PT 111
Gas cooling effect and pressure regulators
June 16, 2026

Overview

Gases expanding from high pressure to low pressure results in a cooling effect known as Joule-Thomson (JT) cooling. The amount of pressure drop and the gas characteristics varies the amount of cooling. Source applications, where the initial pressure drop occurs, is the primary concern – high pressure drop going from cylinder pressure to generally less than 100 psig (0.7 MPag). Line, point of use, applications have a low pressure differential which makes the cooling effect insignificant.

The scope of this document is considerations for mitigating the gas cooling effect in a pressure regulator. System heating design and associated recommendations are beyond the purview of Pure T as it involves understanding the gas system, source vessel, gas demand (flow rates and duration), facilities available, local code requirements, etc. – in other words, requires a gas system design engineer.

Cooling issues

External moisture: As the surface temperature of the regulator drops below the dew point of the air surrounding the regulator, moisture will condense on the exterior of the regulator. Typically, moisture condensation is not a problem for the regulator itself but moisture dripping on other devices, such as transducers or flow switches, can be a problem.

Icing: Frost or ice on the exterior of the regulator is cause for concern. Ice forming can impede the operation of the device, such as adjustment load spring function if ice forms in the cap. If the temperature drops below the rating of the seat material, the seat can fail. Frosting requires attention and potentially actions to mitigate.

Process gas: Gas liquification is a function of temperature and pressure and it can occur in the low pressure side (outlet) of a pressure regulator due to JT effect. If liquid forms in the regulator outlet side, the gas will flash off returning to a gaseous state as the temperature rises. This can cause pressure spikes which potentially cause damage to the regulator itself or downstream devices.

Gases, even UHP grade with advanced purge techniques for cylinder change out, can

have impurities that condense and precipitate from the gas stream. Moisture condensing can lead to internal corrosion and leak to atmosphere with a corrosive gas. Particles precipitate at the point of pressure drop, the seat, which can cause an across the seat leak.

Counter measures

Two stage regulation, two discrete regulators in series, separates the pressure drop into two steps. This effectively divides the cooling effect between the pressure drops which limits the cooling per regulator. Two stage regulation also enables heating the gas twice before each pressure drop to more effectively transfer heat to the gas, while limiting the maximum heating temperature required per regulator.

Heating: Increasing the gas temperature shifts the gas enthalpy curve by the amount of heat transferred. The same total temperature drop occurs as a result of the pressure drop, but the lowest temperature is increased by the amount of heating. Increasing the lowest temperature helps prevent approaching the point that the gas ices or liquifies. Heating needs to be limited to 120° F (48.9° C) to prevent exceeding 125° F (51.7° C), the maximum allowable source vessel temperature per regulations such as CGA Pamphlet P-1 and gas suppliers recommendations. Temperature must also not exceed the maximum of the component manufacturer's rating.

Heat tracing is a means to heat a gas and is best if applied to the piping prior to the regulator. Heating the regulator itself is less than optimal due to the small surface area exposed to the gas and the residency time of the gas. If heating the regulator, tracing must only be applied to the body of the device. Heating the spring housing or cap nut does not properly transfer heat to the gas. Care must be exercised to ensure that the temperature does not spike above the maximum temperature rating of the system as gas flow abruptly stops along with the associated cooling effect.

Heat exchanger is an effective means of transferring heat to a gas prior to pressure reduction.

Heating source cylinder is another means of heating the gas, however care must be exercised to only heat within recommendations of the gas supplier and compliance with applicable codes and regulations.

Moisture condensation on the exterior of a device can be addressed with a flow of low moisture gas, such as CDA or N2, over the device or by an air circulating fan directed at the device. The effectiveness can vary depending upon the humidity of the local air. The beads of moisture can also simply be ignored if not causing collateral damage to another device.

Conclusion

Safe gas delivery and gas system design requires an understanding of the JT cooling effect and how it relates to specific gases. The gas system designer is responsible for engineering appropriate counter measures.