



INDUSTRIAL GAS PIPELINE INTEGRITY MANAGEMENT

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This publication is intended as an international harmonised standard for the worldwide use and application of all members of the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association, and Japan Industrial and Medical Gases Association (JIMGA). Each association's technical content is identical, except for regional regulatory requirements and minor changes in formatting and spelling.

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1 Introduction

Operation and maintenance guidelines for transmission pipelines are an important requirement due to the hazardous nature of certain gases and the presence of the pipelines through the public domain.

2 Scope and purpose

2.1 Scope

This publication covers the integrity of industrial gas transmission pipelines for gaseous nitrogen, oxygen, argon, helium, hydrogen, carbon monoxide, and Syngas. This publication addresses the integrity of industrial gas pipelines in the public domain including maintenance and operation as appropriate.

This publication covers active or in-service pipelines. Out of service or abandoned pipelines are not covered in this publication. However, the information contained in this publication may be applicable to those pipelines.

This publication addresses land-based pipelines and does not specifically address offshore pipelines.

This publication does not cover:

- Carbon dioxide, steam, natural gas, or water;
- Liquid pipelines;
- Pipelines fabricated from non-metallic material such as plastic or composite material; and
- Design of pipelines. For information on design, see EIGA Doc 121, *Hydrogen Pipeline Systems*, EIGA Doc 120, *Carbon Monoxide and Syngas Pipeline Systems*, and EIGA Doc 13, *Oxygen Pipeline and Piping Systems* [1, 2, 3].¹

To the extent that they exist, national laws can supersede the practices included in this publication. It should be noted that all local regulations, tests, safety procedures, or methods are not included in this publication and that abnormal or unusual circumstances could warrant additional requirements.

2.2 Purpose

Managing the integrity of a gas pipeline system is one of the goals of every pipeline system operator. Pipeline system operators' primary goal is the safe and reliable continuous operation of the pipeline to provide safe and reliable delivery of industrial gas to their customers without interruptions, adverse effects on employees, the public, or the environment.

The goal of an integrity management programme is to provide a set of safety management, operations, maintenance, evaluation, and assessment processes that are implemented in a manner to ensure pipeline system operators provide enhanced protection of pipeline assets.

The purpose of this publication is to guide individuals and teams charged with planning, implementing, and improving a pipeline integrity management programme. The pipeline integrity team typically consists of managers, engineers, and operating personnel with specific competence in detection, prevention, and mitigation activities.

3 Definitions

For the purpose of this publication, the following definitions apply.

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

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Area(s) of concern

Specific locales and areas where a release could have significant adverse effects.

3.2.2 Cathodic protection

Technique to reduce the corrosion rate of a metal surface by making that surface the cathode of an electrochemical cell [4].

3.2.3 External corrosion direct assessment

Four step process that combines pre-assessment, indirect inspection, direct examination, and post assessment to evaluate the effect of external corrosion on the integrity of a pipeline [4].

3.2.4 In-line inspection

Inspection of a pipeline from the interior of the pipe using an in-line inspection tool.

NOTE The tools used to conduct in-line inspection are known as pigs or smart pigs [5].

3.2.5 Maximum allowable operating pressure (MAOP)

Maximum internal pressure permitted during the operation of a pipeline [4].

3.2.6 Performance based integrity management programme

Process that uses risk management principles and risk assessments to determine prevention, detection, and mitigation actions and their timing (risk based) [6].

NOTE An example includes integrity assessment.

3.2.7 Pipeline(s)

Underground or aboveground piping system used to convey gaseous or liquid product from a producing facility, crossing third-party, or public property (for example, public road) to a customer's use point on their property.

NOTE This normally necessitates the use of external governmental requirements depending on region.

NOTE This definition does not include interplant process piping, which is underground or aboveground piping used to convey gaseous product from a producing facility to a customer's use point on their property without crossing a third-party or public property.

3.2.8 Prescriptive integrity management programme

Integrity management process that follows pre-set conditions that result in fixed inspection and mitigation activities and timelines (time-based) [6].

NOTE Examples include patrolling and cathodic protection monitoring.

NOTE Many pipeline system operators use a combination of both prescriptive and performance-based integrity management programmes.

3.2.9 Segment(s)

Length of a pipeline or part of the system that has unique characteristics in a specific geography location.

3.2.10 Status

3.2.10.1 Abandoned

Permanently removed from service.

NOTE Pipeline may not be under pressure, may not be under a nitrogen blanket or water blanket, and is physically isolated from other pipelines via cutting and capping or installing a blind flange.

3.2.10.2 Active

Pipeline under pressure and is flowing product.

3.2.10.3 In service

Pipeline is under pressure, contains a product, and is not flowing.

3.2.10.4 Out of service

Pipeline is under pressure, under an inert gas blanket, and is not flowing product.

4 Hazards of gases

This publication does not cover the hazards of gases in detail. For more detailed information on hazards, see the following publications:

- Safety data sheets (SDS);
- EIGA Doc 23.03, *Oxygen* [7];
- EIGA Doc 13 [3];
- EIGA Doc 121 [1];

- EIGA Doc 120 [2];
- EIGA Doc 23.05, *Inert Gases (Nitrogen & Argon)* [8]; and
- CGA Handbook of Compressed Gases [9].

5 Integrity management programme overview

A thorough, organised, and unified integrity management programme provides the means to improve the safety of pipeline systems. Such a programme provides the information for a pipeline system operator to allocate resources for prevention, detection, and mitigation actions that will result in improved safety and a reduction in the number of incidents. See Figure 1.

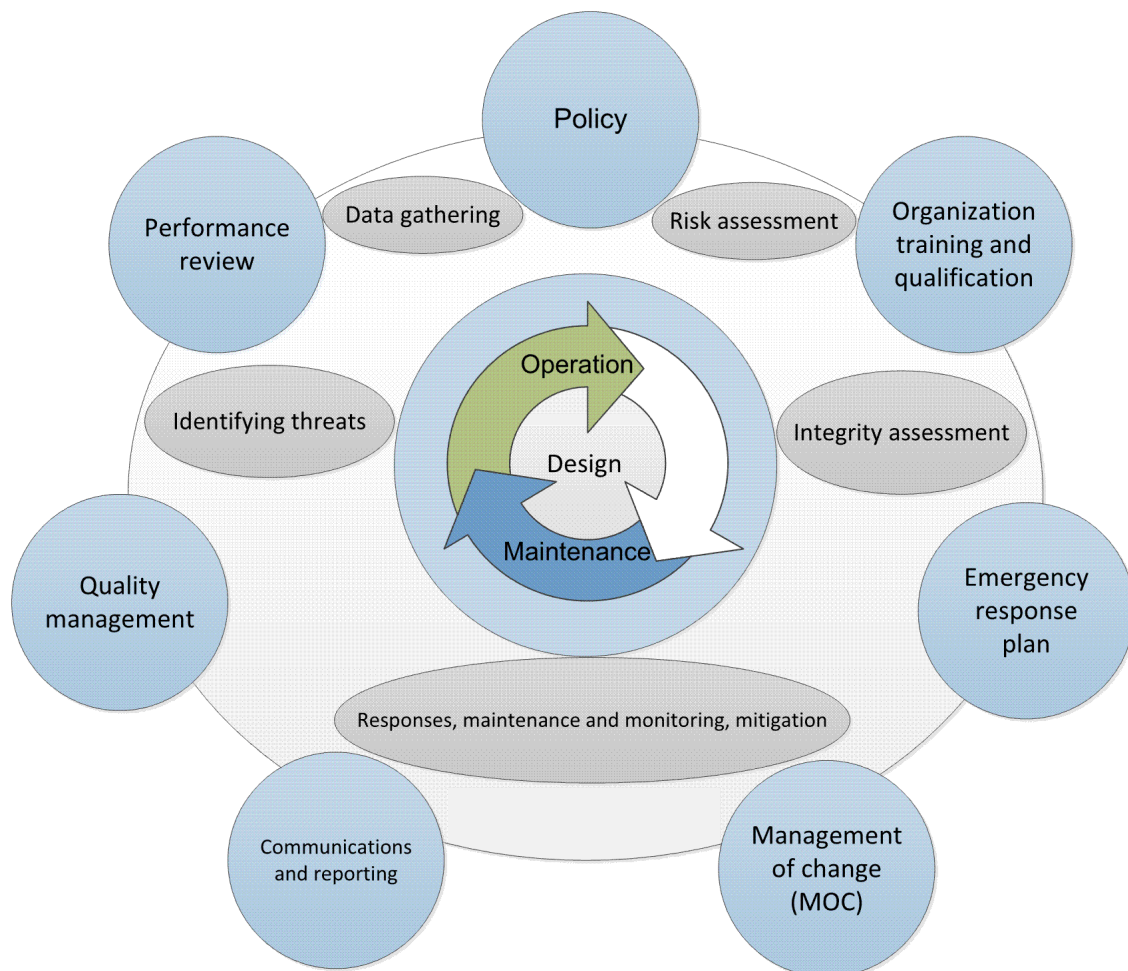


Figure 1 – General overview of a pipeline integrity management system

This publication describes the means that a pipeline system operator may use to determine and mitigate risks to reduce both the probability and consequences of incidents. It covers performance and prescriptive based integrity management.

The performance-based integrity management programme employs more data and broad risk analysis, which permit pipeline system operators to comply with the requirements of this programme in the areas of inspection intervals, tools used, and mitigation techniques used.

Inspection, prevention, detection, and mitigation are all part of the prescriptive process necessary to produce an integrity management programme.

Prior to proceeding with the performance-based integrity programme a pipeline system operator shall first ensure sufficient inspections are performed that provide the information on the pipeline condition required by the prescriptive based programme. The level of assurance of a performance-based programme shall meet or exceed that of a prescriptive programme.

The requirements for prescriptive and performance-based integrity management programmes are provided in each of the sections in this publication. In addition, Appendix A provides specific activities, by threat categories, that a pipeline system operator shall follow in order to produce a satisfactory prescriptive integrity management programme.

See Figure 2 for an integrity management plan process flow diagram.

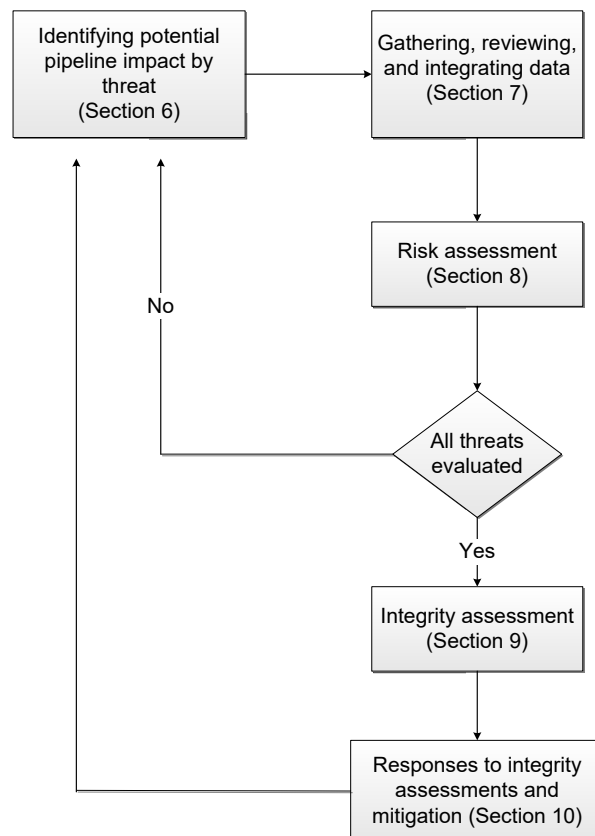


Figure 2 – Integrity management plan process flow diagram²

6 Consequences

6.1 General

Risk is the mathematical product of the probability and the consequences of a failure. Risk can be decreased by reducing either the probability and / or the consequences of a failure. This section specifically addresses the consequences portion of the risk equation. The pipeline system operator shall determine the consequences of a potential failure when prioritising inspections and mitigation activities.

² Reprinted from ASME B31.8S-2004, *Managing System Integrity of Gas Pipelines* by permission of The American Society of Mechanical Engineers [6]. All rights reserved. No further copies can be made without written permission.

6.2 Potential impact area

The potential impact area is typically calculated based on the diameter of the pipeline, the maximum operating pressure, and the type of gas. The potential impact area shall be determined for pipelines based upon applicable national and local regulations.

In a performance-based programme, the pipeline system operator may consider additional factors such as depth of burials that can reduce impact areas.

6.3 Factors to consider

When evaluating the consequences of a failure within the impact area, the pipeline system operator shall consider the following, at a minimum:

- population density;
- proximity of population to the pipeline;
- proximity of populations with limited or impaired mobility (hospitals, schools, day care centres, retirement communities, prisons, and recreation areas);
- property damage;
- environmental damage;
- effects of unignited gas release;
- security of gas supply (interruption of service); and
- potential for secondary failures.

The consequences of a failure can vary based on the properties and composition of the gas transported.

7 Gathering, reviewing, and integrating data

7.1 Procedure

7.1.1 Threat identification

Use the prescriptive approach to identify and evaluate all potential threats to pipelines per ASME B31.8S, *Managing System Integrity of Gas Pipelines* [6]. Threats are identified to determine the mechanisms that can result in the failure of pipelines, facilitate the selection of appropriate integrity assessment methods, set integrity assessment priorities, facilitate the selection of effective preventative and mitigative (P&M) measures, and evaluate the benefits of P&M measures.

As it relates to pipeline integrity, failure likelihood is the relative measure of the likelihood of failure of a pipeline because of an identified threat. The intent of failure likelihood is to provide resolution between each pipeline and to allow for grouping based on the magnitude of the identified threats. For such purposes, a failure likelihood algorithm based on the method of indexing is used.

The failure likelihood algorithm follows the approach employed in ASME B31.8S and addresses the likelihood of failure due to each of the following threats [6]. Within the failure likelihood algorithm, each identified threat is assigned a weighting based on the expected contribution of the identified threat to the overall failure susceptibility. The starting point for the assignment of identified threat weightings determined by failure likelihood is based on industry incident statistics, but may be modified based on accrued pipeline operating experience. See Figure 3.

$$Risk_t = P_t \times C_t \text{ for a single threat}$$

$$Risk = \sum_{t=1}^9 (P_t \times C_t) \text{ for threat categories 1 to 9}$$

$$\text{Total segment risk} = P_1 \times C_1 + P_2 \times C_2 + \dots P_9 \times C_9$$

Where:

C = failure consequence

P = failure likelihood

P_t = P total

C_t = C total

1 to 9 = failure threat category

1) External corrosion

2) Internal corrosion

3) Stress corrosion cracking (SCC)

4) Manufacturing related defects

5) Welding / fabrication related

6) Equipment

7) Third party / mechanical damage

8) Incorrect operational procedure

9) Weather-related and outside force

Figure 3 – Failure likelihood algorithm³

7.1.2 Threats

Per ASME B31.8S, identified threats to pipelines are classified in the following categories:

- Time-dependent threats — external corrosion, internal corrosion, stress corrosion cracking (SCC);
- Stable or resident threats — manufacturing defects, construction defects, equipment failure; and
- Time-independent threats — third party damage, incorrect operations, weather — outside forces [6].

Cyclic fatigue is not typically identified as a threat; however, if a pipeline system operator has a pipeline(s) that sees extreme demand patterns, cyclic fatigue shall be considered. External loading conditions are not typical identified threats. Pipelines shall be monitored for new potential identified threats.

For specific information on embrittlement and environmental damage mechanisms to pipelines used in hydrogen, carbon monoxide, and Syngas, see EIGA Doc 121 and EIGA Doc 120 [1, 2]. For more information on issues concerning oxygen pipelines, see EIGA Doc 13 [3].

7.1.2.1 External corrosion

There are several factors that contribute to the susceptibility of pipelines to failure due to external corrosion including pipe age, factory coating type, field coating type, factory and field coating condition, cathodic protection system compliance, casings, soil-to-air interfaces, and soil type. These factors are offset to a lesser or greater extent by integrity assessments and P&M measures that are directed against external corrosion. Conversely, the factors can be enhanced by localised effects such as stray current and/or interference.

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