Exergy of Steam and of Heat at a Temperature (IAPWS-IF97)

Specific and flow exergy of steam or water at a pressure and temperature relative to a dead state, and the exergy of a heat flow at a temperature (Carnot factor).

Method: IAPWS-IF97 (FireCAD engine); exergy e = h − h_0 − T_0(s − s_0) and E_Q = Q(1 − T_0/T) (Bejan, Tsatsaronis and Moran, Thermal Design and Optimization, Wiley, 1996)

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam pressure (absolute)	10.000	bar
Steam temperature	250.00	°C
Steam flow	10.000	t/h
Dead-state (ambient) temperature	25.000	°C
Dead-state pressure (absolute)	101.33	kPa
Heat flow (for the heat exergy)	1,000.0	kW
Temperature at which the heat is available	150.00	°C

Calculated results

Parameter	Value	Unit
Enthalpy	2,943.2	kJ/kg
Entropy	6.9266	kJ/(kg·K)
Specific exergy	882.61	kJ/kg
Exergy flow of the steam	2,451.7	kW
Exergy share of the energy above the dead state	31.097	%
Exergy of the heat flow	295.40	kW

Notes for this case

- Exergy is the maximum work obtainable by bringing the stream to the dead state; its destruction marks where a plant loses useful energy.

Formula and method

$$e = (h - h_0) - T_0(s - s_0), \quad \dot{E} = \dot{m}e, \quad \dot{E}_Q = Q\left(1 - \frac{T_0}{T_Q}\right)$$

Variables

p	Steam pressure (absolute)	Pa
T	Steam temperature	K
$\dot{m}$	Steam flow	kg/s
T_0	Dead-state (ambient) temperature	K
p_0	Dead-state pressure	Pa
Q	Heat flow (for the heat exergy)	W
T_Q	Temperature at which the heat is available	K
h	Enthalpy	J/kg
s	Entropy	J/(kg·K)
e	Specific exergy	J/kg
$\dot{E}$	Exergy flow of the steam	W

$e/(h-h_0)$	Exergy share of the energy above the dead state	-
$\dot{E}_Q$	Exergy of the heat flow	W

Method and standards

Exergy definitions with IAPWS-IF97 properties.

Assumptions and limits

- Physical exergy only; kinetic and chemical exergy excluded.
- The exergy share is shown as 0 when the stream is at the dead-state enthalpy; below it (cold water) the share is not meaningful and a note appears.
- The dead state must be liquid water: T_0 below the saturation temperature at p_0.
- Heat at a temperature below ambient (T_Q < T_0) gives a negative exergy of heat: the exergy flows opposite to the heat, as in refrigeration.

References

• IAPWS-IF97 (FireCAD engine); exergy $e = h - h_0 - T_0(s - s_0)$ and $E_Q = Q(1 - T_0/T)$ (Bejan, Tsatsaronis and Moran, Thermal Design and Optimization, Wiley, 1996)

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/boilers-power-plant/steam/exergy-steam-and-heat

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Reopens the calculator with the inputs of this report.