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

CONTENTS

FIGURES

TABLES

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 risk 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 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

Environmental Protection Act 1994. Queensland Government

Electrical Safety Act, 2002. Queensland Government

Electrical Safety Regulation, 2013. Queensland Government

Electricity Act, 1994. Queensland Government

Electricity Regulation, 2006. Queensland Government

Work Health and Safety Act, 2011. Queensland Government

Work Health and Safety Regulation, 2011. Queensland Government

National Electricity Rules, 2023. Australian Energy Market Commission

2.2 Energy Queensland controlled documents

Enterprise Risk Management Standard R271 – 689958

Risk Evaluation Matrix R056 – 691861

Standard for Clearances in Air STNW3013 – 3054141

Standard for Substation Fire and Explosion Protection STNW3035 –
3058013 Environmental Management of Spills - 2855014

2.3 Energy Queensland 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/NZS ISO 14001, 2016, Environmental management systems – Requirements with guidance for use

Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
https://www.waterquality.gov.au/anz-guidelines

Guideline - Stormwater and environmentally relevant activities (Qld Dept of Environment & Science)
https://environment.des.qld.gov.au/__data/assets/pdf_file/0028/89119/pr-gl-stormwater-guideline-era.pdf

3 Definitions, acronyms, 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. Excludes assets owned by Yurika.

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	Where the word mobile substation is used, it includes 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 Acronyms and abbreviations

The following acronyms and abbreviations appear in this standard.

ARI	Average Recurrence Interval
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

Where necessary, an environmental risk assessment is to be undertaken, in consultation with an Energy Queensland Environmental Specialist, at any site where insulating fluids in excess of 1000 litres are contained or located in an environmentally sensitive environment.

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.

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

Any major plant item containing oil with a volume exceeding 1000 litres, shall be installed in a dedicated bund.

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 firefighting water for 20 min as per AS 2067. For outdoor installations, the volume of rainwater collected in a 20-year ARI rainfall event (in 24 hours) shall also be considered in determining the final bund volume.

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.

Multiple power and auxiliary transformers shall not be contained within a single common bund. Earthing transformers associated with a power transformer may be installed within a common bund.

Secondary containment bunds can add capacity to supplement upstream bunds for instance where the primary/upstream bund may not be able to meet the 110% requirement. The main advantage is 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.

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 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 400OC). 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

8.1.1 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.

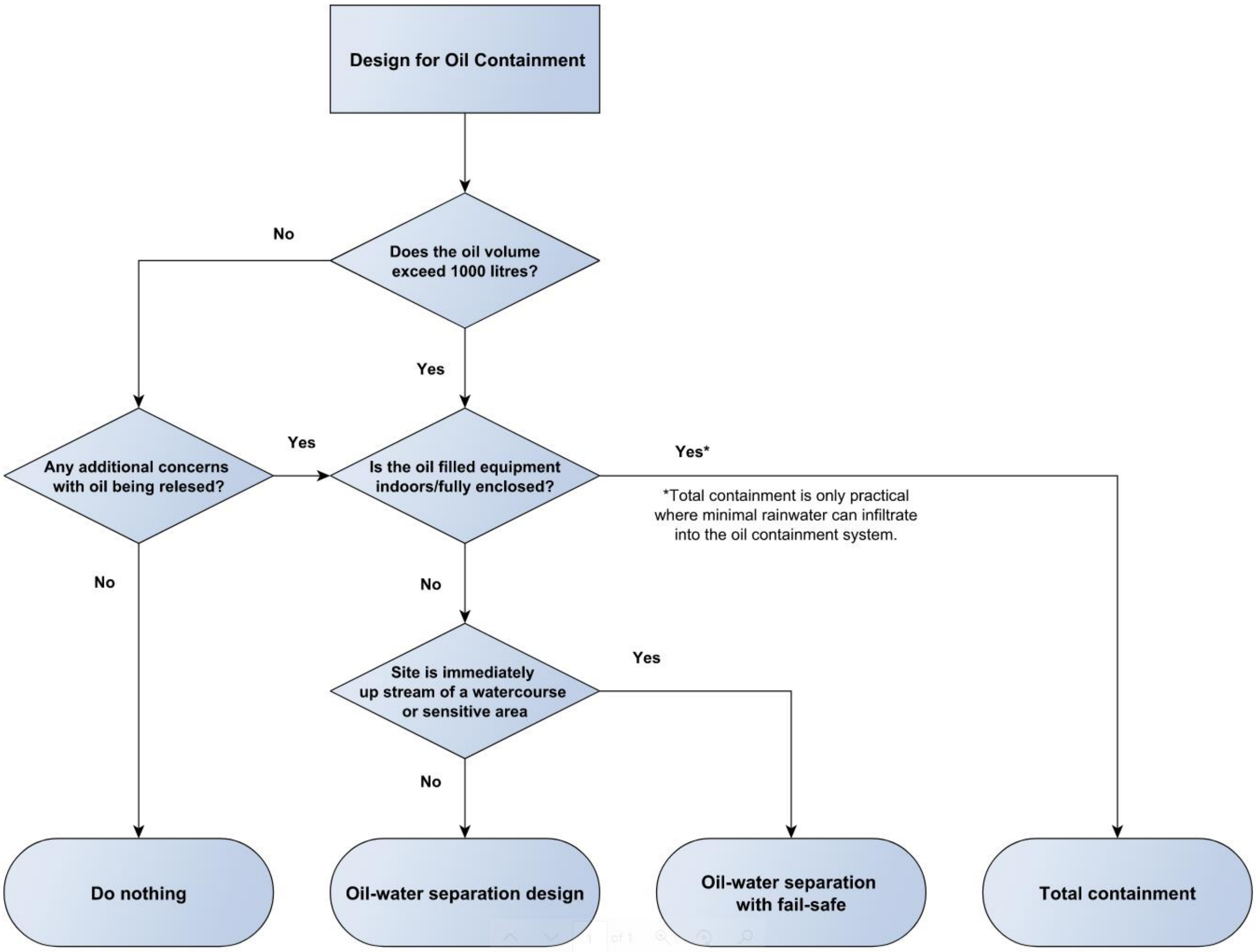

Figure 1: Oil containment selection process

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.

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. 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 that are not of sufficient capacity. Secondary containment can also be used to minimise the risk of an oil fire burning within a bund. Consideration shall be given to 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.

Secondary containment can be in the form of underground tanks, usually directly below the transformer compound, or a separate bund typically located at a sufficient distance away 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 installed, it shall drain into an oil-water separator.

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.

Discharge to a sewer may require approval of the sewerage service provider. Methods of oil-water separation acceptable to sewerage service providers include:

- coalescing plate separators;
- membrane technology;
- dissolved air flotation (DAF);
- chemical precipitation;
- hydrocyclones; and
- 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	< 5 ppm oil in outlet water
Oil to sewer	None	< 30 ppm oil in outlet water
Suspended Solids	Transparent to cloudy	Black-on-white Arial 10-point is legible through 100 mm
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.
- 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.

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, where 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 600mm is to be provided between open cubicle doors and bund wall.

The area 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, cooling system and the conservator.

The design shall allow for a spill angle of 26.5o taken from the top of the transformer, including radiators. Transformer conservators, bushing turrets shall be considered when performing spill angle calculations. Where these components significantly alter the spill angle and resulting bund dimensions, consideration shall be given to the final bund wall location relative to the transformer on a case-by-case basis. Refer Figure 4 in Appendix for details.

If spray screens are required where the crest locus limit cannot be practically met, the design shall ensure adequate ventilation is still 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)
8 MVA 33/11 kV	7,000
6.3 MVA 66/11 kV, 10 MVA 66/11 kV, 15 MVA 33/11 kV	10,000
20 MVA 66/11 kV, 25 MVA 33/11 kV	14,000
25 MVA 66/22 kV, 32 MVA 66/11 kV	18,000
32 MVA 132/11 kV, 32 MVA 132/22 kV, 40 MVA 33/11 kV	19,000
40 MVA 132/66/11 kV, 63 MVA 132/22 kV, 63 MVA 132/11 kV	23,000
63 MVA 132/66/11 kV,	26,000
40 MVA 220/66/11 kV, 60 MVA 110/11 kV, 60 MVA 110/33 kV, 63 MVA 132/33/11 kV 80 MVA 110/33 kV	30,000
100 MVA 132/33/11 kV, 120 MVA 110/33 kV	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 bunded 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 equivalent to the wall.

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.

The bund floor, plinth walls and bund walls shall be painted 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. The below figures show flame traps that are acceptable to Energy Queensland.

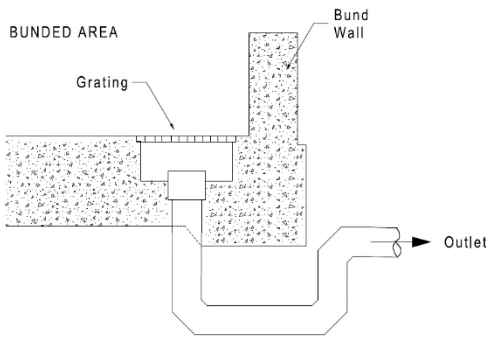

Figure 2: S-trap design

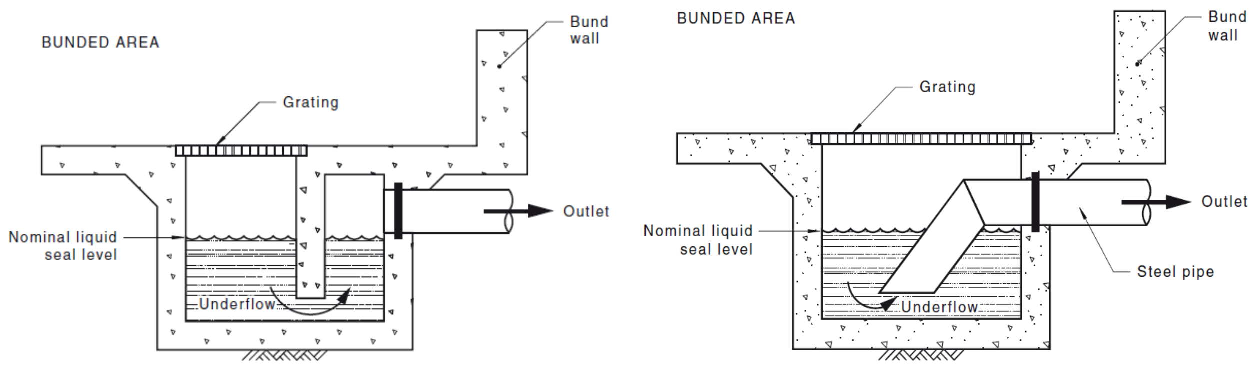

Figure 3: Underflow designs (AS 2067)

9.2.2 Bund drainage system design

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

Drainage material such as pipes or connections shall be designed to cater for hot oil (up to 400oC) 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.

9.2.3 Clearances, access and egress

All clearances must be checked for compliance with EQL STNW3013 Clearances in Air, 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 greater than 500 mm high from the floor level. Access points require handrails and stairs in accordance with AS 1657.

Separation distances to buildings, other transformers or electrical equipment must be in accordance with AS 2067. The G1 separation distance in AS 2067 shall also cover distances between the bund wall and the transformer. Fire barriers shall be designed and constructed around the bund where the separation distances are compromised in accordance with AS 2067 and EQL Standard for Fire and Explosion Protection STNW3035.

9.2.4 Cable entry

Conduits for power and multicore cables within a bund, shall be installed with a concrete plinth and terminated above the lowest bund wall height to prevent liquid spreading through the power cable or conduit penetration.

Consideration shall be made to the height and location of the concrete plinths, as to not encroach on section clearance or introduce additional hazards within the bund area. Consideration shall also be given to the location and height of the transformer control cubicles and cable termination boxes.

Any horizontal run of cable ladders attached to the transformer main tank shall slope towards the transformer to prevent oil spills spreading along cables to outside of the bunded area.

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. Ensure that during testing the oil-water separator is operating with discharge water flowing. Arrange for testing of discharge sample from the discharge outlet. Ensure the sample meets the performance criteria as per 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, cranage, pre-installation works or vandalism.

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.

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. Where ester fluids are used in place of traditional mineral oil, these are treated in the same way as mineral oil.

The chemical properties of ester fluids are very close to those of water. Therefore, where ester fluids are used, the suppliers of oil containment system separators shall provide written confirmation that the product has been type tested using ester fluid.

Where transformers and tanks contain differing classes of liquid, the liquid with the lowest flash point shall be used as per AS 1940 Section 5.1.

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 but not be limited to, 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
- 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 dimensioned for the characteristics of the associated bund 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 allow the VOST to be narrower. The flow rate must be low enough for effective gravity separation but high enough 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. However, if a VOST system is used, ensure the flow rate is verified to meet the performance requirements in this standard.

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 needs to be 60% deeper for 0.92 g/ml natural ester, >4x deeper for 0.97 g/ml synthetic ester, and also needs similar increases in the diameter of the shaft, unless Esterweb or similar fabric is used to hold back the ester.

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 Ergon Energy systems refer EESS-10175-01. For existing Energex systems refer LOSTD-CV002-01.

A1.2 Horizontal oil-water separators

Horizontal oil separation tanks (HOST) are like the separation method in vertical systems, however constructed horizontally. This type of oil-water separator is widely used where water and contained oil will weigh about the same. These tanks are normally used where oil quantities are more than 15000 litres per transformer and usually one is installed per substation.

Under normal operation, the rainwater from the bund area enters the underground separation tank. Any oil in the water will rise to the top in the separation tank. The inflow from the bund area will push the water inside the separation tank out of the outlet pipe. Since the tank is full already, only the water from this level is pushed out.

In the design of the separation tank the following criteria are applied;

- The tank must contain water at all times to form a seal on the discharge pipe, allowing excess water to be discharged whilst retaining the oil.
- The tank is designed with sufficient volume to allow adequate residence time with non-turbulent flow conditions, taking into account local rainfall, to ensure separation of the oil from the water before discharge.
- 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).
- 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 for both 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.

A.2 Hydrocarbon filters/socks

Oil absorbent filters remove hydrocarbons from water where low residue oil levels are required. The use oil filters and 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 short lifespan (typically a few months to a year) before they begin to lose their effectiveness.

A.3 Background information on the popular separation methods

A3.1 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.

A3.2 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 down 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 against the current. 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.

A3.3 Hydrocyclone separation systems

Hydrocyclone oil-water separators operate on the centrifuge principle. Liquid enters the cyclone chamber and is spun. The heavier water and any sediment is 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.

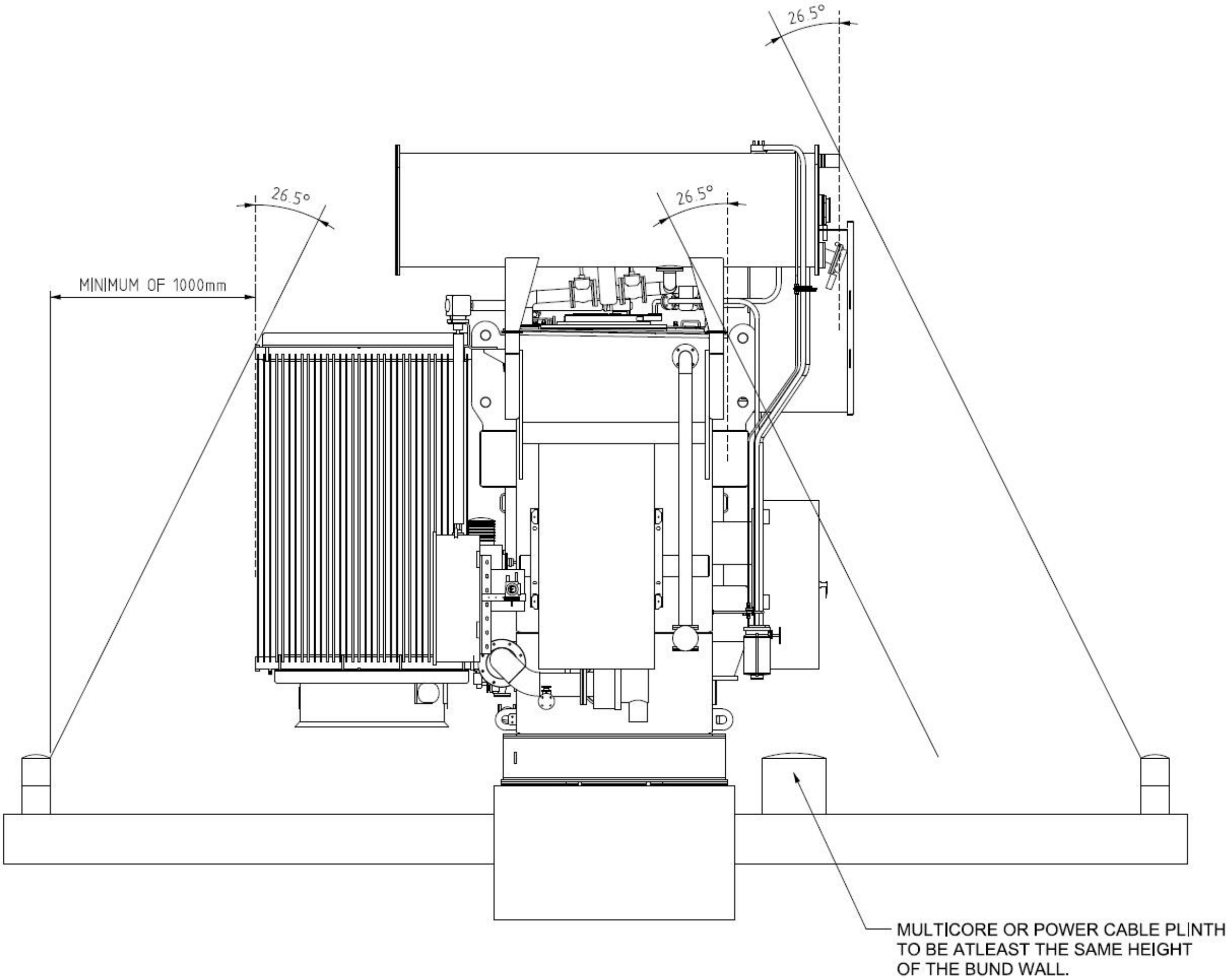

Figure 4: Transformer bund section view

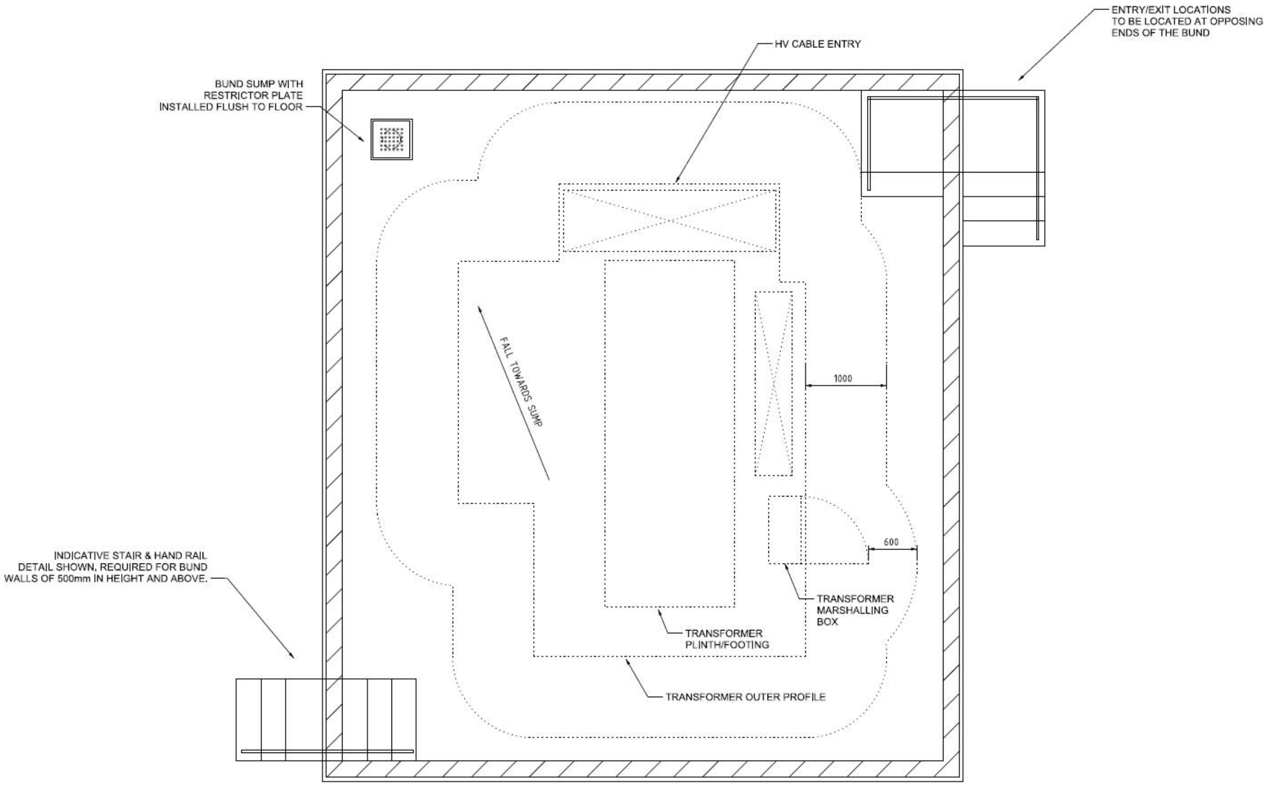

Figure 5: Transformer bund plan view

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 Energex practices.
June 2023	2.0	John Lansley	Update to new template, links added. Table 8-1 updated.