



An Alliance for Energy Pipeline Innovation

Facilities Integrity Management Program Recommended Practice, Second Edition

November 2025

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Contents

List of Tables	6
List of Figures	7
Acknowledgements	8
1. Definition of Terms	9
2. Introduction	12
2.1. Importance of Terminology	12
2.2. Revisions to this Recommended Practice	12
2.3. Background and Philosophy	12
2.4. Framework	13
3. Scope	14
3.1. Facilities Description	14
3.2. Asset Registry	15
3.2.1 Asset Registry	15
3.2.2 Asset Failure Records	16
3.2.3 Asset Operational Status	17
3.3. Scope of Processes and Mechanisms	17
3.4. Prioritization of Equipment Types and Processes	19
3.5. Organization	21
3.6. Performance Indicators and Targets	21
3.6.1 Performance Indicators	21
3.6.2 Performance Targets	22
4. Records	23
4.1. Facility Information	23
4.2. FIMP Information	24
5. Change Management	24
5.1. General	24
5.2. Change Management Process Features	25
6. Competency and Training	26
6.1. Establish Role Requirements	26
6.2. Conduct Gap Analysis	27
6.3. Execute Training Plan	28
6.4. Undertake Follow-Up Discussion	28
7. Hazard Identification and Control	28

7.1.	Choose Hazard Identification Method	30
7.2.	Hazard Identification Exercise	30
7.2.1	Gather Resources	30
7.2.2	Conduct Hazard Identification Exercise	30
7.3.	Review Potential Consequences.....	31
7.4.	Estimate Likelihood of Consequences	31
7.5.	Conduct an Initial Assessment of Significance.....	31
7.6.	Determine Risk Assessment Needs	31
8.	Risk Assessment	32
8.1.	Risk Analysis	32
8.2.	Data Availability	32
8.3.	Organizational Maturity	32
8.4.	Goal of the Analysis.....	33
8.5.	Magnitude of the Decision	33
8.6.	Risk Evaluation	33
8.7.	Risk Refinement.....	33
8.8.	Risk Reduction Evaluation	34
9.	Options for Reducing Uncertainty, Frequency or Consequences of Incidents	34
9.1.	Monitoring and Inspection	35
9.2.	Risk Management.....	35
10.	Planning and Executing	37
10.1.	Plan and Execute Activities	37
10.1.1	Confirm Current Assumptions.....	38
10.1.2	Confirm Monitoring, Inspection and/or Mitigation Methods.....	39
10.1.3	Establish execution plan	39
10.1.4	Execute	39
10.1.6	Review Results	40
10.1.6	Evaluate	40
11.	Repair	40
11.1.	Repair Identification	41
11.2.	Repair Execution	41
12.	Continual Improvement	41
12.1.	Process Characteristics.....	41
12.2.	Specific Considerations	42
13.	Incident Investigations.....	42
	List of References	43
A1.	Sample Performance Indicators.....	44

A2.	Guidance Regarding FIMP Documentation	46
A3.	List of Hazards for Consideration	48
A4.	Monitoring and Inspection	49
A5.	Reference Documents	50
A5.1	Industry Organization Publications and Standards	50
A5.2	Other References.....	51

List of Tables

Table 1: Comparison of Facility and Pipe IMP Programs	13
Table 2: Potential Basis for Initial Prioritization of FIMP Scope.....	19
Table 3: Key FIMP Roles and Responsibilities for Consideration	21
Table 4: Two Types of Performance Indicators.....	22
Table 5: Considerations in Establishing Performance Targets	23
Table 6: Recommendations for Data Capture for FIMP Assets.....	24
Table 7: Potential Triggers for Change Management Process.....	25
Table 8: Minimum Features of Change Management Process	25
Table 9: Considerations in Establishing Competency Requirements.....	27
Table 10: Resources for Determining Training Needs	27
Table 11: Categorization of Qualification Gaps.....	27
Table 12: Mechanisms for Mitigating Qualification Gaps.....	28
Table 13: Objectives of Follow-up Employee Discussion	28
Table 14: Additional Guidance for Establishing Significance of Risk.....	33
Table 15: Parameters for Risk Refinement	34
Table 16: Approaches for Managing Risk.....	34
Table 17: Considerations for Selecting Monitoring & Inspection Activities	35
Table 18: Mitigation Activity Types.....	36
Table 19: Considerations for Determining Acceptable Mitigation	37
Table 20: Considerations for the Review of Current Assumptions	39
Table 21: Considerations for Program Execution	39
Table 22: Considerations for Program Review.....	40
Table 23: Considerations for Addressing Identified Anomalies	40
Table 24: Considerations for Executing Corrective Actions	41
Table 25: Elements of Continual Improvement Process.....	41
Table 26: FIMP Documentation and Reference Guideline.....	46
Table 27: Sample List of Equipment Specific Considerations	48
Table 28: Sample List of Monitoring and Inspection Goals.....	49
Table 29: Industry Published Guidance Documents	50
Table 30: Additional Guidance from Other References	51

List of Figures

Figure 1: Facility Integrity Management Program Process	14
Figure 2: Sample of asset type and equipment pertaining to a FIMP.....	15
Figure 3: Scope of Processes and Mechanisms for Consideration in FIMP	18
Figure 4: Consequence Categories for Consideration ¹⁰	20
Figure 5: Competency and Training Process	26
Figure 6: Hazard Identification and Control Process.....	29
Figure 7: Process for Planning and Executing	38

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1. Definition of Terms

The following definitions apply in this document.

Asset:	A generic reference to an arbitrary grouping of components, equipment or facilities where groupings are usually defined based on rules specific to each Operating Company.
Cathodic Protection:	A technique to prevent the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.
Consequence:	Describes the result of an accidental event. The consequence is normally evaluated for human safety, environmental impact and economic loss.
Engineering Assessment:	A detailed technical analysis, as may be required from time to time, to assess or analyze whether a piece of equipment, or grouping of equipment, is suitable for service in its intended purpose or application.
Equipment:	A grouping of individual components designed and assembled to serve an engineering purpose (e.g., air compressor).
Facilities Integrity Management Program:	A documented program, specific to the facilities portion of a pipeline system, that identifies the practices used by the Operating Company to ensure safe, environmentally responsible, and reliable service.
Facility:	A grouping of individual assets designed and constructed to facilitate a larger (engineering) process. Facilities may include pump, or compressor stations, measurement stations, storage terminals, custody transfer facilities, mainline valves, pipeline relief facilities, and other locations as determined by the Operating Company's delineation practices.
Hazard:	A condition or practice with the potential to cause an event that could result in harm to people, the environment, the company's reputation, business or operation / integrity of its facilities.

Integrity:	Used in the context of managing pipeline systems, a general understanding or definition of integrity has to do with quality; that a mechanical component meets or exceeds design specifications for an intended purpose or application ¹ .
Integrity Management Program	A documented program that specifies the practices used by the Operating Company to ensure the safe, environmentally responsible, and reliable service of a pipeline system. ²
Mitigation	Activities to manage the risk exposure of a particular pipeline system or its individual components. Mitigation activities are broadly ranging and are specific to the context (i.e., the type of equipment, its current state, and operating conditions) ³ . Mitigation may be in the form of threat mitigation or consequence mitigation as discussed in Section 11.
Operating Company:	The individual, partnership, corporation, or other entity that operates the pipeline system or an individual facility.
Pipeline:	Those items through which oil or gas industry fluids are conveyed, including pipe, components, and any appurtenances attached thereto, up to and including the isolating valves used at stations and other facilities ² .
Pipeline Integrity Management Program	A documented program, specific to pipelines, that specifies the practices used by the Operating Company to ensure the safe, environmentally responsible, and reliable service of a pipeline system. ²
Pipeline System:	Pipelines, stations, and other facilities required for the measurement, processing, storage, gathering, transportation, and distribution of oil or gas industry fluids. ²
Risk:	Strictly defined as the probability of an event or occurrence multiplied by the consequence of that event as per Equation (1). A detailed discussion appears in Section 10.

Risk Assessment:

The process of risk analysis and risk evaluation as detailed in CSA Z662-23 Annex B. These are the definitions used by CSA:

Risk – a compound measure, either qualitative or quantitative, of the frequency and severity of an adverse effect.

Risk analysis – the use of available information to estimate the risk, arising from hazards to individuals or populations, property, or the environment

Risk assessment – the process of risk analysis and risk evaluation

Risk control – the process of decision-making for managing risk, and the related implementation, communication, and monitoring activities required to ensure the continuing effectiveness of the risk management process

Risk Evaluation – the process of judging the significance of the absolute or relative values of the estimated risk, including the identification and evaluation of options for managing risk

Risk Management – the ongoing process of risk management and control

Service Fluid:

The fluid contained, for the purpose of transportation, in an in-service pipeline system.

2. Introduction

2.1. Importance of Terminology

Part of the objective of this Recommended Practice is to provide clarity and consistency regarding terminology. As such, the reader is encouraged to review Section 1 of this document with particular attention to the following terms and their usage:

- Facilities Integrity Management Program;
- Integrity;
- Integrity Management Program;
- Mitigation;
- Pipeline Integrity Management Program;
- Pipeline; and
- Pipeline System.

These particular terms are important to understanding the scope and intent of the discussions throughout this recommended practice.

2.2. Revisions to this Recommended Practice

This edition of the Recommended Practice has been developed by ECC's FIMP committee, based on the first edition prepared by CEPA's Pipeline Integrity Working Group (PIWG). It will continue to evolve as new advances and opportunities for improvement are recognized during its use by ECC member companies and from periodic reviews as deemed necessary by ECC.

2.3. Background and Philosophy

This recommended practice provides guidelines for developing, documenting, and implementing a Facilities Integrity Management Program (FIMP) for transmission pipeline-related facilities. Specific guidance is provided regarding the development of goals and objectives, as well as supporting programs and processes, to effectively maintain facilities' integrity. This document puts forth the recommendations to be included in an Operating Company's FIMP based on leading industry practice and building on guidelines established in CSA Z662 Annex N.

The objective of a FIMP is to provide Operating Companies with a formalized mechanism to maintain the integrity of the managed assets that demonstrates a commitment to protect the health and safety of the general public, employees and the environment. Further, the guidelines are intended to allow flexibility in the development of a FIMP and to remain relevant to the Operating Company's context while identifying leading practices in the area. The FIMP is not intended to duplicate any systems, processes or information that may already exist. Thus, this recommended practice is structured to allow Operating Companies the ability to acknowledge any pre-existing body of work that has been incorporated into their

respective processes or programs. It is the intent of this recommended practice to aid in the development of a FIMP that is distinct from a company's integrity management program (IMP) based on the key differences summarized in Table 1.

Table 1: Comparison of Facility and Pipe IMP Programs

Parameter	IMP	FIMP
Scope	Assets relatively uniform (i.e., pipeline(s) of varying grades, wall thicknesses and diameters).	Disparate asset types.
Program Goal	The safe, environmentally responsible, and reliable service of pipeline(s) by working towards minimizing loss of service fluid containment.	- The safe, environmentally responsible, and reliable service of all pipeline system facilities, exclusive of pipelines, by striving to ensure control and containment of service fluids and - Equipment meets or exceeds design life given its intended purpose and actual operating conditions.
Asset Life Cycle	Long lifecycle.	- Life cycles vary significantly and - Assets with long life cycles often contain numerous components with short lifecycles.

Each Operating Company will select processes appropriate for its situation, associated with a FIMP, and separate these from its Pipeline Integrity Management programs. Operating Companies may determine if the FIMP is meant to cover other facilities-related disciplines such as asset maintenance, reliability, operations technical support, process safety, etc.

2.4. Framework

This document builds on the framework outlined in CSA Z662 Annex N as a basis for providing guidance on developing and sustaining a FIMP. Specifically, the elements provided in Figure 2 and holistically aligned with CSA Z662 Annex N (latest Edition), are described and discussed in the context of FIMP development:

- a) Section 3: FIMP Scope;
- b) Section 4: Description of Facilities;
- c) Section 5: Program Records;
- d) Section 6: Change Management;
- e) Section 7: Competency and Training;
- f) Section 8: Hazard Identification and Control;
- g) Section 9: Risk Assessment;
- h) Section 10: Options for Reducing Uncertainty, Frequencies and Consequences;
- i) Section 11: FIMP Planning and Execution;
- j) Section 12: Repair;
- k) Section 13: Continual Improvement; and
- l) Section 14: Incident Investigations.

Figure 1 below provides a recommended flow diagram for the development of a company FIMP, based on a Plan, Do, Check, Act methodology.

PLAN

Program Scope & Standards – Define facility types, asset classes, and applicable acts, codes, standards, and policies. Develop governing documents as needed (standard, manual, process, procedure, etc.). Develop Training & Awareness tools. Define KPIs.

Hazard Identification, Criticality and Risk Assessment – Identify hazards (failure modes and mechanisms), probability and consequence of failure and determine suitable methods to assess the applicable risk.

Define Asset Strategies: Inspection, Monitoring & Maintenance Strategy – Develop scope and intervals

Information Management & Document Control – Define systems for capturing inspection and maintenance results, assessment reports, risk

DO

Execute Maintenance, Inspection and Monitoring

Assess findings (failure, anomalies, incidents, etc.)

Record Keeping – Store inspection, maintenance, and risk data in integrity management systems.

Execute remedial measures from assessments (mitigative and preventive)

Update KPI metrics

Provide Training & Awareness – Train staff and contractors on program requirements

ACT

Management Review – Evaluate program results, residual risks, and measures.

Program Updates – Adjust Asset Strategies (scope and interval), and other program aspects.

Lessons Learned Integration – Feed outcomes into design, construction, and operational procedures.

Continuous Improvement – Benchmark against industry best practices; update governing documents and training content.

CHECK

Performance Monitoring – Track KPIs and evaluate

Audits & Reviews – Conduct internal/external audits of the program against regulations and standards. (including governing documents, training, registries, etc.)

Incident & Deviation Analysis – Investigate failures, near misses, and non-conformances.

Effectiveness Verification – Confirm that mitigations reduce risk to acceptable levels.

Figure 1: Facility Integrity Management Program Process

3. Scope

The FIMP documentation may clearly define which facilities and assets it directly manages, and which are managed through other systems (see Figure 3). For externally managed assets, the FIMP should reference the relevant documentation. Additional guidance is provided later in this section.

3.1. Facilities Description

This document uses a definition of Facilities, assets and Equipment derived from usage of the terms: *Pipeline* and *Pipeline System* in CSA Z662 (latest Edition). That is, a Facilities Integrity Management Program (FIMP) is intended to address components of a *Pipeline System*, with the exclusion of the *Pipeline* itself (to be covered by a Pipeline Integrity Management Program). Operators should identify the asset types relevant to their Facility Integrity Management program, specific to their system. This applies to both new and existing systems. A sample is provided in Figure 2 for reference.

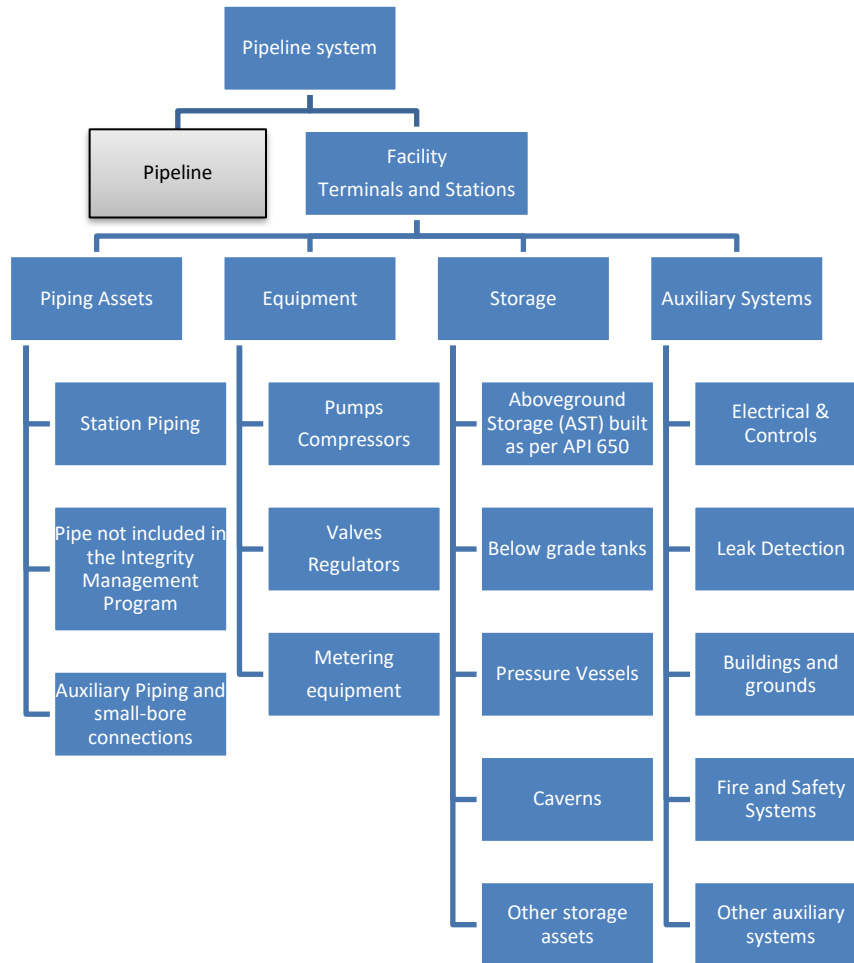


Figure 2: Sample of asset type and equipment pertaining to a FIMP

3.2. Asset Registry

Operating Companies should implement a structured and standardized approach to managing facility asset information. This includes the identification, storage, and integration of key data, such as asset registries and failure records, ensuring it is readily accessible and interconnected. Such an approach supports effective classification, tracking, risk assessment, evaluation, work management, and record keeping.

Furthermore, Operating Companies may require established robust processes to maintain data integrity. This includes ensuring that any changes or modifications to facilities or facility assets are accurately and promptly updated in all relevant databases.

3.2.1 Asset Registry

The purpose of this centralized and structured system is to list the physical assets included in a facility, including relevant information such as:

- Asset name: should have unique asset tags/IDs

- Function: purpose or type of asset (i.e. station piping, booster pump, etc.)
- Location: facility and geographical location that may or might not be geospatially referenced.
- Ownership: describes parties accountable for operating and maintaining facility.
- Characteristics specific to the asset: for example, piping asset should include material, diameter, coating type, pressure rating and temperature rating, between others.
- Condition and status (see section 3.2.3)

The purpose of this Asset Registry is to support effective integrity management, risk assessment, planning, maintenance, and compliance. It helps ensure transparency, accountability, traceability and informed decision-making across the asset lifecycle. To deliver on its purpose, the Asset Registry should allow for easy access (or correlation) to:

- Operational conditions
- Inspection and maintenance history
- Risk evaluation and prioritization
- Acquisition and disposal dates
- Physical surroundings/boundaries or loss of containment consequence information
- Associated documentation or systems

Alternatively, the Asset Registry may be replaced or supplemented by a computerized Asset Management System (e.g., CMMS), which serves the same purpose and contains equivalent information. This system provides a structured, hierarchical view of all physical assets and facilities, showing their relationships from top-level sites down to individual components.

Typical Levels:

- Enterprise/Company
- Site/Facility
- System/Area
- Equipment
- Component/Part

For example: Company → Pump Station → Crude Oil Transfer System → Pump P-101 → Motor → Bearing Assembly.

3.2.2 Asset Failure Records

In addition to the Asset Registry, the Operating Companies should have a system to capture and record facility and asset failures. The system should include information such as: Date/time, description, mode and mechanism of failure, cause, detection method, corrective action taken, downtime, and impact on safety/environment/operations.

The purpose of this system in Integrity Management is to inform the FIMP; providing data for various analyses and assessments, including risk-based

inspection, preventative maintenance, reliability metrics, optimization and other processes encompassing the entire life cycle.

3.2.3 Asset Operational Status

It is important to include the current condition and availability state of an asset in the Asset Registry, whether it is in service, and its capability to perform its intended function. This information enables tracking operational readiness, informs downtime and supports planning, inspections, maintenance, and spares availability.

Common Status Categories:

- Under construction
- Operating/In Service
- Out of Service/idle – temporarily unavailable or not currently being used, unused or under-utilized.
- Deactivated – temporarily removed from service, but preserved/maintained for future operation.
- Decommissioned - permanently cease operation such that the cessation does not result in the discontinuance of service. It's typically removed from place.
- Abandoned: means to permanently cease operation such that the cessation results in the discontinuance of the service. Abandoned assets could remain in place or be removed.

3.3. Scope of Processes and Mechanisms

A FIMP should be documented and should consider the methods for collecting, integrating, and analyzing information related to the processes and mechanisms identified in Figure 3, as appropriate for the type of facility and the Operating Company's operations. The approach should be consistent with Figure 1 and as holistic as possible – that is, incorporate the entire lifecycle to the extent possible. Thus, the process is fundamentally a variant of the Plan-Do-Check-Act cycle.⁴

One of the key implications of adopting a life cycle approach is to ensure that hazard management (as per Section 9) is an inherent part of each major stage of the pipeline system project (e.g., design, construction, operations etc.,).

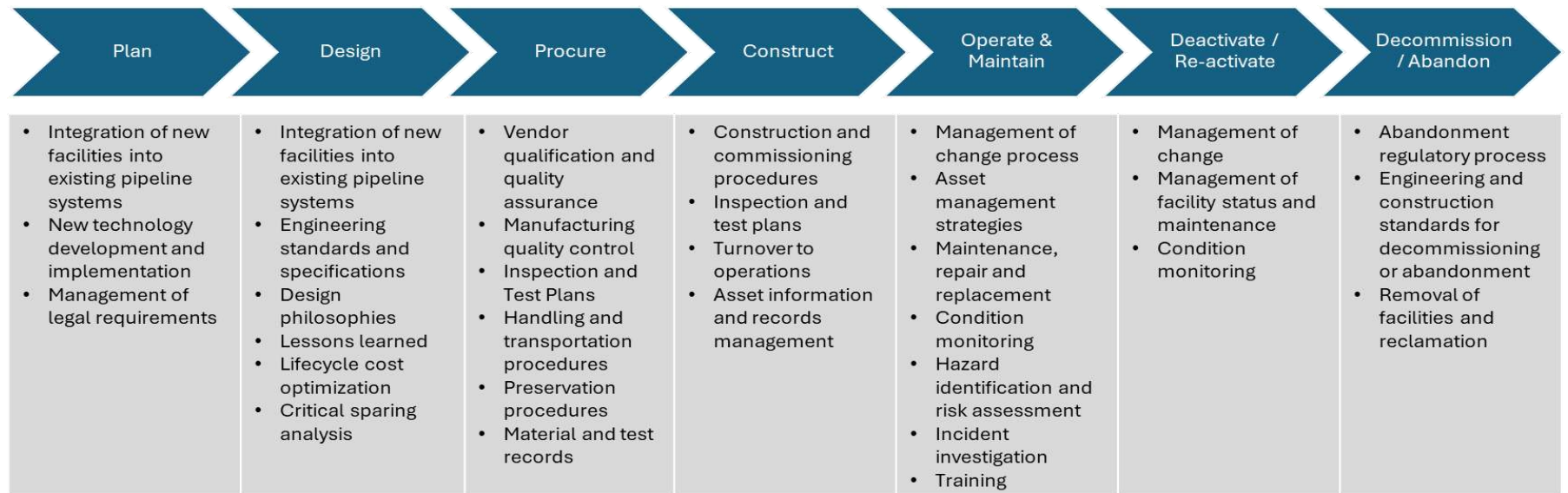


Figure 3: Scope of Processes and Mechanisms for Consideration in FIMP

3.4. Prioritization of Equipment Types and Processes

While attempting to formulate the initial version of a FIMP, the Operating Company may need to prioritize certain equipment types and processes. This initial prioritization as shown in Table 2, can be based on a number of approaches (or combination thereof) – based on what is most relevant for the Operating Company.

Table 2: Potential Basis for Initial Prioritization of FIMP Scope

Description	Approach
Industry Incidents and Failures	• Industry experience with similar facilities – specifically damage incidents, failures and associated consequences.
Company Incidents and Failures	• Corporate experience with similar facilities – specifically damage incidents, failures and associated consequences.
Corporate Policies and Objectives	• Could vary significantly but examples include: ○ Facilities critical to ensuring business continuity and ○ Equipment nearing end of design life (but perhaps no damage or failure incidents).

Once the FIMP has been established, priorities will be established based upon the process itself (specifically, the identification of areas of significant risk as per Section 8.6).

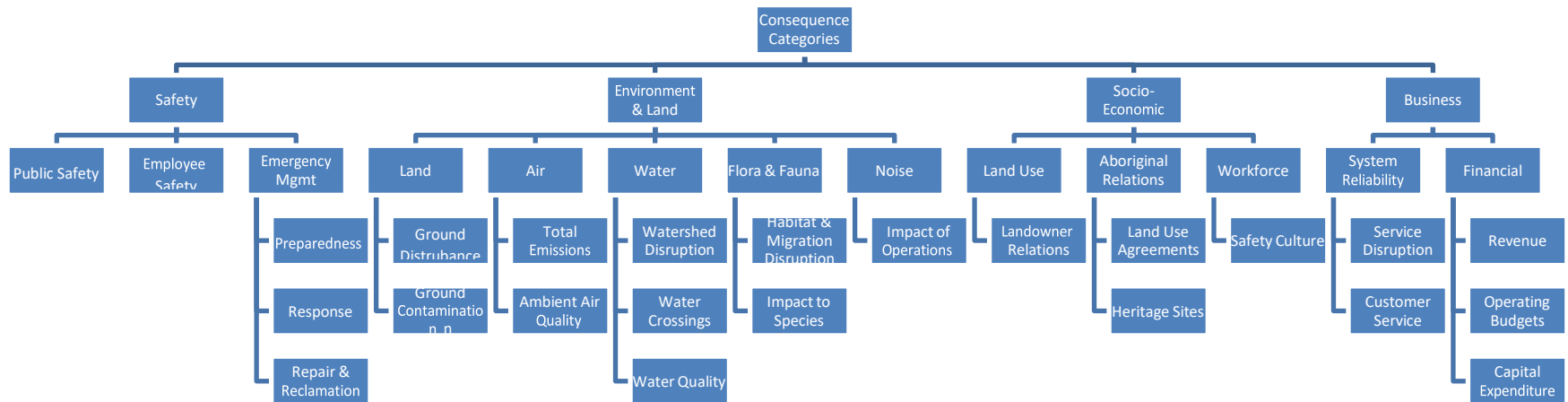


Figure 4: Consequence Categories for Consideration⁵

3.5. Organization

A critical element of successfully implementing the processes and activities associated with a FIMP will be a clear articulation of roles and responsibilities of Operating Company personnel for each aspect of the program. While organizational structures will vary across Operating Companies, the following functions as outlined in Table 3 typically associated with a management systems approach should be identified and assigned to appropriate individuals, groups or departments.

Table 3: Key FIMP Roles and Responsibilities for Consideration

Category	Description
FIMP Accountability	• The accountable individual(s), to whom the Operating Company delegates authority, should be clearly identified: ◦ These functions are responsible for ensuring that appropriate human and financial resources are assigned to establishing, implementing, and maintaining the facility integrity management program.
Program Development and Improvement	• These functions are responsible for the development of the FIMP, identification of hazards and associated risk assessments and identification of hazard control activities as well as oversight of the FIMP processes. • A critical element is the identification of key roles, outside of traditional 'integrity' groups, that support FIMP
Records Management	• These functions are responsible for ensuring that adequate records are maintained in support of FIMP development, implementation and associated activities. • Due to the potentially large breadth and depth of these activities, this function may be dispersed across a number of departments and groups within the Operating Company.
Program Planning, implementation and Reporting	• These functions are responsible for planning and executing integrity related work along with documentation and analysis of results.
Program Audits, Reviews and Evaluations	• These functions work closely with the Program Development and Improvement functions to review, audit and assess the effectiveness of the FIMP and supporting activities.
Communications	• Communications are critical through all stages of FIMP development, execution and management of change. As such, responsibilities for communicating, and nature of such communications, should be established and documented for each stage of the FIMP process.

3.6. Performance Indicators and Targets

A key element of successfully translating relevant corporate direction to a FIMP is to establish performance indicators (and associated targets). Further, the definition and monitoring of performance indicators provides a mechanism to monitor whether the FIMP is functioning effectively.

3.6.1 Performance Indicators

In general, effective performance indicators should be reliable, repeatable, consistent, comparable, and appropriate to the intended need.

There are two main types of performance indicators: Leading and Lagging. These are described in further detail in Table 4 with examples provided in Appendix A1. In

general, a well-structured approach would be comprised of both indicator types.

Table 4: Two Types of Performance Indicators

Category	Description
Leading Indicators	Leading indicators measure the performance of a management system element or process, operating or maintenance procedure, control, mitigation, or evaluation in preventing incidents or loss of integrity events. These indicators look forward and are focused on prevention.
Lagging Indicators	Lagging indicators look at performance that can be measured in relation to the past. They evaluate events that have already occurred, such as leaks, ruptures, fires, and injuries, and the data collected as a result of these events can be utilized to prevent recurrence of similar events in the future. Lagging indicators are typically within an operators control to collect, are relatively easy to measure, and are typically comparable to industry data.

3.6.2 Performance Targets

Targets for performance can be established against which the chosen performance indicators can be measured. From the comparison of results against targets, trends can be identified that can be used to modify or enhance FIMP activities (as warranted). In establishing realistic performance targets, a number of factors need to be considered. These are described in further detail in Table 5.

Table 5: Considerations in Establishing Performance Targets

Category	Description
Current State of Facilities	The current state of facilities (or to the extent this can be inferred), is a critical input parameter in establishing practical performance targets. For example, it is unlikely that poorly maintained equipment can be expected to perform to the same level as well maintained equipment.
Corporate Objectives	Corporate objectives are a critical input to establishing relevant performance targets in the FIMP. For example, it is likely unrealistic to expect significant gains in a specific area of equipment performance if underlying funding is not available.
Benchmark Data	- In the absence of clear performance targets, or in the situation where an Operating Company wishes to gauge its performance relative to its peers, industry benchmarking may also be considered. While this approach can be expensive and time consuming (i.e., use of specialists in this area is warranted), it does allow the Operator a broader perspective with respect to Corporate Performance. Data sources may include (but are not limited too): - API Pipeline Performance Tracking System (PPTS) – for liquid pipelines and API members only; - The Health Safety Executive which regulates off-shore hydrocarbon systems in the United Kingdom has managed a hydrocarbon release database as of October 1, 1992. (www.hse.gov.uk/offshore/statistics.htm) The database is intended as an industry information source to support the management of hydrocarbon releases. Direct database access may be granted on a discreet basis potentially for a fee as described in the database FAQ; and - CONCAWE⁶ The organization is an industry supported research group with a scope that has expanded to track and assess oil pipeline performance in Europe.

4. Records

4.1. Facility Information

Operating Companies should assemble and manage records related to facility design, material selection, purchasing, construction, operation, inspection, testing and maintenance that are needed for performing the activities included in their facilities integrity management program for the equipment included in the FIMP as outlined in Section 3. For new facilities, the process of accumulating this information should be built into and documented in an Operating Company's projects deliverables. It is much more efficient and accurate to compile this information while such projects are active than to undertake it after the fact.

For existing facilities, the availability of records will vary from facility to facility and within types of equipment; items to be considered for inclusion should include as much of the information identified in Table 6 as possible and as appropriate for the type of facility and equipment included. Where data gaps are identified due to legacy issues, Operating Companies should take reasonable measures to gather, reproduce/revalidate the needed records or otherwise show that it has sufficient information to make effective FIMP related decisions. These measures can be prioritized based on the risk associated with data gaps.

The information described in Table 6 would be considered as an indicative data set to adequately support a FIMP.

Table 6: Recommendations for Data Capture for FIMP Assets

Parameter	Description / Examples
Location	• With respect to third party line crossings, nearby land developments (include geotechnical assessments and environmental assessments) and other environmental receptors; • Terrain, soil type, backfill material, and depth of cover for any buried facility piping; • Class Location as per CSA Z662; and • Activities in the area surrounding the facility that may become consequence receptors or increase the risk of external interference.
Construction Records	• Physical attributes and characteristics; • Age/date of installation; • Physical location of the equipment along with orientation and configuration; • Coating type and thickness for piping; • Material of construction; and • Construction quality control documents (e.g. material test reports, NDT reports, hydrotest records).
Operating Conditions	• Design limits on pressure, temperature, loading, and other operating conditions vs., actual limits; • Product corrosivity (water and debris, bacteria, chlorides, etc.); • Product (wet or dry gas, oil, condensate, water, etc.); • Operating history (where available, records regarding pressure, temperature, flow rates immediately prior to failure as well as longer timelines); and • Anomalous weather conditions.
Maintenance / test records	• CP Monitoring for buried facilities; • Repair history; • Maintenance and inspection records; and • Pressure test records for piping and equipment (e.g. hydrotest records, valve body factory tests).
Incidents	• Incidents and near misses related to facility integrity.

4.2. FIMP Information

In addition to the foundational equipment information identified in Section 3.1 Operating Companies should assemble and manage records related to FIMP activities and processes outlined in this document. Additional guidance regarding recordkeeping, regarding the process outlined in this document, is provided in Appendix A2.

5. Change Management

5.1. General

Changes to the Facilities Integrity Management Program should be managed in accordance with the organization's standard Management of Change (MOC) process or industry best practices, as needed and applicable. The MOC should include, at a minimum, a clear description of the proposed change, documented

technical and safety reviews, an assessment of potential impacts on integrity, operations, and regulatory compliance, assignment of roles and responsibilities for implementation, identification of required training or procedural updates, communication to affected stakeholders, and formal approval prior to execution. Completion verification and post-implementation review should also be conducted to ensure the change meets its intended objective. Potential triggers for the change management process are outlined in Table 7.

Table 7: Potential Triggers for Change Management Process

Nature of Trigger	Examples / Description
Internal	• The ownership of a facility; • The organization and personnel of the Operating Company; • The organization and personnel who operate and maintain the facility; • Facility equipment and control systems; • Facility operating status, such as idling, facility shutdown, or decommissioning can introduce “temporary” hazards not expected during normal operations; • Operating conditions; • Product characteristics; • Methods, practices, and procedures related to facility integrity management; and • Program execution findings (see Section 14).
External	• Standards and regulations related to facilities integrity management; • Other installations (e.g., power lines) that cross piping and other equipment or facilities; • Environmental factors, such as flood, fire, ground movement, if changes to the facility should be made to account for these factors; and • Adjacent land use and development.

5.2. Change Management Process Features

The change management process should have procedures in place to address and document the following, as appropriate, for the type of facility:

Table 8: Minimum Features of Change Management Process

Element	Description
Definition of Change	• The change management process should define what constitutes a change. This may take several forms: ○ Based on a specific incident, trigger (new regulation comes into force); ○ Could be based on a threshold (i.e., if failure frequency of a particular piece of equipment exceeds a predetermined value); and ○ Cost or financial impact that exceeds a predetermined value.
Monitoring for Change	• Method of monitoring for and identifying anticipated and actual changes that affect facility integrity.
Establishing RACI	• Identification of responsibilities for identifying, approving, and implementing changes.
Reason for change	• Reasons for changes.
Analysis	• The analysis carried out to identify the implications and effects of the changes.
Communication	• Method of communication of changes to affected parties.
Close out	• Close-out procedures as a means for reinforcing the changes required (including documentation requirements).

6. Competency and Training

Competency and training are a critical element of the FIMP Framework. As such, a standalone scalable process for managing competency and training of those individuals responsible for administering and carrying out FIMP related activities is described herein. Given that corporate performance management systems as well as learning and development philosophies vary greatly from one Operating Company to another, it is acknowledged that this process represents a leading practice approach for a standalone process and that individual operators will need to execute elements of this recommendation within the constraints of their existing processes, initiatives and systems or develop new practices related to competency and training in support of their FIMP. A process map appears in Figure 5; details regarding the process appear below in the remainder of this Section.

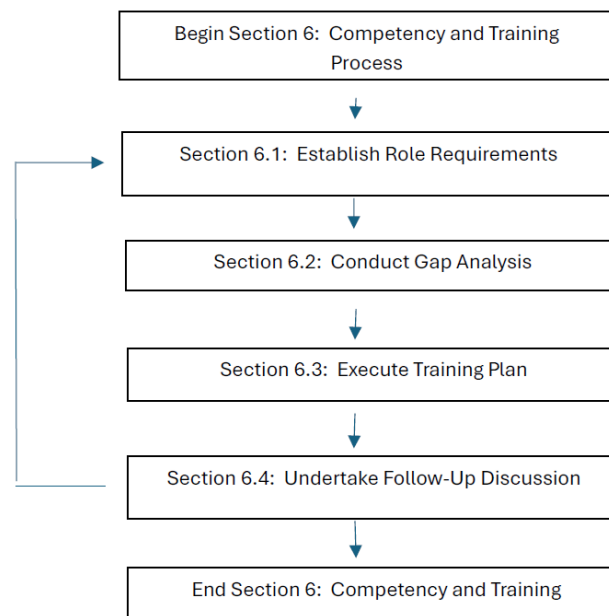


Figure 5: Competency and Training Process

6.1. Establish Role Requirements

The first step in establishing appropriate competency for individuals involved with FIMP-related work is to establish a clear role description. More specifically, FIMP-related tasks should be clearly identified for each role – additional detail is provided below in Table 9.

Table 9: Considerations in Establishing Competency Requirements

Competency / Training Requirement	Description
Basic FIMP Awareness	Existing job descriptions updated for any reorganization and personnel changes.
Task Specific Training	For Design, Procurement , Construction, Operations, Maintenance and Inspection personnel (both company employees and contractor personnel).
Ongoing Training and Development	For those responsible and accountable for elements of the FIMP.

6.2. Conduct Gap Analysis

The gap analysis entails a cross-referencing and documentation of the employee's qualifications relative to the requirements of the current role as well as the expected future needs of the role in light of FIMP requirements. In undertaking this analysis, a number of sources can be used – the primary resources are listed in Table 10.

Table 10: Resources for Determining Training Needs

Source	Description
Job Description	Existing job descriptions updated for any reorganization, responsibility and personnel changes.
Employee Resume	Should be current and include formal education/training, experience and listing of other relevant skills.
Employee Training Records	Internal records.
Discussion with Senior Technical Staff	Senior technical staff may be in a position to provide a long term perspective on FIMP related skills requirements and how this may affect the nature and size of staff required going forward.
Annual goals and objectives	Existing staff performance management related documentation.

Once gaps have been identified, the items need to be categorized and prioritized. Categorization of gaps can be based on one of two parameters as described in Table 11:

Table 11: Categorization of Qualification Gaps

Category	Description
Current	- A gap identified based on the current job description where no alternative is available for performing the given function or task and - Gap to be addressed within 12 months or less.
Development	- A gap identified based on the longer term Employee career goals and/or FIMP medium to long term projected needs and - Gap does not need to be addressed within 12 months.

While the prioritization will need to be specific to each case, typically requirements for immediate / ongoing operations should be prioritized ahead of longer-term requirements. Additional factors in establishing a prioritization include access to alternative resources, feasibility as well as availability of training.

6.3. Execute Training Plan

The Training Plan is a clear articulation of how the gaps identified in Section 6.2 will be mitigated. A number of mechanisms to address gaps appear in Table 12.

Table 12: Mechanisms for Mitigating Qualification Gaps

Mitigation Type	Description
Formal training / Education	• Can be comprised of formal courses delivered either by academic institutions, industry for-profit providers or in-house staff. • Length and nature of training varies significantly and can be accessed through existing offerings or custom training solutions.
On-the-job Training	• Training largely accomplished through work experience. • Requires that senior technical resources are available and accessible to facilitate learning, mentoring and oversight within the context of the project.
Formal Mentoring	• Employee may be formally assigned a mentor for some, or all aspects, of their role. • Nature of mentoring (access, frequency, and scope) is to be agreed in advance.
Self-directed Learning	• Informal learning that can be facilitated a number of ways such as reading technical books, journals and articles. • Discussions with senior technical individuals or industry experts (not in formal mentoring relationships), attendance of works shops and conferences would also fall into this category.

6.4. Undertake Follow-Up Discussion

Once a Training Plan has been articulated, further discussions between the supervisor and employee are needed. The objectives of this discussion are described in Table 13.

Table 13: Objectives of Follow-up Employee Discussion

Objective	Description
Confirmation of understanding	• Confirm employee understands FIMP current and future (anticipated) needs and • Review gap analysis and identify and disconnects
Discussion / agreement of path forward	• Review and agree that Training Plan is relevant and practical

7. Hazard Identification and Control

The Hazard Identification and Control aspect of FIMP is a combination of a significant number of procedures and activities. As such, a standalone scalable process for managing this element of FIMP execution is described herein. It is important to note that the process(es) developed should be suitable for use at all stages of a facilities life-cycle as described in Figure 3. Hazard Identification and Control is not a process that is only applied during the operating life of a facility.

Given that corporate tools, practices and philosophies vary greatly, it is acknowledged that this process represents a leading practice approach for a standalone process and that individual operators will need to execute elements of this recommendation within the constraints of their existing processes, initiatives and systems. Thus, Operating Companies should develop a formal

written process to identify and address hazards that have the potential to impact the integrity of facilities and equipment. The adequacy of any hazard controls implemented should be periodically reviewed. A process map appears in Figure 6; details regarding the process appear below in the remainder of this Section.

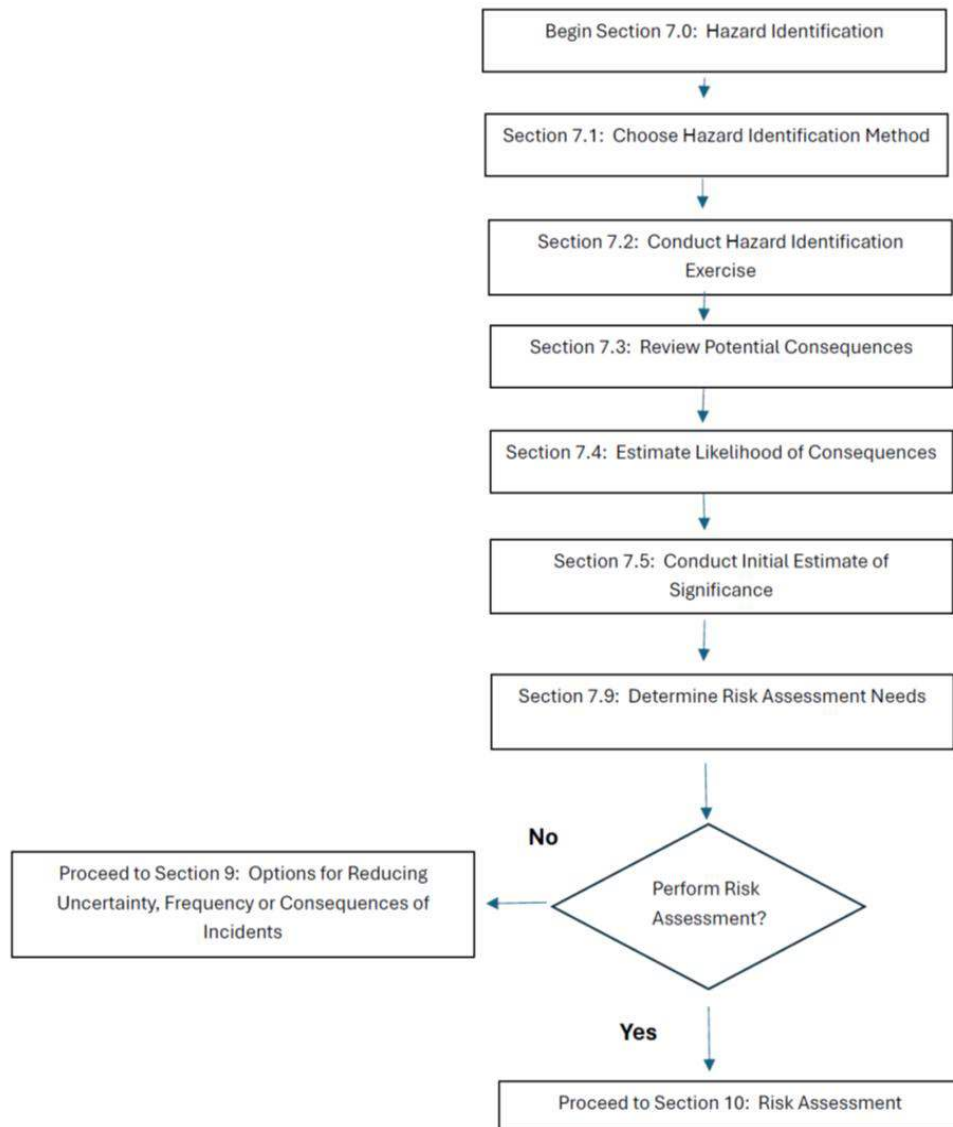


Figure 6: Hazard Identification and Control Process

7.1. Choose Hazard Identification Method

Appropriate tools or methods should be used to identify hazards and threats. The tools and techniques chosen should be suited to the types of risks that are expected to be identified, and should achieve the desired level of granularity and output.

There are a wide range of hazard identification techniques described in the literature; however, with a few exceptions (e.g., HAZOP techniques), there is a general lack of formal guidance to support these techniques. An extensive literature review, published by the UK Health and Safety Executive⁷, can be used as a starting point for selecting an appropriate Hazard Identification Method.

The document provides extensive discussion on the topic; however, in general, the document provides a review of ~40 hazard identification methods; these techniques have been divided into four categories depending on the area in which they are predominantly applied:

- a) Process hazards identification;
- b) Hardware hazards identification;
- c) Control hazards identification; and
- d) Human hazards identification.

Further guidance regarding hazard identification can be found in API 750⁸ as well as CSA Z662².

7.2. Hazard Identification Exercise

7.2.1 Gather Resources

Depending on the Hazard Identification Method chosen, significant resources may need to be gathered. These resources may be in the form of data and/or subject matter experts (SME) as well as additional support tools and resources.

7.2.2 Conduct Hazard Identification Exercise

Conduct the hazard identification activity using the chosen tool(s). Consider typical hazards and incident history, as well as encouraging out-of-the-box thinking to identify hazards that may not be obvious. When identifying hazards, consideration should be given to failure causes and associated events as those listed in Appendix A3. This is not an exhaustive list; however, it provides a starting point for consideration.

It should also be noted that in some cases, sufficient information may not be available to identify all of the relevant hazards. In these situations, an Operating Company may choose to conduct additional monitoring and inspection, as per Section 9.1, before returning to this activity.

7.3. Review Potential Consequences

Whether conducted as part of the Hazard Identification Exercise (as per Section 7.2) or separately, Operating Companies should also consider the range of potential consequences they could face in light of the identified hazards in a systematic and consistent way. The framework for assessing consequences is expected to be Operating Company specific; however, material provided in Figure 4 may be used as the basis for this framework. The magnitude and significance (as per Section 8.5) of these consequences should also be established.

Depending on the nature of the risk analysis method(s) anticipated (as per Section 8), there may be some need at this stage to establish a common “currency” for estimating the magnitude of consequences. Facilities under a FIMP will in all likelihood be situated at different geographical locations. Therefore, in order to make reasonable comparisons between the facilities a common risk comparator will be required. The most common basis for establishing consequence values is in monetary terms; however, based on the nature of the risk analysis to be undertaken (e.g., use of qualitative or points-based relative methods), monetary valuation of consequences may not always be appropriate.

7.4. Estimate Likelihood of Consequences

Whether conducted as part of the Hazard Identification Exercise (as per Section 7.2) or separately, Operating Companies should also estimate the likelihood of various consequences it could face in light of those identified in Section 7.3. This can be done using historical or probabilistic approaches depending upon the nature of the available information.

7.5. Conduct an Initial Assessment of Significance

Once a basic understanding of potential consequences and their frequencies have been established, the Operating Company will be in a position to determine if the consequence is considered to be significant, and document the supporting rationale, using the defined risk criteria. This may be done using a risk ranking, consequence ranking, or description of what the Operating Company considers to be significant (as per the application of Section 8.6); however the Operating Company may choose to define criteria more conservatively for this stage of evaluation based on the uncertainty of the assessment (availability of data, quality of data, disagreement between Subject Matter Experts (SMEs), etc.).

7.6. Determine Risk Assessment Needs

If the hazard(s) is determined to not have the potential to result in a significant consequence, a full risk assessment may not be required; however, Operating Companies should develop a formal written process to monitor the controls that are currently in place, and confirm they are adequately maintained to continue managing the hazard. If a

consequence is determined to be significant, Operating Companies should assess the risks associated with the hazards as noted in Section 8 of this document.

8. Risk Assessment

8.1. Risk Analysis

After having identified the hazards that have the potential to affect facilities, the likelihood that these hazards will lead to a failure or damage incident should be determined by the Operating Company through a risk assessment process. There are numerous literature sources and/or consultants that can provide detailed direction regarding the overall risk analysis process including API 353, API 580/581, Annex B of CSA Z662-latest edition, and others referenced in Appendix A6. In general, the risk analyses considered will fall into one of three categories:

- Qualitative risk assessment;
- Semi-quantitative risk assessment; and
- Quantitative risk assessment.

Factors like hazard complexity, the quality and availability of data, and the potential consequences of failure/hazard also influence which method is most appropriate.

There are a number of industry-published documents available on risk assessment methodologies and techniques. A partial list of these documents appears in Appendix A5.

8.2. Data Availability

In general, a more complex method of risk assessment, particularly quantitative approaches, has a corresponding need for more data and higher data quality (i.e. increased data granularity as well as a greater volume and quality of data). There can often be a significant cost associated with gathering, validating and managing data.

Careful consideration of data requirements and availability is critical in optimizing the choice of a risk assessment method as data is typically the limiting factor in choosing a more complex analysis approach.

8.3. Organizational Maturity

Organizational maturity can be considered in terms of three main dimensions: people, processes and tools. In general, more complex risk methods require a higher employee skill level (technical skills as well as understanding of risk-based concepts at the senior management level), more mature processes (e.g., for data collection as well as use and communication of results). Additionally, greater resources are required to undertake the analysis depending on the complexity of the tools used (e.g., customized software vs. internally developed spreadsheets).

8.4. Goal of the Analysis

The goal of the analysis is also an important consideration. For example, if simple prioritization of activities is the goal a qualitative approach may suffice. However, if the intent is to integrate results with financial and/or corporate risk assessments, a quantified approach (normalized to some comparable parameter) may be required.

8.5. Magnitude of the Decision

Generally, the business implication of the decision (including consideration of safety, environment, cost, etc.,) factors into how much effort is expended in undertaking the risk assessment. Minor or less significant decisions do not require extensive analysis. It should be noted that even if a decision is significant, analysis should be limited to those factors that are material to the decision in order to optimize resources (e.g. reduce data collection).

8.6. Risk Evaluation

The Operating Company should set acceptance criteria and risk tolerances that are relevant and consistent with policies, goals and objectives identified earlier in this document. The criteria should be established by evaluating what level of risk is acceptable considering the range of consequences that an Operating Company faces in light of its identified hazards.

Table 14 lists a number of sources (and associated descriptions) that provide varying levels of guidance regarding the evaluation of risk.

Table 14: Additional Guidance for Establishing Significance of Risk

Document	Description
CSA Z662 (latest Edition)	• Detailed guidance is available in Clause B.5.3.
Chemistry Industry Association of Canada	• Responsible Care® Management System Approach.
UK Health & Safety Executive	• Concept of “As Low as Reasonably Practicable” (ALARP).

It should also be noted that in some cases, sufficient information may not be available to confidently undertake a risk evaluation. In these situations, an Operating Company may choose to conduct additional monitoring and inspection, as per Section 9.1, before returning to this activity.

8.7. Risk Refinement

Upon completion of the Risk Evaluation (detailed in Section 8.6), a risk may still be considered to be significant and it may be necessary to refine the risk assessment as per the parameters outlined in Table 15 in order to clearly identify the drivers for use in formulating an appropriate management strategy.

Table 15: Parameters for Risk Refinement

Document	Description
Additional data collection	In some cases additional data collection will allow a more rigorous or comprehensive analysis to be undertaken.
Alternative analysis methods	In some cases alternative methodologies (typically more rigorous) can be used to refine risk calculations.
Use of more detailed data	In some cases, detailed data may already exist but may not have been used (due to increased time / complexity of analysis).

8.8. Risk Reduction Evaluation

The final stage of the risk analysis is to identify the appropriate risk management method (as per Section 9.2) and to undertake analysis to confirm that the selected option manages risk in an optimal manner.

9. Options for Reducing Uncertainty, Frequency or Consequences of Incidents

Based on the risk assessment process, an Operating Company may identify the need to reduce risk levels. This may be undertaken in a number of ways. Recognizing that:

$$\text{probability of an event} = f(\text{\#of threats, severity of threats}) \quad (2)$$

Two main approaches for managing risk become apparent: monitoring and mitigation. This categorization, described in Table 16, provides the framework for further guidance (in this document) on how to manage risk.

Table 16: Approaches for Managing Risk

Category	Description
Monitoring / Inspection	- In some situations, insufficient information regarding the equipment, or its current state, limits the ability to conduct meaningful analysis regarding the nature of the risks associated with it. In these situations, additional data gathering through monitoring and inspections is a critical part of managing risk and can be used to reduce uncertainty. - Where an Operating Company has made a baseline assumption regarding the risk level, additional information may result in an increase (or decrease) in the assessed risk level. - The goal of various monitoring/inspections programs varies by equipment type and examples of these, while not exhaustive, appear in Appendix A4.
Mitigation	Mitigation can act upon two parts of the risk equation: 1) Threat Mitigation: the reduction in the probability of an event occurring by influencing the: ○ The number of threats and ○ The severity of a given threat. 2) Consequence Mitigation: the reduction in the potential consequences by influencing outcomes should an event occur.

9.1. Monitoring and Inspection

In order to facilitate the selection of appropriate inspection methods, Operating Companies should identify the types of inspection actions that are deemed appropriate for their facilities. The methods and procedures used to conduct inspections, testing, patrols, and monitoring should be executed according to industry standards (where applicable) and documented.

When the timing or frequency of inspection, testing, patrols, or monitoring is not specified through industry practice (e.g., regulations, recommended practice etc), the methods used to determine the timing or frequency should be documented. Consideration should be given to the guiding principles identified in Table 17 for choosing the method and frequency of facility equipment inspection.

Table 17: Considerations for Selecting Monitoring & Inspection Activities

Type	Description
New Hazards	Operating Companies should ensure mitigation and repair activities do not introduce new hazards.
Regulation	Some monitoring and inspection activities may be established through regulation, code or industry guidance documents.
Technology	Where indirect methods of inspection are used, consideration to supplemental inspection using direct methods should be considered.
Corporate Considerations	Corporate risk tolerances (such as definitions of “significant” as per Section 8.6) may drive an Operating Company to increase the frequency of inspections and / or implement multiple inspection methods.
Types of Hazards	- The type of inspection chosen should be matched to the types of conditions and/or imperfections that are intended to be detected and - Experience related to the rate or timing of changes in the imperfections or conditions (and the effect of such changes on the estimate risk of failure incidents).
Influence of Other FIMP Related Decisions	- The options selected to estimate the risk level (see Section 8 and Section 9) and - The options selected to mitigate hazards (see Section 9.2).

9.2. Risk Management

If a risk is assessed as beyond a tolerable level, actions should be identified to mitigate the risk. In order to facilitate appropriate mitigation and repair actions, Operating Companies should review mitigative actions that are deemed acceptable on their facilities.

Within the context of mitigation, there are three main types of activities that can be used for risk management: engineering solutions, process solutions and administrative solutions. These are described, in conjunction with the way they reduce risk, with examples, in Table 18 below.

Table 18: Mitigation Activity Types

Type	Description	Threat Mitigation Examples	Consequence Mitigation Examples
Engineering	Mitigation solutions that primarily rely on technology or physically impacting the property or equipment to manage risk	• Engineering assessment; • Cathodic protection design and monitoring; • Use of increased pipe and vessel wall thickness; • Regular maintenance (e.g., valve lubrication); • Increase depth of cover; • Supplemental markers on pipeline ROW; • Installation of structures or materials (e.g., concrete slabs, steel plates, or casings associated with pipe); • Site selection away from potential or existing threats; • Process and facility equipment upgrades; • Adding site security & monitoring infrastructure • Site signage upgrades; and • Emergency design and methods for site access	• Use of higher toughness materials for pipe and vessels; • Install protective housings and structures; • Improved methods for recovery and clean-up of liquid releases; and • Use of remotely operated valves to limit product release.
Process	Mitigation solutions that rely on how the equipment is operated (or the conditions under which it is operated) as the primary mechanism to manage risk	• Use of corrosion inhibitors and • Modify operating parameters (e.g., reduction of pressure, temperature to mitigate threat of internal corrosion).	• Reduce operating pressure.
Administrative	Mitigation solutions that do not physically impact the equipment or operating conditions – rather the solution is primarily procedural or administrative	• Training and competency development; • Modify maintenance practices (e.g., requirements for work permits, lockout / tag-out procedures); • Improved public awareness programs; • Enhancement of procedures for pipeline system location and excavation; • Implementation of quality management systems; • Site security and monitoring practices; and • Facility patrols and frequency.	• Limit presence of personnel in high risk locations; • Improved emergency response procedures; and • Purchase of insurance.

Additionally, once potential mitigation activities have been identified, they should be further assessed for acceptability. Specifically, Table 19 identifies considerations for identifying appropriate corrective actions.

Table 19: Considerations for Determining Acceptable Mitigation

Type	Examples
New Hazards	Operating Companies should ensure mitigation and repair activities do not introduce new hazards.
Regulation	In the case of some equipment types and repair practices, regulation or code may prescribe acceptable (and / or unacceptable) mitigation methods.
Industry Best Practices	Industry best practice and experience should guide the determination of acceptable mitigation alternatives.
Corporate Considerations	Corporate risk tolerances and or internal technology assessments and reviews may also guide the determination of acceptable alternatives.
Existing FIMP Activities	The review and assessment of the effectiveness of existing FIMP activities.
Influence of Other FIMP Related Decisions	- The options selected to estimate the risk level (see Section 8 and Section 9) and - The options selected to monitor / inspect equipment condition / hazards (see Section 9.1).

10. Planning and Executing

10.1. Plan and Execute Activities

Planned monitoring and mitigation activities will vary from facility to facility depending on the equipment present. These activities should be prioritized and scheduled using a documented process. FIMP planning should take the following into consideration:

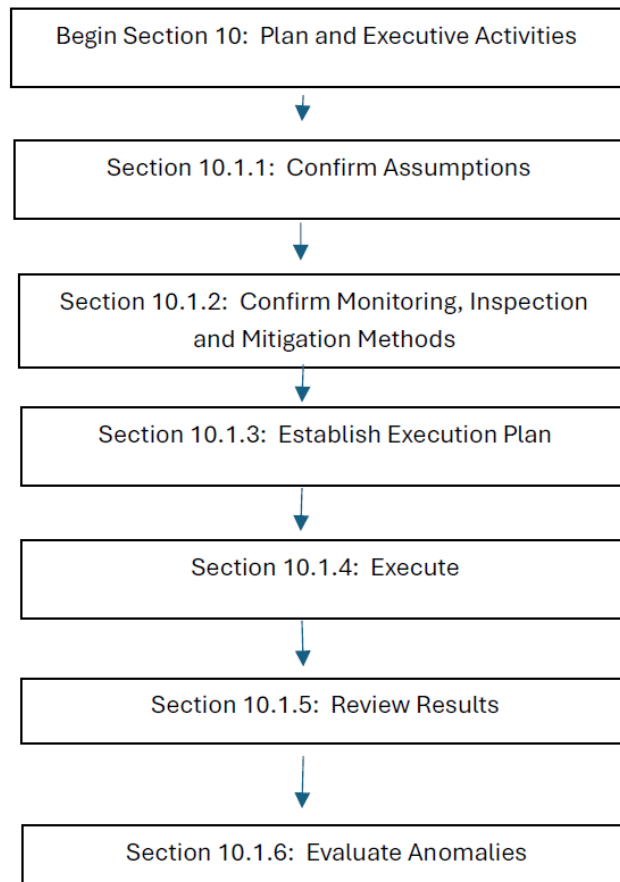


Figure 7: Process for Planning and Executing

10.1.1 Confirm Current Assumptions

Prior to undertaking detailed planning, the data and assumptions used for the risk assessment should be verified to identify any significant changes or inaccuracies. This review could include a number of parameters, identified in Table 20, as appropriate to the situation.

Table 20: Considerations for the Review of Current Assumptions

Type	Examples
Current State of Equipment	Based on the information available, the understanding of the current state of the equipment (e.g., known conditions, damage, or that might lead to failure incidents) should be reviewed.
Time dependent considerations	An assessment of the potential growth of any damage or imperfections (and/or any changes in operating conditions that could impact this) should be reviewed.
Methods, limitations and frequency of inspections	The methods, limitations and frequency of inspections and analyses used to establish the program, or the state of the equipment should be reviewed.
Corporate Data	- Confirmation of any new information failure and damage incident history of the Operating Company; - Recommendations from previous integrity reviews and activities (incomplete work, unresolved issues); and - State of documentation (i.e., lack of documentation increases uncertainty associated with asset condition).
Industry data	Confirmation of any new information such as failure and damage incident experience of the industry.

10.1.2 Confirm Monitoring, Inspection and/or Mitigation Methods

Based on the findings of Section 10.1.1, the appropriateness of the chosen monitoring and mitigation methods should be confirmed. Where these are deemed to require some revision, guidance provided in Section 11 may be followed to establish the appropriate activities and their frequencies.

10.1.3 Establish Execution Plan

Planning for FIMP activities will involve a number of factors specific to each Operating Company; these are described further in Table 21.

Table 21: Considerations for Program Execution

Type	Examples
Options Selected For Risk Reduction	- The options selected to control identified hazards (see Section 9); - The options selected to estimate the risk level (see Section 10 and Section 11); - The options selected to reduce the estimated risk level (see Section 10 and Section 11).
Execution constraints	- Practical implementation of work (bundling of similar work or work in a geographical areas - Constraints to execution (access, weather etc.).
Communication	Facilities integrity management program plans should include a communication strategy for consulting with and informing appropriate personnel about integrity issues and programs.
Corporate Practices	Corporate planning and budgeting cycles may impose additional requirements and extend planning horizons; as such, these factors need to be considered well in advance of work becoming urgent in nature.

10.1.4 Execute

The program should be executed as per the program plan and the results documented for review. Further, Operating Companies should work towards using a scalable and consistent project management framework. A number of approaches are viable but in the absence of

a corporate standard, Operating Companies could pursue the use of any framework broadly accepted across industry (such as that developed by the Project Management Institute⁹).

10.1.5 Review Results

Upon completion of field based work, a formal review should be carried out. This review could encompass a range of parameters but the items identified in Table 22 should be of particular note.

Table 22: Considerations for Program Review

Type	Examples
Execution of Plan	• Ensure that required maintenance, repairs or corrective actions are carried out; • Verify that the relevant methods and procedures for such activities were properly performed; • Identify incomplete work and unresolved issues.
Management of Change	• Verify that changes in planned activities were reviewed and approved.
Documentation	• Verify that the relevant records were created or revised.
Learnings	• Determine whether the intended objectives were achieved and • Develop recommendations and plans for future work.

10.1.6 Evaluate Anomalies

If any anomalies are identified through the execution of FIMP activities, the Operating Company can pursue one of two main options as identified in Table 23.

Table 23: Considerations for Addressing Identified Anomalies

Type	Examples
Further inspection measurement	• Where indications of imperfections are found, these could be subject to additional evaluation through inspection and investigation as appropriate to facilitate evaluation of the imperfection(s) (as per guidance in Section 11.1).
Engineering Assessment	EA may be undertaken to establish whether or not indications or imperfections are expected to be injurious and if further action is required. The EA should consider: • Performance capabilities and limitations of inspection method; • Types of imperfections that might correspond with reported indications; • Accuracy of reported dimension and characteristics needed for evaluating such imperfections; • Likelihood of unreported defects being associated with imperfection indications; • Service conditions; and • Outcome of the EA may include increased inspection, enhance of planned maintenance or proactive repair or other alternatives as deemed appropriate by the analysis.

11. Repair

As Operating Companies move through the process described within this document, the results of the evaluation process described in Section 10.1.6 may identify situations where mitigation and/or repair may be required.

11.1. Repair Identification

In order to facilitate appropriate mitigation and repair actions, Operating Companies should identify/document the types of corrective actions that are deemed acceptable on their facilities. Given the broad range of equipment types encompassed in the FIMP, this activity is likely to be equipment specific and should consider the same factors identified for mitigation (see Table 19). This detailed review activity may also be undertaken to assess the adequacy of an immediate repair completed after the fact.

11.2. Repair Execution

In the process of identifying corrective actions for a specific location or piece of equipment, the list of acceptable options, discussed in Section 12.1 should be reviewed in the context of the specific situation. The review should consider additional factors such as those identified in Table 24.

Table 24: Considerations for Executing Corrective Actions

Type	Examples
Purpose	• The corrective action should be appropriate for the specific situation (i.e., the repair method should be applied / used for the purpose it was intended).
Service conditions	• The repair method should be suitable for the current service conditions as well as the conditions anticipated for the foreseeable future.

12. Continual Improvement

12.1. Process Characteristics

A continual improvement process should be implemented and should incorporate the following characteristics.

Table 25: Elements of Continual Improvement Process

Assessment Parameter	Description
Internal objectives and thresholds	The FIMP should be reviewed and evaluated periodically to determine if they are in accordance with: • Operating Company expectations, and effectiveness towards meeting Facility Integrity goals; • Conformance to the Operating Company-established requirements and risk tolerance criteria, risk reporting criteria, or risk acceptance criteria; and • Effectiveness in achieving stated objectives and targets.
Performance Monitoring and Measurement	• The FIMP should be reviewed and evaluated periodically to determine if they are in accordance with relevant lagging and leading Performance indicators as defined by the Operating Company.

Assessment Parameter	Description
Audit	Operating Companies should periodically audit the FIMP. The items addressed when performing such audits should include: • Audit scope and objectives; • Audit frequency and timing; • Responsibilities for managing and performing the audit; • Auditor independence; • Auditor competency; and • Audit procedures.
Control of non-conformance	In response to audit findings of non-conformances, Operating Companies should establish and maintain procedures for defining responsibility and authority for handling and investigating non-conformances, taking action to mitigate any impacts, and for initiating and completing corrective and preventive action plans.
Changes to governing standards and practices	The FIMP should be reviewed, evaluated and revised periodically to incorporate relevant changes in: • Regulations and • Industry standards and practices.
Review of internal and external incidents	The FIMP should be reviewed, evaluated and revised periodically to incorporate relevant changes in: • Industry incidents and • Corporate incidents.
Advancements / new technology	The FIMP should be reviewed, evaluated and revised periodically to incorporate relevant: • Advances in analysis methods; • Research results; and • New technologies.

12.2. Specific Considerations

The identification of new hazards, new equipment, new equipment types or other new information should prompt review and, where appropriate, revision of FIMP by returning to the activities outlined in Section 3.

13. Incident Investigations

In addition to incident investigation processes, Operating Companies should establish processes for incorporating findings from incidents and near-misses into standards, procedures, and processes to mitigate systemic development of similar circumstances. In addition, any corrective actions applied to local facilities should be reviewed for applicability to a broader scope (geographically or by equipment type). A corrective action process should be considered for the following events, but relevancy to the Company's facility assets should be established before action is taken:

- a) Incident investigations;
- b) Near miss investigations and reports;
- c) Events within the company; and
- d) Events within the industry.

List of References

- ¹ Baker, H.F., "Mechanical Reliability through Mechanical Integrity," Proceedings of 2011 API Inspection Summit and Expo, Galveston Texas, January 2011.
- ² CSA Z662 Oil & Gas Pipeline Systems (CSA Z662-23)
- ³ Desjardins, G. & Sahney, R., "Encyclopedic Dictionary of Pipeline Integrity," Clarion Technical Publishers, Houston, Texas, February 2012.
- ⁴ For further information on the origins and development of the PDCA framework, refer to the article "Foundation and History of the PDSA Cycle", by Ron Moen
- ⁵ Adapted from CEPA Integrity First® (Accessed December 2012)
- ⁶ Concawe www.concawe.eu
- ⁷ [Glossop, M., Ioannides, A., and Gould, J., "Review of Hazard Identification Techniques", Health and Safety Laboratory, An agency of the Health and Safety Executive, United Kingdom, HSL/2005/58, 2000.](#)
- ⁸ API RP 750: Management of Process Hazards
- ⁹ Project Management Institute www.pmi.org

A1. Sample Performance Indicators

Sample Leading Indicators

Examples of leading performance indicators are as follows:

- a) Asset information:
 - i. percent of assets for which information is captured
 - ii. percent of asset attributes captured
 - iii. percent of asset attribute errors found (through audit)
- b) FIMP information:
 - i. percent of FIMP records found / complete (through audit)
 - ii. percent of FIMP records with errors found (through audit)
- c) Change management:
 - i. percent of Management of Changes (MOCs) sampled that are completed according to the company's policy
 - ii. percent of MOCs sampled that are closed prior to startup of the new or modified equipment
 - iii. number of operating and maintenance procedure changes managed by the process
 - iv. number of organizational changes managed according to the process
 - v. percent of MOCs sampled that are communicated to all employees who could be potentially affected by the change
- d) Competency and Training
 - i. percentage of training and competency needs assessments completed
 - ii. percentage of training sessions completed with skills verification
 - iii. number of key FIMP roles with competency criteria defined
 - iv. training and competency provided to individuals in key FIMP roles
 - v. percentage of staff involved in product transfers who have the required level of competence necessary for the successful transfer and storage of product
- e) Hazard Identification and control
 - i. percentage of asset types where hazard identification method has been identified and applied
 - ii. number of hazards identified
 - iii. number of consequence categories used
- f) Risk Assessment
 - i. Number of detailed risk assessments undertaken
 - ii. Number of significant risks identified
- g) Inspection, testing, monitoring and patrols
 - i. percentage of critical equipment/instrumentation that performs to specification when inspected or tested
 - ii. percentage of functional tests of critical instruments and alarms completed according to the defined schedule
 - iii. percentage of maintenance actions identified by inspection activities that are completed to the specified timescale
 - iv. percentage of procedures reviewed and revised within the designated period
 - v. percentage of critical instruments and alarms that correctly indicate the operating conditions
 - vi. percentage of critical instruments and alarms that activate at the desired set point

- vii. percentage of maintenance actions to correct faults related to critical instruments and alarms completed to schedule
- viii. percentage of functional tests of safety instruments and alarms completed to schedule
- h) Repairs
 - i. number (and locations) of repairs undertaken
 - ii. type (and locations) of repairs undertaken

Sample Lagging Indicators

Examples of lagging performance indicators are as follows:

- a) Releases by equipment or installation
- b) Releases by geographic locations
- c) Releases associated with specific Facility Integrity programs
- d) Number of business interruptions [above a predetermined threshold]
- e) Number of equipment failures [by equipment type]

A2. Guidance Regarding FIMP Documentation

Table 26: FIMP Documentation and Reference Guideline

Element	Requirement
Program Scope	• Include methods for collecting, integrating and analyzing information.
	• Identify facilities / equipment and associated programs that are not managed directly through FIMP document.
Corporate Policies, Objectives and Organization	• Document facilities integrity-related corporate policies, values, objectives and performance indicators.
Description of Facilities included in FIMP	• Include in the description the rationale for what is to be considered a “facility”.
	• System description and items to include in description.
FIMP Records	• Record of asset acquisitions and dispositions.
	• Document the methods used for managing facilities integrity management program records.
Change Management	• Include an index of the records included in the FIMP that contain relevant FIMP-related information.
	• Develop and implement a change management process for changes that have the potential to affect the integrity of their facilities or their ability to manage integrity.
Competency and Training	• Ensure change management process procedures are in place to address and document FIMP-related changes.
	• Define and implement performance indicators for change management.
Hazard Identification and Control	• Develop and implement competency and training requirements for company personnel, contractors, and consultants to provide them the appropriate knowledge and skills for performing the activities required to meet the elements of the facilities integrity program for which they are responsible.
	• Maintain training records for FIMP awareness and FIMP-related activities.
Risk Assessment	• Develop a formal written process to identify and address hazards. Put hazard controls in place and check to make sure hazards are being adequately managed.
	• Assess risks in a comprehensive, consistent manner.
Facility Integrity Management Program Planning	• Document the risk assessment conducted and associated recommendations.
	• Establish and document plans and schedules for activities related to facilities integrity management.
Evaluation of Inspection, Testing, Patrols and Monitoring Results	• Document the methods used to prioritize and schedule activities related to facility integrity management.
	• Include steps for consulting with and informing appropriate personnel about integrity issues and programs.
Mitigation and Repair	• Ensure a periodic review process is in place to assess the suitability of the inspection, testing, patrols and monitoring activities.
	• Maintain records of inspections, testing, patrols, and monitoring.
Mitigation and Repair	• Include process for determining corrective actions when inspections or patrols indicate the need.
	• Maintain records of recommendations and closure of recommendations.
Mitigation and Repair	• Document procedures used for mitigation and repair.
	• Document methods for ensuring mitigation and repair activities do not introduce new hazards.
Mitigation and Repair	• Document requirements for additional hazard assessment if new hazards are introduced with mitigation.
	• Include the effect of completed mitigation and repairs when re-evaluating the threat in future risk analyses/assessment.
Mitigation and Repair	• Document mitigations and repairs undertaken along with associated details.

Element	Requirement
Continual Improvement	Establish and maintain documented procedures to monitor and measure, on a periodic basis, the performance of the facilities integrity management program.
	Establish and maintain procedures for defining responsibility and authority for handling and investigating non-conformances, taking action to mitigate any impacts, and for initiating and completing corrective and preventive action.
	Identify process for identifying and integrating new information such as regulatory change, new technology etc.
	Define and implement performance indicators for the facility integrity management program.
Incident Investigations and Learning from Events	Establish procedures for investigating and reporting failure and damage incidents as well as near misses.
	Document and implement formalized feedback loops and methods for communication to potentially affected company and contractor personnel.
	Establish processes and procedures for sharing findings from events and occurrences with employees and contractors who could be affected by similar events.

A3. List of Hazards for Consideration

Table 27: Sample List of Equipment Specific Considerations

Hazard Type	Description / Examples
Metal Loss	• Internal corrosion; • External corrosion (buried); • Atmospheric corrosion; and • Corrosion of pipe/equipment supports.
Cracking	• Environmentally assisted mechanisms and • Fatigue.
External Interference	• Dents; • Gouges; • Sabotage; and • CP interference (AC / DC).
Material / Manufacturing defects	• Weld defect; • Fabrication fault; and • Mis-assembled parts.
Inadequate Construction Quality Control	• Welds; • Dents; • Gouges; and • Improper installation.
Natural Hazards	• Ground movement (geotechnical hazard, seismic); • Flooding / weather; and • Lightning.
Operator Error	• Insufficient training; • Insufficient / incorrect tools and / or procedures; and • Fatigue.
Process Upsets	• Slug (compressor oils, water, condensation); • Cavitation; • Upstream/downstream process change or failure; • Change in fluid dynamics; • Cooling / heating failure (e.g., Compressor upset with cooler failure, resulting in hot compressor gas); • Violation in gas quality; • Overpressures; and • Tank overfills.
Ambient Conditions	• Freezing, resulting in ice plugs and • Hot compressor gas condensing as it cools in the line.
Mechanical Failures	• Excessive vibration; • Normal (expected) wear and tear; and • Inadequate bolted joint assembly.
Other	• Security breaches and • Nonconformance with local, regional and national codes, which could result in integrity-related failures (e.g. improper installation of electrical equipment ; resulting in an AC interference hazard).

A4. Monitoring and Inspection

Table 28: Sample List of Monitoring and Inspection Goals

Program Type	Purpose	Reference Documents
Monitoring Programs	• Cathodic protection effectiveness; • Internal / external corrosion; • Security breaches, encroachments; and • Vibration.	• NACE
Flange / Fitting Inspections	• Corrosion; • Cracking; • Improper flange alignment; • Under-torque connections; and • Weeping or leaking (as an early indicator of sealing problems).	• API 2611
Piping Inspections	• Corrosion (internal / external); • Cracking; • Dents; • Excessive pipe movement; and • Manufacturing features (e.g., laminations).	• API 570 • API 2611
Pressure Vessel Inspections	• A pressure vessel inspection program will identify causes of failure as: • Corrosion (internal / external); • Cracking; and • Improper weld connections to appurtenances.	• API 510 • Jurisdictional Authority
Pump Inspections	• Cavitation and impingement and • Seal failure.	• n/a
Rotating Equipment Inspections	• Bearing failure; • Excessive vibration and overheating; • Liquid carryover into gas compressor; and • Mechanical seal failure.	• n/a
Tank Inspections	• Identify • Corrosion imperfections (metal loss) including shell-to-floor weld corrosion; • Cracking; • Roof and roof support issues; • Roof seal failure; and • Shell distortions.	• API 653
Valve Inspections	• Actuator / operator failure; • Controls failure; • Seal failure; • Stem failure; and • Solids/debris accumulation.	• CSA Z662

A5. Reference Documents

A5.1 Industry Organization Publications and Standards

Table 29: Industry Published Guidance Documents

Document	Title
API 510	• Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration.
API 570	• Piping Inspection Code.
API RP 571	• Damage Mechanisms Affecting Fixed Equipment in the Refining Industry.
API 572	• Inspection Practices for Pressure Vessels.
API RP 574	• Inspection Practices for Piping System Components.
API RP 575	• Inspection of Atmospheric and Low Pressure Storage Tanks.
API RP 576	• Inspection of Pressure-relieving Devices.
API Std 579-1	• Fitness-For-Service.
API RP 580	• Risk-Based Inspection.
API 581	• Risk-Based Inspection Technology, Second Edition.
API 598	• Valve Inspection and Testing.
API 653	• Tank Inspection, Repair, Alteration, and Reconstruction.
API 760	• Model Risk Management Plan Guidance for Petroleum Refineries—Guidance for Complying with EPA's RMP Rule.
API Std 1104	• Welding of Pipelines and Related Facilities.
API RP 2016	• Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks.
API RP 2200	• Repairing Crude Oil, Liquefied Petroleum Gas and Product Pipelines.
API RP 2350	• Overfill Protection for Storage Tanks in Petroleum Facilities.
API Std 2610	• Design, Construction, Operation, Maintenance and Inspection of Terminal and Tank Facilities.
API 2611	• Terminal Piping Inspection—Inspection of In-Service Terminal Piping Systems.
API 4709	• Risk-Based Methodologies for Evaluating Petroleum Hydrocarbon Impacts at Oil and Natural Gas E&P Sites.
API 4716	• Buried Pressurized Piping Systems Leak Detection Guide.
API TR 755	• API TR 755-1 - Fatigue Risk Management Systems for Personnel in the Refining and Petrochemical Industries, First Edition.
ASME PCC-3	• Inspection Planning Using Risk Based Methods.
CSA Z662	• Detailed guidance is available in Annex B.
IGEM/TD/1 Edition 5	• Steel Pipeline and associated installations for high pressure gas transmission.
IGEM/TD/2	• Application of pipeline risk assessment to proposed development in the vicinity of high-pressure Natural Gas pipelines.
IPC2006-10206	• Facility Integrity: A Management Perspective. • Author: Dave B. McNeill and Tom Morrison.
IPC2010-31357	• In-Line Inspection Techniques for "Non-Piggable" Liquid Pipelines. • Author: Damir Grmek.
IPC2012-90730	• The Evolution of Facilities Integrity Management at Enbridge Pipelines Inc. • Authors: Shadie Radmard, Monique Berg.
UK Health & Safety Executive	• KP3 Asset Integrity. www.hse.gov.uk/offshore/programmereports.htm
	• Concept of "As Low as Reasonably Practicable". www.hse.gov.uk/foi/internalops/hid_circs/permissioning/spc_perm37/
	Priority on Release Reduction (Research papers, comparative statistics, management system).

A5.2 Other References

Table 30: Additional Guidance from Other References

Document	Description
Center for Chemical Process Safety	Guidelines for Developing Quantitative Safety Risk Criteria.
Chemistry Industry Association of Canada	Responsible Care® Management System Approach.
Moubray	Reliability Centered Maintenance RCM 2.1.
Muhlbauer	Pipeline Risk Management Manual Ideas, Techniques and Resources Third Edition.