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Sizing Rupture Disk Vent Line Systems for High-velocity Gas Flows

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Abstract

In the chemical and petrochemical industry, vessels and pipes are protected against overpressure using safety relief devices, usually rupture disks (also called a bursting disc) or safety valves installed in a vent-line. Proper sizing of rupture disk vent-line system involves fluid dynamic coupling of the rupture disk device and the entire vent-line with all its fittings. Sizing requires correct consideration of the fitting's and piping's minor loss coefficients to determine of the pressure drop and dischargeable mass flow rate. A fitting's minor loss coefficient is typically determined under low-velocity and incompressible flow. It is however not precisely applicable for all plausible flow cases that occur in practice especially for high-velocity compressible gas flow, two-phase flow, flashing liquids or multiphase service without proper consideration of compressibility. Experiments show that rupture disk irreversible pressure drop, determined assuming a constant minor loss coefficient, with current methods is underestimated by at least 30% for high-velocity compressible gas flow. This is because the compressibility is not accurately considered there and the pressure profile calculated this way is faulty.

This work presents a scientific method to calculate the pressure profile and dischargeable mass flow rate in a vent-line system with a rupture disk installed seamlessly. The pipe and rupture disk loss coefficients are enhanced to factor compressibility fully. Experiments show that this method predicts the pressure profile along a vent-line with a rupture disk installed and the dischargeable mass flow rate better as compared to current methods. The method is applicable for both low-velocity and high-velocity compressible gas flow as is typically the case during pressure relief.

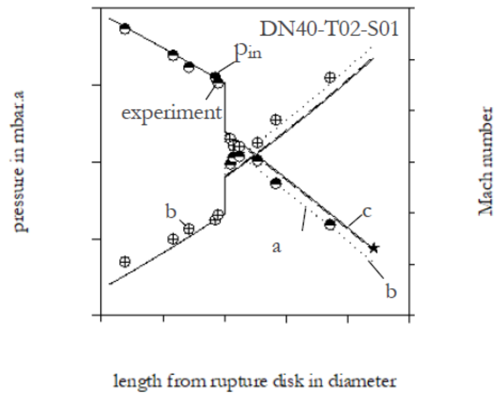

Figure 1 Predicted pressure profile a rupture disk (low-velocity flow)

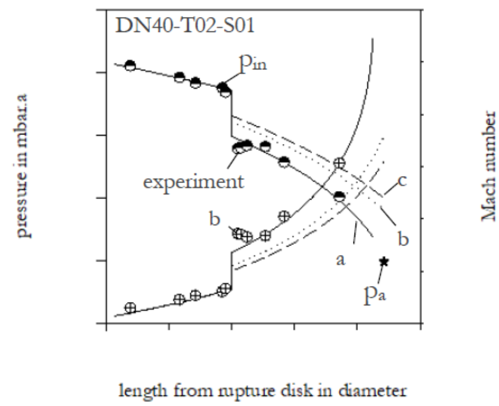

Figure 2 Predicted pressure profile a rupture disk (high-velocity flow)

a: New-theory b: (Levenspiel, 1998) c: (ASME, 2014)

Keywords: Rupture disk, Flow area, Minor loss coefficient, Pressure drop, Dischargeable Mass Flow Rate