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INDUSTRIAL GAS PIPELINE INTEGRITY MANAGEMENT

FIRST EDITION

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PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has published CGA P-8.10, *Industrial Gas Pipeline Integrity Management*, jointly produced by members of the International Harmonization Council.

This publication is intended as an international harmonized 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 (EIGA), 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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Work Item 16-100
Atmospheric Gases and Equipment Committee

NOTE—Appendix A (Normative) is a requirement.

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Contents	Page
1 Introduction.....	1
2 Scope and purpose	1
2.1 Scope	1
2.2 Purpose	1
3 Definitions.....	2
4 Hazards of gases	3
5 Integrity management program overview	3
6 Consequences	5
6.1 General.....	5
6.2 Potential impact area.....	5
6.3 Factors to consider	5
7 Gathering, reviewing, and integrating data.....	6
7.1 Procedure	6
7.2 Data gathering and integration	8
8 Risk assessment	10
8.1 Introduction.....	10
8.2 Definition of risk	10
8.3 Risk assessment objectives	11
8.4 Developing a risk assessment.....	11
8.5 Risk assessment approaches.....	11
8.6 Risk ranking.....	12
9 Integrity assessment	12
9.1 Integrity assessment plan.....	12
9.2 Inspection plan	12
9.3 Selection of assessment method.....	12
9.4 Baseline and continual assessment	14
9.5 Defect assessment.....	15
10 Responses to integrity assessments and mitigation (repair and prevention)	15
10.1 Introduction.....	15
10.2 Responses to pipeline in-line inspections.....	16
10.3 Responses to direct assessment inspections.....	17
10.4 Repair methods	18
10.5 Prevention strategy/methods.....	18
10.6 Prevention options.....	18
11 Integrity management plan	18
11.1 Method selection	18
11.2 Identified threats.....	19
11.3 Integrity assessment methods.....	19
11.4 Environmental and safety risks.....	21
11.5 Scheduling.....	21
11.6 New areas of concern.....	22
11.7 New pipelines	22
11.8 Documentation	22
12 Maintenance and monitoring	22

13	Performance plan	24
13.1	Management review inputs.....	24
13.2	Management review outputs	24
13.3	Key performance indicators.....	24
14	Communications plan	25
15	Management of change process	25
15.1	Temporary changes.....	26
15.2	Emergency changes.....	26
16	Quality control plan.....	26
17	Additional applicable relevant publications.....	26
18	References	27

Figures

Figure 1—General overview of a pipeline integrity management system	4
Figure 2—Integrity management plan process flow diagram	5
Figure 3—Failure likelihood algorithm.....	6

Table

Table 1—Effective integrity assessments based on threats	14
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Appendix

Appendix A—Integrity assessment methods and additional measures (Normative)	29
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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 nonmetallic material such as plastic or composite material; and
- Design of pipelines. For information on design, see CGA G-5.6, *Hydrogen Pipeline Systems*; CGA G-5.7, *Carbon Monoxide and Syngas Pipeline Systems*; and CGA G-4.4, *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 program 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 program. The pipeline integrity team typically consists of managers, engineers, and operating personnel with specific competence in detection, prevention, and mitigation activities.

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

3 Definitions

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

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 program

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 program

Integrity management process that follows preset 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 programs.

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);
- CGA G-4, *Oxygen* [7];
- CGA G-4.4 [3];
- CGA G-5.6 [1];
- CGA G-5.7 [2];
- CGA P-9, *The Inert Gases: Argon, Nitrogen, and Helium* [8]; and
- *CGA Handbook of Compressed Gases* [9].

5 Integrity management program overview

A thorough, organized, and unified integrity management program provides the means to improve the safety of pipeline systems. Such a program 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.

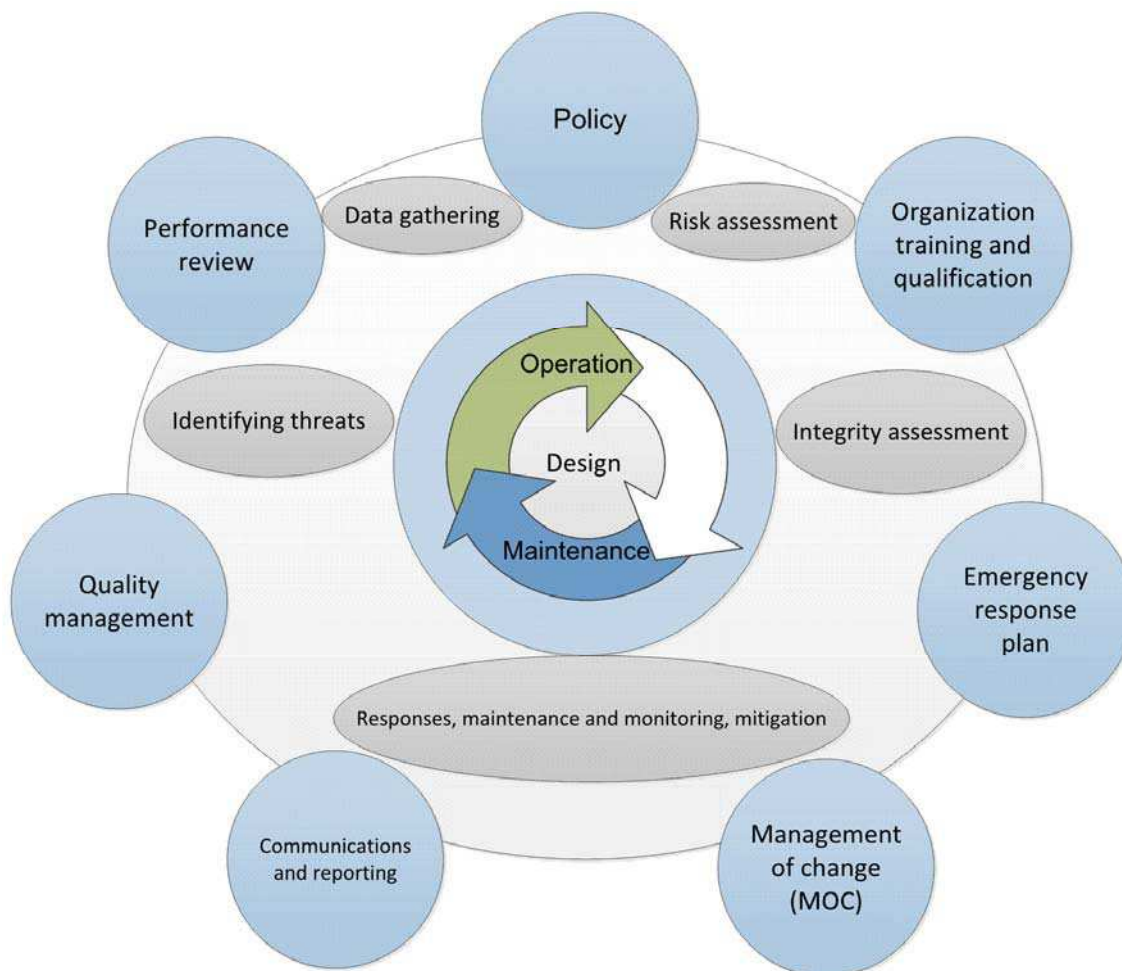


Figure 1—General overview of a pipeline integrity management system

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 program employs more data and broad risk analysis, which permit pipeline system operators to comply with the requirements of this program 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 program.

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

The requirements for prescriptive and performance based integrity management programs 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 program.

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

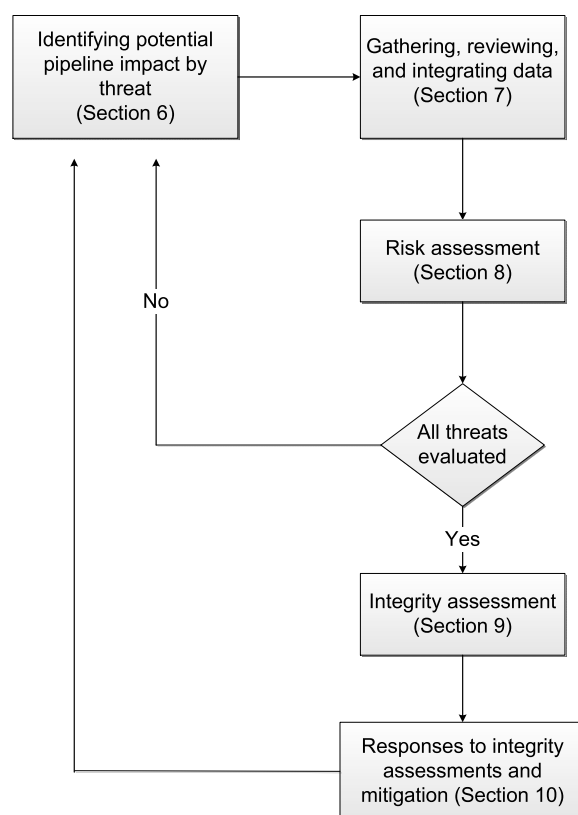


Figure 2—Integrity management plan process flow diagram²

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 prioritizing inspections and mitigation activities.

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 program, 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;

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.

- proximity of populations with limited or impaired mobility (hospitals, schools, daycare centers, 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

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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 CGA G-5.6 and CGA G-5.7 [1, 2]. For more information on issues concerning oxygen pipelines, see CGA G-4.4 [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 localized effects such as stray current and/or interference.

7.1.2.2 Internal corrosion

The threat of internal corrosion to pipelines is very low due to the dryness of the gas. A gas is considered to be dry with a dew point less than or equal to 20 °F (−7 °C).

7.1.2.3 Stress corrosion cracking

The threat of SCC to pipelines is low due to the control of the factors of specified minimum yield strength (SMYS), temperature, age of pipe, type of coating, and the distance from the compressor station.

7.1.2.4 Embrittlement and environmental damage mechanisms

Stress corrosion and embrittlement can occur internally to carbon monoxide and Syngas pipelines. For more information, see Appendix B of CGA G-5.7 [2].

For more information about hydrogen gas embrittlement, see Appendix B of CGA G-5.6 [1].

7.1.2.5 Manufacturing defects

Certain historical manufacturing practices have been shown to contribute to pipeline failure. The presence of seam defects, composition defects, hard spots, and factors leading to manufacturing inconsistencies are of concern.

7.1.2.6 Construction defects

Certain historical construction and joining practices have been shown to contribute to pipeline failure. The presence of wrinkle bends, buried couplings, buried threaded connections, poor selection and application of weld joint coatings, and factors leading to suspect welds are of concern.

7.1.2.7 Equipment failure

A review of historical equipment failure data shall be completed to determine which of the following types of equipment have a history of failure on pipelines:

- Regulator valves (set point drift outside of manufacturers' tolerances);