GUIDELINE FOR
PROCESS SAFETY MANAGEMENT

AIGA 099/20

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As part of a program of harmonization of industry standards, the Asia Industrial Gases Association (AIGA) has published AIGA 099, *Guideline for Process Safety Management*, jointly produced by members of the International Harmonization Council and originally published as CGA P-86 by Compressed Gases Association (CGA) as *Guideline for Process Safety 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), 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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Appendix

1 Introduction

Process safety management is of interest to many organizations looking to adopt a holistic and systematic approach to assuring the integrity of their operations.

This publication was adapted from the Energy Institute's document *High Level Framework for Process Safety Management* to be more specific to the industrial gases industry [1].[1]

The reader may choose to follow other process safety management systems such as the one developed by the American Institute of Chemical Engineers (AIChE) Center for Chemical Process Safety (CCPS) [2]. For sites that are required to follow U.S. Occupational Safety and Health Administration (OSHA) PSM regulations or the U.S. Environmental Protection Agency (EPA) RMP rule or any local country specific more stringent regulatory requirements, those rules take precedence [3, 4].

For the purpose of this publication, process safety management refers to providing guidance to improve process safety in industrial gas facilities. It is not meant to refer to the OSHA Process Safety Management regulations.

Appendix A lists other publications that are relevant to process safety management.

2 Scope

The process safety management framework may be applied to all processes within the industrial and medical gases industry. It is designed to address process safety hazards and be equally suitable for the processes that are found in the industry including:

- air separation units (ASU) and nitrogen generator facilities;

- hydrogen and carbon monoxide (HYCO) production facilities including electrolysis facilities;

- hydrogen purification units;

- acetylene production facilities;

- nitrous oxide production facilities;

- carbon dioxide production facilities;

- cylinder and container filling facilities;

- specialty gas production, package filling, and storage facilities;

- chemical handling and transport facilities;

- pipelines;

- transportation; and

- customer installations.

A facility may include not just the main production plant but all other ancillary equipment that has process hazards.

The decision to apply various process safety management elements to a given process needs to be made by evaluating the tolerance of risk and agreeing on the management approach. For example, transportation and pipeline risks may be managed by applying national and international codes and might not require all the elements of the process safety management framework to be applied.

In some countries, there can be existing regulatory requirements for process safety management systems. This framework is not intended to replace these requirements but may be used to supplement them for all industry regardless of regulatory requirements.

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

3   Purpose

The process safety management framework is intended to provide a design basis for the development of a process safety management system where an organization does not have one. It also may be used as a common basis for benchmarking existing process safety management systems.

Where an organization has a process safety management system or an integrated management system incorporating health, safety, and environmental and process safety management, they may carry out a gap assessment versus the requirements of each element in order to identify any aspects of the system that need to be enhanced.

When the initial assessment has been completed, the significance of the gaps should be determined, and a prioritized plan developed to address the identified issues. In some cases, there can be a significant program of work needed to upgrade the management system to contain all of the elements of the process safety management framework. In these cases, it should be recognized that this upgrade work can take many years to complete effectively.

If an organization does not have a process safety management system in place, a phased approach may be utilized. The following is a recommendation for a phased approach, but the needs of each organization can vary:

Phase 1:

- Leadership commitment and responsibility (Element 1);

- Compliance with legislation and industry standards (Element 2);

- Workforce involvement (Element 4);

- Operating procedures (Element 9);

- Management of change (Element 12);

- Emergency management (Element 14); and

- Work control, permit to work, and task risk management (Element 17).

Phase 2:

- Employee selection, training, and competency (Element 3);

- Hazard identification and risk assessment (Element 6);

- Documentation, records, and knowledge management (Element 7);

- Operational readiness and process startup (Element 13);

- Inspection and maintenance (Element 15); and

- Management of safety critical devices (Element 16).

Phase 3:

- Communication with stakeholders (Element 5);

- Process and operational status monitoring and handover (Element 8);

- Management of operational interfaces (Element 10);

- Standards and practices (Element 11);

- Contractors and suppliers—selection and management (Element 18);

- Incident investigation (Element 19);

- Audit, management review, and intervention (Element 20); and

- Measures and metrics (Element 21).

4   Definitions

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

4.1   Publication terminology

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

4.1.2   Should
Indicates that a procedure is recommended.

4.1.3   May
Indicates that the procedure is optional.

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

4.1.5   Can
Indicates a possibility or ability.

4.2   Technical definitions

4.2.1   Work control
Recognition of potential hazards prior to beginning work, including the limits of the permitted work and defined barriers.

5   Overview of process safety management elements

The elements set out the key aspects to assure the integrity of operations. Each element contains an overview which states its intent and a number of guidelines which define what organizations should address. The elements can be grouped as in the following sections.

5.1   Process safety leadership

There are five elements that set out how organizations should define and communicate the level of performance they are prepared to accept and how they should ensure that they put in place the necessary resources to achieve the required level of performance:

- Leadership commitment and responsibility (Element 1);

- Compliance with legislation and industry standards (Element 2);

- Employee selection, training, and competency (Element 3);

- Workforce involvement (Element 4); and

- Communication with stakeholders (Element 5).

5.2   Risk identification and assessment

There are two elements that set out what organizations should do to identify and assess the risks that they need to manage in order to assure the integrity of their operations. The two elements identify the necessary control measures and how organizations should record and maintain the process safety knowledge developed from the risk identification and assessment activities:

- Hazard identification and risk assessment (Element 6); and

- Documentation, records, and knowledge management (Element 7).

5.3   Risk management

There are eleven elements that set out the control measures that organizations should use to manage key areas of risk:

- Process and operational status monitoring and handover (Element 8);

- Operating procedures (Element 9);

- Management of operational interfaces (Element 10);

- Standards and practices (Element 11);

- Management of change (Element 12);

- Operational readiness and process startup (Element 13);

- Emergency management (Element 14);

- Inspection and maintenance (Element 15);

- Management of safety critical devices (Element 16);

- Work control, permit to work, and task risk management (Element 17); and

- Contractors and suppliers—selection and management (Element 18).

5.4   Review and Improvement

There are three elements within the review and improvement area that set out how organizations should measure and review their compliance with the process safety management framework and how they should ensure that they learn from these measurements and the findings from investigations:

- Incident investigation (Element 19);

- Audit, management review, and intervention (Element 20); and

- Measures and metrics (Element 21).

6   Process safety management elements

This section lists all of the elements in detail. Each element commences with an overview and contains a number of guidelines which set out a more detailed definition of what organizations should ideally address.

6.1   Element 1—Leadership commitment and responsibility

6.1.1   Overview

Assurance of the integrity of an organization's operations requires visible leadership commitment and accountability at all levels of the organization. Management should establish a process safety policy, provide perspective, set process safety performance targets, and provide the structure and resources to achieve them.

6.1.2   Guidelines

The following is a list of guidelines for Element 1:

- Documented process safety policy, which may be a part of a general safety policy, is in place and signed by a senior company executive such as the chief executive officer (CEO) or the responsible unit managing director (MD). These are living systems which are regularly reviewed and updated and communicated to all employees to reflect the needs of the organization;

- Process safety risk management system is in place which meets applicable legislation, the process safety management framework guidelines, and any other guidelines to which the organization subscribes with regard to its process safety activities;

- Management establishes the scope, priority, and schedule for the process safety risk management system implementation, considering the complexity and risks involved with their operations and products;

- Roles, responsibilities, authorities, and accountabilities for the management of process safety are known and exercised. Sufficient competencies and resources are made available to meet the desired process safety plan;

- Clear process safety objectives, performance targets, and action plans are established and performance is periodically evaluated;

- Directors and managers:

  - Visibly demonstrate personal commitment and accountability for process safety, leading by example and upholding core values and standards of the organization and

  - Recognize and reward positive process safety behaviors and performance and intervene to correct deviations from required performance at all levels in the organization; and

- Leadership responsible for sites operated by others, (e.g., joint venture companies), encourage the adoption of a process safety management framework.

For more information, see:

- *Guidelines for Managing Process Safety Risks During Organizational Change*, AIChE CCPS [5]; and

- EIGA Info HF 11/10, *Organization - "Safety Culture"* [6].

6.2   Element 2—Compliance with legislation and industry standards

6.2.1   Overview

Compliance with legislation is a fundamental requirement for organizations. Management should ensure that the requirements of applicable legislation are identified, understood, and complied with.

6.2.2   Guidelines

The following is a list of guidelines for Element 2:

- Requirements of current and forthcoming applicable legislation, regulations, licenses, permits, codes, industry standards, and other governmental requirements are identified, documented, kept current, and communicated to those affected; and

- Compliance with legislation and mandatory or applicable industry standards is systematically verified.

For more information, see EIGA Doc 60/15, *Seveso Documents - Guidance on Applicability, Assessment and Legal Documents for Demonstrating Compliance of Industrial Gases Facilities with Seveso Directive(s)* [7].

6.3   Element 3—Employee selection, training, and competency

6.3.1   Overview

Control of processes depends upon having competent people in position. Management should ensure that existing and new personnel have the required competencies.

6.3.2   Guidelines

The following is a list of guidelines for Element 3:

- Required process safety competencies and requirements are defined for all roles in the organization;

- Process is in place for evaluation, selection, and training of employees which confirms their competency with the specified requirements for the role;

- When organizational changes are made, ensure that knowledge transfer occurs to maintain continuity of critical activities;

- Roles and responsibilities should take into account human capabilities and limitations as well as human and organizational factors;

- Appropriate training is carried out for personnel taking up a new or revised position;

- Training plans are in place for all positions that impact process safety;

- Organizational structure and continuity of process safety management critical positions are reviewed periodically to ensure that it can meet the process safety management guidelines;

- Employee competency should be periodically assessed against requirements of their assigned role and responsibilities, or should be maintained via continuing professional development;

- Employee training and development needs are identified through a systematic process; and

- Training and development programs are a combination of formal courses, coaching, and practical work.

For more information, see:

- EIGA Info HF 02/17, *Individual - "Training and Competence"* [8]; and

- AIGA 009, *Safety Training of Employees* [9].

6.4   Element 4—Workforce involvement

6.4.1   Overview

Achieving process safety performance requires the commitment of the whole workforce. Management should align, involve, and empower the whole workforce in the identification and management of process safety hazards.

6.4.2   Guidelines

The following is a list of guidelines for Element 4:

- Employees and full-time contractors are actively engaged in the improvement of process safety performance related to their work scope and have an understanding of process safety hazards, their identification, and management/control;

- Employees and full-time contractors are engaged with management in two-way communication regarding process safety policies, objectives, performance targets, action plans, and sharing of lessons learned related to their work scope; and

- Process safety promotion and engagement programs are in place to continually increase the awareness, participation, and commitment of employees and full-time contractors.

6.5   Element 5—Communication with stakeholders

6.5.1   Overview

Establishing and maintaining stakeholders' confidence is a key factor in maintaining an organization's license to operate.

In relation to major hazards, management shall identify key stakeholder groups and develop and maintain a good working relationship with them, understanding and addressing their issues and concerns.

External stakeholders may include industrial neighbors, local communities, customers, enforcement authorities and agencies, and local civil authorities.

Internal stakeholders may include business, operations, engineering and construction teams, and worker representatives (unions or workers councils, etc.).

6.5.2   Guidelines

The following is a list of guidelines for Element 5:

- Communications system is defined to develop and maintain a good working relationship with the identified stakeholders about its activities, including emergency response communications;

- Appropriate safety information is shared with stakeholders to demonstrate the organization's commitment to process safety; and

- Effectiveness of programs for communication with stakeholders is periodically reviewed by management.

6.6   Element 6—Hazard identification and risk assessment

6.6.1   Overview

A fundamental requirement of any process safety management system is the identification and assessment of risk. Management should ensure that a comprehensive risk assessment process systematically identifies, assesses, and provides mitigations for the risks arising from the organization's operations.

6.6.2   Guidelines

The following is a list of guidelines for Element 6:

- A structured process is applied to identify the hazards and ensure that the risks arising from the organization's assets and operations are systematically assessed;

- Appropriate risk assessments are conducted for:

  - Ongoing operations

  - Handling and storage of hazardous materials

  - Existing and new products and services

  - New projects and new technologies and

  - All changes requiring management of change;

- Risk prevention and mitigation measures are identified and implemented, using hierarchy of control principles (including inherently safer design), to manage the identified risks to a tolerable level;

- Tolerable level of risk is defined for all risks (impact to human health, safety, environment, and, where necessary, property);

- Risk assessments consider process safety risk as well as risk to environment, reputation, asset integrity, business interruption, security, third party assets, and customers;

- Risk assessments consider human (including organizational) factors, which could affect the likelihood or severity of outcomes;

- Risk assessments are led by competent personnel with no conflicts of interest with the affected process. Team members shall be selected considering the scope of the risk assessment and should include safety, operations or technology subject matter experts, and process safety professional;

- Risk assessments take into account learnings from incidents from both inside and outside the organization;

- Completed risk assessments are reviewed, approved, and accepted by specific levels of management appropriate to the magnitude of the risk and any decisions are clearly documented;

- Identified stakeholders are kept informed about the risk assessment process and results;

- Risk assessment recommendations are reviewed periodically by the appropriate management and resolved in a timely manner; and

- Risk assessments are updated as changes occur or are reviewed and updated at a defined frequency.

For more information, see:

- *Hazard Identification Procedures*, AIChE CCPS [10]; and

- EIGA Doc 75/07, *Determination of Safety Distances* [11].

6.7 Element 7—Documentation, records, and knowledge management

6.7.1 Overview

Accurate records and information are essential to identify, assess, and manage process safety risk. Management should ensure that the information required to support safe operation is identified, available, and up to date.

6.7.2 Guidelines

The following is a list of guidelines for Element 7:

- Measures or practices are in place to define, develop, and maintain the required documentation and records necessary to support robust operation and maintenance of facilities;

- Documentation and records are available to those who need to use them;

- Documentation and records including those kept electronically are appropriately safeguarded from unauthorized revision or deletion;

- Measures or practices are in place to ensure that documentation is periodically reviewed and kept up to date;

- Procedure defining retention period for all documentation and records; and

- Documentation and records include those generated to meet the requirements of all other process safety management elements such as but not limited to:

  - Process safety information including process design considerations and basis for safe operating limits, design drawings (for example, P&IDs, PFD, Single line electrical diagrams, hazardous area drawings, relief system data, ventilations system data for hazardous occupied enclosures, etc.)

  - Equipment records (inspection, testing, maintenance, and modification)

  - Work and operating logs

  - Training and competency records

- Incident investigation reports

- Operating and maintenance procedures

- Permits and licenses

- Risk assessments

- Management of change documents and

- Hazard review information.

6.8 Element 8—Process and operational status monitoring and handover

6.8.1 Overview

Comprehensive process and operational status monitoring and effective handover between work groups is essential to assure the continued integrity of the organization's operations. Management should ensure that the process and operational status monitoring and handover requirements are defined, understood, and carried out.

6.8.2 Guidelines

The following is a list of guidelines for Element 8:

- Safe operating limits (SOLs) are defined for equipment and processes and are kept up to date;

- Operating parameters are systematically monitored;

- Excursions beyond SOLs are identified and followed up; and

- Handover arrangements for the following are defined, understood, and implemented:

  - Operational and maintenance shift handover

  - Successive work groups and

  - Job positions (one to another).

For more information, see:

- EIGA Info HF 07/18, *Organization - "Communications on Safety"* [12]; and

- AIGA 028, *Unmanned Air Gas Plants: Design and Operation* [13].

6.9 Element 9—Operating procedures

6.9.1 Overview

Facilities shall be operated within established parameters and according to legislation. In order to achieve this, management should ensure that process safety information is available and utilized.

6.9.2 Guidelines

The following is a list of guidelines for Element 9:

- Approved operating manuals and procedures are identified, available, accurate, up to date, understood and used, and include human factors considerations;

- Operating manuals are designed to maximize usability by providing clear step by step directions and minimize the likelihood of error and noncompliance;

- Operating manuals and procedures should state clear SOLs, the steps required to prevent an excursion outside the SOL, and clear instructions on actions to be taken if an excursion outside the SOL occurs;

- Operating manuals should cover normal start up and shutdown and steady state operation as well as temporary operations and emergency shutdowns; and

- Operating manuals and procedures are periodically reviewed and updated. These reviews involve supervisors and personnel who are required to use them.

For more information, see:

- *Guidelines for Risk Based Process Safety*, AIChE CCPS[14]; and

  NOTE—Section 4.3.1 of this AIChe guideline focuses on operational procedures.

- EIGA Info HF 04/17, *Task - "Design and Effectiveness of Procedures"* [15].

6.10   Element 10—Management of operational interfaces

6.10.1   Overview

Operational interfaces with customers, suppliers, contractors, as well as interfaces between internal groups, who provide or receive services, utilities, or products, can impact the organization's operations. Management shall ensure that operational interfaces are identified, assessed, and managed.

6.10.2   Guidelines

The following is a list of guidelines for Element 10:

- Operational interfaces are identified, documented, and risks from failures of the interface are assessed. Both parties of the interface should be included in the assessment; and

- Based on the risk assessed, measures should be in place to ensure process safety is maintained.

The Project Management Institute (PMI) has extensive information on this element [16].

6.11   Element 11—Standards and practices

6.11.1   Overview

Process safety performance is enhanced by using applicable standards and safe working practices. Management should ensure that the standards and safe working practices to support project, maintenance, and operational activities are identified, developed, and consistently applied.

6.11.2   Guidelines

The following is a list of guidelines for Element 11:

- Design, inspection, and maintenance standards are defined, which bring together legislative requirements, industry and the organization's standards, and good practices;

- Safe working practices are defined, which bring together legislative requirements and industry standards and guidelines and the organization's good practices into a set of guidelines;

- Standards and practices:

  - Meet or exceed applicable legislative requirements

  - Ensure process safety risks are accounted for and

  - Take into account possible human failures and other factors that could influence the likelihood of those failures;

- Approved standards and practices are periodically reviewed to take into account changes to legislation, industry standards and guidelines, and the organization's best practices and findings from incidents;

- Approved standards and practices are available to those who need them, including contractors;

- Authority to approve standards and practices is formally assigned to nominated competent individuals;

- Deviation from design standards is permitted only after assessment, review, and approval by nominated competent individuals and after the rationale for the decision is documented;

- When a new or updated standard or practice is issued, the new standard or practice is communicated to existing facilities for risk evaluation; and

- Project management work processes ensure that key stages in the project development lifecycle are reviewed and approved by specified levels of management with due consideration of process safety management practices. Work process requirements include:

  - Project management procedures are documented, well understood, readily available to those who need to use them (including contractors) and executed by qualified personnel

  - Criteria are established and procedures are in place for conducting and documenting risk assessment at specific project stages to confirm the integrity of new assets and existing assets which have been substantially modified (see Element 6)

  - Any changes in the process safety impact of a facility on the local community are assessed and, if required, communicated to relevant authorities

  - Design and construction of new or modified facilities use approved standards and practices that:

    - Meet or exceed applicable regulatory requirements

    - Embody responsible requirements where legislation does not exist

    - Encompass robust process safety management practices and

    - Address vulnerability and security

  - Pre-commissioning review is performed (see Element 13) and documented

  - Procedures are in place to identify and manage the process safety risks arising from the mothballing and decommissioning or disposal of assets including dismantling, demolition, and site remediation and

  - Performance measures are established to monitor the success or failure of a change to meet its intended purpose and whether it has any unintended effect on safety.

There are numerous AIGA, CGA and EIGA practices that are documented and published. They are too numerous to reference in this publication. The relevant publications are best searched for using AIGA, CGA and EIGA's websites.

6.12   Element 12—Management of change

6.12.1   Overview

The introduction of any form of change into an organization, if not appropriately managed, can significantly increase the levels of process safety risk. Management should ensure that risks arising from any form of change are systematically identified, assessed, and managed.

6.12.2   Guidelines

The following is a list of guidelines for Element 12:

- Process is in place to systematically identify, assess, and manage the risks arising from both temporary and permanent changes;

- Process for managing change addresses:

  - Authority for approval of changes

  - Compliance with legislation and approved standards

  - Acquisition of needed permits

  - Documentation including reason and technical basis for change

  - When process hazard analysis is required due to the complexity or scope of the change being proposed and

  - Communication of risks and their mitigations associated with the change;

- Management of change addresses changes to:

  - Equipment not being replaced in kind

  - Interconnections between a new process and any existing processes

  - Operations or operating procedures

  - Organization, reporting structures, or working patterns that affect the operating process

  - Feedstocks, products, materials, or substances outside of the design parameters

  - Software or control configuration

  - Design or specifications

  - Standards or practices and

  - Inspections, maintenance, or testing programs;

- Management of change considers impacts to:

  - Health and safety (including process safety)

  - Environment

  - Reputation

  - Quality of final product

  - Security

  - Third-party assets and

  - Business interruption;

- Management of change considers human and organizational factors and ensures that responsibilities for critical tasks remain clearly assigned throughout the change;

- Temporary changes do not exceed initial authorization for scope or time without review and approval;

- Risks of the change are assessed by nominated competent individuals;

- Changes are approved by nominated competent individuals commensurate with the risk associated with the proposed change; and

- Pertinent records covering all changes are maintained.

For more information, see:

- EIGA HF 10/10, *Organization - "Managing Organizational Change"* [17];

- ISO 45001:2018, *Occupational health and safety management systems* [18]; and

    NOTE— ISO 45001 provides requirements with guidance for use. Clause 8.1.3 covers management of change.

- AIGA 010, *Management of Change* [19].

6.13   Element 13—Operational readiness and process startup

6.13.1   Overview

The commissioning and startup of new, modified, or existing plant and equipment is a high-risk operation. Management should ensure that there is a systematic process to verify that plant and equipment is in a safe condition and that personnel are prepared before startup or return to normal operation.

6.13.2   Guidelines

The following is a list of guidelines for Element 13:

- There is a systematic process for checking operational readiness and the integrity of systems before they are brought into service;

- Checking process addresses:

    - New or modified plant, processes and equipment

    - Major equipment returned from maintenance and

    - Restart after a trip or a planned shutdown of the full plant or a part of the plant;

- There are defined criteria for operational readiness. The criteria should cover, but are not limited to:

    - Equipment

    - Control system and software

    - Operating procedures and documentation and

    - Human and organizational factors

- Selected criteria should address the following items:

    - Construction is in accordance with specifications

    - Risk management recommendations have been addressed and required actions taken

    - Regulatory and permit requirements are met and

    - Emergency and operations procedures are in place and adequate;

- Maintenance procedures are assigned for development:

    - Required training of personnel and communication related to process safety management aspects has been accomplished and

    - Necessary process safety documentation is readily available to those who need to use it;

- System checks are carried out and documented by competent personnel;

- There are defined criteria for categorizing and handling identified issues and outstanding work items;

- Completed system checks are reviewed, approved, and accepted by specific levels of management appropriate to the magnitude of the risk; and

- Commissioning and startup procedures have defined stages, hold/check points, and progression criteria and review authorities.

6.14 Element 14—Emergency and crisis management

6.14.1 Overview

The consequences of an incident can be significantly reduced if the organization is prepared to handle potential emergency situations. Management should ensure that, in the event of an incident, the organization is prepared for all necessary actions which might be required for the protection of the public, all personnel on site, the environment, plant, equipment, and the organization's reputation.

6.14.2 Guidelines

The following is a list of guidelines for Element 14:

- Emergency procedures are prepared for all identified credible emergency scenarios including those created by neighboring facilities. Emergency response plans (ERPs) are documented, accessible, and clearly communicated. The ERPs should cover but may not be limited to:

    - Response organization structure

    - Defined roles and responsibilities

    - Internal and external communication procedures

    - Procedures for accessing and mobilizing personnel and equipment for emergency response

    - Locations for assembly or muster for evacuation scenarios

    - Procedures for interfacing with other organizations, including the general public and external emergency response organizations

    - Public relations and

    - Recovery and remediation;

- Regular program of training and physical performance drills involving internal and external resources is used to exercise, develop, and improve capabilities for a range of emergencies;

- There are arrangements to ensure that specified levels of management periodically review ERPs, using findings from drills and incidents to identify and address issues and opportunities for improvement;

- Equipment and facilities needed for emergency response are readily available and maintained and information (e.g., site layout drawings and hazardous inventory data) that might be needed in an emergency is kept up to date;

- Adequate numbers of competent personnel are available to fulfill the defined roles in the emergency plans; and

- Mutual aid schemes involving relevant third parties and external services are established and agreed.

For more information, see:

- NFPA 1600®, *Standard on Continuity, Emergency, and Crisis Management* [20];

    NOTE—The National Commission on Terrorist Attacks Upon the United States (the 9/11 Commission), recognized NFPA 1600® as our National Preparedness Standard. Widely used by public, not-for-profit, nongovernmental, and private entities on a local, regional, national, international, and global basis, NFPA 1600® has been adopted by the U.S. Department of Homeland Security as a voluntary consensus standard for emergency preparedness.

- NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response* [21];

- ISO 45001:2018 [18];

  NOTE—ISO 45001 provides requirements with guidance for use. Clause 8.2 covers emergency management;

- EIGA Info HF 06/09, *Organization - "Site Emergency Response"* [22]; and

- AIGA 004, *Handling Gas Container Emergencies* [23].

6.15   Element 15—Inspection and maintenance

6.15.1   Overview

Maintaining the integrity of plant and equipment is an essential component of process safety. Management should ensure that the necessary inspection and maintenance requirements are identified and carried out to reduce the likelihood of a significant incident as a result of failure of plant or equipment.

6.15.2   Guidelines

The following is a list of guidelines for Element 15:

- Equipment is uniquely identified and a file is kept of all design information and maintenance activity on the equipment;

- Equipment inspection and maintenance programs are risk-based and/or time-based. Inspection and maintenance programs should address and integrate long term equipment integrity and process safety compliance assurance;

- There are systems in place to ensure that equipment inspection and maintenance programs are reviewed periodically, using findings from the programs, industry experience, and incidents to identify and address issues and opportunities for improvement;

- Competent personnel are available to establish and perform the inspection and maintenance programs;

- There are systems in place to ensure that findings and recommendations from the equipment inspection and maintenance programs are prioritized and addressed; and

- Deviations from established inspection and maintenance programs are approved by management.

There are numerous AIGA, CGA and EIGA practices that are documented and published. EIGA Info HF 05/18, *Task - "Maintenance"* is a specific example [24]. The relevant publications are best searched for using AIGA, CGA and EIGA's website.

6.16   Element 16—Management of safety critical devices

6.16.1   Overview

An essential requirement for process safety is that safety critical equipment and devices (SCDs) are in service and functioning correctly. Management should ensure that safety critical equipment and devices are identified and appropriately managed, so that they are in service and functioning correctly.

6.16.2   Guidelines

The following is a list of guidelines for Element 16:

- SCDs are uniquely identified and a file is kept of all design information and maintenance activity on the equipment;

- SCD testing, inspection and maintenance programs are in place and approved by competent individuals;

- There are systems in place to ensure that SCD testing, inspection, and maintenance programs are reviewed periodically using findings from the program, industry experience, and incidents to identify and address issues and opportunities for improvement;

- Plans and schedules are developed for execution of testing, inspection, and maintenance programs based upon the risk associated with failure of the SCDs;

- Competent personnel are available to establish and perform the testing, inspection, and maintenance programs;

- There are systems in place to ensure that findings and recommendations from the SCD testing, inspection, and maintenance programs are prioritized and addressed; and

- Procedures for disarming, deactivation, or bypassing of SCDs are reviewed and approved by management.

Safety critical devices are referred to and discussed in several AIGA and CGA publications. AIGA 047 and CGA P-36, *The Safe Preparation of Gas Mixtures*, and AIGA 056, *Safe Practices Guide for Cryogenic Air Separation Plants*, are specific examples [25, 26]. AIGA and CGA publications related to this element are often specific to generic equipment such as storage vessels or specific to products such acetylene, nitrous oxide, oxygen, and other compressed gases and liquids.

6.17 Element 17—Work control, permit to work, and task risk management

6.17.1 Overview

The execution of maintenance and other work activities, if not appropriately managed, can significantly increase the levels of process safety risk. Management should ensure that effective work control, permit to work, and task risk management arrangements are in place and followed to control the risks arising from work activities.

6.17.2 Guidelines

The following is a list of guidelines for Element 17:

- Appropriate work control and permit to work arrangements are employed to assure the safety of personnel, plant, processes, and the integrity of the equipment during work and maintenance activities;

- There are systems in place that ensure that process safety risks arising from work tasks are systematically identified and assessed before work starts, as circumstances change, and where new risks arise during execution of work;

- Risk control measures are identified and implemented to mitigate and manage the identified risks;

- Task risk assessments consider risk to:

  - Health and safety of employees, contractors, customers, and members of the public

  - Environment and

  - Equipment;

- Completed task risk assessments are reviewed and approved by nominated competent individuals and any decisions are clearly documented;

- All of the workgroup is made aware of task risk assessments and required control processes; and

- Competent personnel are available to perform the required work control, permit to work, and task risk management arrangements.

For more information, see AIGA 011, *Work Permit Systems* [27].

6.18   Element 18—Contractors and suppliers — selection and management

6.18.1   Overview

Contractors and suppliers doing work on the organization's behalf can impact its operations and its reputation. Management should ensure that contractors and suppliers perform in a manner that is consistent and compatible with the organization's process safety requirements.

6.18.2   Guidelines

The following is a list of guidelines for Element 18:

- There is a process to ensure that services from contractors and suppliers are evaluated and selected against criteria that include an assessment of capabilities to perform work safely and in compliance with all applicable legislation;

- All contractors are informed and trained on relevant organization procedures and practices for the work that they undertake;

- Effective organizational, communication, and control arrangements are in place between organization personnel and contractor personnel to manage the risks effectively;

- Contractor and supplier performance is routinely monitored and assessed, feedback is provided, and non-conformities are corrected. Poor performance results in removal from approved contractor/supplier list; and

- Competent personnel are available to carry out the required contractor and supplier selection and management arrangements.

For more information, see AIGA 015, *Safe Management of Contractors* [28].

6.19   Element 19—Incident investigation

6.19.1   Overview

An essential aspect of process safety performance improvement is learning from incidents and near misses and taking action to prevent their recurrence. Management should ensure that incidents and near misses are consistently reported and investigated, and that identified actions and learnings are implemented on a timely basis.

6.19.2   Guidelines

The following is a list of guidelines for Element 19:

- System is in place for incident reporting, investigation, follow-up and capturing lessons learned from incidents and near misses including but not limited to:

  - Injury to people

  - Environment incidents

  - Damage to assets or reliability events

  - Loss of process containment

  - Energy release and

  - Deactivation of safety critical devices;

- Reporting of incidents and near misses by all personnel including contractors and suppliers is mandatory;

- Incidents and near misses are classified and investigated on the basis of actual and potential outcome;

- Incidents and near misses are investigated according to a documented procedure on a timely basis;

- Investigations identify root causes and management system failures, including technical, human, and organizational factors;

- Effective arrangements are in place to ensure that incidents or near misses are investigated when they involve customers, contractors, or supplier personnel;

- There are processes in place to learn from relevant incidents, near misses, and good practices;

- Competent personnel are available to perform the required investigations;

- Completed investigations are reviewed and approved by specific levels of management appropriate to the classification of the incident;

- Where appropriate and recognizing legal and security constraints, identified stakeholders who could be impacted by hazards are kept informed about the findings and recommendations from investigations;

- Recommendations are monitored and tracked to completion; and

- Process safety incident statistics and performance trends are reviewed by specified levels of management.

For more information, see:

- AIGA 013, *Incident/Accident Investigation and Analysis* [29];

- EIGA Info HF 03/17, *Organization - "Human Factors in Incident Investigation"* [30]; and

- EIGA Info HF 01/17, *Human Factors - "An Overview"* [31].

6.20   Element 20—Audit, management review, and intervention

6.20.1   Overview

Regular review and audit of effective application of the process safety management framework is vital to ensure that process safety performance continues to meet the defined targets. Management should ensure that there is both routine review and independent audit of each element of the process safety management guidelines.

6.20.2   Guidelines

The following is a list of guidelines for Element 20:

- Performance measures are established to monitor the degree to which the process safety management guidelines are being met for each implemented element;

- Organization's operations are routinely monitored, incorporating process safety management performance measures, and are periodically reviewed by specified levels of management;

- Process safety management guidelines implemented within the organization are periodically reviewed and updated as necessary to ensure that they continue to meet the needs of the organization;

- Audit criteria are defined to provide a consistent basis for audit and a consistent basis for development of the audit analysis;

- Defined internal (second party) and/or external (third party) audit program is in place. The audit assesses application of process safety management guidelines and the effectiveness of the management review;

- Audits are conducted by trained and competent persons. Whenever possible, multidisciplinary teams, including process safety professionals and personnel with operational and technical expertise, should be used;

- Frequency and scope of the audits should reflect the complexity of the operation, the level of risk, and previous compliance history;

- Audit findings are documented and reviewed with the auditee. Audit summary is communicated with management;

- Necessary actions to correct and prevent identified issues and deviations in performance below defined tolerance levels are identified, appropriately prioritized, scheduled, and tracked to completion;

- Effectiveness of the audit program is periodically reviewed and the findings are used to make improvements;

- Understanding of the requirements of all elements and effective application of the process safety management guidelines are periodically tested within the organization; and

- Audit performance trends for all elements are periodically reviewed by management.

For more information, see:

- AIGA 014, *Safety Audit Guidelines* [32]; and

- EIGA Doc 135/12, *Environmental Auditing Guide* [33].

6.21 Element 21—Measures and metrics

6.21.1 Overview

Process safety performance indicators, measures, and metrics are important for improvement of process safety. Two types of indicators are required; leading and lagging. Leading indicators show if controls are working as intended while lagging indicators show whether or not an outcome is being achieved. Management should ensure that performance indicators, measures, and metrics are appropriate and effective in improving process safety performance.

6.21.2 Guidelines

The following is a list of guidelines for Element 21:

- Correct selection of indicators is important since inappropriately selected indicators can result in knowledge gaps or can result in unwarranted confidence. Indicators should provide a means to measure activity, status, or performance against requirements and goals:

  - Lagging indicators should identify and classify incidents and

  - Leading indicators should identify and classify conditions that could ultimately lead to more severe consequences; and

- Indicators should be tracked and periodically reviewed by management to identify actions to drive improvement.

7 References

Unless otherwise specified, the latest edition shall apply.

[1] *High Level Framework for Process Safety Management*, First Edition, Energy Institute. www.publishing.energyinst.org

[2] Center for Chemical Process Safety, American Institute for Chemical Engineers. www.aiche.org

[3] *Code of Federal Regulations,* Title 29 (Labor), U.S. Government Printing Office. www.gpo.gov

[4] *Code of Federal Regulations*, Title 40 (Protection of Environment), U.S. Government Printing Office. www.gpo.gov

[5] *Guidelines for Managing Process Safety Risks During Organizational Change*, Center for Chemical Process Safety, American Institute for Chemical Engineers. www.aiche.org

[6] EIGA Info HF 11, *Organization - "Safety Culture,"* European Industrial Gases Association. www.eiga.eu

[7] EIGA Doc 60, *Seveso Documents - Guidance on Applicability, Assessment and Legal Documents for Demonstrating Compliance of Industrial Gases Facilities with Seveso Directive(s)*, European Industrial Gases Association. www.eiga.eu

[8] EIGA Info HF 02/17, *Individual - "Training and Competence*," European Industrial Gases Association. www.eiga.eu

[9] AIGA 009, *Safety Training of Employees*, Asia Industrial Gases Association. www.asiaiga.org

[10] *Hazard Identification Procedures*, Center for Chemical Process Safety, American Institute for Chemical Engineers. www.aiche.org

[11] EIGA Doc 75/07, *Determination of Safety Distances*, European Industrial Gases Association. www.eiga.eu

[12] EIGA Info HF 07/18, *Organization – "Communications on Safety*," European Industrial Gases Association. www.eiga.eu

[13] AIGA 028, *Unmanned Air Gas Plants: Design and Operation*, Asia Industrial Gases Association. www.asiaiga.org

[14] *Guidelines for Risk Based Process Safety*, Center for Chemical Process Safety, American Institute for Chemical Engineers. www.aiche.org

[15] EIGA Info HF 04/17, *Task - "Design and Effectiveness of Procedures,"* European Industrial Gases Association. www.eiga.eu

[16] Project Management Institute. www.pmi.org

[17] EIGA Info HF 10/10, *Organization - "Managing Organizational Change,"* European Industrial Gases Association. www.eiga.eu

[18] ISO 45001:2018, *Occupational health and safety management systems*, American National Standards Institute. www.ansi.org

[19] AIGA 010, *Management of Change*, Asia Industrial Gases Association. www.asiaiga.org

[20] NFPA 1600®, *Standard on Continuity, Emergency, and Crisis Management*, National Fire Protection Association. www.nfpa.org

[21] NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, National Fire Protection Association. www.nfpa.org

[22] EIGA Info HF 06/09, *Organization - "Site Emergency Response,"* European Industrial Gases Association. www.eiga.eu

[23] AIGA 004, *Handling Gas Container Emergencies*, Asia Industrial Gases Association. www.asiaiga.org

[24] EIGA Info HF 05/18, *Task - "Maintenance Error,"* European Industrial Gases Association. www.eiga.eu

[25] AIGA 047, *The Safe Preparation of Gas Mixtures*, Asia Industrial Gases Association. www.asiaiga.org

[26] AIGA 056, *Safe Practices Guide for Cryogenic Air Separation Plants*, Asia Industrial Gases Association. www.asiaiga.org

[27] AIGA 011, *Work Permit Systems*, Asia Industrial Gases Association. www.asiaiga.org

[28] AIGA 015, *Safe Management of Contractors*, Asia Industrial Gases Association. www.asiaiga.org

[29] AIGA 013, *Incident/Accident Investigation and Analysis*, Asia Industrial Gases Association. www.asiaiga.org

[30] EIGA Info HF 03/17, *Organization - "Human Factors in Incident Investigation,"* European Industrial Gases Association. www.eiga.eu

[31] EIGA Info HF 01/17, *Human Factors - "An Overview,"* European Industrial Gases Association. www.eiga.eu

[32] AIGA 014, *Safety Audit Guidelines*, Asia Industrial Gases Association. www.asiaiga.org

[33] EIGA Doc 135/12, *Environmental Auditing Guide*, European Industrial Gases Association. www.eiga.eu

[34] Sutton, Ian. *Process Risk and Reliability Management*, Gulf Professional Publishing, 2014. https://www.elsevier.com/books-and-journals/gulf-professional-publishing

[35] Spellman, Frank. *A Guide to Compliance for Process Safety Management/Risk Management Planning (PSM/RMP)*, CRC Press, 1998. www.crcpress.com

[36] OSHA 3132, *Process Safety Management*, U.S. Department of Labor. www.osha.gov

[37] OSHA 3133, *Process Safety Management Guidelines for Compliance*, U.S. Department of Labor. www.osha.gov

[38] OSHA 3909, *Process Safety Management for Storage Facilities*, U.S. Department of Labor. www.osha.gov

[39] EIGA Info HF 08/18, *Task - "Alarm Handling*," European Industrial Gases Association. www.eiga.eu

[40] EIGA Info HF 09/09, *Task – "Fatigue from Working Patterns - Shiftwork and Overtime*," European Industrial Gases Association. www.eiga.eu

[41] EIGA Info HF 12/12, *Task - "Human Factors in Design,"* European Industrial Gases Association. www.eiga.eu

[42] EIGA Info HF 13/12, *Organization - "Human Reliability,"* European Industrial Gases Association. www.eiga.eu

Appendix A—Related publications
(Informative)

This appendix lists other publications that are relevant to process safety management and align with the specific process safety management elements listed in this document. Some publications listed in this appendix are in need of review, (in some cases specifically to integrate process safety related items) and will be updated in due course. Resources specific to each element are referenced in each element's section.

A1   General process safety management related documents and publications

- *Guidelines for Risk Based Process Safety*, Center for Chemical Process Safety, American Institute for Chemical Engineers [14];

  NOTE—In addition to this publication, CCPS has an extensive library of process safety guidelines for each element of a process safety program.

- Sutton, Ian. *Process Risk and Reliability Management* [34];

- Spellman, Frank. *A Guide to Compliance for Process Safety Management/Risk Management Planning (PSM/RMP)* [35];

- OSHA 3132, *Process Safety Management* [36];

- OSHA 3133, *Process Safety Management Guidelines for Compliance* [37]; and

- OSHA 3909, *Process Safety Management for Storage Facilities* [38].

There are numerous EIGA publications that are related to process safety management, examples include:

- EIGA Info HF 08/18, *Task - "Alarm Handling"* [39];

- EIGA Info HF 09/09, *Task - "Fatigue from Working Patterns - Shiftwork and Overtime"* [40];

- EIGA Info HF 12/12, *Task - "Human Factors in Design"* [41]; and

- EIGA Info HF 13/12, *Organization - "Human Reliability"* [42].