

Hazardous Liquid Pipeline Facilities Integrity Management

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Introduction

This document is, in part, the successor to API Recommended Practice 2611, *Terminal Piping Inspection—Inspection of In-service Terminal Piping Systems*, which was published in 2011 and is now withdrawn. That document is no longer supported by API, but is available for use by industry.

Hazardous Liquid Pipeline Facilities Integrity Management

1 Scope

1.1 General

This recommended practice (RP) covers the integrity management of hazardous liquid facilities. This RP provides guidance on:

- high-consequence area impact determinations;
- data integration;
- threat identification;
- risk assessment;
- inspection and reinspection;
- preventive and mitigative measures (P&MM);
- performance measures.

Facilities include terminal and pipeline station piping systems within terminal and pipeline facility boundaries and includes off-plot piping. Off-plot piping includes, but is not limited to, piping between facilities, piping that comes from or goes to a refinery or other type facility, or piping that may cross a road, ditch, or other property outside the confines of a terminal facility. This RP covers the integrity management of all pressure-containing components directly used in the transport or storage of hazardous liquids within a liquids pipeline facility.

Piping for transportation of hazardous liquids, such as but not limited to crude oil, highly volatile liquids (HVLs), gasoline, diesel, biofuels, lubricating oils, jet fuel, and aviation fuel are covered by the scope of this document.

This RP does not apply to refinery piping, sanitary waste piping, cast iron piping, or nonmetallic gravity flow piping systems. Tanks are considered and reviewed as part of the high-consequence area analysis and risk assessment. For guidance on the inspection and maintenance of tanks, refer to API 653 or API Std 2610^[1].

This RP builds on concepts developed in API RP 1160, *Managing System Integrity for Hazardous Liquid Pipelines*. Additional guidance is available in documents such as API 570 and API Std 2610.

1.2 Integrity Management of Facilities

1.2.1 General Considerations

A facility integrity management program is a documented set of policies, processes, and procedures to manage facility risk. Integrity management is more complex for facilities than for mainline pipe due to the nature and complexity of facility assets and operations. Attributes of facility assets that can distinguish it from mainline piping are:

- variable operating stresses;
- multiple types and sizes of piping and tubing, both aboveground and belowground, which may be insulated and/or on pipe supports;
- smaller sizes of pipe often joined by nonwelded fittings;

- piping used infrequently leading to low or intermittent flow, and/or piping configurations that result in deadlegs where water may accumulate;
- non-pipe, pressure-containing components such as meters and instrumentation connections;
- difficult-to-inspect and unpiggable piping, and components of a piping system;
- complex system loads such as pulsation and mechanical vibration from equipment and turbulent flow paths;
- variety of different materials;
- located where access is controlled by the operator and often protected with secondary containment;
- locations where non-mainline piping inspection and monitoring techniques are typically employed.

1.3 Plan–Do–Check–Act

The Plan–Do–Check–Act (PDCA) cycle is a four-step model for carrying out continuous assessment and improvement. This methodology can be applied to the facility integrity management program as well as to individual elements and processes within the program. The PDCA principle is at the core of many management systems, and its principal aim is to encourage creating strategies and plans, executing those strategies and plans in line with guidelines, checking those actions for conformity, and using those results to adjust the next generation of plans. This cycle is iterative and is maintained to achieve continuous improvement. See [Figure 1](#) for a diagram illustrating the PDCA cycle.

There are inputs (e.g. data, information, and resources) to the processes within each element yielding a set of outputs (e.g. prioritized work that reduced risk and ultimately improved safety performance). The operator defines facility integrity management program inputs and outputs within the execution of each of the essential elements. The operator defines these inputs and outputs for each of the elements to be described, and through the public awareness program reviews them periodically.

The PDCA cycle is useful when starting a new facility integrity management program; when developing a new or improved design of a process, product, or service; or when defining a repetitive work process.

The PDCA cycle is also useful as a model for continuous improvement and when planning data collection and analysis; when selecting and prioritizing threats or causes; and when implementing any changes.

The components of the PDCA cycle are:

- 1) *Plan*—This step entails the establishment of the objectives and processes necessary to deliver results in accordance with the organization’s policies and the expected goals. By establishing output expectations, the completeness and accuracy of the process is also a part of the targeted improvement.
- 2) *Do*—This step is the execution of the plan designed in the previous step.
- 3) *Check*—This step entails the review of the results compared with established objectives; comparing those results to the expected goals to ascertain any differences; and looking for deviation in implementation from the plan.
- 4) *Act*—This step is where a pipeline operator takes actions to continuously improve process performance, including corrective actions on significant differences between actual and planned results; analyzes the differences to determine their root causes; and determines where to apply changes that will include improvement of the process or product.

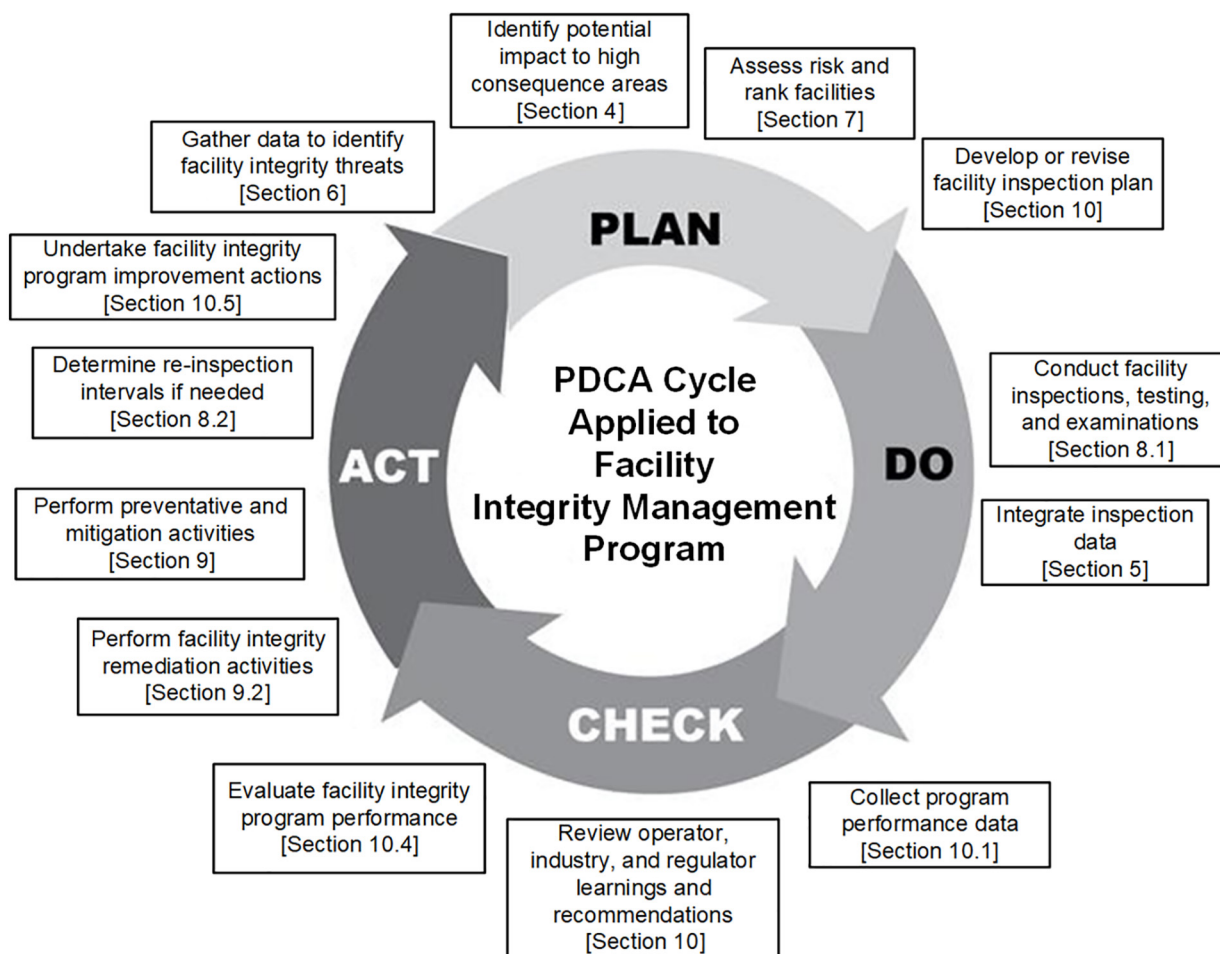


Figure 1—Plan–Do–Check–Act (PDCA) Cycle

Reflecting the cyclical nature of PDCA and the dynamic/evolutionary nature of the facility integrity management program, the entire process begins again from the start. Each cycle through PDCA produces opportunities for improvement. The application of PDCA logic to individual elements within the process can provide similar insights and opportunities for improvement within that element.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API 570, *Piping Inspection Code: In-service Inspection, Repair, and Alteration of Piping Systems*

API Recommended Practice 571, *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*

API Recommended Practice 574, *Inspection Practices for Piping System Components*

API Recommended Practice 577, *Welding Processes, Inspection, and Metallurgy*

ASME B31.4, *Pipeline Transportation Systems for Liquids and Slurries*

U.S. DOT Title 49, CFR Part 195, *Transportation of Hazardous Liquids by Pipeline*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1.1

corrosion under insulation

CUI

Corrosion on the outer surface of piping beneath fully encompassing insulation.

3.1.2

deadlegs

Segments of a piping system in which fluid flow is negligible or intermittent, which includes piping no longer in use but still connected to the process.

NOTE 1 Deadlegs are often created by isolation valves.

NOTE 2 Deadlegs can include relief lines or other piping that does not operate on a regular basis.

3.1.3

defect

A physically examined anomaly with dimensions or characteristics that exceed acceptable limits.

3.1.4

design pressure

design temperature

Temperature of a piping system at which, under the coincident pressure, the greatest thickness or highest component rating is required.

3.1.5

facility

All those systems, equipment, components, and pipe that are physically located within the confines of a pumping or meter station usually delineated by fencing and that are sites intended to transport, store, or measure hazardous liquids moving within the site that contains structures, equipment, piping systems, and controls.

NOTE Facilities may include, for example, meters, pumps, motors, tanks, vessels, flares, launcher/receiver stations, and pressure vessels.

3.1.6

environmentally assisted cracking

EAC

The intergranular or transgranular cracking of a material due to the combined action of residual and applied tensile stresses in a specific environment.

3.1.7

guided wave ultrasonic testing

GWUT

Nondestructive examination technique that utilizes ultrasonic waves that travel down the length of pipe, screening areas that are otherwise difficult to access.

3.1.8

high-consequence area

HCA

Those locations where a facility release might have a significant adverse effect on a population area, an ecological area, a public drinking water source, or a commercially navigable waterway, or area as determined by the operator.

NOTE For operators within the US, refer to the regulatory definition found in 49 *CFR* Part 195.

3.1.9

in-service

Piping systems that have been placed in operation, as opposed to new construction prior to being placed in operation.

3.1.10

inspector

An individual qualified to monitor, assess, evaluate, verify, discuss, decide, resolve, report, and document facility integrity activities to establish that the requirements of the specifications, regulations, and industry practices are being met safely, efficiently, and in an environmentally sound manner.

3.1.11

magnetic particle testing

Nondestructive examination that is used to detect surface and subsurface flaws in ferrous materials.

3.1.12

nondestructive examination

NDE

Any recognized test procedure that does not compromise the integrity of the object being examined/tested.

3.1.13

operator

Authority of a facility who exercises control over the operation, engineering, inspection, repair, alteration, testing, and rerating of its piping system.

3.1.14

pipe

Pressure-tight cylinder used to convey a fluid or to transmit a fluid pressure.

NOTE Materials designated “tube” or “tubing” in specifications are treated as pipe when intended for pressure service.

3.1.15

piping segment

Section of piping that has all points exposed to an environment of similar corrosivity and that is of similar design and construction material.

NOTE Complex process units or piping systems are usually divided into piping segments to manage the necessary inspections, calculations, and recordkeeping. When establishing the boundary of a particular piping segment, the inspector may also size it to provide a practical package for recordkeeping and performing field inspection.

3.1.16

piping system

Assembly of interconnected piping components that is subject to the same set or sets of design conditions and is used to convey, distribute, mix, separate, discharge, meter, or control hazardous liquid flows.

NOTE Piping system also includes pipe supports but does not include support structures, such as structural frames and foundations.

3.1.17

radiography

Nondestructive examination that uses an x-radiation source to provide a film image of defects in welds and structures.

3.1.18**repair**

Work necessary to restore a piping system to a condition suitable for safe operation at design or desired operating conditions.

NOTE 1 If any of the restorative changes result in a change of design temperature or pressure, the requirements for rerating also shall be satisfied.

NOTE 2 Any welding, cutting, or grinding operation on a pressure-containing piping component not specifically considered an alteration is considered a repair.

3.1.19**rerating**

Change in either the design temperature or the maximum allowable working pressure of a piping system that may consist of an increase, a decrease, or a combination of both.

NOTE Derating below original design conditions is a means to provide increased corrosion allowance.

3.1.20**small-bore piping**

Piping that is typically less than or equal to NPS 2.

3.1.21**soil-to-air interface**

An area in which external corrosion may occur or be accelerated on partially buried pipe or buried pipe near where it egresses from the terrain.

NOTE The size of the interface and the rate of potential corrosion will vary depending on factors such as moisture, oxygen content of the soil, and operating temperature. The interface is generally considered to be at least 305 mm below to 150 mm above (12 in. below to 6 in. above) the soil surface.

3.1.22**spool**

Prefabricated section of piping with ends that are plain-end for field cutting, prepared for welding or flanged.

3.1.23**trap space**

Any pipe configuration that allows for a water phase to stagnate in low points in a piping section.

3.1.24**ultrasonic examination**

Nondestructive examination that uses ultrasonic acoustic waves to detect anomalies in pipe material and welds by creating a detection signature.

NOTE The material mass and any anomalies are represented as an electronic signature on a video screen and/or graph.

3.2 Acronyms and Abbreviations

For the purposes of this document, the following abbreviations and acronyms apply.

ACVG	alternating current voltage gradient
ALARP	“as low as reasonably practical”
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials

CIS	close interval survey
CoF	consequence of failure
CUI	corrosion under insulation
DCVG	direct current voltage gradient
EMAT	electromagnetic acoustical transducer
GIS	geographic information system
GWUT	guided wave ultrasonic testing
GPR	ground penetrating radar
HVL	highly volatile liquid
ILI	in-line inspection
JSA	job safety analysis
LoF	likelihood of failure
MAH	major accident hazard
MFL	magnetic flux leakage
MOP	maximum operating pressure
MTR	mill test report
NACE	National Association of Corrosion Engineers
NDE	nondestructive examination
NPMS	national pipeline mapping system
NPS	nominal pipe size
OQ	operator qualification
P&MM	preventive and mitigative measures
PDCA	Plan–Do–Check–Act
PFD	process flow diagrams
PSDTS	Pipeline Strategic Data Tracking System
PT	[liquid] penetrant testing
RBI	risk-based inspection
SCC	stress corrosion cracking
SHE	safety, health, environment

4 High-consequence Areas (HCA)

4.1 General

As an initial process step of integrity management, an operator must determine if assets could impact a high-consequence area. As part of the process of data gathering and integration of information into a facility integrity management program (described in [Section 5](#)), an operator may develop a process to determine if, in the event of a failure, facility piping or associated assets and operations could affect an HCA. The potential impact to high-consequence areas may be used by the operator as part of the determination of the consequences of a failure for a risk assessment, as outlined in [Section 7](#).

In determining if a facility could affect an HCA, the boundary of each HCA should be defined in a way that delineates the physical area that has increased sensitivity to a release of product. Consideration should be

given to the nature of individual HCA areas and how that could influence the extent of a sensitive area (e.g. habitat range of a species or ecological community or whether a drinking water resource is surface- or well-based). Furthermore, allowance should be made for any possible inaccuracies (e.g. spatial) of the locations of the boundaries.

4.2 Facility Asset HCA

In determining if facility assets could affect HCAs, operators may consider:

- a) taking a holistic view of facility assets involved in transportation of products that could contribute to a release that impacts an HCA such as:
 - 1) rotating equipment such as pumps, compressors, and mixers;
 - 2) aboveground or belowground storage tanks;
 - 3) metering systems;
 - 4) heaters;
 - 5) valves, flanges, and fittings;
 - 6) seals, packing, gaskets, O-rings, etc.
- b) employing 49 *CFR* Part 195 HCA locations or HCAs identified by the facility operator;
- c) secondary or connected asset(s) and how these could contribute to or compound a failure;
- d) locations where a pipeline entering or leaving a facility could affect an HCA;
- e) identifying locations where facility assets are in or directly intersect HCAs;
- f) identifying locations where, in the event of a failure, HCAs could be indirectly impacted (in determining indirect impacts, a facility operator may consider):
 - 1) product types and characteristics (e.g. refined products, crude oil, and highly volatile liquids [HVLs]);
 - 2) operating conditions (e.g. operating pressures, temperature, and flow rate);
 - 3) area topography;
 - 4) soil porosity and permeability;
 - 5) water pathways (e.g. rivers, streams and aquifers);
 - 6) local features (e.g. ditches, storm sewers, outfalls, and other means of conveyance);
 - 7) potential for air dispersion of toxic and flammable constituents;
 - 8) presence and effectiveness of containment barriers such as dikes and berms;
 - 9) leak detection capabilities;
 - 10) isolation capabilities;
 - 11) spill and emergency response capabilities;