# Dryer Exhaust Air Recirculation: Humidity and Heat Saving

Inlet and exhaust humidity and heat per kg of water of an adiabatic hot-air dryer with part of the exhaust recirculated, compared with once-through air.

**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 |
|---|---|---|
| Ambient air temperature | 30.000 | °C |
| Ambient relative humidity | 60.000 | % |
| Air inlet temperature (after the heater) | 150.00 | °C |
| Exhaust temperature | 70.000 | °C |
| Share of fresh air in the heater feed | 50.000 | % |
| Pressure | 1.0132 | bar |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Ambient humidity ratio | 16.043 | g/kg |
| Exhaust humidity, once-through | 47.538 | g/kg |
| Heat per kg of water, once-through | 3,946.8 | kJ/kg |
| Exhaust humidity with recirculation | 82.807 | g/kg |
| Heat per kg of water with recirculation | 3,251.8 | kJ/kg |
| Heat saved | 17.609 | % |
| Exhaust relative humidity with recirculation | 38.158 | % |

### Notes for this case

• In an adiabatic dryer the air cools along a constant-enthalpy line, picking up water. Once-through, every kg of air is heated from ambient and thrown away still warm. Recirculating part of the warm, humid exhaust raises the humidity in the dryer but the heater then only needs to warm the mixture from a higher temperature, so the heat per kg of water falls. The limit is the exhaust humidity: too much recirculation slows drying and risks condensation in ducts and on the product. The steady state is found by iterating the mixing and drying balances.

## Formula and method

$$h_{in} = h_{out}, \quad x_m = f x_a + (1 - f) x_e, \quad q = \frac{h(T_{in}, x_m) - h_m}{x_e - x_m}$$

### Variables

| | | |
|---|---|---|
| $T_a$ | Ambient air temperature | K |
| $\varphi_a$ | Ambient relative humidity | - |
| $T_{in}$ | Air inlet temperature (after the heater) | K |
| $T_{out}$ | Exhaust temperature | K |
| $f$ | Share of fresh air in the heater feed | - |
| $p$ | Pressure | Pa |
| $x_a$ | Ambient humidity ratio | kg/kg |
| $x_{e,1}$ | Exhaust humidity, once-through | kg/kg |
| $q_1$ | Heat per kg of water, once-through | J/kg |

| | | |
|---|---|---|
| $x_{e,2}$ | Exhaust humidity with recirculation | kg/kg |
| $q_2$ | Heat per kg of water with recirculation | J/kg |
| $1 - q_2/q_1$ | Heat saved | - |
| $\varphi_{e,2}$ | Exhaust relative humidity with recirculation | - |

### Method and standards

Recirculation.

### Assumptions and limits

- Adiabatic dryer; humid enthalpy with constant specific heats.

### 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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|---|---|
| Report reference | FCC-WFND-CRNW (the same inputs always give the same reference) |
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| Software release | FireCAD Calc, release of 22 November 2026 |
| 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/dryer-air-recirculation-saving

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.