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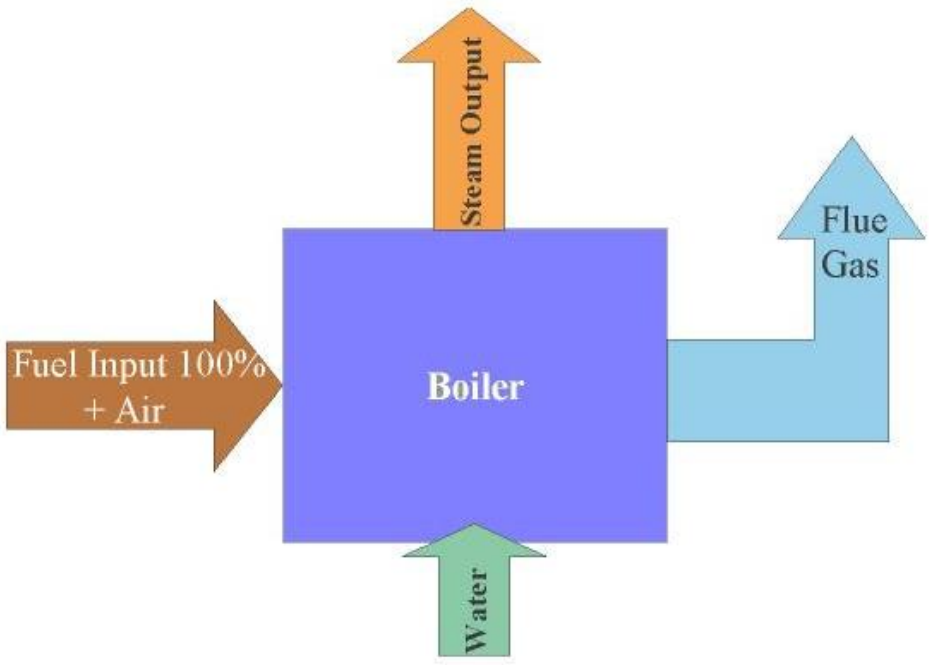
Steam boiler calculation formulas

Boiler formulas are useful tools for anyone who operates or installs boilers. In this article we will provide some useful boiler formulas, along with a few other calculations you can use with your system.

All formulas on this page are typical in nature and will change with actual site conditions, equipment capabilities, efficiencies, etc.. These are offered as a general means of estimating requirements or conditions without all necessary values known. Assuming a boiler 'Fuel to Steam' efficiency of 80%.



$$\text{Efficiency} = \frac{\text{Heat addition to Steam} \times 100}{\text{Gross Heat in Fuel}}$$

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Steam Boiler Calculation Formulas

Step 1: Determine the properties of the generated steam

Take advantage of the steam property calculator. Determine steam properties using steam pressure and selected secondary parameters (temperature, specific enthalpy, specific entropy or dryness). The specific enthalpy is then multiplied by the mass flow to obtain the energy flow.

★ Steam energy flow =specific enthalpy x mass flow

Step 2: Define Feed Water Energy and Mass Flow

From the steam mass flow rate and the blowdown rate, the make-up water flow rate can be calculated.

Sewage mass flow = supply water mass flow x sewage rate

Steam mass flow = Supply water mass flow - Sewage mass flow

Steam mass flow = supply water mass flow - supply water mass flow * blowdown rate

Supply water mass flow = steam mass flow / [1 - blowdown rate]

Using the Steam Properties Calculator, determine the steam properties

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from the deaerator pressure and steam fraction = 0 (saturated liquid). The specific enthalpy is then multiplied by the mass flow to obtain the energy flow.

★ Supply water energy = specific enthalpy * mass flow rate

Step 3: Define Blowdown Characteristics and Mass Flow

Using the calculated feedwater mass flow and air release rate

Sewage mass flow rate = Supply water mass flow rate x Sewage discharge rate

Using the Steam Properties Calculator, determine the steam properties from the steam pressure and steam fraction = 0 (saturated liquid). The specific enthalpy is then multiplied by the mass flow to obtain the energy flow.

★ Blowdown energy flow = specific enthalpy * mass flow

Step 4: Define Boiler Efficiency

★ Boiler energy = steam energy flow + sewage energy flow - water supply energy

Step 5: Define Fuel Efficiency

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★ Fuel Energy = Boiler Energy / Combustion Efficiency

Suppose of Steam Boiler Calculation Formulas

· Set the operating pressure (saturated liquid) for the deaerator, and the deaerator provides water supply at a temperature close to the boiling point

· Steam pressure, boiler pressure and blowdown pressure are all the same

· Combustion efficiency is the percentage of fuel energy that is transferred directly to the feed water without loss or use.

· Blowdown rate refers to the ratio of the saturated water discharged from the boiler under the boiler pressure to the input boiler feed water

· Complicated boiler configuration and operational fluctuations are not considered

· Energy from motors (pumps, fans) is not considered. Boiler type and fuel type are not considered.

Useful Gas/Oil Boiler Formulas Unit Conversion

KW x 0.10 = BHP

34.5 x Boiler Horsepower (BHP) = LB/STM/HR (from and at 212°F)

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0.069 x Boiler Horsepower (BHP) = GPM (evaporation rate)

33,479 x Boiler Horsepower (BHP) = BTUH (nominal gross output) (divide x.8 to get input)

0.3 x **Boiler Horsepower (BHP)** = GPH No.2 Fuel Oil

0.28 x Boiler Horsepower (BHP) = GPH No.5/6 Fuel Oil

42 x **Boiler Horsepower (BHP)** = CFH Nat. Gas

139 x **Boiler Horsepower (BHP)** = SQ/FT EDR

9.809 x Boiler Horsepower (BHP) = KW

LB/STM/HR x 0.002 = GPM

LB/STM/HR x 1000 = BTU/HR (nominal gross output)

Gallon of Water @ 70°F x 8.34 = LB of water

2.31 x PSIG = FT of water

6.9 x PSIG = kPa

27.71 x PSIG = in w.c.

1.73 x Ounce = in w.c.

1 lb of Steam = 970.2 Btu

1 Sq ft EDR (steam) = 240 Btu per hour

Typical Fuel Values

1 CU/FT Natural Gas @ 60°F = 1,000 BTU/CU/FT

1 Therm = 100,000 BTU's (100 CU/FT natural gas)

1 Dekatherm = 1,000,000 BTU's (1,000 CU/FT natural gas)

1 GAL of LPG (propane liquid) @ 60°F = 91,600 BTU/GAL

1 CU/FT of LPG vapor (propane gas – raw) @ 60°F = 2,500 BTU/CU/FT (typical @ 1.53 SG)

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NOTE: LPG may be blended with air to approximate the operational characteristics of Natural Gas. It may have a nominal BTU content of 1,300 to 1,500 BTU/CU/FT (determine by application).

1 GAL No.2 Fuel Oil = 140,000 BTU/GAL

1 GAL No. 5/6 Fuel Oil = 150,000 BTU/GAL

Boiler efficiency

In an article written by Forbes Marshall, they provide a formula to find the direct efficiency of a boiler. The formula is as follows:

η=(Energy output)/(Energy input) X 100

In order to calculate boiler efficiency, we divide the total energy output by total energy input, multiplied by hundred.

This formula further breaks down to:

E= [Q (H-h)/q*GCV]*100

Where,

Q= Quantity of steam generated (kg/hr)

H= Enthalpy of steam (Kcal/kg)

h= Enthalpy of water (kcal/kg)

GCV= Gross calorific value of the fuel