National Environment and Planning Agency

Natural Resources Conservation Authority

Guidelines for the Structural Integrity Inspection of Petroleum Storage Tanks and Pipelines

March 2025

Foreword

These guidelines have been prepared by the National Environment and Planning Agency (NEPA) in good faith exercising all due care and attention, but no representation or warranty, expressed or implied, is made as to the relevance, accuracy, completeness or fitness of this document for any other purpose in respect of a particular user's circumstances. Users of this document should satisfy themselves about its application to their situation and, where necessary, seek expert advice.

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The guidelines will be revised periodically following feedback from stakeholders using it, ensuring its on-going relevance and reflecting advances in best practice as the result of regulator and industry experience. Comments are invited and should be sent via email to pubed@nepa.gov.jm.

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Related documents

The following documents are referenced in this guideline, as they provided essential context, regulatory requirements and technical standards relevant to the structural integrity assessment of petroleum storage systems:

API 650 – Welded Tanks for Oil Storage

API 653 – Tank Inspection, Repair, Alteration, and Reconstruction

40 CFR 280 – Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)

US EPA Release Detection for Underground Storage Tanks (USTs) - Internal Methods

Environmental Guidelines for Petroleum Storage in the Australian Capital Territory (ACT) Environment Protection Authority June 2019

Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019

Environmental Code for Aboveground and Underground Storage Tank Systems Containing Petroleum Product (PN 1326)

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Terms and Definitions

For the purposes of these guidelines, the following definitions apply.

“Cathodic protection” is a technique to prevent corrosion of a metal surface by making that surface the cathode of an electrochemical cell. For example, a tank system can be cathodically protected through the application of either galvanic anode for impressed current.[1]

"Corrective action" means an action required by the department to minimize, contain, eliminate, remediate, mitigate, or clean up a release, including any remedial emergency measures. The term does not include the repair or replacement of equipment or pre constructed property[2]

“Environmental harm” is defined under the Environment Protection Act (Australia) as any impact on the environment as a result of human activity that has the effect of degrading the environment (whether temporary or permanent).[3]

“Environmental nuisance” is defined under the Environment Protection Act (Australia) as an unreasonable interference with the enjoyment by the public, a section of the public or a person of a place or area, if the interference caused or likely to be caused by dust, fumes, light, noise, odour or smoke, or an unhealthy, unsightly or otherwise offensive condition because of pollution.[3]

“**Leak**” in relation to a storage system, means any loss of petroleum from the system because it is not providing full and continuous containment of petroleum[4]

“**Leak detection system**” means a system designed to detect contamination by, or failure of, a storage system in the event of a failure in loss monitoring systems that consists of either—

(a) groundwater monitoring wells, or

(b) an alternative leak detection system[4]

"Operator" means a person in control of, or having responsibility for, the daily operation of a tank[2]

"Owner" means a person who holds title to, controls, or possesses an interest in the tank before the discontinuation of its use.[2]

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[1] Definition extracted from *40 CFR 280.12*

[2] Definition extracted from *North Dakota Legislative Council, 2019*

[3] Definition extracted from *Law Insider, 2023*

[4] Definition extracted from Australian Capital Territory Government, 2019

"**Petroleum**" means any fuel that consists predominantly of a mixture of hydrocarbons, whether or not the fuel includes additives (such as ethanol), and includes used oil.[4]

"**Portable tank**" means a storage tank along with its piping and wiring that is not stationary or affixed, including a tank that is on skids[2]

"Precision leak detection test" means a test capable of detecting a storage tank leak as small as 0.38 L/h with a probability of detection of 0.95 or greater and a probability of false alarm of 0.05 or less, within a period of 24 hours, accounting for variables such as vapour pockets, thermal expansion of product, temperature stratification, groundwater level, evaporation, pressure and end deflection.[5]

"**Release**" means any unintentional spilling, leaking, emitting, discharging, escaping, leaching, or disposing of petroleum from a tank into the environment, but does not include discharges or designed venting allowed under local law or under adopted rules[2]

"**Storage system**" means a system of tanks, pipes, valves and other equipment that is designed —

(a) to contain petroleum, or

(b) to control the passage of petroleum into, out of, through or within the system,

and includes any structure through which petroleum routinely passes from one part of the system to another.[4]

"**Tank**" means any one or a combination of containers, vessels, and enclosures, whether above ground or underground, including associated piping or appurtenances used to contain an accumulation of petroleum.

The term does not include:

1. Tanks used for the transportation of petroleum
2. A pipeline facility
3. A surface impoundment, pit, pond, or lagoon
4. A storage tank situated in an underground area such as a basement, cellar, mine working, drift, shaft, or tunnel, if the storage tank is situated upon or above the surface of the floor
5. A tank used for the storage of propane[2]

"Tank integrity test" means a test to determine that a tank is sound and not leaking.[6]

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[5] Definition extracted from *Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019*

[6] Definition extracted from CCME

"**Third party**" means a person who is damaged by the act of a registered owner, operator, or dealer requiring corrective action, or a person who suffers bodily injury or property damage caused by a petroleum release[2]

"**UST system or tank system**" means an underground storage tank (UST), connected underground piping, underground ancillary equipment and containment system, if any.[1]

Acronyms

AST	Aboveground Storage Tank
ATG	Automated Tank Gauge
CCME	Canadian Council of Ministers of the Environment
EIT	Equipment Integrity Test
EPA	Environmental Protection Agency
IG	Imperial Gallon
NEPA	National Environment and Planning Agency
NRCA	Natural Resources Conservation Authority
UPSS	Underground Petroleum Storage System
UST	Underground Storage Tank

1.0 Introduction

The Natural Resources Conservation Authority (NRCA) Guidelines for Determining the Frequency of Structural Integrity Tests for Underground Storage Tanks, 2011, has had a critical role in the defence of the environment from petroleum products for well over a decade. There continues to be a need for the sound storage of petroleum products, but not only is the guideline dated, but a significant level of noncompliance has been observed with the requirements of environmental permits for structural integrity assessments to be conducted on tanks and pipelines.

On multiple occasions the guidelines were consulted for applicability to scenarios being addressed by the team. However, they were at times assessed to be limited and narrow in scope. Most obvious is the focus on underground storage tanks, when there are a significant number of aboveground petroleum storage operations, as well as the need for adequate coverage of the conveyance mechanisms (i.e. pipelines and possibly tankers). The title of the guideline also connotes a general applicability to varied materials being secured or stored in the tanks; however, the introduction places a focus on petroleum products.

A broader scope has been explored and established through jurisdictional review and the review of associated standards. It is anticipated that the title is better aligned with the objective of the guideline, and as much as practicable there has been adoption to the local context, consideration of the socio-economic implications and key stakeholder consultation.

1.1 *Background*

Structural integrity is of paramount importance when it comes to Aboveground Storage Tanks (ASTs) and Underground Storage Tanks (USTs) and associated fuel lines. These containers and pipelines serve a critical role in industries such as petroleum, chemical, and agriculture, where the safe storage and transportation of hazardous materials are vital. Any compromise in the structural integrity of these storage systems can lead to disastrous consequences, including leaks, spills, and environmental contamination.

To address this essential concern, a comprehensive set of guidelines has been developed to ensure the structural integrity of AST and UST systems. These guidelines serve as a roadmap for tank owners and operators, providing them with the necessary knowledge and strategies to ensure the tanks remain sound and secure throughout their operational lifespan.

The aim of these guidelines is to establish a proactive approach towards storage system safety, minimizing the potential risks associated with structural failures. By adhering to these guidelines, tank owners and operators can effectively mitigate the potential threats posed by corrosion, mechanical stress, and other factors that could compromise the tanks' integrity.

The development of these guidelines is the result of extensive research, collaboration, and expertise from various stakeholders, including regulatory bodies, industry associations, engineering organizations, and experienced professionals. Each aspect of the guidelines has been carefully

crafted to address specific challenges, account for different tank types and materials, and align with existing safety standards and regulations.

In this document, the key components of these guidelines will be focused on by exploring the best practices and measures recommended for maintaining the structural integrity of AST and UST systems. From routine inspections and maintenance to advanced monitoring techniques and risk assessment strategies, the crucial steps necessary to ensure these tanks remain safe, reliable, and risk-free will be highlighted.

By following these guidelines, tank owners can enhance their operational efficiency, protect the environment, and safeguard the health and safety of both personnel and surrounding communities. Moreover, compliance with these guidelines demonstrates a commitment to responsible storage practices and sets a standard for tank integrity across industries.

1.1.1 Jurisdictional Review

Jurisdiction/ Technical Standard	Targeted Audience/ Stakeholder/ User	Structural Integrity Requirements	Reference
CANADA/ Canadian Council of Ministers of the Environment (CCME)	Canadian Legislative Authorities	1. A storage tank system is to be tested for leaks: a. *At the point of final installation* - i. for UST system, final installation shall be at the point of final installation of surface material before the storage tank system is put into service. ii. ii. for AST system, final installation shall be before the storage tank system is put into service b. *Whenever a leak is suspected in the primary or secondary containment of the storage tanks, piping, containment sumps or related components.* 2. Types of monitoring and leak detection of storage tank systems include: a. Leak detection interlocks and alarms b. Monitoring wells c. Groundwater monitoring wells d. Vapour monitoring wells 3. Extracted Tables 2 to 9 in Appendix 1 provide a simplified guide on the frequency, method of leak detection and monitoring for the following categories: a. New Underground Storage Tanks b. Aboveground Storage Tanks c. Underground Piping d. Aboveground Piping e. Turbine, Transition and Dispenser Sumps f. Existing Single-Wall Underground Storage Tanks g. Existing Single-Wall Underground Piping	Environmental Code for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Product (PN 1326)

CANADA/ Environment and Climate Change Canada	Owners and operators of storage tank system	1. Single-walled underground tanks: should be removed, except steel tanks with cathodic protection and tanks constructed with material other than steel. These exceptions must have one of the following: a leak detection method, groundwater monitoring wells or vapour monitoring. a. Exempted systems must have completed an initial tank precision leak test and must have in place an ongoing leak detection program using one of the following methods: • an annual precision leak detection test • automatic tank gauging • continuous in-tank leak detection If a single-walled underground tank leaks, it must be withdrawn from service immediately and permanently. It must be removed within two (2) years from the date the leak is detected. 2. Horizontal Aboveground Tanks without Secondary Containment - an initial visual inspection of the tank walls for leaks is to be conducted and an ongoing leak detection program must be installed using one of the following methods: • an annual precision leak detection test • a monthly visual inspection of the walls of the tanks along with inventory reconciliation • continuous in-tank leak detection • continuous external leak monitoring 3. Vertical Aboveground Tanks without Secondary Containment - an initial visual inspection of the tank walls or floors and an ongoing leak detection program must be installed using one of the following methods: • an inspection of the tanks or the tank floors every 10 years from the date of the initial inspection • continuous in-tank leak monitoring • continuous external leak monitoring	http://www.canada.ca/petroleum-productsstorage-tanks (link seen on document) TankTip4_EN_LeakDetection.pdf

USA/ 40 CFR 280 (Main focus on section 280.43 - Methods of release detection for tanks)	UST owners and operators	Methods of release detection identified include: 1. *Inventory control* - (or another test of equivalent performance) - must be conducted monthly and able to discover a release of at least 1% of flow-through and 130 gallons monthly given specific requirements. 2. *Manual tank gauging* - conducted weekly (one test) or monthly (four test average) following specific requirements including recording the difference between the starting and final tank liquid level of at least 36 hours in which there is no addition or subtraction of the current liquid in the tank ***NB. See table with Test Standards for Manual Gauging*** 3. *Tank tightness testing* (or another test of equivalent performance) - must be capable of detecting a 0.1 gallon per hour leak rate from any portion of the tank that routinely contains product while accounting for the effects of thermal expansion or contraction of the product, vapor pockets, tank deformation, evaporation or condensation, and the location of the water table. Testing is to be conducted at least every 5 years until 10 years after tank is installed (see subsection 280-41 for frequency) 4. *Automatic tank gauging* - must be able to identify a 0.2 gallon per hour leak rate from any portion of the tank that routinely contains product. 5. *Vapour monitoring* - Testing or monitoring for vapors within the soil gas of the excavation zone must meet the following specific requirements. 6. *Groundwater monitoring* - Testing or monitoring for liquids on the groundwater which must meet specific requirements. 7. *Interstitial monitoring* - Interstitial monitoring between the UST system and a secondary barrier immediately around or beneath it may be used, but only if the system is designed, constructed, and installed to detect a leak from any portion of the tank that routinely contains product and meets specific requirements. ***NB. Section 280.44 refers to methods of release detection for piping***	eCFR :: 40 CFR Part 280 -- Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST) Release Detection for Underground Storage Tanks (USTs) - Internal Methods | US EPA

USA/ United States Environmental Protection Agency (EPA)	UST owners and operators	1. *Automatic tank gauging* - This method uses automated processes to monitor product level and inventory control. A probe permanently installed in the tank is connected to a monitor to provide information on product level and temperature. Testing done on tanks containing diesel or gasoline. 2. *Manual tank gauging* - This method involves keeping the tank undisturbed for at least 36 hours each week, during which the tank's contents are measured, twice at the beginning and twice at the end of the test period. Manual tank gauging can be used as the sole method of leak detection for the life of the tank only for tanks up to 1,000 gallons. Tanks between 1,001 and 2,000 gallons can use this method only in combination with tank tightness testing. This combined method, however, can be used only during the first 10 years following tank installation. **NB. See table with Test Standards for Manual Gauging in Appendix 2.** 3. *Tank tightness testing* is also known as precision, volumetric and nonvolumetric testing. Tank tightness testing must: a. be able to detect a leak at least 0.1 gallon per hour (0.38 L/h) b. be performed periodically. Existing UST systems prior to April 11, 2016, are to undergo tightness testing every 5 years for 10 years installation. However, after the time indicated above, a monitoring method capable of being conducted once every 30 days must be implemented c. be performed by well- trained, experienced and qualified testing company/ testers d. be used for tanks no greater than 15,000 gallons in capacity storing diesel and gasoline	Release Detection for Underground Storage Tanks (USTs) - Internal Methods | USEPA

AUSTRALIA (New South Wales)/ Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019 under the Protection of the Environment Operations Act 1997	• Industry - person responsible for a storage system • Local government	1. Equipment integrity test is to be conducted, system certified as having satisfied the test, and test results provided to the person responsible for a new, repaired or a modified storage system before it is commissioned. A storage system is not to be used or authorized for use without an installed leak detection system, and a loss monitoring system that is properly designed and installed by a duly qualified person.	Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019 (nsw.gov.au)

AUSTRALIA (New South Wales) Guidelines for Implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019	• Industry - person responsible for a storage system • Local government	1. Loss monitoring discrepancies (fail or inconclusive result) are not necessarily indicative of a leak in the UPSS. Dispensers in need of calibration, inaccurate delivery meters, human error in reading or stolen product could be likely. Investigate all possible reasons. 2. Source of confirmed leaks are to be identified, stopped and fixed. 3. All UPSS, 'old' or 'new', must have a leak detection system installed and regularly tested. 4. Types of leak detection system include: a. *Groundwater monitoring well* - test at least every 6 months or when leak found, b. *Vapour monitoring well* - continuously or regularly to monitor for hydrocarbon vapours in the soil around the tanks, c. *Equipment Integrity Testing (EIT)* d. *Tank pit observation wells* - check for vapour, leaked petroleum or spilled petroleum in the tank pit e. *Interstitial monitoring* - every 6 months; and f. *Visual leak detection (*i.e. observation of shoreline for oil slick or sheen where a fuel tank is in an intertidal zone or near a waterway) 5. Cathodic protection of steel tanks and piping against corrosion - minimize the risk for the UPSS to leak petroleum. Inspect within 12 weeks of installation and at least annually thereafter. 6. Monthly monitoring where impressed-current cathodic protection is used. 7. Equipment Integrity Test duly conducted must be passed for all tanks (new and significantly modified) being made operational. 8. Prepare current "as-built" drawings on completion of installation 9. Equipment Integrity Test (EIT): a. Measures the containment integrity of the tanks, fittings and pipes by applying a pressure or vacuum to them and measuring any pressure changes.	Underground-Petroleum-StorageSystems-Guidelines.pdf(Review) - Adobe cloud storage

		b. A requirement for execution on all UPSS (new, repaired and significantly modified) systems being commissioned. c. Useful diagnostic tool to assist in confirming location of a leak detected by a loss monitoring system d. Certificate for a certified method is to be provided by the tester to the responsible person for the UPSS stating how the test was conducted, and results. e. Records or documents are to be retained for 7 years after the system is decommissioned. 10. Minimum requirements for EIT: a. Capability to detect a leak of 0.38 L/hr, b. Probability of detection of at least 95% c. Probability of false detection of 5% or less in accordance with AS 4897 - 2008, *The Design, Installation and Operation of Underground Petroleum Storage Systems* d. Conducted by a duly qualified person in accordance with the manufacturer's written instructions specific to the UPSS component/s e. Use a nationally approved and certified method of testing that meets the requirements or certification standards of General Guidance for Using EPA's Standard Test Procedures for Evaluating Release Detection Methods (USEPA 510-B-19-006; May 2019) f. Typically involves a vacuum or pressure test, using inert gasses on both the tanks and pipework. 11. Frequency of EIT by Regulation • Before a new UPSS is commissioned • After any modification or upgrade of UPSS • (including tank relining) • After any repair following the discovery of a leak in the system or replacement of tanks or piping • Due to being done infrequently EIT is not considered an ideal or adequate sole method for leak detection. • In the capacity as an alternative leak detection system for a UPSS EIT is recommended to be conducted annually and done along with monthly statistical inventory reconciliation analysis (SIRA)	

AUSTRALIA (Australian Capital Territory) Environmental Guidelines for Petroleum Storage in the Australian Capital Territory (ACT) Environment Protection Authority June 2019	Persons responsible for petroleum storage systems	The guidelines are controls to minimise the risk of environmental harm or environmental nuisance from spills or leaks of petroleum products into the environment. 1. **Underground Petroleum Storage Systems (UPSS)** - tanks and pipelines a. Be non-corrodible and comply with section 4.2.1 of AS 4897 b. Be double walled and have interstitial space between the two walls of the tank that allows for monitoring breach of either the inner or outer wall of the tank c. Installed in a tank pit according to manufacturer's recommendation and AS 2758 d. Steel tanks and piping should be cathodically protected and coated with a suitable di-electric material to minimise the risk of corrosion and leaks happening. Cathodic protection systems should be inspected and tested 6-12 weeks after installation and at least annually thereafter as per Part 1 & 2 of AS 2832 and instructions from a corrosion specialist. e. Install tank pit observation wells to monitor for the presence of liquid which may contain leaked or spilled petroleum products and also monitor for vapours. f. All UPSSs require a leak detection system for tanks and piping. Where not practicable a suitable alternative process is to be implemented that checks for any loss on a regular basis g. Various available methods of leak detection include: • Automatic tank gauging • Statistical inventory analysis • Interstitial monitoring • Groundwater monitoring • Line leak detection for pressure piping h. To effectively demonstrate that all practicable and reasonable steps are being taken to prevent or minimize environmental harm, it is necessary to employ more than one of the previously mentioned leak detection methods. All are required to: • at least meet the detection limit of 0.76 litres per hour, with at least 95% accuracy • be capable of detecting a leak from tank(s) and piping • be conducted at least monthly	Australian Capital Territory Government. (2019). Environmental Guidelines for Petroleum Storage in the ACT Environment Protection Authority June 2019. www.environment.act.gov. https://acrobat.adobe.com/id/urn:aaid:sc:VA6C2:ee8664a4-2095449d-84a74d8aabc131c6

		• be installed, calibrated and commissioned in accordance with the manufacturer's specifications **2. Above-ground Petroleum Storage Systems** a. Designed, installed and maintained in accordance with AS 1940 (The Storage and Handling of Flammable and Combustible Liquids) and AS 1692 (Steel Tanks for Flammable and Combustible Liquids). b. Self-bunded petroleum storage tanks are constructed of double-walled materials that provide double protection against leakage. The outer wall prevents the contents of the tank from spilling and contaminating the surrounding area. c. Requirements to be met for the installation of self-bunded petroleum tanks are, • suitability to be filled with petroleum products • clear access route to the fuel tank that is clear of clutter, hanging branches of trees and electrical lines • suitable position that considers the location of waterways, the stormwater system, and drainage patterns on the site • steel bollards must be installed to protect the tanks from damage • dispensing areas must be roofed with a minimum 100 overhang • Generators with an incorporated fuel storage must have bunding of at least 110% of the fuel storage capacity d. Requirements to be met for the installation of single-wall petroleum storage tank • Bunded area of capacity at least 110% of the tank's volume • Bunded areas must be roofed with a minimum 100 overhang • Spills in bund must be recovered, removed and disposed by a suitably qualified person to a suitably licensed facility, not discharged to stormwater or sewer • Steel bollards must be installed to protect the tanks from damage • Suitability to be filled with petroleum products **3. Equipment Integrity Test (EIT)** a. Conducted to evaluate if an UPSS is leaking to the environment or is not providing containment as originally designed.	

		b. Performed on all new, repaired and significantly modified UPSS after installation is complete, and before the full commissioning of the system. c. Required to be capable of detecting a leak of 0.38 litres per hour, with a probability of detection of at least 95% and of false detection of 5% or less in accordance with AS 4897 d. Required to be conducted by a competent and experienced person who is to provide the person responsible for the UPSS with a certificate that states the system passed the test, along with the results of the test. The documents are to be retained for the life of the UPSS. e. Required to be a nationally approved and certified method of EIT that meets, at a minimum, the requirements or certification standards of the United States Environmental Protection Agency (USEPA).	

1.1.2 Structural Integrity Test Methods

Testing the structural integrity of storage tanks is crucial to ensure their safety and reliability. It's essential to choose the appropriate test methods based on the tank's construction material, design, and the specific structural issues being addressed. Inspection and testing should be performed regularly as part of a comprehensive maintenance and integrity management program to ensure the continued safe operation of storage tanks. Additionally, adherence to relevant industry standards and regulations is crucial when conducting these tests. The table below outlines some common structural integrity test methods utilized during the inspection of storage tanks.

Method	Description
Ultrasonic Testing (UT)	A non-destructive testing method that detects internal defects and small surface cracks through the characterization of the material's thickness by high-frequency sound waves. This method is widely utilized on materials made of metals, plastics, composites and ceramics.
Phased Array Ultrasonic Testing (PAUT)	An advanced non-destructive examination technique that uses a set of ultrasonic transducers to steer and focus sound waves, allowing for better imaging and defect characterization, especially in complex geometries.
Magnetic Particle Testing (MPT)	A non-destructive examination that detects surface and sub-surface defects by using a magnetic field and magnetic particles in ferromagnetic material.
Liquid Penetrant Testing (LPT)	A non-destructive testing method that inspects a material for surface defects by applying a coloured or fluorescent dye and drawing out any penetrant that has seeped into surface cracks or defects using a developer/ colour activator.
Radiographic Testing (RT)	This method is capable of detecting defects that provide a sufficient difference in thickness or density of the material by the penetration of X-rays or gamma rays. Similar to ultrasonics, radiography is generally used for the successful detection of internal flaws that are located beneath the surface. Radiographic inspection technique is also used to check welds and casting as well as inspect assemblies to check the condition and proper placement of components in a system.

Eddy Current Testing (ECT)	A non-destructive inspection method that is performed on conductive materials to detect surface and sub-surface degradation, determine the thickness of surface coating, provide information about structural features and measure physical properties. It involves passing an electrical current through a coil to generate an alternating magnetic field that produces eddy currents in the material being tested.
Acoustic Emission Testing (AET)	A non-destructive testing method that analyses emitted sound waves induced by defects and/ or discontinuities. This technique is often used to monitor the integrity of pressure vessels and pipelines.
Guided Wave Testing (GWT)	A non-destructive evaluation method that employs low frequency ultrasound that propagates along elongated metallic structures for the detection of defects caused by corrosion or erosion. It's commonly used for corrosion monitoring in pipelines.
Pressure Testing	A non-destructive testing method that is used to assess for leaks and verify the performance and durability of pressure vessels, tanks, boilers, gas cylinders and pipelines. It is performed by filling (pressurizing) the vessel or piping being examined and subsequently monitoring the level of pressurization for changes. There are two methods for pressure tests: hydrostatic and pneumatic. A hydrostatic test is performed by using water as the test medium, whereas a pneumatic test uses inert gas.
Vacuum Box Testing	A non-destructive method that assesses tanks for weld seam leaks through its ability to maintain a vacuum or negative pressure.
Microwave Testing	A non-destructive method for non-metallic pipes that uses microwaves scanned along the pipeline surface to identify defects within the structure.

1.3 *Purpose*

To provide a contemporary, relevant guideline that supports the mandate of environmental defence and sustainable development through the documentation of the NRCA's procedures and requirements for conducting structural integrity inspections on petroleum storage tanks and pipelines.

1.4 *Scope*

This guideline document applies to all parties responsible for the operation of petroleum storage facilities/ and/or duly qualified persons responsible for the conduction of structural integrity assessments.

2.0 Regulatory Requirements

All underground petroleum storage systems, 'old' or 'new', must have a leak detection system installed and regularly tested. Types of leak detection system is inclusive of but not limited to:

a. *Groundwater monitoring well* - test at least every 6 months or when leak found,
b. *Vapour monitoring well* - continuously or regularly to monitor for hydrocarbon vapours in the soil around the tanks,
c. *Equipment Integrity Testing (EIT)/ Structural Integrity Testing*
d. *Tank pit observation wells* - check for vapour, leaked petroleum or spilled petroleum in the tank pit e. Interstitial monitoring - every 6 months; and
e. *Visual leak detection* (i.e. observation of shoreline for oil slick or sheen where a fuel tank is in an intertidal zone or near a waterway)

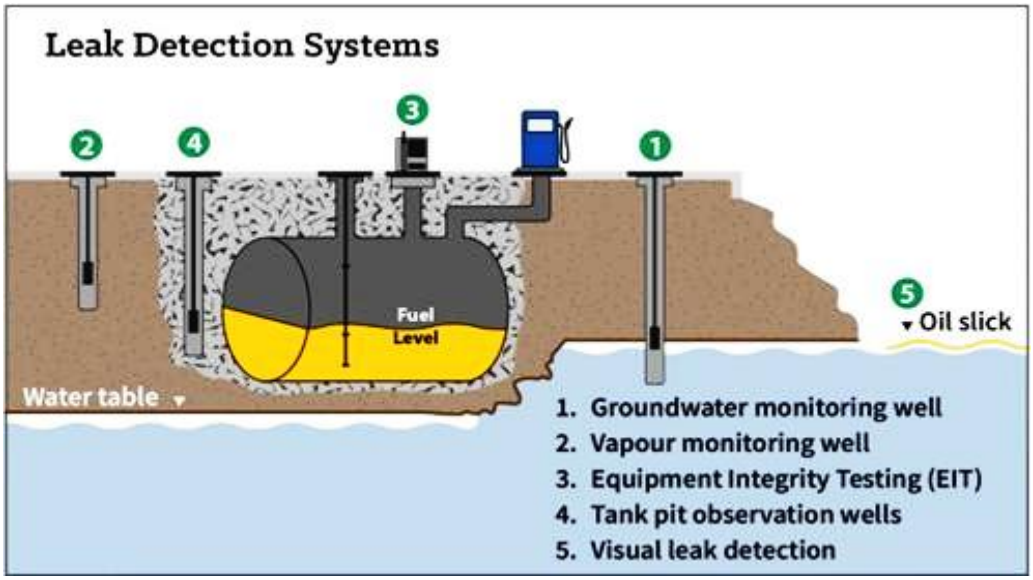

Figure 1. Leak Detection Systems. Retrieved from NSW EPA. *Guidelines for Implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019*.

Structural integrity testing must be conducted by a duly qualified person in accordance with the manufacturer's written instructions specific to the UPSS component(s) and requirements stipulated by the Agency.

2.1 *Integrity Inspection Method*

The prescribed method of choice should be capable of detecting a leak of 0.38 L/hr with a probability of detection of at least 95%.

2.2 *Integrity Inspection Schedule/Frequency*

Integrity tests are infrequently administered and thus considered inadequate as a sole method of leak detection. Best practice is that it be complemented by frequent (*conducted annually and done along with monthly statistical inventory reconciliation analysis*) applied leak detection (for e.g. automatic tank gauging (ATG) systems, groundwater monitoring, corrosion monitoring systems) and/or loss monitoring system.

1. *Before a new petroleum storage system is commissioned*
2. *After any modification or upgrade of petroleum storage system (including tank relining)*
3. *After any repair following the discovery of a leak in the storage system or replacement of tanks or piping*
4. *In accordance with prescribed specific inspection frequencies by the Agency/ regulatory requirements*

2.3 *Exceptions to Structural Integrity Inspections*

Structural integrity inspections for tanks, whether aboveground or underground, are essential for maintaining safety, environmental compliance, and the integrity of the storage system. However, there may be some exceptions or circumstances where inspections are not required or can be deferred, subject to specific conditions and regulatory approvals.

1. *Temporary storage tanks, which are used for an extremely short duration and meet certain criteria, may not require the same level of inspection as permanent tanks.*

2. *Small Tanks: Smaller storage tanks with storage capacity less than 4000 litres (880 I.G), may be exempt from some inspection requirements.*

3. *Non-Hazardous Materials: Tanks storing non-hazardous materials may be exempted from some inspection requirements.*

2.4 *Reporting Requirements*

The permittee must submit a Structural Integrity Assessment Report to the Agency in accordance with the reporting timeline stipulated within the granted environmental permit.

The Reporting Form in Appendix 1, can be utilized for test reporting; otherwise, the report shall be prepared to include, but not be limited to, the following information:

- description of the storage system (capacity, material stored, material of construction, location, associated pipelines)
- purpose and scope of the inspection (routine, post-repair, incident-driven, etc.)
- date of inspection and testing
- structural integrity test method applied
- test results, findings and observations
- next proposed scheduled test date

References

Australian Capital Territory Government. (2019). *Environmental Guidelines for Petroleum Storage in the ACT Environment Protection Authority June 2019*. www.environment.act.gov. https://acrobat.adobe.com/id/urn:aaid:sc:VA6C2:ee8664a4-2095-449d-84a7-4d8aabc131c6

Canadian Council of Ministers of the Environment. (n.d.). *Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products (PN 1326)*.

Code of Federal Regulations. (n.d.). *40 CFR Part 280 -- Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)*. eCFR. Retrieved September 22, 2023, from https://www.ecfr.gov/current/title-40/chapter-I/subchapterI/part-280

Environment and Climate Change Canada. (n.d.). *Tank Tip 4 - Leak Detection and Monitoring*. file:///P:/STANDARDS%20OFFICER/Structural%20Integrity%20Guideline%2023.24/Canada/Ta nkTip4_EN_LeakDetection.pdf

Hull, B. & John, V. (1988). *Non-Destructive Testing*. Red Globe Press London. https://doi.org/10.1007/978-1-349-85982-5

Ida, N. & Meyendorf, N. (2019). *Handbook of Advanced Non-Destructive Evaluation*. Springer Cham. https://doi.org/10.1007/978-3-319-30050-4

Law Insider. (2023). *Tank integrity test definition*. Law Insider. https://www.lawinsider.com/dictionary/tank-integrity-test

Lowe, M.J.S. & Cawley, P. (2006). *Long Range Guided Wave Inspection Usage – Current Commercial Capabilities and Research Directions*. Department of Mechanical Engineering Imperial College London. https://www.guided-ultrasonics.com/wpcontent/uploads/2023/02/Lowe-2006-Long-Range-GW-Review.pdf

North Dakota Legislative Council. (2019, February 8). *North Dakota Century Code Proposed Amendments to House Bill No. 1024*. Retrieved September 12, 2023, from https://www.ndlegis.gov/assembly/66-2019/documents/19-0212-01003a.pdf

Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019. (n.d.). NSW Legislation. https://legislation.nsw.gov.au/view/pdf/asmade/sl-2019-411

Hijazi, A. *Introduction to Non-Destructive Testing Techniques*. Magnetic Particle Testing. The Hashemite University.

https://eis.hu.edu.jo/ACUploads/10526/Magnetic%20Particle%20Testing.pdf

Hijazi, A. *Introduction to Non-Destructive Testing Techniques.* Ultrasonic Testing. The Hashemite University. https://eis.hu.edu.jo/ACUploads/10526/Ultrasonic%20Testing.pdf

Tripathi, D.M. (2016). NDT by Microwave Test Method for Non-Metallic Component. https://www.ndt.net/article/nde-india2016/papers/A147.pdf

United States Environmental Protection Agency (EPA). (n.d.). *Release Detection for Underground Storage Tanks (USTs) - Internal Methods*. EPA. https://www.epa.gov/ust/release-detectionunderground-storage-tanks-usts-internal-methods

Worman, J. (2011). *Summer National Board Bulletin: Magnetic Particle Examination*. The National Board of Boiler and Pressure Vessel Inspectors. Retrieved from https://www.nationalboard.org/index.aspx?pageID=164&ID=377

Worman, J. (2011). *Winter National Board Bulletin: Liquid Penetrant Examination*. The National Board of Boiler and Pressure Vessel Inspectors. https://www.nationalboard.org/index.aspx?pageID=164&ID=374

Appendix 1

The Natural Resources Conservation Authority Act
Underground and Aboveground Storage Tanks and Pipeline Structural Integrity Testing

REPORTING FORM

Name of Facility: _____
Location of Facility: _____
Date: _____ NRCA Permit #: _____

Purpose of Inspection: _____
Type of Test: _____

A. Results for Tank Pressure Tests

Tank #	Product in Tank	Tank Material	Tank Volume (Litres)	Maximum Pressure Applied (psi)	Time Held	Comments

B. Results for Pipeline Pressure Tests

Product Type run in Pipeline	Length of Pipes (Meters)	Pipeline Material	Maximum Pressure Applied (psi)	Time Held	Comments

C. Results from Plate Testing

Method Used:

_____

Please attached diagram of tank showing plates tested and plate thickness.

D. Results from Volumetric Tank Testing

Please attach tank reconciliation data for each tank.

Tank #	Product in Tank	Tank Material	Tank Volume (Litres)	Volume Start of Test (Litres)	Volume End of Test (Litres)	Volume Lost	Comments

E. External Tank Inspections: Yes □ Date: _____ No □

Tank Inspected	Findings
_____	_____
_____	_____
_____	_____
_____	_____

F. Internal Tank Liner Inspections: Yes □ Date: _____ No □

Tank Inspected	Findings
_____	_____

Recommendations/ Comments:

Next Recommended Test Date: _____

Test & Recording by	Signature	Date
Plant Operator Name	Signature	Date
Owner Name	Signature	Date

Supporting Documentation and Information

These items must be attached to the Reporting Form:

- Inspection checklists, forms, reports
- Photographs, diagrams, drawings
- Other relevant supporting documents

Appendix 2

Extracted tables from Environmental Code for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Product (PN 1326)

Table 2 - Leak Detection and Monitoring Methods

Abbreviation	Leak detection and Monitoring Method Description[1][2]
ATG	Automatic tank gauge with monthly *precision leak detection* test
CITLD	Continuous in-tank *leak detection* system with monthly *leak detection* test (results are limited to an evaluation of the *storage tank* only)
CITLDS	Continuous in-tank *leak detection* system with monthly *leak detection* test (results provide an evaluation of the *storage tank* and *piping* system)
ELLD	Electronic line *leak detection* device
HPVLDT	High-pressure inert gas or vacuum *leak detection* test
HTSCM	High-technology *secondary containment* monitoring
IR	Manual dip and inventory reconciliation; electronic dip and electronic inventory reconciliation; or electronic dip and manual inventory reconciliation in conformance with Section 8.3
LPVLDT	Low-pressure inert gas or vacuum *leak detection* test
MLLD	Mechanical line *leak detection* device
OWM	Observation well vapour or groundwater monitoring (monthly)
PLDT	*Precision leak detection test of a storage tank* (See Appendix B, note B.6.2.13(1))
PLMLDT	*Pressure liquid media leak detection test*
SIR	Statistical inventory reconciliation (monthly reporting)
SLMLDT	*Static liquid media leak detection test*
SVCV	Single, vertical check valve
VLD	Visual *leak detection* (weekly)

[1]See Section 6.2 for definition and performance requirements of the prescribed methods.
[2]See Appendix B, note B.6.3.2(1)

Table 3 – New Underground Storage Tanks

Containment	Final Installation Leak Detection	In-service Monitoring	Periodic Leak Detection	Leak Suspected
Double-wall tanks	PLDT	SIR; VLD; ATG; HTSCM; CITLDS; or CITLD	Not required	PLDT

Table 4 – Aboveground Storage Tanks

Containment	Final Installation Leak Detection	In-service Monitoring	Periodic Leak Detection	Leak Suspected
Double-wall tanks	VLD	HTSCM; or VLD	Not required	VLD[1]; PLDT; or LPVLDT[1]
API Std 650-98 *(within approved secondary containment)*	API 650 standard	IR and VLD; or HTSCM	API 653	PLDT; or API 653
API Std 650-98 *(within non-approved secondary containment)*		IR and VLD	API Std 653-01; or PLDT (annually)	PLDT; or API Std 653-01
Single wall vertical tanks *(within approved secondary containment)*	VLD	IR and VLD ; or HTSCM	API Std 653-01	PLDT; or API Std 653-01
Single-wall vertical tanks *(within non-approved secondary containment)*		IR and VLD	API Std 653-01; or PLDT (annually)	PLDT; or API Std 653-01
Horizontal tanks	VLD	IR and VLD	Not required	VLD[2]; or PLDT

[1]on the interstice only
[2]where entire system including *piping* is visible

Table 5 - Underground Piping

Containment	Final Installation Leak Detection	In-service Monitoring	Periodic Leak Detection	Leak Suspected
Single-wall (greater than 75mm)	PLMLDT; or HPVLDT	OWM	PLMLDT; or HPVLDT (every year)	PLMLDT; or HPVLDT
		CITLDS; or ELLD	Not required	
Double-wall	PLMLDT; or HPVLDT and LPVLDT	ELLD; Sensor; CITLDS; or SVCV[1]	Not required	PLMLDT; or HPVLDT

[1]Suction style system only

Table 6 - Aboveground Piping

Containment	Final Installation Leak Detection	In-service Monitoring	Periodic Leak Detection	Leak Suspected
All types	PLMLDT; or HPVLDT	VLD	Not required	PLMLDT; or HPVLDT

Table 7 – Turbine, Transition and Dispenser Sumps

Containment	Final Installation Leak Detection	In-service Monitoring	Periodic Leak Detection	Leak Suspected
Dispenser Sumps	SLMLDT	HTSCM; or VLD	Not required	SLMLDT
Turbine and transition sumps	SLMLDT		VLD (annually) [1]	SLMLDT

[1]In conformance with Clause 8.4.1(4)(g)

Table 8 - Existing Single-Wall Underground Storage Tanks

Type	In-service Monitoring	Periodic Leak Detection	Leak Suspected
Steel without CP[1]	IR; and OWM or SIR	PLDT (annually)	PLDT
Steel with CP[1]; or FRP[2];	IR	PLDT (every 2 years)	
	IR; and OWM or SIR	PLDT (every 5 years)	
	ATG; or CITLDS	Not required	
	OWM and SIR	Not required	

[1]CP - *Cathodic protection*
[2]FRP - Fibreglass-reinforced-plastic

Table 9 – Existing Single-Wall Underground Piping

Type	In-service Monitoring	Periodic Leak Detection	Leak Suspected
Steel without CP[1]	IR; and OWM or SIR	PLMDT; or HPVLDT (annually)	PLMDT; or HPVLDT
Steel with CP[1], plastic, or FRP[2]	IR; and OWM or SIR	PLMDT; or HPVLDT (every 2 years)	
	CITLDS; or OWM and SIR	Not required	
	SVCV[3]; or ELLD[4]	Not required	

[1]CP - *Cathodic protection*
[2]FRP - Fibreglass reinforced plastic
[3]Suction style system only
[4]Pressure Piping

Extracted table United States Environmental Protection Agency (EPA)

Table of Test Standards for Manual Tank Gauging

Tank Size	Minimum Duration of Test	Weekly Standard (1 test)	Monthly Standard (4-test average)
up to 550 gallons	36 hours	10 gallons	5 gallons
551-1,000 gallons (when tank diameter is 64")	44 hours	9 gallons	4 gallons
551-1,000 gallons (when tank diameter is 48")	58 hours	12 gallons	6 gallons
551-1,000 gallons (also requires periodic tank tightness testing)	36 hours	13 gallons	7 gallons
1,001-2,000 gallons (also requires periodic tank tightness testing)	36 hours	26 gallons	13 gallons

Appendix 3

National Environment and Planning Agency

NRCA GUIDELINES FOR DETERMINING THE FREQUENCY OF STRUCTURAL INTEGRITY TESTS FOR UNDERGROUND STORAGE TANKS

Introduction

The definition of structural integrity test as outlined in the *NEPA Interim Guidelines for Proponents* - Structural Integrity Testing of Petroleum Storage Tanks (Tank Tightness Testing) 2003; is any method that can be used to determine whether there is a leak in a petroleum storage tank or pipeline. There are different kinds of tests.

The test which is usually called a pressure test, or a tightness test must be capable of detecting a leak of 0.76 litres per hour. This test is recommended to be done annually on tanks.

A second structural integrity test; the Precision test should be capable of detecting a leak at least as small as 0.38 litres per hour. This is to be done every five years. These types of tests are called volumetric methods.

Another method of structural integrity testing is called Acoustics or tracer testing which are physical tests used to determine the presence of a hole in a tank.

NEPA will approve the type of tests to be used by a Permittee; however, it is the responsibility of the Permittee to put forward the most convenient type of structural integrity tests for their facility.

Jurisdictional Review

The following are some of the findings based on a review of structural integrity testing done in other countries.

In Australia the frequency of testing ranges from annually to every 3 years. Monitoring of USTs and ASTs and piping for leaks are conducted through tightness testing ranging annually to every three years for existing facilities in combination with inventory reconciliation, consisting of an analysis of daily inventory compared to delivered quantities and volumes dispensed.

In the USA, testing frequency ranges from 5 to 10 years in respect of frequency. This is dependent on whether the tank is new, had history of leaks and the type of tank design. Unless a cathodic protection system is applied when the tank is lined or within 10 years, the tank must be internally inspected periodically after the initial 10-year life of the lining to make sure that tank's structural integrity will continue for the remainder of its operating life.

NEPA requirements for frequency of structural integrity testing

Assessment Criteria	Category 1	Check √	Category 2	Check √	Category 3	Check √
Ground water level	**within ground water**		**Within 6m from groundwater**		**6m Above groundwater**	
Age of Tank	**Tank age N/A**		**Tank age older than 10 years**		**Tank age less than 10 years**	
Proximity to fault zones	**Within 30m of an active fault zone**		**Unstable soil/ earth movement**		**Stable soil**	

The following are the recommendations to determine the frequency of structural integrity testing.

The assessment criteria relate to the age of the tank, the vulnerability of the site as well as the compliance and leak history of the tank. The Criteria classification is organized in the table below.

Category 1 tanks: Structural integrity test to be done every 18 months

- Two years with submitted reconciliation inventory monitoring reports
- Two years if Steel tank and piping is well-coated with a dielectric material and cathodically protected.

Category 2 tanks: Structural integrity test to be done every two to three years

- Three years with submitted reconciliation inventory monitoring reports
- Three years if electronic leak detection is done
- Three years if Steel tank and piping is well-coated with a dielectric material and cathodically protected.
- Two years if there are enforcement issues inclusive of history of leaks and non-submittal of reconciliation inventory monitoring reports etc.

Category 3 tanks: Structural integrity test to be done every 3-5 years

- 5 years if no enforcement issues related to the site
- 5 years with submitted reconciliation inventory monitoring reports
- 5 years if electronic leak detection is done
- 5 years if Steel tank and piping is well-coated with a dielectric material and cathodically protected.
- Three years if there are enforcement issues inclusive of history of leaks and non-submittal of reconciliation inventory monitoring reports etc

Application of categories:

Once the tank fits any of the assessment criteria for category 1 it automatically fits within category 1

Once the tank fits any of the assessment criteria for category 2 but none for category 1 it is deemed as category 2.

It must be noted that old tanks (tanks 10 years or older) require closer monitoring as after 10 years it is found that most tanks start to have holes. Also, special considerations may be given for less testing frequency of old tanks that are well-coated with a dielectric material and cathodically protected.

Reporting

Reports on the results of the structural integrity tests should be submitted using the form attached as Appendix I with accompanying documents.

Prepared by Andrea Bennett
Policy Planning Evaluation & Research Division on behalf of the NEPA Petroleum Working Group- November 2011.

Approved by the Natural Resources Conservation Authority (NRCA) - December 2011

APPENDIX I

The Natural Resources Conservation Authority Act
Underground and Aboveground Storage Tanks and
Pipeline Structural Integrity Testing
REPORTING FORM

Name of Facility: _____
Location of Facility: _____
Date: _____ NRCA Permit #: _____

Type of Test: _____

Results for Tank Pressure Tests

Tank #	Product in Tank	Tank Volume (Litres)	Maximum Pressure Applied (psi)	Time Held	Comments

Results for Pipeline Pressure Tests

Product Type run in Pipeline	Length of Pipes (Meters)	Maximum Pressure Applied (psi)	Time Held	Comments

Results from Plate Testing

Method Used:

_____

Please attached diagram of tank showing plates tested and plate thickness.

Volumetric Tank Testing

Please attach tank reconciliation data for each tank.

Tank #	Product in Tank	Tank Volume (Litres)	Volume Start of Test (Litres)	Volume End of Test (Litres)	Volume Lost	Comments

Tank Inspections: Yes □ Date: _____ No □

Tank Inspected Findings

_____

_____

Internal Tank Liner Inspections: Yes ☐ Date: _____ No ☐

Tank Inspected	Findings

Comments:

Test & Recording by	Signature	Date
Plant Operator Name	Signature	Date
Owner Name	Signature	Date