POWER REQUIREMENT FORMULAS

Formula A :

Wattage required for heat-up = $\dfrac{\text{Weight of material (lbs) x Specific Heat(*) x Temperature Rise (°F)}}{\text{3.412 x Heat-up Time (Hours)}}$

*For specific heat and density values, please refer to pages ((X-X))

Formula B :

Wattage losses at operating temperature = Wattage loss/ft^2(**) x Area (ft^2)

**To find values for wattage losses, refer to the curves shown on page ((X))

Formula C :

Wattage for melting or vaporizing = $\dfrac{\text{Weight of material (lbs) x Heat of fusion or vaporization(BTU/lb) (***)}}{\text{3.412 x Heat-up Time (Hours)}}$

*** The Specific Heat of a material changes at some temperature due to melting (fusion) or evaporation (vaporation). To calculate wattage, use formula A for the heat needed to rise from initial to the point of change. Then calculate using formula A with the new specific heat from the point of change to the final temperature. Add these two values to formula B and C to calculate the total wattage

Specific Calculations

To Heat Liquids :

Wattage for initial heat up = (A) + (B)/2

Wattage for heating added material = (A for new material) + (B)

To Melt Metals :

Wattage for initial heat up = (A to melting point) + (C to melt) + (A to heat above melting point) + (B)/2

Wattage for heating added material = (A to melting point) + (C to melt) + (A to heat above melting point)

For the two calculations above, add the two values and multiply the final wattage by 1.2 to compensate for additional heat losses (Safety Factor)

To Heat Ovens :

Wattage = [(A for air) + (A for material introduced into oven) + (B for external oven losses)]*1.25 (door heat loss)

Forced Air Heating :

Wattage = $\dfrac{\text{Ft}^3\text{/min. x Temperature Rise (°F)}}{3}$

POWER FORMULA EXAMPLE 1

Basic Heating Calculations

A mold is being heated to form rubber parts. Every hour, 100 ounces of rubber is placed into the 10” x 10” x 4” steel mold which is attached between two stainless steel platens measuring 15” x 15” x 2”. Each platen is insulated on it’s horizontal surface with 1/2” thick insulation.

The mold must reach an operating temperature of 400°F in one hour from room temperature (70°F).

We first find the specific heat and weight values for each of our materials:

Specific Heat of Steel:	$0.12 \frac{BTU}{Lb \times °F}$	Weight of Steel Mold: $10 \times 10 \times 4 \times .284 \frac{Lb.}{In^3} = 113.6 \times 2pc = 227.2$ lbs
Specific Heat of S. Steel:	$0.12 \frac{BTU}{Lb \times °F}$	Weight of SS316 Platen: $15 \times 15 \times 2 \times .288 \frac{Lb.}{In^3} = 129.6 \times 2pc = 259.2$ lbs
Specific Heat of Rubber:	$0.44 \frac{BTU}{Lb \times °F}$	Weight of Rubber: 100 ounces x 0.0625 = 6.25 lbs.

Formula A : Wattage required for heat-up

To Heat Mold: $\frac{227.2 \text{ (lbs)} \times 0.12 \text{ (BTU/Lb°F)} \times 330 \text{ (°F)}}{3.412 \times 1 \text{ (hr.)}} = 2637$ Watts

To Heat Platens: $\frac{259.2 \text{ (lbs)} \times 0.12 \text{ (BTU/Lb°F)} \times 330 \text{ (°F)}}{3.412 \times 1 \text{ (hr.)}} = 3008$ Watts

To Heat Rubber: $\frac{6.25 \text{ (lbs)} \times 0.44 \text{ (BTU/Lb°F)} \times 330 \text{ (°F)}}{3.412 \times 1 \text{ (hr.)}} = 266$ Watts

Safety Factor: (2637 + 3008 + 266) x 20% = 1182 Watts

Total wattage required for heat-up: 7093 Watts

Formula B : Wattage losses at operating temperatures:

Heat Loss from Mold (vertical surfaces): $\frac{10” \times 4” \times 4 + 10” \times 4” \times 4}{144 \text{ in}^2/\text{ft}^2} = 2.2 \text{ ft}^2 \times 350 \frac{Watts}{ft^2} = 778$ Watts

Heat Loss from Platen (vertical surfaces): $\frac{15” \times 2” \times 4 + 15” \times 2” \times 4}{144 \text{ in}^2/\text{ft}^2} = 1.7 \text{ ft}^2 \times 350 \frac{Watts}{ft^2} = 583$ Watts

Heat Loss from Platen (bare horizontal): $\frac{(15” \times 15” \times 2) - (10” \times 10” \times 2)}{144 \text{ in}^2/\text{ft}^2} = 1.7 \text{ ft}^2 \times 250 \frac{Watts}{ft^2} = 434$ Watts

Heat Loss from Platen (insul. horizontal): $\frac{15” \times 15” \times 2}{144 \text{ in}^2/\text{ft}^2} = 3.13 \text{ ft}^2 \times 100 \frac{Watts}{ft^2} = 313$ Watts

Safety Factor: (778 + 583 + 434 + 313) x 20% = 422 Watts

Total wattage losses at operating temperature: 2530 Watts

Total wattage required for heat-up: 7093 Watts

Total wattage required: 9623 Watts

POWER FORMULA EXAMPLE 2

Melting Calculation

An open top uninsulated steel tank measures 20” x 22” x 18” and weighs 140 lbs. The tank is used to melt 175 pounds of paraffin wax from room temperature (72°F) to 150°F in 3 hours.

We first find the properties of the materials we will be using:

Specific Heat of Steel:	0.12 BTU / Lb °F	Heat of Fusion of Paraffin:	63 BTU / Lb
Specific Heat of Solid Paraffin:	0.70 BTU / Lb °F	Wax Surface Loss @150°F:	55 Watts / ft²
Specific Heat of Melted Paraffin:	0.71 BTU / Lb °F	Steel Surface Loss @150°F:	70 Watts / Ft²
Melting Point of Paraffin:	133 °F	Wax Surface Area:	(20” x 22”)/144 = 3 ft²
		Tank Surface Area:	[(20” + 22”) x 18” x 2]/144 = 11 ft²

Formula A : Wattage required for heat-up

To Heat Tank: $\frac{140 \text{ (lbs)} \times 0.12 \text{ (BTU/Lb°F)} \times (150-72)\text{(°F)}}{3.412 \times 3 \text{ (hrs)}}$ = 128 Watts

To Heat Wax: $\frac{175 \text{ (lbs)} \times 0.70 \text{ (BTU/Lb°F)} \times (133-72)\text{(°F)}}{3.412 \times 3 \text{ (hrs)}}$ = 730 Watts

To Heat Melted Wax: $\frac{175\text{(lbs)} \times 0.71 \text{ (BTU/Lb°F)} \times (150-133)\text{(°F)}}{3.412 \times 3 \text{ (hrs)}}$ = 206 Watts

Safety Factor: (128 + 730 + 206) x 20% = 213 Watts

Total wattage required for heat-up: 1277 Watts

Formula C : Wattage required for melting

Heat of Fusion for Paraffin: $\frac{175 \text{ (lbs)} \times 63 \text{ (BTU/lb)}}{3.412 \times 3 \text{ (hrs)}}$ = 1077 Watts

Safety Factor: 1077 x 20% = 215 Watts

Total wattage required for melting: 1292 Watts

Formula B : Wattage losses at operating temperature

Heat loss from Paraffin: 3 ft² x 70 Watts/Ft² = 210 Watts

Heat Loss from tank (vertical surfaces): 11 ft² x 55 Watts/Ft² = 605 Watts

Safety Factor: (210 + 605) x 20% = 163 Watts

Total wattage losses: 978 Watts
Total wattage required for heat-up: 1277 Watts
Total wattage required for melting: 1292 Watts

Total wattage required: 3547 Watts