Directive 055

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Storage Requirements for the Upstream Petroleum Industry

Contents

Abbreviations

ABSA	Alberta Boilers Safety Association
AEP	Alberta Environment and Parks
AER	Alberta Energy Regulator
ASCA	Alberta Safety Codes Authority
AST	aboveground storage tanks
AWSS	aboveground synthetically lined walled storage systems
CCL	compacted clay liner
ECP	engineered containment pond
EPEA	*Environmental Protection and Enhancement Act*
GCL	geosynthetic clay liners
LEE	lined earthen excavations
OGCA	*Oil and Gas Conservation Act*
OGCR	*Oil and Gas Conservation Rules*
UST	underground storage tank

1 Introduction

1.1 Purpose

This directive identifies requirements for the storage of materials produced, generated (including wastes), or used by the upstream petroleum and geothermal resource development industries that, if released into the environment, may cause an **adverse effect**. The purpose is to prevent soil, groundwater, and surface water contamination. The implementation of appropriate storage practices should reduce the long-term costs associated with decontamination activities and make it easier for upstream petroleum and geothermal resource development sites to be reclaimed to conditions suitable for the next intended land use.

In many cases, multiple sets of requirements apply to a specific storage system or material. An authorization under this directive may not be sufficient. Other approvals under other legislation may also be required.

Definitions applicable to *Directive 055* are included in appendix 1, and defined terms are set in **bold face** at first use.

1.2 AER Requirements

Following AER requirements is mandatory for the responsible duty holder as specified in legislation (e.g., licensee, operator, company, applicant, approval holder, or permit holder). The term “must” indicates a requirement, while terms such as “should,” “recommends,” and “expects” indicate a recommended practice. Each AER requirement is numbered.

Information on compliance and enforcement can be found on the AER website.

1.3 What’s New in This Edition

This directive now also applies to geothermal resource development. References to the *Geothermal Resource Development Act* and *Geothermal Resource Development Rules*, as well as other appropriate references to geothermal development, have been added.

1.4 How to Use This Directive

This directive is divided into four sections. The first gives general requirements and best practices that are broadly applicable. The next discusses each of the applicable storage systems, including their design and required components. This is followed by requirements for each of the system components. Finally, requirements related to the day-to-day operation of the systems are given.

1.5 Jurisdictional Overview

In Alberta there is no single body that regulates the storage of all materials. Those that do include the AER, Alberta Municipal Affairs, Alberta Environment and Parks (AEP), and local authorities.

The duty holder of an upstream petroleum or a geothermal resource development site is responsible for all activities occurring on its site, including any incidents that occur during an activity or operation provided by a service company. Unless the service company is conducting activities that require AER approval (e.g., oilfield waste management), they are typically not under AER jurisdiction. In those cases, the storage of materials in **tanks**, containers, or other devices on a service company's site would be governed by one or more of the other bodies.

Alberta Municipal Affairs administers the *National Fire Code (Alberta Edition)*, which applies throughout Alberta and regulates the storage, handling, use, and processing of flammable and combustible liquids in buildings, structures, and open areas. In 2020, Alberta Municipal Affairs delegated the responsibility for administering specific portions of the *National Fire Code (Alberta Edition)*, including the registration of storage tank systems containing flammable or combustible liquids, to Alberta Safety Codes Authority (ASCA). The *National Fire Code (Alberta Edition)* distinguishes between upstream raw exploration and production processes and the downstream use of refined products and exempts certain upstream raw exploration and production processes. Specifically, part 4 of the *National Fire Code (Alberta Edition)* does not apply to the storage and handling of raw production flammable or combustible liquids and the incidental storage and handling of hydrocarbon-based chemicals resulting from or used during crude oil or natural gas exploration, production, or transmission.

Where upstream petroleum or geothermal resource development sites use refined fuels for supplying vehicles, aircraft, emergency generators, or other similar equipment, then the storage and handling of these fuels in storage tanks, containers, or other devices are subject to the other jurisdictions, including the *National Fire Code (Alberta Edition)* and ASCA.

AEP and the AER regulate the storage of materials produced, generated, and used in activities or at facilities subject to notification, registration, or approval as specified in the *Activities Designation Regulation* under the *Environmental Protection and Enhancement Act* (*EPEA*). In situations where both *EPEA* and *OGCA* approvals are required, *Directive 055* sets the minimum storage requirements, while additional requirements may be specified in the *EPEA* approval.

1.6 Applicability

Directive 055 outlines the minimum storage requirements for the upstream petroleum and geothermal resource development industries. The implementation of alternative storage systems and provisions requires AER approval, as outlined in section 2.1.4.

The storage requirements apply to the following:

- upstream petroleum facilities (including oilfield waste management), well sites, and pipelines licensed or approved by the AER, but excluding oil sands mining and processing plant operations as defined in the *Oil Sands Conservation Act*
- well sites and facilities licensed by the AER under the *Geothermal Resource Development Act*

1.6.1 Material Types

This directive applies to any material that could adversely affect the environment and is produced, generated, or used on upstream petroleum or geothermal resource development sites under the jurisdiction of the AER. Examples include the following:

- production fluids such as produced water, **crude oil**, emulsions, **condensates** (C5+, nonpressurized storage), crude **bitumen**
- chemicals such as solvents and lubricants other than for motor vehicle use
- oilfield waste such as produced sand, oily waste, produced water (hydrocarbons removed)
- **alternative water** for reuse in hydraulic fracturing

This directive does *not* apply to the following materials because they are covered by other legislation and technical bodies:

- natural gas liquids (C2 to C4, pressurized storage)
- fuels (e.g., diesel and gasoline), refined flammable liquids, and combustible liquids
- natural gas and liquefied petroleum gas
- lubricants for motor vehicles
- coke
- pipeline drip fluids
- sewage
- final treated effluent
- sulphur
- scrap metal
- fresh water

Although *Directive 055* does not specifically apply to **freshwater** storage, duty holders should consider the design and construction provisions outlined in this directive for their chosen storage system.

1.6.2 Storage Systems

This directive applies to the following storage systems:

- containers
- aboveground storage tanks (ASTs)
- underground storage tanks (USTs)
- bladders with structural frame (BwSFs)
- lined earthen excavations (LEEs)
- bulk pads
- aboveground synthetically lined walled storage systems (AWSSs)
- engineered containment ponds (ECPs)

This directive does *not* apply to the following storage systems because they are covered by other legislation and standards:

- lime sludge being stored in a cell system that is part of a landfill on an upstream petroleum site
- lime sludge ponds at in situ oil sands plants
- aboveground and underground pressurized vessels that are part of an active production process and pipeline drip vessel, have been designed for a working pressure of 103.4 kilopascals (kPa) (15 pounds per square inch [psi]), and are registered with the Alberta Boilers Safety Association (ABSA).
- aboveground flare and incinerator separators or knockout drums part of an active production process
- brine storage ponds as defined in the *Activities Designation Regulation*
- oil sands tailings ponds
- underground cavern storage
- fresh water reservoirs
- dams, as defined in section 27(1) of the *Water (Ministerial) Regulation*

1.6.3 Sites with ASTs and USTs Operated Before January 1, 1996

Directive 055 was first published in 1995. In the subsequent 2001 edition, a number of exemptions were introduced for sites operating before January 1, 1996, with any ASTs with an internal storage capacity of 5 m^3 or more or USTs of any capacity. Because some of these tanks are still in service, these exemptions still apply and are stated below:

1) If at any point in the life of the pre-1996 site, the tank farm area must be reconstructed (e.g., expand the site to include more tanks), then this section no longer applies, and the duty holder must meet all the secondary containment and leak detection requirements of this directive.

The 2001 edition of *Directive 055* required duty holders to either regularly verify the mechanical integrity of the tanks or to retrofit the site to meet the 2001 requirements for secondary containment and leak detection.

2) Duty holders that did not retrofit their tank farms must continue to use a dike if storing fluids other than fresh water.

3) Duty holders that did not retrofit their tank farms must continue to verify the tanks' mechanical integrity at least every five years for ASTs and at least every three years for USTs. As per the previous edition, the initial integrity testing was to have been completed by 2003. If the tanks were not verified before 2003, the duty holder is in noncompliance, and the tank must be upgraded to meet all the current requirements of this directive.

4) Duty holders who retrofitted integrity-verified single-walled ASTs with a second bottom and a system to monitor the interstitial space between the two bottoms must continue to monitor the interstitial space monthly as per section 4.3.4.

5) If a duty holder replaces or adds an additional AST in a pre-1996 site, they must ensure that the capacity of the dike is still at least 100 per cent the volume of the largest AST within the tank farm and must do *one* of the following:

   a) Continue to verify the new tank's mechanical integrity every five years.

   b) Install a liner under the new tank and monitor as per section 4.3.1.

   c) Install a weeping tile system under the new tank. The weeping tile system must be monitored at least monthly, and any liquids collected in the weeping tile system must be field tested for pH, chlorides, and visible oil sheen and action taken as per section 4.3.5.

6) If a duty holder replaces an existing AST or adds additional AST in a pre-1996 site that was not retrofitted to meet secondary containment and leak detection requirements, a new replacement AST or additional AST can only be added if the capacity of the dike is at least 100 per cent the volume of the largest AST within the tank farm. Upon removal of the old AST, any contamination must still be managed as per section 5.5.2.

7) Duty holders who chose to retrofit their single-walled USTs must continue to monitor the **leak detection system** monthly as per section 4.3.1.

8) If a UST fails a mechanical integrity test, the duty holder may attempt to repair it and retest. If that second test also fails, then the duty holder must replace the UST and meet all the current requirements of this directive. Upon removal of the old UST, any contamination must be managed as per section 5.6.2.

Examples of mechanical integrity testing methods for ASTs and USTs are included in appendix 2. The tables highlight the pros and cons for each test method; it is ultimately the responsibility of the duty holder to determine which test method is appropriate.

1.6.4 Sites with Bulk Pads or Lined Earthen Excavations Operated Before January 2, 2002

In the 2001 edition, a number of exemptions were introduced for sites operating before January 1, 2002, with any bulk pad or lined earthen excavation using concrete for primary containment. Because some of these bulk pads and lined earthen excavation are still in service, these exemptions still apply and are stated below:

9) If at any point in the life of the pre-2002 site, the bulk pad or lined earthen excavation must be reconstructed, then this section no longer applies, and the duty holder must meet all requirements of this directive.

10) If the bulk pads used concrete for primary containment, and there is a potential to generate leachate, the duty holder must continue to regularly verify that there has been no breach of containment. The leak detection system must be monitored and results recorded as per section 4.3 of this directive.

11) If the lined earthen excavation used concrete for primary containment but no secondary containment, the duty holder must continue to regularly verify the integrity of the storage system at least every three years. As per the previous edition, the initial integrity testing was to have been completed by 2003. If the lined earthen excavation was not verified by 2003, the duty holder is in noncompliance, and the lined earthen excavation must be upgraded to meet all the current requirements of this directive. The leak detection system must be monitored and results recorded as per section 4.3 of this directive.

12) If the bulk pad or the lined earthen excavation leak detection system indicates a breach of containment, or if an integrity test fails, the duty holder may attempt to repair the concrete once and retest. If the resulting repair fails, then the duty holder must reconstruct the bulk pad or lined earthen excavation and meet all the current requirements of this directive. Upon removal of the old bulk pad or lined earthen excavation, any contamination must be managed as per section 5.6.2.

2 General Storage Practices and Requirements

2.1 Notifications and Authorizations

2.1.1 Notification

13) Unless otherwise directed by the AER, duty holders must notify the AER by email at Directive055@aer.ca two weeks before setting up an AWSS for use less than two years or to use a bladder with structural frame with "Use of AWSS or Bladder with Structural Frame" (whichever device is applicable) in the subject field. The notification must include the following:

    a) name, BA code, and contact information of licensee

    b) licence numbers of the wells being fractured (if known)

    c) the proposed area of use map (if applicable)

    d) legal land location of the site and licence or approval number, if available, on which the storage device will be situated

    e) the number, capacity, and **freeboard** to be maintained of the AWSSs on the site, and/or the number and capacity of the bladders with structural frame on the site

    f) the sources and types of fluids being stored (e.g., produced water for reuse)

    g) proposed duration of use

2.1.2 After-Use Notification

14) For AWSSs, unless otherwise directed by the AER, when the duration of use exceeds three months, duty holders must notify the AER by email to Directive055@aer.ca no later than 30 calendar days after the removal of the AWSS. The notification must include the following:

    a) name, BA code, and contact information of licensee

    b) licence numbers of the wells that were fractured

    c) legal land location of the site and licence or approval number, if available, on which the AWSS was situated

    d) the number, capacity, and freeboard levels maintained of AWSSs on the site

    e) sources and types of fluids stored

    f) the setup and removal dates of the AWSSs

    g) the original notification email submitted under section 2.1.1

15) Although the AER does not require the duty holder to notify the AER after using bladders with structural frame or AWSSs for less than three months, the above information must be documented for future reference. Duty holders must complete the documentation no later than 30 calendar days after the removal of the storage system and, if requested, make it available to the AER within five business days.

2.1.3 Application for a Facility Approval

The AER does not allow the use of AWSSs for longer than two years or ECPs at all without an approval.

16) The following must be within the boundaries of an AER-approved oilfield waste management facility:

    a) AWSSs intended for use for two years or longer that will contain **alternative water**, such as produced water or other waste

    b) ECPs that will contain alternative water, such as produced water or other waste

    c) single-walled aboveground tanks intended for use more than one year and that will contain water for reuse in hydraulic fracturing, such as produced water or other waste

Refer to *Directive 058* for requirements for an oilfield waste management facility storing water for reuse in hydraulic fracturing. As industry moves to decrease the use of high-quality nonsaline water to align with the *Water Conservation Policy*, the use of alternative water (e.g., produced water reuse in hydraulic fracturing) is increasing as is the need for larger capacity storage systems such as ECPs and AWSSs.

2.1.4 Alternative Storage Systems

As per section 8.030(3) of the *OGCR*, upon application via the designated information submission system, a duty holder may propose alternative storage methods systems or devices to those set out in this directive. To be approved, the application must contain enough information to substantiate that an equivalent level of environmental protection and safety will be achieved.

17) The application must include at least the following:

    a) a description of the waste streams or materials that will be stored

    b) methods for receiving and removing materials from the storage system to ensure that spills, leaks, and tracking of material outside the system will be prevented

    c) design of the primary and secondary containment systems, leak detection systems, and **leachate collection systems**, including details of the construction materials and any liner specifications as per section 4

d) engineering diagrams, designed and authenticated by a professional engineer, including cross-sectional diagrams, showing the primary and secondary containment, leak detection, and leachate collection systems to comply with the information requirement in section 4

e) total storage capacity of the system (in cubic metres)

f) details of the storage system safety features, such as overfill/release protection measures (e.g., high-level shutdown, alarms at an attended facility)

2.2 Environmental Protection and Safety Practices

In addition to the specific measures addressed in this directive, the AER expects duty holders to consider the following environmental protection and safety practices:

- Select the location of a storage system to minimize the potential for environmental concerns.
- Implement operating procedures, maintenance practices, and inspection programs to maintain the integrity of the **primary containment device** and any associated equipment such as valves, fittings, piping, or pumps.
- Implement operating practices to prevent the buildup of static electricity during the transfer of flammable liquids.
- Store the materials so that
  - materials do not generate extreme heat or pressure or cause a fire or explosion,
  - materials do not produce uncontrolled fumes or gases that pose a risk of fire or explosion,
  - materials do not damage the structural integrity of a storage device or system, and
  - incompatible materials are segregated to prevent contact even in the event of a possible release.

2.3 Spill Prevention

Experience has shown that when prevention systems are in place (e.g., primary containment, secondary containment, leak detection), the most significant contributor to environmental contamination is accumulated releases.

Often small in nature (less than the volumes that require reporting under AER requirements), these releases occur for a variety of reasons, such as load line connection spills, tank overflows, truck overfilling, and flange, valve, and fitting leaks. These types of releases indicate opportunities for operational improvement.

18) The duty holder must protect the storage device from damage that can result in releases or spills.

Duty holders should include within their operating procedures proactive measures to prevent releases (such as plans and policies) and document their frequency and cause to determine the overall program effectiveness. These measures should include contracted services, as contractors are often responsible for the loading operations that may result in intermittent releases. Some of the measures that have proven to reduce release volumes and frequency include the following:

- company inspection and maintenance programs
- company operations handbooks and environmental bulletins
- operator and contractor training on company expectations and reporting
- contractor pre-job orientations
- detailed records and reports
- a database of incidents to allow for analysis of spill cause and frequency

Preventing releases in the first place is cheaper than cleaning up after the fact and is most protective of the environment.

2.4 Storage Duration

Materials are expected to be consumed within a two-year period.

19) Oilfield wastes and empty barrels must not be stored for longer than one year.

20) Alternative water must be actively used and not sit stagnant for longer than a year. For every volume that goes into the storage device, an equal volume must be withdrawn within twelve months.

Products, materials, alternative waters, and wastes will usually move through production processes more quickly than the abovementioned timeframes. Where necessary, procedures should be implemented to minimize the inventory of empty barrels stored on site.

2.5 Siting of Storage Areas and Facility

21) Duty holders must consider site location when designing storage areas and facilities. At a minimum, the following requirements must be met:

    a) The site must be readily accessible for firefighting and other emergency procedures.

    b) The site must be chosen so as to minimize the risk of environmental damage, including any threats to the integrity of the storage devices (e.g., slope instabilities, vehicular traffic, drilling operations); the quality of soils, surface water, and groundwater; and the health of humans, animals, and plants during the construction, operation (e.g., controlled access to the site, bollards, guard rails, concrete barricades), and closure of the storage area or facility.

c) The site must be chosen and designed to minimize landscape disturbance.

d) The site must not be within 100 m of the normal high-water mark of a body of water, permanent stream, or a water well used for domestic purposes.

22) For AWSSs deployed for more than three months and for ECPs, the storage area or facility must also meet the following requirements:

a) It must have controls preventing off-site releases. These controls must be documented.

b) It must not be where the natural drainage from the storage site and surrounding area would cause a release to flow directly into the normal high-water mark of a body of water or permanent stream.

c) It must not be within 100 m of land predisposed to slope failure.

d) It must not be within a ravine, coulee, or gully.

e) It must not be within a recharge area of an unconfined aquifer.

f) For AWSSs, there must be a continuous deposit of clayey soils within the area the AWSS is situated to prevent vertical migration of any leaks.

i) For AWSSs deployed less than one year, the presence of a clayey deposit can be determined from regional data or data gathered during site construction.

ii) For AWSSs deployed for one year or longer, the deposit of clayey soils directly below the base of the AWSS must have a minimum thickness of 0.6 m with a minimum in situ hydraulic conductivity of 2.5×10^{-6} cm/sec or a hydraulically equivalent deposit above the groundwater table

g) For AWSSs, the seasonal high-groundwater table (determined from regional data) must be greater than 1 m below the base of the AWSS.

h) For AWSSs, site suitability assessment procedures must be included in the standard operating procedures. The standard operating procedures must be developed and implemented by a qualified person. Qualified person means a professional engineer and the field staff that report to them.

i) For ECPs, the base of an ECP must not be within 10 vertical metres of fractured bedrock or karst features.

The duty holder should locate an oilfield waste management facility with an ECP further than 300 m from a natural area that permanently contains water and from the wellhead protection zone of a municipal or community water supply.

The geological material underlying the storage area or an oilfield waste management facility with an ECP should consist of fine-grained sediments and glacial till consisting predominantly of clay and silt.

2.6 Spacing and Identification of Storage Facilities

Duty holders must post signage, as per section 6.020 and Schedule 12 of the *OGCR*, at the entrance to the facility indicating the duty holder's name, emergency phone number, and legal surface description. Within a storage facility and at storage areas that form part of an operating upstream petroleum site, signs should indicate the materials that are stored, warnings, and any general housekeeping practices that should be followed in the storage area (e.g., segregation).

23) The duty holder must space adjacent storage systems and their associated equipment, including the dike wall, within a secondary containment area to prevent further damage and harm if a failure of the storage system was to occur. For example, section 4.3.2 of the *National Fire Code (Alberta Edition)* sets minimum distances for ASTs storing flammable materials from other tanks and from dike walls.

3 Requirements for Storage Devices

24) All storage systems and their components must be designed, fabricated, tested, installed, and operated to applicable engineering, manufacturing, regulatory, and operational standards. If no standards exist, the storage system must be designed and authenticated by a professional engineer.

25) When requested, the duty holder must be able to demonstrate that the manufacturer, the supplier, and the installer that supplied, fabricated, or installed the storage system and its various components followed documented quality assurance and quality control (QA/QC) programs applicable to the application. Below are some examples:

    a) Manufacturer QC program for the fabrication of a synthetic liner for an AWSS would include raw material testing, certified seamers, in-factory seam testing, shipping and handling protocols, job site delivery and inspections protocols.

    b) Manufacturer QA program for the manufacturing of a synthetic liner would include testing protocols for the incoming raw resin for the liner.

c) Construction QA program for the installation of a synthetic liner would include certified installers, subgrade suitability sign-off, deployment of material protocols, and field seam testing.

d) Construction QC program for the installation of a compacted clay liner would include material selection evaluation criteria, construction equipment and methods to be used, and testing.

26) Concrete must not be used as primary containment in situations where liquids are being stored or where there is potential for **leachate** to be generated. Concrete does provide a durable working surface, but it is too porous and susceptible to cracking to be used for these situations for primary containment.

3.1 Containers

A container is any portable aboveground storage device (e.g., drums, pails, bags, boxes, totes, bins) that does not exceed 1 m^3 in capacity.

27) If the total combined on-site volume of containers exceeds 1 m^3, duty holders must have secondary containment for any volume exceeding 1 m^3, as per section 4.2.

28) Instead of the dike and liner system described in section 4.2, duty holders may also use an alternative method of secondary containment (such as a storage building with curbing, a storage trailer, bins, overpacks, drip/collection trays, spill pallets), provided that the following requirements are met:

a) The secondary containment must be constructed of materials that are impervious to the materials being stored and that will not react with or absorb any material being stored.

b) There must be no openings that may provide a direct connection to the ground underneath or surrounding the primary container, including building and trailer floor drains directly connected to the outside.

c) The secondary containment must have a volumetric capacity of not less than the capacity of the largest container or 10 per cent of the total volume of all containers in the storage area, whichever is greater.

d) Storage buildings and trailers must include clad structures with a concrete floor and a perimeter curb at least 15 cm high to prevent contained material from seeping out between the floor and curb; and clad structures, sealed shipping containers, or loading dock buildings must each constructed with a containment floor.

e) Storage buildings and trailers must be fitted with proper ventilation of any potential vapour emissions from the stored materials and comply with fire and electrical codes.

f) Licensees must prevent unauthorized entry to storage buildings and trailers.

29) Weather protection must be provided to maintain the integrity of the container. The type of secondary containment and weather protection depends on the nature of the contained material, the type of container, and the design of the storage compound.

Weather protection is a physical cover or coating over containers. Weather protection is intended to preserve the condition of the primary container and hence the usefulness of the material contained therein. As a result of this protection, the containers and its contents are preserved. Secondary containment systems for containers often are designed, or can be designed, to include provisions for protection from the weather.

3.2 Aboveground Storage Tanks

30) Aboveground storage tanks (ASTs) must be constructed from materials that will not be compromised by the stored contents (e.g., steel-welded or skid-mounted tanks, plastic totes or slips, or fibreglass-reinforced plastic tanks).

Welded tanks are preferred over bolted tanks for new installations. ASTs with an internal volume less than 1 m^3 are considered containers (see section 3.1).

31) Double-walled ASTs require secondary containment unless the following requirements are met:

a) The primary tank wall must be separated from the secondary tank wall so as to provide a continuous interstitial space below and around the primary tank.

b) The interstitial space between the tank walls must be monitored (e.g., pressure, vacuum, electronic, or vapour monitoring or manual sampling) as per section 4.3.4.

32) The duty holder must design the foundation and supports to minimize or eliminate the risk of differential settlement, subgrade movement (including sinking, low spots, slumping, sloughing), and corrosion and to meet the *National Fire Code (Alberta Edition)*, section 4.3.3.1(3), for fire resistance rating.

33) Open-topped non-metallic tanks do not require secondary containment and leak detection provided the following requirements are met:

a) are constructed of a heavy synthetic material,

b) have a capacity no greater than 30 m^3,

c) are located on the well site producing the fluid, and

d) only store produced water from shallow, low-pressure gas wells from the Milk River, Medicine Hat, or Second Whites Specks pools.

34) Duty holders must visually inspect ASTs with a capacity of up to 5 m^3 and open-topped tanks (as per section 5.7) at least monthly.

35) Duty holders must test the integrity of open-topped tanks at least every five years.

36) Duty holders must equip ASTs with nonleaking fittings, nozzles, and hoses.

37) ASTs must be either externally coated (e.g., painted, galvanized steel) or be made from a weather-resistant and corrosion-resistant material (e.g., plastic, fibreglass) regardless of volume.

ASTs with a capacity of greater than 5 m^3, that are constructed with steel, and are storing corrosive liquids should be internally coated or lined to minimize corrosion.

In corrosive environments, it may also be appropriate to apply **cathodic protection**, either internally or externally, to aboveground steel tanks.

Duty holders may store up to a total combined on-site volume of 5 m^3 in small tanks without secondary containment.

38) Single-walled ASTs must meet the secondary containment, leak detection, and spill control provisions in sections 4.2, 4.3, and 5.1.

If the AST is indoors (inside a building or other type of enclosed structure, resting on or elevated above an impermeable floor), one of the following secondary containment options may be chosen instead of the default dike and liner:

- Surround the AST with a containment system (e.g., an impervious base, wall, or curbing) that has a volumetric capacity as per section 4.2.
- Drain into a collection tank that has a volumetric capacity as per section 4.2.

Additional provisions of the *National Fire Code (Alberta Edition)* may also apply to indoor ASTs.

3.3 Underground Storage Tanks

39) Underground storage tanks (USTs) may be of any volume and must be constructed from materials that will not be compromised by the stored contents (e.g. steel, fibreglass-reinforced plastic, plastic storage tanks). Flares, incinerators, knockouts, drip collection devices, floor trenches and sumps, and receiving tanks for incoming trucked fluids at oil sands cleaning facilities where the entire sides and bottom cannot be visually examined for integrity are considered underground tanks.

40) Underground storage tanks must be double walled. Secondary containment for underground storage tanks is achieved using double-walled tanks that allow monitoring of the interstitial space between the two walls and containment of any leakage (see section 4.3.4).

41) If the underground storage tank is a flare knockout or incinerator separator, is single-walled, and was installed before this directive took effect, then the duty holder must verify the tank's mechanical integrity at least every three years as per appendix 2. The initial verification must occur within three years of this directive's effective date.

42) Duty holders must test the integrity of newly installed underground storage tanks and associated piping as a complete system before using.

43) Duty holders must minimize corrosion in steel underground storage tanks with cathodic protection and an external coating. An internal lining may be installed to prevent internal corrosion of an underground storage tank, but by itself is not considered to be an acceptable corrosion protection measure.

3.4 Bladder with Structural Frame

The AER considers bladders with structural frame a different type of storage device than ASTs; they do not meet our definition of "tank." The primary containment device of a bladder with structural frame includes a wall system and a fabricated synthetic bladder.

44) Prior to placement, the duty holder must prepare the subgrade to distribute weight, prevent differential settlement, prevent freeze-thaw action, and protect the bladder from punctures (e.g., rock-free, sand layer or geotextile cushion).

45) The wall system must be constructed of a rigid structural component that is designed to withstand the hydraulic pressure of the stored contents at maximum capacity.

46) The duty holder must fabricate the bladder with an appropriate synthetic liner as per section 4.1.

47) The duty holder must document the history of the synthetic bladder (e.g., ongoing integrity testing, in-service length, and types of fluids stored). The duty holder may redeploy the bladder with structural frame as per section 5.6.1.

48) Duty holders must follow manufacturer requirements during installation, operational use, dismantling, and redeployment of a bladder with structural frame, including signoff by **qualified persons** that are certified by the manufacturer during the various phases.

49) The duty holder must notify the AER as per section 2.1 when using a bladder with structural frame.

50) Duty holders may deploy a bladder with structural frame on a single location for up to one year without prior AER approval. If the proposed duration at a single location will exceed one year, the duty holder must apply for an authorization as per section 2.1.4 prior to deployment.

51) After installation, the duty holder must test the integrity of the bladder with structural frame before using it.

3.5 Lined Earthen Excavations

Lined earthen excavations (LEEs) are a storage system consisting of primary containment, secondary containment, and leak detection systems. LEEs are *not* Engineered Containment Ponds (ECPs), which are described in section 3.8.

LEEs are typically used to

- store oily wastes (produced sand/slop oil) from in situ oil sands operations,
- receive oilfield waste or store process **solids** at an oilfield waste management facility, or
- receive blowdown fluids from shallow gas wells.

The following designs are the only ones acceptable to the AER:

- Earthen excavation with a primary containment device, a secondary containment device with a synthetic liner, and a leak detection system that monitors the space between the primary and secondary containment devices.
- Semiburied metal tank with external and internal corrosion protection, a synthetic liner for secondary containment, and a leak detection system.
- Steel or other storage device constructed on grade and then backfilled on one or more sides, with a synthetic liner or a compacted clay liner for secondary containment and leak detection systems.

When selecting the primary containment device, it’s important to consider how the LEE will be operated. For example, while synthetic liners provide an impervious barrier, they often require protection from daily operations (e.g., from equipment used for loading or unloading operations).

52) Duty holders must design the LEE to collect and contain any spills that may occur during loading and unloading operations and operate the LEE to prevent overflowing (e.g., sufficient freeboard maintained).

53) The duty holder must position the LEE’s lowest component at least one metre above the seasonably high groundwater level.

54) For LEEs constructed below or partially below grade, duty holders must include an impervious synthetic liner, as per section 4.1 as part of the secondary containment.

    a) In order to protect the synthetic liner, accommodate the leak detection system, and support the primary containment device (which in some situations may be a tank or another liner), the secondary containment design must incorporate a protective layer (e.g., sand, geotextile cushion) above and below the synthetic liner and be installed on a prepared subgrade.

b) In order to accommodate the leak detection system, the duty holder must design the prepared earthen excavation to be sloped, with the low point being down gradient of the directional flow of groundwater.

3.6 Bulk Pads

Duty holders may store solid materials (e.g., contaminated soils, spent desiccant, catalyst, or activated carbon) on permanent bulk pads at a site.

55) A bulk pad must consist of a compacted clay or synthetic liner, concrete or asphalt base pad with a slope directed to a catchment device to allow for the collection of precipitation and any generated leachate, and a continuous curb with a minimum height of 15 cm on at least three sides.

56) Duty holders must not stockpile material in a manner that causes spillage off the bulk pad.

57) If the stored material has a potential to generate a leachate, concrete or asphalt may be used as a durable working surface but not for the primary containment, and the duty holder must incorporate in the design a compacted clay or synthetic liner as per section 4.1 under the working surface. Duty holder must also include a leachate collection system as per section 4.4 above the primary containment device and a leak detection system as per section 4.3 under the primary containment system.

3.7 Aboveground Synthetically Lined Wall Storage Systems

AWSSs are a different type of storage system than an AST; AWSSs do not meet our definition of a "tank."

An AWSS can be used to store water-based fracturing and flowback fluids for use in hydraulic fracturing operations and alternative waters for reuse in hydraulic fracturing operation. An AWSS must not be used to store hydrocarbon-based fracturing fluids or fracturing flowback fluids.

The primary containment device of an AWSS includes a wall system, one or more prefabricated or field-installed synthetic liners, and a properly prepared subgrade or engineered foundation.

58) The wall system must be constructed of a rigid structural component that is designed to withstand the hydraulic pressure of the stored contents at maximum capacity.

59) The synthetic liner must provide a continuous impervious layer by covering the base, extending up the walls, and being keyed securely onto the outside of the walls without damaging the synthetic liner.

60) In order to achieve a continuous impervious layer, there must be no penetrations through the walls and synthetic liner of the AWSS (e.g., no fluid receipt or transfer lines through the walls and synthetic liners).

61) The duty holder must use a prefabricated synthetic liner as opposed to a field-installed one if the AWSS will be in use for less than two years (see section 4.1.2).

62) Prior to placement of an AWSS, the duty holder must prepare and document the designed base (e.g., prepared subgrade or engineered foundation) taking into account duration of use to distribute the weight; to minimize or eliminate the potential for differential settlement, subgrade movement (e.g., sinking, low spots, slumping, sloughing), slope instabilities, and freeze-thaw action; and to protect the synthetic liner from punctures (e.g., rock-free, sand layer or geotextile cushion).

63) A qualified person must certify that the prepared subgrade or engineered foundation is acceptable before the wall system and synthetic liner can be installed. A qualified person in this circumstance would either be an individual certified by the AWSS provider in the case of a prepared subgrade or a professional engineer in the case of an engineered foundation.

64) After the AWSS is dismantled, the duty holder must either recycle or dispose of the synthetic liners as per section 5.6.1, and the duty holder may redeploy the wall structure as per section 5.6.1. Any associated fluids associated with the synthetic liners (e.g., wash waters, residuals) must be managed as oilfield waste as per *Directive 058*.

65) Duty holders must prevent surface water from collecting around an AWSS (e.g., contouring, dikes, placement).

66) Duty holders must locate AWSSs on an **active AER-licensed well or facility** or AER-approved oilfield waste management facility.

The AER expects AWSSs used for less than three months to be placed on the well site being fractured.

3.7.1 Duration of Use

There are additional requirements based on the actual duration of an AWSS's use at an individual site, calculated from the time installation is complete to the time it is dismantled. See section 2.1 for notification and approval requirements based on duration of use.

67) When using an AWSS for three months or longer, the duty holder must document the design of the AWSS, including supporting diagrams and a statement from a qualified person that the AWSS design is appropriate for its duration of use and for the fluids being stored. The qualified person in this case is a professional engineer.

3.7.1.1 Less Than Three Months

68) The duty holder must use at a minimum a single synthetic liner with a minimum thickness of 30 mil.

Neither secondary containment nor leak detection are required unless warranted by site conditions.

3.7.1.2 Three Months to Less Than Two Years

69) The duty holder must use two synthetic liners: a primary synthetic liner with a minimum thickness of 30 mil and a redundant synthetic liner with a minimum thickness of 30 mil beneath and in direct contact with the primary synthetic liner for the entire duration.

70) Duty holders must implement secondary containment consisting of either a dike wall as per section 4.2 or, if site configuration does not enable the use of a dike, a 1 m high impervious perimeter berm around the entire site.

71) For AWSSs deployed for one year or longer, a professional engineer or geologist must conduct a site-specific geotechnical investigation confirming that the subgrade conditions are conducive to preventing migration of a release vertically, especially directly below the footprint of the AWSS (e.g., the hydraulic head from stored fluids is a significant driving force).

72) If the subgrade is *not* conducive, the secondary containment must, in addition to the dike, also include an impervious liner and leak detection as per sections 4.2 and 4.3.

3.7.1.3 Two Years or Longer

73) The duty holder must site, design, and operate the storage facility such that the likelihood of a release occurring and the consequences of a release are minimized.

74) The AWSS must consist of the following:

   a) two synthetic liners: a primary synthetic liner with a minimum thickness of 40 mil and a redundant synthetic liner with a minimum thickness of 30 mil liner beneath and in direct contact with the primary synthetic liner for the entire duration

   b) leak detection beneath the primary containment device as per section 4.3.3

   c) secondary containment as per section 4.2 consisting of dike system and synthetic liner with leak detection as per section 4.3.3

d) an engineered foundation certified by a qualified person as per section 4.6. The qualified person in this case is a professional engineer.

75) Duty holders must be able to demonstrate the integrity of their AWSS system during operations and verify whether any fluid has leaked through the primary containment system. This means that a duty holder will be required to implement both a groundwater monitoring program and a soil monitoring program as outlined in directive 058.

76) The design must be completed and the construction overseen by qualified persons with expertise in applicable areas, including tank farms and use of geosynthetics for containment applications as they relate to storage of fluids that will cause an adverse effect if released. The qualified persons in this case are professional engineers, either geotechnical or civil, or certified technologists who report to the engineer on record.

77) Before putting an AWSS into service, the duty holder must record the elevation of the top of the AWSS's walls in at least two locations sufficiently spaced to establish a baseline for determining differential settlement.

3.7.2 Site Assessment

This section only applies to AWSSs used for three months or longer.

78) The duty holder must undertake a site assessment to determine the design parameters of the overall AWSS system

79) The scope and level of detail for the assessment must take into consideration the duration of use. The duty holder must confirm the suitability of the site for the duration of the activity in the site assessment results. If the site assessment deems the site is not suitable then the duty holder must select an alternative site. For AWSSs for use less than one year, duty holders may use standard operating procedures to address site-specific assessment criteria. The standard operating procedures must be developed and implemented by a qualified person. Qualified person means a professional engineer and the field staff that report to them

80) There must be no receptors or potential contaminant migration pathways within the immediate vicinity of the storage area, including surface water bodies and shallow domestic water wells.

81) The results of site-specific assessment (e.g., geological, hydrological, and hydrogeological conditions) must be documented.

82) The assessment must be planned, conducted, and certified by qualified persons. The qualified persons in this case include professional engineers, geologists, hydrogeologists, biologist and hydrologists and their field staff that report to them.

Duty holders should select the site based on avoiding receptors and eliminating pathways (transport mechanisms) as opposed to mitigating through controls.

83) For a duration of use two years or longer, the duty holder must also identify as part of the site selection, the geological, hydrological, hydrogeological, and geotechnical characteristics of the site (both regional and local), including potential contaminant flow paths into receiving environment, potential impacts on groundwater and surface water regimes, and groundwater and surface water regimes associated with the proposed site.

84) If the subgrade is used instead of an engineered foundation, the assessment must determine suitability of subgrade in order to prevent differential settlement and freeze-thaw displacement and determine the bearing capacity of soils over the expected duration of AWSSs usage.

85) For duration of use two years or longer, the hydrogeological investigation undertaken by the duty holder must confirm the storage activity will not cause any adverse effects on the quality, quantity, or natural timing of flow in any underlying aquifer.

3.7.3 Storage Capacity

The majority of AWSSs are used for large-volume storage; however, small AWSSs are a practical storage option for cement returns from drilling and completion operations when the intent is to dispose of the cement after it has hardened. Refer to *Directive 050* for requirements relating to AWSSs storing cement returns, including a reduced maximum capacity.

86) The maximum capacity of any single AWSS must not exceed 6600 m^3.

87) The collective usable capacity of AWSSs on a site must not exceed 30 000 m^3.

88) Duty holders must always maintain a minimum freeboard of one metre within the AWSS.

Duty holders should monitor freeboard levels and have controls in place to ensure precipitation events do not reduce the freeboard below this minimum.

89) Duty holders may reduce the minimum freeboard to not less than 0.5 m provided the following requirements are met:

   a) The reduction must not interfere with operations (e.g., decrease effectiveness of bird deterrents).

   b) The reduction must not lead to an overflow due to precipitation.

   c) The duty holder must have a professional engineer complete a wave study for the specific geographic area of the site which considers weather patterns and precipitation events.

3.7.4 Integrity Testing Requirements

90) After installation, the duty holder must test the integrity of the AWSS before putting it into service and as per section 5.6 before putting it back into service after withdrawal from service.

91) Duty holders must maintain the structural and containment integrity during operations, including when the AWSS is empty or almost empty.

92) Duty holders must have a site-specific response plan that will ensure the protection of groundwater resources at the site in the event of a failure of the primary containment system.

3.8 Engineered Containment Ponds

ECPs are in-ground storage systems engineered to securely contain fluids. ECPs are a different type of storage system than LEEs and should not be referred to as LEEs or pits.

93) ECPs must only be used to store large volumes of alternative waters (e.g., produced water and water-based flowback) for reuse in hydraulic fracturing unless otherwise authorized by the AER (see section 2.1.4).

The requirements for ECPs are based on the anticipated risk profile of fluids including produced water and water-based flowback, being stored.

94) A professional toxicologist or other chemical professional must characterize the fluid being stored in the ECP by identifying its chemistry and toxicology in order to identify any contaminants of concern. This must happen at a frequency that ensures the characterization is current.

95) Duty holders must keep a detailed record of all chemical constituents potentially being stored within the ECP.

96) The duty holder must conduct a site assessment and reflect the site-specific conditions in the design, operation, and closure plans of the ECP. The site assessment must include both a regional assessment and a site-specific investigation that includes

   a) descriptions of both local and regional topography, surface drainage patterns, geology, hydrogeology, geotechnical characteristics;

   b) existing and surrounding land use within a sufficient radius to adequately characterize potential receptors and pathways outside the ECP site boundary;

   c) identification of potential contaminant flow paths into receiving environment; and

   d) identification of potential impacts on groundwater and surface water regimes.

97) The duty holder must document the site assessment, including the determination that the site is suitable for the activity.

98) Siting, design, and construction must be overseen by qualified persons with expertise in applicable areas including containment ponds, impoundments, and geotechnical slope stability as they relate to storage of fluids that will cause an adverse effect if released. The qualified persons in this case include professional engineers, geologists, hydrogeologists, biologist and hydrologists and their field staff that report to them.

99) An ECP must consist of the following components:

a) both a primary and a secondary containment system

b) a primary synthetic liner as per section 4.1 with a minimum thickness of 60 mil

c) A secondary composite liner as per section 4.1

d) a leakage collection and removal system as per section 4.5 beneath the primary liner and above the secondary liner

e) leak detection as per section 4.3.6

f) groundwater monitoring as per *Directive 058*

g) soil monitoring as per *Directive 058*

100) The ECP must not have any punctures through the primary and secondary containment systems.

101) Duty holders must prevent damage to the primary containment during equipment placement and maintenance activities.

It is of utmost importance that the duty holder implements rigorous third-party QA/QC during the installation of the primary and secondary containment design components of the ECP, which will significantly decrease holes, defects, and failures. Conducting post-installation QA/QC may also be beneficial and serve as additional risk mitigation as they can be conducted at any point in the life cycle of the ECP.

102) Duty holders must demonstrate site suitability by adequately characterizing potential receptors and pathways within and outside the proposed ECP site boundary through a site-specific investigation as described in the following requirement. These assessments must be conducted by qualified person and documented. The qualified persons in this case are professional engineers, hydrologists, hydrogeologists, geologists, and soil scientists.

Duty holders should select the site based on avoiding receptors and eliminating pathways (transport mechanisms) as opposed to mitigating through controls.

103) The site investigation must consist of at least the following information:

a) Geology and hydrogeology

i) Detailed borehole records showing geological and hydrogeological conditions as well as construction and completion details of groundwater **monitoring wells**

ii) Drawings showing borehole and groundwater monitoring well locations

iii) Site-specific cross-sections interpreting the geological and hydrogeological conditions

iv) Identification of any known buried channels within at least five kilometres of the site

v) At least two test holes completed to the depth of 15 metres below the base of the ECP or 5 metres into the bedrock, whichever is shallowest

vi) Thicknesses of any natural confining geological unit

vii) A description of the bedrock geology including data to confirm the base of the ECP is not within 10 m of fractured nonporous bedrock or karst features

viii) Data to confirm the site has a vertical separation greater than 15 m above a domestic use aquifer with connectivity from the shallow confining layer

ix) Groundwater data including depth to water table (seasonal variation), flow direction (horizontal and vertical), and velocity (horizontal and vertical gradients)

x) Background chemistry of any shallow groundwater

xi) Identification of all groundwater users within a 5 km radius including proximity to site and completion details of the wells

b) Terrain and topography

i) A description of the drainage, terrain and topography, and water bodies (natural and constructed) within a 5 km radius of the storage facility

c) Geotechnical

i) The geotechnical parameters for the local and global slope stability of the ECP throughout its lifespan, as well as the geotechnical parameters for any earthwork construction, including bearing capacity and subgrade preparation

d) Surficial geology

i) A soil survey to determine the pre-development soil availability and depth and volume of topsoil and upper subsoil available at the site for future reclamation

104) The duty holder must maintain a minimum freeboard of 1.0 m in the ECP even during storm events.

105) The duty holder must prevent the hydrostatic uplift of components such as synthetic liners, including, if necessary, by controlling groundwater levels below the ECP.

4 Requirements for Components of Storage Systems

4.1 Liners

Natural, compacted clay, synthetic and composite liners are used in both primary and secondary containment applications and in storage and treatment areas to impede the movement of materials that could adversely affect soil, surface waters, or groundwater.

106) The duty holder must select the liner based on the specific needs of the intended use and storage device (e.g., storage duration, environmental conditions, chemical compatibility to materials stored, operational conditions). The purpose of a liner in a secondary containment application is not to function as a tank or as the primary containment.

Although no liner material is completely impervious or impermeable, the selection, type, design, and installation of a liner is extremely important in achieving the desired level of impermeability.

107) Unless otherwise noted, for primary containment applications, duty holders must use a synthetic liner with a hydraulic conductivity of 10^{-7} cm/sec or less and a minimum thickness of 30 mil or a compacted clay or natural liner with a determined in situ hydraulic conductivity of 10^{-7} cm/sec or less or a laboratory determined hydraulic conductivity of 10^{-8} cm/sec or less and a minimum thickness of 0.6 m and 0.9 m respectively.

108) Unless otherwise noted, for secondary containment applications, duty holders must use a synthetic liner with a hydraulic conductivity of 10^{-6} cm/sec or less and a minimum thickness of 30 mil or a compacted clay or natural liner with an in situ hydraulic conductivity of 10^{-6} cm/sec or less or a laboratory hydraulic conductivity of 10^{-7} cm/sec or less and a minimum thickness of 0.6 m.

109) Duty holders must protect above and below the liner from damage, including the use of a cushion or protective layer on the subgrade.

110) The duty holder must implement and document a quality assurance and quality control program to ensure that the installation of the primary containment, including when a foundation is required, does not negatively affect the integrity of the secondary containment system.

4.1.1 Natural and Compacted Clay

111) A professional engineer, including civil and geotechnical disciplines, must oversee and document natural liner construction and compacted clay liner installation.

112) Duty holders must retain the quality assurance and quality control program documentation for the compacted clay installation (e.g., clayey material used for the liner, details of the construction) and for the natural liner construction (e.g., site delineation information).

113) Duty holder must implement measures to protect the natural liner and the completed compacted clay liner from degradation (e.g., mechanical damage and weathering) and operational damage (e.g., equipment, wildlife).

4.1.1.1 Compacted Clay

114) Compacted clay liners must be constructed with suitable clayey soils. Best practices for compacted clay liner construction should be followed.

115) Duty holders must select materials and employ construction methods to prevent desiccation cracking from occurring.

4.1.1.2 Natural

Construction of a natural liner differs from a compacted clay liner; natural liners involve the scarification and recompaction of in situ clay, while compacted clay liners involve excavation of the underlying clay and placing it in lifts to obtain the desired thickness. Duty holders should only consider natural liners when the site is on relatively low-permeability clay or till.

116) Duty holders must confirm that the site has suitable in situ clayey soils with a minimum thickness of 0.9 m and that the seasonal high-groundwater table is greater than 1 m below the expected bottom of the liner.

117) A qualified person must conduct a site investigation to delineate the in situ clayey deposit, with focus on hydraulic defects (e.g., sand seams, cracks, and fissures). The qualified person in this case is either a professional engineer or geologist.

118) The duty holder must determine the orientation of any significant geological planes with a minimum of three boreholes, arranged in an approximate equilateral triangle. The duty holder must sample at least 3 m below surface to characterize the underlying soil material, with one sample deeper to determine depth to groundwater.

119) The duty holder must have the clayey soil analyzed in a lab to determine the overall suitability of the in situ clayey deposit (e.g., liquid limit, plasticity index, clay content, fines content) to achieve the desired hydraulic conductivity of the application. A qualified person must certify the soils meet the specified requirements.

4.1.2 Synthetic

There are numerous types of synthetic liners, including geomembranes (e.g., coated fabrics or laminates, extruded film or sheet, spray-on coatings), and **geosynthetic clay liners** (GCLs), many of which were developed for waste containment applications. The long-term integrity of a synthetic liner is dependent on the physical strength of the liner, its resistance to effects of aging or environmental degradation, upkeep and maintenance of its protective cover, and its resistance to the substances contained in the storage system. Because secondary containment applications do not require long-term, continuous contact with the contained substances, the requirements for liner performance in secondary containment applications may be less rigorous than those for primary containment.

The most important physical and mechanical attributes used to determine the suitability of a synthetic liner for a given application are thickness, density, mass per unit area, tensile properties, tear resistance, hydrostatic resistance, and puncture resistance. Other key physical properties include linear expansion properties, cold temperature properties, resistance to ultraviolet light, resistance to soil burial, and dimensional stability.

120) The duty holder must document the liner material specifications and be able to demonstrate that it is suitable for its intended application.

121) Synthetic liners must be sourced from manufacturers that have documented quality assurance and quality control programs to ensure the consistency of these physical properties and mechanical attributes.

Some geomembranes can be prefabricated into large panels for deployment in the field reducing the risks associated with field seaming in detrimental weather (wet, cold, hot). Some geomembranes can be prefabricated into bladders for use in storage devices.

122) Prefabricated liners (e.g. panels and bladders) must be sourced from distributors and manufacturers with documented quality assurance and quality control programs for the prefabricated products (e.g., panels and bladders) including a documented quality assurance and quality control program for their field deployment.

Prefabricated panels, including those used in AWSSs, and temporary spill material containment cannot be reused after their original use due to the high likelihood of damage occurring during its removal, with the following exception.

123) Bladders may be reused if the following requirements are met:

   a) The bladder is designed and fabricated to be re-deployed.

   b) The bladder has documented inspection protocols undertaken to confirm the integrity of the bladder before its next installation.

124) Duty holders must install synthetic liners in accordance with manufacturer's specifications.

125) Synthetic liners must be installed by persons certified to install the material with third-party quality control and quality assurance programs.

126) Duty holder must properly assess and prepare the subgrade before installing the synthetic liner.

127) The duty holder must have the synthetic liner installation contractor certify that the subgrade is acceptable before the synthetic liner is installed.

128) Duty holders must protect synthetic liners from mechanical, environmental, and chemical damage, including damage from operations (e.g., lines and hoses within the AWSS, sludge cleanout), and unauthorized access (e.g., wildlife).

129) The duty holder must maintain documentation from construction and installation quality assurance and quality control programs and be able to obtain documentation from the manufacturer and fabricator quality assurance and quality control programs to demonstrate compliance.

4.1.3 Composite

A composite liner consists of a synthetic liner and either a compacted clay liner (CCL) or a GCL, that is in direct contact with the synthetic liner.

Composite liners present significant benefits to a singular liner and are the preferred secondary containment liner for ECPs. There is significant reduction of leakage with a composite liner compared to a singular liner. Proper operation of the leakage collection and removal system will minimize the hydraulic head above the secondary containment system, thus further reducing the likelihood of a release into the environment to occur

4.2 Secondary Containment

130) Duty holders must contour the site to prevent the collection of surface water on the ground immediately surrounding the secondary containment system.

131) A secondary containment system must consist of a dike wall and an impervious liner. Alternatively, a concrete or steel containment structure that creates a walled impervious barrier, including bins for small tanks, may be used as an integrated dike wall and liner. The following requirements apply to both configurations.

Dike walls may be constructed of soil, steel, concrete, solid masonry, or synthetic material.

132) The dike walls must be designed

   a) with no openings,

b) to contain fluids within the diked area, and

c) to withstand the fluid’s hydrostatic pressure at full capacity.

133) Additionally, dikes surrounding an AWSS must also be designed to withstand any wave impact should the AWSS fail.

Openings in dike walls are permitted if the penetration structure is directly connected to a storage device or is a maintenance access door and the opening is hydraulically sealed and designed to prevent excessive stresses from settlement and fire exposure.

134) When the diked area contains only one storage device, it must have a volumetric capacity of not less than 110 per cent of the capacity of the storage device plus the displacement volume from any structures, including piping and granular layers below the height of the dike.

135) When the diked area contains more than one storage device, it must have a volumetric capacity of not less than the sum of the capacity of the largest storage device and either 10 per cent of the capacity of largest storage device or 10 per cent of the aggregate capacity of all other storage devices in the diked area, whichever is larger. Additionally, the volumetric capacity must include the displacement volume from any other storage devices and any associated structures, including piping and granular layers, below the height of the dike.

136) For diked areas constructed before the effective date of this directive, and that did not include the displacement volume, if at any point it will be reconstructed (e.g., expand the site to include more tanks, repair or improve the dike), then the duty holder must meet the above requirements.

137) The secondary containment area, including the dike, must be maintained in good condition and kept free from weeds, debris, and extraneous combustible material.

138) Duty holders must not use a lease berm on an upstream petroleum site in place of a dike wall unless previously authorized by the AER.

139) The impervious liner must be either a compacted clay liner, a natural clay liner, or a synthetic liner as per section 4.1.

140) The impervious liner must create a continuous barrier by covering the area within the dike, including the area beneath the storage devices, and be keyed into the dike walls.

141) The duty holder must have the area within the secondary containment graded to a sump or low-lying area (within the diked area) to allow for the collection of rainwater, snow-melt water, and any possible leakage from the storage device.

142) No uncontrolled discharge of collected fluids or discharge of untested fluids is permitted.

The duty holder must meet surface discharge requirements as per section 5.3 before discharging any of the collected fluids.

4.2.1 Permanent Storage Devices Not Requiring Secondary Containment

In the following circumstances, secondary containment is not required:

- Small tanks with a total combined volume not exceeding 5 m^3 on a site (see section 3.2)
- Containers with a total combined volume not exceeding 1 m^3 on a site
- Open-topped, nonmetallic tanks with an internal volume less than 30 m^3 used to store produced water from *only* the Milk River, Medicine Hat, or Second White Specks pools (see Section 3.2)
- During emergency situations or maintenance activities when the storage device (aboveground or underground) is part of the permanent site infrastructure and is used infrequently, provided they are emptied immediately after use and are regularly inspected to verify their integrity (e.g., pop tanks and other emergency containment tanks, compressor oil drain tanks, floor drains, trenches and sumps, and pigging fluid catchment devices)

143) As part of the monthly inspections required in section 5.7, duty holders must record any spill, leak, or discharge from storage devices used infrequently, including any corrective action undertaken.

When opting to not dike a storage device in a permanent or temporary situation, duty holders are expected to use reasonable judgement to ensure that environmentally sensitive areas are protected.

144) Storage devices closer than 100 m to a body of water, a permanent stream or in a location where, in the opinion of the AER, a spill or leak may reach the water, the duty holder must construct a barrier or submit a plan to the AER to contain any spill material.

4.2.2 Temporary Storage Operations

Temporary storage refers to the intermittent or unexpected storage of materials that should typically not exceed three months (from time of storage device setup to time of dismantling), and the AER expects temporary storage will not exceed one year. Examples of temporary storage include the following:

- plant turnarounds
- construction operations
- remediation and spill cleanup
- emergency conditions

- well drilling, completions, testing, and servicing operations (e.g., portable test tanks)
- fracturing well operations (e.g., AWSSs and bladders with structural frame).

Single-walled aboveground tanks, AWSSs, and bladders with structural frame used to store fluids in the above-cited operations do not require the impervious liner component of secondary containment, and the diking component is optional if

- the site is manned for the duration that fluids are being produced into the storage device (e.g., during loading and unloading of fluids),
- the storage device is fitted with a high-level shutdown device to prevent fluids from overflowing, or
- the fluids are not being produced to the storage device but are simply being stored.

145) If using single-walled aboveground tanks or bladders with structural frame to store fluids in the above-cited operations for more than three months, or if total combined storage capacity exceeds 3000 m^3, diking is required. Alternatively, the duty holder may surround the site with a one-metre high impervious berm. The total storage duration must not exceed one year.

Duty holders using steel-fabricated, solids-storage bins (e.g., lugger bins, drilling rig tanks) to temporary store sludges or solids (e.g., contaminated soil, spill debris, oily waste, drilling waste) in the above-cited operations do not require secondary containment (neither an impervious liner nor diking).

146) Even in temporary storage operations, the duty holder must not store directly on the ground contaminated materials or materials possessing the potential to leach.

147) "Temporary facilities" as defined in *Directive 056* (facilities for use twelve months or less) do not require impervious liners, but they must still meet the diking requirements as per section 4.2.

148) Temporary storage areas for contaminated soil excavated during spill cleanup or remediation activities must be diked and synthetically lined.

a) The synthetic liner must be a minimum of 15 mil, meet synthetic liner requirements in section 4.1, extend over the dike, and be keyed into the outside of the dike.

b) Any leachate, including any precipitation that may come in contact with the contaminated soil, must not overflow the diked area.

c) If the temporary storage area is used for more than three months, upon removal of diking and synthetic liner, the underlying soil must be assessed for contamination as per section 5.6.2.

149) At the end of the temporary storage operations, the duty holder must transfer the stored material to a permanent storage facility or area to be appropriately managed (e.g., treated or disposed of).

4.3 Leak Detection System

150) Duty holders must document the ongoing integrity of their storage systems and verify whether any material has escaped by monitoring for leaks with leak detection systems. Leak detection systems can be beneath the primary containment, between the secondary and primary containment, and below the secondary containment system.

4.3.1 Frequency and Testing Parameters

151) Unless otherwise noted, duty holders must monitor leak detection systems at least monthly. The duty holder must field test the collected liquids for pH (e.g., using test strips or meter, or onsite laboratory), chlorides (e.g., using test strips), and a visible oil sheen.

152) The duty holder must record the results from the field tests, and if there is indication of a problem (e.g., change in parameters from previous results indicating there may be a leak), laboratory analyses must be performed for verification.

153) If a problem is verified, corrective actions must be undertaken, and the duty holder must document the parameters that changed, the investigative work conducted, and any remedial or corrective work that has occurred.

4.3.2 For Storage Devices Within a Diked Area

154) Leak detection provision for storage devices within a diked area must incorporate a layer to allow leakage to move preferentially through the layer to a collection area within the dike's area.

This leak detection layer may consist of porous material (such as sand) over the secondary containment impervious liner and underneath the storage device, the incorporation of subliner leakage detection devices (e.g., weeping tile system and geosynthetics such as geonets and geocomposites), or a physical gap between the base of the storage device and the impervious liner.

4.3.3 AWSS – Two Years or Longer

155) AWSSs for use for two years or longer must have a leak detection system directly beneath the primary containment and above the secondary containment taking the engineered foundation into consideration in order to provide early warning of a potential problem.

Leak detection methods may include the incorporation of a layer of porous material and sub-liner leakage detection devices (e.g., piping, monitoring portals, weeping tile system and geosynthetics such as geonets and geocomposites).

156) Despite requirement 151, the duty holder must monitor these leak detection systems at minimum quarterly and more frequently if fluid is present. The duty holder must still field test the collected liquids for the same parameters.

4.3.4 Interstitial-Space Monitoring

157) For storage devices with interstitial-space leak detection (e.g., double-walled ASTs, USTs and some LEEs), duty holders must inspect the interstitial-space monitoring system at least monthly to confirm the integrity of the device. The duty holder must record the results. Monthly monitoring may not be required if the interstitial space is equipped with a continuous monitoring system that will indicate when the primary or secondary containment system is leaking.

158) Duty holders must check and record automatic shutdown systems at least monthly and maintain them to ensure continuous functionality.

Examples of interstitial-space monitoring systems for leak detection include pressure monitoring, vacuum monitoring, electronic monitoring, vapour detection, manual sampling, or an equivalent method.

4.3.5 Leak Detection Between Primary Containment and Secondary Containment (Subgrade)

159) For storage systems with the leak detection system between the secondary containment liner and the primary containment device (e.g., LEE below or partially below grade, bulk pads), duty holders must have an engineered seepage pathway (e.g., weeping tile) leading to at least one monitoring point (e.g., sump, well, portal), with the monitoring points completed at the lowest point, positioned between the secondary containment liner and the primary containment device.

160) The duty holder must annually have the collected liquids analyzed by a laboratory for pH, electrical conductivity, major ions (e.g., Ca, Mg, Na, K, NO3, SO4, Cl, PO4), BTEX and petroleum hydrocarbons F1 to F4, and any other parameter deemed necessary by the AER.

Although an ECP also requires an engineered pathway between the primary and secondary containment systems, it is referred to as a leakage collection and removal system. The leakage collection and removal system is covered in section 4.5

4.3.6 Leak Detection Beneath Secondary Containment

The purpose of a leak detection system beneath the secondary containment system of an ECP is to detect and quantify a potential release to the environment. The leak detection system may be a leak detection layer as described in requirement 150, a subdrain, or a groundwater control system. The subdrain or groundwater control system may be used both for leak detection as well as to prevent hydrostatic uplift of the synthetic liners.

161) The duty holder must position the leak detection system below the secondary containment and design it to pump fluid out from the lowest point in the ECP.

162) Despite requirement 151, the duty holder must monitor the leak detection system at minimum quarterly and more frequently if its associated action leakage rate as per section 4.5 has been exceeded.

Provided the collected fluid meets the surface discharge criteria in section 5.3, the duty holder may direct the accumulated fluids within the leak detection system to the surface water run-on/run off system. Alternatively, any accumulated fluid may be directed back into the ECP provided the proper authorizations, as required have been obtained from the AER.

4.3.7 Visual Leak Detection

163) For containers, provided the duty holder can demonstrate that the storage area is protected from the elements or has an appropriate secondary containment system, only visual leak detection is required.

4.4 Leachate Collection System

164) If leachate may be generated during bulk pad operations, the duty holder must incorporate a leachate collection system to direct (e.g., gravity flow) the leachate to a collection sump for removal (e.g., pump) and proper management.

4.5 Leakage Collection and Removal System

Part of an ECP design is the incorporation of a leakage collection and removal system.

165) Duty holders must locate the leakage collection and removal system between the primary and secondary containment to provide early detection of leakage through the primary barrier.

166) The duty holder must accurately measure the leakage at a minimum weekly to determine the actual monthly leakage rate for comparison to the allowable action leakage rate.

The duty holder should analyze the collected leakage regularly for parameters representative of fluid being stored (requirement 94); chemistry will be important to determine the appropriate response when exceedances to the allowable action leakage rates occur or a release occurs.

167) The duty holder must either direct the collected leakage back into the ECP provided there is enough capacity; manage the collected leakage as a waste; or manage the collected leakage by an alternative method approved by the AER.

The leakage collection and removal system may comprise either geonets or granular drainage materials or a combination of both, leading to a removal port (e.g., sump, riser pipe).

168) The duty holder must position the removal port at the lowest point of the ECP, between the primary and secondary containment.

169) Over the lifespan of the ECP, the leakage collection and removal system capacity must be large enough to contain twice the maximum allowable action leakage rate.

170) Duty holders must calculate the allowable action leakage rate for the various depths of the pond, including at maximum depth, according to the liner performance method as described in the Government of Alberta's *Action Leakage Rate Guideline*. The action leakage rate is used to monitor the performance of the primary containment.

171) If the allowable action leakage rate is exceeded, duty holders must

   a) ascertain without delay if a release has also occurred,

   b) immediately implement a response action plan to reduce the leakage rate to the maximum allowable,

   c) notify the AER within seven days, and

   d) document the source, location, size, and cause of leakage as well as the remedial actions taken to restore the ECP to the allowable action leakage rate.

172) The duty holder must submit monthly progress reports to the AER until the allowable action leakage rate has been re-established.

4.6 Civil Works (Subgrade Preparation, Engineered Foundation, Embankments)

Several storage systems require additional civil works as part of the functional design to ensure their structural integrity: bladders with structural frame and some AWSSs require properly prepared subgrades, other AWSSs require an engineered foundation, and ECPs require earthworks and often embankments.

173) The duty holder must design and maintain the civil works to minimize or eliminate the risk of differential settlement, freeze-thaw cycles, subgrade movement (including sinking, low spots, slumping, sloughing), and slope instability, for the duration of the intended use.

174) Relevant geotechnical investigations, earthworks and foundation design, and installation and verification for the specific storage system needs must be performed by a professional engineer, geologist, or field staff under their supervision.

5 General Operational Requirements for Storage Devices

5.1 Spill Control

175) Duty holders must design the loading and unloading areas to contain any spills or leaks.

176) Duty holders must prevent stored materials from leaking or spilling into the environment at fluid transfer points on storage systems (e.g., hoses, transfer lines, piping, flanges, valves), including through the use of **spill control devices**.

177) Duty holders must design the underground storage tank breathing vents to prevent the overflowing of fluids onto the ground.

178) Duty holders must incorporate measures to prevent the overfilling of storage systems. Measures may include automatic sensing devices for interconnection with shutoff equipment at the supply point, automatic overfill shutoff devices of a float valve or other mechanical type, vent restriction devices, high-level alarms and overfill alarm devices of the audible or visual indicator type (single-stage or two-stage activation), inventory control, and any other appropriate measure that will prevent overfilling. USTs and double-walled ASTs must *not* use inventory control alone.

179) Duty holders must equip double-walled ASTs with a valve as close as practical to the tank to prevent draining of the tank should a leak or break occur in the piping.

180) Systems designed with delivery connections at grade level (bottom load) must be equipped with provisions to allow the delivery hose to be safely emptied, including through the use of spill control devices.

181) Duty holders must size the spill control devices for the application.

The duty holder should include methods to

- keep precipitation and other materials out of the spill control devices,
- prevent rusting and allow for easy inspection to verify their integrity (e.g., elevation aboveground level), and
- recover any spilled or leaked materials from the spill control device.

Section 8.060(c) of the *OGCR* requires that if the storage area is within 100 m of the normal high-water mark of a body of water or permanent stream, spill control methods, such as constructed pits, dikes, trenches, or other structures to contain effluent or spill materials, must be present.

5.2 Wildlife and Bird Controls

182) If the material in the storage system is open to the environment, duty holders must implement terrestrial control measures (e.g., deer fencing, amphibian fencing) and bird control measures to prevent wildlife (which includes birds) from coming in contact with the stored material and from damaging the primary containment (e.g., deer hooves puncturing an impervious liner).

a) For storage of fluids, bird decoys are not enough by themselves; duty holders must also implement bird netting or a bird-wire system.

b) Duty holders must consider the habituation of birds to the storage systems when implementing bird deterrents, especially when the area was used for fresh water initially or during its life span.

c) Duty holders must report any wildlife fatalities to the Energy and Environmental Emergency 24-Hour Response Line and report any wildlife coming into contact with the stored material to the local AER field centre.

183) Duty holders must monitor terrestrial and bird control measures for effectiveness. If the current controls in place become ineffective, the duty holder must implement other or additional measures.

184) Duty holders must adaptively manage both the terrestrial and bird control measures as changes to site conditions occur (e.g., large influx of waterfowl or amphibians during their migratory periods).

5.3 Noxious Substances

185) Duty holders must have operational controls in place to prevent unwanted microbial and biological growth that may cause **noxious substances** in storage systems.

5.4 Surface Discharge of Collected Surface Run-on/Runoff Waters

If the site has approval conditions relating to the discharge of collected surface water or operate under an *EPEA* code of practice and they conflict with the requirements in this section, the approval conditions govern.

Duty holders should release collected surface water back into the hydrological cycle whenever it is safe to do so, as described below.

186) Surface run-on/runoff waters collected on an upstream petroleum site (collected water; e.g., within a diked area of a tank farm, within the surface water collection system) must not be released back into the environment unless the following criteria are met:

a) chloride content no greater than 500 mg/L

b) pH between 6.0 to 9.0

c) no visible hydrocarbon sheen (roughly equates to less than 10 mg/L)

d) no contamination has occurred (e.g., clean operating conditions such that collected waters are not impacted by spills or releases)

e) water will not flow directly, including via ditches, into any **watercourse**

f) release is controlled

g) each release is recorded, including the pre-release test data and the estimated volume of collected water released

h) landowner or occupant on occupied public land (e.g., grazing lease holder) consents when releasing collected waters off the licensed or approved site

187) The parameters listed above are intended as screening criteria for sites exhibiting good housekeeping practices. On sites where spills or releases have occurred or may have occurred, the duty holder must test the collected water for material-specific parameters that would demonstrate that the collected water has not been affected.

188) Water that does not meet these criteria must be sent to an approved facility for treatment or disposal, be treated on site to meet discharge criteria prior to release, or used in other applications in accordance with any relevant requirements.

189) Duty holders must not discharge collected water into any watercourse unless otherwise specified in an *EPEA* approval.

5.5 Use of Storage Systems in Hydraulic Fracturing

190) Duty holders must not conduct waste processing within AWSSs, bladders with structural frame, or ECPs; treatment must occur prior to storage, including the removal of any gas and liquid hydrocarbons. These storage systems must not be used to store non-water-based fluids, fluids containing hydrocarbons or fluids containing H_2S.

Biocides and other fracture treatment proppants may be added to the fluids stored in the AWSS or bladder with structural frame at a well site, subject to relevant requirements, including *Directive 058*.

Storage devices such as AWSSs and bladders with structural frame are used both to receive the flowback and to store alternative waters for reuse for hydraulic fracturing.

191) At the well site, the duty holder must first direct fluids to a tank, series of tanks, or other separation equipment or technology to drop out solids, remove H_2S, separate out any hydrocarbons that may have infiltrated from the reservoir, and reduce fluid temperature prior

to receiving the flowback in the AWSS or bladder with structural frame. The same applies to fluids destined for a facility with an ECP.

5.6 Withdrawal of Storage Devices from Service

Reuse and redeployment of storage devices is permitted as constrained by the requirements in this section.

192) When a storage tank (e.g., AST and UST) is taken out of service the duty holder must isolate the tank (i.e., remove or block off all connected piping, to stop flow through the piping, and prevent fluids or gasses from entering the tank while it is out of service).

193) If present, the duty holder must maintain the impressed current cathodic corrosion protection system until the storage tank is permanently removed from site.

194) When a storage tank is taken out of service for a period not exceeding 180 days, the duty holder must either empty the tank or record the fluid level in the tank on a monthly basis and maintain monthly leak detection monitoring.

195) When a storage tank is taken out of service for a period exceeding 180 days, the duty holder must remove all fluids, solids, and gases from the storage tank and its connecting piping and clearly mark it empty and out of service.

196) If the tank has been out of service for longer than one year, the duty holder must verify the integrity of the storage tank prior to putting it back in service. Refer to appendix 2 for examples of integrity testing.

The AER expects duty holders to remove the storage device from the active part of the upstream petroleum or geothermal resource development site and either relocate it to an appropriate storage area on the site or send it for disposal. If the removal of a storage device compromises site operations, it can remain in place provided the duty holder has appropriately isolated the tank and removes it when the site is decommissioned.

197) Upon permanent removal of a storage system, the duty holder must assess the soil for contamination as per section 5.6.2.

5.6.1 Redeployment of Non-Permanent Storage Devices

Some storage devices, including bladders with structural frame and in some cases AWSSs, are not permanently used on a site. Duty holders may redeploy all or part of these storage devices at other active sites upon proper withdrawal from the active site.

When a non-permanent storage device is removed, the duty holders must remove all fluids and sludges from the storage device and connecting piping, verify the bladder integrity if applicable (e.g., bladder with structural frame), and verify the integrity of structural components (frame or wall whichever is applicable) before redeploying. Refer to section 3.4 and 3.7 for additional requirement relating to redeployment of bladders with structural frame and AWSSs (less than two years).

5.6.2 Contamination Assessment

198) The duty holder must conduct confirmatory soil sampling upon removal of a storage system (e.g., AST, UST, AWSS, bladder with structural frame) in the following scenarios:

   a) if the integrity of the storage device was compromised or was suspected of being compromised

   b) if the location of the storage device was other than the well site where hydraulic fracturing was occurring

   c) if the time between setup to dismantlement for redeployment of the storage system was greater than three months

   d) if it is being permanently removed from service

199) The duty holder must sample the soils beneath and around where the storage device was located.

200) The duty holder must assess the samples for contaminants related to the materials being stored.

201) The duty holder must analyze the samples for the following parameters and document the sample locations and depths:

   a) pH

   b) electrical conductivity (EC)

   c) sodium adsorption ratio (SAR)

   d) petroleum hydrocarbon fractions (F1 to F4)

   e) benzene, toluene, ethyl benzene, and xylene (BTEX)

   f) chlorides

   g) any other potential contaminants of concern that may be material-specific

202) If the results from sampling indicates contamination has occurred, the duty holder must follow AER release reporting requirements. Information on contamination management can be found on the "Contamination Management Tools and Resources" page on our website.

5.7 Monitoring and Inspections

Monitoring and inspections provide early indications that a storage device may be compromised or leaking.

203) Unless otherwise noted, the duty holder must conduct at least monthly site inspections of its storage system for evidence of problems, including those related to subsidence, differential settlement, freeze-thaw activity, irregularities, vandalism, erosion, wildlife and bird activity, damage, and leakage.

Duty holders should also inspect the storage devices and its associated systems after a period of significant weather events (e.g., a period of heavy precipitation, a substantial storm event, strong winds).

For example, inspection activities for an AWSS might include the following:

- Walking around the AWSSs to visually inspect the primary liners, wall structure, foundation integrity, and potential leaks through the AWSS system
- Walking around the secondary containment to visually inspect the dike walls and liner integrity, including its leak detection system
- Checking the AWSS overflow prevention devices
- Implementing the manufacturer's maintenance program

For an ECP, one might walk around it to visually inspect the primary containment for mechanical damage or access by wildlife, birds, or amphibians.

Duty holders should also be aware of and implement the inspection frequencies referenced in applicable API standards and manufacturer's maintenance recommendations specific to the storage device.

204) Duty holders must immediately correct any deficiencies (e.g., erosion, liner damage, differential settlement exceedance) identified during the inspections to prevent further damage.

205) For ECPs and AWSSs for use three months or longer, duty holders must do the following:

   a) Conduct weekly site inspections (e.g., visual) of the synthetic liners, wall system (AWSS only) and bird controls measures.

   b) Inspect associated facility infrastructure semi-annually and after a significant weather event. Inspections should include, as applicable, subsoil/topsoil piles, perimeter access roads, embankments, drainage swale, culverts, perimeter fencing, bird-wire system, anchor trenches, and all other facility components for signs of deterioration such as slope instability, damage of netting, siltation of drainage, and erosion of embankments and piles.

206) For AWSSs for use three months or longer, duty holders must do the following:

a) Have a qualified third-party vendor or vendor-certified in-house personnel complete a detailed structural inspection at least quarterly.

b) Immediately take out of service and repair or replace any component (e.g., synthetic liner, wall structure) that is suspected of being compromised or is showing signs of fatigue or structural weakness.

c) Have emergency contingency plans in place to manage the contents of a compromised AWSS to ensure timely transfer of fluids and to prevent an environmental release.

207) For AWSSs for use two years or longer, duty holders must do the following:

a) Evaluate each primary liner's integrity annually by testing sacrificial synthetic liner material within each AWSS that will have been in contact with the actual fluid stored and exact environmental conditions.

b) Determine the top elevation of the AWSSs walls at least semi-annually and compare to baseline measurement to ensure differential settlement does not exceed recommended manufacturer allowances.

c) Conduct a performance review of the AWSS at least once every five years. As part of the performance review, the duty holder must include an evaluation of the AWSS system (AWSS walls, liners and foundation), and a discussion on the remaining operational life of the AWSS system (e.g., synthetic liners and structural walls).

208) In the event that a storage device or system has overflowed, an upset is experienced, a routine inspection raises a potential concern, or its respective leak detection system indicates there is a potential release, the duty holder must do the following:

a) Immediately investigate the situation.

b) Verify the integrity of the containment system.

c) Report the release as required in section 8.050(2) of the *OGCR* and AER release reporting requirements.

d) Implement and document corrective actions, including actions taken to prevent it from reoccurring. The duty holder must also implement any necessary repairs or replacement of the storage device, operational changes, and remediation activities as quickly as practical, including assessing the soil and groundwater for contamination. As per section 8.050(1) of the *OGCR*, the duty holder must immediately clean up after the incident and not wait until decommissioning.

5.8 Documentation and Record-Keeping Requirements

It is the responsibility of the duty holder to maintain records in order to demonstrate ongoing compliance. Inventory records for production materials are typically handled using standard AER production reporting forms. Record retention and tracking requirements for oilfield waste are addressed in *Directive 058*. *Directive 058* also contains annual reporting requirements for some facilities that include AWSSs and ECPs.

209) Duty holders must maintain inventory records and retain those records (other than production reporting forms) on site or at the local field office for two years. Where applicable, this includes copies of dockets for material received and shipped.

210) Duty holders must document and retain the following for a minimum of five years, but preferably for the lifetime of the storage system or the lifetime of the upstream petroleum or geothermal resource development site:

a) information as per notification requirements

b) inspections (e.g., visual)

c) monitoring systems (e.g., automatic shutdown systems, corrosion, leak detection, interstitial space, leakage collection and removal, groundwater, soils, surface water release, effectiveness of wildlife controls) and resulting work (e.g., retrofitting, repairing, removal)

d) sampling results (e.g., from collected fluids)

e) integrity tests (e.g., structural wall, bladder, device, piping, systems, performance review)

f) any abnormal circumstances

g) spills and releases, including measures taken to prevent reoccurrence

h) corrective action undertaken or proposed (e.g., site investigation, decontamination work)

i) signoffs (e.g., subgrade suitability)

j) documentation from quality assurance and quality control programs (manufacturers, fabrication, installation, construction)

k) analysis (e.g., wave studies)

l) site selection assessment results (e.g., from standard operating procedures)

m) site investigation results (e.g., geological, hydrology)

n) names of responsible persons who conducted inspections and monitoring programs

o) circumstances that can affect the integrity of the storage system (e.g., excavations, nearby construction)

p) history of use (e.g., fluids stored and duration of each use; only applicable to bladders with structural frames) as per section 3.4

211) Duty holders must keep all required approvals, licences, and permits on site or at the field/plant offices.

Some storage systems currently do not have CSA, ASTM, API or similar types of standards for all of their various components; they are independently engineered.

212) For these systems, the duty holder must document the details of any foundation, structural wall, synthetic liner design, composite liner manufacturing, fabrication, and installation, including supporting engineering diagrams of the entire system, certified by a professional engineer and certified installation and fabrication personnel.

213) The installation signoff document must clearly demonstrate that the site is suitable for the duration of use (e.g., the adequacy of surface conditions, the need for an intervening geotextile cushion, substrate stability and bearing capacity, and slope and grade).

Appendix 1 Glossary

active AER-licensed site An AER-licensed well or facility that has *not* been designated one of the following: RecExempt, Cancelled, Abandoned, or RecCertified.

adverse effect An impairment of or damage to the environment, human health or safety, or property (*EPEA*, section 1(b))

alternative water Water that is designated for reuse in hydraulic fracturing, including produced water, water-based hydraulic fracturing flowback, waste, and some recycled waters.

bitumen, crude bitumen As per *Directive 056*.

cathodic protection A method for preventing corrosion on metallic structures.

condensate As per the *OGCA*.

crude oil As per the *OGCA*.

freeboard The vertical distance between the top of the primary containment device and the maximum operating fluid surface. Freeboard prevents overtopping of fluid from the storage system.

freshwater For the purpose of this directive, freshwater is defined as waters including collected surface run-on/runoff waters and nonsaline surface source waters that, if released to the environment, will not cause an adverse effect, including any exceedance for soils as set out in the Alberta Tier 1 Soil and Groundwater Remediation Guidelines for the applicable land-use category.

geomembrane Synthetic membrane liners or barriers used to control fluid migration in a manmade project, structure, or system.

geosynthetic clay liner Geosynthetic Institute defines a GCLs as a "factory manufactured Geosynthetic hydraulic barrier consisting of clay supported by geotextiles or geomembranes, or both, that are held together by needling, stitching, or chemical adhesives." See the institute's *GCL 5: Design Considerations for Geosynthetic Clay Liners (GCLs) in Various Applications* for standards.

leachate A liquid that has been in contact with waste.

leachate collection system	A seepage pathway and collection system constructed on the surface of the primary containment device to allow for the drainage, collection, and removal of any generated leachate.
leak detection system	A system designed for the early detection of any leakage from a primary containment device or secondary containment; may include visual, electronic, or statistical inventory methodologies.
leakage collection and removal system	A system designed to verify the primary containment synthetic liner's performance by measuring the actual action leakage rate and comparing it to the maximum allowable leakage rate.
monitoring well	A well used to detect liquid or vapour leakage from a primary or secondary containment device or to sample a groundwater aquifer or unsaturated zone to detect the presence of any contaminants.
noxious substance	One that is harmful or damaging to living things, including H_2S.
oilfield waste	As defined in the *OGCR* under section 1.020(12.1) and in the *Geothermal Resource Development Rules* under section 1(1).
primary containment device	A device used to physically contain materials produced, generated, or used in processes regulated by this directive. Primary containment devices include single-walled tanks, the internal wall of double-walled tanks, containers, liner and wall structure of AWSSs, primary liner of ECPs and the liners of LEEs and bulk pads.
qualified person or personnel	A licensee-appointed technical person who has the necessary training, expertise, and technical knowledge of subject matter to ensure licensee adherence to the requirements of this directive. The person is expected to be a member in good standing of an association regulated by a professions or societies act of Alberta or be certified in Canada, including trained and experienced members of the Alberta Institute of Agrologists; Association of Science & Engineering Technology Professionals of Alberta; Alberta Society of Professional Biologists; Association of the Chemical Profession of Alberta; Association of Professional Engineers and Geoscientists of Alberta; and College of Alberta Professional Foresters.
secondary containment system	An impervious barrier or liner and diking system used for the purpose of containing and preventing any leakage from the primary containment device from impacting the environment.
solid	A substance that does not contain free liquids as determined by the United States Environmental Protection Agency Method 9095 Paint Filter Liquids Test and is not gaseous at standard conditions.

spill control device	A device (e.g., load box) used to physically collect and recover spills and leaks of materials from process equipment, piping valves, flanges, and other equipment, especially at material transfer points.
tank	A device designed to contain liquid materials that has an internal capacity of more than 1 m^3 and is constructed of impervious materials that provide structural support and may include such materials as plastic, fibreglass-reinforced plastic, or steel, but does not include piping.
tank farm	A collection of one or more tanks in an area.
watercourse	The bed and shore of a river, stream, lake, creek, lagoon, swamp, marsh, or other natural body of water or a canal, ditch, reservoir, or other man-made surface feature, whether it contains or conveys water continuously or intermittently.

Appendix 2 Examples of Integrity Testing

The integrity tests are listed in alphabetical order without regard for the accuracy or cost of the test. Underground storage tank (UST) integrity tests are not directly transferable for use on aboveground storage tanks (AST). ASTs are subject to larger temperature fluctuations, are influenced more by atmospheric pressure changes and wind, and are usually larger than USTs.

Below are some explanatory notes:

Cost The terms "inexpensive" and "expensive" are used relatively—for example:

- ultrasonic testing can cost thousands of dollars,
- a precision leak test can cost approximately $500 and up,
- an external visual inspection performed by an approval holder or licensee working at the facility has no real cost associated with it.

So in relative terms the external visual inspection is inexpensive compared to the relatively expensive ultrasonic test.

Note that costs can vary within each test method depending on the availability of equipment, how difficult the tank is to isolate, whether product needs to be added or removed from the tank, what type of product is stored in the tank, the size of the tank, and the amount of time required to perform the test.

Additional costs that occasionally need to be factored in are the potential costs associated with taking the tank out of service while performing the test. This is especially true for larger tanks, where it is more economical to consider using a testing method that allows the tank to stay in service even if that test is more expensive.

Difficulty Statements on the difficulty of implementing a test are also relative. For example, if a pressure test is listed as "easy to perform," this means that a pressure test is easier to perform relative to performing something like a tracer test. This designation is only in regards to the general case. There will be many cases where it is impossible to isolate a tank from the lines connected to it. Then it would be easier to perform the tracer test (which does not require the complete isolation of a tank). However, the tester will not be able to identify a test failure as a tank problem or a line problem.

Certification The United States Environmental Protection Agency has issued protocols that test methodologies must meet in order to be classified as a precision test. With respect to the downstream petroleum industry, most Canadian jurisdictions have adopted those parameters, which include the ability to identify a leak as small as 0.38 L/hour, 95% accuracy, and false positive outcomes of 5% or less. This applies to test methodologies for underground tanks only. Some aboveground tank testing methodologies have had third-party performance evaluations, but the parameters for sensitivity and accuracy have not been established by any government body.

For various reasons, the use of only certified, precision tests is not required by this directive. However, owners of tanks should consult with the tester to determine if an evaluation has been completed by a third party to ensure that the test is appropriate.

Application The application section of the table is vague due to the diversity of tanks used in the industry. A test may be applicable/inapplicable to a tank based on factors such as size, shape, positioning, environment (e.g., climate), product stored, material the tank is made out of, how many lines are connected to the tank, and if the tanks are manifolded.

Aboveground Storage Tanks

Method	Description	Pros	Cons	Applications
External visual inspection	An external visual inspection can be performed on all aboveground storage tanks that are visible on all sides. These inspections should be performed in conformance with API Standard 653 and may be combined with an ultrasonic test.	• Inexpensive. • Easy to perform. • The whole outside of the tank can be inspected.	• There is the possibility of overlooking smaller leaks. • It is only possible to inspect the part of the tank not resting on the ground • If bottom of tank cannot be inspected, the inspection must be combined with some other method.	Works on most aboveground storage tanks.
Hydrostatic test	The tank is completely filled and stabilized. Tank pressure is raised by 5 to 7 psi by a pump or by adding a similar hydrocarbon. If pressure is maintained for 1 hour, tank is leak free.	• Inexpensive. • Easy to perform test. • Stored product does not always have to be removed.	• Does not account for varying temperatures. • It could cause a tank rupture. This method is not recommended by tank manufacturers. • The tank has to be full and all vapour pockets need to be identified and removed. • There is the potential for product being leaked into the environment. • Only identifies there is a leak, not the size or location of the leak. • The presence of sludge in a tank may mask any leaks underneath the sludge.	Only works on smaller tanks.
In-fill test	This test involves the overflowing of a tank (preferably with water) and the subsequent recording of liquid levels over time. This requires the hydraulic isolation of the tank.	• Least expensive. • Easy to perform. • Stored product does not always have to be removed.	• Does not account for varying temperatures. • The tank has to be full and all vapour pockets need to be identified and removed. • There is the potential for product being leaked into the surrounding soils. • Only identifies there is a leak, not the size or location of the leak.	Works on most aboveground storage tanks, but is impractical for larger tanks.

Method	Description	Pros	Cons	Applications
Internal visual inspection	An internal visual inspection can be performed by emptying and cleaning the inside of the tank and then visually inspecting it for signs of weakness or holes. These inspections should be performed in conformance with API Standard 653 and may be combined with an ultrasonic test.	• Inexpensive. • Easy to perform. • The whole inside of the tank can be inspected.	• The tank needs to be emptied and cleaned before inspection. • There is the possibility of overlooking smaller leaks.	Works on most aboveground storage tanks.
Inventory reconciliation	The approval holder or licensee maintains records on all of the product that enters and leaves the tank. By examining these records, the approval holder or licensee should be able to tell if there is a leak in the tank. There are a number of companies that offer software programs that use leak detection algorithms for analyzing inventory, sales, and delivery data to conduct leak-detection testing.	• Easy to implement. • Can be done while the tank is in operation.	• May not be accurate due to the inaccuracy of measuring the volumes entering and leaving the tank. Also, the volume of product entering and leaving the tank isn't usually corrected for temperature. • Does not take into account evaporation from the tank. • Location of the leak can't be identified. • Will overlook smaller leaks. • Results are open to interpretation and additional investigations.	Works on most tanks, but the most practical application is on manifolded tanks and large tanks.
Mass Integrity test	A small trickle of nitrogen is forced into the bottom portion of the tank (in the product) and the pressure required to maintain a continuous flow of bubbles is measured (measuring for head pressure). The test procedure measures the change in the product mass during an overnight data collection. The rate of mass change is determined and described in a leak rate.	• Corrects for thermal expansion and temperature stratification. • Will work on any size of tank. • Compensates for tank shell dynamics. • Third-party performance rated.	• It only tests for leaks below the product line. • Affected by large fluctuations in barometric pressure.	Works on most aboveground storage tanks.

Method	Description	Pros	Cons	Applications
Mass-based systems	The test is designed to measure any changes in the buoyancy force acting on a probe inserted into the tank. Uses mass measurement technology to determine if product is entering or leaving the tank. The technology is based on the fact that buoyancy force only varies as a direct result of a change in the mass of the liquid. Buoyancy force is not affected by changes in product temperature, since the change in volume due to temperature change is offset by a corresponding change in liquid density.	• Same-day results. • The tank doesn't have to be completely empty. • The test is not affected by temperature.	• Testing at low product levels could allow a leak to remain undetected. • Tests only the portion of the tank containing product. • There are several mass-based systems being used in the industry today. However, they are not designed to handle the large temperature fluctuations or the changing atmospheric pressures associated with ASTs. These systems were designed for USTs, where different types of forces are present. • Results are affected by wind, vibration, and tank shell dynamics.	Works on most ASTs.
Permanent leak- detection devices	There are ways of installing a tank so that when there is a leak it will be noticed by the approval holders or licensees. One is setting the tanks on liners in the shape of coasters. When the tank is leaking, product will appear on the edges of the coaster, alerting the approval holder or licensee to the leaking. Another is the weeping tile system. A system is installed under the tank with the capability of collecting fluids leaked out of the tank and directing them to a collection device. The approval holder or licensee can check the collection device regularly for product, which would indicate a leak.	• Cost effective. • Continuous monitoring by approval holders or licensees. • Early leak-detection capabilities.	• Relies on the release of product (this is the same for all of the other tests except for ultrasonic testing, which is capable of finding signs of weakness). • Must lift the tank for installation or be installed prior to placement of the tank within tank farm area.	Works on most aboveground storage tanks.

Method	Description	Pros	Cons	Applications
Pressure test	This test involves the introduction of slight pressure (nitrogen gas) to the tank. A decrease in pressure is measured over a time interval. If the pressure decreases, the tank may have a leak. This test requires the pneumatic isolation of the tank and/or lines being tested. The tank must also be empty of fluids.	• Inexpensive. • Easy to perform.	• Potential to damage the tank if too much pressure is applied. Many of the tank manufacturers warn against pressure testing. • The tank may be difficult to isolate if there are a number of lines connecting to it. • If there is sludge in the tank that can't be removed, this method may be ineffective, as the sludge could act as a plug when pressure is applied, concealing any leaks the tank might have underneath the sludge. • Only reveals that there is a leak, not the size or location of the leak.	Only works on smaller tanks.
Robotic inspection	A visual inspection can be performed internally on an aboveground storage tank while it is in operation. The robot is lowered into the tank and performs ultrasonic testing on the floor of the tank, providing video footage of the tank bottom for analysis. The robot also has the capability of cleaning the tank.	• Can be performed while the tank is in operation. • Can be used on very large tanks. • Will inspect the entire tank bottom for areas of weakness and holes.	• A very expensive piece of equipment, requiring specialized people to operate the robot and interpret the results. • Expensive.	Works on larger tanks.
Tracer test	A tracer gas (or liquid) is injected into the tank. Soil gas samples are taken from probes installed into the ground around the tank. A leak is declared if tracer is detected outside the tank.	• The production system can remain in service through the entire procedure. • There are no fill or underfill requirements. • The system is designed for easy retesting, since the probes are permanent. • Can test any size of tank without a loss in test sensitivity. • Not affected by hydrocarbons from previous leaks or spills.	• Lab results are generally not available until 10 to 14 days after the start of the test. • The test can be strongly affected by the type of soil (i.e., the test will not work well in low-porosity soils). • Only able to test for leaks on the tank bottom. • Underground piping could be damaged during probe installations.	Works for most tanks placed on the ground.

Method	Description	Pros	Cons	Applications
Ultrasonic test	Ultrasonic testing checks components and structures to detect internal and surface breaking defects and measures wall thickness. Ultrasonics operates on the principle of infecting a very short pulse of ultrasound into a component or structure and then receiving and analyzing any reflected sound pulses. There are different kinds of ultrasonic tests. The A-Scan point-to-point technique, used for decades, involves taking a thickness reading at one point on a section of the tank and repeating this process several times on the same tank to generate a sample. The B-Scan technique can take ultrasonic thickness readings over every 0.04 inch of the surface, which results in almost 100% coverage of the tank surface. This eliminates the problems associated with the A-Scan technique missing problem areas. The B-Scan can also scan through coatings, unlike the A-Scan technique.	• Only one side of the surface needs to be assessed. • It can locate areas of both leaks and potential leaks. When these areas of potential leaks are identified, they can be revisited on subsequent inspections.	• Requires specialized equipment that needs an experienced approval holder or licensee to interpret the results. • The tank may need to be cleaned before the inspection can take place.	Works on most aboveground storage tanks.
Vacutect system	All openings to the tank are sealed off and a mild vacuum (less than half of 1 psi) is applied to the tank using a vacuum pump. The vacuum level is constantly monitored and maintained by the computer in the testing unit. While under vacuum, Vacutect monitors for three things: water level, noise (via a hydrophone), and the pressure in the tank. This test has been modified from the test performed on USTs for use on ASTs.	• Allows the technician to perform trouble shooting to determine whether the system is leaking and the nature and location of the leak. • Same-day results. • Product may remain in the tank. • Not affected by temperature.	• The expertise of the approval holder or licensee is crucial for this test to effectively determine the location of the leak. • Vibrations from nearby equipment or vehicles may interfere with the test, making testing difficult on active sites. • May be ineffective in clay soils because it may plug up holes in the tank bottom (see under Vacuum Test and Pressure Test for additional problems). • May be influenced by tank sludge and sedimentary accumulations.	Works on tanks up to 500 barrels (16 feet in diameter). Larger tanks may prove difficult for obtaining a vacuum.

Method	Description	Pros	Cons	Applications
Vacuum test	A vacuum test involves the introduction of a slight vacuum to the tank. A decrease in vacuum is measured over a time interval. If the vacuum decreases, the tank may have leak. This test requires the pneumatic isolation of the tank and/or lines being tested. The fluid level in the tank should be noted.	• Inexpensive. • Easy to perform.	• Potential to collapse the tank. Many of the tank manufacturers warn against vacuum testing. • The tank may be difficult to isolate if there are a number of lines connecting to it. • If there is sludge in the tank that can't be removed, this method may be ineffective, as the sludge could act as a plug when pressure is applied, concealing any leaks the tank might have underneath the sludge. • Soil beneath the tank may plug holes and mask a leak. • Only reveals that there is a leak, not the size or location of the leak.	Only works on smaller tanks.
Vigilant test	The method is based on sensing the vacuum changes that occur in the interstitial space between an outer rigid tank and an inner wall formed by installing a flexible membrane liner in the tank. Vacuum changes are analyzed continuously with a microprocessor to determine the rate of change. Very slow changes occur on tight tanks due to molecular permeation through the membrane into the interstitial space. This baseline behaviour is determined experimentally for each tank after installation of the membrane is complete. The vacuum behaviour will vary significantly if a leak is present. Both liquid and air leaks may be detected using this method.	• There are no fill or underfill requirements. • Will work on all products. • The tank needs very little time after product is added before the tank is stable enough for testing.	• The tank liner must be carefully fitted to the tank. Liners that are too small will produce larger interstitial spaces, decreasing the sensitivity of the leak detection system. • A baseline behaviour must be established for each tank. An error in establishing the baseline could result in either missed detections or masked leaks.	May be used on tanks that have liners and are under 400 barrel capacity.

Underground Storage Tanks

Method	Description	Pros	Cons	Applications
Fill test	Involves the overflowing of a tank (preferably with water) and the subsequent recording of liquid levels over time. This requires the hydraulic isolation of the tank and/or lines being tested.	• Least expensive. • Easy to perform.	• Does not account for varying temperatures. • The tank has to be full and all vapour pockets need to be identified and removed. • Trapped air pockets, line swags, and other difficulties impact the evaluation of the connected underground piping. • If there is high groundwater or if the tank is surrounded by thick clays, a leak could be disguised. • There is the potential for product being leaked into the surrounding soils. • Only reveals that there is a leak, not the size or location of the leak.	Most underground tanks.
Hydrostatic test	The tank is completely filled and stabilized. Tank pressure is raised by 5-7 psi by a pump or by adding a similar hydrocarbon. If pressure is maintained for 1 hour, tank is leak free.	• Inexpensive. • Easy to perform. • Stored product does not always have to be removed. • Same-day results.	• Does not account for varying temperatures. • Could cause tank or piping to rupture. Many tank manufacturers recommend against applying pressure to a tank. • Tank has to be full and all vapour pockets need to be identified and removed. • Trapped air pockets, line swags, and other difficulties impact the evaluation of the connected underground piping. • Difficult to interpret the result. • Potential for product being leaked into the environment. • Only reveals that there is a leak, not the size or location of the leak.	Most underground tanks.

Method	Description	Pros	Cons	Applications
Out-fill test	Involves the emptying of the tank and the subsequent recording of liquid levels over time. This requires the hydraulic isolation of the tank and/or lines being tested.	• Least expensive. • Easy to perform. • Useful for areas where there is a high groundwater table.	• Only reveals that there is a leak, not the size or location of the leak. • Only works in high groundwater situations. • If the leak is small, it may take a long time for a measurable amount of groundwater to infiltrate the tank. • May not evaluate risers, connections, and connected underground piping.	Will work for most tanks situated in soils with a high groundwater table.
Pressure decline test procedure	Involves the introduction of slight pressure (nitrogen gas) to the tank (approximately 5 psi or less). A decrease in pressure is measured over a time interval. If the pressure decreases over time, the tank may have a leak. The test requires the pneumatic isolation of the tank and lines being tested. The fluid level in the tank should be noted.	• Inexpensive. • Easy to perform. • Same-day results.	• Potential to damage the tank if too much pressure is applied. Many tank manufacturers recommend against applying pressure to a tank. • The tank may be difficult to isolate if it has a number of lines coming into it. • If there is sludge in the tank that can't be removed, this method may be ineffective, as the sludge could act as a plug when pressure is applied, concealing any leaks the tank might have underneath the sludge. • Only reveals that there is a leak, not the size or location of the leak.	Most underground tanks.

Method	Description	Pros	Cons	Applications
Suretest volumetric leak detection procedure	A probe is inserted into the tank (product). The probe is sensitive to the outflow or inflow of any liquids within the tank and can detect product loss or gain to an accuracy of .001 litres per hour. Temperature sensors are spaced to take the temperature at each level of product. The probe's microprocessor corrects for volume changes that are due to thermal expansion or contraction of the product.	• The test is not affected by temperature. • Same-day results. • Third-party performance rated. • Can detect the presence and rate of a leak.	• Important that technician is trained. • Product volume level restrictions. • Product type and temperature change limitations. • Evaluates the lower tank portion, which contains product. An alternative test procedure is required to test above the product level, risers, connections, and underground product piping. • Groundwater level must be known to ensure that equilibrium does not occur within the tank product level. Product does not leave or enter the tank during the test procedure and groundwater does not infiltrate the tank.	Most underground tanks.
Tracer test	A tracer gas (or liquid) is injected into the tank. Soil gas samples are taken from probes installed into the ground around the tank. A leak is declared if tracer is detected outside the tank.	• The production system can remain in service through the entire procedure. • There are no fill or underfill requirements. • The leak location can be determined. • The system is designed for easy retesting, since the probes are permanent.	• Lab results are not generally available until 10 to 14 days after the start of the test. • The test can be strongly affected by the type of soil (i.e., the test will not work well in low-porosity soils) and the groundwater level around the tank. • Tank and piping system may have to be sealed and pressurized with tracer gas in order to evaluate risers and connected underground piping.	Most underground tanks.

Method	Description	Pros	Cons	Applications
Ullage acoustics leak detection test procedure	The fluid is removed from the tank and a microphone is placed into the tank. The storage tank and connected openings are sealed off. A computer connected to the microphone measures the amount of background noise present in the tank. 2-3 psi nitrogen pressure is placed in the sealed tank system. The computer determines a leak by measuring a change in the background noise (caused by the vibrations created by escaping nitrogen). A pressure decline procedure is performed simultaneously to evaluate the connected piping.	• Same-day results. • Can identify the location of leaks. • Allows for trouble shooting while the test is being performed. • Nonvolumetric, and not affected by temperature or vapour pockets. • Third-party performance evaluated.	• The expertise of the approval holder or licensee is crucial for this test to effectively determine the location of the leak. • Vibrations from nearby equipment or vehicles may interfere with the test, making testing difficult in some situations. • High groundwater levels may affect results.	Most underground tanks.
Underfill leak detection procedure (e.g., PetroTite II, Alert 1000)	The underfill test is designed to measure any changes in buoyancy force acting on a probe inserted into the tank. It uses mass measurement technology to determine if product is entering or leaving the tank. The technology is based on the fact that buoyancy force only varies as a direct result of a change in the mass of the liquid. It is not affected by changes in product temperature, since the change in volume due to temperature change is offset by a corresponding change in liquid density.	• Same-day results. • Not affected by temperature. • Third-party performance rated.	• Minimum 40% and maximum 95% product levels required. • Tank's product must be a consistent type, otherwise stratification will affect results. • If the groundwater is above the bottom of the tank, it increases the product level that will be required to perform the test.	Most underground tanks.
Vacutect leak detection system	All openings to the tank are sealed off and a mild vacuum is applied to the tank using a vacuum pump. The vacuum level is constantly monitored and maintained by the computer in the testing unit. While under vacuum, vacutect monitors for three things: water level, noise (via a hydrophone), and pressure in the tank.	• Can perform trouble shooting to determine not only if the system is leaking, but the nature and location of the leak. • Same-day results. • Product can remain in the tank. • The test is not affected by temperature. • Third-party performance rated.	• Expertise of the approval holder or licensee is crucial for this test to effectively determine the location of the leak. • Vibrations from nearby equipment or vehicles may interfere with the test. This makes testing difficult in some situations. • Using the vacuum or the pressure may be ineffective in clay soils because it may plug up holes in the tank.	Most underground tanks.

Method	Description	Pros	Cons	Applications
Vacuum decline test procedure	Involves the introduction of a slight vacuum to the tank. A decrease in vacuum is measured over a time interval. If the vacuum decreases, the tank may have a leak. This test requires the pneumatic isolation of the tank and lines being tested. The tank must also be empty of fluids.	• Inexpensive. • Easy to perform. • Same-day results.	• Potential to collapse the tank. Many tank manufacturers recommend against applying vacuum to a tank. • The tank may be difficult to isolate if it has a number of lines coming into it. • If there is sludge in the tank that can't be removed, this method may be ineffective, as the sludge could act as a plug when pressure is applied, concealing any leaks the tank might have underneath the sludge. • Soil on the outside of the tank may plug holes and mask a leak. • Only reveals that there is a leak, not the size or location of the leak.	Most underground tanks.
Visual inspection	In some of the tanks with large manways it may be possible to inspect the tanks visually for leaks.	• Inexpensive. • Easier to locate the leak than other methods. • The whole inside of the tank can be inspected.	• Tank must be completely emptied and cleaned before a thorough visual inspection can be performed. • Might overlook smaller leaks. • An alternative procedure is required to evaluate the connected underground piping. • Tank must be completely isolated for safety reasons. • Outside of the tank can't be visually inspected unless the tank is unearthed.	Will only work on tanks with large enough manways for someone to enter through.