

OIL CONTAINMENT AT ELECTRICITY SUBSTATIONS AND OTHER OPERATIONAL SITES

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PURPOSE AND SCOPE

In the UK *Oil* is one of the most commonly reported types of water pollution and causes nearly a quarter of all pollution incidents. Adequate measures must be taken to prevent the risk of pollution of *Surface Waters*, groundwater, sewers and drains by *Oil*.

National Grid is committed comply with all relevant environmental laws. See National Grid Environment Policy for information.

This technical specification is applicable to containment of *Oil* at new and existing (i.e. retrofit) electricity substations and other relevant operational sites. It shall also apply, as appropriate and via agreement, to third party assets installed on National Grid owned land.

The Environment Agency for England and Natural Resources Wales are responsible for protecting *Controlled Waters* from pollution. This responsibility extends to the prevention of pollution of the environment, harm to human health and detriment to local amenity by waste management activities.

It is an offence to pollute *Controlled Waters* either deliberately or accidentally and the formal consent of the appropriate Agency is often required for discharges to such waters, whether these are direct or via soakaways. This specification defines the mandatory prescriptive and functional requirements by which National Grid shall ensure compliance with its legal obligations. Installations not specifically covered by this document shall, as a minimum, comply with current legislation and the relevant Agency guidelines, specifically those included in the References Section 13.

Works shall be divided into two categories *New Work* and *Improvement Work* as defined in Part 2. Unless specifically identified in the contract specification as *Improvement Work* all relevant parts of a project shall be assumed to be *New Work*.

Retrospective application of this specification to existing sites will be determined on a risk based approach, taking into account National Grid engineering policy, technical feasibility, cost and the site-specific risks. Guidance for *Improvement Work* is given in Part 1, Section 8 of this document.

Definitions are detailed in Part 2 and are italicised throughout this specification.

Text contained in boxes, such as this, provides an **informative commentary**. It does not form part of the formal requirements of the document, but aims to explain the rationale and 'spirit' of the requirements and aid in preparation of Technical Deviation requests if appropriate.

PART 1 - PROCEDURAL

1 DESIGN PHILOSOPHY

- 1.1.1 The purpose of this technical specification is to ensure National Grid discharges its legal and social responsibilities with regard to protecting the environment from the damaging effects of any *Oil* it uses in carrying out its business activities at electricity substations and other operational sites.
- 1.1.2 A key document in achieving this objective is the Control of Pollution (Oil Storage) (England) Regulations 2001 (known as the 'Oil Storage Regulations' or OSR) noting that much of the *Oil* on electricity substation sites is technically exempt from these as it is in use rather than stored. Notwithstanding this, National Grid adopts the principles of the legislation and associated guidance (for example that issued by the Environment Agency and CIRIA) as a starting point and extends these as necessary to suit specific operational circumstances.
- 1.1.3 Quantities of *Oil* in excess of 200 litres, stored in containers other than operational plant, outside of buildings, shall be subject to OSR.
- 1.1.4 This section is intended to highlight the key 'building blocks' of the National Grid *Oil* containment requirements to assist the reader in understanding the detail of the specification and to ensure that these principles are consistently adopted in all designs.
- 1.1.5 Oil containment design within National Grid shall follow one of two types:-
 - Type 1 - *Secondary Containment System* which shall comprise an above ground *Oil Retaining Area* (or 'bund') only.
 - Type 2 - *Secondary Containment System* which shall in addition to Type 1 incorporate an *Underground Oil Containment Facility*. This shall be in the form of either an underground integral moat or *remote underground oil containment* (dump tank).
- 1.1.6 Type 1 is the default and National Grid shall indicate in the project document if Type 2 is required.
- 1.1.7 Where an *Underground Oil Containment Facility* is installed (Type 2) it shall always be connected to an *Oil Retaining Area* via a free draining closed gravity system such that leaked *Oil*, being a potential fuel supply, would quickly be removed from the source of the fire and then stored at a safe separation for a specified period of time.
- 1.1.8 An oil draw-off system shall be installed in all cases ie Type 1 and Type 2 except where a *remote underground oil containment (dump tank)* is installed. Appendix C gives a typical Draw-off system which should be modified to suite particular site conditions.

- 1.1.9 Flame Traps shall be installed as necessary to ensure that any fire accompanying a catastrophic equipment failure is extinguished prior to the leaked Oil draining into an Oil Draw-Off system or an Underground Oil Containment Facility.
- 1.1.10 Where an Oily Water Drainage System necessitates lift pumps e.g. in Secondary Containment Systems and other non-free draining areas at risk from Oil contamination, a Bund Water Control Unit (BWCU) shall be used to manage the quality of discharge.
- 1.1.11 Penstocks and sampling chambers shall be installed at designated locations to manage the discharge and monitor its quality. See Appendix A for guidance.

INFORMATIVE Type 1 and Type 2 construction came about as a result of a study by WSP that concluded that the inclusion of underground oil containment or moat had no noticeable effect on the intensity of the fire and therefore no effect on the fire pool

2 LOCATION REQUIREMENTS

2.1 Design Consultation

This Specification prescribes the parameters for the design and construction of *Oil* storage, containment and associated *Site Drainage* systems. The designer is required to consult the Environment Agency Regional Office, local to site, to determine any additional site-specific factors which may need to be considered, including the need for consents. In addition, any other relevant authorities such as Internal Drainage Boards shall be contacted where necessary.

2.2 Flooding

Designers are required to take due account of the requirements of PS(T) 095 – Flood Mitigation Policy when producing designs for *Oil* containment infrastructure. Where it is reasonably practicable and safe, designers are to ensure the level of *Oil Retaining Area* walls and control panels and dump tank inspection covers are above flood resilience levels. Designers shall balance the benefits of doing so against the expected costs. Designers shall also consider the risk of flood water washing *Oil* out of the *Oily Water Drainage System* during a flood event.

2.3 Areas Subject to Oil Contamination

2.3.1 Areas to be drained via an Oil Separator

Where pumps other than BWCU are used, they shall always be located downstream of an *Oil Separator* to prevent the *Oil Separator* processing emulsified *Oil* and water.

Areas to be drained via an *Oil Separator* are listed below.

- a) *Oil* handling areas, workshops, maintenance and test areas for *Oil* containing equipment.
- b) Tunnels containing *Oil* filled cables
- c) Interconnected trench systems that pass within 5 metres of any Operational *Oil* containing plant (containing over 200 litres of *Oil*) or containment area. Alternatively where trenches are filled with sand there is no requirement for draining via an oil separator.

INFORMATIVE: Historically Tanker standing areas and skidways, provided to facilitate transformer installation/removal, were also routinely drained in this manner. This prescriptive requirement has now been purposely excluded.

- 2.3.2 Compressor installations and blow down pits shall be drained via a discrete retention tank or chamber, for emptying by sludge/Oil tanker for off-site disposal:

INFORMATIVE: Oil condensates tend to emulsify and are not amenable to separation in *Oil Separators*. Proprietary water/Oil demister filters are available to separate and collect all condensate and sludge from compressor installations.

- 2.3.3 The following areas in substations have been deemed not to typically require drainage via an *Oil Separator*:

- a) Substation roads unlikely to be affected by an incident associated with items listed in 2.3.1
- b) Open areas surfaced by gravel.
- c) Roof drainage (excluding HV plant noise enclosures).
- d) Sections of roads or areas that are designated for the siting of plant/vehicles for servicing of *Oil* containing plant or storage tanks.

2.4 Secondary Containment Systems

- 2.4.1 *Secondary Containment Systems* for large items of *Oil* filled plant shall comprise an *Oil Retaining Area* only (Type 1) or an *Oil Retaining Area* in conjunction with an *Underground Oil Containment Facility (Type 2)*. Criteria for determining which elements of the *Secondary Containment System* are required are shown below.

- 2.4.2 The following items of *Oil* filled plant shall be installed in *Oil Retaining Areas*

- a) *Transformers* (including Supergrid, Converter, Earthing, Auxiliary and Station Transformers)
- b) *Reactors*
- c) Quadrature Boosters
- d) Diesel *Generators*
- e) *Oil storage* Tanks
- f) *National Spare Transformers* and similar ' non-operational' plant

- 2.4.3 Suitable *Secondary Containment Systems* shall also be provided where the following features are present

- a) *Oil* filling points
- b) Fill and draw off pipes, excluding draw off systems that facilitate the emptying (by pumping) of the below *ground* containment system used in the event of a catastrophic failure of the contained HV equipment, see section 5.5

INFORMATIVE: Emergency draw-off systems (see Section 5.5.3) shall not be provided with a dedicated vehicle standing/parking area.

- c) Sight *gauges*
- d) Fixed *interconnecting* pipework

2.4.4 Twin walled, non corrosive pipework is the preferred method of providing *Secondary Containment* to pipes in permanent installations and is mandatory for temporary systems.

3 DIMENSIONAL REQUIREMENTS AND CLEARANCES

3.1 General Clearances

Where practical, no part of any *Oil* filled equipment, *Oil* storage area, or mobile tanker shall be sited within:

- a) 50m of any borehole or well used for water abstraction
- b) 10m of any Surface Watercourse
- c) 5m of any drain through which *Oil* could enter and discharge directly into *Controlled Waters*

Where such separation is not possible, alternative solutions shall be agreed with National Grid.

3.2 Oil Containment/Storage Requirements

The volumetric requirements for the various components of a *Secondary Containment System* depend on numerous variables including the type of plant served and the presence of fire protection systems etc. Specific requirements for *Oil Retaining Areas* and *Underground Oil Containment Facilities* are given in Appendix B. The 'Gross' volume shall be taken as the total area enclosed by the external walls of the item under consideration with no deductions. The 'Net' volume shall be taken as the 'Gross' volume minus the volume displaced by items of plant or other permanent features.

INFORMATIVE: On a significant number of substation sites, remote *Underground Oil Containment Facilities* ('dump tanks') have been discovered to be full of water. This has been variously due to ground water ingress caused by poor installation (e.g. differential settlement, inadequate backfilling, damage during construction) and/or a build up of rain water due to the failure of poorly maintained *BWCU*. Should there have been a catastrophic failure of the equipment associated with these 'dump tanks' accompanied by the release of large quantities of *Oil* a major environmental incident would have resulted.

As a consequence of this risk all 'bunds' (Oil Retaining Areas) connected to 'dump tanks' are required to have a minimum gross capacity, see Appendix B (i.e. it is not necessary to remove the volume occupied by the *Oil* containing equipment) as stated. Where an active automatic fire protection system is fitted to the associated equipment there is no requirement to increase this capacity to allow for the additional volume of fluid.

The requirement does not apply to 'moat' type foundations because as these are integral with the equipment foundations as opposed to being sited remotely as is often the case with 'dump tanks' it is considered less likely that an overfilling problem will go unnoticed.

3.3 Oil Retaining Area dimensions and clearances

3.3.1 HV Plant Oil Retaining Area

- a) The height of all *Oil Retaining Area* walls shall be a minimum of 400mm above finished substation ground level or the support plinth(s) of the associated *Oil* containing equipment, whichever is the greater. Bund walls of more than 500mm above finished substation level shall have access/egress steps which if made of steel shall be appropriately earthed (see TS 3.01.04).
- b) The minimum clear horizontal distance (to facilitate access) between the internal face of an *Oil Retaining Area* wall and any *Oil* containing plant within it shall be 2.0 m for Transformers, Reactors and Quadrature Boosters and 1.0m for all other equipment unless it can be demonstrated via reference to CIRIA Report 163 that a lesser dimension is appropriate.
- c) As far as is reasonably practicable bushings shall not project beyond the internal face of an *Oil Retaining Area* wall.

INFORMATIVE: The clear horizontal distance is specified to give some protection against 'jetting' failure and also provide a safety zone in the event of a cooler collapse – something which is known to be a real possibility in the event of a transformer fire.

Provided bushings have an independent, low pressure oil system (e.g. one which is separate to that of the main equipment) the clearance requirements do not apply. Bushings shall however be within the plan area defined by the internal faces of the 'bund' wall.

- d) Where *Oil Retaining Areas* are connected to an *Underground Oil Containment Facility*, the system shall be capable of draining *Oil* at a rate of at least 7,000 litres per minute.

3.3.2 Coalescer Washdown/Maintenance Bunds

A concrete bund shall be constructed directly above, and around all access turrets of each *Oil Separator* to provide a wash down and maintenance area for the coalescer and other components. This shall have minimum internal dimensions of 3.0m wide by 5.0m long with a perimeter wall 0.2m wide by 0.2m deep, see Figure 3.1

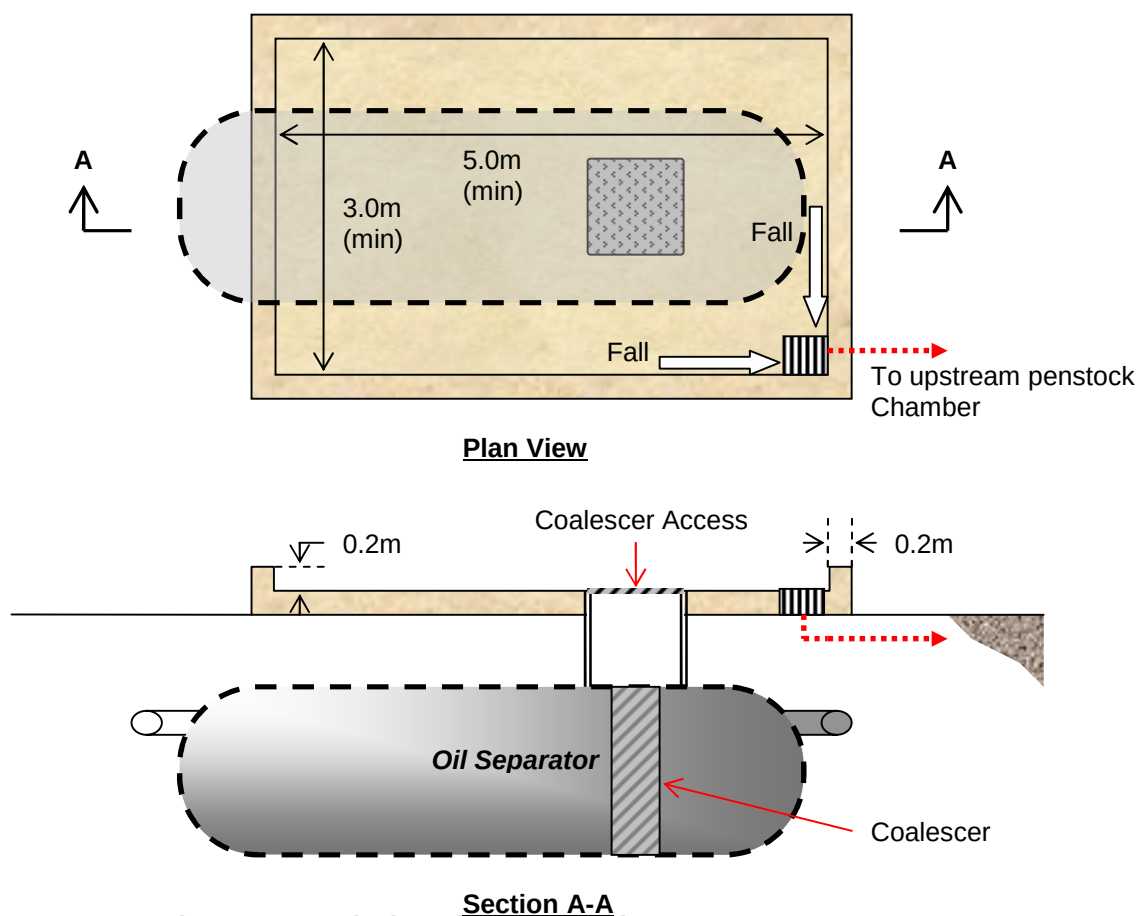


Figure 3-1: Typical Coalescer Washdown Area

The washdown area shall be constructed of C30/37 reinforced concrete in accordance with BS EN 206-1 and BS 8500.

3.4 Fire Damage Zone

- 3.4.1 The *Fire Damage Zone* is the area immediately around specified types of *Oil* filled plant within which all items are assumed to be at risk from the damaging effects of a fire due to a catastrophic failure of that *Oil* filled plant. This is an important concept when considering the siting of *Oil* Containment features. The process for calculating the dimensions of the *Fire Damage Zone* is detailed in TS 3.01.03.
- 3.4.2 The location of *Penstock* valves, surface inspection hatch covers and access roads for remote *Underground Oil Containment Facilities* ('dump tanks') and *Oil Separators* shall be positioned outside of the *Fire Damage Zone* of the HV equipment or plant they are directly associated with. This is to facilitate emptying of the contents of the containment tank during fire-fighting activities. Where this is not practicable due to site space constraints, alternative arrangements shall be agreed with National Grid to determine a suitable safe layout solution.
- 3.4.3 Riser pipes (as defined in clause 5.5.3) used for draining *Oil* from *Underground Oil Containment Facilities* and from *above ground (Type 1 Installation)* system following a failure shall be a minimum of 40m and maximum of 50m from the bund wall of the equipment they serve. A 1.8m X 1.8m fire barrier walls can reduce the 40m distance.

3.5 Control Panels

Control panels forming part of the *Oil* containment system shall be sited within the

associated substation compound. They shall be mounted as close as practicable to the controlled equipment a minimum of 1.2m above ground level and more than 2m from the substation security fence.

4 SITE DRAINAGE SYSTEM

4.1 General Considerations

4.1.1 Drainage to be routed via an *Oil Separator* shall be limited to those areas subject to *Oil* contamination as defined in Clause 2.3.1, and shall specifically exclude *Surface Water* drainage from areas defined in Clause 2.3.3 where practical. It is permissible to drain *Surface Water* from areas defined in Clause 2.3.3 through a separator where the impact on the size of the separator is small and where it is impractical to have a separate drainage system, e.g. discharge from small roofs.

4.1.2 Where the drainage system carries significant quantities of silt, provision shall be made for extracting the silt by either:

- a) Providing silt trap facilities, separate from and upstream of Oil Separators, or
- b) The use of an *Oil Separator* specifically designed and tested to accommodate silt.

4.1.3 The covers to all parts of the *Surface Water* and *Oily Water Drainage System* shall be painted BLUE (as opposed to foul water drains which are coloured RED) with a suitable approved non slip exterior coating system. See TS 3.10.05 for further details.

4.1.4 All covers to *Oil Separators* and *Penstock* valves shall be labelled to indicate the type and number of the device (for example 'PENSTOCK No 1') with the same information recorded on the site *Emergency Oil Containment and Drainage Plan*.

4.1.5 *Secondary Containment Systems* shall be gravity draining to a sump or remote underground tank. Rainwater shall be removed from the sump or tank by a BWCU discharging into a closed drainage system that incorporates an *Oil Separator* to remove *Oil* prior to discharge from site. The sump shall be integral with the foundation and sized to ensure the operation of the BWCU in the presence of up to 100 litres of *Oil*. It is not necessary for the base of an 'underground moat' type *Secondary Containment System* to be built to a fall.

4.1.6 Compressor installations shall be drained to a discrete retention tank or chamber, for subsequent off site disposal. The capacity of the tank shall be 1,000 litres per 100 CFM of compressor capacity with a minimum capacity of 1,000 litres.

4.1.7 Unless the topography of the site dictates otherwise, pumps (except for a BWCU see clause 5.17) shall not be used in *Oil* containment systems. Where it can be demonstrated that there are no alternatives, pumps shall always be installed downstream of any *Oil Separators* to avoid the possible emulsification of *Oil* and water prior to treatment. In this situation, a standby pump shall be provided to operate in the event of failure of each and any duty (i.e. main) pump. All such pumps shall be designed to operate after long periods of inactivity. Suitable alarm systems shall indicate the failure of any pumps (see TPS 2.7.1).

4.1.8 Cover and/or protection to buried sections of pipework shall suit the proposed vehicular loadings, above and adjacent to their position. As a minimum this shall be taken as a 5 tonne wheel load.

4.1.9 Wheel loads shall be distributed over a circular or square contact area at the point of application assuming a uniform pressure of 1.1N/mm^2 . Dispersal shall be assumed to be as follows:

- a) 1 horizontally to 2 vertically through surfacing material and fill.
- b) 1 horizontally to 1 vertically through reinforced concrete cover slabs.

4.1.10 Exposed metallic pipework shall be earthed in accordance with TS 3.01.02, 'Earthing'

4.2 Assessment of Design Run-Off Flows

In the design of the *Site Drainage* system, run off flows shall be taken as that generated by a rainfall intensity of 50 mm/hour. Volumetric flow shall be determined using the *Wallingford Procedure* or other established method. Run off from permeable areas such as those surfaced with stone chippings may normally be excluded as making negligible contribution to peak flows. Due consideration shall be given to the quantities of water discharged by a BWCU and other pumps.

Surface Water from the access road and car parking area shall drain to the adjacent stone surfacing.

INFORMATIVE: There is no specific requirement for the car parking area to drain via an *Oil Separator* provided a site management system is in place that ensures plant, equipment or vehicles containing significant quantities (nominally 200 litres or more) of possible pollutant (e.g. *Oil*) will not be located in that area.

4.3 Effluent Sampling and Monitoring

Sampling chambers shall be provided at the following locations;

- a) Immediately downstream of *Oil Separators*
- b) Upstream of *Penstock* valves
- c) At or before the final discharge point. Where the discharge is consented the location shall be agreed with the Environment Agency otherwise it shall be at an accessible location between the outfall and the last manhole chamber before the outfall.

Wherever practicable, sampling facilities shall be incorporated into *Penstock* chambers. See clause 5.15 for further details.

5 FEATURE REQUIREMENTS

5.1 Earthing

The installation of *Oil* containment infrastructure is likely to involve the inclusion of metallic items such as pipes and access steps at *Oil Retaining Areas* etc. In such cases, where there is a risk to individuals from transferred touch potentials on the infrastructure during system fault conditions or where the installation may be subject to induced voltages or circulating currents, then the designer shall ensure that all equipment and materials are installed in accordance with the earthing requirements outlined in TS 3.01.02 'Earthing'. Use of GRP steps is recommended.

5.2 Oil Retaining Area Design

- 5.2.1 The *Oil Retaining Area* shall consist of a base slab, formed around plant foundations as necessary, and single skin walls not less than 230mm thick forming a container impermeable to *Oil* and water and constructed to provide an effective life in excess of 40 years, with appropriate maintenance. It shall be of reinforced concrete, designed and constructed in accordance with TS 3.10, BS EN 1992-3 and the associated UK National Annex. Where no *Underground Oil Containment Facility* is present, a sump shall be incorporated to accommodate a BWCU. For existing 225mm thick concrete bund walls it shall not be necessary to increase to 230mm unless new walls are being installed.

INFORMATIVE: The majority of fire engineering design standards are intended to address domestic fires rather than the hydrocarbon oil fires that would typically result from the failure of a SuperGrid Transformer or similar item of *Oil containing plant*.

Consequently, in order to simplify the design process (specifically in relation to reinforced concrete) the fire resistance requirements are stated in terms of a domestic fire. However, it should be noted that the actual requirement relates to a two hour hydrocarbon fire (the time/temperature curves for the two are very similar in their initial stages) and, where it can be substantiated, design work may be in accordance with this measure.

- 5.2.2 All impermeable internal surfaces shall be designed to maintain their load bearing function and integrity in the event of a fire for a minimum of four hours in accordance with BS EN 1991-1-2, BS EN 1992-1-2 and the associated UK National Annexes.

Walls shall be designed to be monolithic with the base slab. In addition no contraction or expansion joints shall be incorporated in the design of walls and slabs, which should allow for full restraint of shrinkage and thermal contraction. All construction joints shall have continuous reinforcement, and shall be prepared in accordance with TS 3.10.04.

- 5.2.3 Crack width and spacing shall be controlled by the reinforcement which shall be designed to achieve 'Tightness Class 1' as defined in BS EN 1992-3 Clause 7.3 and the associated UK National Annex.

- 5.2.4 No external holes shall be allowed through any part of the *Secondary Containment System*. All services, pipes, cables etc. shall be carried over walls to maintain their integrity.

- 5.2.5 *Oil Retaining Area* walls may be detailed to facilitate the installation of HV plant by allowing sections to be cast after the main construction. Continuity of such sections should be achieved by conventional lapped reinforcement. However, where this is not practicable, continuity may be provided by the use of reinforcing bar couplers. Where couplers are to be used, allowance shall be made at the design stage to ensure the required cover is maintained to both the reinforcement and the couplers.

- 5.2.6 Slabs formed within *Oil Retaining Areas* between transformer/plant plinths shall be laid to a minimum fall of 1 in 80 to collecting sumps or channels (or *Flame Traps* where an *Underground Oil Containment Facility* is present).

- 5.2.7 All pedestrian access areas shall have an approved slip resistant surface and be capable of supporting a minimum imposed load of 5kN/m². The surfacing shall not comprise stone chippings, cobbles, pebbles or other loose media. *Major Maintenance* and *General Maintenance* requirements shall be identified and suitable additional provision (e.g. load from scaffold) accommodated in the design as necessary. Areas or surfaces not suitable for loads greater than pedestrian access shall be marked with suitable warning signage indicating their limitations (e.g. 'Pedestrian Access Loading Only'). This shall also be recorded in the SHES File (see TP 137)

INFORMATIVE: Historically stone chippings or similar have been used to surface the base of 'bunds'. This has proven problematic from the health and safety perspective when inappropriately sized or shaped stone has formed tripping and/or stepping hazards and from the environmental and commercial perspective when contaminated waste in the form of *Oil* stained chippings requires specialist disposal. Additionally the presence of a stone layer often prevents the early identification of drainage and/or oil leakage problems.

5.3 Flame Traps

5.3.1 *Flame Traps* shall comprise of a pit/chamber of 300mm depth filled with washed and uniformly sized stone of 38mm diameter or greater. Other configurations shall not be used unless proven by testing. Plan dimensions of *Flame Traps* shall be governed by the greater of the following requirements:

- a) The *Flame Trap(s)* must facilitate a total flow rate of at least 7,000 litres/minute. Testing indicates a flow rate of 4,000 litres/minute/m² is achievable with this configuration (see Technical Report TR(E)472)
- b) Where provision for planned access to the *Underground Oil Containment Facility* is required, the plan dimensions of individual traps shall be a minimum of 600mm by 600mm (see 6.2). Any site specific SHES issues which necessitate a larger opening shall take precedence over this requirement. Note that access to the *Underground Oil Containment Facility* should not be a routine operation and should only be considered after a detailed assessment of the risks and consideration of alternative options available.

5.3.2 The metal grating used to support the loose stone shall be designed such that it does not excessively deform or lose a significant proportion of its strength in the event of a fire. Openings in the grating should be sized appropriately so that they do not restrict the flow of *Oil* through the *Flame Trap*.

A typical *Flame Trap* detail is shown in figure 5-1.

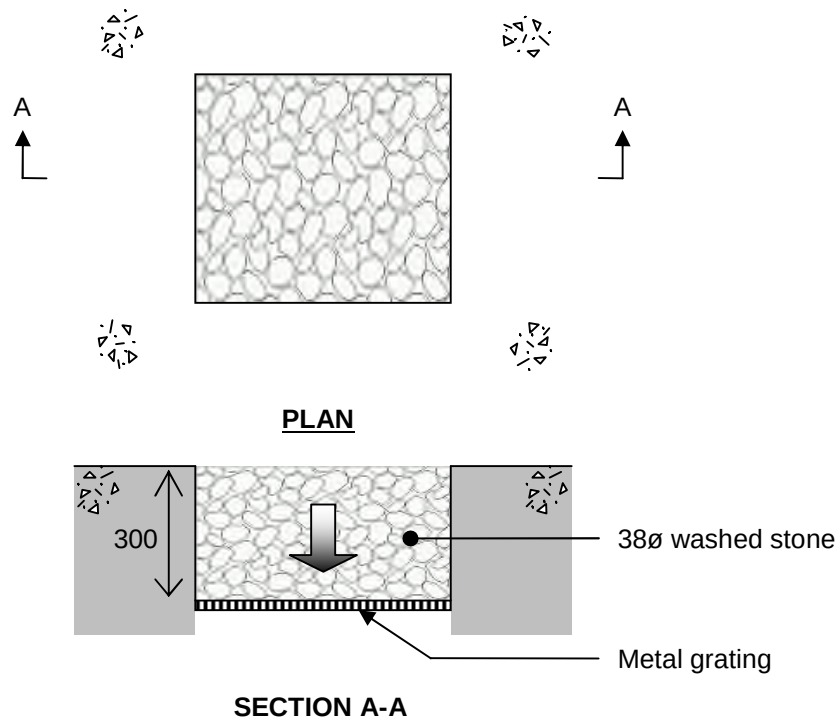


Figure 5-1: Typical flame trap detail

5.4 Underground Oil Containment Facilities (Type 2 Installations) - General

5.4.1 Items of plant listed in Clause 2.4.2 shall be sited within *Oil Retaining Areas*.