

ELECTRICAL DATA

VOLTAGE	CURRENT	LOAD	RESISTANCE
$V = IR$	$I = \frac{V}{R}$	$P = \frac{V^2}{R}$	$R = \frac{V}{I}$
$V = \frac{P}{I}$	$I = \frac{P}{V}$	$P = VI$	$R = \frac{V^2}{P}$
$V = \sqrt{PR}$	$I = \sqrt{\left(\frac{P}{R}\right)}$	$P = I^2 R$	$R = \frac{P}{I^2}$

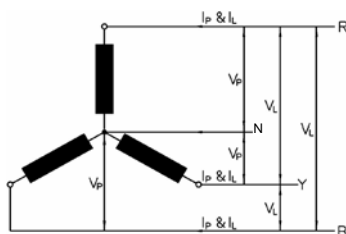
V - Voltage measured in Volts (V)
I - Current measured in Amperes (Amps)
R - Resistance measured in Ohms (Ω)
P - Power measured in Watts (W) **N.B.** 1kW = 1000W

THREE PHASE CALCULATIONS FOR HEATER BATTERIES

V_L - Line Voltage	: voltage between lines i.e. R-Y, R-B, B-Y
I_L - Line Current	: current through each line.
V_P - Phase Voltage	: voltage over each phase i.e. Star : R-N, B-N, Y-N; Delta : R-Y, R-B, B-Y
I_P - Phase Current	: current through each phase.
P - Load (Power) of the system measured in Watts (W).	N.B. 1kW = 1000W

Note: Heating elements are purely resistive i.e. they do not possess inductive or capacitive characteristics.

STAR CONNECTED



Star Connected
For Balanced Systems

Line Current (I_L)

$$I_L = I_P$$

$$I_L = P / (\sqrt{3} \times V_L)$$

$$I_L = P / (3V_P)$$

Phase Current (I_P)

$$I_P = I_L = P / (\sqrt{3} \times V_L)$$

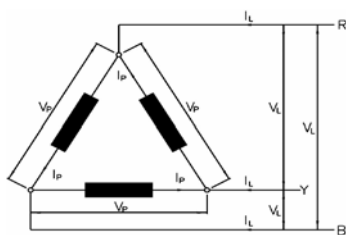
Line Voltage (V_L)

$$V_L = \sqrt{3} \times V_P$$

Phase Voltage (V_P)

$$V_P = V_L / \sqrt{3}$$

DELTA CONNECTED



Delta Connected
For Balanced Systems

Line Current (I_L)

$$I_L = \sqrt{3} \times I_P$$

$$I_L = P / (\sqrt{3} \times V_L)$$

Phase Current (I_P)

$$I_P = (1/\sqrt{3}) \times I_L$$

$$I_P = P / (3V_P)$$

Line Voltage (V_L)

$$V_L = V_P$$

Phase Voltage (V_P)

$$V_P = V_L$$

Note 1: For a given load the line current in star and delta systems is the same.

Note 2: In star systems where the neutral is left to float and where the system becomes unbalanced, then the voltage across each phase may rise or fall below the phase voltage as stated above. This should be taken into account when selecting components to be wired within a phase, e.g. thermostats should be rated for operation up to the line voltage.

LOAD CALCULATION AT VARIOUS VOLTAGES

All heaters in this catalogue are rated at either 240 volts single phase or 415V volts three phase. The table below gives a list of factors which when multiplied to the loading at either 240 volts or 415 volts will give the equivalent loading at the new voltage.

e.g. A 3kW heater rated at 240V will give 2.5kW (3kW x 0.84) at 220V.

Load Factor	0.84	0.92	1.00	1.12
Single Phase	220V	230V	240V	254V
Three Phase	380V	400V	415V	440V

Note: While there is no detrimental effect of operating a heater at a voltage lower than it's rating, operating the heater at a voltage higher than it's rating may cause the heater to fail prematurely.

HEAT ABSORPTION

WATER

• Load required to heat X litres of water per second.

$$\text{Load (kW)} = \text{Volume (litres/sec)} \times \text{rise in temp. (}^\circ\text{C)} \times 4.19$$

• Load required to heat X litres of water over X minutes.

$$\text{Load (kW)} = \frac{\text{Volume (litres)} \times \text{rise in temp. (}^\circ\text{C)}}{\text{Time (minutes)} \times 14.3}$$

• Time required for X kW to heat X litres of water.

$$\text{Time (minutes)} = \frac{\text{Volume (litres)} \times \text{rise in temp. (}^\circ\text{C)}}{\text{Load (kW)} \times 14.3}$$

Note: 1kg of water = 1 litre

AIR

• Load required to heat X m³ of air per second.

$$\text{Load (kW)} = \text{Volume (m}^3\text{/s)} \times \text{rise in temp. (}^\circ\text{C)} \times 1.3$$

OTHER MATERIALS (INCLUDING OIL)

• Load required to heat X kg per second.

$$\text{Load (kW)} = \text{Mass (kg)} \times \text{specific heat (kJ kg}^{-1}\text{ }^\circ\text{C}^{-1}) \times \text{temp rise (}^\circ\text{C)}$$

• Load required to heat X kg over X minutes.

$$\text{Load (kW)} = \frac{\text{Mass (kg)} \times \text{specific heat (kJ kg}^{-1}\text{ }^\circ\text{C}^{-1}) \times \text{temp rise (}^\circ\text{C)}}{\text{Time (minutes)} \times 60}$$

• Load required for X kW to heat X kg.

$$\text{Time (min)} = \frac{\text{Mass (kg)} \times \text{specific heat (kJ kg}^{-1}\text{ }^\circ\text{C}^{-1}) \times \text{temp rise (}^\circ\text{C)}}{\text{Load (kW)} \times 60}$$

Note: Mass (kg) = Volume (litres) x density (kg l⁻¹)

PROPERTIES OF MATERIALS

Substance	Specific Heat (kJ kg ⁻¹ °C ⁻¹)	Density (kg l ⁻¹)	Minimum Storage Temp.	Minimum Handling Temp.
Air	0.993	0.00129	-	-
Fuel Oil - Light (E)	1.930	0.960 (Max)	7-10 °C	7-10 °C
Fuel Oil - Medium (F)	1.890	0.990 (Max)	20-25 °C	27-30 °C
Fuel Oil - Heavy (G)	1.890	0.995 (Max)	32-40 °C	38-50 °C
Water - Distilled/Tap	4.190	0.998	4 °C	4 °C
Water - Sea	3.900	1.025	4 °C	4 °C
45% Caustic Solution	3.270	1.530	10 °C	12 °C

HEAT LOSS

$$\text{Average Heat Loss (Watts)} = 2.72 \times \text{Temp (}^\circ\text{C)}^{1.3} \times \text{Area (m}^2\text{)}$$

$$\text{Heat Loss from vertical surface} = 1 \times \text{average heat loss}$$

$$\text{Heat Loss from top side of horizontal surface} = 1.29 \times \text{average heat loss}$$

$$\text{Heat Loss from bottom side of horizontal surface} = 0.63 \times \text{average heat loss}$$

Note: This does not apply to open topped tanks where heat loss due to evaporation may occur.