Probe in Hot Gas: Radiation Error of a Thermocouple or Lance

Temperature a bare thermocouple, probe or soot-blower lance reaches in hot gas with cooler walls around it, and its radiation error.

Method: Ganapathy; Industrial Boilers and Heat Recovery Steam Generators (Marcel Dekker, 2003); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Gas temperature	1,093.3	°C
Surrounding wall temperature	204.44	°C
Gas-to-probe convective coefficient	85.170	W/(m²·K)
Probe emissivity	90.000	%
Wall emissivity	90.000	%

Calculated results

Parameter	Value	Unit
Probe temperature	678.70	°C
Radiation error (gas minus probe)	414.63	K
Heat flux through the probe surface	35.314	kW/m²

Notes for this case

• Effective emissivity taken as ε_p·ε_w, as in Ganapathy's example; conduction along the probe is neglected. A suction (aspirated) pyrometer raises h and cuts the error.

Formula and method

$$h_c(T_g - T_p) = \sigma \varepsilon_p \varepsilon_w \left(T_p^4 - T_w^4\right)$$

Variables

T_g	Gas temperature	K
T_w	Surrounding wall temperature	K
h_c	Gas-to-probe convective coefficient	W/(m²·K)
ε_p	Probe emissivity	-
ε_w	Wall emissivity	-
T_p	Probe temperature	K
$T_g - T_p$	Radiation error (gas minus probe)	K
q	Heat flux through the probe surface	W/m²

Method and standards

Convection–radiation balance.

Assumptions and limits

- Steady state; no conduction along the probe.
- Effective emissivity ε_p ε_w as in Ganapathy. For a small probe in a large enclosure the classical exchange uses ε_p alone, which gives a larger radiation error than shown here.

References

• Ganapathy
• Industrial Boilers and Heat Recovery Steam Generators (Marcel Dekker, 2003)
• Q8.09b (soot blower lance temperature: convection–radiation balance)

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/instrumentation/temperature/probe-radiation-temperature-error

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.