ESP Collection Efficiency and Area (Deutsch–Anderson)

Collection efficiency of an electrostatic precipitator from its plate area, gas flow and migration velocity, and the area for a target efficiency.

Method: Deutsch (1922); Anderson; White; Industrial Electrostatic Precipitation (1963)

Input parameters

Unit system: SI

Parameter	Value	Unit
Gas flow through the ESP (actual)	216,000	m³/h
Effective migration velocity Depends on the dust's resistivity and particle size; take it from the ESP maker or from tests on a similar plant.	0.080000	m/s
Collecting plate area	4,000.0	m²
Target efficiency (for the area required)	99.500	%
Dust at the ESP inlet Any basis (actual, normal, dry or wet); the outlet value comes out on the same basis. Only the ratio is used.	40,000	mg/Nm³

Calculated results

Parameter	Value	Unit
Collection efficiency	99.517	%
Dust at the ESP outlet	193.12	mg/Nm³
Plate area for the target efficiency	3,973.7	m²
Specific collecting area A/Q	66.667	m²/(m³/s)
Penetration	0.48279	%

Formula and method

$$\eta = 1 - e^{-wA/Q} \qquad A_{req} = -\frac{Q\,\ln(1-\eta_t)}{w} \qquad SCA = \frac{A}{Q} \qquad c_{out} = c_{in}(1-\eta)$$

Variables

Q	gas flow through the ESP, actual	m³/s
w	effective migration velocity	m/s
A	collecting plate area	m²
η_t	target efficiency	–
c_{in}	dust at the ESP inlet	kg/m³
η	collection efficiency	–
c_{out}	dust at the ESP outlet	kg/m³
A_{req}	plate area for the target efficiency	m²
SCA	specific collecting area	s/m
$1-\eta$	penetration	–

Method and standards

The Deutsch–Anderson equation for the collection efficiency of an electrostatic precipitator, with an effective migration velocity that lumps the electrical and particle properties (Deutsch 1922; White, Industrial Electrostatic Precipitation, 1963).

Assumptions and limits

- Effective migration velocity from experience; the equation itself does not predict it.
- Uniform gas distribution and no re-entrainment or sneakage; real ESPs fall short of the ideal at very high efficiencies.

- The outlet concentration is on the same basis (dry or wet, reference conditions) as the inlet value; the mg/Nm³ unit shown is only a label for that basis.
- A note appears above 99.9 %, where real ESPs fall short of the ideal.
- SCA is shown in s/m (m² per m³/s) in every unit system; for ft² per 1000 acfm multiply by 5.08.

References

- Deutsch (1922); Anderson; White
- Industrial Electrostatic Precipitation (1963)

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/emissions-stacks/esp-collection-efficiency

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.