



Part of Energy Queensland

## Substation Standard

# Standard for Oil Containment

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**Abstract:** The aim of this document is to establish the requirements and considerations for the design of an oil containment system inside a substation to avoid foreseeable risk of watercourse pollution and soil contamination and to comply with legislation.

**Keywords:** Oil containment, bunding, separator, environment, insulating fluid, fire, protection, standard, substation

# Standard for Oil Containment

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## 1 Overview

### 1.1 Purpose

Power transformers, oil-filled reactors and large regulators are the greatest potential source of major oil spills in substations, since they typically contain the largest quantity of oil. Spills may be caused by electrical failure, leaks, vandalism, sabotage, or accident.

All insulating fluids, even those that are non-toxic and readily biodegradable, can damage the environment, so any spills must be contained within the substation.

This document describes the requirements and considerations for the design of an oil containment system inside a substation to avoid foreseeable watercourse pollution and soil contamination, and to comply with legislation.

### 1.2 Scope

This standard shall be applied to all high voltage installations within an Energy Queensland substation that contain equipment with a total of more than 1000 litres of an insulating liquid.

This standard shall also be followed where equipment containing less than 1000 litres of insulating liquid requires oil containment, typically as an outcome from an environmental risk assessment.

Excluded from this standard are:

- Fuel/oil storage installations
- Pad mounted and pole mounted transformers used for local supply services.
- Instrument transformers, circuit breakers, and similar items in an outdoor switchyard.
- Oil filled cables

Oil containment is intended to capture inadvertent leaks from plant and equipment. The repair of leaking equipment shall always be considered as the first course of action when addressing the mitigation and control of an oil spill.

This standard also covers the requirements for oil-water separators used in conjunction with oil containment systems. These systems treat oil-water mixtures from a containment system prior to water discharge.

## 2 References

### 2.1 Legislation, Regulations, Rules, and Codes

Document	Type
<i>Electricity Act 1994</i> (Qld)	Legislation
Electricity Regulation 2006 (Qld)	Regulation
<i>Electrical Safety Act 2002</i> (Qld)	Legislation
Electrical Safety Code of Practice – Works, 2020 (Queensland Government)	Code
Electrical Safety Regulation 2013 (Qld)	Regulation
Environmental Protection Act, 1994 (Queensland Government)	Legislation

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Document	Type
National Electricity Rules	Regulation
<i>Queensland WH&amp;S Regulation 2011</i>	Legislation

## 2.2 Controlled Documents

Document	Alternative Doc ID
Enterprise Risk Management Standard - 689958	R271
Environmental Management Standard - 2947192	
Risk Evaluation Matrix - 691861	R056
Clearances in Air - 3054141	STNW3013
Standard for Substation Fire and Explosion Protection - 3058013	STNW3035

## 2.3 Other Documents

Energex Standard Civil, Drainage (various) - LOSTD-CV002 (all sheets)

## 2.4 Other Sources

AS 1530.4:2014, Methods for fire tests on building materials, components and structures – combustibility test for materials

AS 1940:2017, The storage and handling of flammable and combustible liquids

AS 2067:2016, Substations and high voltage installations exceeding 1 kV a.c.

AS 2419.1:2021, Fire Hydrant Installations

AS/NZS ISO 14001, 2016, Environmental management systems – Requirements with guidance for use

[Australian and New Zealand Guidelines for Fresh and Marine Water Quality.](#)

[Guideline - Stormwater and environmentally relevant activities \(Qld Dept of Environment & Science\)](#)

AS/NZS 3500.3:2025, Plumbing and drainage

## 3 Definitions and Abbreviations

### 3.1 Definitions

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

Bund	A wall or embankment which may form part or all the perimeter of a compound. [SOURCE: AS 1940:2017, 1.4.5]
Compound	An area bounded by a bund or ground contours intended to retain spillage or leakage. This includes the floor of the compound. Later

referred to as "spillage containment compound" or "oil spill containment facility". [SOURCE: AS 1940:2017, 1.4.12, modified]

Containment system	Tank and or bund around equipment to prevent the escape of insulating liquid. [SOURCE: AS 2067:2016, 1.4.11] Also known as bunding and oil separation system. A containment system includes some combination of bund (always), sump, flame trap, oil-water separator, secondary oil containment.
Energy Queensland substation	Refers to bulk supply, zone or C&I substations owned by Ergon Energy or Energex DNSP's.
Fire fighting	Either manual or automatic or a combination of the two.
Flame trap	A liquid seal used to prevent the passage of flame through a drain.
Insulating fluid	All types of insulating fluid including mineral oil and ester fluids (O, K type).
Liquids	Where the word liquids is used without further qualification, it includes both flammable and combustible liquids.
Mobile substations	This phrase refers to Ergon Energy Nomad and Energex mobile substations, and SKID designs.
Oil-water separator	A system to separate insulating fluid from water comprising a sludge trap, an oil-separator, and a sampling/test point. May also be referred to as an oil arrestor or oil interceptor.
Remote supervision	To remotely monitor the functions of the oil containment system. E.g., bund/oil- water separator fluid level, status of mechanical equipment.
Sensitive environment	The term includes, but is not limited to— (a) a water catchment area; (b) a reservoir for drinking water; (c) a freshwater or marine environment; and (d) a national park or equivalent.
Transformer	Transformer, reactor or regulator
Watercourse	This term includes, but is not limited to: river, creek, stream, wetland, drainage path, or inlet of the sea.

## 3.2 Abbreviations

This list does not include well-known unambiguous abbreviations, or abbreviations defined at their first occurrence within the text.

AEP	Annual Exceedance Probability
EQL	Energy Queensland Limited

FRL	Fire-resistance level in accordance with AS 1530.4:2014.
PCB	Polychlorinated biphenyls.
RPEQ	Registered Professional Engineer of Queensland
SCADA	Supervisory control and data acquisition

## 4 Authorities and Responsibilities

The responsibility for the management of oil containment devices at EQL is as follows:

**Table 4-1: List of Teams and Associated Responsibilities for Oil Containment**

Authority	Responsibilities
Asset Standards	Substation Standard for Oil Containment Establish oil-water separator minimum discharge performance
Asset Maintenance	Performance and maintenance of existing devices Bunding Defect Program
Environmental Specialist	Review of environmental controls and legal obligations
Substation Design	Civil Engineering RPEQ Site-specific application of this standard, including performing the environmental risk assessment.

## 5 Existing Oil Containment Facilities

This standard does not mandate upgrade of existing oil containment facilities. Repair or like for like replacement may be to the standard of the existing facility. Where a change requiring more than 10% difference to the existing oil containment facility is required the whole facility is to be brought into compliance with this standard.

## 6 Environmental Risk Assessment

An environmental risk assessment is to be undertaken, in consultation with an Energy Queensland Environmental Specialist, before bringing insulating fluids onto any site located in an environmentally sensitive environment, or at any site where more than 1000 litres of insulating fluid will be contained.

A risk assessment shall be made as set out in Energy Queensland's R271 - Risk Management Guide.

## 7 Design Principles

The overriding principle of a substation oil containment system is that it prevents oil escape from the substation, whether it be from leaky or ruptured plant, within a reasonable level of likelihood (i.e. not assuming a co-incident event of a 1 in 100-year rain event, as well as the tank rupturing, and firefighting water).

Substation oil containment systems shall be designed in accordance with the requirements specified in AS 2067 and in relevant parts of AS 1940.

Any plant item containing oil with a volume exceeding 1000 litres shall be installed in a dedicated bund, except that an earthing transformer may share a bund with its power transformer.

If the concentration of PCB in oil requiring a containment system exceeds 2 ppm, consult an Environmental Specialist.

The minimum capacity of a bund shall be 110% of the associated equipment's total oil volume together with expected firefighting water for 20 min as per AS 2067. For reticulated hydrant systems the minimum flow rate as per AS 2419.1 is 10L/s (12,000L over a 20-minute period). For sites not located near reticulated hydrant systems the local firefighting expected response must be considered. **Firefighting allowance is not applicable if all fluid is K class and plant and protection is FM / UL approved or equivalent standard (except for indoor transformers >10 MVA).**

For outdoor installations, the volume of rainwater collected in a 5% AEP rainfall event shall also be considered in determining the final bund volume. The greater of the rainfall or firefighting water volume shall be used in determining the bund size.

For installations where water can enter the bund, the bund shall drain into a suitable oil-water separator prior to discharge. The performance criteria of oil-water separators are set-out in Section 8.4.

For installations (typically indoor) where minimal rainwater can enter the bund, oil capture by total containment, typically to a dump tank, is preferred over an oil-water separator.

Secondary containment bunds or tanks can add capacity, where the primary/upstream bund volume is insufficient, and to mitigate fire risk by distancing combustible liquid from the most likely source of ignition. Multiple equipment bunds may be drained via segregated pipes and flame traps to a common secondary containment bund. High-volume oil-water separators are secondary containment.

The impact on the adjacent plant, properties (e.g. buildings), structures, fire walls, stormwater, sewer lines, the effect of firefighting facility and requirements for ventilation, access for maintenance, testing, etc., shall be considered. These aspects will directly affect the bund designs and location of the oil collector/oil-water separator.

The design of the bund shall ensure a safe work area and facilitate egress for personnel in accordance with access requirements in AS 2067 and Clearances in Air - 3054141 (STNW3013).

All new oil containment systems or modifications to existing systems shall be subject to the approval by the responsible RPEQ.

Whilst the containment and oil-water separator systems generally carry stormwater only, they have the potential to carry hot oil from a transformer fire that may equal or exceed the auto-ignition temperatures for mineral oil (up to 400°C). In the event of a transformer fire the containment system

and oil-water separator system will need inspection to confirm they remain operational prior to return to service.

## 8 Selection of Oil Containment Solution

### 8.1 Oil Containment Selection Process

The following flow chart shall be used to assist in designing the correct oil containment system for an individual site/installation. The total cost of ownership of each potential solution shall be considered, including the purchase price, maintenance and other operating costs. The lowest total cost of ownership solution is preferred.

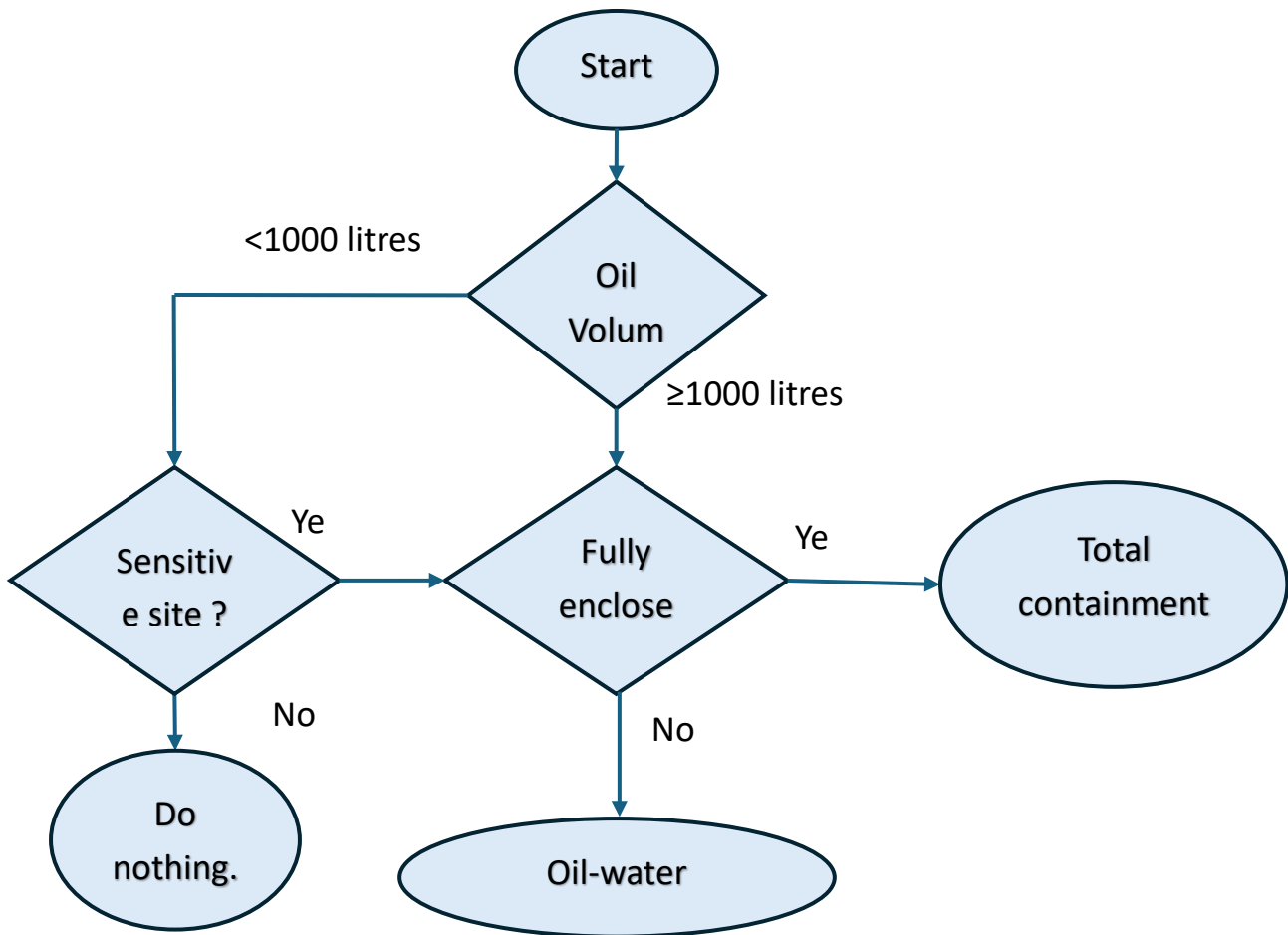


Figure 1: Oil Containment Selection Process

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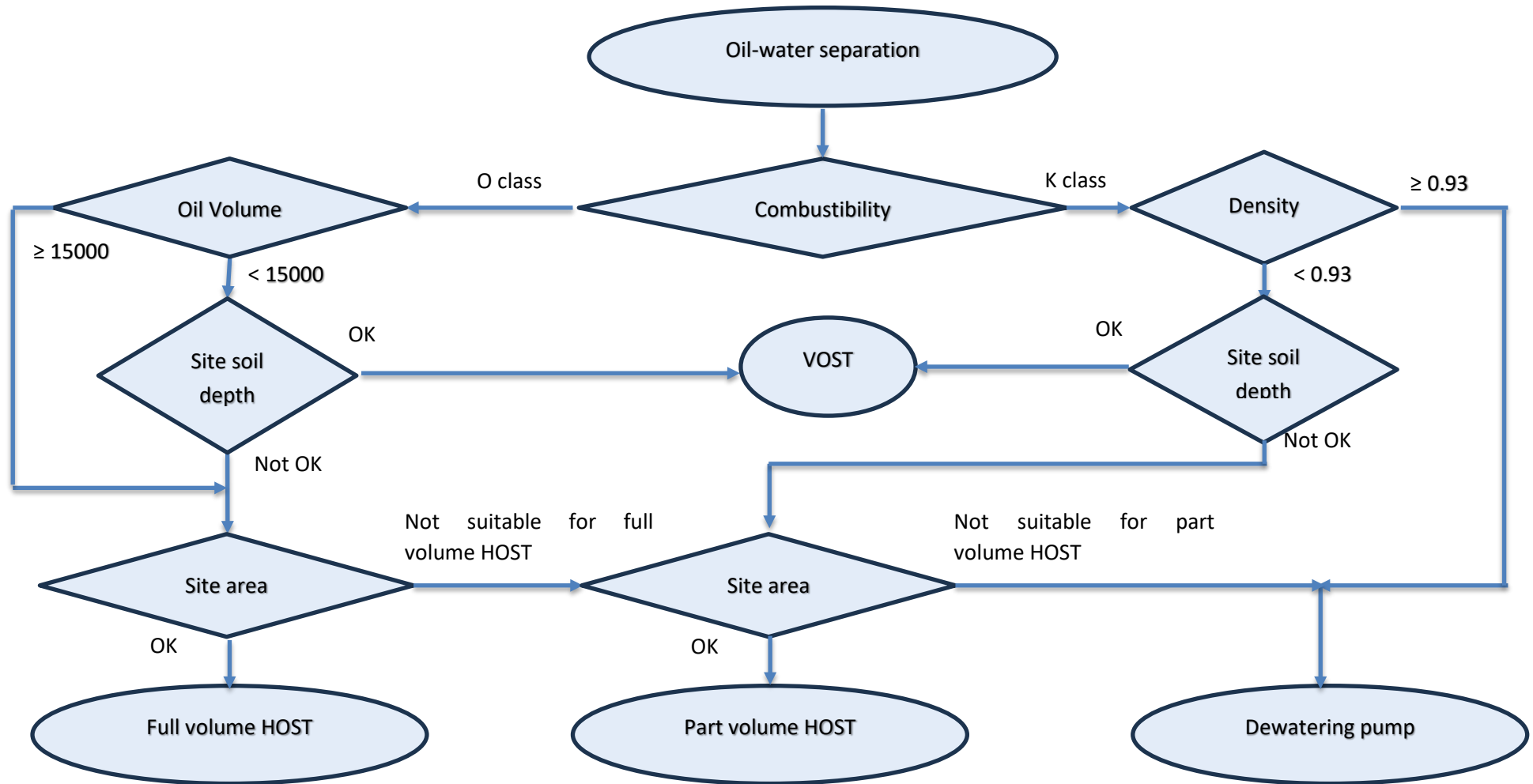


Figure 2: Oil Containment Selection Process Continued

There are two fundamentally different approaches:

- A total containment system holds spilt oil, usually in a transformer room bund or a dump tank, until it is removed from the site by a tanker truck.
- An oil-water separation system collects spilt oil deliberately and stormwater incidentally, separates the two and discharges the treated water, while collecting the oil in a separate holding tank.

## 8.2 Total Containment

Total containment is only practical where minimal rainwater can infiltrate into the oil containment system, typically where equipment is located indoors. The performance criterion for a total containment system is that it must never leak or overflow. A dump tank that receives oil from more than one transformer must have a minimum volume of 110% of the largest transformer volume plus prospective firefighting water. A mobile tanker will typically be required to pump out the spilt liquid from the tank.

## 8.3 Secondary Containment

Secondary oil containment may be used to supplement the capacity of upstream bunds and to reduce the fuel potentially available to an oil fire burning in a bund. Consider the consequences of an oil fire within a bund that may impact adjacent equipment (e.g., power transformers, HV busbars and associated equipment, buildings, etc). If this results in significant damage to the network, secondary containment measures shall be considered in minimising this risk. Note that the use of K class fluids in the transformer is one method of reducing the likelihood and risk.

Secondary containment can be in the form of underground tanks, usually directly below the transformer compound, or a separate bund located a sufficient distance from the transformer compounds and other switchyard equipment. These systems shall be connected to the primary containment systems in accordance with this standard. Where a secondary containment system is not an oil-water separator it shall discharge through one.

## 8.4 Oil-Water Separation System

The performance criteria for oil-water separation systems relate to the quality of the discharge and the reliability of the system.

The options for discharge from the oil-water separator in order of preference shall be:

- Discharge to the ground
- Discharge to stormwater
- Discharge to sewerage as trade waste (non-preferred, may require demonstration that separators can meet waste thresholds).

Discharge to a sewer shall require approval of the sewerage service provider and the creation of a trade waste agreement. Methods of oil-water separation acceptable to sewerage service providers include:

- coalescing plate separators
- membrane technology
- dissolved air flotation (DAF)
- chemical precipitation

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- hydrocyclones
- other apparatus /methods.

Some of these may also meet the water quality performance levels suitable for discharge to the environment.

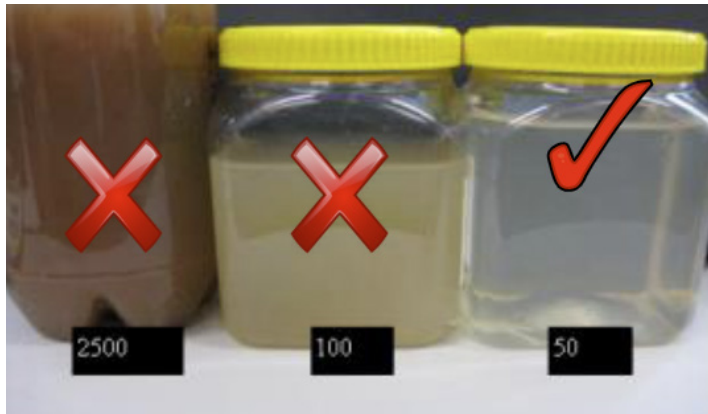
Any discharge from a fully functioning separation system to the environment shall have the following:

- no visible oil sheen, and
- almost transparent clarity

Under all operating conditions, the oil-water separator minimum discharge performance shall be in accordance with the table below:

**Table 8-1: Oil-Water Separator Discharge Performance Criteria**

Stressor	Performance	
	Qualitative	Quantitative
Oil to environment	No oil sheen on treated water	< 10 ppm oil in outlet water (5ppm may be required in sensitive environments)
Oil to sewer	None	Meets oil thresholds as per relevant council trade waste agreements
Suspended Solids	Transparent to cloudy	See objects through 100 mm of water depth (see jar below where 50mg/l would be acceptable)
Debris, litter	None	Zero



The discharge from the oil-water separator to the environment shall be directed on to the bare ground or gravel within the substation. The discharge shall be directed away from sewers, stormwater pipes, pits or drains. Site drainage shall be arranged to avoid long term ponding or erosion.

The existing types of oil-water separation systems used in Energy Queensland substations are vertical or horizontal drum type, vertical water column or proprietary systems. The selected system design shall include all low-cost measures that improve reliability.

Annex A contains a list of separation systems and technology. Alternative oil-water separators will be considered subjected to a risk assessment and approval by an RPEQ.

## 8.4.1 Fail-Safe System

A fail-safe system is meant to be inherently safe, ensuring no discharge under contemplated operation.

A fail-safe system is required when the site is located in or upstream of an environmentally sensitive area. A fail-safe system may also be used where there is insufficient space for a separator sized to hold all of oil from the largest transformer it serves. When combined with the risk of this coinciding with a major oil spill or heavy rainfall, the probability of an oil release is extremely low.

Design measures contributing to a fail-safe system include:

- Inlet of pipe to separator from within compound located higher than top of the bund to prevent siphoning if the pump is inhibited.
- Low flow rate, float switch operated, non-emulsifying, discharge pump installed in a sump within the compound, the outlet of which discharges into the pipe feeding the separator. Pump discharge must not be greater than the capacity of the separator.
- The separator may be smaller than that required to hold all of oil from the largest transformer it serves
- Low voltage power supply to the pump via transformer protection trip relays such that any relay operation results in de-energisation of the pump
- Electrically operated control valves/gates shall not be used as part of a fail-safe system.

## 8.5 Alarms and Indication

Alarms shall be provided to indicate levels of oil and/or water contained within a particular system. Dump tanks and sumps shall be fitted with float switches indicating low (10% of volume) and high levels (70% of volume) of fluid containment. Consideration shall be given to the setting of the alarm levels based on the final design solution. Pumps and other mechanical systems relating to the oil containment system shall also be monitored. Where pumps are installed, a bund level alarm shall be installed to monitor operation of the system; normal operation of rainwater buffering is not to instigate an alarm. The transformer cooling system shall be disabled upon operation of a transformer protection trip.

Oil-water separators may be supplied from the manufacturer with multiple alarm options. For underground horizontal tank oil-water separators, a 'high oil level' alarm (or equivalent) is acceptable. Other available alarms are generally not required. For all oil-water separators, any monitoring equipment, such as control boards and sensors shall be monitored by the use of a watchdog contact where available. All alarms are to be wired to the substation SCADA system. It is preferred to have summary alarms on SCADA with detail available by remote connection to the monitor.

## 9 General Design Requirements

### 9.1 General

This section specifies the general requirements and considerations for the design of a bund. Bunds shall be designed in accordance with this standard and the relevant sections of AS 2067 and AS 1940.

### 9.2 New Bund Designs

This section applies to any new bund installed in a greenfield application. If applicable, this section may apply to new bunds or bunds requiring refurbishment in brownfield applications, unless site constraints or future works may require alternative solutions.

A minimum clearance of 1000 mm between the transformer extents (including radiators, pipework, cubicles etc.) and the inside of the bund wall is required to allow sufficient access within the compound. A minimum 600 mm is to be provided between open cubicle doors and bund wall.

The area and height of the bund shall be designed using the outline of the outer profile of the unit, to be able to capture all oil ejected from pressure relief devices, ruptured bushing turrets, main tank, and cooling system. (Due to the low pressure and small head of oil in the conservator it is unlikely that the oil will spray from the conservator and therefore can be discounted from the spray angle calculations).

The design shall allow for a minimum spill angle of 26.5° taken from any oil-filled part of the transformer, including radiators, and bushing turrets. Refer Figure 5 in the Annex. Where one or two components would significantly alter the spill angle and resulting bund dimensions, consider using deflector plates mounted on the transformer or screens above sections of the bund wall. If spray screens are required, check that adequate ventilation is maintained.

Delivery, installation, and decommissioning of the transformer/regulator must be considered in the design of the bund. This shall include but not be limited to access for the crane and truck, slew paths, overhead restrictions, and crane outrigger placement.

Bund capacity shall accommodate future needs by allowing for the largest anticipated transformer and any spare that could be installed at the site. Listed below are approximate oil volumes for previously contracted transformers. Actual oil volumes with appropriate safety factors should be used to determine bund volume.

**Table 9-1: Approximate Transformer Oil Volumes**

Transformer Size	Typical oil volume (litres)
3.15 MVA 33/11kV, 8 MVA 33/11 kV	7,000
6.3 MVA 66/11 kV, 10 MVA 66/11 kV, 15 MVA 33/11 kV, 3.15 MVA 66/11kV, 3.15 MVA 66/22kV	10,000
20 MVA 66/11 kV, 25 MVA 33/11 kV	14,000
25 MVA 66/22 kV, 32 MVA 66/11 kV, 32 MVA 33/11kV	18,000
32 MVA 132/11 kV, 40 MVA 33/11 kV	19,000
40 MVA 132/66/11 kV, 32 MVA 132/22 kV, 63 MVA 132/22 kV, 63 MVA 132/11 kV	23,000
40 MVA 220/66/11 kV, 60 MVA 110/11 kV, 60 MVA 110/33 kV, 60 MVA 132/11kV, 63 MVA 132/33/11 kV, 63 MVA 132/66/11 kV, 80 MVA 110/33 kV	30,000
100 MVA 132/33/11 kV, 120 MVA 110/33 kV, 120 MVA 11/33/11kV, 40 MVA 220/66/11kV	39,000

## 9.2.1 Bund Walls and Floor

All bund containment walls shall be installed as set out in clause 5.8.3 of AS 1940 and this standard.

Gravel and rocks are not permitted inside the banded area.

Bund walls shall be constructed from reinforced masonry blockwork or reinforced concrete. The bund floor shall be reinforced concrete.

Walls shall be impervious to oil impregnation and all joints must be sealed with oil resistant mastic.

All joints in the wall must have a fire resistance level (FRL) 120/120/120 (unless fire suppression is installed).

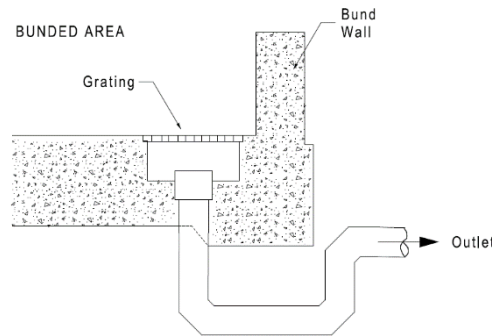
The bund shall be self-draining with a minimum fall of 1 in 200 across the bund towards the sump. No ponding shall occur in the bund.

A bund sump shall be located at the lowest point on the bund floor and must be fitted with grates or grills installed flush with the bund floor to ensure personnel safety.

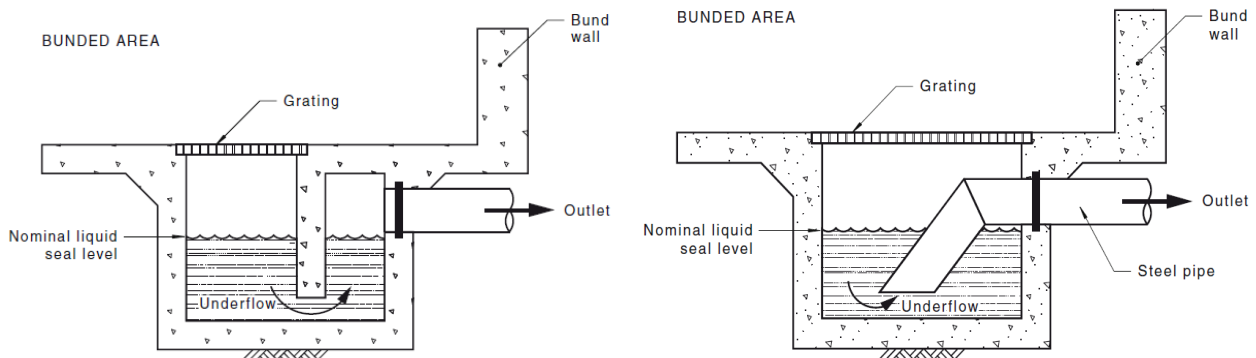
Where required, to prevent debris from clogging the sump, a perforated mesh shall be installed and shall be easily removable to allow sump cleaning.

Consideration should be given to painting the bund floor, plinth walls and bund walls with oil resistant paint.

All bunds shall be installed with a flame trap in the bund outlet to prevent fire from entering the drainage network. A vertical oil separator tank installed in or beside the bund is a flame trap if all materials above water level are fire resistant. The below figures show other flame traps that are acceptable to Energy Queensland.



**Figure 3: S-trap Design**



**Figure 4: Underflow Designs (AS 2067)**

## 9.2.2 Fire Walls

Where fire barriers are installed between transformers they shall have an FRL of 120/120/120 unless fire suppression is installed, in accordance with AS2067. There shall be a minimum 1m separation between the inside of the wall and equipment for access purposes.

## 9.2.3 Bund Drainage System Design

An interconnecting bund drainage system may service multiple transformer units using a common oil-water separator. Bunds are to not drain into adjacent bunds.

Pipes must be sized so that water can be drained for the intensity of a 5% AEP rainfall event 5-minute max in mm/h as outlined in AS3500.3, with some examples given in Appendix D for QLD locations.

Drainage material such as pipes or connections shall be designed to cater for hot oil (up to 400°C) in the event of a transformer fire.

Control valves/gates are not to be installed at any location between the bund sump and the oil water separator.

Each drain from a transformer to a dump tank shall have a gate valve to enable safe access to the dump tank for maintenance purposes.

## 9.2.4 Clearances, Access and Egress

All clearances must be checked for compliance with Clearances in Air - 3054141 (STNW3013), including the potential for personnel climbing and standing on bund walls.

A minimum of two exits must be located within the bund preferably on diagonally opposite walls.

Dedicated access points are required where bund walls are higher than 500 mm from the floor level. Access points require handrails and stairs in accordance with AS 1657.

Where the separation distances to buildings, other transformers or electrical equipment specified in AS 2067 cannot be met, design and construct fire barriers around the bund in accordance with AS 2067 and Substation Fire and Explosion Protection - 3058013 (STNW3035).

## 9.2.5 Cable Entry

Cables may cross the bund overhead where supports do not impede access. Slope overhead ladders slightly towards the transformer if they fall within the spray locus.

Conduits for power and multicore cables entering a bund from below shall be encased in a concrete plinth higher than the lowest bund wall height to prevent liquid draining into the conduits – see Figure 5. For transformers with air-insulated connections, ensure section clearance to any part of the plinth top that someone could stand on.

## 9.3 Separation System Sampling/Test Points

All oil-water separation systems shall incorporate a suitable discharge water sampling/test facility in the outlet of the oil-water separator. Sample the discharge with water flowing. Arrange for analysis of the discharge sample and ensure it meets the performance criteria in Table 8-1 - Oil-water separator discharge performance criteria.

## 9.4 Mobile Substations

Where it is reasonably practicable, mobile substations can be placed in an existing oil containment system. In instances where this is not possible, temporary bunding shall be used.

Some mobile substations have their own integral bunds. Refer to operation and installation manuals for these applications.

## 9.5 Transformers in Storage

For de-energised transformers an oil spill may be caused by transport, cramage, pre-installation works or vandalism.

For transformers stored without oil, an oil containment system is not required.

For short term (typically six months or less) storage during construction or other reasons a risk assessment shall be carried out, followed by cost-benefit calculations if necessary, to justify the acceptable risk.

For long term or permanent storage an oil containment system shall be provided.

## 9.6 Temporary Bund

For temporary installations, the level of risk shall be assessed for each case. The designers shall carry out a risk assessment prior to the construction of temporary bunds for temporary installations. The risk assessment shall include, but not be limited to environmental considerations, the method of

oil separation, drainage, step and touch potential issues, high voltage clearances and the anticipated life of the bund.

Oil filled assets not in service but stored at site will also need to be banded. Temporary bands should consider the ability to still undertake maintenance activities on these assets. Spray angles may not need to be maintained for transformers not in service, where the main risk is slow leaks around the immediate perimeter of the transformer.

## 9.7 Synthetic and Natural Ester Fluids

Although some ester fluids are fully biodegradable, there is still a potential for pollution if discharged to the ground or watercourses during the biodegradation period. Containment standards are therefore the same as for mineral oil.

Where an ester fluid is used, the suppliers of oil containment system separators shall provide written confirmation that the product has been type tested using a comparable ester fluid.

When a transformer is retro-filled with ester or replaced with an ester-filled transformer, the existing oil containment system shall be assessed by an RPEQ and modified or replaced as required.

For example, gravity oil separators depend on the difference in density between oil and water. For clean mineral oil this is about 12%, but for natural ester it is around 8% and for synthetic ester it is 3%.

The use of specialised filter fabrics designed for the separation of ester oils from water is allowed. Filter fabrics will require inspection and replacement to ensure the bund remains free draining and free from any contaminants from the biodegrading esters.

## 9.8 Deviations from this Standard

Alternative construction practices may be considered upon completion of a risk assessment and once approval has been sought from an Energy Queensland Civil RPEQ.

## 10 Documentation Required

The following design inputs are considered critical in the design process and determine the outcome of the oil containment system design. Documentation on the design of an oil containment system shall take the form of a design report addressing at least the following:

- Substation site and location
- Environmental aspect identification and risk assessment
- Values for the critical design factors and the methods used and assumptions made in ascertaining these values
- Quantity of oil and the proximity of plant requiring oil containment
- Details on calculations used in the design process
- Design flow rate of the bund volume(s) and oil-water separator
- Site geo-technical data
- Site survey indicating site boundary, any significant environmental sensitive characteristics, drainage paths, stormwater and sewer lines
- Local rainfall

# Standard for Oil Containment

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- Civil and construction drawings showing the arrangement of the oil containment system
- Emergency oil spill response procedures
- Fire fighting flow conditions
- Approval obtained from the relevant local authority prior to any work commencing on the construction of the oil containment system
- Certification that the design output meets all legislative and local government requirements
- Maintenance procedures to ensure the effective operation of the installed system, including periodic testing and monitoring requirements and alarm response plans.
- Distance to reach the site (unless remote monitoring can adequately provide sufficient information to be able to adequately address any device issues)

## Annex A

### Informative

## Examples of Types

### A.1 Existing Systems in the Network

#### A1.1 Vertical Oil Water Separators

Vertical oil-water separator tanks (VOSTs or U-Tubes) are gravity oil-water separators assisted by an oleophilic filter. They are designed for the associated oil volume and density, bund dimensions and the rainfall statistics of the site. The depth of the water column must be sufficient to support the oil level in the bund if the protected plant ruptures. The velocity of the downward flow of stormwater determines the size of the oil droplets that will be entrained, against their buoyancy, and reach the discharge filter. A flow regulator or restriction will usually be required, to allow the VOST to be narrower. The flow rate must be low enough for effective gravity separation but may require a higher bund to prevent overtopping of the bund in extreme rain events. The advantage of a VOST is that it can be used at sites where there are space constraints.

Design considerations for a VOST include the following:

- Remote monitoring of bund fluid level (high level) and oil-water separator water level (low level).
- A shallow silt trap beside or around the top of the well is required to minimise silt build-up on the bottom of the well.
- Plumb in a water supply to ensure the correct water level is maintained at all times.
- If esters are used, the well will need to be deeper and the shaft wider to cater for the difference in specific gravity between mineral oil and ester fluids. Synthetic ester has a specific gravity closer to 1 than natural ester and hence will require relatively larger changes in dimensions. Esterweb or similar fabric may be used to hold back the ester as an alternative.

The filter shall be situated so that would not be damaged should a fire (of indefinite length of time) occur in the bund.

U-tubes must be pressure tested by an independent testing authority for a period of 12 hours pressurised to a minimum of 9psi, subject to fluid type.

Because the vertical oil-water separator holds the oil from a major leak in the bunded area, any ensuing fire will need to be dealt with at the location of the plant.

. For existing Energex systems refer LOSTD-CV002-01.

#### A1.2 Horizontal Oil-Water Separators

Horizontal oil separation tanks (HOST) use gravity separation like vertical systems, however they are usually high-volume tanks intended to contain the spilled oil rather than keep it in the bund. This is a significant advantage in fire risk mitigation. Another advantage is that only one is needed per

substation, although the rain catchment area is multiplied and may determine volume. These tanks are normally used where oil quantities are more than 15000 litres per transformer.

Under normal operation, the rainwater from the bund area enters the underground separation tank. Most oil in the water will rise to the top in the separation tank. The inflow from the bund area will push water from the bottom of the separation tank out of the outlet pipe. The water level is not as critical as for a VOST but must never be allowed to fall below the outlet baffle.

In the design of the separation system the following criteria are applied:

- Backflow between bunds is prevented
- The outlet pipe must prevent siphoning.
- The tank dimensions allow adequate residence time with non-turbulent flow conditions, taking into account local rainfall, for effective separation of the oil from the water before discharge. (Flow restriction is not an option because a bulk oil spill must drain quickly.)
- In order to determine the tank volume required to ensure separation of the oil from water, calculations of the flow rate of oil-water as it enters the tank are carried out using the Bernoulli equation. Separation volume is calculated using the total velocity through the tank and separation factor of the oil-water (mm/min). It shall separate and capture all globules larger than 33 microns for rainfall for 5-minutes at 5% AEP rainfall intensity.
- The tank is nominally sized to allow for the full volume of oil of the largest container plumbed to the oil-water separator tank plus one third of the oil volume to allow for additional air and water.

For existing Energex systems refer LOSTD-CV002-02.

## **A1.3 Proprietary Systems**

Proprietary systems are acceptable if they are:

- Provided with a manufacturer's guarantee that discharge shall not exceed the requirements of this standard.
- Fitted with oil alert probes
- Capable of being remotely monitored
- Approved by an EQL Civil RPEQ.

## **A1.4 Hydrocarbon Filters/Socks**

Oil absorbent filters remove hydrocarbons from water where low residue oil levels are required. Filter socks should be used in conjunction with other separation methods to remove visible oils and contaminants from discharged water. Most filter socks have a relatively small capacity (often only a litre or two of oil) before clogging up.

## **A.2 Background Information on the Popular Separation Methods**

### **A2.1 Gravity Oil-Water Separators**

In gravity oil-water separators, high density contaminants fall into a sludge retaining area at the bottom of the vessel, oil droplets rise to the top of the vessel and water flows from an outlet above the sludge. Smaller oil droplets need more time to separate, so the performance of the oil-water

separator declines as flow rate increases or droplet size decreases. Performance also depends on the relative densities of the materials, so oil droplets contaminated by fine sediment may pass through the water outlet.

An Enhanced Gravity Oil Water Separator has been patented by UNSW's New South Innovations gateway. This device exploits the episodic nature of flows experienced by substation separators, discharging very clean water during quiescent periods to increase residence times at times of fast inflow.

## **A2.2 Plate Oil-Water Separators**

Plate oil-water separators are gravity oil-water separators that include a stack of inclined plates. The oil-water emulsion flows between the plates, so oil droplets only need to rise a short distance before collecting on the underside of a plate. Here they coalesce and migrate to the top edge of the plate. The plate releases the oil as big droplets that can float up faster. Sediment is intended to slide down the topside of each parallel plate and fall into a sludge sump, but in practice it can adhere to the plates, requiring periodic removal and cleaning of the plate stack.

Plates may be flat, corrugated or have proprietary profiles, and stainless steel, fibreglass or polypropylene are commonly used. Often the oil-water separator is an above-grade apparatus fed by a low-turbulence pump, but a plate stack can also improve the performance of an underground passive gravity oil-water separator.

## **A2.3 Passive Gravity Oil-Water Separator with Coalescer**

A proprietary horizontal gravity separator, with a second chamber in which flow is directed upwards through a sponge-like coalescer, achieves effluent mineral oil concentrations less than 5 ppm. Between the chambers is a hydrometer-like automatic shutoff that retains bulk spills in the first chamber and upstream pipework. The coalescing filter requires annual maintenance.

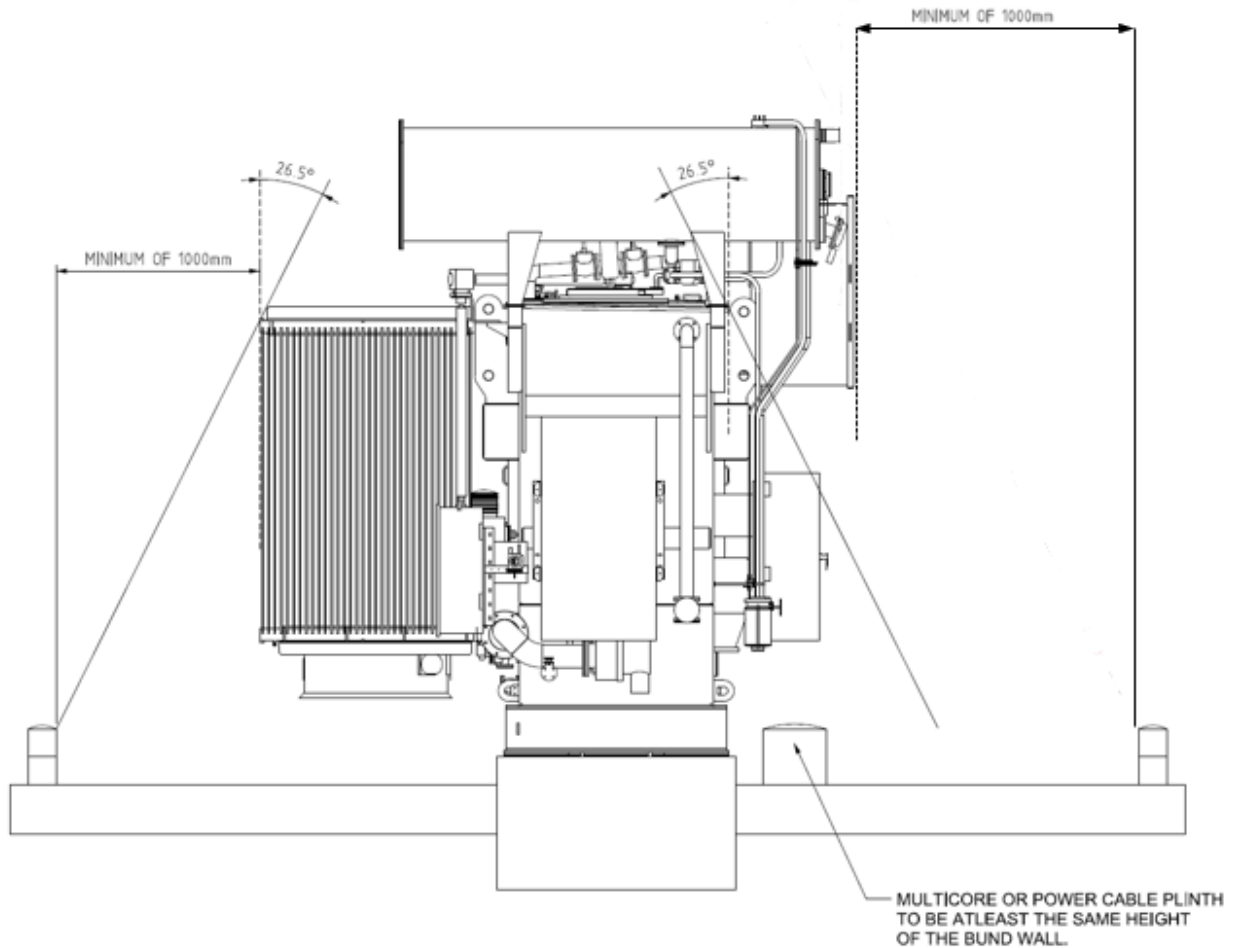
## **A2.4 Hydrocyclone Separation Systems**

Hydrocyclone oil-water separators operate on the centrifuge principle. Liquid enters the conical cyclone chamber tangentially and swirls around. The heavier water and any sediment are forced outward towards the cyclone wall, and the lighter oil phase migrates towards the centre core. The separated oil is discharged from one end and treated water is discharged through the opposite end for further treatment, filtration or discharge. This system is not commonly used in substations as the flow rate and pressure are insufficient.

## **A2.5 Optical Contamination Sensors**

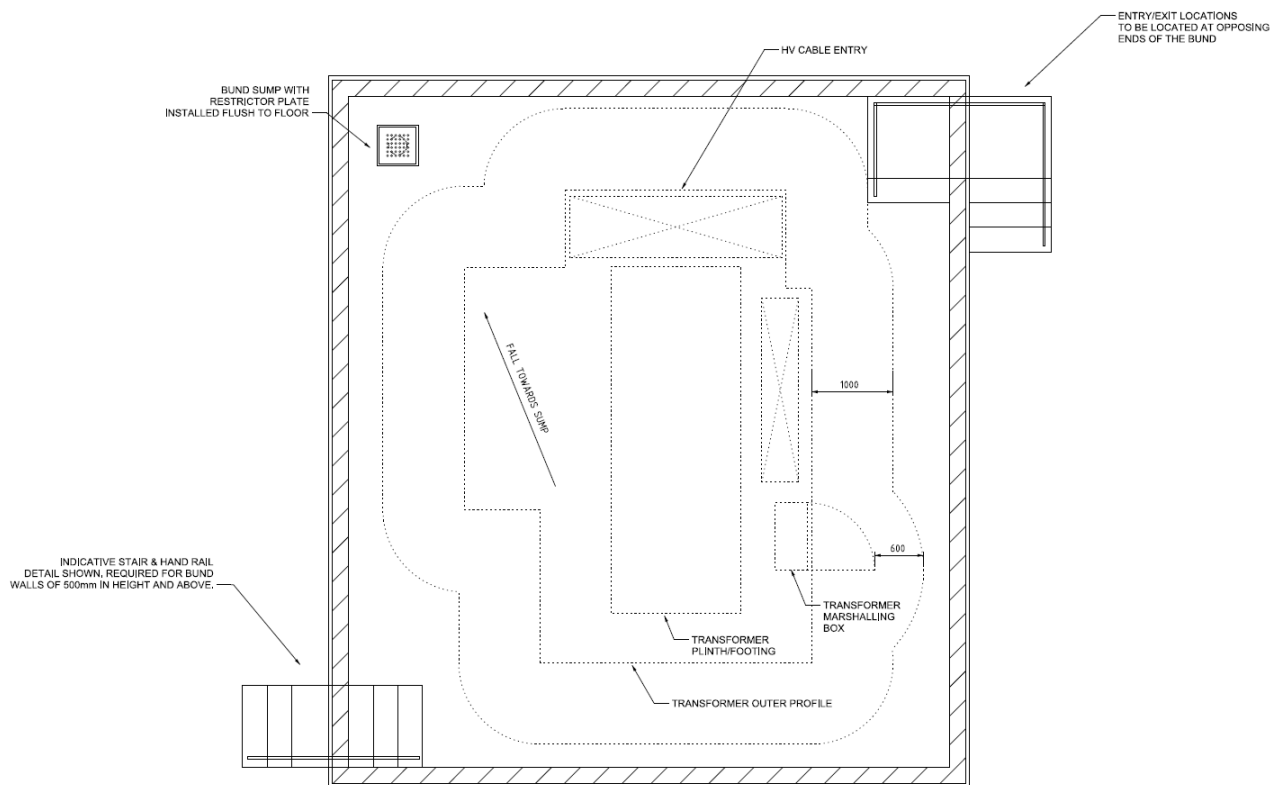
An optical sensor can detect very low levels (about 1 ppm) of oil contamination in water, control the operation of an electric sump pump and send an alarm. A bulk oil spill will be trapped in the bund. Minor oil leaks will prevent discharge of bund water until it has clarified sufficiently. A redundant system may be needed in areas with high rainfall intensity unless staff can attend quickly enough.

## A.3 Transformer Bund Reference Drawings



**Figure 5: Transformer Bund Section View**

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**Figure 6: Transformer Bund Plan View**

## Appendix A

### Revision History

Revision date	Version number	Author	Description of change/revision
13/7/2021	1.0	Substation Design Standards	SS-1-9.2 has been superseded by STNW3036; Ver 1.0. References revised and updated. Standard has been aligned with latest version of AS 2067. Standard has developed to combine Ergon and Energen practices.
June 2023	2.0	John Lansley	Update to new template, links added. Table 8-1 updated.
May 2026	3 & 4	Michael Blomfield	Removed locus crest requirement from transformer conservator. Updated references. Clarified bund sizing requirements (rainfall). Updated bund selection flow chart. Clarified oil water separator discharge performance criteria.