

Formulas

Measurement unit abbreviations

°C	degree Celsius
°F	degree Fahrenheit
°K	degree Kelvin
A	ampere
BHP	boiler horsepower
BTU	British thermal unit
Btuh	British thermal units per hour
CFH	cubic feet per hour
CFM	cubic feet per minute
ft.	foot
ft ²	square foot
ft ³	cubic foot
gal.	imperial gallon
gpm	imperial gallons per minute
hr	hour
in.	inch
in ²	square inch
in ³	cubic inch
kg	kilogram
kPa	kilopascal
kPaG	kilopascal gauge
kW	kilowatt
L	litre

Formulas (continued)

Measurement unit abbreviations (continued)

lb.	pound
lbf	pound - force
m	metre
m ²	square metre
m ³	cubic metre
min	minute
mm	millimetre
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
s	second
SCFM	standard cubic feet per minute
SPR	seconds per rotation
t	ton (ice melted over a 24 - hour period)
USG	American gallon
USGPM	American gallons per minute
V	volt
VA	volt - ampere
W	watt

Formulas (continued)

Values

ΔT	temperature difference
B	base
BarG	bar gauge
C	specific heat of fluid
CO ₂	carbon dioxide
D	distance
FCS	fully closed signal
FOS	fully open signal
H	height
HV	heating value
I	current (in amperes)
IS	input signal
L	length
M	mass of fluid per hour
P	pressure
P _{base}	base / atmospheric pressure
P _{test}	test pressure
PF	pressure factor
r	radius
R	resistance (in ohms)
SF	safety factor
stoich	stoichiometric

Formulas (continued)

Values (continued)

T	temperature
T _{amb}	ambient temperature
W	width

Constants

π	3.1416
1 ft ³ of water	6.228 gal.
1 USG	8.33 lb.
45° offset	1.414
12 000 BTU (cooling capacity)	1 t
Air - fuel ratio	14.7
Base/ atmospheric pressure	14.73 psig/ psia
Boiler horsepower (BHP)	33 500
BTU per 1 000 W (single phase)	3.414
BTU per 1 000 W (three phase)	1.73
Heat content – natural gas	1 000 BTU/ ft ³
Heat content – propane	2 500 BTU/ ft ³
Pressure head conversion unit	0.433 psi/ ft.
Specific heat of air	1.08
Standard for air at sea level	4.5

Formulas (continued)

Conversion factors

To convert	To	Multiply by
°C	°F	1.8 and add 32
°C	°K	1 and add 273
decimal	second	60
ft ²	in ²	144
ft ³	USG	7.48
kg	lb.	2.205
kPa	lbf / ft ²	20.88
kPa	lbf / in ² (psi)	0.1450
kPaG	lbf / in ² gauge (psig)	0.1450
L	USG	0.2200
L / min	USGPM	0.2641
L / s	gpm	13.20
m	ft.	3.281
m ²	ft ²	10.76
m ³	ft ³	35.31
mm	in.	0.03937

Formulas (continued)

General formulas

Descriptions	Full	Abbreviated
% of CO ₂	$\frac{\text{stoichiometric CO}_2}{1 + (\% \text{ of excess air} \div 100)}$	$\frac{\text{stoich CO}_2}{1 + \left(\frac{\% \text{ excess air}}{100} \right)}$
Actuator position (%)	$\frac{\text{input signal} - \text{fully closed signal}}{\text{fully open signal} - \text{fully closed signal}}$	$\frac{\text{IS} - \text{FCS}}{\text{FOS} - \text{FCS}}$
Btuh	mass of fluid per hour × specific heat of fluid × temperature difference	$M \times C \times \Delta T$
CFH	$\left(\frac{\text{appliance output in Btuh}}{\text{appliance efficiency \%}} \right) \div \text{heating value}$	$\frac{\text{output}}{\text{efficiency}} \div \text{HV}$
CFH	$\frac{\text{appliance output in Btuh}}{\text{heating value}}$	$\frac{\text{output}}{\text{HV}}$
CFH	(dial size ÷ seconds per rotation) × seconds in 1 hour × pressure factor	$\frac{\text{dial}}{\text{SPR}} \times 3\,600 \times \text{PF}$
CFH	$\frac{\text{seconds in 1 hour} \times \text{dial size}}{\text{seconds per rotation}}$	$\frac{3\,600 \times \text{dial}}{\text{SPR}}$
CFM	$\left(\frac{\text{British thermal units per hour}}{\times \text{efficiency}} \right) \div (\text{specific heat of air} \times \text{temperature difference})$	$\frac{\text{Btuh} \times E}{1.08 \times \Delta T}$
CO ₂ volume (combustion)	appliance output in Btuh × cubic feet of CO ₂ per cubic foot of gas ÷ heating value	$\frac{\text{output}}{\times \text{ft}^3 \text{ of CO}_2 / \text{ft}^3 \text{ of gas} \div \text{HV}}$
Fuse rating	amperes × safety factor	$A \times \text{SF}$

Formulas (continued)

Gauge pressure reading	$\left(\frac{(\text{pressure} + \text{air-fuel ratio}) \times \left(\frac{\text{temperature difference}}{\text{ambient temperature} + \text{temperature}} \right)}{\text{air-fuel ratio}} \right)$	$\left(\frac{(P + 14.7) \times (\Delta T + T)}{T_{\text{amb}} + T} \right) - 14.7$
Input (Btuh)	$\frac{\text{appliance output in Btuh}}{\text{appliance efficiency \%}}$	$\frac{\text{output}}{\text{efficiency}}$
Input (Btuh)	$\begin{aligned} &(\text{base pressure} + \text{dial size}) \\ &\times \text{cubic feet per hour} \\ &\div \text{base pressure} \\ &\times \text{heating value} \end{aligned}$	$\left(\frac{[P_{\text{base}} + \text{dial}] \times \text{CFH}}{P_{\text{base}}} \right) \times \text{HV}$
Input (Btuh)	cubic feet per hour $\times$ heating value	CFH $\times$ HV
Input (Btuh)	$\begin{aligned} &\left(\frac{\text{seconds in 1 hour} \times \text{bar gauge}}{\text{seconds per rotation}} \right) \\ &\times \left(\frac{\text{base pressure} + \text{bar gauge}}{\text{base pressure}} \right) \\ &\times \text{heating value} \end{aligned}$	$\begin{aligned} &\left(\frac{3\,600 \times \text{BarG}}{\text{SPR}} \right) \\ &\times \left(\frac{P_{\text{base}} + \text{BarG}}{P_{\text{base}}} \right) \times \text{HV} \end{aligned}$
Net stack temperature	downstream flue temperature – ambient temperature	downstream flue T – T _{amb}
Output (Btuh)	$\begin{aligned} &\text{temperature difference} \times 1 \text{ USG} \\ &\times \text{minutes in 1 hour} \\ &\times \text{American gallons per minute} \end{aligned}$	$\begin{aligned} &\Delta T \times 8.33 \times 60 \\ &\times \text{USGPM} \end{aligned}$
Output (Btuh)	$\begin{aligned} &\text{total number of boiler horsepower} \\ &\times \text{number of boilers} \end{aligned}$	$\begin{aligned} &\# \text{ BHP} \times 33\,500 \\ &\times \# \text{ boilers} \end{aligned}$

Formulas (continued)

Power	volt × ampere	$V \times A$
Pressure factor	(base pressure + bar gauge) ÷ base pressure	$\frac{P_{\text{base}} + \text{BarG}}{P_{\text{base}}}$
Pressure test	$\left(\begin{array}{l} [\text{combustion rate} \\ \times \text{number of cylinders}] \\ + (136.354 \\ \times \text{air-fuel ratio}) \\ \hline [\text{test pressure} \\ \times \text{number of cylinders}] \\ + 136.354 \\ - \text{air-fuel ratio} \end{array} \right)$	$\left(\begin{array}{l} [\text{comb. rate} \\ \times \# \text{ cyl.}] \\ + (136.354 \\ \times 14.7) \\ \hline [P_{\text{test}} \\ \times \# \text{ cyl.}] \\ + 136.354 \end{array} \right) - 14.7$
Purge time	cubic feet per minute × number of air changes ÷ exhaust fan capacity measured in standard cubic feet per minute	$\frac{\text{CFM} \times \# \text{ air changes}}{\text{SCFM}}$
Seconds per rotation	$\frac{\text{cubic feet per hour}}{\left(\frac{\text{seconds in 1 hour}}{\times \text{pressure factor}} \right)} \times \text{dial size}$	$\left(\frac{\text{CFH}}{3\,600 \times \text{PF}} \right) \times \text{dial}$
Travel	offset distance × 45° offset constant	offset D × 1.414
Volt - ampere	current × voltage	$I \times E$
Voltage	current × resistance	$I \times R$

Formulas (continued)

Area formulas

Description	Full	Abbreviated
Circle	$\pi \times \text{radius squared}$	πr^2
Rectangle	$\text{length} \times \text{width}$	$L \times W$
Sphere	$4 \times \pi \times \text{radius squared}$	$4 \pi r^2$
Triangle	$\frac{\text{base} \times \text{height}}{2}$	$\frac{B \times H}{2}$

Volume formulas

Description	Full	Abbreviated
Cuboid	$\text{length} \times \text{width} \times \text{height}$	$L \times W \times H$
Cylinder	$\pi \times \text{radius squared} \times \text{height}$	$\pi r^2 H$
Sphere	$\frac{4 \times \pi \times \text{radius cubed}}{3}$	$\frac{4 \pi r^3}{3}$