



CGA P-91—2021 PLANT INTEGRITY MANAGEMENT

FIRST EDITION

This document licensed for the sole use of the purchaser. It may not be shared with any other person or used after the expiration date without the express written permission of the CGA. Any unauthorized use, reproduction, distribution, or modification of this printed page will result in a \$5,000 liquidated damages fee plus loss of access to CGA publications for one year for your company.

Full document details: CGA P-91-2021



Documents
Document Sharing Hub

PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has issued CGA P-91, *Plant Integrity Management*, jointly produced by members of the International Harmonization Council and originally published by the European Industrial Gases Association (EIGA) as EIGA Doc 190, *Plant Integrity Management*.

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.

PLEASE NOTE:

The information contained in this document was obtained from sources believed to be reliable and is based on technical information and experience currently available from members of the Compressed Gas Association, Inc. and others. However, the Association or its members, jointly or severally, make no guarantee of the results and assume no liability or responsibility in connection with the information or suggestions herein contained. Moreover, it should not be assumed that every acceptable commodity grade, test or safety procedure or method, precaution, equipment or device is contained within, or that abnormal or unusual circumstances may not warrant or suggest further requirements or additional procedure.

This document is subject to periodic review, and users are cautioned to obtain the latest edition. The Association invites comments and suggestions for consideration. In connection with such review, any such comments or suggestions will be fully reviewed by the Association after giving the party, upon request, a reasonable opportunity to be heard. Proposed changes may be submitted via the Internet at our web site, www.cganet.com.

This document should not be confused with federal, state, provincial, or municipal specifications or regulations; insurance requirements; or national safety codes. While the Association recommends reference to or use of this document by government agencies and others, this document is purely voluntary and not binding unless adopted by reference in regulations.

A listing of all publications, audiovisual programs, safety and technical bulletins, and safety posters is available via the Internet at our website at www.cganet.com. For more information contact CGA at Phone: 703-788-2700, ext. 799. E-mail: customerservice@cganet.com.

Work Item 17-120
Atmospheric Gases and Equipment Committee

NOTE—Appendices A and B (Informative) are for information only.

FIRST EDITION: 2021

© 2021 – Reproduced with permission from, the European Industrial Gases Association. All rights reserved.

 **Documents**
Document Sharing Hub

Contents	Page
1 Introduction.....	1
2 Scope and purpose	1
2.1 Scope	1
2.2 Purpose	2
3 Definitions.....	2
4 Plant integrity management programme	2
4.1 General.....	2
4.2 Organisational arrangements for integrity management	4
4.3 Technical arrangements for integrity management	5
5 Data gathering.....	5
6 Risk assessment	6
6.1 Operational excursions and fitness for service assessment.....	6
6.2 Modifications.....	6
7 Inspection plan	7
7.1 Selection of inspection types	7
7.2 Strategies for determining testing or inspection interval.....	8
8 Inspection	8
8.1 Individuals involved	9
8.2 Inspections during plant shutdowns	9
8.3 Management of findings during inspection	9
9 Post assessment	10
9.1 Assessment of deterioration.....	10
9.2 Changes to subsequent inspections	10
9.3 Assessment record.....	10
9.4 Repair, rerate, or retire	11
9.5 Incomplete or postponement of inspections	11
10 Inspection, testing, and preventive maintenance reporting	11
11 Record keeping	12
12 Integrity management of electrical, control, and instrumentation and safety systems	13
12.1 Degradation mechanism of electrical, control, and instrumentation systems and equipment.....	13
12.2 Integrity management.....	14
13 Degradation mechanism	14
13.1 General or local corrosion	15
13.2 Atmospheric corrosion.....	15
13.3 Galvanic corrosion.....	15
13.4 Erosion corrosion.....	15
13.5 Stress corrosion cracking	15
13.6 Pitting (crevice) corrosion.....	16
13.7 Fatigue cracking	16
13.8 Corrosion fatigue	16
13.9 Erosion	16
13.10 Cavitation corrosion.....	16
13.11 Carbon dioxide (sweet) corrosion.....	16
13.12 Hydrogen sulfide (sour) corrosion	17
13.13 Microbiological corrosion.....	17
13.14 Metal dusting	17
13.15 Creep.....	17
13.16 Concrete degradation	17
13.17 High temperature hydrogen attack	17
13.18 Aluminum sensitisation.....	18

14 Detection and sizing of defects and damages.....18

 14.1 Inspection procedures 18

 14.2 Inspection methods 18

15 References 19

16 Additional references.....21

Figure

Figure 1—Integrity management work process 5

Appendices

Appendix A—Cryogenic coldbox located pressure equipment (Informative) 22

Appendix B—Cryogenic bulk storage tanks at production sites (Informative) 23

1 Introduction

This publication has been prepared by industrial gas companies to establish a common position and give guidance on plant integrity management. This topic is also referred to as plant ageing and is increasingly included in authority inspections of plants subject to regulations such as *Directive 2012/18/EU on the control of major-accident hazards involving dangerous substances* (Seveso III Directive) and Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM) in Title 29 of the U.S. *Code of Federal Regulations*, etc. [1, 2].¹

Ageing is not about the age of the equipment. It is about its condition and how that changes over time. Ageing is the effect whereby equipment suffers some form of material deterioration and damage (usually, but not necessarily, associated with time in service) with an increasing likelihood of failure over the lifetime. For more information, see HSE RR823, *Plant Ageing Study – Phase 1 Report* and HSE RR823 Summary Report, *Managing Ageing Plant—A Summary Guide* [3, 4].

The integrity of equipment can be ensured by:

- operation of the equipment within design conditions;
- documented programme of procedures, training, inspections, tests; and
- preventive/predictive maintenance including inspection based upon good engineering practice, applicable codes, standards, specifications, and manufacturers' recommendations.

It is important to recognise that equipment can be subject to ageing, can contribute to the health, safety, and environmental performance of a plant, and/or can compromise the performance if they fail or collapse. Therefore, a broad view is required when assessing the potential impact of ageing at a given installation.

2 Scope and purpose

2.1 Scope

This publication gives general guidance on integrity management of process plants including, but not limited to, air separation plants, HYCO plants, cylinder filling plants, and carbon dioxide, acetylene, and nitrous oxide plants. The goal is to keep hazardous fluids and energy contained in order to maintain safe working conditions for personnel and prevent unacceptable environmental releases. The information contained in this publication applies to both new and existing equipment. Integrity management starts when the equipment is first put into service and continues throughout its lifecycle.

This includes:

- piping;
- static and rotating equipment;
- equipment civil structures and foundations;
- electrical, control, and instrumentation equipment;
- pressure vessels; and
- combinations thereof.

The user is cautioned that this publication is not a design handbook and does not exclude the need for competent engineering judgement and interpretation. To the extent that they exist, national laws may supersede the information included in this publication.

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



2.2 Purpose

The purpose of this publication is to give guidance on plant integrity management to operations management within the industrial gases industry to ensure the safety of equipment. The industrial gases industry has fewer damage mechanisms than the general process industry. This publication identifies damage mechanisms specific to the industrial gases industry, explains the basis for them, and provides guidance on how to develop an integrity management programme. This publication does not give guidance on plant reliability or efficiency.

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 Ageing

Effect whereby a component or equipment suffers some form of material deterioration and damage usually, but not necessarily, associated with the time in service with an increasing likelihood of failure over its lifetime.

3.2.2 Competent person(s)

Individual or a group of people who have the theoretical knowledge, practical experience, and training to identify design defects, to detect defects, to assess their importance, and to ultimately endorse equipment as fit for continued service.

NOTE—In some countries, regulations require that the final endorsement be carried out by a notified body/competent authority/accredited organisation.

3.2.3 Formal periodic inspection plan

Defines what inspections shall be carried out, when, by whom, and how the results should be reported.

3.2.4 Process plants

Assembly of process equipment and piping including their primary protection devices; electrical, control, and instrumentation equipment; and equipment civil structures and foundations.

4 Plant integrity management programme

4.1 General

For more information, see EEMUA 231, *The mechanical integrity of plant containing hazardous substances—A guide to periodic examination and testing*; HSE RR509, *Plant Ageing: Management of Equipment Containing Hazardous Fluids or Pressure*; and Center for Chemical Process Safety (CCPS), *Dealing with Aging Process Facilities and Infrastructure* [5, 6, 7].

Successful management of plant integrity requires a clear strategy not just for periodic inspection, but for the whole lifecycle of the plant. This is especially important on sites storing and processing hazardous substances, where the effects of integrity failure can have serious consequences.

The requirements for inspection may change throughout the equipment life. In the early stages, it may be necessary to ensure that a whole range of issues potentially arising from the design, manufacture, and first exposure to service conditions are addressed. It can also be required to test assumptions on active degradation mechanisms or verify predicted rates. This can lead to relatively shorter intervals between inspections, compared to later stages of its life.

With further service, degradation can begin to accumulate. Safety margins such as remaining corrosion allowance or remaining fatigue life can decrease. Degradation rates can increase and overall confidence in the mechanical integrity can decrease. Service periods between inspections may be reduced. For more information, see HSE RR509 [6].

While this publication focuses on inspection and how to define rules for inspection, it is very useful to put this into context as this is only one element of an integrity management programme. The design of a plant can impact the integrity management programme. Getting the original plant specification correct is key so the plant is designed to be suitable for the intended duty.

Key to maintaining integrity is the assessment of the results of inspections, especially when the report states that the equipment has defects.

Any integrity management system should be able to provide answers to the following questions:

- What pressure systems and equipment storing, processing, or transferring hazardous substances are on site;
- Who is responsible for these pressure systems and equipment;
- What considerations are given to equipment ageing and life extension;
- What company strategies or policies are in place for managing ageing;
- What records/documentation about the equipment are maintained;
- Can your company demonstrate it has the competencies required;
- What provisions are in place for the retention and use of corporate knowledge;
- Does the plant/equipment have a retirement date;
- How well is the equipment life cycle known;
- How aware is your company of the indicators of ageing;
- Does the approach to inspection take account of the stage of equipment life;
- What options are considered when ageing related damage is detected;
- How is fitness for service assessed for aged components and components where the remaining life is uncertain;
- What procedures are used in the event that equipment requires repair;
- What procedures are in place regarding revalidation of equipment;
- Does the formal periodic inspection plan reflect the equipment's age; and
- What policies are in place for determining the end of equipment life.

4.2 Organisational arrangements for integrity management

A thorough, organized, and unified integrity management program provides the means to improve the safety of process plants. Such a program provides the information for operations management to allocate resources for prevention, detection, and mitigation actions that can result in improved safety and a reduction in the number of incidents. An integrity management program requires a multidisciplinary approach with a range of different disciplines and competencies bringing the required information and controlling the whole process from planning and execution through to decision making and review.

4.2.1 Competence

Those responsible for managing and undertaking maintenance, testing, and inspection shall be competent. Someone with an appropriate engineering qualification and relevant experience should manage the maintenance, inspection, and testing systems and arrangements.

Inspection bodies shall be able to demonstrate competence.

Non-destructive examination (NDE) personnel shall be able to demonstrate training and competence. Official certification can be achieved under either an outside body certification or an employer-based scheme.

In addition to the formal arrangements for qualification and accreditation described previously, an effective plant integrity management program requires consideration of all aspects of the potential degradation, inspection, and assessment of the equipment involved. Therefore, the team involved requires competency to provide input in the following areas:

- design of the equipment;
- process conditions and potential consequences of a loss of containment;
- operating conditions;
- maintenance;
- materials technology (including corrosion or metallurgy expertise, where relevant);
- risk assessment; and
- inspection techniques.

The use of third parties in equipment integrity management shall have checks in place to confirm the competency of those parties involved. These shall include competence checks as part of the selection and monitoring processes for contractors. Where in-house resources are used, it is equally important that there are means to ensure the competence of those involved.

4.2.2 Roles and responsibilities

The clarification of roles and responsibilities is required to ensure that the different parties involved in a plant integrity management program interact effectively, and each role is filled by competent persons and regulatory requirements are met. Arrangements shall ensure independence of the inspection body from the site operating and supply requirements.

The responsibility for assessment of the integrity of the plant and/or equipment shall be clearly defined. This assessment is required to determine fitness for continued service and may involve specification of conditions for continued service or repair.

It is important to ensure that whoever is responsible for integrity assessment is able to undertake this task without undue influence from other parts of the organisation that can have other potentially conflicting responsibilities or priorities. Furthermore, those in ultimate authority for the site or company operations should be able to demonstrate a commitment to equipment integrity by providing the necessary independence to those they charge with making key decisions regarding fitness for service.

Operations management shall ensure the plant is maintained in a safe condition. While site operations management can seek to rely on third party expertise to help ensure equipment integrity, they should be aware that the responsibilities cannot be delegated.

4.3 Technical arrangements for integrity management

The integrity management program shall include the following elements:

- data gathering;
- risk assessment;
- inspection plan;
- inspection; and
- post assessment.

Figure 1 shows an overview of an integrity management work process. Elements of this process may vary on a case-by-case basis (for example, individual equipment, multiple pieces of similar equipment, or generic equipment classes across multiple plants).

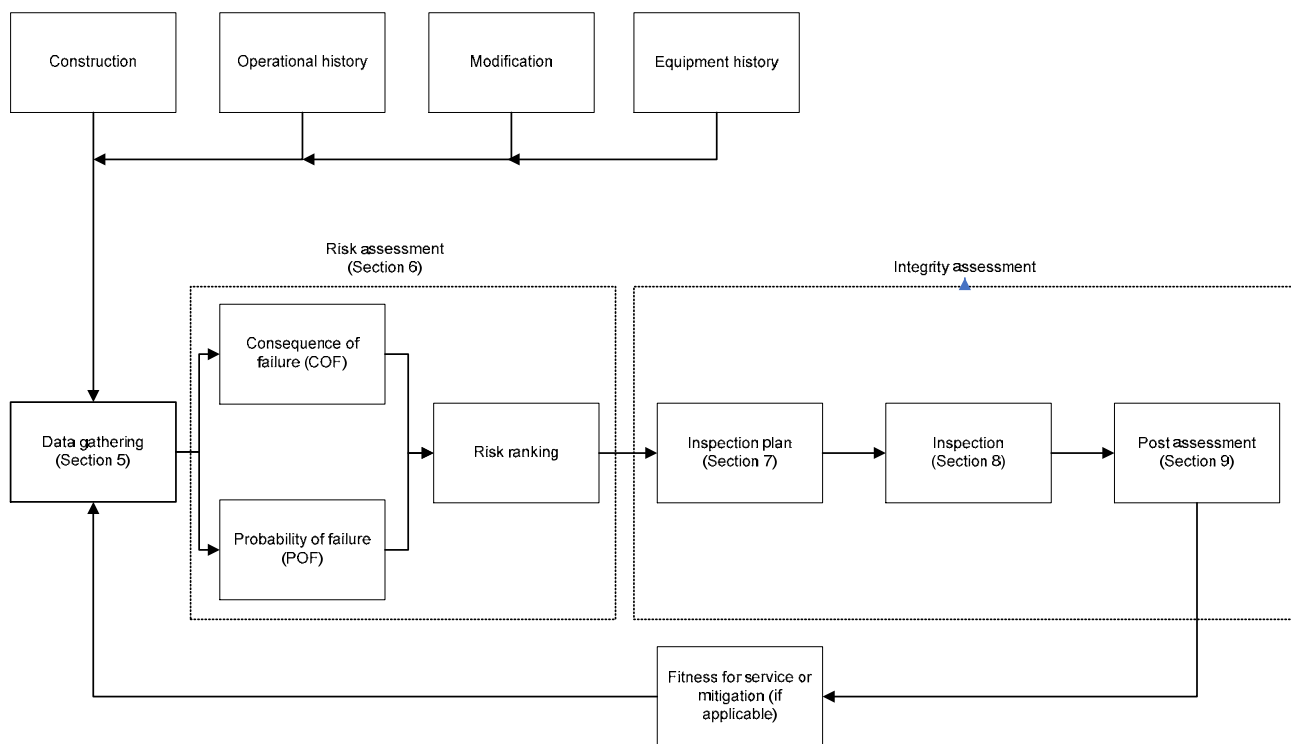


Figure 1—Integrity management work process

5 Data gathering

Data shall be gathered and should be maintained for the life of the plant. This data can build up a written history and can reveal ongoing problems/failure modes. The amount and quality of data can improve the validity of the integrity management program. Data can include, but are not limited to, records for:

- design and construction;