Paul David Process Ltd

Understanding ideal gas ratio of specific heats (part 2)

Introduction

The ideal gas ratio of specific heats is used in the API 520 formulae for calculating pressure relief valve required area. Process simulators typically report the specific heat at constant pressure (Cp) in the stream summary and this is often used to calculate Cp/Cv using the relationship Cp - Cv = R. Only the ideal gas Cp should be used – this is not the same as the real Cp. The following is a simple illustration of why they are different.

Ideal gas Cp vs real gas Cp

The following equations all assume the use of a consistent set of units

Molar enthalpy H is given by

$$dH = dU + d(PV)$$

For 1 mol of an ideal gas PV=RT, therefore

$$dH = dU + RdT$$

$$Cp = dH/dT = dU/dT + R$$

$$Cp = Cv + R$$

$$Cp/Cv = Cp/(Cp-R)$$

For a real gas

$$dH = dU + d(PV)$$

For 1 mol of a real gas we could write PV=ZRT where Z is the compressibility factor, therefore

$$dH = dU + ZRdT$$

(assuming Z and R are constant for 1 degree C change in temperature).

$$Cp = Cv + ZR$$

$$Cp/Cv = Cp/(Cp-ZR)$$

Therefore real gas Cp and Cp/Cv deviates from ideal gas Cp and Cp/Cv as Z deviates from 1.

Conclusion

Care should be taken when extracting Cp from process simulators for relief valve calculations.

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