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Compressed Gas Association

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# CGA TR-7—2023

## METHODOLOGY TO DETERMINE PIPING FAILURE RATES FOR NONTOXIC CRYOGENIC INDUSTRIAL GAS SUPPLY SYSTEMS WITH PIPE SIZE UP TO 6 INCHES

**FIRST EDITION**

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# 1 Executive summary

This technical report applies to 300 series austenitic stainless steel piping up to and including 6 inches in diameter, suitable for nontoxic cryogenic service, and where the design pressure stress of pipe and tube does not exceed one half of the basic allowable stress.

Small scale industrial gas installations, and in particular ones for cryogenic service, need reasonable equipment failure rates to drive risk informed frameworks for siting and guideline setbacks. Current failure rate guidance does not fit well for small scale and is unnecessarily conservative. The study of recent efforts in this area demonstrates interest but no useful guidance on approaches.

Such guidance should be practical in its application and transparent in its design basis. The publicly available Hydrocarbon Release Database (HSE Hydrocarbon Release Database, www.hse.gov.uk/offshore/statistics) (HCRD) for leak rates is used to generate a universal failure rate equation that has small scale and cryogenic considerations included [1].[1]

$$FFcryo(d1, d2, D) = \left[\frac{1}{1+\left(\frac{\frac{d2}{mm}}{1.5}\right)^{-1.5}} - \frac{1}{1+\left(\frac{\frac{d1}{mm}}{1.5}\right)^{-1.5}}\right]\cdot\left[\left(2.539 + 25.2\cdot e^{\frac{\frac{-D}{mm}}{29.412}}\right)\cdot 10^{-5}\right]\cdot 40\%\cdot\frac{1}{m\cdot yr}$$

Additionally, a simplified approach to estimate equipment limits is developed that allows for quick estimates of system aggregate risks using an equivalent length approach.

**Table 1—Equivalent length of various equipment**

| Equipment type | Equivalent length (m) | Notes |
|---|---|---|
| Pipe or tube (per meter) | 1 | Welded joints are assumed to be part of this equipment type and are not subject to additional equivalent length consideration |
| Static mechanical joints (each) | 1 | These are mechanical seals held in place by some threaded, bolted, crimped, or swaged joint |
| Valves (each) | 2 | This is for any valve that has a body seal and packing. Features such as flanged inlets, 2-piece bodies, etc. do not require additional equivalent length. Automatic valves that have more than 96 full cycles (full return to starting position as in open to closed and returning to open) in an 8-hour period shall be evaluated as a dynamic seal at the nominal diameter of the shaft being sealed. |
| Hose not under flexure (per meter) | 20 | Hoses are assumed to be stainless steel, corrugated, and reinforced with a stainless-steel braid and properly maintained in accordance with CGA P-82, *Standard for Maintenance of Transfer Hoses* [2]. |
| Dynamic seals and hoses (bellows) under flexure (each) | $350 - 349\cdot e^{\left(\frac{-cycles}{10^7}\right)}$ | This equivalent length should be added to the aggregate of shaft diameters for valves, pumps, and compressors. For hoses in flexure, they should be aggregated against the full inside diameter of the hose corrugation.<br>Cycles= the annual number of full design cycles. When less than full cycle range can be demonstrated, the annual number of full cycles can be pro-rated accordingly. |
| Make-and-break connections (each) | $350 - 349\cdot e^{\left(\frac{-breaks}{10^2}\right)}$ | This equivalent length should be added to the aggregate for the full piping diameter being assessed<br>Breaks= the annualized number of connect breaks. |

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.