Sulphuric Acid Dew Point of Flue Gas

Acid dew point by Verhoff–Banchero from flue gas water vapour and SO_3, with SO_3 entered directly or estimated from fuel sulphur.

Method: Verhoff & Banchero (1974); ASME PTC 4.3 air heaters

Input parameters

Unit system: SI

Parameter	Value	Unit
Water vapour in flue gas Wet basis, by volume.	10.000	%
Flue gas pressure (absolute)	1.0132	bar
SO_3 source	Estimate from fuel sulphur	
Sulphur in fuel (as fired)	2.5000	%
Specific wet flue gas volume Nm³ of wet flue gas per kg of fuel at 0 °C and 101.325 kPa (normal), wet basis, as the combustion calculator gives it. A volume at 15 or 20 °C understates SO_2 by 5–7 %.	10.000	Nm³/kg
$SO_2 \rightarrow SO_3$ conversion Typically 1–3 % for coal, 2–5 % for heavy oil with vanadium.	2.0000	%
SO_3 in flue gas	15.000	ppm

Calculated results

Parameter	Value	Unit
Acid dew point	150.14	°C
SO_3 used in the correlation	0.003496	%
SO_2 from the fuel sulphur	0.17478	%
Partial pressure of water vapour	0.10132	bar
Partial pressure of SO_3	3.5419e-05	bar

Formula and method

$$\frac{1000}{T_{dp}} = 2.276 - 0.02943 \ln p_{H_2O} - 0.0858 \ln p_{SO_3} + 0.0062 \ln p_{H_2O} \ln p_{SO_3}$$

$$p_{H_2O} = y_{H_2O}\, p \qquad p_{SO_3} = y_{SO_3}\, p$$

$$y_{SO_2} = \frac{S/M_S \cdot V_m}{V_g} \qquad y_{SO_3} = f_{SO_3}\, y_{SO_2}$$

Variables

T_{dp}	sulphuric acid dew point	K
y_{H_2O}	water vapour in wet flue gas, volume fraction	–
p	absolute flue gas pressure	Pa
mode	SO_3 estimated from fuel sulphur, or entered	–
S	sulphur in the fuel as fired, mass fraction	–
M_S	molar mass of sulphur, 32.06	kg/kmol
V_m	molar volume at 0 °C and 101.325 kPa, 22.414	Nm³/kmol
V_g	wet flue gas volume per kg fuel, at 0 °C and 101.325 kPa	Nm³/kg

f_{SO_3}	fraction of SO_2 converted to SO_3	–
y_{SO_2}	SO_2 in wet flue gas, volume fraction	–
$y_{SO_3,in}$	SO_3 entered directly, volume fraction	–
y_{SO_3}	SO_3 used in the correlation	–
p_{H_2O}	partial pressure of water vapour (converted to mmHg in the correlation)	Pa
p_{SO_3}	partial pressure of SO_3 (converted to mmHg in the correlation)	Pa

Method and standards

The Verhoff–Banchero correlation is widely used in boiler and air-heater design practice. It was fitted to measured dew points with partial pressures in mmHg; the calculator converts the SI partial pressures to mmHg (1 mmHg = 133.322 Pa) before taking the logarithms. Entering the pressures in atmospheres instead, a common mistake, gives dew points about 125 K too low.

Assumptions and limits

- Fitted range roughly 5–15 % H_2O and 1–100 ppm SO_3; outside it the result is indicative.
- The SO_2 estimate assumes all fuel sulphur reaches the gas (no sulphur retained in ash or sorbent). For fluidised beds with limestone, enter the measured SO_2 or SO_3 directly.
- A separate water dew point governs when SO_3 is nil.

References

• Verhoff & Banchero (1974)
• ASME PTC 4.3 air heaters

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/furnace-heating-surfaces/acid-dew-point

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Reopens the calculator with the inputs of this report.