minimum Thickness of Flat Plates for Various Size Staybolts with V Threads
12 Threads Per Inch

Outside Dia. of Staybolt Inches	Net Cross-Sectional Area at Bottom of Thread Square Inches	Area One Thread at Base or Root Square Inches	Minimum Number Threads Required	Minimum Thickness of Flat Plate to Give Required No. of Threads
¾	0.228	0.155	2.10	.175
13/16	0.351	0.175	2.33	.194
⅞	0.419	0.192	2.52	.21
15/16	0.494	0.208	2.80	.233
1	0.575	0.224	2.97	.247
1 1/16	0.662	0.240	3.19	.266
1⅛	0.755	0.257	3.40	.283
1 3/16	0.855	0.273	3.60	.30
1¼	0.960	0.290	3.82	.318
1 5/16	1.072	0.306	4.05	.357
1⅜	1.190	0.322	4.27	.355
1 7/16	1.313	0.339	4.47	.372
1½	1.444	0.355	4.70	.392

From: Ohio Boiler Inspection Laws and Rules, 1954

MAWP of Flat Stayed Surfaces based on the Tensile Strength of the Staybolt Material

$$MAWP = \frac{S \times A}{P^2}$$

MAWP = Max Allowable Working Pressure
A = Cross sectional Area of Staybolt (Table B -1)
S = Maximum Allowable Stress on a Staybolt = 11,300 PSI
P = Pitch, Length X Height equals the area supported by one Staybolt, or if the Length and the Height are the same, square the one measurement to get the area.

Pressure Applied Staybolt due to the Area Supported by one Staybolt, based on a flat Surface

$$S = \frac{P^2 \times MAWP}{A}$$

MAWP = Max Allowable Working Pressure
A = Cross sectional Area of Staybolt (Table B -1)
S = Maximum Allowable Stress on a Staybolt = 11,300 PSI
P = Pitch, Length X Height equals the area supported by one Staybolt, or if the Length and the Height are the same square the one measurement to get the area.

Stayed Surfaces

Determine the minimum thickness of the stayed plates

The minimum allowable thickness of the stayed surfaces shall be determined on the basis of the setting of the safety valve and the spacing of the staybolts using the equation:

$$\text{Minimum Allowable Thickness} = \sqrt{\frac{\text{MAWP} \times p^2}{S \times C}}$$

MAWP

p = pitch of the staybolts, if the pattern is square

S = 13,800 psi, (This is based on a factor of safety of 4)

C = 2.2

If the pitch is not equal, p^2 = the area, in square inches, supported by one staybolt.

Determine the MAWP of the stayed plates

$$\text{MAWP} = t^2 \times S \times C \div p^2$$

t = Thickness

S = 13,800

C = 2.2

p = pitch of staybolts

The above calculations from: 49CFR parts 209 and 230, Inspection and Maintenance Standards for Steam Locomotives