A.O.Smith
Water Heaters

SERVICE INFORMATION GUIDE

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Water Heaters

FORMULAS & FACTS

BTU (British Thermal Unit) is the heat required to raise 1 pound of water 1°F

1 BTU = 252 cal = 0.252 kcal
1 cal = 4.187 Joules
BTU X 1.055 = Kilo Joules
BTU divided by 3,413 = Kilowatt (1 KW)

To convert from Fahrenheit to Celsius:
(°F – 32) x 5/9 or .556 = °C.

FAHRENHEIT	CENTIGRADE
32	0
41	5
60.8	16
120.2	49
140	60
180	82
212	100

One gallon of 120°F (49°C) water weighs approximately 8.25 pounds.

Pounds x .45359 = Kilogram
Gallons x 3.7854 = Liters

% of hot water =
(Mixed Water Temp. – Cold Water Temp.) divided by (Hot Water Temp. – Cold Water Temp.)

% thermal efficiency =
(GPH recovery X 8.25 X temp. rise X 1.0) divided by BTU/H Input

BTU output (Gas) =
GPH recovery x 8.25 x temp. rise x 1.0

BTU output (Electric) =
BTU Input (Not exactly true due to minimal flange heat loss.)

Capacity of a cylindrical tank
– 1/2 diameter (in inches) x 3.146 x length. (in inches) Divide by 231 for gallons.

Doubling the diameter
of a pipe will increase its flow capacity (approximately) 5.3 times.

Linear expansion of pipe – in inches per 100 Ft.

TEMP °F RISE	STEEL	COPPER
50°	0.38″	0.57″
100°	.076″	1.14″
125°	.092″	1.40″
150°	1.15″	1.75″

Grain – 1 grain per gallon = 17.1 Parts Per million (measurement of water hardness)

FORMULAS & FACTS

TC-092

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GPH (Gas) =
(BTU/H Input X % Eff.) divided by (temp. rise x 8.25)

GPH (Electric) =
(KW x 3413) divided by (temp. rise x 8.25) or (KW x 414) divided by (temp rise.)

KW required =
(GPH X 8.25 X temp. rise) divided by 3413 or
(GPH x Temp. rise) divided by 414

1 KW =
3413 BTH = 4.1 GPH @ 100° temp. rise or 4.6 GPH @ 80° temp. rise

Meters = Inches x .0254
Centimeters = Inches X 2.54
mm (millimeters) = Inches x 25.4

One boiler horsepower (BHP) = 33,475 BTU

One cubic foot of Natural Gas contains about 1000 BTU of heat.

One "therm" is equal to 100,000 BTU (100 CU. FT.)

One cubic foot of Propane Gas contains about 2500 BTU of heat.

One gallon of Propane gas contains about 91,250 BTU of heat.

One pound of Propane gas contains about 21,600 BTU of heat.

One pound of **gas pressure** is equal to 27.7 inches water column pressure

Inches of Water Column x .036091 = PSI

Inches of Water Column x .073483 = Inches of Mercury (Hg.)

One pound per sq. in. = 16 oz per sq. in.

Water expands
approximately 2% in volume for a 100°F temperature rise (from 40°F to 140°F)

Water confined
to a storage tank or piping system, when subjected to a temperature rise of 10°F (increasing from 75° to 85°), **increases pressure** from 50 psi to 250 psi.

Water capacity of copper tubing per foot

TUBING SIZE	½	¾	1	1½	2	3
g/ft type L	.012	.025	.044	0.92	.161	.354

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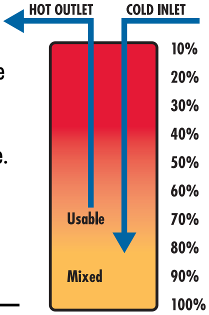
COMMON TERMS



Draw efficiency is the quantity of hot water available to the consumer before the outlet water temperature decreases 25°F. A 40-gallon water heater will typically provide 70% (28 gallons) within this temperature range. The burner or elements are allowed to operate during this test. Incoming, cold water mixes the remaining stored water below this 25° limitation.

Energy factor is an indicator of the combined thermal efficiency and standby efficiency of a water heater. The higher the energy factor, the more efficient the water heater will be.

What Happens When Water Is Heated:

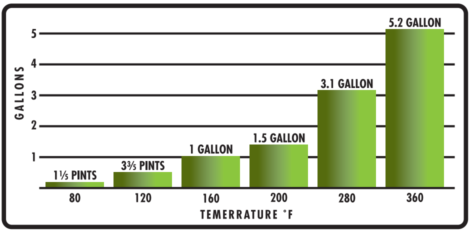
1 **The relationship between water temperature and time to burn normal adult skin.**

WATER TEMP. °F	TIME FOR 1ST DEGREE BURN	TIME FOR PERMANENT BURNS (2nd AND 3rd DEGREE)
105	Normal shower temperature	
122	1 minute	5 minutes
131	5 seconds	25 seconds
140	2 seconds	5 seconds

2 **Water cannot** (for all practical purposes) be compressed.

3 **Water expands** when it is heated. Approximately .00023% per degree F temperature rise.

This expansion will result in a pressure increase in a "closed" system. Water confined to a storage tank or piping system will, when subjected to a temperature rise of 10°F (increasing from 75°F to 85°F) increase in pressure from 50 psi to 250 psi.



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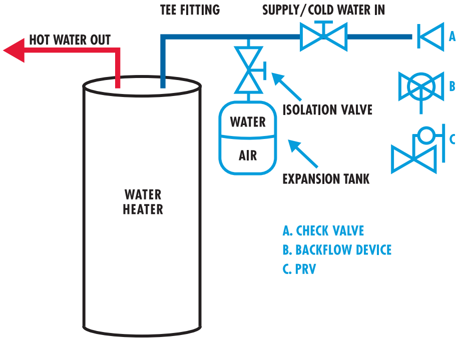

The closed system illustrated requires the thermal expansion tank because of the preceding #2 and #3 facts.

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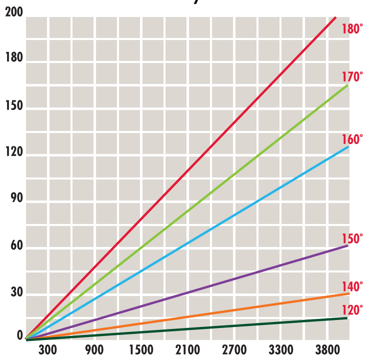
4 **Gases** in the water **will separate** from the water as temperature rises.

5 **Water boils at 212°F** – at sea level – unless it is contained under pressure. At 52 psi gauge pressure, water would not boil until it exceeded 300° F.

6 **Minerals** in the water **will separate** from the water as temperature is added. This may lead to a much faster scaling rate in the tank.

Ex: *10 grains hardness; 2700 gallons of hot water per day.*
Water stored at 140°F in the tank may accumulate 19 lbs. of lime per year.

160°F in the tank may accumulate 85 lbs. of lime per year.
180°F in the tank may accumulate 135 lbs. of lime per year.



7 Adding heat to water may make it **more corrosive**.

Water may be ***2 times*** *more corrosive at 160°F than at 140°F.*
Water may be ***2 times*** *more corrosive at 180°F than at 160°F.*

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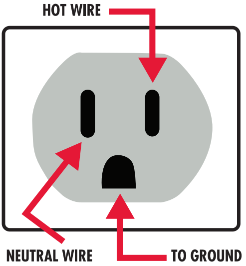

Polarity – Verify that an electrical socket has correct "polarity." Verify that the "Neutral" (typically white on a 120V circuit) wire has no power to ground and that the "Hot" (typically black wire on a 120V circuit) has 115 – 125V to ground.

Watts divided by Volts = Amps (single phase)

(**Watts** x .557) divided by (Volts) = Amps (3 phase)

Volts x amps = watts.

Volts divided by amps = ohms (resistance)

For insulating purposes "R" value is a measure of the resistance of a substance to heat flow.

Recovery rate is the amount of water that is heated to a specific temperature rise, per hour. An example might be that a water heater has a recovery rate of 30 gallons of water per hour at 80° F temperature rise.

Thermal efficiency is approximately the percentage of generated BTU that enters the stored water. A percentage of the total BTU input passes out through the vent piping.

Temperature rise is the increase in the temperature from its coldest "inlet" water temperature to the desired hot (outlet) setting. Typically this is assumed to be 40° entering water; 120° desired stored water or 80° "temperature rise."

Standby efficiency is the water heater's ability to contain heat in the tank. A minimum of tank water heat loss per hour is desired.

Sample: $\dfrac{\textit{temperature change per hour}}{\textit{“R” value}}$ *= BTU/H loss/square foot of tank surface*

Water hammer is a concussion of moving water against the sides of a containing pipe or vessel on a sudden stoppage of flow.

Ex: *1/2˝ copper pipe, 5GPM flow (7.2ft/sec.) – stop.*
Pressure rise of approximately 412 psi

3/4˝ copper pipe, 5GPM flow (3.3ft/sec) – stop.
Pressure rise of approximately 188 psi

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