Form 1

Hobby Boiler

Boiler owner complete lines 1, 2, & 3 prior to initial inspection:

1. Boiler Identification (owner): _____
2. Washington State Special Number: _____
3. Owner's Address: _____

City, State & Zip: _____

Inspection

Verify Materials Form 2* _____

Verify Design Disclosure Form 3* _____

Verify Boiler Drawings* _____

Enter Certificate Pressure _____ PSIG

Hydrostatic Pressure Test** _____ PSIG

Verify Satisfactory Pressure Test: _____

Verify Satisfactory Visual Inspection

Internal: _____

External: _____

Verify Satisfactory Steam Gauge Operation _____

Verify Satisfactory Safety Valve Operation _____

ASME ☐ Non-ASME ☐

Witness Satisfactory Boiler Operation _____

Certify Boiler Yes_____ No_____ (***)

Inspector_____ Number_____ Date:_____

*Not required for Annual Testing.

**Enter pressure corresponding to test requirements.

***Attach written reason for not accepting, including reference to requirements.

Maximum Allowable Working Pressure (MAWP) is defined as the maximum pressure determined by the lowest calculated pressure of each separate component.

Component	Form 2: Material List and MAS:	Form 3: (MWAP)
1. Boiler shell (Boiler Barrel)	SA 53 gr. B Smls - Pipe - 15,000 MAS	_____ PSI
2. Front Tube Sheet (Plate)	SA 36 - Plate - 14,500 MAS	_____PSI
3. Rear Tube Sheet (Firebox Tubesheet)	SA 36 - Plate - 14,500 MAS	_____ PSI
4. Flues (fire tubes)	1/2" Tubes B-88 copper	_____ PSI
5. Super heater tubes	1" Tubes B-88 copper	_____ PSI
6. Firebox Side (Leg) Stays	SA 36 - Plate - 14,500 MAS	_____ PSI
7. Firebox sides	SA 36 - Plate - 14,500 MAS	_____ PSI
8. Crown Sheet Round stays	SA 36 - Plate - 14,500 MAS	_____ PSI
9. Crown Sheet Girder Stays:	SA 36 - Plate - 14,500 MAS	_____ PSI
10 Crown Sheet	SA 36 - Plate - 14,500 MAS	_____ PSI
11 Mud Ring	SA 36 - Bar Stock - 13,300 MAS	_____ PSI
12 Siphon Tubes	1/2" Tubes B-88 copper	_____ PSI
13 Throat Sheet	SA 36 - Plate - 14,500 MAS	_____ PSI
14. Steam Dome	Unidentified Steel - All Forms - 10,300 MAS	_____ PSI
15. Firebox Backplate	SA 36 - Plate - 14,500 MAS	_____ PSI
16 Backhead	SA 36 - Plate - 14,500 MAS	_____ PSI

Note: Under Form 3 above, if “N/A” appears, that component is not installed in this boiler.

The lowest MAWP from the above chart is _____ PSI (_____). However, this exceeds the MAWP allowed by the Washington State Miniature Hobby Boiler Guidelines. Therefore:

The MWAP for this boiler shall be _____ PSIG

1. The materials utilized in boiler fabrication shall be noted in the application sections of the Boiler Material Form (Form 2). When completed, the form shall be signed by the owner or fabricator thereby certifying that the noted materials used are as indicated.

2. Maximum allowable material stress will be indicated in the following table. This table lists materials and the stress that may be used in fabrication of boilers fabricated in accordance to the requirements set forth in this procedure. However, the boiler is not limited to these materials only.

3. Seamless and welded shells made from pipe for miniature boilers shall be not less than 3/16 in. (5.0 mm) in thickness. Shells or heads made from plate shall be not less than 1/4 in. (6 mm) in thickness. Heads used as tube-sheets, with tubes expanded, shall be at least 5/16 in. (8 mm) in thickness.

4. The maximum allowable stress (MAS) to be used for maximum allowable working pressure (MAWP) calculations shall be 0.75 times the maximum stress allowed at 400 deg. F, by Section II Part D, ASME code for specific known materials. All other shall be prescribed in the table below.

Form 2: Weld/Solder Material

Area: _____All_____ Filler: _____ Root: _____

Tested by: _____Date: _____/_____/_____

Preamble to Calculations and their results

Boiler Design Calculations

Background:

The Revised Code of Washington (RCW 70.79.070) places the responsibility on the owner for certification of Miniature Hobby Boilers with the Department of Labor and Industries, Boiler and Pressure Vessel Section. Under this authority, the Boiler and Pressure Vessel Section have developed the following dimensional limitations and criteria (taken from the 1998 ASME code, Section I, PMB-2, pg 157).

For a boiler to be certified as a Miniature Hobby Boiler, it must fall within the following guidelines:

1) The *maximum* of sixteen inches inside boiler shell diameter;
2) A *maximum* of twenty square feet of total heating surface;
3) A *maximum* gross volume of five cubic feet, and a *minimum* of seventy five cubic inches;
4) A *maximum* allowable working pressure of 150 psig

BOILER DESIGN CALCULATIONS AND THEIR RESULTS

I Inside boiler shell diameter shall be sixteen inches or less:

Boiler OD: _____ inches

Boiler Wall Thickness: _____ Inches

Barrel ID: _____ Inches

Inside diameter (ID) of boiler shell =_____ Inches

Boiler design calculations and their results continued:

II. Heating area of the boiler components shall be twenty square feet or less.

A. Tubes: The tubes shall consist of the sum of the areas being heated, or the circumferential surface times the length of the tubes times the number of tubes.

Superheater: Note: Superheater tubes ☐ are or ☐ are not installed in this boiler

ID of Tube: _____ inches
Length of Tube: _____ inches
Number of Tubes: _____

Formula: π * Tube ID radius * Tube Length * Number of tubes = _____Sq In.

Boiler tubes also known as boiler tubes or flues:

ID of Tubes _____ inches
Length of Tube _____ inches
Number of Tubes: _____

Formula: π x Tube ID radius * Tube Length * Number of tubes = _____ Sq In.

Total of tube heating area = _____ Sq In

B: Front tube sheet: The front tube sheets shall consist of the area of the tube sheet less the sum of the areas of the tubes.

Front tube sheet OD _____ Sq In
OD of Superheater tubes if present: _____ Inches (Note: enter n/a if not present)
Number of Tubes _____
OD of firebox flues _____ Inches
Number of Tubes _____

Formula: π * Front tube sheet radius squared* less the heating area of the tubes = _____ Sq In

Total Tube sheet heating area: _____ Sq In

C: Crown Sheet: The surface area of the crown sheet is calculated using the length times the width measurements. In this case the area was calculated using the "Area" function within the Cad program used to generate the area. See the attached drawing.:

Formula: Length * Width = Total Sq In. _____ Sq In

The area of the Crown Sheet using the above formula is _____ Sq In

Total crown sheet heating area: _____ sq In

D: Firebox sides (legs): The surface area of the firebox sides is calculated using the length times the width measurements. In this case the area was calculated using the "Area" function within the Cad program used to generate the area. See attached drawing.:

Formula: Height * Average length * 2 as there is two sides.

The area of the firebox sides (legs) using the above formula is: _____Sq In

Total crown sheet heating area: sq In

E: Firebox backplate: The surface area of the firebox backplate is calculated using the height times the width measurements. In this case the area was calculated using the "Area" function within the Cad program used to generate the area. See the attached drawing:

Formula: height * width

The area of the firebox backplate using the above formula is: _____ sq in.

Total Firebox Backplate heating area: Sq In

F: Firebox Front Tube Sheet: The surface area of the Firebox front tube sheet is calculated using the height times the width measurements. In this case the area was calculated using the "Area" function within the Cad program used to generate the area. See the attached drawing:

Formula: (Height * average width) – area of tube ends

The area of the Firebox Front Tube Sheet using the above formula is: _____ sq In

Total Firebox Front Tube Sheet heating area: In

G: Firebox Siphon Tubes: Note: if firebox box siphon tubes are not present, the values will show "N/A".

OD Tube _____ inches
Length of tube _____inches
Number of tubes _____

Formula: Total of tube heating area = OD * p * Length * # of tubes = 65.53 sq In

Total Firebox Siphon Tubes heating area is: Sq In

A. Total of tube heating area: Sq In
B. Total front tube sheet heating area: Sq In
C. Total of crown sheet heating area: Sq In
D. Total of firebox sides heating area: Sq In
E. Total of firebox rear heating area: Sq In
F. Total of front tube sheet heating area: Sq In
G. Firebox siphon tube heating area: _____Sq In
Total: _____ Sq In

144 Sq In = 1 Sq Ft, so /144 = Sq ft

Total heating area: Square Feet

Gross volume *maximum* of five cubic feet, and a *minimum* of seventy five cubic inches.

III. Total gross volume of this boiler shall include the following calculations:

A. Boiler Barrel:

Barrel OD: _____ inches
Boiler wall thickness: _____ Inches
Barrel ID: _____ Inches
Radius: _____ Inches
Length* _____ Inches
*Note: inches between inside of front tube sheet to the forward side of the back tube sheet.
Formula: Volume = π * barrel ID radius * barrel length = _____Cubic Inches

Total Boiler Barrel Volume - 2,695.83 Cubic Inches

B. Firebox Legs (Sides):

The firebox legs (Sides) are of an irregular shape and are equal to the previous calculations for the heating surface. The square inch calculations are used for that portion of the volume calculations.

Area of Firebox legs from cad drawings: _____ Sq In
Distance between the water side of the
Firebox legs and the inside of the firebox sides _____ Inches

Formula: Area of firebox legs * Distance between = _____ Cu In

Total Firebox Legs Volume = Cubic Inches

C. Firebox Rear End:

The firebox rear end is calculated based upon the height of the firebox backplate x its average width x the space between the firebox backplate and the firebox backhead.

Area of the Firebox back plate from Cad drawing: _____ Sq In
Distance between firebox backplate and backhead: _____ Inches

Formula: Area of firebox back plate * Distance between = _____ Cu In

Total Firebox Rear End Volume = Cubic Inches

D. Firebox front end:

Area of firebox rear end from Cad drawing: _____ Sq In
Distance between firebox rear end and backhead: _____ Inches

Formula: Area of firebox rear end * Distance between = 41.494 Cu In.

Total Firebox Front End Rear End Volume = Cubic Inches.

E. Firebox crown sheet area:

Radius of barrel: _____ Inches
Height between top of crown sheet and underside of barrel: _____ Inches
Distance from front edge of crown sheet to inside back edge of backhead: _____ Inches

Formula: segment of a circle times the distance from the front end of the crown sheet to the middle of the backhead above the crown sheet = _____ Cu In.
The formula for a segment of a circle required to calculate this can be found at: http://www.mathopenref.com/segmentareaht.html.

Total Firebox Crown Sheet Volume _____ Cubic Inches.

Summary of the gross volume for this boiler:

A. Total boiler Barrel volume = _____ Cu. In.
B. Total Firebox leg volume = _____ Cu. In.
C. Total Firebox rear volume = _____ Cu. In.
D. Total Firebox front volume = _____ Cu. In.
E. Total fire box crown sheet volume: = _____ Cu. In.
Total: _____ Cu. In.

The conversion of Cu. In. to Cu. Ft.. _____ is divided by 1728 = _____ Cu Feet
Total Boiler Volume = _____ Cubic Feet.

IV Boiler Calculations to determine the *maximum* boiler pressure allowed for this boiler:

Maximum Allowable Working Pressure (MAWP) is defined as the maximum pressure determined by the lowest calculated pressure of each separate component.
If the MAWP of any component is less than 150 psi, that will be the MAWP for the boiler, otherwise the MAWP shall not be more than 150 psi.

Maximum Allowable Stress (MAS) is the maximum stress on each separate component. Washington State allows the following stress ratings on material used within this boiler at 400 degrees Fahrenheit:

Material, Form and Stress Value (MAS)
See page 2 of 13 for a complete list of all materials, form and stress values (MAS)

Copper Tube The values to be determined by information available on a case by case basis.

1. **Boiler Shell (Barrel)**

For Boiler Shells, cylinders, and parts of Cylinders, the following equation is limited to longitudinal sections.

$$P = \frac{2 * S * E * t}{D - (2 * Y * t)}$$

Where:

P = MWAP

S = MAS: _____

D = OD of Cylinder (Barrel): _____ inches

E = Constant for Seamless or welded pipe: 0.90

Y = Constant for conditions less than 900 Deg F: 0.40

T = Cylinder (Barrel) wall thickness: _____ Inches

Using the formula above the MWAP for this component is: PSI

2. **Front Tube Sheet**

$$P = \frac{S * C * t^2}{X * Y}$$

Where:

P = MAWP

S = MAS: _____

t = Thickness of front tube sheet: _____ Inches

X = Distance between C/L of hollow stays: _____ Inches

Y = Distance between C/L of hollow stays & C/L if 1st row of tubes: . _____ Inches

C = Constant**: 2.1

*A=X*Y, where x & y are pitches at right angles passing through the center of a stay.

**Constant is 2.1 for stayed surfaces (From 1998 ASME Code, Section I, PFTG-23.1.3 pg 140)

Using the formula above the MWAP for this component is: PSI

3. **Rear Tube Sheet (Firebox Tubesheet)**

$$P = \frac{S * C * t^2}{X * Y}$$

Where:

P = MAWP

S = MAS: _____

t = Thickness of front tube sheet: _____ Inches

X = Distance between C/L of tube sheet stays: _____ Inches

Y = Distance between C/L of bottom row of flues to C/L of tube sheet stays: _____ Inches

C – Constant**: 2.1

*A=X*Y, where x & y are pitches at right angles passing through the center of a stay.

**Constant is 2.1 for stayed surfaces (From 1998 ASME Code, Section I, PFTG-23.1.3 pg 140)

Using the formula above the MWAP for this component is: PSI

4. Flues (fire tubes)

$$P = S * [\frac{\mathbf{2t-0.01D-2e}}{\mathbf{D-t-(0.005*D)-e}}]$$

Where:

P = MAWP

S = MAS for 1/2" Tubes B-88 copper:* 8,700

D = Outside diameter of tubing in inches _____ Inches

t = Thickness of the tubing wall in inches _____ Inches

e = A constant: for welded tube ends, e = 0.0 0.00

Note: For other end conditions, refer to ASME Power Boiler Section I, Part PG-27

Using the formula above the MWAP for this component is: PSI

5. Superheater tubes

Note: enter n/a if not present

$$P = S * [\frac{\mathbf{2t-0.01D-2e}}{\mathbf{D-t-(0.005*D)-e}}]$$

Where:

P = MAWP

S = MAS for 1" Tubes B-88 copper: 8,700

D = Outside diameter of tubing in inches: _____ Inches

t = Thickness of the tubing wall in inches: _____ Inches

e = A constant: For welded tube ends, e = 0.0 0.00

Note: For other end conditions, refer to ASME Power Boiler Section I, Part PG-27

Using the formula above the MWAP for this component is: PSI

6. Firebox Sides (Legs) Stays:

$$\boldsymbol{P = \frac{Sa}{A}}$$

Where:

P = MAWP

S = MAS: _____

A = Area of the plate in inches (Use x and y below)

X = Distance that separates the stays center to center: _____ Inches
Use vertical distance for x

Y = Distance that separates the stays center to center: _____ Inches
Use horizontal distance for y

a = Cross sectional area of stays: _____ Sq In

Using the formula above the MWAP for this component is: PSI

7. Firebox sides:

$$P = \frac{S * C * t^2}{X * Y}$$

Where
P = MWAP
S = MAS: _____
t = Thickness of plate: _____ Inches
X = Vertical distance between C/L to C/L of stays: _____ Inches
Y = Horizontal distance between C/L to C/L of stays: _____ Inches
C = is defined as the constant for flat stayed surfaces*: 2.1
(1998 ASME Code, Sect 1, Pg 46.1 pg 36 eq #2)

Using the formula above the MWAP for this component is: PSI

8. Crown Sheet Round Stays

Note: enter n/a if not present

$$P = \frac{Sa}{X * Y}$$

Where
P = MWAP
S = MAS: _____
a = Cross sectional area of the stays in inches: _____
X = Vertical distance that separates the stays C/L to C/L: _____
Y = Horizontal distance that separates the stays C/L to C/L: _____

Using the formula above the MWAP for this component is: PSI

9. Crown Sheet Girder Stays:

PFT-30.1 gives this formula:

$$P = \frac{C * d^2 * t}{(W - p)D_1 * W}$$

Note: Enter n/a if not present
Where
P = MWAP
C = a constant with a value that depends on the number of staybolts on each girder*: _____
D_1 = Distance between girders from center to center: _____ In.
d = Height of the girder: _____ In
p = Pitch of supporting bolts (1/2 of the length of the girder if so built w/o the bolts: _____ In
t = Thickness of the girder(s) combined _____ In
W = the distance of the crown sheet front to back exposed to the fire: _____ In
*Note: C = 7,000 if the girder is fitted with one supporting bolt, 10,000 if two or three, and 11,000 if four or five. Most of the girders used in model boilers have notches for water circulation which take the place of the bolts (Refer to the attached drawings). The leg between the centers of the notches represent the single bolt.

Using the formula above the MWAP for this component is: PSI

10 Crown Sheet:

$$P = \frac{S * C * t^2}{X * Y}$$

Where
P = MWAP
S = MAS _____
t = thickness of the crown sheet _____ Inches
C = Is defined as the constant for stayed surfaces 2.1
X = Distance that separates the stays or girders center to center: _____ Inches
Y = Distance that separates the stays center to center front to back of boiler*: _____ Inches
*Use ½ the length of the girder if used.

Using the formula above the MWAP for this component is: PSI

11 Mud Ring:

$$P = \frac{S * C * t^2}{X * Y}$$

Where
P = MWAP
S = MAS _____
t = Thickness (height) of the Mud Ring: _____Inches
C = Defined as the constant for stayed surfaces: 2.1
X = Width of the mud ring: _____Inches
Y = Length of the longest mud ring: _____Inches

Using the formula above the MWAP for this component is: PSI

12 Siphon Tubes: Pg-27.2.2

$$P = \frac{2 * S * E * t}{D - (2 * Y * t)}$$

Where
P = MWAP
S = MAS for K copper tube* _____3,000
D = OD of tubing in inches _____0.625 Inches
E = Constant for seamless or welded pipe: _____1.00
Y = Constant for conditions less than 900 deg F _____0.40
t = Thickness of tubing wall in inches _____0.049 Inches
*Note: Internal MAS for copper tubes with internal pressure (ASME B41)

Using the formula above the MWAP for this component is: PSI

13 Throat Sheet:

$$P = \frac{S * C * t^2}{X * Y}$$

Where
P = MWAP
S = MAS _____
T = Thickness of throat sheet _____ Inches
C = Constant for flat stayed surfaces: 2.1
X = Distance C/L to C/L of throat sheet Stays: _____ Inches
Y = Distance C/L of throat sheet stays to inside bottom of barrel: _____ Inches

Using the formula above the MWAP for this component is: PSI

14 Steam Dome:

$$P = \frac{2 * S * E * t}{D - (2 * Y * t)}$$

Where

P = MWAP

S = MAS _____

D = Outside diameter of the Steam Dome cylinder in inches: _____ Inches

E = 1.00 for seamless pipe, 0.90 for welded seam or 0.60 for other seams: 1.00

Y = 0.40 for conditions less than 900 degrees F: 0.40

T = cylinder wall thickness: _____ Inches

Using the formula above the MWAP for this component is: _____ psi.

15. Firebox Backplate:

$$P = \frac{S * C * t^2}{X * Y}$$

Where

P = MWAP

S = MAS: _____

t = Thickness of backhead sheet: _____ Inches

C = Constant for flat stayed surfaces: 2.1

X = Distance C/L to C/L of backplate stays: _____ Inches

Y = distance C/L of backplate stays to bottom of firebox door: _____ Inches

Using the formula above the MWAP for this component is: _____ PSI

16 Backhead:

$$P = \frac{S * C * t^2}{X * Y}$$

Where

P = MWAP

S = MAS _____

t = Thickness of backhead _____ Inches

C = Constant for flat stayed surfaces: 2.1

X = Distance C/L to C/L of backplate stays: _____ Inches

Y = Distance C/L of hollow stays down to top of crown sheet: _____ Inches

Using the formula above the MWAP for this component is: _____ PSI

The maximum allowable working pressure (MAWP) for this boiler as shown in the calculations for the weakest component _____ is: _____PSI. Therefore, the maximum allowable working pressure will be _____ PSI.