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**Elements of a Fixed Equipment Mechanical Integrity Program**

## Editor’s Note: Table of Contents and Sections 1-3 are a work in progress, included here simply to show context for this RP. Section 4 is the only part for which comments are sought

# Scope

This recommended practice (RP) covers the development of a Fixed Equipment Mechanical integrity Program for petroleum refineries, petrochemical plants along with other, related industries. The practices described in this document are focused to improve equipment reliability and plant safety. The intent is to provide a program …

# Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

List to follow…

# Terms, Definitions, and Acronyms

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

## Terms and Definitions

3.1.1

aboveground storage tank

odd that I cannot find an API definition for ASTs

3.1.2

applicable construction code

The code, code section, or other recognized and generally accepted engineering standard or practice to which the pressure vessel was built or that is deemed by the owner/user or the engineer to be most appropriate for the situation.

3.1.3

atmospheric pressure

When referring to (vertical) tanks, the term “atmospheric pressure” usually means tanks designed to API 650, although API 620 uses the term atmospheric pressure to describe tanks designed to withstand an internal pressure not exceeding the weight of the roof plates.

NOTE API 650 also provides for rules to design tanks for “higher internal pressure” up to 2.5 lbf/in.2 (18 kPa). API 653 uses the generic meaning for atmospheric pressure to describe tanks designed to withstand an internal pressure up to, but not exceeding 2.5 lbf/in.2 (18 kPa) gauge.

**3.1.4**

**boiler**

Fired equipment that generates steam.

**3.1.xx**

**corrosion allowance**

Additional material thickness available to allow for metal loss during the service life of the vessel component.

**3.1.xx**

Critical check valve

Check valves in piping systems that have been identified as vital to process safety.

NOTE Critical check valves are those that need to operate reliably in order to avoid the potential for hazardous events or substantial consequences should reverse flow occur.

3.1.xx

design metal temperature

DMT

The tube metal or skin temperature used for design.

.**3.1.xx**

**design pressure**

The pressure, together with the design temperature, used to determine the minimum permissible thickness or physical characteristic of each vessel component as determined by the vessel design rules.

NOTE 1 The design pressure is selected by the user to provide a suitable margin above the most severe pressure expected during normal operation at a coincident temperature. It is the pressure specified on the purchase order.

NOTE 2 This pressure may be used in place of the MAWP in all cases where the MAWP has not been established. The design pressure is equal to or less than the MAWP.

**3.1.xx**

**design temperature**

The temperature used for the design of the pressure vessel per the applicable construction code.

**3.1.xx**

**facility**

Any location containing equipment and/or components to be addressed under this RP.

**3.1.xx**

**firetube boiler**

**fired tube boiler**

A shell and tube heat exchanger in which steam is generated on the shell side by heat transferred from hot gas or fluid flowing through the tubes.

**3.1.xx**

**fireproofing**

A systematic process, including materials and the application of materials that provide a degree of fire resistance for protected substrates and assemblies.

**3.1.xx**

**furnace**

Fired equipment that provides heat to process streams to create a molecular change.

**3.1.xx**

**heater**

Fired equipment that provides heat to process streams.

**3.1.xx**

**In service**

Designates a pressure vessel that has been placed in operation as opposed to new construction prior to being placed in service or retired vessels. A pressure vessel not in operation because of a process outage is still considered an in-service pressure vessel.

NOTE Does not include pressure vessels that are still under construction or in transport to the site prior to being placed in service or pressure vessels that have been retired from service. It does include pressure vessels that are temporarily out of service but still in place in an operating site. A stage in the service life of a vessel between installation and being removed from service.

3.1.xx

jurisdiction

A legally constituted government administration that may adopt rules relating to equipment.

3.1.xx

level bridle

The piping assembly associated with a level gauge attached to a vessel.

.**3.1.xx**

**maximum allowable working pressure**

**MAWP**

The maximum gauge pressure permitted at the top of a pressure vessel in its operating position for a designated temperature.

NOTE 1 This pressure is based on calculations using the minimum (or average pitted) thickness for all critical vessel elements, (exclusive of thickness designated for corrosion) and adjusted for applicable static head pressure and nonpressure loads (e.g., wind, earthquake, etc.).

NOTE 2 The MAWP may refer to either the original design or a rerated MAWP obtained through a FFS assessment.

3.1.xx

**owner-operator**

The party who owns the facility where the asset is operated. The owner is typically also the operator.

3.1.20

**pipe**

A pressure-tight cylinder used to convey, distribute, mix, separate, discharge, meter, control or snub fluid flows, or to transmit a fluid pressure and that is ordinarily designated “pipe” in applicable material specifications.

NOTE Materials designated as “tube” or “tubing” in the specifications are treated as pipe in this Code when intended for pressure service external to fired heaters. Piping internal to fired heaters should be in compliance with API 530.

3.1.xx

**piping circuit**

A subsection of piping systems that includes piping and components that are exposed to a process environment of similar corrosivity and expected damage mechanisms and is of similar design conditions and construction material whereby the expected type and rate of damage can reasonably be expected to be the same.

NOTE 1 Complex process units or piping systems are divided into piping circuits to manage the necessary inspections, data analysis, and record keeping.

NOTE 2 When establishing the boundary of a particular piping circuit, it may be sized to provide a practical package for record keeping and performing field inspection.

3.1.xx

**piping system**

An assembly of interconnected pipe that typically are subject to the same (or nearly the same) process fluid composition and/or design conditions.

NOTE Piping systems also include pipe-supporting elements (e.g., springs, hangers, guides, etc.) but do not include support structures, such as structural frames, vertical and horizontal beams and foundations.

3.1.xx

**tubing**

**tube**

See Note in **3.1.20, pipe**

## Acronyms

TEMA Tubular Exchangers Manufacturers Association

.Other Acronyms

.

# Mechanical Integrity Program

## Application

Mechanical integrity (MI) is a key pillar in safe operation of facilities handling hazardous chemicals. The term mechanical integrity (or asset integrity) applies broadly to all process equipment types including rotating equipment, fixed equipment, and instrumentation/controls. Inspection, testing, and preventive maintenance tasks for each equipment type are crucial for safe operation and reliability of a process facility.

This RP provides guidance on the application of the MI program to the different types of fixed equipment in the industries. Other process equipment, such as rotating equipment and instrumentation/controls, are not covered in this document. Determination of MI applicability for commonly used equipment types may be straightforward, but others may involve interpretation of regulations, and case-by-case decision making, depending on the complexity. The contents of this document are intended to assist in determination of:

* What type of equipment should be included in the MI program?
* What in-service inspection codes & standards are typically applied for each type of equipment?

### Unfired Pressure Vessels

The term “pressure vessel” is generally used to cover a variety of process equipment types that are subject to internal (or external) pressure. Although the term covers equipment commonly known as pressure vessels (e.g., towers, air-cooled heat exchangers, shell-and-tube heat exchangers, and bullet tanks), it can also cover other equipment types which are less commonly used, such as brazed aluminum heat exchangers, pipe-in-pipe exchangers, spiral exchangers, and plate-frame heat exchangers.

When determining the applicability of MI of a pressure vessel, the owner-operator or inspector should consider several factors including:

* the equipment construction code,
* hazards of the process,
* risk of loss of containment, and
* potential secondary consequences in case of equipment failure.

#### Inclusion of Piping Components

Some types of equipment which are typically considered as piping components, such as small strainers, filters, instrument bridles, and accumulators, may be considered as pressure vessels based on factors including size, and design pressure.

#### Construction Code

The most commonly used construction code for pressure vessels is the ASME Boiler & Pressure Vessel Code, Section VIII (Section VIII), but some equipment built to other construction codes may also meet the applicability of a pressure vessel. Other construction codes include but are not limited to API 661 for air-cooled heat exchangers, TEMA document(s) for shell and tube heat exchangers, and company-specific internal design standards (sometimes referred to as “non-code”).

#### Inspection Code

API 510 describes the in-service inspection, rating, repair, and alteration requirements and recommendations for pressure vessels. API 572 is a Recommended Practice (RP) document which supplements API 510 by providing specific guidance on inspection and testing of pressure vessels.

#### Guidance for Code Exempted Pressure Vessels

API 510, Annex A lists a number of criteria in which a pressure vessel may be exempted from the requirements of API 510. Even some pressure vessels that are constructed in accordance with Section VIII may meet the exemption criteria of API 510 Annex A. Although the pressure vessels that meet these criteria can be exempted from the specific requirements of API 510, owner/operators should still consider including the exempted equipment in the facility’s general MI program based on the associated potential risk.

##### Common Practices

The owner-operator may choose to adopt the requirements of API 510 for exempted pressure vessels. Another common practice is for the owner-operator to develop appropriate inspection practices to verify the integrity of those pressure vessels.

##### Common Exemption Mistakes

When considering exempting a pressure vessel from the MI program, the owner-operator should take caution in justifying the exemption and be aware of common mistakes. For example, a common mistake is assuming pressure vessels that are not built to a known construction code (e.g., Section VIII Div.1) are automatically exempted from the inspection code (e.g., API 510); exemption in one does not necessarily mean exemption in the other. The risk, and subsequent consequences, associated with loss of containment of the contents of the pressure vessel should be considered when justifying an exemption.

### Aboveground Storage Tanks

The term “aboveground storage tank” generally refers to tanks that are vertical, cylindrical, and uniformly supported at the bottom. The commonly used construction codes for these types of storage tanks include API 620, API 650, and API 12 series (12B, 12D, 12F, and 12P), each operating under the pressure limitations prescribed in the specific standards. In addition to the storage tank itself, the secondary containment systems such as dikes, curbs, and sumps should be considered for inclusion in the MI program for storage tanks.

#### Inspection Documents

API 653 describes the inspection, repair, alteration, and reconstruction requirements for storage tanks constructed to API 650 and its predecessor API 12C. Applicable parts of API 653 are also commonly adjusted as necessary and used for tanks constructed to API 620 API 12R1 describes the installation, operation, maintenance, inspection, and repair of tanks in production service. API 12R1 applies primarily to tanks fabricated to API 12-series specifications for onshore production services, although it may be applied to other tanks and services at the discretion of the owner-operator.

#### Other Inspection Options

For aboveground storage tanks constructed to standards other than API 620, API 650, or API 12-series specifications, other inspection and repair standards may be most appropriate. Inspection documents to consider for such tanks include (Steel Tank Institute) STI SP001, and (Fiberglass Tank & Vessel) FT&V 2007-01.

### Piping

Piping in an operating facility setting is generally divided into piping systems and/or circuits to efficiently manage inspection and testing activities. The term “piping system” not only includes piping, but also the associated components that are essential to the function and purpose of the pipe, such as fittings, flanges, valves, eductors, in-line strainers, and supporting elements. Flex hoses, and flexible joints are also considered a part of a piping system when used in the MI covered process. Piping and components that are included as a part of a skid package (e.g., pre-assembled compressor package) are treated the same as other process piping.

#### Inspection and Construction Documents

API 570 describes the in-service inspection, rating, repair, and alteration requirements for piping systems, while API 574 covers inspection practices for piping system components. Various codes are commonly used in the design and construction of piping respective to their service application. Some of the most commonly used construction codes are ASME B31.3, ASME B31.8, ASME B31.1, and ASME B31.10.

#### Tubing

The term “tubing” can imply different meanings depending on its context, and often causes confusion when considering its applicability of MI. When used in context of pressure service (not including the heat transfer coils in fired heaters), tubing used for bridle connections or as an alternative to small bore piping is considered piping and should follow the appropriate inspection and testing practices. When used in context of impulse tubing, heat tracing, seal flush lines, instrumentation lines, or heat exchangers, tubing is not normally considered as piping.

#### Critical Check Valves

The reliable functionality of critical check valves play a role in mitigating the potential for hazardous events. API 570 and API 574 provide guidance on the inspection and testing of critical check valves. Critical check valves are normally identified during a Process Hazard Analysis (PHA), or a separate risk evaluation.

#### Guidance for Code Exempted Piping Systems

Piping that is physically open to atmosphere, and poses no structural risk is generally included as a part of its adjacent (or parent) equipment for MI inspections. For example, the outlet piping of a pressure relief device that discharges to atmosphere may be included in the inspection of the pressure-relieving device, or the pressure vessel to which it is connected.

### Pressure Relief Devices

“Pressure Relief Device” is a general term used to describe the devices that physically activate to provide protection against an overpressure scenario, including pressure safety valves, rupture disks, conservation vents, and weighted hatches.

#### Requirements

API 510 and API 576 describe the inspection, testing, and repair requirements for pressure relief devices. Further guidance for relief devices can be found in the National Board Inspection Code (see Bibliography).

#### Thermal Relief Devices

Thermal relief devices may require inspection and testing that is different from the requirements of API 510 and API RP 576. When the application is not clear, the manufacturer of the device should be consulted to find the appropriate testing requirements.

### Fired Equipment

Fired equipment refers to equipment utilizing combustion to heat the process such as fired boilers, heaters, boilers or furnaces.

#### Fired Heaters, Furnaces, and Boilers

API RP 573 provides inspection and testing guidance for fired boilers, heaters, and furnaces. API RP 530 provides guidance on determining the tube thickness of fired equipment.

#### Other Fired Equipment

For equipment such as reboilers and bath heaters, which may not meet the typical configuration of fired heater described in API RP 573, the owner-operator should determine the most appropriate inspection practices (e.g., API 510, API 570), as API RP 573 may not be the most applicable inspection document for all fired equipment. Further guidance for fired equipment can be found in the National Board Inspection Code (see Bibliography)

#### Jurisdictional Involvement

Boilers are typically inspected and certified by the applicable jurisdiction’s program. Additional review should be included by the owner-operator in the facility MI program.

### Critical Utility Systems

Process equipment in utility systems such as steam, lube oil, and cooling water may be included in the MI programs despite the nature of the fluid being categorized as Class 4 (as defined by API 570). Maintaining the integrity of certain utility systems may be critical to process safety. Some utility systems are designed to play a key role in safeguarding against potential safety risks. Before excluding utility systems, the owner-operator should consult the process hazards analysis (PHA), and consider the risk associated with failure of the utility systems.

### Pipelines

Pipelines are complex piping systems through which liquid and gas are transported from production areas to refineries and other facilities. Pipeline systems include pipes, valves, fittings, flanges (including bolting and gaskets), pressure and flow regulators, pulsation dampeners, relief valves, appurtenances attached to pipe, pump units, metering facilities, pressure-regulating stations, pressure-limiting devices and fabricated assemblies.

AP 1160 and ASME B31.8S provide a systematic, comprehensive, and integrated approach to managing the safety and integrity of hazardous liquid and gas pipeline systems, respectively. Both documents provide a way to enhance the safety of pipeline systems and to allocate operator resources effectively to:

* identify and analyze actual and potential precursor events that could result in pipeline incidents,
* examine the likelihood and potential severity of pipeline incidents,
* provide a comprehensive and integrated method for examining and comparing the spectrum of risk and risk reduction activities available,
* provide a structured, easily communicated way of selecting and implementing risk reduction activities, and
* establish and track system performance with the goal of improving that performance.

### Other Fixed Equipment

The following sections provide general guidance and information on inspection and testing for fixed equipment types that are not covered by API. Following the Recognized and Generally Accepted Good Engineering Practices (RAGAGEPs) for the equipment types below is recommended.

#### Assets Owned by a Third Party

A facility may have process equipment and systems that are owned by another company. This can cause confusion on whether the responsibility for inspection and testing falls under the host facility, or the third-party company. While the equipment owner is generally responsible for conducting the testing and inspection for the equipment, the host facility should ensure that the inspection and testing is being conducted. Often, the host facility and the equipment owner establish a work process or a contract for how the equipment will be maintained and inspected. It is also common for the host facility to include these types of equipment in their MI program and treat them as though they were owned by the host facility.

#### ISO Storage Container or Other Transportable Storage Totes Regulated by DOT

Transportable storage equipment are often included as part of the supplier’s MI program. In cases where such equipment is treated as a permanent structure of the facility, the owner-operator should include the equipment as part of the facility MI program.

#### Fire Protection Equipment

Another important type of asset for consideration are those assets and systems in place to mitigate or to act as the final means to address chemical releases, fires, and other adverse events. This may include, but not limited to, flame arrestors, suppression systems, fixed and portable fire protection equipment, and sprinkler or deluge systems.

Such equipment is normally inspected and tested by personnel other than inspectors (e.g., safety personnel, fire chief). Fire protection equipment are generally managed outside of a fixed equipment MI program and driven by the requirements of other standards (e.g., NFPA). The owner-operator should, however, ensure that the inspection and testing is being conducted and documented.

#### Marine Docks and Other Transportation Assets

Owner-operators of waterfront facilities, including static liquid-pressure test of the piping, hoses, and loading arms located in the marine transfer area, may be subject to specific inspection and testing regimes at a certain prescribed frequency by the local jurisdiction.

As an alternative compliance practice, regulators may consider piping inspection practices in accordance with API 570 as acceptable and providing an equivalent level of safety and protection against potential failures. Owner-operators should maintain an effective and demonstrable record of their piping inspection compliance with minimum requirements established by API 570.

### Structural Integrity

Careful consideration of including the condition of structural components in the MI program should be given. Such consideration can include, but is not limited to:

* regions where the environment presents higher susceptibility for damage and corrosion (e.g., atmospheric corrosion, or impact by hurricane),
* the age of the facility and its structural components,
* environmental conditions in operating context (e.g., drift from cooling towers),
* fireproofing,
* post-seismic event inspection, or
* status of ladders, stairs, platforms, grating, and guy-wires.



(informative)

**Title**

# Bibliography

COMPLETE REWORK!!