Boiler Chemical Cleaning: Acid for a Magnetite Deposit

Hydrochloric acid to dissolve a magnetite (Fe_3O_4) deposit by stoichiometry, with an excess, and the acid solution mass and volume at a strength.

Method: $Fe_3O_4 + 8\ HCl \rightarrow FeCl_2 + 2\ FeCl_3 + 4\ H_2O$ with IUPAC atomic masses

Input parameters

Unit system: SI

Parameter	Value	Unit
Deposit (as Fe_3O_4)	400.00	kg
Excess acid	50.000	%
HCl strength of the cleaning solution	5.0000	%
Solution density	1,025.0	kg/m³

Calculated results

Parameter	Value	Unit
HCl (100 %) needed	755.83	kg
Cleaning solution	15.117	t
Solution volume	14.748	m³

Notes for this case

- Inhibited acid and the solution volume to fill the circuit both set the batch; use the larger quantity.

Formula and method

$$m_{HCl} = m_d \frac{8 M_{HCl}}{M_{Fe_3O_4}} (1 + k_x), \quad m_s = \frac{m_{HCl}}{w}, \quad V_s = \frac{m_s}{\rho}$$

Variables

m_d	Deposit (as Fe_3O_4)	kg
k_x	Excess acid	-
w	HCl strength of the cleaning solution	-
ρ	Solution density	kg/m³
m_{HCl}	HCl (100 %) needed	kg
m_s	Cleaning solution	kg
V_s	Solution volume	m³

Method and standards

Stoichiometry of magnetite dissolution in hydrochloric acid, $Fe_3O_4 + 8\ HCl \rightarrow FeCl_2 + 2\ FeCl_3 + 4\ H_2O$, with IUPAC atomic masses; the acid is raised by the excess entered and diluted to the solution strength.

Assumptions and limits

- Magnetite only. The ferric chloride formed attacks the base metal and consumes more acid (often controlled with a reducing agent); copper and other deposits also take acid. The excess is the only allowance for all of these.

References

- $Fe_3O_4 + 8\ HCl \rightarrow FeCl_2 + 2\ FeCl_3 + 4\ H_2O$ with IUPAC atomic masses

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/water-treatment/chemical-cleaning-acid

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Reopens the calculator with the inputs of this report.