Storage Requirements for the Upstream Petroleum Industry

December 2001

Effective January 1, 2008, the Alberta Energy and Utilities Board (EUB) has been realigned into two separate regulatory bodies, the Energy Resources Conservation Board (ERCB), which regulates the energy industry, and the Alberta Utilities Commission (AUC), which regulates the utilities industry.

As part of this realignment, the title pages of all existing EUB directives now carry the new ERCB logo. However, no other changes have been made to the directives, and they continue to have references to “EUB.” As new editions of the directives are issued, these references will be changed.

ENERGY RESOURCES CONSERVATION BOARD
Directive 055: Storage Requirements for the Upstream Petroleum Industry

December 2001

Published by

Energy Resources Conservation Board
640 – 5 Avenue SW
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T2P 3G4

Telephone: 403-297-8311
Fax: 403-297-7040
Publications@ercb.ca
Web site: www.ercb.ca

Directive 055

Storage Requirements for the Upstream Petroleum Industry

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GUIDE RENAMED AS A DIRECTIVE

As announced in *Bulletin 2004-02: Streamlining EUB Documents on Regulatory Requirements*, the Alberta Energy and Utilities Board (EUB) will issue only "directives," discontinuing interim directives, informational letters, and guides. Directives set out new or amended EUB requirements or processes to be implemented and followed by licensees, permittees, and other approval holders under the jurisdiction of the EUB.

As part of this initiative, this document has been renamed as a directive. However, no other changes have been made. Therefore, the document text continues to have references to "guides." These references should be read as referring to the directive of the same number. When this directive is amended, these references will be changed to reflect their renaming as directives.

Alberta Energy and Utilities Board

ALBERTA ENERGY AND UTILITIES BOARD
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Foreword

The Alberta Energy and Utilities Board (EUB) first published *Interim Directive (ID) 95-3* and *Guide 55: Storage Requirements for the Upstream Petroleum Industry* in July 1995. The Storage Committee, which developed *Guide 55,* consisted of membership from the EUB, Alberta Environment (AENV), and the Canadian Association of Petroleum Producers (CAPP) and was under the umbrella of the Oilfield Waste Management Steering Committee. This Steering Committee consisted of membership from EUB, AENV, CAPP, Alberta Special Waste Management Corporation, Alberta Oilfield Treating & Disposal Association, Environmental Services Association of Alberta, Toxic Watch Society, and the Pembina Institute for Appropriate Development, with input from Alberta Health and the Health Unit Association.

The Steering Committee oversaw the development of EUB *Guide 58: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*. Initially, one section of the draft report that eventually became *Guide 58* was on storage of oilfield waste. Through the public review of the draft report, it was recommended that the storage section be expanded to cover all materials used, produced, and generated by the upstream petroleum industry. As a result, the storage requirements were removed from the draft report and developed as *Guide 55*. Prior to publication, *Guide 55* underwent stakeholder review through the Steering Committee.

The Storage Committee recommended that the document be subject to future reviews. In 2000 the EUB initiated a technical review of *Guide 55*. The *Guide 55* Review Committee consisted of the following membership:

Susan Halla	Alberta Energy and Utilities Board
Allison Wolfe	Alberta Energy and Utilities Board
Elaine Wasylenchuk	Alberta Environment
Joseph Feehan	Alberta Environment
Raymond Ligenza	Alberta Municipal Affairs
Don Edgecombe	Petroleum Tank Management Association of Alberta
Karen Blank	National Energy Board
Abby Dorval	National Energy Board
Darryl Hass	Canadian Association of Petroleum Producers
Richard Clark	Canadian Association of Petroleum Producers
Allen Hein	Canadian Association of Petroleum Producers
Michael O'Connell	Environmental Services Association of Alberta
Jim Gordon	Canadian Association of Petroleum Producers
Mark Blundell	Canadian Energy Pipeline Association

The technical review of *Guide 55* included an assessment of the Canadian Council Ministers of the Environment (CCME) document *Environmental Guidelines for the Control of Volatile Organic Compounds from Aboveground Storage Tanks*. As the overall issue of the emission of volatile organic compounds from the upstream petroleum industry and their appropriate control is very complex and broad, the *Guide 55* Review Committee recommended that this issue be reviewed independently of the *Guide 55* process. Should *Guide 55* be the appropriate document to contain any requirements developed to address this issue for Alberta, they will be incorporated at a later date.

1 Introduction

1.1 Purpose

The purpose of this guide is to identify requirements for the storage of materials produced, generated (including wastes), or used by the upstream petroleum industry. Here the term "upstream petroleum" industry is limited to facilities, well sites, and pipelines licensed or approved by the EUB for the exploration, production, recovery, handling, processing, treatment, disposal, or transmission of hydrocarbon-based resources or any associated substances or wastes, but does not include oil sands mining operations or the underground cavern storage of natural gas. The guide comprises a set of technical requirements designed to provide an acceptable level of storage practices for the upstream petroleum industry in Alberta.

1.2 Intent

The intent of these requirements is to prevent soil, groundwater, and surface water contamination at upstream petroleum sites. The implementation of appropriate storage practices should reduce the long-term costs associated with decontamination activities and enhance the capability for upstream petroleum sites to be reclaimed to conditions suitable for the next intended land use.

Guide 55 establishes requirements that address

- primary containment (storage) devices,
- secondary containment systems,
- leak detection systems,
- spill prevention and loss control systems,
- weather protection, and
- operating procedures, maintenance practices, and inspection programs to maintain the containment systems, as well as associated documentation and record retention requirements.

1.3 Storage Jurisdictional Overview

In Alberta there is no single jurisdiction that regulates the storage of all materials. Jurisdictions that are involved with various aspects of storage include the Alberta Energy and Utilities Board (EUB), Alberta Municipal Affairs (AMA), and Alberta Environment (AENV).

With respect to *Guide 55*, the term "upstream petroleum" is intended to apply to facilities, well sites, and pipelines licensed or approved by the EUB for the exploration, production, recovery, handling, processing, treatment, disposal, or transmission of hydrocarbon based-resources or any associated substances or wastes, but does not include oil sands mining operations or the underground cavern storage of natural gas. The licensee or approval holder of an upstream petroleum site is responsible for all activities occurring on its site, including any incidents that occur during an activity/operation provided by a service company. The site on which the service company resides typically is not under the jurisdiction of the EUB, unless the service company is conducting an activity/operation on the site that requires EUB approval (e.g., oilfield waste management). Therefore, in almost all situations the storage of materials in tanks, containers, or other devices on a service company's site is under the jurisdiction of AMA, AENV, or perhaps even the local authority (local by-laws and/or conditions specified in the development permit for the site) or a combination thereof. See Appendix 1 for a glossary of storage terms.

AMA administers the Alberta Fire Code (AFC), which applies throughout Alberta and regulates the storage, handling, use, and processing of flammable and combustible liquids in buildings, structures, and open areas. The Petroleum Tank Management Association of Alberta (PTMAA) has been delegated the responsibility for administering specific portions of the AFC, including the registration of storage tank systems containing flammable or combustible liquids. The AFC delineates the jurisdiction between upstream raw exploration and production processes and the downstream use of refined products. Specifically, Part 4 of the AFC 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, as mandated under the scope of *Guide 55*.

Where upstream petroleum 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 requirements of Part 4 of the AFC. In addition, storage tank systems for refined product use in these situations are subject to tank registration through the PTMAA.

AENV regulates 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 an upstream petroleum facility requires both EUB and AENV approval, *Guide 55* sets the minimum storage requirements, while additional requirements may be specified in the AENV approval.

1.4 Effective Dates

1.4.1 Facilities Operating Prior to January 1, 1996

As outlined in Appendix 2 approval holders or licensees of upstream petroleum facilities, well sites, and pipelines constructed and operating prior to January 1, 1996, are reminded that they are required to

- reverify the integrity of aboveground and underground tanks at the frequency outlined in Appendix 2 or retrofit them to meet the secondary containment and leak detection requirements, and

- comply with the requirements for containers, lined earthen excavations, and bulk pads.

1.4.2 Facilities Constructed on or after January 1, 1996

Upstream petroleum facilities, well sites, and pipelines constructed between January 1, 1996, and January 1, 2002, are expected to have met the storage requirements outlined in the 1995 edition of *Guide 55*. Subsection 1.4.3 highlights the changes introduced in this 2001 edition of *Guide 55*, while Subsection 1.4.4 outlines implementation dates for new or revised storage requirements. For facilities, well sites, and pipelines that have implemented storage options that are to be discontinued, see Appendix 2 for further direction.

1.4.3 Changes to *Guide 55*

The changes made to *Guide 55* include

- clarification of secondary containment requirements for small tanks (Section 5.1 and Appendix 2, parts 2, and 2.3) and containers (Section 7 and Appendix 2, parts 2 and 2.3);
- addition of requirements for the storage of produced water from shallow, low-pressure gas wells in the Milk River, Medicine Hat, and Second Whites Specks pools in open-topped, nonmetallic tanks (Section 5.2);
- minor adjustment of dike capacity (Section 5.3.2.1[a]);
- addition of requirements for double-walled aboveground tanks (Section 5.3.3);
- removal of the option to use single-walled underground tanks (Sections 1.4.4 and 6 and Appendix 2, parts 1 and 2.2.1);
- removal of the option to use concrete as primary containment in situations where liquids are being stored or where there is potential for leachate to be generated (Sections 1.4.4, 8, and 9 and Appendix 2, parts 1 and 2.3);
- consistent monitoring frequency (monthly) of all leak detection systems (Sections 1.4.4, 5, 6, 7, 8, and 9 and Appendix 2, parts 2.1.2, 2.1.3, 2.1.4, 2.2.1, and 2.3);
- clarification of the criteria for the surface discharge of collected surface run-on/runoff waters (Section 11);
- addition of procedures to follow for the withdrawal of storage tanks from service (Section 12);
- further information on liner specifications (Section 13);
- clarification of the frequency for repeating integrity verification tests and/or inspections of aboveground and underground tanks and lined earthen excavations installed prior to January 1, 1996 (Appendix 2, parts 2.1.2, 2.2.2, and 2.3); and
- further information on the types of integrity verification tests available for aboveground and underground tanks (Appendix 2, Tables A1, A2, and A3).

1.4.4 Implementation Dates for New/Revised Requirements

As of January 1, 2002, the following requirements shall be effective:

- Any storage device installed shall meet the requirements presented in the 2001 edition of *Guide 55*.

- The frequency for the monitoring of all leak detection systems associated with all storage devices shall be monthly.

- The use of single-walled underground tanks where a synthetic liner or the natural impermeable soil conditions (i.e., hydraulic conductivity of 10^{-6} cm/s or less) are used as secondary containment will no longer be allowed. Any such systems installed between January 1, 1996, and January 1, 2002, must meet the requirements outlined in Appendix 2.

- The use of concrete-lined earthen excavations with an underlying leakage monitoring system (no secondary containment) and the use of concrete as primary containment for lined earthen excavations or for bulk pads where there is potential for the stored materials to generate a leachate will no longer be allowed. Any such systems installed prior to January 1, 2002, must meet the requirements of Appendix 2.

For upstream petroleum facilities, well sites, and pipelines that were constructed and operating prior to January 1, 1996, approval holders or licensees have until October 31, 2004, to meet the secondary containment requirements, as outlined in Section 5.3 for small aboveground storage tanks exceeding the total combined volume of 5 m^3 per site. For further details, see Appendix 2, Section 2.3.

This 2001 edition of *Guide 55* requires

- aboveground storage tanks with an interval volume of 5 m^3 or greater to have secondary containment consisting of a dike and liner system or to be double-walled;

- underground storage tanks to be doubled-walled;

- small aboveground storage tanks (interval volume between 1 m^3 and 5 m^3) that exceed a total combined volume of 5 m^3 per site to have secondary containment or be double-walled;

- containers (portable storage devices that do not exceed 1 m^3 in volume) that exceed a total combined volume of 1 m^3 per site to have secondary containment;

- all lined earthen excavations to have secondary containment;

- bulk pads storing materials that may generate a leachate to have leak detection systems;

- monthly monitoring of all leak detection systems, including visual and interstitial space monitoring, associated with aboveground and underground tanks, containers, lined earthen excavations, and bulk pads;

- monitoring and inspection information to be retained for a minimum of 5 years.

Licensees and approval holders are directed to Tables 2 and 3 on pages 18 and 19 and to the appropriate section of *Guide 55* that sets out the specific requirements for the storage devices identified above.

2 Scope

2.1 *Guide 55* Overview

Guide 55 outlines the minimum storage expectations that the upstream petroleum industry must meet. The implementation of storage systems alternative to the ones described within this guide requires EUB approval, as outlined in Section 2.5. For information pertaining to the application, approval, or licensing of upstream petroleum developments, refer to the following EUB documents:

- *Guide 56: Energy Development Application Guide*—covers oil/bitumen and gas batteries, satellite batteries, gas processing facilities, straddle gas plants, compressor stations, custom treating plants, injection/disposal facilities, pump stations, tank farm/oil loading and unloading terminals, pipelines, and wells.

- *Guide 58: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*—covers oilfield waste management facilities and oilfield waste storage areas constructed on an upstream petroleum facility for the purpose of collecting oilfield or oily wastes from sites within the same production system

- *Guide 23: Guidelines Respecting an Application for a Commercial Crude Bitumen Recovery and Upgrading Project*, *Informational Letter (IL) 85-12: Oil Sands Primary Production: Well Spacing Primary Recovery Scheme Approvals*, and the Oil Sands Conservation Act and Regulations—covers oil sands developments

The storage requirements in *Guide 55* apply to upstream petroleum facilities, well sites, and pipelines licensed or approved by the EUB, including

- well sites,
- gas batteries (single and multiwell),
- oil/bitumen batteries (single and multiwell),
- oil/bitumen satellites,
- custom treating plants,
- compressor stations,
- straddle plants,
- gas processing/fractionating facilities,
- pump stations,
- tank farms/oil loading and unloading terminals, and
- oilfield waste management facilities.

Note that *Guide* 55 does not apply to oil sands mining operations or to the underground cavern storage of natural gas.

For those facilities that also require an approval from Alberta Environment (AENV) (e.g., sour gas plants, compressor stations, some in situ oil sands facilities), storage requirements may also be specified in the AENV approval. The AENV requirements are generally consistent with the requirement in *Guide 55*.

2.2 Containment Devices

Containment devices addressed by this guide include
- aboveground tanks (single walled and double walled),
- underground tanks,
- containers,
- lined earthen excavations, and
- bulk pads.

2.3 Applicable Material Types

Any material that could adversely affect the environment and is produced, generated, or used on upstream petroleum sites under the jurisdiction of the EUB must be stored in accordance with these requirements. Applicable material types (as noted below and in Table 1) include, but are not limited to,
- produced water,
- crude oil,
- emulsions,
- condensates (C5+, nonpressurized storage),
- chemicals,
- solvents,
- produced sand,
- lubricants other than for motor vehicle use,
- oilfield wastes,
- oily waste, and
- bitumen.

2.4 Excluded Material Types and Storage Systems

The storage requirements for the following materials are currently addressed by other requirements, regulations, or standards (as noted below and in Table 1) and are therefore, not covered by these requirements:
- natural gas liquids (C2 to C4, pressurized storage),
- fuels, refined flammable liquids, and combustible liquids,
- sewage,
- scrap metal,
- sulphur,
- collected surface run-on/runoff waters (see Section 11 for surface discharge criteria),
- garbage,
- construction materials, and
- lime sludge (pond storage).

Note that lime sludge being stored in a cell system that is part of a landfill on an upstream petroleum site must be designed, operated, and approved as an oilfield landfill (see *Guide 58*). However, lime sludge ponds at in situ oil sands plants are covered by EPEA approvals.

Table 1. Summary of requirements applicable to oilfield material storage

Material stored	Applicable	Further reference
Bitumen	Yes	
Blowdown water from shallow gas operations	Yes	EUB *IL 99-5*
Chemicals	Yes	
Coke	No	EUB *IL 96-7*
Condensate (C_5+, nonpressurized)	Yes	
Construction debris	No	Oil and Gas Conservation Regulations, Section 8.150(6)[1] and *Guide 58*
Crude oil/bitumen	Yes	
Drilling fluids	No	Oil and Gas Conservation Regulations, Section 8.150(3)[2] and (4)[2] EUB *IL 96-13*, *Guide 50*
Emulsions	Yes	
Fuels	No	Alberta Fire Code, Petroleum Tank Management Association of Alberta
Garbage	No	EPEA, Waste Control Regulations, Code of Practice for Landfills
Lubricants (motor vehicle)	No	Alberta Fire Code
Lubricants (nonmotor vehicle)	Yes	
Liquefied petroleum gas (LPG)	No	CSA International B 149.2-00, *Propane Storage and Handling Code*
Natural gas (NG) C_2 to C_4 in pressurized storage	No	CSA International B 149.1-00, *Natural Gas and Propane Installation Code*
Natural gas in underground cavern storage	No	EUB *Guide 65*
Oil sands tailings	No	EUB *IL 96-7*, EUB *Guide 23*
Oilfield wastes	Yes	*Guide 58*
Pipeline drip fluids	No	Canadian Standards Association Oil and Gas Pipeline Standards, Z662-94
Produced sand	Yes	*Guide 58*
Produced water	Yes	*Guide 51, Guide 58*
Scrap metal	No	Oil and Gas Conservation Regulations, Section 8.150(6)[1] and *Guide 58*
Sewage	No	EPEA, Wastewater and Storm Drainage Regulation; Domestic Wastewater Management Guidelines for Industrial Operations, AENV
Solvents	Yes	
Sulphur	No	EUB IL *84-11*, GB *92-4, EUB IL 96-7*
Lime sludge-surface pond/oil sands site	No	EPEA approval
-landfill cell	Yes	EUB *Guide 58*

[1] Proposed changes to the Oil and Gas Conservation Regulations are in progress. Upon publication of the changes, the requirements currently in Section 8.150(6) will be found in Section 8.150(4).

[2] Proposed changes to the Oil and Gas Conservation Regulations are in progress. Upon publication of the changes, the requirements currently in Section 8.150(3) and (4) will be found in Sections 8.151 and 8.152.

Aboveground and underground pressurized vessels that are part of an active production process (e.g., flare knockouts and amine surge/drain tanks) and pipeline drip vessels are not within the scope of these requirements provided that they 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). All aboveground and underground nonpressurized storage vessels not registered ABSA are subject to these requirements.

Tornado systems or other positive pressure systems used as a product stabilizer/ accumulator are considered a process vessel and not a conventional storage tank and, therefore, are not required to meet the secondary containment requirements outlined in *Guide 55*.

For storage of fuels (e.g., diesel and gasoline) in aboveground and underground storage tanks, refer to the Alberta Fire Code, Part 4. These storage tanks also require registration with the PTMAA.

For storage of natural gas (NG) and liquefied petroleum gas (LPG), see

- CSA International B 149.1-00, *Natural Gas and Propane Installation Code,* and
- CSA International B 149.2-00, *Propane Storage and Handling Code.*

The underground cavern storage of natural gas is covered under Section 26(1)(b) of the Oil and Gas Conservation Act and Unit 4.3 of *Guide 65: Resources Application for Conventional Oil and Gas Reservoirs*.

The storage of sulphur on upstream petroleum sites must conform to the requirements of *IL 84-11: Approval, Monitoring, and Control of Sulphur Storage Sites.*

2.5 Alternative Storage Systems

The provisions of this guide are intended to permit the use of alternative storage systems if it can be shown that the materials, systems, equipment, procedures, or new technologies can meet the objectives and intent of the requirements described in the guide.

Approval holders or licensees wishing to implement storage systems alternative to the requirements outlined in this guide must include the design details in the application for the upstream petroleum development (either an application for a new development or for a modification to an existing one). The application must contain sufficient information to substantiate that an equivalent level of environmental protection and safety will be achieved by the proposed storage system. If the application is made pursuant to *Guide 56*, then it must be filed as nonroutine.

3 General Storage Practices and Requirements

3.1 Environmental Protection and Safety Practices

Any material produced, generated, or used by the upstream petroleum industry that may cause an adverse effect if introduced into the environment must be stored in a manner that meets the intent of these requirements. In addition to the specific measures addressed in Sections 5 to 9, the following environmental protection and safety practices should be considered:

- Selecting a storage site that minimizes the potential for environmental concerns.

- Implementing 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.

- Implementing operating practices to prevent the buildup of static electricity during the transfer of flammable liquids.

- Storing the materials in a manner such that
  a) materials do not generate extreme heat or pressure or cause a fire or explosion,
  b) materials do not produce uncontrolled fumes or gases that pose a risk of fire or explosion,
  c) materials do not damage the structural integrity of a storage facility, and
  d) incompatible materials are segregated to prevent contact even in the event of a possible release.

3.2 Release/Spill Prevention

The purpose of this guide is to ensure that materials stored in the upstream petroleum industry are adequately contained to prevent soil, surface water, and groundwater contamination through effective primary containment, secondary containment, and leak detection. Experience has shown that when these prevention systems are in place, the next most significant contributor to contamination is accumulated releases/spills.

While often small in nature (less than the release volumes that require reporting under EUB requirements), these releases/spills may occur for a variety of reasons, such as load line connection spills, tank overflows, truck overfilling, and flange, valve, and fitting leaks. The occurrence of these types of releases/spills are an indication of opportunities for improvements in operations.

Approval holders or licensees should include within their operating procedures proactive measures to prevent the occurrence of these releases, such as plans and policies to prevent releases, as well as documentation of their frequency and the cause of occurrence in order 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

- company inspection and maintenance programs,
- company operations handbooks/environmental bulletins,
- operator and contractor training on company expectations and reporting,
- contractor prejob orientations,
- detailed records (internal spill/incident reports), and
- a database of incidents to allow for analysis of spill cause and frequency.

Measures that prevent spills and releases are the most effective in terms of both cost and environmental protection. This is recognized by Section 8.050 of the Oil and Gas Conservation Regulations, which requires all spills to be immediately contained, cleaned up, and reported to the appropriate agency, and Section 8.150(6)*, which requires well sites and facilities to be maintained in a clean condition. Failure to meet these requirements is considered a noncompliance event and will result in escalating consequences if not satisfactorily addressed. For further information pertaining to the EUB enforcement process or release notification and site decontamination requirements, refer to the following EUB informational letters:

- *IL 99-4: EUB Enforcement Process, Generic Enforcement Ladder, and Field Surveillance Enforcement Ladder,*

- *IL 98-1: Coordination of Release Notification Requirements and Subsequent Regulatory Response,* and

- *IL 98-2: Suspension, Abandonment, Decontamination, and Surface Land Reclamation of Upstream Oil and Gas Facilities.*

3.3 Storage Duration

In the interest of increased public safety and environmental protection, materials shall not be stored indefinitely:

- Materials are expected to be consumed within a period of two years.
- Oilfield wastes and empty barrels must not be stored for longer than one year.

In the majority of cases, products, materials, and wastes will usually move through the production system in less time. Where necessary, procedures should be implemented to minimize the inventory of empty barrels stored at the upstream petroleum site.

3.4 Permanent Storage

Permanent storage refers to the storage of materials produced, generated, or used by the upstream petroleum industry in a device that is a permanent, fixed part of an operating facility. Such devices may include

- aboveground tanks,
- underground tanks,
- container storage areas,
- lined earthen excavations, and
- bulk pads.

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* Proposed changes to the Oil and Gas Conservation Regulations are in progress. Upon publication of the changes, the requirements currently in Section 8.150(6) will be found in 8.150(4).

3.4.1 Permanent Storage Devices Not Requiring Secondary Containment

The following storage devices are not required to meet the secondary containment requirements outlined in Sections 5 and 6:

- aboveground or underground tanks used to store water meeting surface water discharge criteria (see Section 11 for surface discharge criteria),
- small tanks with a total combined volume not exceeding 5 m^3 on a site (see Section 5.1),
- 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 5.2), and
- storage devices (aboveground or underground) used to infrequently store fluids for very short durations, provided they are emptied immediately after use and are regularly inspected to verify their integrity. Examples include
  - pop tanks and other emergency containment tanks,
  - compressor oil drain tanks,
  - wash water collection systems from floor drains, and
  - pigging fluid catchment devices.

Note that any spill, leak, or discharge from storage devices used infrequently must be recorded as part of the monthly documentation requirements, along with any corrective action that was undertaken to prevent the recurrence of a similar release.

If the characteristics of the site (e.g., topography, hydrogeology, and geology) are such that the risks associated with surface water contamination, subsurface contaminant migration, and impact to groundwater are high, leak detection and secondary containment are required for any storage device regardless of its usage frequency.

3.5 Temporary Storage

Temporary storage refers to the storage of materials produced, generated, or used in specific operations of the upstream petroleum industry and should typically not exceed three months. Specific operations associated with temporary storage are

- plant turnarounds,
- construction operations,
- containment and cleanup of a spill,
- emergency conditions, and
- well drilling, completions, testing, and servicing operations (e.g., portable test tanks).

Temporary single-walled aboveground tanks used to store fluids in the above-cited operations do not require an impervious liner; they do require diking unless the operation qualifies for it to be optional. Diking is optional in situations where

- the site is manned for the duration that fluids are being produced into the tank,
- the tank is fitted with a high-level shutdown device to prevent fluids from overflowing, or
- the fluids are not being produced to the tank, but are simply being stored.

Approval holders or licensees exercising the option to not dike a tank for well drilling, completions, testing, or servicing operations must empty the tank or remove it from the site within 72 hours of completing the operation. Approval holders or licensees must use reasonable judgement to ensure that environmentally sensitive areas are protected and as such should not consider the option to not dike a tank when it is located close to a water body.

The temporary storage of sludges or solids (e.g., contaminated soil, spill debris, oily waste, drilling waste) from the above-listed operations in steel-fabricated, solids-storage bins (e.g., lugger bins, drilling rig tanks) does not require diking or secondary containment.

It is expected that temporary storage will meet the intent of these requirements to minimize environmental impact and ensure public safety. Even in temporary storage situations, contaminated materials or materials possessing the potential to leach must not be stored directly on the ground. At the end of the specific operation, the stored materials must be transferred to a permanent storage facility/area or be appropriately treated and/or disposed. Application for the approval of temporary storage is not required.

Production batteries used for a temporary period of 12 months or less are not required to install impervious liner systems. However, the equipment spacing and diking requirements must be met.

3.6 Siting

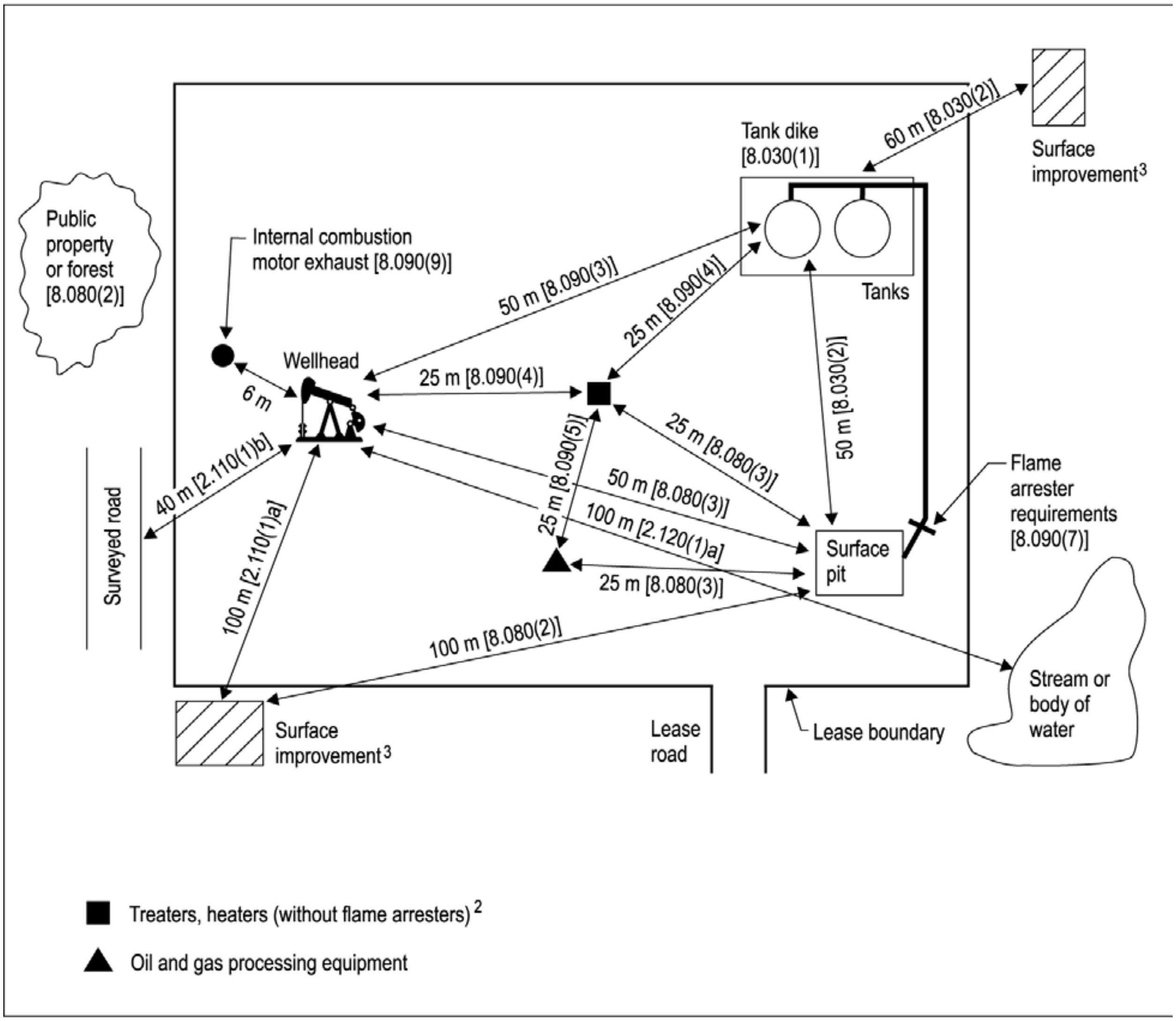
Siting considerations must be incorporated into the design of storage areas/facilities. A storage area/facility must be located so that it meets the following criteria:

- Readily accessible for fire fighting and other emergency procedures.
- Not located in a floodplain, unless appropriate alternative secondary containment measures are incorporated into the design and installation.
- Chosen so as to minimize the risk of environmental damage, including any threats to the integrity of the storage facility, the quality of soils, surface water, and groundwater, and the health of humans, animals, and plants during the construction, operation, and closure of the storage area/facility.
- Not located within 100 m of the normal high-water mark of a body of water, permanent stream, or water well used for domestic purposes.

It is recognized that when temporary storage is associated with emergency situations, fully implementing the above criteria may not be feasible.

3.7 Equipment Spacing

All storage areas/facilities must comply with the equipment spacing requirements identified in the Oil and Gas Conservation Regulations, Sections 8.030(2), 8.080(2), and 8.090 (see Figure 1).



1 The spacing requirements illustrated here are as specified in the Oil and Gas Conservation Regulations sections indicated within square brackets alongside or underneath each measurement.
Note that there is no smoking within 25 m of a well, separator, oil storage tank, or other unprotected source of ignitable vapour [Section 8.120(1)].

2 Treaters and heaters without flame arresters are not to be housed in the same building unless air intakes, flues, vents, ignitable vapours, etc., are vented outside above roof level and the building is cross-ventilated [8.090(6)a,b,c]. Treaters and heaters with flame arresters must also be 25 m from a well, oil storage tank, or other source of ignitable vapour [8.090(4)].

3 "Surface improvement" means a railway, pipeline or other right-of-way, road allowance, surveyed roadway, dwelling, industrial plant, aircraft runway or taxiway, building used for military purposes, permanent farm building, school or church [1.020(1)28].

Figure 1. Equipment Spacing Diagram

The following exceptions to the equipment spacing regulations are allowed for by *ID 91-3: Heavy Oil/Oil Sands Operations:*

- No open flame shall be permitted within 25 m of a heavy oil/oil sands well, storage tank, or other source of ignitable vapour, including Board-approved desand and oily waste storage facilities.
- No oil storage tanks or desand and oily waste storage facilities may be located within 25 m of a heavy oil/oil sands well.
- Diesel engines operating within 25 m of an oil sands/heavy oil well, process vessel, or production storage tank must be equipped with an adequate air intake shutoff valve.

3.8 Identification of Storage Facilities

All stand-alone storage facilities shall have signs, as per section 6.020 and Schedule 12 of the Oil and Gas Conservation Regulations, at the entrance to the facility indicating the approval holder or licensee name, emergency phone number, and legal description (see Figure 2). 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).

3.9 Compliance and Enforcement

The EUB considers compliance with the storage requirements outlined in this guide to be extremely important in preventing soil, groundwater, and surface water contamination at upstream petroleum sites. The EUB uses a combination of audits and inspections to ensure compliance with all EUB regulatory requirements, including the storage requirements, outlined in this guide. The following audits and inspections include a component to check for compliance with *Guide 55*:

- facility application audits pursuant to *Guide 56: Energy Development Application Guide*,
- oilfield waste management facility audits pursuant to *Guide 58: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*,
- drilling rig inspections pursuant to *Guide 36: Drilling Rig Inspection Manual*,
- service rig inspections pursuant to *Guide 37: Service Rig Inspection Manual*,
- oilfield waste management facility inspections pursuant to *Guide 63: Oilfield Waste Management Facility Inspection Manual*,
- production facility inspections pursuant to *Guide 64: Facility Inspection Manual,* and
- pipeline inspections pursuant to *Guide 66: Pipeline Inspection Manual*.

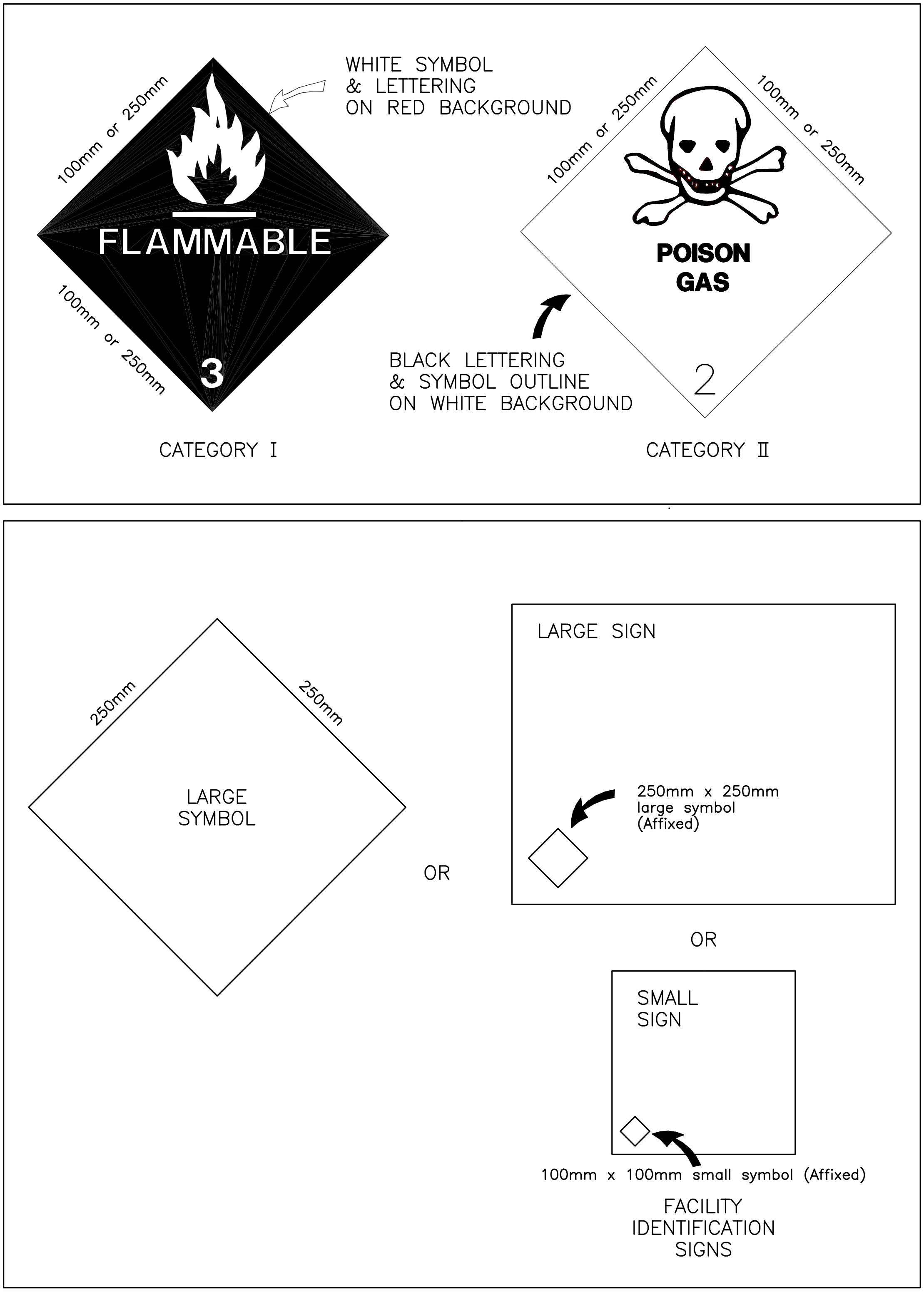


Figure 2. Facility Identification and Warning Signs (from Schedule 12 in Oil and Gas Conservation Regulations)

Failure to comply with *Guide 55* requirements may result in enforcement actions. The inspection manuals, which are revised as necessary when regulatory expectations are introduced or updated, list specific noncompliant items and identify each item as being a minor, major, or serious noncompliant event. Noncompliance is managed in accordance with the EUB's enforcement ladders, which are based on a concept of escalating consequences for repeated noncompliance. For further information, see EUB *Informational Letter* (*IL) 99-4: EUB Enforcement Process, Generic Enforcement Ladder, and Field Surveillance Enforcement Ladder* and *IL 99-4 Clarification*.

4 Requirements Summary

Storage requirements for materials produced, generated, and used by the upstream petroleum industry are based on concern about

- the type of material being stored,
- the volume of material being stored,
- the environmental sensitivity of the site where material is being stored,
- the length of time the material is stored, and
- the nature and integrity of the primary containment device.

The following sections outline the primary containment, secondary containment, and leak detection requirements for aboveground storage tanks, underground storage tanks, containers, lined earthen excavations, and bulk pads.

Table 2 presents a summary of the general storage requirements for the above-mentioned containment devices.

Table 3 presents a summary of the inspection, monitoring, and record-keeping requirements applicable to the containment devices described in this guide.

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Table 2. General requirements for containment devices[1]

Primary containment device/size[2]	Section in *Guide 55*[3]	Design and construction	Secondary containment	Leak detection	Weather protection
Aboveground tank (1-5 m^3)[4]	5.1	Supplier specifications. Nonleaking hoses, fittings, and nozzles. Spill control devices.	Not required.	Monthly visual inspection.	External weather-protective coating or made from a weather-resistant material.
Aboveground open-topped nonmetallic tanks (<30 m^3)	5.2	Supplier specifications.	Not required.	Monthly visual inspection. Integrity verified every 5 years.	Not applicable.
Single-walled aboveground tank (>5 m^3)[4]	5.3.1 5.3.2	Cathodic protection in corrosive environments. External coating for steel tanks and internal coating in corrosive environments. Spill control devices.	Graded containment area. Dike (or curbing for indoor tanks) capacity 110% of tank or 100% of largest tank plus 10% of aggregate volume if more than one tank. Impervious liner.	Monthly visual inspection. Sand over liner and leakage collection area.	External weather-protective coating or made from a weather-resistant material.
Double-walled aboveground tank (>5 m^3)[4]	5.3.1 5.3.3	Cathodic protection in corrosive environments. External coating for steel tanks and internal coating in corrosive environments. Spill control devices including overfill protection.	Double walls with interstitial space.	Monthly monitoring of interstitial space.	External weather-protective coating or made from a weather-resistant material.
Underground tank[4] (any size); includes tanks and sumps)	6	Integrity testing of tank and piping prior to servicing. External coating and cathodic protection for steel tanks. Possible internal coating. Spill control devices.	Double walls with interstitial space.	Monthly monitoring of interstitial space.	Not applicable.
Container or group of containers (≤1 m^3 total)	7	Not applicable.	Not required.	Monthly visual inspection.	Not required.
Container or group of containers (>1 m^3 total)	7	Compatibility between container and stored materials. Segregated areas.	Dike, curb, and/or collection tray with a capacity of 100% of largest container or 10% of aggregate volume, whichever is greater.	Monthly visual inspection.	Physical cover (e.g., covered container or roof) or protective coating.
Lined earthen excavation	8	Specific to facility. Spill control devices.	Impervious liner.	Weeping tile. Monitoring well. Monthly monitoring.	Specific to facility and material type.
Bulk pad (solid material)	9	Specific to facility.	Impervious liner. Containment curb or dike.	Specific to material type.	Specific to facility and material type.

[1] Applies to new storage facilities constructed and operated after January 1, 2002. Applies to the permanent storage of produced water, crude oil, emulsions, condensates, chemicals, solvents, produced sand, lubricants other than for motor vehicle use, oilfield wastes, oily waste, and bitumen. Maximum storage duration should not exceed 2 years, except for oilfield wastes which should not exceed 1 year. All inventory records must be kept for 2 years. All leak-detection monitoring results must be kept for 5 years.

[2] Internal volume.

[3] See *Guide 55* section cited for more detailed information.

[4] Tank requirements apply unless the fluids being stored are waters that meet the surface discharge criteria (chloride < 500 mg/litre maximum; pH 6.0 to 9.0; no visible hydrocarbon sheen; and no other chemical contamination) or are fluids that are infrequently stored in tanks and the tanks are emptied immediately.

Table 3: A summary of inspection, monitoring, and record-keeping requirements

General	Aboveground storage tanks	Underground storage tanks	Container storage areas	Lined earthen excavations	Bulk pads
Inspection and monitoring					
• Field test retained surface waters prior to discharge for Cl (<500 ppm), pH (6-9), no visible sheen, no chemical contamination, landowner consent, no release to water (Section 11).	• Monthly external visual inspection of tank and diked area (Table 2, Section 5.3.2.2). • Integrity verified every 5 years (if installed prior to 1996 and >5 m^3 or a tank under Section 5.2) (Table 2). • Monthly interstitial space monitoring for double wall tanks (Table 2) unless equipped with a continuous monitor (Section 5.3.3). • Alternative inspection frequencies allowed as per Section 4 of API Standard 653 (Section 5.3.2.2).	• Monthly interstitial space monitoring for double wall tanks (Table 2, Section 6.2). • Integrity verified every 3 years (if single wall tank and installed prior to 1996) (Table 2). • Monthly monitoring of monitoring wells associated with single wall tanks with secondary containment. Field test any liquids for pH, Cl, hydrocarbon odour, and visible oil sheen (Appendix 2.2.1).	• Monthly external visual inspection (Table 2, Section 7.2).	• Monthly monitoring of leak detection system (Table 2, Section 8.2). - Field test any collected liquids for pH, Cl, hydrocarbon odour, and visible sheen. If any problems encountered, send to lab for analysis. • Annual lab sample from leak detection liquids for pH, EC, major ions, oil and grease, and any other parameter at EUB discretion (Section 8.2).	• If storing materials that may generate leachate, see Section 8.2.
Record-keeping					
• Maintain inventory records for wastes and chemicals for 2 years (Section 10). • Maintain groundwater monitoring records for 5 years, but preferably for the lifetime of the facility (Section 10). • Maintain alternative leak detection records (e.g., vapour surveys, EM surveys) for 5 years, but preferably for the lifetime of the facility (Section 10). • Maintain copies of all required approvals, licences, registrations, and permits on site or at the Field Centre (Section 10). • Maintain names of all persons conducting inspection and monitoring programs (Section 10). • Maintain records of surface water discharges, including pre-release field test results and volume released (Section 11).	• Maintain tank inspection records/results for 5 years, but preferably for the lifetime of the tank (Section 10). • Maintain corrosion monitoring records for 5 years, but preferably for the lifetime of the tank (Section 10). • Document abnormal circumstances and corrective actions from monthly visual tank and dike inspections and retain for 5 years, but preferably for the lifetime of the tank (Section 10). • Document abnormal circumstances and corrective actions from monthly interstitial monitoring of double wall tanks and retain for 5 years, but preferably for the lifetime of the tank (Section 10).	• Maintain tank inspection records/results for 5 years, but preferably for the lifetime of the tank (Section 10). • Maintain corrosion monitoring records for 5 years, but preferably for the lifetime of the tank (Section 10). • Document abnormal circumstances and corrective actions from monthly interstitial monitoring of double wall tanks and retain for 5 years, but preferably for the lifetime of the tank (Section 10). • Maintain monthly monitoring well results and any corrective actions from single wall tanks with secondary containment (Appendix 2.2.1).	• Document abnormal circumstances from monthly visual inspections and retain for 5 years (Section 7.2).	• Maintain monitoring results (including field and laboratory analytical results) and any subsequent corrective actions from leak detection systems for 5 years (Section 10). • EUB notification required if contamination found in leak detection system. Report must include 1) the parameters that changed, 2) investigative work conducted, 3) remedial work proposed (Section 8.2).	• If storing materials that may generate leachate, see Section 8.2.

5 Requirements for Aboveground Storage Tanks

Aboveground storage tanks must be constructed from suitable metallic or nonmetallic materials capable of containing the stored materials (e.g., steel-welded and/or skid-mounted tanks, plastic totes or slips, or fibreglass-reinforced plastic tanks). Bolted tanks are not a preferred containment device for new installations. Aboveground storage tanks with an internal volume less than 1 m^3 are considered to be containers (see Section 7, Storage Requirements for Containers).

5.1 Aboveground Storage Tanks with an Internal Volume Less Than 5 m^3

Aboveground storage tanks with an internal volume greater than 1 m^3 but less than 5 m^3 (e.g., mounted methanol/glycol/chemical tanks) must

- be visually inspected on a monthly basis to verify their integrity,
- have operable and nonleaking fittings, nozzles, and hoses,
- have preventive measures implemented to avoid spills and leaks at fluid transfer points (e.g., piping, flanges, valves), and
- be either externally coated (e.g., painted, galvanized steel) or made from a weather- and corrosion-resistant material (e.g., plastic, fibreglass).

Upstream petroleum sites can store a total combined volume of 5 m^3 per site of fluids in small tanks without secondary containment. However, nonvisual leak detection and secondary containment provisions should be considered if a release or spill could not be contained on site or if a spill or release could reasonably be expected to present a risk to a stream, water body, or groundwater or cause other environmental concerns.

Small tanks exceeding the total combined volume of 5 m^3 per site require secondary containment.

5.2 Aboveground Open-Topped, Nonmetallic Tanks with an Internal Volume Less Than 30 m^3

The storage of produced water from shallow, low-pressure gas wells in **only** the Milk River, Medicine Hat, or Second Whites Specks pools is allowed in open-topped, non-metallic tanks, provided the tank volume is less than 30 m^3. These types of containment devices are made of a thick synthetic material and do not require secondary containment and leak detection. These tanks must be visually inspected monthly and be verified for integrity every five years.

In the spirit of continuous improvement, EUB *IL 99-5: The Elimination of the Surface Release of Produced Water* ended the exemption that allowed shallow gas producers in the southeastern portion of Alberta to release produced fluids and solids to the well-site surface. This was previously allowed in *IL 93-10: Revised Measurement and Accounting Procedures for Southeastern Alberta Shallow Gas Wells*. As per *IL 99-5*, approval holders or licensees of shallow gas wells are to have appropriate storage and disposal systems for produced water in place as of September 30, 2000. The exemption from produced water reporting requirements, as per *IL 93-10*, for qualified wells remains.

5.3 Aboveground Storage Tanks with an Internal Volume Equal to or Greater Than 5 m^3

Aboveground storage tanks with an internal volume of 5 m^3 or greater (except as detailed in Section 5.2) and small tanks exceeding the total combined volume of 5 m^3 (as outlined in Section 5.1) must meet the construction, leak detection, secondary containment, weather protection, and spill control provisions outlined in the following subsections.

5.3.1 Construction

General construction and installation factors for aboveground storage tanks are as follows:

- Tanks must be designed, fabricated, tested, and installed to applicable engineering, manufacturing, and regulatory standards.
- Tanks must either be made from or externally coated with a weather-resistant material.
- Steel tanks must be externally coated (e.g., painted, galvanized), and if storing corrosive liquids, they should be internally coated or lined to minimize corrosion. In corrosive environments, it may be appropriate to apply cathodic protection to aboveground steel tanks.
- Transfer lines and hoses must be compatible with the material being transferred and shall have leak-proof connections.
- Spill control devices must be used around hose connections at fluid transfer points to help prevent the contamination of soil, surface runoff water, and groundwater. Spill control devices should include methods to
  - keep precipitation or other materials out of the spill control device,
  - prevent rusting and allow for easy inspection of their integrity (e.g., elevation above ground level), and
  - recover any spilled or leaked fluids from the device.
- Tank loading and unloading areas must be designed to contain any spills or leaks.
- Sites must be appropriately contoured to prevent the collection of surface water on the ground immediately surrounding the secondary containment system (e.g., tank farm area).
- Tanks that have been withdrawn from service are permitted to be reused if they comply with Section 12, Withdrawal of Storage Tanks from Service.
- Measures must be incorporated to prevent the overfilling of tanks. Examples 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, and overfill alarm devices of the audible or visual type

(single-stage or two-stage activation), inventory control, and any other appropriate measure that will prevent overfilling.

For further information regarding the construction and installation of aboveground tanks, see Appendix 3: References—Construction Standards for Aboveground and Underground Storage Tanks.

5.3.2 Single-Walled Aboveground Tanks with an Internal Volume of 5 m^3 or Greater

5.3.2.1 Secondary Containment

The area around a single-walled aboveground storage tank must have a secondary containment system designed to contain leakage and prevent it from impacting the surrounding environment. Secondary containment systems must consist of an impervious liner and a dike. At in situ oil sands operations, if a conventional dike interferes with operations (e.g., production trucking and tank clean-outs), the secondary containment system must be lined and graded to collection area(s) so that the system meets the capacity requirement of a conventional diked system, as outlined in Section 5.3.2.1(a).

The area within the secondary containment system must be 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 tanks. No uncontrolled discharge of collected fluids or discharge of untested fluids is permitted. (See Section 11 for surface water discharge criteria.)

5.3.2.1(a) Dikes

A dike must

1) be constructed of soil, steel, concrete, solid masonry, or synthetic material and designed to contain liquids within the diked area, to be able to withstand the hydrostatic head associated with it being full of liquid, and so that it will not deteriorate or develop leaks during the projected life of the structure;

2) be sized to have a volumetric capacity of not less than 110 per cent of the capacity of the tank when the diked area contains one tank or when the diked area contains more than one tank of not less than the sum of

    a) the capacity of the largest tank located in the diked area, and

    b) 10 per cent of the greater of

        - the capacity specified in (a), or

        - the aggregate capacity of all other tanks located in the diked area;

3) have no openings in it (e.g., dike drains to the surrounding area); and

4) be maintained in good condition. The area encompassed by the dike must be kept free from weeds, debris, and extraneous combustible material.

5.3.2.1(b) Impervious Liners

A liner must meet the following criteria:

1) consist of a material that is inert to or compatible (chemically resistant) with the material being stored in the tank;

2) be impervious (i.e., a compacted clay liner meeting the criteria specified in Section 13.1, a natural liner meeting the criteria specified in Section 13.2, or a synthetic liner as described in Section 13.3);

3) be durable and appropriate for the operating and ambient conditions; and

4) cover the area within the dike, including the area beneath the tanks, and be keyed into the dike walls.

5.3.2.2 Leak Detection

Approval holders or licensees must be able to demonstrate the integrity of their tanks and verify whether any material has escaped. Leak detection methods for aboveground storage tanks include the following:

- Incorporation of a layer of porous material, such as sand, over the liner and underneath the tanks to provide protection to the liner and to allow any leakage to move preferentially through the porous material to a collection area within the diked area.

- Monthly visual inspections of tanks and the surface of the diked area for evidence of problems, damage, or leakage. Any spills or leaks must be cleaned up immediately and reported if required (see *IL 98-1*), and corrective action must be initiated as required. Abnormal circumstances and corrective actions must be documented.

Additional leak detection provisions may also include the incorporation of subliner leakage detection devices (e.g., weeping tile system). Refer to Section 10 for record-keeping information. Approval holders or licensees should also be aware of the inspection frequencies referenced in Section 4 of API Standard 653.

5.3.2.3 Secondary Containment for Indoor Single-Walled Aboveground Storage Tanks

Indoor aboveground storage tanks must be surrounded by a containment device (e.g. an impervious containment base and wall or curbing) and/or drain and collection tank that has a capacity as described in Section 5.3.2.1(a)(2). Additional provisions of the Alberta Fire Code may also apply.

5.3.3 Double-Walled Tanks (Internal Volume ≥ 5 m^3)

A double-walled aboveground tank may be used as an alternative to a single-walled aboveground tank using a secondary containment system consisting of a liner and a dike.

Aboveground storage tanks with double walls must

- have the primary tank separated from the secondary containment so as to provide a continuous interstitial space below and around the primary tank;
- be equipped with a method of overfill protection that incorporates an audible or visual alarm that alerts the approval holder or licensee of a potential overfill condition or an automatic shutoff mechanism to prevent the overflow of the primary tank;
- be equipped with an effective spill control device at the fill/delivery connection;
- have a system to monitor the interstitial space between the tank walls (e.g., pressure, vacuum, electronic, or vapour monitoring or manual sampling);
- be protected against damage from vehicular traffic (e.g., controlled access to the site, bollards, guard rails, or concrete barricades);
- be equipped 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; and
- for systems designed with delivery connections at grade level (bottom load), be equipped with provisions to allow the delivery hose to be emptied and with a drip catchment device for the hose.

Approval holders or licensees must check the interstitial-space monitoring device at least monthly to ensure that the tank system is not leaking and must document any abnormal circumstances, as well as any corrective actions taken. Monthly checks may not be required if the interstitial space is equipped with a continuous monitoring system that will indicate when the primary or secondary tank is leaking. Automatic shutdown systems must be checked monthly and maintained to ensure continuous functionality, and documentation pertaining to this and any abnormal circumstances from the monitoring/sampling of the interstitial-space must be retained and made available to EUB staff upon request.

Any spills or releases must be cleaned up immediately and reported if required (refer to *IL 98-1*). As required, corrective action must be initiated and abnormal circumstances and corrective actions must be documented. Refer to Section 10 for more detail on record keeping.

6 Requirements for Underground Storage Tanks

Since aboveground storage tanks are preferable to underground storage tanks, the decision to install an underground storage tank must include sound justification, giving consideration to environmental, safety, operational, and economic factors. Underground tanks may be of any volume and may include steel, fibreglass-reinforced plastic, plastic storage tanks, and drip collection devices. Receiving tanks for incoming trucked fluids at oil sands cleaning facilities may also be considered as underground tanks.

6.1 Construction

General construction factors for underground storage tanks are as follows:

- Underground storage tanks must be double-walled, designed, fabricated, tested, and installed to applicable engineering, manufacturing, and regulatory standards.
- Newly installed underground storage tanks and associated piping must be tested for integrity as a complete system prior to placing in service.
- Steel tanks must have cathodic protection and an external coating to minimize corrosion. 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.
- Transfer lines and hoses must be compatible with the material being transferred and have leak-proof connections.
- Spill control devices must be used around hose connections at fluid transfer points to help prevent the contamination of soil, surface runoff water, and groundwater. Spill control devices should include methods to
  - keep precipitation or other materials out of the spill control device,
  - prevent rusting and to allow for easy inspection of their integrity (e.g., elevation above ground level), and
  - recover any spilled or leaked fluids from the device.
- Tank loading and unloading areas must be designed to contain any spills and leaks.
- Breathing vents must be designed to prevent the overflowing of fluids onto the ground.
- Tanks that have been withdrawn from service are permitted to be reused where they comply with Section 12, Withdrawal of Storage Tanks from Service.
- Measures must be incorporated to prevent the overfilling of tanks. Examples include automatic shutoff devices, high-level alarms, two-stage alarms, visual indicators, and any other measure that will prevent overfilling.

For further information regarding the construction and installation of underground tanks, see Appendix 3: References—Construction Standards for Aboveground and Underground Storage Tanks.

6.2 Secondary Containment and Leak Detection

Approval holders or licensees must provide a secondary containment system that will contain any leakage and prevent it from impacting the environment. Secondary containment is achieved through the use of double-walled tanks that allow monitoring of the interstitial space between the two walls.

The interstitial space of the double-walled tanks must be monitored monthly using pressure monitoring, vacuum monitoring, electronic monitoring, vapour detection, manual sampling, or an equivalent method. Any abnormal circumstances must be documented, as well as any corrective actions taken. Any spills or releases must be cleaned up and reported if required (refer to *IL 98-1*). Refer to Section 10 for more detail on record keeping.

7 Storage Requirements for Containers

It is recognized that in some circumstances the storage of material in containers may pose an environmental hazard due to the nature of the stored materials, the material quantity, and the topography, hydrogeology, and surficial geology of the site. The following requirements have been prepared to address these concerns and are applicable to the storage of both solids and liquids in containers.

A container is considered a portable aboveground storage device that does not exceed 1 m^3 in capacity. The total combined volume of containers without secondary containment cannot exceed 1 m^3 (e.g., approximately five barrels or five 45-gallon drums) on any site. However, secondary containment should be considered if a release or spill could not be contained on site or if a spill or release could reasonably be expected to present a risk to a stream, water body, groundwater or cause other environmental concerns.

All containers that exceed the total combined volume of 1 m^3 require secondary containment (e.g., five or fewer barrels on a site do not require secondary containment, but for sites with more than five barrels, the number of barrels exceeding five require secondary containment). Weather protection may also be appropriate 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.

7.1 Secondary Containment

Secondary containment systems for containers (e.g., dikes, curbs, and collection trays) must be constructed of materials that are impervious to the materials being stored and must

- be constructed of material that will not react with or absorb any material being stored and that has no openings that may provide a direct connection to the ground underneath or surrounding the primary container;
- have a net capacity greater than that of the largest container within the storage area or 10 per cent of the total volume of all containers in the storage area, whichever is greater;
- be achieved through the proper use of at least one of the following devices:
  - storage compound that meets the secondary containment criteria for aboveground storage tanks (e.g., impervious liner and dike; see Section 5.3.2.1(a)(2)),
  - storage building with curbing,
  - storage trailer,
  - metal and plastic bins,
  - overpacks, or
  - drip trays or spill pallets.

Storage trailers and buildings must include the following:

- clad structures with concrete floors and curbing that is a minimum height of 15 cm and is placed on the perimeter of the floor in such a manner that the contained material cannot escape between the floor and curb,
- clad structures with a containment floor,
- sealed shipping containers with a containment floor, and
- loading dock buildings with a containment floor.

Design considerations for trailers and buildings must include the following:

- compatibility of the construction materials with the materials being stored,
- proper ventilation of vapour emissions from the materials being stored,
- compliance with fire and electrical codes,
- security measures or procedures to prevent unauthorized entry, and
- absence of floor drains directly connected to the outside.

7.2 Leak Detection and Weather Protection

Leak detection systems, other than visual leak detection, are not required for the storage of containers, provided that the approval holder or licensee can demonstrate that a container storage area is protected from the elements and/or has an appropriate secondary containment system. Any abnormal circumstances must be documented.

Weather protection is intended to preserve the condition of the primary container and hence the usefulness of the material contained therein. Weather protection is considered to be a physical cover/coating over containers. 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.

8 Requirements for Lined Earthen Excavations

The storage systems described below are typically used to

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

8.1 Construction

Acceptable designs include

- earthen excavations with a primary containment device, an impervious synthetic liner system for secondary containment, and a leak detection system between the secondary and primary containment devices;
- semi-buried metal tanks with external and internal corrosion protection and an appropriate leak detection and secondary containment system; and
- steel or other storage devices constructed on grade and then backfilled on one or more sides, with an appropriate secondary containment and leak detection system.

Operational procedures must be considered when choosing the primary containment device. Although concrete provides a durable working surface, it is too porous and susceptible to cracking to be considered primary containment. While synthetic liners provide an impervious barrier, they often require protection from daily operations (e.g., from equipment used for loading or unloading operations).

The above storage systems must be designed to provide for the collection and containment of spills that may occur during loading or unloading operations and to operate with sufficient freeboard to prevent their overflowing. The bottom of these storage systems must not be within 1 metre of the seasonably high-groundwater table.

Due to the nature of the operations typically associated with these types of storage systems, they are usually of an open-top construction. In situations where fugitive odours and access by wildlife are concerns, these storage systems should be fitted with mitigative measures.

8.2 Secondary Containment and Leak Detection

For those storage systems that are below grade, the secondary containment system must include an impervious synthetic liner, as detailed in Section 13.3. In order to protect the 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 liner must be laid down in the appropriately prepared earthen excavation with an appropriate amount of sand or other material placed on top of the liner surface. The earthen excavation receiving the liner must be sloped, with the low point being down gradient of the directional flow of groundwater.

The leak detection system must have an engineered seepage pathway (e.g., weeping tile) leading to at least one monitoring well. The monitoring well(s) must be completed at the low end, positioned between the secondary containment liner and the primary containment device. To avoid compromising the integrity of either the primary or secondary containment device, the piping for the monitoring well(s) must not go through them.

For those storage systems constructed on grade and then backfilled on one or more sides, the use of a compacted clay liner as described in Section 13.1 with an appropriate leak detection system may be considered.

The leak detection system must be monitored on a monthly basis. Any collected liquids must be field tested for pH (e.g., using test strips or meter), chlorides (e.g., using test strips), hydrocarbon odour, and a visible oil sheen. The results from the monthly field tests must be recorded, and if there is indication of a problem, laboratory analyses must be performed for verification and then, if necessary, followed by appropriate corrective measures.

On an annual basis, a sample of the liquids collected from the leak detection system must be analyzed by a laboratory for the parameters listed below:
- pH,
- electrical conductivity,
- major ions (e.g., Ca, Mg, Na, K, NO_3, SO_4, Cl, PO_4),
- oil and grease, and
- any other parameter deemed necessary by the EUB.

Note that if any of the parameters have changed significantly in comparison to previous results or monitoring results indicate there may be a potential concern, additional analyses should be performed for verification and, if necessary, followed by corrective measures.

The EUB must be notified if any of the monitoring results indicate a concern. The notification must describe
- the parameters that changed,
- the investigative work conducted, and
- any remedial or corrective work that has occurred or is proposed.

Refer to Section 10 for more detail on record keeping.

9 Requirements for Bulk Pads

Approval holders or licensees may require the construction of permanent bulk pads on sites to be used for the storage of solid materials, such as contaminated soils, spent desiccant, catalyst, or activated carbon. In such cases, the bulk pad storage area must incorporate

- 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 of the bulk pad.

Materials must be stockpiled in a method that will not exceed the capacity of the bulk pad (e.g., piled at an appropriate distance from the curbs and with an appropriate slope to prevent the material from tumbling over the curbs surrounding the bulk pad).

In situations where the stored material(s) may potentially generate a leachate, concrete or asphalt may be used as a durable working surface but are not considered adequate as primary containment. The design of the pad must appropriately incorporate a compacted clay or synthetic liner under the working surface. In these situations the incorporation of a leachate collection system above the primary containment device and a leak detection system under the primary containment device is also required. Refer to Section 8.2 for the requirements for the design and monitoring of the leak detection system. Refer to Section 10 for more detail on record keeping.

For bulk pads, the liner or pad is considered the primary containment device and must have a hydraulic conductivity of 10^{-7} cm/s or less. Compacted clay liners must also meet the criteria specified in Section 13.1. Synthetic liners must be appropriate to serve as the primary containment device and meet the requirements outlined in Section 13.3.

10 Inspection, Monitoring, and Record-Keeping Requirements

The EUB requires companies to maintain records to demonstrate compliance. Inventory records for production materials are typically handled through the use of standard EUB production reporting forms, while the record retention and tracking requirements for oilfield wastes are addressed in EUB *Guide 58*.

With respect to the storage requirements outlined in this guide, approval holders or licensees of upstream petroleum sites must do the following:

- Maintain inventory records and retain the records (other than production reporting forms) on site or at the local field office for 2 years. Where applicable, this includes copies of dockets for material received and shipped.

- Maintain inspection and corrosion monitoring programs to provide an indication of the integrity of tanks and piping. Records of test or maintenance checks must be retained for a minimum of 5 years, but preferably for the lifetime of the tank or facility.

- Document and retain for a minimum of 5 years, but preferably for the lifetime of the tank(s), any abnormal circumstances identified from the monthly visual inspections of aboveground storage tanks, the monthly interstitial space monitoring of double-walled aboveground tanks, or the monthly interstitial space monitoring of double-walled underground storage tanks, as well as any corrective actions taken to remedy the situation and prevent it from reoccurring.

- Document and retain for a minimum of 5 years, but preferably for the lifetime of the storage device(s), the monitoring results from the leak detection system for lined earthen excavations and bulk pads, as well as any investigative work or corrective actions taken to remedy a breach of the storage devices.

  Note that in the event that a storage device has overflowed or its leak detection system indicates that it may be leaking, the approval holder or licensee must investigate the situation, verify the integrity of the storage device, report the release if required (see *IL 98-1*), and, if required, implement corrective actions. The actions must be documented and may include
  - repairing and testing the storage device,
  - replacing the storage device, or
  - implementing cleanup activities as required, including assessing the soil for contamination (see *IL 98-2*).

- Where applicable, retain groundwater monitoring records for a minimum of 5 years, but preferably for the lifetime of the upstream petroleum site.

- Maintain records from alternative leak detection systems (electromagnetic surveys, soil vapour surveys, weeping tile monitoring wells, and inventory reconciliation, etc.) for a minimum of 5 years, but preferably for the lifetime of the upstream petroleum site.

- Keep all required approvals, licences, and permits on site or at the field/plant offices.

- Maintain records on excavation or nearby construction that could affect the integrity of the storage system.
- Maintain the names of all person who conducted the inspection and monitoring programs.

11 Criteria for the Surface Discharge of Collected Surface Run-on/Runoff Waters

This section applies to EUB-only regulated upstream petroleum sites and to those EUB/AENV jointly regulated sites that do not have conditions in the EPEA approval pertaining to the discharge of collected surface run-on/runoff waters.

Provided the water has not been contaminated, surface run-on/runoff waters collected on an upstream petroleum site (e.g., within a diked area of a tank farm, within the surface water collection system) should be released back into the environment (hydrology cycle). Collected waters must be tested and meet the following criteria prior to being released in a controlled fashion to adjacent lands:

- chloride content 500 mg/L maximum (e.g., test strips),
- pH 6.0 to 9.0 (e.g., test strips and/or meter readings),
- no visible hydrocarbon sheen (roughly equates to less than 10 mg/L),
- no other chemical contamination (e.g., clean operating conditions such that collected waters are not impacted by spills/releases),
- landowner or occupant consent,
- water not allowed to flow directly into any watercourse, and
- each release recorded, including the prerelease test data and the estimated volume of water released.

Contaminated water must not be released into the environment. It should be sent to an approved facility for treatment and/or disposal or, if possible, treated on site and then released. The minimal parameters listed above are intended as screening parameters for sites exhibiting good house-keeping practices. On sites where spills or releases have occurred, the collected surface water should be tested for parameters that would demonstrate that the water has not been affected.

The discharge of collected surface waters into a watercourse is not permitted unless otherwise specified in an EPEA approval. Approval holders or licensees wishing to use collected surface waters in a facility's process must consult with AENV regarding the need for a water diversion licence.

12 Withdrawal of Storage Tanks from Service

This section applies to the procedures to be followed when aboveground or underground storage tanks used for upstream petroleum fluids are taken out of service.

12.1 Temporary Withdrawal from Service Not Exceeding 180 Days

When an aboveground or underground storage tank is taken out of service for a period not exceeding 180 days, the approval holder or licensee must

- isolate the tank,
- empty the tank or measure and record the fluid level in the tank and then repeat this procedure on a monthly basis, making records available to EUB staff upon request,
- maintain the impressed current cathodic corrosion protection system, if applicable, and
- maintain monthly leak detection monitoring.

12.2 Temporary Withdrawal from Service Exceeding 180 Days

When an aboveground or underground storage tank is taken out of service for a period exceeding 180 days, the approval holder or licensee must

- remove all liquids and vapours from the storage tank and its connecting piping,
- isolate the tank and mark it to clearly indicate that it is empty,
- maintain the impressed current cathodic corrosion protection system, if applicable, and
- verify the integrity of the tank prior to reactivation if the tank has been out of service for longer than 1 year (refer to Appendix 2 for integrity verification requirements) and then appropriately relabel the tank.

Should the approval holder or licensee wish to change the service of a tank, prior to reactivation the tank must be cleaned and refurbished if necessary and then verified for compatibility with the new service.

12.3 Permanent Withdrawal from Service

Aboveground and underground tanks permanently taken out of service must have all fluids and sludges removed and be purged of all combustible vapours. It is expected that aboveground tanks will be removed from the active part of the upstream petroleum site and either be relocated in an appropriate storage area on the site or sent for disposal. It is also preferred that underground tanks be removed from the active part of the upstream petroleum site. If this activity might compromise the operation of the upstream petroleum site, the underground tank must be appropriately isolated and then removed when the upstream petroleum site is decommissioned.

Upon removal of a tank, the soil surrounding the tank must be assessed and appropriately decontaminated. Excavated contaminated soils must be managed in accordance with *Guide 58,* while all in situ remediation programs must be managed to the satisfaction of Alberta Environment. Also refer to *IL 98-2* for further information regarding the contamination management. All decontamination work, including verification (through confirmatory soil samples) that remediation objectives were achieved, must be documented and made available upon request to the EUB or Alberta Environment.

13 Liner Specifications

Natural and synthetic liners are used in storage and treatment areas to impede the movement of materials that could adversely impact soil or groundwater. The initial decision in the installation of any liner is whether the liner type is appropriate for the given application. It is important to remember that the purpose of a secondary containment liner is not to function as a tank or other primary containment. When the leak detection system is activated, the tank or storage system must be shut down, inspected, and repaired.

There are two modes of mass transfer through a barrier such as a liner: liquid transfer (through hydraulic conductivity) and vapour transfer (through molecular diffusion). Hydraulic conductivity is applicable to natural materials, where mass transfer depends on the movement of liquid through pore structure of a soil and the driving force is hydraulic pressure or head. Vapour transfer is applicable to polymer barriers, where the driving force is the concentration gradient of the permeating substance across the barrier. Although no material is completely impermeable, the type, design, and installation of a liner is extremely important in achieving the desired level of impermeability for both primary and secondary containment liners.

13.1 Compacted Clay Liners

Clayey soils may be suitable material from which to construct a compacted clay liner. For the purpose of secondary containment, the clayey soil must be compacted to achieve a hydraulic conductivity of 1×10^{-6} cm/s or less determined in situ or 1×10^{-7} cm/s or less determined in a laboratory from a representative disturbed sample (material must meet hydraulic conductivity requirements under full hydrostatic head). For use as primary containment, compacted clay liners must have a hydraulic conductivity that is at least one order of magnitude less than that required for secondary containment.

Literature suggests that a hydraulic conductivity of $\leq 1 \times 10^{-7}$ cm/s is achievable if suitable starting material (clayey soil) is excavated, reworked, or homogenized and laid down in lifts following appropriate construction protocol on a properly prepared sub-base. Key properties in achieving low hydraulic conductivity are the Plasticity Index and clay content of the soil. There are reasons to prefer a soil of low plasticity over highly plastic clay, as soils with low plasticity are often easier to mix, hydrate, and homogenize in the field and tend to be less susceptible to desiccation cracking. The ideal situation involves small, soft, weak clods of clay that are easily remolded and compaction with a heavy roller that effectively remolds and melds the clay clods together.

Literature identifies that the most important factors in achieving low hydraulic conductivity in compacted clay liners include

- using suitable clayey soils that meet the following specifications:
  - greater than 30 per cent fines (defined as dry weight percentage passing the No. 200 sieve)
  - greater than 20 per cent clay (0.002 mm or smaller as determined by hydrometer method)
  - well graded (no excess of particles in any size range and no intermediate sizes lacking)

    - Liquid Limit (LL) equal to or greater than 30
    - Plasticity Index (PI) equal to or greater than 10

- laying the clayey soil down in lifts
    - a minimum of four lifts, with each being 15 to 20 cm thick (loose thickness)

- properly preparing the surface to receive a lift of soil
    - if placing the soil on sub-grade, the sub-grade must be adequately compacted
    - if placing the soil on a previously compacted lift, the surface should be scarified to a nominal depth of 2.5 cm prior to placing the next lift of soil

- using the clayey soil at the correct water content
    - each lift must be placed at approximately 2 to 3 per cent wet of optimum moisture

- compacting each lift to a minimum of 95 per cent of the Standard Proctor maximum dry density using the proper type of compactor with an appropriate number of passes
    - the best type of compactor in most instances is a heavy, footed roller with feet that fully penetrate the loose lift of soil
    - the compactor must be heavy enough to ensure that adequate compactive energy is delivered to the soil and that the feet fully penetrate the full depth of the lift to kneed it and bond it to the previous lift
    - the number of compactor passes over a given area varies between soil and compactor type, but sufficient passes must be conducted to achieve the desired density

- placing down sufficient lifts to achieve a final compacted thickness of 0.6 m or greater

- protecting each compacted lift from damage
    - a smooth-drum roller is often used to compact the surface of a completed lift, as this forms a hard skin, which helps to minimize desiccation and sheds water
    - the smooth surface should be roughened with a disc prior to placing the next lift
    - upon completion of the liner, an appropriate overlying material must be used to protect the liner from mechanical damage and weathering

The construction of a compacted clay liner requires application by qualified personnel overseen by a professional geotechnical engineer. The specifications of the clayey material used for the liner and the details of the liner construction (quality assurance/quality control [QA/QC] data) must be documented and made available to EUB staff upon request.

13.2 Natural Liners

Natural liners involve scarification and recompaction of in situ clay, without excavating the underlying clay, and placing it in lifts as for a compacted clay liner. Natural liners may only be used at sites that have a deposit of appropriate clayey soils with a minimum thickness of 0.9 m and where the seasonal high groundwater table is greater than 1 m below the expected bottom of the liner.

The potential for in situ clayey deposits to serve as natural liners should only be investigated when sites are located in relatively low-permeability clay or till. Delineation of the in situ clayey deposit requires a site investigation by a qualified person. Attention should be focused on looking for hydraulic defects, such as sand seams, cracks, and fissures. A minimum of three boreholes, arranged in an approximate equilateral triangle, is required to establish orientation of any significant geologic plane. Depth of sampling from the surface to characterize underlying soil materials must be at least 3 m. One sampling must be extended to establish depth to groundwater. The clayey soil must be analyzed in a lab to determine Liquid Limit, Plasticity Index, clay content, and fines content (refer to criteria in Section 13.1).

Literature identifies that the most important factors in achieving suitable natural liners include

- preparing the site for the construction
    - remove the topsoil from the site and appropriately salvage and store it
    - remove rocks or clumps greater than 50 mm in size

- scarifying and recompacting the in situ clayey deposit to 95 per cent of the Standard Proctor maximum dry density
    - only scarify the in situ clayey deposit to a depth that can be recompacted using select equipment
    - the in situ clay must be at 2 to 3 per cent wet of optimum

- smoothing out the completed liner with a smooth barrel compactor and applying overlying material to protect the liner from mechanical damage and weathering.

The completed liner must achieve a hydraulic conductivity as specified in Section 13.1. A variety of geochemical, geophysical, and engineering tools are available for investigating the hydraulic integrity of natural liners. Literature indicates that for natural liners, in situ hydraulic conductivity tests can be more accurate than laboratory tests.

The construction of a natural liner requires application by qualified personnel overseen by a professional geotechnical engineer. The specifications of the clayey deposit, including the site delineation information, and the details of the liner construction (QA/QC data) must be documented and made available to EUB staff upon request.

13.3 Synthetic Liners

A wide array of synthetic liners are available, many of which were developed for applications such as waste containment. 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 cover, and its resistance to the substance contained in the storage system. As secondary containment application does not require long-term, continuous contact with the contained substances, the requirements for liner performance in secondary containment systems may be less rigorous than those for primary containment systems.

Most synthetic liners are impermeable to liquid transfer but are permeable to vapour to a degree that depends on the solubility of the liquid in the polymer, temperature, and the thickness of the membrane. The most important physical and mechanical attributes of the liner that determine its suitability 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.

The physical configuration of the liner determines the seaming and construction procedures used to install it. Therefore, the installation of synthetic liners must follow the manufacturer's specifications and be conducted by qualified personnel. The specifications of the liner material (suitability for its intended use) and the details of its installation (QA/QC data) must be documented and made available to EUB staff upon request. To be suitable for secondary containment, the synthetics liner must be a minimum of 30 mils.

Synthetic liners used for secondary containment in the petroleum industry include

- coated fabrics or laminates,
- extruded film or sheet, and
- spray-on coatings.

13.3.1 Coated Fabrics and Laminates

These geomembranes include polymer films coated or laminated onto a textile substrate by means of a manufacturing process such as calendaring or coating. Polymer formulations include chorosulfonated polyethylene, neoprene, ethylene, interpolymer alloy, butyl rubber, epichlorohydrin rubber, ethylene proylene diene monomer (EPDM), and various combinations. The coatings are typically elastometric or rubbery in character, and the substrates are usually high-strength textiles with a broad weave (e.g., nylon, polyester).

13.3.2 Extruded Film or Sheet

Geomembranes of this kind are manufactured in a one-step process without the use of a textile backing or substrate and are made from polyvinyl chloride (PVC), high-density polyethylene (HDPE), polyethylene of lower densities, and elastomers. Because of its chemical resistance, HDPE is widely used and is available in thickness ranging from 20 mils to greater than 100 mils.

13.3.3 Spray-on Coatings

These products are usually installed by spraying elastomers (e.g., polysulfide, polyurethane) onto a geotextile or other material for backing. The coating thickness is variable and is a function of the spray dwell time, flow rate, and operator technique. Both polysulfide and polyurethane have good resistance to petroleum products. The resulting sprayed-on coating has added durability and strength because of the geotextile backing.

Appendix 1 Glossary of Storage Terms

The words and terms used in *Guide 55* have the following meanings unless otherwise indicated in a particular context.

Aboveground storage tank: A tank that sits on or above the ground surface and whose top and complete external sides can be visually inspected.

Adverse effect: An impairment of or damage to the environment, human health or safety, or property.

Bulk pads: A ground surface area designated for the segregated storage of materials without the use of a container or tank.

Cathodic protection: A method of preventing corrosion to a metal surface by introducing another metal (anode) into the ground to create a corrosion cell in which the surface to be protected becomes a cathode. If deterioration or corrosion occurs at the anode (introduced metal), the cathodic protection may be of a sacrificial type or impressed current design.

Condensate: A mixture mainly of pentanes and heavier hydrocarbons that may be contaminated with sulphur compounds, that is recovered or is recoverable at a well from an underground reservoir, and that may be gaseous in its virgin reservoir state but is liquid at the conditions under which its volume is measured or estimated.

Container: Any portable aboveground containment device (e.g., drums, pails, bags, boxes, totes) with a capacity not exceeding 1 m^3.

Containment device: See "Primary containment device" and "Secondary containment device."

Crude bitumen: A naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane, that may contain sulphur compounds and that in its naturally occurring viscous state will not flow to a well.

Crude oil: A mixture mainly of pentanes and heavier hydrocarbons that may be contaminated with sulphur compounds, that is recovered or is recoverable at a well from an underground reservoir, and that is liquid at the conditions under which its volume is measured or estimated and includes all other hydrocarbon mixtures so recovered or recoverable except raw gas, condensate, or crude bitumen.

Environment: All components of the earth including air, land, and water; all layers of the atmosphere; all organic and inorganic matter and living organisms; and interacting natural systems.

Facility: Any building, structure, installation, equipment, or appurtenance over which the EUB has jurisdiction and that is connected to or associated with the recovery, development, production, handling, processing, treatment, or disposal of hydrocarbon-based resources or any associated substances or wastes and includes, without limitation, a battery, a processing plant, a gas plant, an oilfield waste management facility, a central processing facility as defined in the Oil Sands Conservation Regulation (AR 76/88), a compressor, a dehydrator, a separator, a treater, a custom treating plant, a produced water injection plant, a produced water disposal plant, a miscible flood injection plant, a satellite, or any combination of them, but does not include a well, a pipeline as defined in the Pipeline Act, a mine site or processing plant as defined in the Oil Sands Conservation Regulation (AR 76/88), or a mine or coal processing plant as defined in the Coal Conservation Act.

Freeboard: The unused upper portion of a primary containment device.

Impervious: A natural material that demonstrates a hydraulic conductivity of 10^{-6} cm/s or less as determined in situ or of 10^{-7}cm/s or less as determined in a laboratory from a representative disturbed sample, or a synthetic membrane liner or barrier appropriately selected to control the migration of specific fluids.

Leachate: Interstitial fluids separated from materials or fluids generated by the percolation of liquids (e.g., water) through materials.

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; may include visual, electronic, or statistical inventory methodologies.

Liquid: A substance that contains free liquids as determined by the US EPA Method 9095 Paint Filter Liquids Test, *Test Methods for Evaluating Solid Wastes Physical/Chemical Methods* (EPA Publication No. SW 846).

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.

Oilfield waste: An unwanted substance or mixture of substances that results from the construction, operation, abandonment, or reclamation of a facility, well site, or pipeline but does not include an unwanted substance or mixture of substances from such a source that is received for storage, treatment, disposal, and/or recycling at a facility regulated by Albert Environment.

Oilfield waste storage area: An area of an EUB-licensed or approved facility (on-site oilfield waste management component) that is used for the purpose of collecting and storing in containers, tanks, bulk pads, or lined earthen excavations oilfield or oily wastes from sites within the same production system.

Oilfield waste storage facility: An EUB-approved stand-alone storage facility constructed for the purpose of collecting and storing one company's oilfield wastes until volumes are sufficient for economic transfer of the wastes to treatment/disposal facilities.

Oily waste: A specific type of oilfield waste that contains oil or bitumen generated primarily during heavy oil production and typically consists of mainly produced sand and slop oil.

Petroleum product: A single product or a mixture of at least 70 per cent hydrocarbons refined from crude oil, with or without additives, that is or could be used as a fuel, lubricant, or power transmitter. Without restricting the foregoing, such products include gasoline, diesel fuel, aviation fuel, kerosene, naphtha, lubricating oil, fuel oil, and engine oil (including used oil) and exclude propane, paint, and solvents.

Primary containment device: A device used to physically contain materials produced, generated, or used in processes regulated by this guide. Primary containment devices include, but are not limited to, single-walled tanks, the internal wall of double-walled tanks, containers, and the liners of lined earthen excavations and bulk pads.

Same production system: An interconnected system of upstream production facilities (e.g., wells, pipelines, batteries). An oil/gas production site receiving oilfield waste for on-site management or storage must be within the same interconnected system of upstream production facilities as the oil/gas production site from which the oilfield waste originated. Both the receiving site and originating site shall have the same licensee or approval holder.

Secondary containment system: An impervious barrier or liner used for the purpose of containing and preventing any leakage from the primary containment device from impacting the environment.

Site: The area defined by the boundaries of a lease site for an upstream petroleum facility or well site.

Small quantity exemption: Oilfield wastes (other than those substances listed in AENV's *Alberta Users Guide for Waste Managers*, Schedule, Table 4, Part B) are not considered dangerous and are exempt from the storage requirements if they are produced at any single site in an amount less than 5 kilograms (kg) per month if a solid or 5 litres (L) per month if a liquid and the total quantity accumulated does not exceed 5 kg or 5 L at any time.

Solid: A substance that does not contain free liquids as determined by the US EPA 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. Spill control devices must be maintained to ensure their integrity and that they are of sufficient capacity to be functional (e.g., free of precipitation).

Storage: The holding of materials produced, generated, and used by the upstream petroleum industry for a period of time until the products or wastes are transported, treated, or disposed.

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.

Underground storage tank: A tank, of any volume, that is partially or completely buried and does not allow for the visual inspection of the top, complete sides, and bottom of the tank without excavation.

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.

Weather protection: A structure, protective coating, or cover that ensures that the integrity of the primary containment device and its labelling are not compromised by the elements of nature.

Appendix 2 Storage Requirements for Existing Facilities, Well Sites, and Pipelines

1 Discontinued Storage Options (Effective January 1, 2002)

Upstream petroleum facilities, well sites, and pipelines constructed between January 1, 1996, and January 1, 2002, are expected to meet the storage requirements outlined in the 1995 edition of *Guide 55*. This 2001 edition of *Guide 55* discontinues the following options as of January 1, 2002:

- the use of single-walled underground tanks where a synthetic liner or the natural impermeable soil conditions (i.e., hydraulic conductivity of 10^{-6} cm/s or less) are used for secondary containment,
- the use of concrete-lined earthen excavations with an underlying leakage monitoring system, but no secondary containment, and
- the use of concrete as primary containment for lined earthen excavations or for bulk pads where there is potential for the stored materials to generate a leachate.

Any of the above storage systems installed prior to January 1, 2002, will be required to meet the requirements within the appropriate sections of this appendix.

Upstream petroleum facilities, well sites, and pipelines constructed as of January 1, 2002, must meet the storage requirements as outlined in the body of this 2001 edition of *Guide 55*.

2 Storage Requirements for Facilities, Well Sites, and Pipelines Operating Prior to January 1, 1996

Approval holders or licensees of upstream petroleum facilities, well sites, and pipelines operating prior to January 1, 1996, were required to demonstrate by October 31, 2001, that their storage practices and devices met the intent of the 1995 edition of *Guide 55* and follow existing EUB regulations. For aboveground tanks (internal volume 5 m^3 or greater) and underground tanks, approval holders or licensees had the option to either retrofit their upstream petroleum sites to meet the secondary containment and leak detection requirements outlined in Sections 5 and 6 (or if applicable, the requirements outlined in this appendix) or to test/inspect the tanks to verify their mechanical integrity. For small aboveground tanks where the total combined volume per site exceeded 5 m^3, approval holders or licensees were to either have met the secondary containment requirements outlined in Section 5.3 or to have verified the integrity of these tanks by October 31, 2001. Approval holders or licensees will be required to meet the secondary containment requirements for small aboveground tanks exceeding the total combined volume of 5 m^3 per site by October 31, 2004. For containers, lined earthen excavations, and bulk pads, approval holders or licensees must meet the requirements outlined in Sections 7, 8, and 9 or, if applicable, the requirements outlined in this appendix.

The objective of the requirements for existing facilities, well sites, and pipelines is to verify and possibly enhance the integrity of their existing primary containment devices. Approval holders or licensees were and will continue to be responsible to select and implement a suitable testing/inspection program to verify the mechanical integrity of existing storage devices. It is expected that professional engineering judgement was and will be exercised when selecting methodologies and integrity verification companies to ensure that the type of test planned is appropriate for the specific storage device application and the materials it stores.

Due to the large number of upstream petroleum sites, six years were provided to allow approval holders or licensees the opportunity to establish a schedule for the retrofitting or testing/inspection of their primary containment devices, as well as a schedule for the frequency to repeat the integrity verification tests/inspections. Factors to be considered in scheduling the retrofitting or testing/inspection of primary containment devices include age of device, type of service, site-specific environmental sensitivities, general lack of available information on the device, as well as the opportunity to combine it with a plant turnaround.

Approval holders or licensees repairing or replacing storage devices are reminded that the potential for contamination as a result of leaks or failures must be investigated and then managed in accordance with EUB *IL 98-2: Suspension, Abandonment, Decontamination, and Surface Land Reclamation of Upstream Oil and Gas Facilities.*

The results of the retrofitting, repairing, tests/inspections, or any corrective action (e.g., site investigation, decontamination work) must be documented, retained by the approval holder or licensee, and made available to the EUB upon request.

2.1 Aboveground Storage Tanks (Internal Volume ≥ 5 m^3)

2.1.1 Retrofitting

Approval holders or licensees that have retrofitted their upstream petroleum sites to meet the secondary containment requirements for aboveground tanks (i.e., installed double-walled tanks or secondary containment consisting of a dike and liner system meeting the requirements outlined in Section 5) are not required to integrity test these tanks, but must meet the monthly monitoring requirements for leak detection.

2.1.2 Integrity Testing

Approval holders or licensees that chose to verify the mechanical integrity of their aboveground tanks were to have the initial test/inspection completed by October 31, 2001. The intent of the 1995 edition of *Guide 55* was to provide industry with enough time to work out a schedule that would fit operations, especially for those companies with numerous facilities. It was intended that the integrity test/inspection be repeated on a five-year frequency, which was to be established by the date of the initial integrity test. However, this intent was not stated clearly. The revised integrity test/inspection schedule for aboveground tanks is as follows:

Year of first test	Year of second test	Year of third test
1998 or earlier	2003	2008
1999	2004	2009
2000	2005	2010
2001	2006	2011

Note that except for the duration between the first and second test for those tanks initially tested before 1998, integrity tests for aboveground tanks must be repeated at a minimum of every five years.

For information on the methodologies available for integrity testing aboveground storage tanks, see Table A1; for further explanatory notes, see Table A3. Approval holders or licensees must be able to verify that the test method used was appropriate for the specific situation and that the results were reliable. Approval holders or licensees may conduct alternate inspection schedules based on Section 4 of API Standard 653.

If the initial integrity test identified a problem with the aboveground storage tank, approval holders or licensees had the option to replace the tank with one that was integrity verified and appropriate for the type of service or to repair the tank and then retest it. If the results of the retest did not confirm the integrity of the tank, the tank was to be replaced with one that was integrity verified and appropriate for the type of service. These requirements are also applicable when the tanks are being reverified.

Note that approval holders or licensees must conduct monthly visual inspections of all aboveground tanks and the diked area for evidence of problems, damage, or leakage. Any spills or leaks must be cleaned up and, as required, corrective action initiated. Any abnormal circumstances must be documented.

2.1.3 Replacement of an Existing Aboveground Storage Tank or Addition of a New Tank to an Existing Tank Farm

When replacing an existing tank, it is not mandatory to upgrade the tank farm to meet full secondary containment and leak detection requirements as outlined in Section 5. As these sites were constructed prior to January 1, 1996, the capacity of the dike must as a minimum be 100 per cent the volume of the largest tank within the tank farm. Upon removal of the old tank, any contamination must be managed, and then the ground must be compacted and appropriately prepared for placement of the new tank.

Should an existing multi-tank farm have sufficient capacity to accommodate an additional tank, it may be added. However, if the addition of a new tank results in reconstruction of the tank farm area, it is expected that the reconstruction will meet the secondary containment and leak detection requirements outlined in Section 5.3.2.

Approval holders or licensees replacing a tank or adding a new one to an existing tank farm must meet the construction requirements outlined in Section 5.3.1. These tanks must be integrity verified every five years, unless the tank farm area has been reconstructed to meet the secondary containment and leak detection requirements outlined in Section 5.3.2 or an option to replace the integrity verification requirement (next section) has been implemented.

2.1.4 Options to Replace the Requirement to Integrity Verify Aboveground Tanks

The replacement of an existing tank or the addition of a new tank to an existing tank farm presents approval holders or licensees with the opportunity to install a liner or weeping tile system under the tank (see leak detection method in Table A1).
Although not mandatory, the installation of a weeping tile system or liner, combined

with monthly monitoring, may be used to replace the requirement to reverify the integrity of the tanks every five years. Any liquids collected in the weeping tile system must be field tested for pH (e.g., using test strips or meter), chlorides (e.g., using test strips), hydrocarbon odour, and a visible oil sheen. The results from the monthly field tests must be recorded, and if there is indication of a problem, investigative work must be conducted, followed by any necessary corrective measures.

Integrity verified, single-walled aboveground tanks within a diked area (on sites constructed prior to 1996) may be retrofitted with a second bottom and a system to monitor the interstitial space between the two bottoms. Provided the interstitial space is monitored monthly, this option may be used to replace the requirement to reverify the tank every five years.

Any abnormal circumstances from the monthly monitoring must be documented, as well as any corrective actions implemented to remedy the abnormal circumstance.

2.2 Underground Storage Tanks

2.2.1 Retrofitting

Approval holders or licensees that have replaced single-walled underground storage tanks with double-walled tanks meeting the requirements in Section 6 or that have retrofitted their single-walled underground tanks with secondary containment (i.e., synthetic liner or natural soil conditions exhibiting a hydraulic conductivity of 10^{-6} cm/s or less) and leak detection were not required to integrity verify these underground storage tanks. The leak detection systems for these tanks must be monitored monthly.

As of January 1, 2002, the option to retrofit single-walled underground storage tanks will no longer be available. For those tanks that have been retrofitted, the following requirements are expected to have been met.

- For synthetic liners surrounding the underground tank with a monitoring well positioned between the tank and liner:
  - The bottom of the liner should be sloped to encourage any leakage from the tank to collect at the low point, which should be down gradient of the directional flow of groundwater.
  - At least one monitoring well must be completed in the low point and positioned between the secondary containment liner and the tank for the purpose of monitoring any leakage from the tank.
- For weeping tile systems installed with single-walled underground storage tanks:
  - Such a system is only permitted where there are low-permeable soil conditions (i.e., the hydraulic conductivity of the soil is 10^{-6} cm/s or less) and the seasonal high groundwater table is not within 1 m of the bottom of the tank.

- A continuous loop of weeping tile should be placed around the tank at a depth approximating the deepest portion of the tank and in such a fashion as to encourage the movement of groundwaters that may occur under the tank towards the weeping tile.

- The weeping tile should be sloped to encourage the collection of fluids at the lowest point, which should be down gradient of the directional flow of groundwater.

- At least one monitoring well must be completed at the collection point for the purpose of monitoring any leakage from the tank.

- Criteria for the installation of weeping tile may be found in the Drainage and Plumbing Act.

The leak detection systems for the above options must be monitored monthly. Any liquids collected in the monitoring well(s) must be field tested for pH (e.g., using test strips or meter), chlorides (e.g., using test strips), hydrocarbon odour, and a visible oil sheen. The results from the monthly field tests must be recorded, and if there is indication of a problem, investigative work must be conducted, followed by any necessary corrective measures. The results from the monthly monitoring must be retained for a minimum of 5 years, but preferably for the lifetime of the facility.

2.2.2 Integrity Testing

Approval holders or licensees that chose to verify the mechanical integrity of their underground tanks were to have the initial test/inspection completed by October 31, 2001. The intent of the 1995 edition of *Guide 55* was to provide industry with enough time to work out a schedule that would fit operations, especially for those companies with numerous upstream petroleum sites. It was intended that the integrity test/inspection be repeated on a three-year frequency, which was to be established by the date of the initial integrity test. However, this intent was not stated clearly. The revised integrity test/inspection schedule for underground tanks is as follows:

Year of first test	Year of second test	Year of third test
1999 or earlier	2002	2005
2000	2003	2006
2001	2004	2007

Note that except for the duration between the first and second test for those tanks initially tested in 1999 or earlier, integrity tests for underground tanks must be repeated at a minimum of every three years.

For information on the methodologies available for integrity testing underground storage tanks, see Table A2; for further explanatory notes, see Table A3. Approval holders or licensees must be able to verify that the test method used was appropriate for the specific situation and that its results were reliable.

If the integrity test identified a problem with the underground storage tank, approval holders or licensees had the option to replace the tank with a double-walled one as per the requirements outlined in Section 6 or to repair the tank and then retest it. If the results of the retest did not confirm the integrity of the tank, the tank was to be replaced as per the requirements outlined in Section 6.

2.3 Small Aboveground Tanks, Containers, Lined Earthen Excavations, and Bulk Pads

Appendix 1 of the 1995 edition of *Guide 55* did not differentiate between small and large aboveground tanks. Therefore, approval holders or licensees of pre-1996 facilities that have small aboveground tanks (internal volume greater than 1 m^3 but less 5 m^3) where the total combined volume per site exceeds 5 m^3 were to either provide secondary containment or verify the integrity of the tanks by October 31, 2001. This 2001 edition of *Guide 55* drops the option to verify integrity, and approval holders or licensees have until October 31, 2004, to provide secondary containment, as outlined in Section 5.3 for small aboveground tanks that exceed the total combined volume of 5 m^3 per site.

Appendix 1 of the 1995 edition of *Guide 55* required approval holders or licensees of facilities, well sites, and pipelines to have met, by October 31, 2001, the storage provisions for containers, oily waste storage facilities (lined earthen excavations), and bulk pads.

Note that approval holders or licensees that prior to January 1, 2002, installed concrete-lined earthen excavations with an underlying leakage monitoring system but no secondary containment are allowed to continue to use these storage systems provided that the integrity can be verified and then reverified, following the frequency established for underground storage tanks.

Approval holders or licensees that have prior to January 1, 2002, used concrete as primary containment for lined earthen excavations or for bulk pads where there is potential for the stored materials to generate a leachate are allowed to continue to use the storage systems provided that the associated leak detection systems do not indicate a breach of containment.

The leak detection systems for the lined earthen excavations and bulk pads described above must be monitored and the results recorded and reported as per the requirements detailed in Section 8.2.

3 Existing Monitoring Programs

Results from existing monitoring programs can also be used to help determine whether or not storage devices are leaking. Methods used to detect contaminants such as salts and hydrocarbons in the soil or groundwater within the immediate vicinity of a storage device are considered indirect methods, as opposed to direct methods that actually verify or test the integrity of the storage device. Examples of existing monitoring programs include

- groundwater or soil vapour monitoring wells installed in the immediate vicinity (e.g., down gradient of the groundwater flow) of the storage device,
- electromagnetic surveys (for tanks containing brine or brine-equivalent liquids), and
- soil vapour surveys for hydrocarbons (for tanks containing hydrocarbons).

Table A1. Integrity tests for aboveground storage tanks[1]

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.
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.
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.

(continued)

[1] The integrity tests are listed in random order without regard for the accuracy or cost of the test.
See Table A3 for explanatory notes.
Underground storage tank (UST) integrity tests are not directly transferable for use on aboveground storage tanks (AST). ASTs are subject to larger temperature fluctuations, influenced more by atmospheric pressure changes and wind, and usually larger than USTs.

Table A1. Integrity tests for aboveground storage tanks[1] (continued)

Method	Description	Pros	Cons	Applications
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.
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.
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.

(continued)

Table A1. Integrity tests for above ground storage tanks[1] (continued)

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.
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.
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.

(continued)

Table A1. Integrity tests for aboveground storage tanks[1] (continued)

Method	Description	• Pros	• Cons	Applications
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.
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.
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.

(continued)

Table A1. Integrity tests for aboveground storage tanks[1] (concluded)

Method	Description	• Pros	• Cons	Applications
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.
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.
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.

Table A2. Integrity tests for underground storage tanks[1]

Method	Description	Pros	Cons	Applications
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 (see Table A3). • Easy to perform (see Table A3). • 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 (see Table A3).
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.

(continued)

[1] The integrity tests are listed in random order without regard for the accuracy or cost of the test.

Table A2. Integrity tests for underground storage tanks[1] (continued)

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.
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.
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.

(continued)

Table A2. Integrity tests for underground storage tanks[1] (continued)

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 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.

(continued)

Table A2. Integrity tests for underground storage tanks[1] (continued)

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.

(continued)

Table A2. Integrity tests for underground storage tanks[1] (concluded)

Method	Description	Pros	Cons	Applications
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.

Table A3. Explanatory notes

Item	Explanation/discussion
Costs	The terms "inexpensive" and "expensive" are used in relative terms in this report. Some examples of costs are that • 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 of performing the test	In this report, the statements on the difficulty of implementing a test are used in relative terms. For example, 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), rather than the pressure test. However, the tester will not be able to identify a test failure as a tank problem or line problem.
Certification	The US EPA 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 certification 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 for the upstream petroleum industry. 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.
Applications	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.

Appendix 3 References

Regulatory

Alberta Energy and Utilities Board Documents

General Bulletin (GB) 92-4: Requirements for Sulphur Storage Facilities

Informational Letter (IL) 84-11: Approval, Monitoring, and Control of Sulphur Storage Sites

Informational Letter (IL) 85-12: Oil Sands Primary Production Well Spacing Recovery Scheme Approvals

Informational Letter (IL) 93-10: Revised Measurement and Accounting Procedures for Southeastern Alberta Shallow Gas Wells

Informational Letter (IL) 96-7: EUB/AEP Memorandum of Understanding on the Regulation of Oil Sands Developments

Informational Letter (IL) 96-13: Revision of Guide 50 Drilling Waste Management

Informational Letter (IL) 98-1: Coordination of Release Notification Requirements and Subsequent Regulatory Response

Informational Letter (IL) 98-2: Suspension, Abandonment, Decontamination, and Surface Land Reclamation of Upstream Oil and Gas Facilities

Informational Letter (IL) 99-4: EUB Enforcement Process, Generic Enforcement Ladder, and Field Surveillance Enforcement Ladder

Informational Letter (IL) 99-5: The Elimination of the Surface Release of Produced Water

Interim Directive (ID) 91-3: Heavy Oil/Oil Sands Operations

Interim Directive (ID) 95-3: Storage Requirements for the Upstream Petroleum Industry

Interim Directive (ID) 96-3: Oilfield Waste Management Requirements for the Upstream Petroleum Industry

Guide 23: Guidelines Respecting an Application for a Commercial Crude Bitumen Recovery and Upgrading Project

Guide 36: Drilling Rig Inspection Manual

Guide 37: Service Rig Inspection Manual

Guide 50: Drilling Waste Management

Guide 51: Injection and Disposal Wells

Guide 55: Storage Requirements for the Upstream Petroleum Industry (1995 edition)

Guide 56: Energy Development Application Guide

Guide 58: Oilfield Waste Management Requirements for the Upstream Petroleum Industry

Guide 63: Oilfield Waste Management Facility Inspection Manual

Guide 64: Facility Inspection Manual

Guide 66: Pipeline Inspection Manual (to be released in fall 2001)

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API-12P: Fiberglass Reinforced Plastic Tanks

API-620: Design and Construction of Large, Welded, Low-Pressure Storage Tanks

API-650: Welded Steel Tanks for Oil Storage

API-653: Tank Inspection, Repair, Alteration, and Reconstruction

ULC-S601: Shop Fabricated Steel Aboveground Horizontal Tanks for Flammable and Combustible Liquids

ULC-S602: Aboveground Steel Tanks for Fuel Oil and Lubricating Oil

ULC-S603: Steel Underground Tanks for Flammable and Combustible Liquids

ULC-S603.1: Galvanic Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids

ULC-S615: Reinforced Plastic Underground Tanks for Flammable and Combustible Liquids

ULC-S630: Shop Fabricated Steel Aboveground Vertical Tanks for Flammable and Combustible Liquids

ULC-S643: Shop Fabricated Steel Aboveground Utility Tanks for Flammable and Combustible Liquids

ULC-S652: Tank Assemblies for Collection of Used Oil

ULC-S653: Aboveground Steel Contained Tank Assemblies for Flammable and Combustible Liquids

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ULC-S655: Aboveground Protected Tank Assemblies for Flammable and Combustible Liquids

ULC/ORD-C142.18: Rectangular Aboveground Steel Tanks for Flammable and Combustible Liquids

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ULC/ORD-C142.22: Contained Vertical Steel Aboveground Tank Assemblies for Flammable and Combustible Liquids

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ULC/ORD-C142.13: Mobile Refueling Tanks

ULC/ORD-C142.6: Storage Vaults

ULC/ORD-C142.1: Secondary Containment Tank Assemblies for (Upstream Industry) Unrefined Petroleum Products