Product Cooling and Freezing Load

Refrigeration load to cool, freeze and sub-cool a product from specific heats above and below freezing and its latent heat, over a set pull-down time.

Method: Sensible and latent heat Q = m[c_1(T_1 − T_f) + L_f + c_2(T_f − T_2)] (ASHRAE Handbook—Refrigeration, load calculations)

Input parameters

Unit system: SI

Parameter	Value	Unit
Product mass per batch	2,000.0	kg
Entering temperature	30.000	°C
Freezing point	-2.0000	°C
Final temperature	-18.000	°C
Specific heat above freezing From a food or product data table; your figure.	3.6000	kJ/(kg·K)
Latent heat of freezing of the product	250.00	kJ/kg
Specific heat below freezing	1.9000	kJ/(kg·K)
Pull-down time	24.000	h

Calculated results

Parameter	Value	Unit
Cooling to the freezing point	64.000	kWh
Freezing	138.89	kWh
Sub-cooling	16.889	kWh
Total per batch	219.78	kWh
Average load over the pull-down	9.1574	kW

Notes for this case

• Average load; the early part of a pull-down needs more. Add packaging, respiration heat and a safety margin as your practice requires.

Formula and method

$$Q = m\left[c_1(T_1 - T_f) + L_f + c_2(T_f - T_2)\right], \quad \dot{Q} = \frac{Q}{t}$$

Variables

m	Product mass per batch	kg
T_1	Entering temperature	K
T_f	Freezing point	K
T_2	Final temperature	K
c_1	Specific heat above freezing	J/(kg·K)
L_f	Latent heat of freezing of the product	J/kg
c_2	Specific heat below freezing	J/(kg·K)
t	Pull-down time	s
Q_1	Cooling to the freezing point	J
Q_2	Freezing	J
Q_3	Sub-cooling	J

Q	Total per batch	J
$\dot{Q}$	Average load over the pull-down	W

Method and standards

Sensible and latent heat.

Assumptions and limits

- Freezing at one temperature, with all the latent heat released there and the product fully frozen; real foods freeze over a range and keep some unfrozen water, so the latent part is slightly overstated at moderate final temperatures.

References

- Sensible and latent heat Q = m[c_1(T_1 − T_f) + L_f + c_2(T_f − T_2)] (ASHRAE Handbook—Refrigeration, load calculations)

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/hvac/refrigeration/product-cooling-load

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.