Feedwater Heater Extraction Steam Flow

Extraction steam a closed feedwater heater needs for a feedwater temperature rise, with terminal temperature difference and drain cooler approach (IAPWS-IF97).

Method: IAPWS R7-97(2012) IF97; HEI Standards for Closed Feedwater Heaters (terms)

Input parameters

Unit system: SI

Parameter	Value	Unit
Feedwater flow	216,000	kg/h
Feedwater pressure (absolute)	180.00	bar
Feedwater inlet temperature	200.00	°C
Feedwater outlet temperature	240.00	°C
Extraction steam pressure at the heater (absolute)	40.000	bar
Extraction steam condition	Superheated at the temperature below	
Extraction steam temperature (superheated only)	350.00	°C
Drain leaving the heater	Sub-cooled by a drain cooler (DCA)	
Drain cooler approach Drain temperature minus feedwater inlet temperature; used only with a drain cooler.	5.6000	K

Calculated results

Parameter	Value	Unit
Extraction steam flow	17,579	kg/h
Extraction per kg of feedwater	8.1382	%
Heat duty	10,815	kW
Shell saturation temperature	250.36	°C
Terminal temperature difference	10.358	K
Drain temperature	205.60	°C
Feedwater inlet enthalpy	859.47	kJ/kg
Feedwater outlet enthalpy	1,039.7	kJ/kg
Extraction steam enthalpy	3,093.3	kJ/kg
Drain enthalpy	878.56	kJ/kg

Formula and method

$$\dot{Q} = \dot{m}_{fw}\left(h_{fw,2} - h_{fw,1}\right) \qquad \dot{m}_e = \frac{\dot{Q}}{h_e - h_d}$$

$$TTD = T_{sat,e} - T_{fw,2} \qquad T_d = T_{fw,1} + DCA \ \text{(drain cooler)} \quad \text{or} \quad T_d = T_{sat,e}$$

Variables

$\dot{m}_{fw}$	feedwater flow	kg/s
p_{fw}	feedwater absolute pressure	Pa
$T_{fw,1}$	feedwater inlet temperature	K

$T_{fw,2}$	feedwater outlet temperature	K
p_e	extraction steam absolute pressure at the heater	Pa
state	dry saturated, or superheated at T_e	–
T_e	extraction steam temperature when superheated	K
drain	saturated drain, or drain cooler with DCA	–
DCA	drain cooler approach	K
$\dot{m}_e$	extraction steam flow	kg/s
$\dot{m}_e/\dot{m}_{fw}$	extraction per kg of feedwater	–
$\dot{Q}$	heat duty	W
$T_{sat,e}$	shell saturation temperature at p_e	K
TTD	terminal temperature difference	K
T_d	drain temperature	K
$h_{fw,1}$	feedwater inlet enthalpy	J/kg
$h_{fw,2}$	feedwater outlet enthalpy	J/kg
h_e	extraction steam enthalpy	J/kg
h_d	drain enthalpy	J/kg

Method and standards

First-law balance with enthalpies from FireCAD's IAPWS-IF97 implementation; TTD and DCA as defined in the HEI Standards for Closed Feedwater Heaters.

Assumptions and limits

- No drains cascaded in from a higher-pressure heater; for a heater that receives drains, subtract their heat from the duty first.
- No shell heat loss; the drain leaves at the extraction pressure.
- Pressure drop in the extraction line is included by entering the pressure at the heater.
- With dry saturated steam the feedwater must leave below the shell saturation temperature; with superheated steam it must leave below the steam temperature. A negative TTD (desuperheating zone) is allowed only with superheated steam.
- A warning appears when the drain cooler approach puts the drain above the feedwater outlet.

References

• IAPWS R7-97(2012) IF97
• HEI Standards for Closed Feedwater Heaters (terms)

Report details

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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/feedwater-heater-extraction

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Reopens the calculator with the inputs of this report.