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ENGINEERING DESIGN STANDARD

EDS 07-4070

GRID AND PRIMARY TRANSFORMER BUNDS AND ENCLOSURES

Network(s): EPN, LPN, SPN

Summary: This document gives guidance for the design of oil containment structures, acoustic enclosures and transformer bays at grid and primary substations

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Revision Record

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Date	26/06/2020	**Author**	Uriel Arias
New design standard for grid and transformer bunds and enclosures.			

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1 Introduction

This standard outlines the principle of design and construction for transformer bays, secondary oil containment and acoustic enclosures around grid and primary transformers.

2 Scope

This standard applies to the civil design of the following:

- New and existing grid and primary transformers connected to a one-way feed header tank with a capacity of 201 litres or greater.
- Transformers requiring enclosures for noise control and/or low frequency nuisance to members for the public.
- Fully enclosed transformer rooms.

3 Glossary and Abbreviations

Term	Definition
AONB	Area of Outstanding Natural Beauty
Bund	Secondary oil containment structure attached to a transformer's plinth. Typically made up of reinforced concrete cast-in slabs designed to contain oil and residual rainwater.
ESQC	Electricity Safety, Quality and Continuity (regulations)
GRP	Glass Reinforced Plastic
HDPE	High Density Polyethylene
RCD	Residual Current Device
SCADA	Supervisory Control and Data Acquisition
SPZ	Source Protection Zones
SSSI	Site of Special Scientific Interest

4 Mandatory Requirements

The mandatory requirements outlined in document EDS 07-4000 are applicable for the design and construction of transformer bunds and acoustic enclosures and shall be read before progressing into the detailed design phase.

Prior to determining the construction details of the civil works around transformers, a site risk assessment shall be carried out in accordance with EDS 07-1109. This shall specify the security rating required for building items such as doors, ventilation louvres, blast vents and building fabric.

Local planning requirements may affect the design of the transformer enclosures. In some areas, particularly around town centres, additional fire resistance of walls and ceilings may be necessary and the positioning of doors and ventilation louvers may be restricted.

The control of pollution (oil storage) regulations apply to transformers that have a connected header tank of one-way feed pipe with a capacity of 201 litres or more, in the form of a transformer header tank connected to the transformer by a one-way feed pipe.

5 Design Functionality

5.1 Access and Escape

Two pedestrian gates shall be provided to allow safe access and egress to/from outdoor transformers with a palisade fence surround.

Permanent steps shall be provide when the wall height above the walking surface exceeds 450mm. During construction when the bund is empty, temporary steps with handrail shall be provided for safe access/egress.

Where acoustic enclosures or firewalls impede a straight escape route, the maximum distance from the point of operation to the nearest escape door shall not exceed 9m.

Acoustic enclosures around transformers shall have a minimum of two doors. Additional escape doors shall be specified if the enclosure is of an unusual shape.

Escape distances shall be designed in accordance to EDS 07-4000.

5.2 Design Loads

Typical design loads are shown in Table 5-1 for reference, but actual plant and equipment loads shall be checked and confirmed for each specific project. The loads shown are based on accommodating transformers, coolers and ancillary equipment. All other loads shall be in accordance with BS EN 1991-1. Transformer suppliers shall confirm the mass and sizes, including transportation mass of each disassembled piece.

Table 5-1 – Design Loads

Location	Design Load	Reference values
Transformer Bay	• Operational weight of transformer on the plinth. • Operational weight of other plant items in the bay. • Bund area required to hold transformer oil capacity +10%. • Transformer pulling points: 2No on the back wall, each adequate for a horizontal load of 5% of transformer weight. Pulling points are not often required at open transformer bays. • Floor of bay not occupied by plant 5kN/m^2. • The indicative internal overpressure in an enclosed transformer room can reach 15kN/m^2. At sites where it is not feasible to achieve the required overpressure resistance around the whole transformer enclosure a pressure relief system, consisting of approved fire rated ducts and pressure relief panels shall be introduced.	• Operational transformer loads can be up to 90 ton for grid transformers and 60 ton for primary transformers. **Note**: Figures are indicative only. • Typical auxiliary transformer and NER load is 5 ton each. • Oil relative density as assumed as 0.895kg/L at 20°C. • Fire dampers on the ventilation systems, upon operation, shall withstand overpressure.
Cooler Bay	• Operational weight of cooler on the plinth. • Operational weight of other plant items in the bay. • Floor of bay not occupied by plant 5kN/m^2.	• Typical oil filled cooler weight is 25 ton on four feet. • Typical water filled cooler weight is 15 ton on 6 feet.

5.3 Volume Capacity

Bunds are required for each individual transformer, or for a group of these. The total capacity of the bund shall be greater than 110% of the oil contained in the largest transformer in the system or 25% of the aggregate total capacity of the transformers, whichever is the greater.

To prevent the spread of fire, the calculation of the volume capacity of the bund shall allow for the total volume of oil to be contained within the aggregate material.

For calculation purposes, one cubic metre of 40mm single sized aggregate material retains 300 litres of oil.

When calculating the depth of the aggregate material inside the bund, it shall be considered that the top 300mm layer of aggregate acts as a flame trap and only the aggregate below this layer holds the oil safely without the possibility of catching fire.

A 150mm freeboard above the aggregate material is required to allow for rainfall and the use of firefighting foam.

5.4 Rainwater and Drainage

Any rainwater within the bund shall pass through a class 1 certified oil separator to BS EN 858-1 before discharging into the substation or surface drainage system, using a pump or the natural gradient.

The Local Authority, the Water Authority or the Environmental Agency shall be consulted for allowable discharge rates to a local soakaway or watercourse. The choice of a full retention oil interceptor shall comply with Environment Agency policy.

Only ‘uncontaminated surface water’ does not require a discharge consent. If the discharge is into a surface water sewer, the local water/wastewater company shall be consulted in case a trade effluent licence is required.

The quality of the discharge shall not exceed 5mg/litre of oil under standard test conditions. For some environmentally sensitive areas, 5mg/litre is too high and the permitted value shall be confirmed with the Environment Agency.

5.5 Noise and Vibration Nuisance

The positioning of transformers shall be such that noise and vibration are not transmitted into sensitive areas, particularly residential areas or at locations where low frequency noise is likely to be a nuisance.

To prevent transformer vibration causing noise nuisance, wherever possible, transformers should be located at least at 25m from residential properties. If this distance in not achievable, an acoustic enclosure should be considered.

Pre and post-construction noise surveys shall be undertaken when placing new transformers, particularly those being carried out adjacent or within view of residential areas. A model of the transformer noise condition shall inform the noise baseline and the requirement to provide an acoustic enclosure.

Noise surveys should also be considered where an existing substation façade or acoustic enclosure is modified.

For a fully-enclosed transformer, it is important to assess the effect of 100Hz standing waves that are emitted by the transformer, as this can induce resonance on the larger structure.

5.6 Segregation of Transformers and Buildings

The distance between transformers, public footpaths, urban public roads, third party properties, other substation buildings and outdoor substation equipment shall follow BS EN 61936-1 and the guidance provided in EDS 07-0116.

Following the guidance in BS EN 61936-1, the segregation between transformers is proportional to the volume of oil and the combustibility of the buildings at risk.

The clearance between transformers is referred to as G_1 in BS EN 61936-1, shown in Figure 5-2; G_1 is also used to refer to the clearance from the transformer to a building surface made of a combustible material.

The clearance from a transformer to a building made of a non-combustible surface is known as $G_{2,}$ see Figure 5-2.

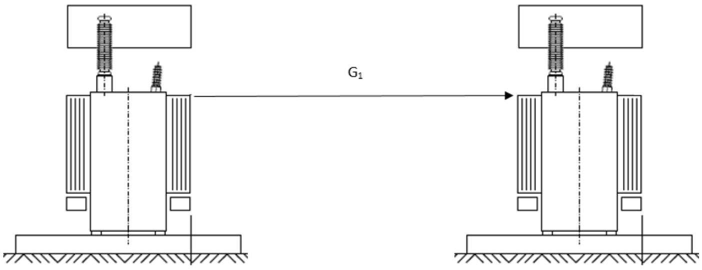

Figure 5-1 – Segregation between Transformers

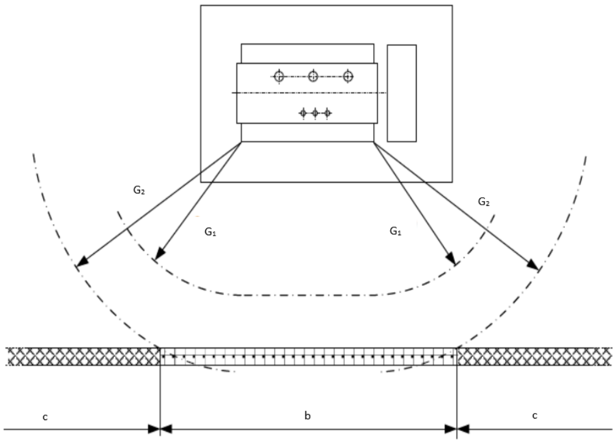

Figure 5-2 – Fire Protection between Transformer and Building Surface

The minimum values for G_1 and G_2 are given in Table 5-2; if these values cannot be achieved fire mitigation measures shall be introduced.

For bund designs where the oil level is allowed to rise above the aggregate level during a major oil spillage, the fire pool created changes the way in which G_1 and G_2 are measured in the figures. For this scenario, the clearances shall be measured from the internal face of the bund wall, not from the transformer.

When assessing the distance from transformers to third party properties, there is no certainty as to what may be constructed in the future, therefore to ensure that the clearance is compliant during the life of the asset, the designs shall assume that any third party property is (or will be) built using combustible surface materials.

Table 5-2 – Clearance to Other Transformers and Buildings

Transformer Type	Liquid Volume Range [l]	Clearance G_1 to other Transformer or Building Surface of Non-combustible Material [m]	Clearance G_2 to Building Surface of Combustible Material [m]
Oil insulated transformers	[1000, 2000]	3	7.5
	[2000, 20000]	5	10
	[20000, 45000]	10	20
	> 45000	15	30
Less flammable liquid insulated transformers without enhanced protection	[1000, 3800]	1.5	7.5
	> 3800	4.5	15

Notes:

1. Clearance to footpaths and public roads shall be assumed as G_1
2. Fire clearances apply in all directions.
3. Clearances associated with less flammable liquid insulated transformers apply when FR3 fluid filled transformers are in place.

The fire clearance shall be measured from the transformer to the nearest part of plant/equipment that is at risk when the transformer is on fire.

Based on the low fire risk of coolers, housings around these are only expected to perform to the acoustic specification; the fire rating for these enclosures is not a requisite unless otherwise determined by site risk assessment. Similarly, for transformers located in substations with equal or larger G_1 and G_2, the enclosure is not required to have a certified fire resistance. Where G_1 and G_2 are not achieved, the minimum fire rating of the building materials shall be 1-hour, but higher ratings might be needed as per fire risk assessment.

Fire-fighting equipment in substations shall be introduced in accordance with EDS 07-0116 guidelines.

Sprinkler systems shall not be fitted in substations and customer systems shall be external to the substation.

5.7 Acoustic Enclosures

5.7.1 General

The typical section through a transformer acoustic enclosure is shown in Figure 5-3. This consists of surrounding brick walls and a sloped reinforced concrete roof slab. Heat loss shall be encouraged around transformer enclosures.

The roof shape shall allow for adequate drains, including rain down pipes. Typically, this is insulated profiled colour coated cladding, composite or built-up, supported on a portal frame at a nominal pitch of 10 degrees, subject to design and cladding type.

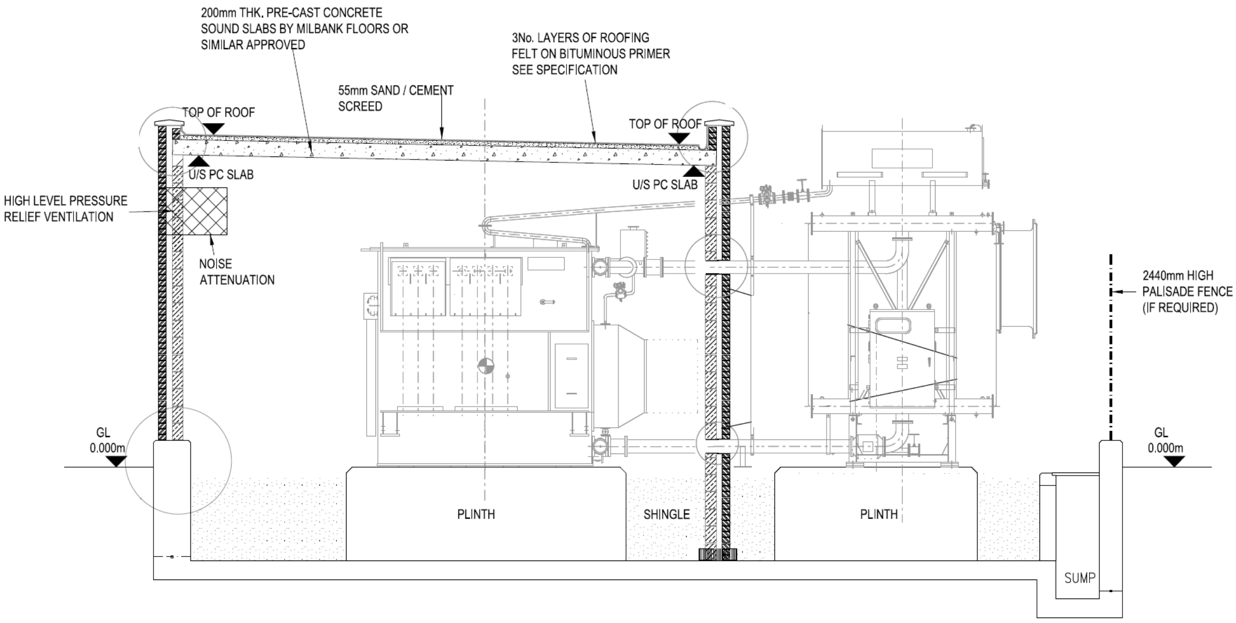

Figure 5-3 - Acoustic Enclosure Section through Building

Acoustic enclosures are generally required in residential areas and therefore subject to planning constraints/conditions and required to be aesthetically sympathetic with surrounding structures. The details of roof construction shall be designed according to conditions imposed by the local planning authority or building control office.

5.7.2 Standing Waves

All transformers generate noise, the principal component being a continuous tone of 100Hz. While considering minimum safe clearances for operation and maintenance, the transformer enclosure shall be designed to avoid constructive interference wavelengths. In order to avoid these, the distance between the transformer tank, walls and the roof soffit shall follow the recommendations detailed in Table 5-3.

Table 5-3 – Intervals where Enclosing Walls shall be Avoided

Interval to be avoided [m]
[0.375, 0.475]
[0.800, 0.900]
[1.225, 1.325]
[1.650, 1750]
[2.075, 2.175]
Theoretical conditions: λ = 100hz, Temp: 20ºC, Safe distance from peak +/-50mm

5.7.3 Building Requirements

Subject to a fire risk assessment, where a transformer is within another building, near third party buildings or places of public assembly, the enclosure shall be designed to a 4-hour fire resistance. Refer to Section 5.6 for separation between transformers.

The roof shall be constructed from a suitable dense material, for instance a proprietary PCC flooring / roofing system.

Consideration shall be given to a detachable panel within the housing to allow transformer and coolers to be removed without the need to demolish the full housing.

At least two sound attenuating doors shall be provided per enclosure, opening outwards with panic bars and to the appropriate fire rating (1 or 4 hours as applicable), diagonally opposed where reasonably practicable.

When proven unfeasible to fulfil the requirement of 4-hour fire resistance of the acoustic enclosure, a suitable approved fire suppression system may be installed within the enclosure. Refer to EDS 07-0116 for fire protection standards for operational sites.

5.8 Transformers within Fully-enclosed Substations

5.8.1 General

The requirements outlined in this section are relevant to fully enclosed transformers within major enclosed substations (e.g. substation below ground level), however these can be applicable in other cases should the site risk assessment require it.

All structural elements potentially exposed to the transformer oil fire shall be insulated with a 4-hour fire resistant material. Where heat sensitive equipment or areas are located adjacent to the transformer enclosures 4-hour fire insulation is required over and above the integrity rating.

General fire mitigation measures to prevent fire propagation shall be implemented e.g. the installation of steel doors and avoiding the use of combustible materials where possible. Cable routes and other holes through walls and floors shall be capable of being fire sealed after installation of all plant and cables.

5.8.2 Ventilation

All ductwork and fittings within transformer bay shall be of 4-hour fire resisting ductwork. Fire resistant ductwork shall be constructed of materials with an elevated rating of not less than 600°C or equivalent to the fire resistance rating of any compartment boundary.

Ductwork shall be designed and constructed to the DW144.

Ventilation shall be designed in association with the transformer manufacturer to minimise the risk of the bay temperature exceeding 40°C.

The ventilation system specification including air changes per hour shall follow guidance given in EDS 07-4060.

Smoke extraction shall be provided for below ground areas as described in BS 9999 and Part B of the Building Regulations.

5.8.3 Fire Detection, Suppression and Alarm Systems

Fire detection and suppression shall be provided in fully enclosed transformer areas. With the exception of the cooler where they are separated from the transformer and are out in the open. Given the inherently low fire risk of coolers and the perceived ineffectiveness of fire suppression systems when outdoor, there is no justification for the installation of fire suppression systems around cooler bays. Where the risk of fire around coolers is a concern, the use of water-filled coolers complete with a heat exchanger shall be considered.

Fire alarms, fire suppression system, smoke/fire dampers shall be provided in accordance with EDS 07-0116 and EDS 07-4060.

5.8.4 Blast and Fire Dampers

The blast and fire dampers shall be designed as follows:

- Unless otherwise recommended by the fire risk assessment, fire dampers shall be installed on all openings within the transformer bay.
- The dampers shall be integrated into the fire alarm and detection system and shall close upon the detection of fire.
- Subject to the required overpressure relief mechanism identified for the site, to prevent structural damage, the overpressure damper can open or close once the overpressure within the transformer bay has removed. The dampers configuration event depends on whether the pressure is designed to be released through proprietary blast vents or through the ventilation system.
- The interlocking ribbed blades shall be held out of the airstream against constant force springs by a fusible link. The fusible link shall have a melting temperature of 72°C. The link melting shall allow the springs to close the damper.
- The fusible link assembly shall be installed so that test release may be safely from either side of the damper.
- The overpressure system should direct the blast energy to a safe point of release to the atmosphere, away from publicly accessible areas.
- Transformer bays shall be protected using an approved blast / fire damper (e.g. SHX-UN MOT Blast / fire damper manufactured by AFP Airtech limited or similar approved) tested to a 4-hour fire resistance rating. Motorised blade operation makes it suitable for ventilation. The motor mechanism opens the blades allowing an instant reaction to pressure increase at any time during closing or full closure.
- For maintenance of the integrity of compartmentation, the fire dampers shall have an E classification to BS EN 13501-3.
- The fire damper case shall be fully welded to meet the air-tightness requirements of HVAC specification DW144 to classes A, B and C up to 1500 Pa.
- The ventilation system from the transformer bay shall be provided with overpressure dampers located upstream from the smoke dampers.
- Fire dampers shall have a tested or assessed installation method that matches the requirements of its supporting construction.

5.8.5 Vertical Separation between Transformer and Cooler

Where transformers and/or coolers are not located at the same level, vertical distances between the coolers and the transformers of greater than 8m will result in excessive pressure on the seals of the transformer where oil cooling is used. Where a cooler bay is to be positioned greater than 8m above the transformer, a water-cooling and heat exchanger system shall be utilised.

Separate and segregated cooling systems shall be used for each transformer; air conditioning/chilling shall not be used in these locations.

5.8.6 Access Hatches

If a fully enclosed transformers requires an access hatch, it shall be watertight to prevent water from entering the cell/enclosure.

5.8.7 Steel Pipes to Top up Oil Levels

Where transformers and/or coolers are not located at ground level, stainless steel pipes shall be installed from a suitable point at ground level to the transformer and cooler bays to facilitate the topping up of the plant with oil. There should be two 25mm diameter pipes, one ‘clean’, one ‘dirty’. This requirement is intended to remove the need to transport oil barrels to and from the transformer and cooler bay areas.

5.9 Retrospective Bunds

This section focuses on the use of existing walls, plinths and slabs to form the secondary oil containment around an in-use transformer and cooler bay.

When new concrete is to be used, this shall be dowelled to and cast against the existing structure, thus preventing differential settlement that might break the watertight seals.

Options for site decontamination, equipment repair and the provision of permanent bunding shall be investigated prior to developing a retro-bunding scheme. The most suitable and effective combination of mitigation options shall be employed in order to eliminate the risk of oil pollution to ground water, watercourses and ground strata.

5.9.1 Pollution Control Measures

The design of retro-fit solutions and control measures shall take into account:

- Environmental risk: site proximity to an environmentally sensitive area. Potential risk (high, medium or low) to ground water sources or surface water (e.g. rivers and streams). The greater the risk the more priority shall be given to provide a bund to the transformer(s).
- Asset strategy: design solutions shall match the strategic plans for the site and the transformers. Future works required to transformers (e.g. re-gasketing) may drive design decisions. Major substation projects shall look to incorporate retro-bunding of existing transformers.
- Transformer oil fill rate and transformer health index: transformers with a history of regular topping up of oil or where maintenance records show that large volumes of oil have been used in keeping the transformer oil to the correct level shall not make use of short lifespan bunding solutions.
- Surrounding structures: given space constraints in some substations, walls from adjacent substation buildings may be used to create the structure for the containment of oil.
- Existing cables: no main cable shall be covered with or cast into concrete. In planning and constructing of a bund, it is essential that cable disturbance is kept to a minimum and future access is allowed.
- Location: whilst all transformers with header tanks shall be bunded, the priority shall be for transformers located at less than 10m away from any inland freshwater or coastal waters, or less than 50m away from a from a well or borehole otherwise known as a Source Protection Zone (SPZ).

5.9.2 Oil Resistant Coating Applied on Existing Slabs and Walls

Oil resistant flexible coating spray or hand applied polyuria may be used to repair/upgrade existing walls, when one or more of the following is found on site:

- The existing walls can withstand the hydrostatic pressure of the volume to be contained.
- The walls are only affected by minor cracking (less than 4mm crack width); therefore, the containment capacity can be safely achieved with the application of the polyuria.
- The existing volume capacity is insufficient but there are surrounding walls that can form the new bund.

The warrantied lifespan of the coating should be no less than twenty years. Anti-slip surfaces along the designated walkways shall be included.

5.10 Firewalls

Although firewalls are often an element outside the bunded area, it is important to consider them when G_1 and G_2 from Figure 5-1 and Figure 5-2 are not achievable. Where possible, the firewall should be supported by the bund wall.

Internal firewalls protect the main transformer from fires that originate in the auxiliary transformer. The length of the internal wall shall exceed that of the auxiliary transformer bund along the side adjoined with the main transformer bunded area. The excess distance shall be at least 1m in each direction. The height of the internal firewall shall be at least 1m above the top of the auxiliary transformer's conservator.

Firewalls are made of materials such as conventional brick, cast in-situ or pre-fabricated concrete or any proprietary and certified 4-hour fire rated panels.

Where firewalls cannot be fitted, a fire supressing system shall be introduced.

5.11 Finishes

The top of concrete bund walls and the bund slab shall be steel float finish.

Plinths shall be finished to the tolerance dictated by the transformer manufacturer, typically +/- 4mm over a 5m straight edge.

6 Layout and Configuration

6.1 General

Transformers shall be located within a secured operational area, separated from non-operational areas by internal palisade fences or a secure enclosure. At some sites, it is possible to use the walls of adjacent buildings (e.g. acoustic enclosures) to complete the perimeter of the secured compound, thus reducing the length of internal fence required.

Reference shall be made to the standard drawings listed in Appendix A for transformer location within the substation compound and to allow for the replacement of faulty plant while other plant is live.

The minimum clearance around plant shall be 750mm in all directions.

The bund walls and plinth shall not impede operational functionality of the equipment, e.g., airflow for coolers, operational access, earthing, sump pump arrangements or location of the drainage system.

There should be sufficient space for placing scaffolding and temporary lifting equipment for the removal of transformer bushings, turrets and tap-changers.

Prior to confirming the size of the enclosure, the size of the tap changer and its access requirements shall be confirmed with the manufacturer. A minimum 1200x1200mm clear floor area shall be allowed for the lowering of the tap-changer for maintenance purposes.

Subject to the site voltage, adequate safety electrical clearances between structural elements and any exposed electrical equipment, e.g. bushings and busbars, shall be introduced.

Allowance shall be made for safe access to pumps, control panels and ancillary equipment.

Where site conditions dictate, transformer bunds shall be designed to accommodate the future construction of an acoustic enclosure.

Figure 6-1 shows an off-tank transformer with acoustic enclosure. 750mm minimum clearance applies around the equipment excepted in front of the tap changer. This applies equally to outdoor on-tank transformers.

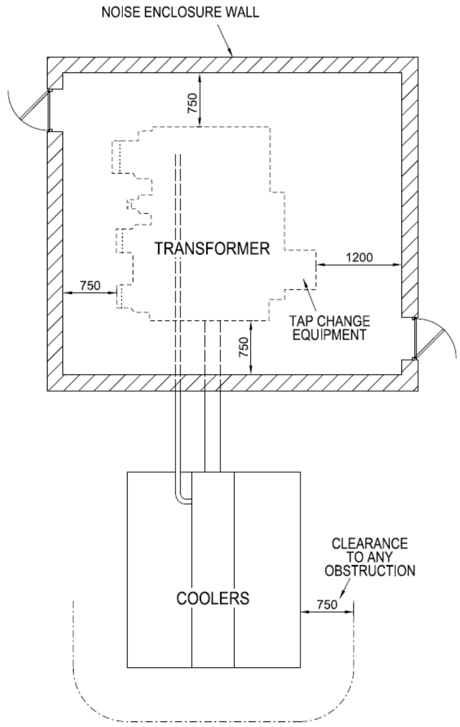

Figure 6-1 – Transformer with Acoustic Enclosure Typical Setting Out

6.2 Plinth

The size of the plinth is determined by the location of the jacking points around the transformer. The distance from the outer edge of the each jacking point in each direction to the internal line of the plinth's chamfer shall be greater than 300mm. A typical plinth layout is shown in Figure 6-2.

The plinth shall have the centre lines inscribed to allow accurate positioning of transformer.

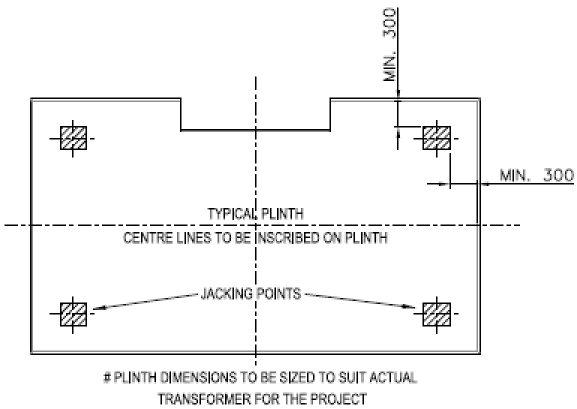

Figure 6-2 – Typical Transformer Plinth

6.3 Bund Walls and Base

Where a substation benefits from existing flood barriers, the height of the bund wall depends on the volume capacity requirement, as defined in Section 5.1. In contrast, for sites that are not flood-protected, the top level of a bund wall shall be above the flood depth of the surrounding area, as recommended by the flood risk assessment.

Bund walls and base shall be impermeable to water.

Where the clearance to overhead live equipment is compromised, the top of the bund wall shall be provided with a physical means to prevent personnel from standing on the wall. Acceptable methods to achieve this are fixing a steep top chamfer or a post and chain arrangement.

Where the design of the bund makes use of existing transformer plinths, refer to Section 5.9, where retrospective bunding is discussed.

6.4 Winching Eyes for Cables and Transformer Pulling Points

The design of the bund shall allow for the temporary forces and loadings exerted during pulling of the transformer and cables into position.

Long cable runs will require a cable winching eye, with a suitable anchor point, opposite the incoming cable position.

Certain sites and bund layouts require pulling points to move the transformer onto the plinth. These pulling points are typically designed for a 5 ton pulling force, based on a roller friction of 5% and a transformer weight of 100 ton, displaced horizontally. The pulling force for larger transformer weights and sloped surfaces shall be increased to suit. The pulling points shall be located either at the plinth or the bund walls to cater for a transformer delivered on steel roller skates and using a portable hand operated hoist. Where reasonably practicable, consideration shall be made to locate the pulling points at the top of the bund wall, so that the anchors are used in shear, reducing the risk of a sudden concrete failure. Pulling points shall be at least 500mm above the bund floor level, and a minimum of 300mm from the top of the bund wall.

6.5 Cable Pit

Cable penetrations through the liquid containing area of the bund are not permitted, as these become weak points and the water or oil can find a way out of the bund. Cables shall reach the transformer via penetrations made in the cable pit. The cable pit typically forms part of the bund but is separated from the liquid containing area by internal walls.

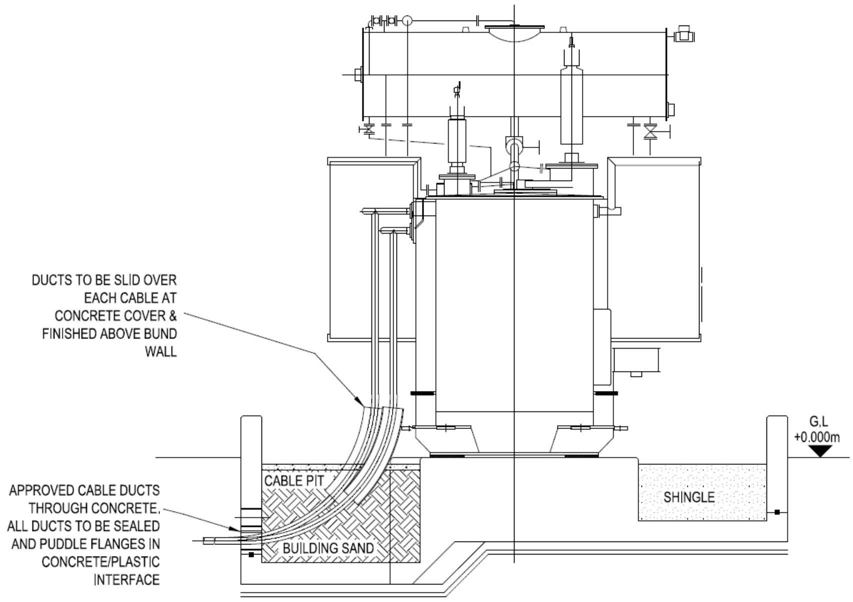

Figure 6-3 – Cable Pit

Typical cable pit details are shown in Figure 6-3. The cable pit shall be designed to retain the clean sand fill. The pit shall be covered with a 75mm thick fibre reinforced concrete slab. Cable joints shall not be installed within the bund or the cable pit.

Approved duct seals shall be used on all the cable duct ends to prevent any residual oil spillage being released to the ground via the cable pit. In addition, at the interface between the concrete and the cable ducts hydrophilic and/or cast-in water bars/puddle flanges shall be used.

6.6 Fire Traps

At sites with severe space constraints, the use of flame traps on metal grating should be considered, as shown in Figure 6-4. Flame traps allow the oil to safely enter into the lower part of the containment area, where no aggregate material is present, thus increasing the volume capacity of the bund.

Provisions shall be made to allow for safe access into the space below the flame trap for personnel intending to carry out cable works or maintenance.

The supporting structure for the 40mm aggregate material shall be specified to withstand the temperatures produced by the hot oil.

The flame trap arrangement shall enable a total through flow of at least 7,000 litres/minute.

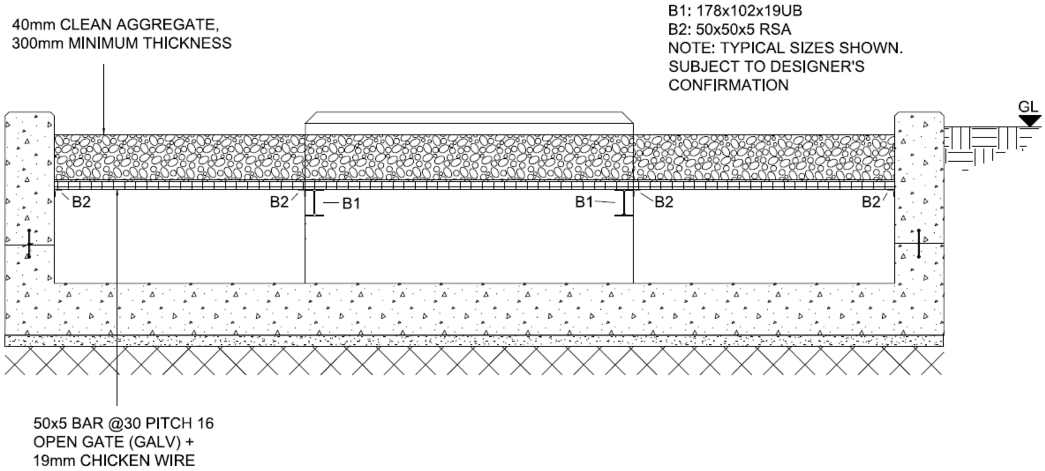

Figure 6-4 – Flame Trap Typical Detail

7 Building and Electrical Services

Transformer enclosure building and electrical services, including alarms, shall be designed in accordance with EDS 07-4060 and EDS 07-1119.

8 Earthing

The transformer earthing system shall be designed and constructed in accordance with EDS 06-0013 and ECS 06-0022.

To provide earth continuity, it is considered a good practice to have the longest reinforcement bar connected to the external part of the earthing system as well as to the rebar ring inside the bund concrete work.

The number and location of internal clamps shall be to the designer specification. It is important to ensure the connection of enough bars all around to whole bund for earthing continuity.

A minimum of two earth lugs shall be allowed to connect the reinforcement of the bund to the earthing system.

9 Handover and Post-Construction

9.1 Water Test

A water test shall be carried out to check the quality of all seals and joints. Backfilling shall not be carried out until the test is completed to ensure that any leakage is readily observed.

Preparation for the water test shall consist of:

- Stopping any duct/cable penetrations with proprietary duct bungs.
- Filling the bund to 200mm above the highest duct or joint.
- Testing no less than 24h of bund being filled.
- Topping up if required prior to commencing the test.

The bund is considered to have passed the test if the water depth loss is no more than 1mm/hour over a continuous 6-hour period. A test compliance certificate shall be produced on successful completion of the test by the nominated engineer.

9.2 Fire Plan

A fire plan specific to the premises shall detail the pre-planned procedures in place in the event of a fire.

The emergency plan shall be recorded where a license under an enactment is in force or where an ‘Alterations Notice under the Fire Safety Order’ requires it.

Refer to EDS 07-0116 and EDS 07-4000 for further information on fire safety

9.3 Integrity Inspection

Following completion, every bund shall be inspected for integrity and assessed during each major substation inspection as detailed in EMS 10-6501.

10 Materials

10.1 Structural Concrete for Bunds

Secondary oil containment has traditionally been built using reinforced concrete, because it is cost-effective and provides durable structures. Where there is a requirement for a noise enclosure, firewalls or for a fence line above/adjacent to the bund, the reinforce concrete provides a stable foundation.

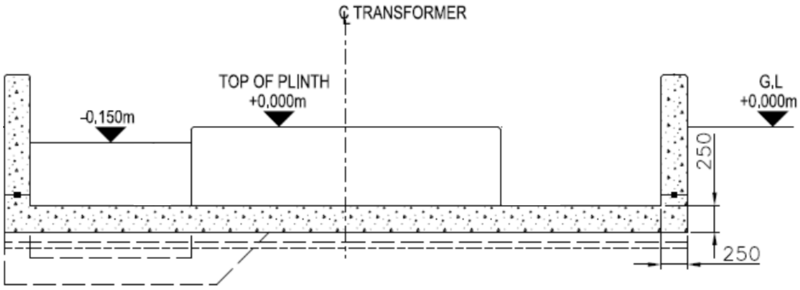

Figure 10-1 – Typical Section through Bund Wall

The typical section through a bund wall, shown in Figure 10-1, presents vertical and horizontal reinforced concrete slabs of a minimum 250mm thickness. The reinforced concrete work shall be designed as follows:

- Foundations and reinforcement details to suit local site conditions.
- Remove ground contaminants, excavate local soft spots and bring up to formation level with a designated GEN1 mix to BS 8500-2.
- Pour structural concrete on 50mm GEN1 mix concrete blinding, on 1200 gauge polyethylene slip membrane, on DTp1 type material compacted to designer's specification.
- Sulphate resistance cement combination to BS EN 197-1 unless otherwise specified.
- RC32/40 concrete mix with 20mm aggregate to BS 8500-2 unless otherwise specified.
- 40N/mm² minimum compressive strength of the concrete after 28 days.
- Concrete cover to rebar 40mm nominal. 50mm on all faces exposed to fire and/or bottom face in contact with blinding. 75mm where in direct contact to soil.
- 25mm chamfers to all sharp external edges above ground level.
- Fair face finish to exposed concrete.
- Ribbed bar reinforcing to BS 4449, strength grade B500B. Steel fabric reinforcement square mesh to BS 4483.
- Hydrobar PVC water bar for newly constructed joints; Hydrophilic type for retro fit and sealing against existing structures.
- Welded or exothermic type connections to be indicated on the reinforcement drawings.
- Reinforcing bars to allow for earthing continuity. The reinforcement design to specify the bars and type of bonding required to achieve continuity throughout the bund.

For new bunds at locations where it is known that the water table is high and the surrounding environment is highly sensitive to contamination, the crack width shall be limited to 0.2mm to create a liquid retaining structure to BS EN 1992-3.

10.2 Plastic Bunds

Plastic bunds are considered an efficient alternative to concrete where shallow cables make excavation works too onerous and risky. The approved plastic bunds are made of HDPE, which is a synthetic rubber used in construction.

The advantage of the plastic bunds is that given their flexible nature, the preparation of the ground can be limited to clearing the area receiving the bund. An example is shown in Figure 10-2. However, there are sites where plastic bunds are not suitable, such as:

- Substations where the bund wall height is determined by the flood depth and not by the volume of oil in the system. Plastic bunds are designed to contain the oil inside the bunded area, but the joints are not designed to take an external pressure.
- Sites where the transformer requires an acoustic enclosure. For this scenario, refer to reinforced concrete bunds in Section 10.1. When the full amount of oil is not contained within the voids of the aggregate material, the segregation needed to protect plant/personnel increases as detailed in Section 5.6. Unless fire mitigation measures are introduced (e.g. fire walls), the case for plastic bunds becomes less attractive. This limits the use of plastic bunds to locations where burning oil cannot put members of the public, third party buildings or substation plant/equipment at risk.

Figure 10-2 – Plastic Bund Details

10.3 Proprietary Bund Walls

Proprietary bund walls can be formed with materials of low conductivity (e.g. GRP or plastic); and can be designed with demountable sections for planned or emergency maintenance. However, it is important to note that the fire resistance of low conductivity materials is generally low and for this reason, 4-hour fire rated shields shall be added to provide a compliant bunding arrangement. Under no circumstance shall the fire safety requirements be relaxed. This includes ancillary materials and fixings.

10.4 Aggregate Inside the Bund

Aggregate material inside a bund shall be 30mm to 50mm size, G_C85/20 to BS EN 12620. This material shall be deep enough to provide a regular/walkable surface, sufficient volume capacity to keep the full amount of oil in the system and a safe fire trap for the oil not to ignite if the transformer catches fire.

10.5 Cable Ducts and Seals

Ducts and seals shall be specified and supplied to EAS 02-0000.

Cable entries and unused ducts shall be sealed against ingress of water, dust and other materials.

10.6 Pumps

An outdoor bund shall be equipped with an oil discriminating pump, located in a sump, to remove rainwater. The pump shall discharge at a minimum flow rate of 2.1l/s over a 3m head.

The pump control box shall be preferably located in the relay or control room. However, at space-constrained sites, if a suitable location is available near the pump, is acceptable as long as the control box is inside an approved weather-resistant enclosure.

The pump shall discharge into an oil separator sized for the pump's discharge rate.

An alarm shall be connected through SCADA to give warning of sump pump failure and potential high water levels.

10.7 Oil Water Interceptor

The oil water interceptor shall be Class 1 full retention type with automatic closing devices complying with the requirements of BS EN 858: Parts 1 and 2.

The oil interceptor shall be resistant to transformer oil.

When the effluent has passed through the oil interceptor, the discharge may go into a local soakaway or watercourse providing approval from the Water Authority/Environmental Agency shall is sought.

10.8 Automatic Bund Dewatering System

Automatic bund dewatering systems treat oil-contaminated rainwater before it leaves the bund; the system consists of an oil discriminating pump discharging into a proprietary oil interceptor unit inside the bund. The unit comprises of a full retention oil separator designed to remove a limited amount of hydrocarbons. This unit negates the need for an external oil interceptor and the associated drainage pipework.

An acceptable bund dewatering system shall be:

- Manufactured to BS EN 858.
- Certified as a Class 1 oil interceptor.
- Provided with a 'Declaration of Conformity' stating the name and address of the organisation taking responsibility for the product, the product specifications, the safety directives the product complies with and details of relevant standards used.

A typical automatic bund-dewatering unit is shown in Figure 10-3, note that it is placed at ground level and its location is flexible within the bund wall.

The location within the bund and above ground facilitates the installation, inspection and maintenance during the operational life of the unit.

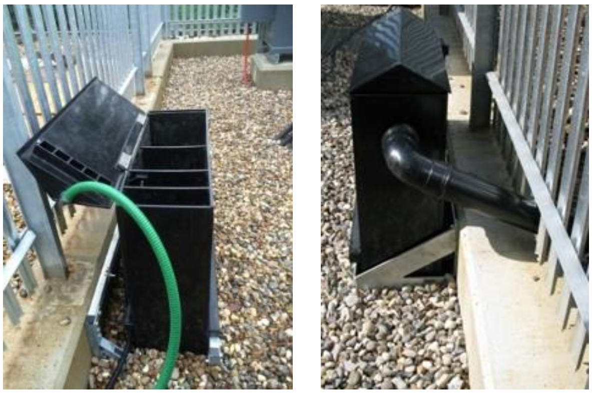

Figure 10-3 – Bund Dewatering Unit

10.9 Doors

Doors shall be certified and complete with appropriate ironmongery including panic push bar and escape door furniture to BS EN 1125 to suit application and test certification. Doors leading to outdoor environments shall be fitted with external door furniture.

Doors and frames shall be steel galvanised and powder coated.

Door fire ratings and specification shall be as follows:

- Transformer and enclosed cooler cells 4-hour fire rating complete with viewing panel or porthole, smoke seals.
- Security rating to meet LPCB LPS 1175 Level 2 as a minimum, subject to site risk assessment.
- Doors to be equipped with either TDSi magnetic access system or locks matching the local area locking suite.

10.10 Blast and Fire Dampers

As defined in Section 5.8.4 of this document.

11 References

11.1 UK Power Networks Standards

EAS 02-0000	Approved Materials List – Cables
EDS 06-0013	Grid and Primary Substation Earthing Design
ECS 06-0022	Grid and Primary Earthing Construction
EDS 07-0106	Substation Flood Protection
EDS 07-0116	Fire Protection Standard for UK Power Networks Property and Operational Sites
EDS 07-1109	Security Requirements for Operational Sites
EDS 07-1119	Substation Electrical Services
EDS 07-4000	Grid and Primary Substation Civil Design
EDS 07-4060	Grid and Primary Substation Building Services
EMS 10-6501	Inspection and Maintenance of Civil Assets

11.2 National and International Standards

Control of Pollution (Oil Storage) (England) Regulations 2001

Electricity Safety, Quality and Continuity Regulations (ESQC)

Environment Act 1995

Environmental Protection Act 1990

Health and Safety at Work Act 1974

DW144	Specification of Steel Metal Ductwork
BS 4483	Steel fabric for the reinforcement of concrete
BS 4449	Steel for the reinforcement of concrete
BS 8500-2	Concrete. Complementary British Standard to BS EN 206-1
BS 9999	Fire safety in the design, management and use of buildings. Code of practice
BS EN 197-1	Cement. Composition, specifications and conformity criteria for common cements
BS EN 206-1	Concrete. Specification, performance, production and conformity
BS EN 858-1	Separator systems for light liquids (e.g. oil and petrol)
BS EN 1125	Building hardware. Panic exit devices operated by a horizontal bar, for use on escape routes. Requirements and test methods
BS EN 1991-1	Eurocode 1. Actions on structures. General actions. Densities, self-weight, imposed loads for buildings
BS EN 1992-3	Design of Concrete Structures
BS EN 12620	Aggregates for concrete
BS EN 13501-3	Fire classification of construction products and building elements. Classification using data from fire resistance tests on products and elements used in building service installations: fire resisting ducts and fire dampers
BS EN 61936-1	Power installations exceeding 1 kV a.c. Common rules

12 Dependent Documents

The documents below are dependent on the content of this document and may be affected by any changes.

EDS 07-4000	Grid and Primary Substation Civil Design

Appendix A – List of Standard Drawings

Drawing	Title	Revision
EDS 07-4070.01	On-Tank Transformer Bund	
	Sheet 1: General Arrangement	A
	Sheet 2: Concrete GA and Cable Ducts	A
EDS 07-4070.02	Off-Tank Transformer Bund	
	Sheet 1: General Arrangement	A
	Sheet 2: Concrete GA and Cable Ducts	A
EDS 07-4070.03	Off-tank Transformer Bund with Masonry Acoustic Enclosure	
	Sheet 1: General Arrangement	A
	Sheet 2: Elevations	A
	Sheet 3: Builders Details	A
	Sheet 4: Door Schedule	A
	Sheet 5: Electrical Services	A
EDS 07-4070.04	Miscellaneous	A
EDS 07-4070.05	Retrospective Concrete Bund	
	Sheet 1: General Arrangement	A
	Sheet 2: Builders Details	A
EDS 07-4070.06	Plastic Bund	
	Sheet 1: General Arrangement	A
	Sheet 2: Builders Details	A