Molecular Sieve: Water Load and Regeneration Heat

Water a molecular sieve removes, desiccant per bed for a cycle at a water loading, and heat of desorption at 1 800 BTU/lb (Alcohol Textbook ch. 23).

Method: Jacques; Lyons and Kelsall (eds.); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Anhydrous ethanol product	10,000	kg/h
Ethanol in the feed vapour (mass)	92.500	%
Water allowed in the product (mass)	0.20000	%
Adsorption period per bed	6.0000	min
Working water loading of the sieve Type 3A sieve can hold up to 22 % of its weight; pressure-swing units run far lower to limit the temperature swing.	8.0000	%
Heat of desorption Alcohol Textbook: 1 800 BTU per lb of water = 4 186.8 kJ/kg.	4,186.8	kJ/kg

Calculated results

Parameter	Value	Unit
Feed vapour	10,789	kg/h
Water removed	789.19	kg/h
Water adsorbed per cycle	78.919	kg
Desiccant per bed	986.49	kg
Heat of desorption of the water removed	917.83	kW

Notes for this case

- Part of the dry product (often a fifth to a third) is used to purge the regenerating bed and returns to the rectifier; the feed here excludes that recycle.
- The heat shown is the whole heat of desorption, not the external heat demand: much of it comes from heat stored in the bed during adsorption.

Formula and method

$$\dot{m}_f = \frac{\dot{m}_E(1 - x_p)}{x_f}, \quad \dot{m}_w = \dot{m}_f - \dot{m}_E, \quad m_s = \frac{\dot{m}_w t_c}{q}, \quad \dot{Q} = \dot{m}_w \Delta h_d$$

Variables

$\dot{m}_E$	Anhydrous ethanol product	kg/s
x_f	Ethanol in the feed vapour (mass)	-
x_p	Water allowed in the product (mass)	-
t_c	Adsorption period per bed	s
q	Working water loading of the sieve	-
Δh_d	Heat of desorption	J/kg
$\dot{m}_f$	Feed vapour	kg/s
$\dot{m}_w$	Water removed	kg/s
$m_{w,c}$	Water adsorbed per cycle	kg
m_s	Desiccant per bed	kg

$\dot{Q}$	Heat of desorption of the water removed	W

Method and standards

Mass balance and the heat of desorption.

Assumptions and limits

- Water removed only by adsorption.
- The heat is the full heat of desorption of the water removed, not the external heat to supply: much of it is the heat stored in the bed during adsorption.

References

• Jacques
• Lyons and Kelsall (eds.)
• The Alcohol Textbook
• 4th ed. (Nottingham University Press, 2003)
• ch. 23 (Swain)
• development and operation of the molecular sieve
• Mass balance of ethanol and water

Report details

Report reference	FCC-MCX5-9RVG (the same inputs always give the same reference)
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Calculator	Molecular Sieve: Water Load and Regeneration Heat
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Release checks	2 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/sugar-ethanol/ethanol-distillation/molecular-sieve-desorption-heat

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.