Grain Bin Dryer: Water to Remove, Air Flow and Drying Time

Water to remove from a batch of grain, the air flow and its humidity pick-up from the air conditions, and the drying time and heat for a bin or batch dryer.

Method: Psychrometrics: humidity ratio 0.621945 p_v/(p − p_v); humid enthalpy 1006 t + x(2 501 000 + 1860 t); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Wet grain mass	20,000	kg
Initial moisture (wet basis)	22.000	%
Final moisture (wet basis)	14.000	%
Air flow per tonne of wet grain	3.0000	m³/min
Ambient air temperature	25.000	°C
Ambient relative humidity	70.000	%
Air temperature after heating	40.000	°C
Air temperature leaving the grain	27.000	°C
Pressure	1.0132	bar

Calculated results

Parameter	Value	Unit
Water to remove	1,860.5	kg
Dry air flow	3,969.1	kg/h
Humidity pick-up	5.2581	g/kg
Drying time	89.145	h
Heater duty	17.066	kW
Heat for the batch per kg of water	2,943.7	kJ/kg
Relative humidity of air leaving	84.970	%

Notes for this case

• A balance on the grain's dry matter gives the water to remove. Air from the fan, warmed a little, cools along a constant-enthalpy line as it picks up water from the grain; the humidity rise times the air flow is the drying rate, assuming the air leaves at the stated temperature (in practice it leaves near equilibrium with the grain, so drying slows as the grain dries). The estimate suits batch and in-bin drying with modest heat; deep beds dry as a moving front and need more air than this average suggests.

Formula and method

$$m_w = M\frac{w_0 - w_1}{1 - w_1}, \quad h(T_{in}, x_a) = h(T_{out}, x_o), \quad t = \frac{m_w}{\dot{m}_a(x_o - x_a)}$$

Variables

M	Wet grain mass	kg
w_0	Initial moisture (wet basis)	-
w_1	Final moisture (wet basis)	-
q	Air flow per tonne of wet grain	m³/s
T_a	Ambient air temperature	K
φ_a	Ambient relative humidity	-
T_{in}	Air temperature after heating	K

T_{out}	Air temperature leaving the grain	K
p	Pressure	Pa
m_w	Water to remove	kg
$\dot{m}_a$	Dry air flow	kg/s
Δx	Humidity pick-up	kg/kg
t	Drying time	s
$\dot{Q}$	Heater duty	W
E	Heat for the batch per kg of water	J/kg
φ_{out}	Relative humidity of air leaving	-

Method and standards

Grain dryer.

Assumptions and limits

- Average air outlet state over the batch; adiabatic bin.

References

Psychrometrics: humidity ratio 0.621945 p_v/(p − p_v), humid enthalpy 1006 t + x(2 501 000 + 1860 t), saturation pressure from IAPWS-IF97

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/chemical/drying/grain-dryer-airflow-time

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.