Oil Containment and Fire Protection

Design Standard

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Revision Details

Version	Date	EDM Version	Summary of change
0	20/08/2019	1	New issue. Supersedes NADS – Transformer Oil Containment, Fire Protection and Noise Control and NADS – Fire Protection General
1	12/06/2023	2	Oil containment section revised to cover ester transformers and SIPP oil/water separator system. Fire detection section general revisions. Preferred equipment list added in Appendix D.
2	03/01/2024	3	Standards Online Update

1 Introduction

The occurrence of fires in substations has been historically low but the impacts of a fire can be catastrophic. Fires can severely damage equipment in a substation, interrupt supply of power to customers and negatively affect revenue and business reputation. Fires can also be hazardous to employees, emergency personnel and the general public.

The major impacts of fire in a substation can include:

- risk to human life
- risk to continuity of supply to customers
- direct impact on equipment
- indirect impact on adjacent equipment
- cost of restoration and the time involved
- risk of fire spreading to adjacent properties

Oil containment systems are required to contain the insulating liquid of all transformers (with oil volume greater than 1000L) installed within substations. Western Power has an environmental obligation under the Environmental Protection Act 1986 to ensure that oil spilt in a transmission substation cannot leave the site or cause contamination of the soil and groundwater beneath the site. As transformers contain most of the oil used within a substation, containment measures in this Engineering Design Instruction mainly involve managing spills from power transformers but can apply to any oil filled substation equipment.

1.1 Purpose and scope

It is important to recognise and consider the management of the risks and effects of fires to ensure the safest and most efficient operation possible throughout a substation's life.

This Engineering Design Instruction addresses the basic principles of fire protection in substations and establishes the design requirements necessary to reduce the risk of fire. It also covers the requirements to minimise the effect of a fire, through the use of fire detection and suppression systems.

This Engineering Design Instruction also defines the oil containment and fire protection requirements for transformer installations in transmission zone and terminal substations.

The scope of the Engineering Design Instruction covers the application of the subject matter to Greenfield and Brownfield sites.

1.2 Acronyms

Acronym	Definition

1.3 Definitions

Term	Definition
Active fire suppression system	A system that has moving parts or relies on mechanical, chemical or electrical controls in order to function. eg: high velocity/pressure, low volume water mist fire protection system.
Aggregate	Blue metal stones of nominal size 50mm as per AS2758.7-2015 Table 1
AZC	Alarm Zone Circuits
AZF	Alarm Zone Facilities
Brownfield	An existing substation site
Bund	An embankment or wall which may form part or all of the containment of transformer oil
CBD	Central Business District
CIE	Control and Indicating Equipment
Combustible liquid	Any liquid, other than a flammable liquid, that has a flash point, and has a fire point that is less than it's boiling point. Class C1 – A combustible liquid that has a closed cup flash point of greater than 60 and no greater than 93 Class C2 – A combustible liquid that – i) Has a flash point of greater than 93 C; or Has been excluded from being a flammable liquid by any of the criteria for sustaining combustion.
EDI	Engineering Design Instruction. Describes in detail a particular type of design. This is the "how" to implement a design with clear boundaries defined.
FESA	Fire and Emergency Services Authority
FIP	Fire Indicator Panel
Fire wall	A fire rated wall located between transformers to protect one unit from damage from a fire in an adjacent unit
Fire point	In relation to a liquid, the fire point is the temperature at which the liquid, when tested according to the method set out in ISO 2592, first evolves vapour at a sufficient rate to sustain burning for at least five seconds after application of the specified test flame.
Flame trap	A pit with a down turned pipe used as a fire quenching mechanism
FRL	Fire Resistance Level as defined in the National Construction Code (NCC)
G1 safety distance	Fire separation distance between a transformer and adjacent transformer bunds, or between transformer bund and a non-combustible building surface as defined in AS 2067
G2 safety distance	Fire separation distance between transformer bund and combustible building surface as defined in AS 2067
Greenfield	A new substation site
NOC	Network Operations Controller/Centre
Oil/water separator	Class 1 Oil Separator according to EN BS858-1:2002
Passive fire system	A system that has no moving parts or external controls in order to provide protection. eg: firewalls, aggregate in bunds
SIP	Sub Indicator Panel

Tank	The tank is considered as the transformer tank, radiators and bushing turrets only (ie excludes the bushings themselves and the conservator tank)
Transformer	Includes the tank, radiators, bushings and conservator
Void ratio	The volume ratio of air between aggregate

1.4 References

References which support implementation of this document

Table 1.1 References

Reference No.	Title

2 Supporting Documentation[1]

3 Compliance[2]

This Engineering Design Instruction complies with all higher-level Western Power technical documents and relevant Australian Standards.

This Engineering Design Instruction should encompass all requirements of the relevant Australian Standards which are current at the time of issue. These relevant Australian Standards are listed in Table 3.2 below. A period will be set when the standard needs to be reviewed. If significant changes occur on an Australian Standard which affects safety, then an out of cycle review can be completed.

Table 3.1: Relevant documentation

Document Title
SEQT – Oil and Chemical Containment Procedure
Network Standard – Substation Site Selection – Technical, Social and Environmental Aspects
Automation and Control – Protection Design Guidelines
Engineering Design Instruction – Substation Building Design
Engineering Design Instruction – Earthworks, Roads and Drainage
Engineering Design Instruction – Substation Structures and Foundations
Engineering Design Instruction – Substation Layout
Engineering Design Instruction – Substation Lighting Design
Engineering Design Instruction – Safety and Maintenance Clearances
Engineering Design Instruction – Substation Labelling and Numbering
Safety in Design booklet – Our Rules for Designing Safe Workplaces
Hazard Management Register – Oil Containment and Fire Protection
Template - Fire Risk Assessment
SHE – Confined Space Procedure
SHE – Confined Space Assessment

1 See Western Power Internal Document
2 See Western Power Internal Document

Table 3.2: Australian Standards, guidelines and other legislation

Standard Number	Standard Title
Environmental Protection Act 1986	Environmental Protection Act 1986
Dangerous Goods Safety Act 2004	Dangerous Goods Safety Act 2004
Dangerous Goods Safety Regulations 2007	Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007
Electricity (Network Safety) Regulations 2015	Electricity (Network Safety) Regulations 2015
AS 2067:2016	Australian Standard: Substations and High Voltage Installations exceeding 1kV
AS 1940:2017	Australian Standard: The Storage and Handling of Flammable and Combustible Liquids
AS 1670.1-2018	Australian Standard: Automatic Fire Detection and Fire Alarm Systems Design, Installation and Commissioning
AS 4214:2018	Gaseous Fire-Extinguishing Systems
AS1603 – Parts 1-6, 11	Australian Standard: Automatic Fire Detection and Alarm Systems
ENA Doc 018-2014	Energy Networks Association: Guideline for the Fire Protection of Electricity Substations
AS 7240.2 - 2018	Australian Standard: Fire Detection and Alarm Systems – Fire Detection Control and Indicating Equipment
AS 7240.4 - 2018	Australian Standard: Fire Detection and Alarm Systems – Power Supply Equipment
AS 2118.1-2017	Automatic Fire Sprinkler Systems – General Requirements
AS 1319:1994	Safety Signs for the Occupational Environment
AS 7240.2-2018	Fire Detection and Alarm Systems – Fire Detection Control and Indicating Equipment
AS 2758.7-2015	Aggregates and Rock for Engineering Purposes – Railway Ballast

4 Functional Requirements

This Engineering Design Instruction is intended to be used by Substation Engineering staff and by companies completing outsourced design work for Western Power, as it outlines the Western Power requirements pertaining to earthing design for transmission substations.

5 Safety in Design[3]

When designing oil containment systems and fire protection measures at a substation, an important consideration must be the end user. The Safety in Design process ensures that the safety of all personnel is considered during design by ensuring that potential hazards are identified and eliminated or minimised so far as is reasonably practicable (SFAIRP).

The substation designer may start identifying hazards by considering potential fire sources and how a fire in these locations would be managed. Prompt points could be considered such as:

- Has the substation been designed with adequate fire clearances between transformers?
- Have the transformers and buildings been located to reduce the risk of a building being affected by a transformer fire?
- Is there risk of a fire within the substation affecting neighbouring properties?
- Have adequate measures been taken to reduce the risk of fire spreading beyond the affected asset?
- Is there fire risk to the substation from external sources?
- Have emergency exit routes been designed to avoid fire risk areas?
- How will the transformer oil containment be managed before the site is completed and commissioned?
- Have adequate precautions been taken to prevent the spread of burning oil between the affected transformer and other assets (including cables)?
- Has the environmental sensitivity of the substation been considered when designing the oil containment system?
- Has the containment system been designed such that it is fail safe, ie an outage will leave the bund valve closed?
- Are there environmental or fire risk requirements that may require the consideration of a different transformer insulating medium ie natural or synthetic ester?
- Does the design include the creation of spaces which could be classified as 'confined'? If so, assess these spaces and use the hierarchy of controls to assess, and if possible reduce, the risk they pose.

Any identified hazards shall be documented in the Hazard Management Register (HMR) and shall be eliminated, or have risks reduced to SFAIRP. The HMR and relevant design drawings shall undertake a construction, operation and maintenance (C.O.M) review at relevant stages of the project.

6 Overview of the Main Design Elements

There are many variables to consider when designing the oil containment and fire protection systems of a substation. Some of these considerations are discussed in detail in this Engineering Design Instruction, others are mentioned because they must be considered but refer to other Engineering Design Instructions for more detail.

The following main elements should be considered when starting new designs. See the relevant chapter for more information:

- Section 7.2 - Bund Design
- Section 7.3 - Oil Water Separator
- Section 9 - Fire Risk Assessment

[3] See Western Power Internal Document

- Section 10 - Fire Protection Design Requirements – General, Outdoor Transformer, Indoor Transformer and Building
- Section 11 - Fire Detection System Requirements and Design
- Section 12 - Fire Suppression System
- Section 13 - Brownfield Policy

7 Oil Containment

7.1 Functional Requirements[4]

To ensure that Western Power complies with the relevant legislation, codes and standards, oil containment systems must be designed and installed for any oil volume greater than 1000L located within Transmission substations. These requirements are outlined in SEQT - Oil and Chemical Containment Procedure and in AS 2067:2016. How the oil containment system is designed also has an impact on the fire performance of the substation.

Generally transformers and reactors are the plant items containing over 1000L of oil and therefore require a bund, however the requirements discussed in this chapter would apply to any other equipment containing over 1000L of oil. The oil containment system used for transformers consists of various plant items. See Section 7.2 for requirements of this system.

It is preferable for earthing transformers to be located within their associated power transformer bunds, otherwise they may require separate bunds depending on their oil volume. Station transformers containing over 1000L must be bunded. Station transformers containing less than 1000L may not need to be bunded. For transformers (containing between 250L and 1000L of oil) located in sensitive locations, an environmental risk assessment may conclude that a bund is required. An example of this requirement is for an underground water protection zone, where legislative approval requirements are applicable.

Under normal conditions the bund shall meet the following requirements:

- be totally sealed
- allow rainwater to discharge via an approved filtration system under normal conditions but automatically block flow when prescribed conditions arise (an actual or potential major oil spill)
- enable accumulated oil/water to be easily recovered
- be safe for personnel to work in and around
- complement sustainable development of the substation

Under fault conditions the bund shall meet the following requirements:

- be totally sealed
- For mineral oil (type C1 as defined in AS1940) insulated transformers, provide a passive method of extinguishing burning oil and preventing pool fires
- capture oil jets falling inside the prescribed maximum crest locus angle
- enable accumulated oil/water to be easily recovered after major oil spill

Dependant on the type of oil / water separator system used, the bund shall also:

4 See Western Power Internal Document

- retain a prescribed volume of oil plus an allowance of 10% for firefighting medium for gravity fed oil/water separator type bunds, OR
- retain a prescribed volume of oil plus an allowance for a prescribed amount of rainfall to allow time for maintenance for active separation system (such as SIPP) type bunds.

7.2 Bund Design

Bund design is different for mineral oil (type C1) insulated transformers and ester (type C2) insulated transformers. The type of oil separation system used also influences bund design.

7.2.1 Volume

7.2.1.1 Mineral Oil Transformers

Volume calculations shall consider the following:

- Bunds shall be filled with 50mm aggregate with a design void ratio of 40%
- Bund volume is dependent on the type of oil water separation system used:
  - For puraceptor oil water separators, bunds shall be sized to contain 100% of the total transformer oil volume (tank + conservator) plus 10% allowance for firefighting medium[5], OR
  - For active separation systems such as SIPP, bunds shall be sized to contain 100% of the total transformer oil volume (tank + conservator) plus an allowance of 150mm of rainfall to allow system maintenance. This allows for a period of one-month average winter rainfall to fall in the time between receiving the water flow blocked alarm and cleaning out of the filter.
- The maximum combined oil and water level shall be 50mm below the top of the aggregate
- Any cable protecting strategies such as sand boxes and conduits shall be subtracted in the bund volume calculations
- The top of the aggregate layer shall preferably be at the same elevation as the finished site level (F.S.L) – refer to Section 7.2.3 for guidance on the preferred maximum height of bund walls
- Earthing transformers shall preferably be installed in the main transformer bunds

7.2.1.2 Synthetic Ester Transformers

Volume calculations shall consider the following:

- No aggregate is required.
- FRP grating (with maximum aperture size of 20mmx20mm) is to be installed level with top of bund walls to be provide a working surface to access the transformer and allow leaking transformer oil to flow through into the bund below.
- Synthetic Ester transformers may only be installed together with an active separation system such as SIPP. As such, bunds shall be sized to contain 100% of the total transformer oil volume (tank + conservator) plus an allowance of 150mm of rainfall to allow for system maintenance, plus 50mm

[5] Although now not approved for new installations, existing triple interceptor separator connected bunds were also sized on this basis.

freeboard. This allows for a period of one-month average winter rainfall to fall in the time between receiving water flow blocked alarm and cleaning out of the filter.

- Any cable protecting strategies such as sand boxes and conduits shall be subtracted in the bund volume calculations
- Earthing transformers shall preferably be installed in the main transformer bunds.

7.2.2 Crest Locus

The position and dimensions of a bund relative to a transformer tank shall be such that the top inside perimeter of the bund walls are not inside the crest locus limit specified in Figure 1. The following issues should be considered during design:

- the tank is considered as the transformer tank, radiators and bushing turrets, the conservator does not need to be included
- the area of the bund shall be designed to meet crest locus requirements
- on brownfield sites where crest locus compliance cannot be met, splash walls may be considered to raise the effective height of a bund, however due to the maintenance problems that splash walls can create, this is a last option
- minimum height of splash walls to be 1000mm to prevent creation of a tripping hazard.
- fire walls between transformers provide the splash wall function in one direction
- potential de-rating of transformers due to restricted air flow should be considered depending on the location and height of splash walls
- where splash walls are required, access to all areas of a bund and access and maintenance requirements to cabinets or cubicles must be considered and shall not be compromised
- splash walls may not be installed on greenfield sites - on greenfield sites bunds shall be sized to meet crest locus requirements without the need for splash walls. This does not preclude the installation of fire walls on greenfield sites
- if there are legitimate reasons why compliance cannot be met, an appropriate oil spill management plan shall be considered. The non-standard and non-compliance process then needs to be followed.

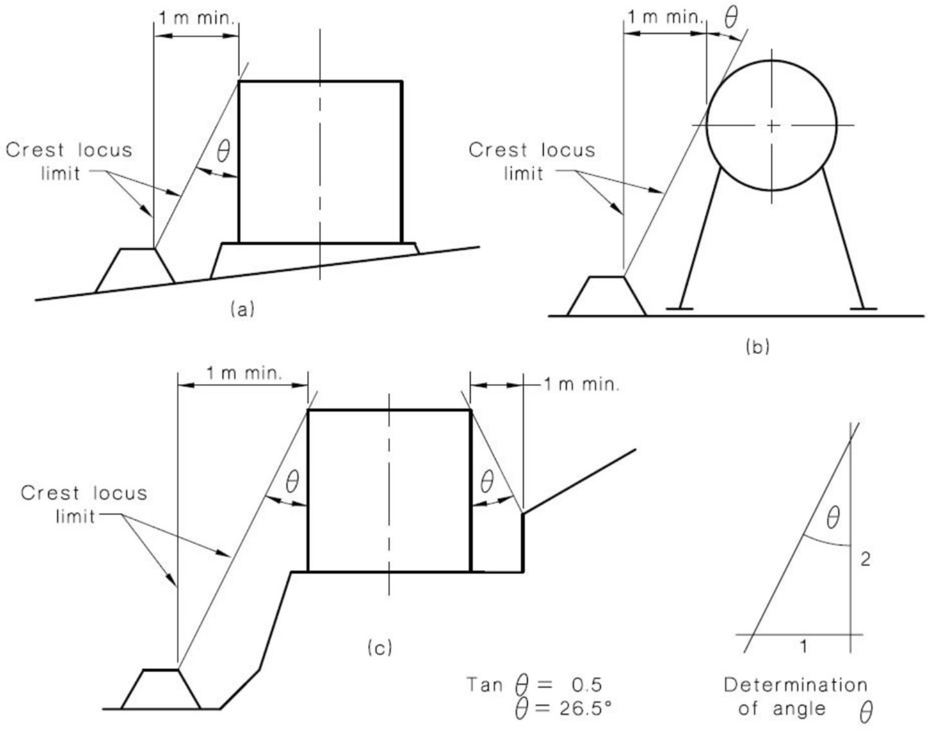

Figure 1: Crest Locus Limit

7.2.3 Bund Wall Height

To prevent bund contamination by sand and debris from a substation yard, cast in-situ concrete bund walls shall protrude above the finished site level (FSL) to provide a physical barrier. From a safety point of view the following issues shall be considered:

- to minimise the tripping risk, the preferred height is a minimum of 100mm
- where necessary, a greater height may be considered but with a maximum of 300mm, after which guard rails would be required for fall prevention as the bund would represent a platform. Safe access to the bund via stairs must then be designed. See Engineering Design Instruction – Substation Structures and Foundations for more information.
- safety clearance risks due to people standing on the wall and being able to contravene safety clearances to electrical equipment. Section safety clearance shall be checked from all standing positions. See Engineering Design Instruction – Safety and Maintenance Clearances for more information.
- The wall height must allow for the secondary and protection cables and earthing conductor to enter the bund above the maximum bund oil level whilst not causing a trip hazard.

7.2.4 Water Discharge

Because outdoor bunds are exposed to rain, they need to discharge rainwater through an oil water separator under normal conditions to prevent accumulation of water that would reduce the capacity for oil containment.

In the event of a major oil leakage or potential leakage, the discharge system shall retain all bund fluid within the bund to prevent inundation of any oil/water separation system and therefore also prevent oil from reaching the surrounding soil or any storm water system. Refer to Section 7.3 for details of the design and operation of the automatic water discharge isolation requirements.

Refer to Engineering Design Instruction – Earthworks, Roads and Drainage for drainage design requirements.

7.2.5 Spilt Oil Recovery

To enable oil and oily water to be readily recovered from a bund, during both normal and firefighting situations, a sump or filter pit shall be provided in the bund floor to provide a low point for oil to drain to. Permanent ready access for inspection of the sump or pit and the insertion of oil removal equipment shall be provided within the bund.

7.2.6 Sealing

Full sealing against oil and water leakage is required to prevent contamination of the soil beneath and around the bund. See Engineering Design Instruction – Substation Structures and Foundations for more information.

7.2.7 Bund Penetrations and Cabling

Penetrations through the bund shall be avoided wherever possible. For zone substations the transformer power cables shall exit though the sand box. The sand box shall be sealed over the top to prevent oil from entering and contaminating the sand.

For ester filled transformers with unfilled bunds, secondary cables shall be run on covered cable ladder level with the top of the ladder level with the top of the bund wall within the bund and then exit the bund via a cut-out at the top of the bund wall into the adjacent cable trench. Cables shall not be run over the top of the bund wall since this creates a tripping hazard.

For mineral oil transformers with rock filled bunds, secondary cables shall be run through conduit within the bund and then exit the bund above the surface of the blue metal into the adjacent cable trench. The bund height may have to be increased to meet this requirement.

Wherever cables are potentially exposed to the bund aggregate, they shall be installed in a conduit. Conduits should be supported and clamped in bund. Nylon hammer in clamps shall be used so that rebar within the floor and plinth is not compromised.

7.2.8 Earthing[6]

An earth ring shall be run within the bund and connected to the main grid in two places.

[6] See Western Power Internal Document

For ester filled transformers, the connections to the main grid shall be run using PVC insulated earthing conductor run on the same cable ladder as the secondary control cables, maintaining adequate separation between the earth conductors and the secondary cables.

For mineral oil filled transformers, the connections to the main earth grid shall be run in dedicated conduit, passing through the bund wall above the level of the blue metal.

7.2.9 Structural Requirements

Structural requirements for the bund and transformer plinth are included in the Engineering Design Instruction – Substation Structures and Foundations.

7.2.10 Other structures within bund

Other structures may sit within the bund, such as surge arrestors, lightning / lighting masts, or current transformers. The void area for the foundations for these items shall be considered in the bund volume calculation. Earthing of these items shall be connected to earth ring within the bund (See Section 7.2.8) except for Surge Arrestors which must run directly to the main substation earth grid.

7.3 Oil Water Separator Systems

Oil separator/interceptor devices shall be installed in substations to remove the oil from the discharge from a bund. The discharge will normally be rainwater, but it can be contaminated with leaked oil and degreasing agents used to wash down transformers. Designs of the oil separators/interceptors shall consider the following:

- Where Puraceptor or triple stage separator systems are used, they shall contain at least 6% of the largest transformer oil volume, which is typically the volume lost before a low-level oil alarm is initiated and the relevant valve is closed to retain all fluid in the bund. This criteria may need to be checked if installing a larger transformer than existing at a site when planning to utilise an existing Puraceptor.
- Based on the geotechnical investigation report and the site drainage requirements, they shall discharge to the stormwater drainage system.

7.3.1 Approved Type of Oil Separator

Class 1 oil water separators must be used for all new and retrofit installations. Class 1 classification is as per BS EN 858-1:2006. The output of these systems has an effluent oil of less than 5ppm. This level is less than the 10-15ppm which is widely recognised as being a sheen on water effluent and therefore classed as an oil contamination.[7]

The current type of class one separator to be used for all greenfield and brownfield retrofit applications within Western Power substations is an active separation system. The current approved model is the SIPP® system supplied by Gomero.

[7] Environmental legislation does not set a minimum hydrocarbon concentration of stormwater effluent. Without specific guidance in this matter, reference is made to the ACAPMA Best Practice Guidelines (2017) – Management of hydrocarbons in stormwater at retail fuel outlets". The recommended level in that document is also 5ppm (mg/L)

To allow sufficient time from receipt of the alarm and mobilising to site to pump out the bund, the bund capacity needs to allow for 150mm of rainfall on top of the total oil in the transformer, plus 50mm freeboard. 150mm is the average maximum 1-month rainfall for the Perth metropolitan area.

An individual SIPP® system is installed on each transformer bund, with discharge outlets connected to a common rainwater disposal system. The SIPP® system includes the submersible pump to be installed in the bund sump or new pit for retrofit applications, a “big blue” filter mounted to the bund wall, and the SIPP® Node 2000 control box which needs to be mounted to a support structure also mounted on the bund wall.

7.3.2 Alternative system for equipment other than power transformers

A concrete bund with a polymer filter as the oil water separator may be considered as an exception to a SIPP® for equipment other than power transformers (ie station transformer, STATCOM) where:

- the equipment contains greater than 1000L of oil, AND
- the equipment is located a large distance from the transformer bunds, AND
- connecting it to substation rainwater discharge system is not viable.

This situation must be discussed with the Principal Electrical Design Engineer for approval.

7.3.3 Previously used oil water separator types

7.3.3.1 Puraceptor®[8]

7.3.3.2 Triple Stage Separator

7.3.3.3 Polyvinyl/Polymer bunds

7.3.4 Bund Valves and Alarms

7.3.4.1 SIPP

The SIPP® system incorporates two electrically operated valves controlled by the SIPP® control unit. One valve allows water to be pumped to the substation rainwater discharge system and the other valve returns pumped water back to the bund should the water be contaminated with oil.

A water flow meter is incorporated in the system to detect a slowing of the water flow rate, indicating a filter becoming blocked. A non-urgent alarm is generated to warn of the need to replace the filter.

An urgent alarm is generated when the oil sampling system detects oil contamination of the water and re-directs discharge water back into the bund. This alarm indicates the bund needs to be pumped out, oil source located and rectified, and filter unit replaced.

[8] See Western Power Internal Document

The SIPP® unit also generates other alarms indicating failure of the SIPP® system.

7.3.4.2 Puraceptor[9]

7.3.4.3 Triple Stage Separator[10]

7.3.4.4 Polymer Bund[11]

7.4 Pipe Work

All pipe work shall:

- not pass through a bund wall unless absolutely necessary. In this case the penetrations shall be fire resistant
- be earthed where metallic pipes are exposed
- preferably consist of individual drainage routes to a common discharge system or oil separator - where this is not feasible, then a common "manifold" system can be used with tee-off connections into each bund
- prevent contamination of "clean" bunds by considering the use of non-return valves where self-contained proprietary oil separators are used

Flexible hoses used with the SIPP® system are to be suitably supported by use of saddle clamps.

8 Fire Protection Functional Requirements

8.1 Functional Requirements

For any new greenfield sites and for major work in brownfield sites (including transformer replacement, new transformer, new building projects) a fire risk assessment must be undertaken. This is a fundamental requirement of AS 2067:2016. See Section 9 for more information.

The basic principles of fire protection in substation installations are summarised below:

8.1.1 Prevention

The design of a substation shall be such as to minimise the probability of a fire. Considerations include;

[9] See Western Power Internal Document
[10] See Western Power Internal Document
[11] See Western Power Internal Document

- High speed detection of faults and operation to disconnect faulted equipment. This includes provision of reliable and fast acting electrical protection schemes (with suitable clearance times, duplication, back up etc). See Automation and Control – Protection Design Guidelines for protection requirements.
- Design of a robust system including selection and installation of adequately rated plant and equipment (load and fault ratings etc). See Engineering Design Instruction – Substation Layout for rating requirements.
- Separation from external sources by ensuring adequate clearances between equipment and potential external fire sources (bush fires, neighbouring buildings etc). See Network Standard – Substation Site Selection for Substation Site Requirements.

8.1.2 Detection

Fire detection systems give early warning of the outbreak of a fire. They can provide local and remote alarms and, where necessary, initiate automatic fire control, containment and extinguishing actions.

Fire detection systems are required for all new relay rooms and switchrooms. The fire detection system shall comprise a VESDA type system for the main building areas plus photoelectric sensors for minor building areas.

Fire detection systems are not required to be retrofitted into existing relay rooms or switchrooms unless a fire risk assessment indicates that one must be installed. See Section 9 for more information.

8.1.3 Containment

Containment procedures are aimed at preventing the spread of fire to restrict potential damage to a limited area of a substation as well as protecting the safety of personnel and the public.

The following requirements must be met at all new greenfields substations:

- Separation distances in AS 2067:2016 must be met. This includes between transformers, between transformers and buildings, between buildings, building compartments (e.g. switchroom, basement) and between any fire hazard in the substation and neighbouring buildings.
- All nominated escape routes and emergency exits shall be designed such that they can be used safely in the event of a fire.
- Bund designs to comply with the requirements of Section 6.2.1.

8.1.4 Extinguishment

Extinguishment can be manually or automatically initiated. It is aimed at minimising the damage caused to burning equipment and reducing or eliminating any fire or smoke damage to other equipment.

Transformers located indoors must have automatically initiated extinguishment systems installed or utilise other measures such as using high flash point oil (e.g. FR3 or Midel) as determined in a risk assessment. For requirements see Section 9.

Outdoor transformers shall rely on the emergency services to extinguish a fire, unless otherwise determined by a risk assessment.

Switchroom buildings generally also rely on emergency services to extinguish a fire, together with portable handheld extinguishers provided for personnel to use on small fires. Automatic extinguishment systems may be required as determine by a risk assessment (eg. CBD substations).

9 Fire Risk Assessment[12]

A Fire Risk Assessment must be completed for all new substations and for work in brownfield substations which changes the current fire assessment (e.g. the installation of a new transformer or building, replacement of existing transformer or major changes to fire risk at the site). A fire risk assessment shall be undertaken at the planning stage of the project and shall include all personnel who will be involved in the design, construction, commissioning, operation and maintenance of the substation. The risk assessment shall be undertaken early enough in the project life cycle such that recommendations from the risk assessment are able to be included in the project scope. The fire risk assessment shall be updated during the detailed design stage.

Items that shall be considered in the fire risk assessment include:

- The division or segregation of plant to prevent the spread of fire, protect personnel and limit the damage. Recommendations may include changes to the layout or installation of fire barriers.
- The elimination or control of fire sources
- The presence or absence of bunding for oil filled equipment
- The detection and suppression of fires
- Protection of adjacent property
- Safety of public and people working within the substation over the different stages in the asset life
- Protection of the substation from external fire risks
- Building fire exits and site escape routes

10 Fire Protection Design Requirements

10.1 Cable Design Considerations

Control and protection cables shall be routed such that they are at least 3m from any oil filled equipment (excluding the equipment they are connected to) and they shall not be routed through any oil containment facilities. Transformer control cables must exit the bund and run directly to their destination without passing through or within 3m of other bunds.

Cables of different voltages should be separated from each other where possible. Cables from duplicated systems should be run on different routes if they are available.

All cable installations shall comply with the following requirements to reduce the potential for a cable being a source of fire:

12 See Western Power Internal Document

- Avoid cable congestion wherever possible
- Seal cable penetrations to the required fire rated level (FRL) through fire rated walls, floors or compartments. Penetrations shall match the FRL of the walls or floors they pass through
- Support and space the cables adequately

Consider the positioning of cables with respect to their purpose. Separate cables from different parts of the installation and avoid running cables in a fire risk area when they do not terminate in that area. Consideration shall be given to running power cables in conduit to reduce the fire risk to other cables running in the cable trenches.

In critical installations, consideration should include:

- Using flame retardant outer sheaths
- Using flame retardant cable coating

In general, to reduce the spread of fire, segregate assets from separate circuits and locate logical assets together (e.g. plant items within the same circuit).

10.2 Outdoor Transformer Requirements

10.2.1 General Requirements

Outdoor transformers installations shall comply with the following requirements:

- For mineral oil filled transformers, bunds filled with blue metal aggregate to provide passive fire protection. Blue metal is not required in bunds for transformers filled with less combustible liquid (K type).
- adequate separation between transformers and adjacent equipment, infrastructure and neighbouring properties to reduce the risk of damage from transformer fires
- where adequate separation distances cannot be achieved, appropriately rated fire barriers/walls employed
- protection from the effects of fires external to substations
- reliance on external intervention from bodies such as FESA to extinguish major fires

For mineral oil filled transformers, the following requirements must be met to help extinguish burning oil:

- the aggregate in a bund cools burning oil as it drops through it, therefore reducing the oil temperature to reduce the likelihood of a fire being sustained
- the sustainability of a pool fire is also reduced by ensuring the maximum possible oil level, including the allowance for firefighting medium, is not less than 50mm below the surface of the aggregate, thus starving the fire of oxygen

10.2.2 Required Clearances

Transformers filled with mineral oil contain a large quantity of fuel. Once ignited a mineral oil filled transformer will burn fiercely forming a large fire front with flames that can extend up to 10m above the transformer. It is prudent to keep in mind that although AS 2067:2016 states clearance requirements between transformers and buildings, these clearances are minimum requirements and if possible (without having detrimental effects on the substation layout) larger clearances will improve the overall fire performance of the substation.

AS 2067:2016 nominates minimum clearance distances between the different types of transformers in Table 6.1. Horizonal separation G1 must be met between transformers. When the bund is filled with blue metal this distance is taken from the outside edge of the transformer tank. If there is no blue metal in the bund then the distance must be measured from the inside edge of the bund.

Table 6.1 in AS 2067:2016 also applies to the separation between transformers and buildings. For greenfield sites the minimum horizontal separation of G1 must be met between a transformer and any building. For brownfield sites, it is preferred to meet the G1 clearance wherever possible. If it is not possible to meet the G1 distance, then meeting the G3 distance may be considered, however extra measures are required, such as a fire wall, parapet wall or a 2 hour fire rating of the exposed building wall and roof. See AS 2067:2016 Section 6.7.4.4 and Table 6.1. As detailed in Section 9, a fire risk assessment must be completed for any new installation, transformer replacement or significant change to fire risk in a brownfield site.

The separation distance from a transformer to the property boundary shall be a minimum of the G2 clearance in AS 2067:2016 Table 6.1.

If any of the required clearances cannot be met, then a fire wall must be installed. Fire wall requirements are detailed in Section 10.8.

10.3 Indoor Transformer Requirements

Indoor transformers will usually be confined to sensitive locations such as the CBD or where space for an outdoor installation is not available. The approach to fire protection in these installations is different to outdoor installations.

The intent is to ensure a fire is confined within an enclosure and brought under control in as short a time as possible without external intervention.

Transformers located indoors must have automatically initiated extinguishment systems installed. For all new transformers located indoors, high flash point oil with fire point greater than 300 degrees (e.g. FR3 or Midel) and enhanced protection shall also be used (either FM Global approved or equivalent). Transformers located outdoors but within full enclosures may also require automatic fire suppression, as determined by the site fire risk assessment (see Section 9).

Indoor transformer installations shall comply with the following requirements:

- transformer tanks shall be housed in fire isolated compartments to ensure safety to surrounding properties as well as other Western Power equipment. Fire resistance level of compartments to be decided in Fire Risk Assessment and comply with minimum requirements of AS 2067:2016 Table 6.2.
- transformer cooler banks shall be housed in separate compartments to ensure the ventilation system operates as required and the transformer rating is not compromised
- automatic detection and active suppression systems shall be used to detect and extinguish fires in the shortest possible time without the need for external intervention
- because blue metal aggregate is not practical, rapid removal of burning oil is required from each compartment floor through flame traps
- oil/water holding tanks shall accommodate 100% of the transformer oil plus a volume of firefighting medium that depends on the design and operational philosophy of the suppression system

- holding tanks can be shared between transformers provided that flame traps have been installed.

10.4 Building Requirements

10.4.1 General

10.4.1.1 Fire Resistance Level

The fire resistance level required for substation buildings is covered in the Engineering Design Instruction – Substation Building Design. This EDI also covers the required separation and segregation within buildings.

10.4.1.2 Hand held extinguishers

- zone substations shall have a single hand held 9kg dry powder unit installed on an external wall of each building, adjacent to the main access door, housed in a weatherproof wall cabinet with appropriate signage
- terminal substations shall have one of these extinguishers adjacent to each building entry door
- CBD indoor substations shall be fitted with extinguishers (suited to the equipment installed) in each building compartment and additional requirements as outlined in the Fire Risk Assessment for the site

It should be noted that hand held fire extinguishers mounted outdoors have been the target of thieves in some areas. Depending on the perceived risk, it is prudent to install these units indoors or at least out of public view.

Each switchroom, relay room and cable basement shall be equipped with at least one 5kg hand held CO2 extinguisher.

Each unit shall be located in a conspicuous and readily accessible position along normal paths of travel or near exits. The number of extinguishers installed in any room shall be such that the unobstructed distance from any part of the room to the nearest extinguisher does not exceed 15 metres.

10.4.2 Switchroom[13]

All zone substation switchroom buildings shall be fitted with a VESDA detection system . The system shall meet all requirements set out in Section 11 and in the Technical Specification – Substation Electrical Construction. Any ducted air conditioning system installed in the switchroom shall be shut down for a fire system alarm. It is not a requirement to shut down split system air conditioners for a fire alarm.

There is very little risk of failure that would cause a fire in modern indoor circuit breakers as they are either filled with SF6 gas or vacuum. Therefore, it is not considered necessary to protect these switchboards with fire suppression facilities. Depending on the site, a risk analysis may be considered necessary.

In older brownfields substations with oil filled circuit breaker switchboards, consideration may be given to the value of retrospective installation of fire detection and/or suppression facilities.

[13] See Western Power Internal Document

All compartments of the switchroom shall be fire segregated. See Engineering Design Instruction – Substation Building Design for more information on fire segregation in buildings.

External access to the basement shall be provided in all new buildings for fire services to prevent smoke/fire spread to the switchroom above.

No fire detection is required within the ceiling space of switchroom buildings.

10.4.2.1 Cable Basement

Cable basements shall be protected by a separate zone of the same VESDA system used to protect the switchroom above.

10.4.3 Relay Room

10.4.3.1 Zone Substation[14]

Due to the value of equipment in the relay room and its criticality in maintaining and protecting the network, all relay rooms installed shall be fitted with a VESDA detection system. Any ducted air conditioning system installed in the switchroom shall be shut down for a fire system alarm. It is not a requirement to shut down split system air conditioners for a fire alarm. No fire detection is required within the ceiling space of relay room buildings.

10.4.3.2 Terminal Substation[15]

Due to their importance to the network, terminal substation relay rooms shall also be fitted with VESDA detection systems. Any ducted air conditioning system installed in the switchroom shall be shut down for a fire system alarm. It is not a requirement to shut down split system air conditioners for a fire alarm. No fire detection is required within the ceiling space of relay room buildings.

10.4.3.3 Battery Room

Where dedicated battery rooms are used, due to the potential for a build-up of gas in the battery room, all links, fuses, power switches or any equipment which can cause an electric arc shall be excluded from the battery room. Lights shall be a sealed type, see Engineering Design Instruction – Substation Lighting Design for more information. A smoke detector shall be located in the battery room. See Section 11.2.11 for more information. These requirements do not apply where VRLA batteries are located in the main relay room.

Any fans installed for ventilation purposes in the battery room shall be shut down for a fire system alarm.

[14] See Western Power Internal Document
[15] See Western Power Internal Document

10.4.3.4 Underfloor cable space

Where a low height under floor cable space exists for the purposes of running secondary cabling, utilising computer flooring or other suspended floor coverings, no fire detection is required under the floor in the cable space. Note this does not apply to full height cable basements.

10.4.4 Other rooms

The standard fire detection system for all Western Power rooms and installations is a VESDA system. The only exception to this is for a customer connection where Western Power has a small relay room as part of the customers installation; in this case a VESDA system is not required.

10.5 Cables Tunnel (and other cable spaces) Requirements

Full height cable tunnels are not commonly used within the network and are normally associated with CBD or inner suburban substations.

Because of the numerous cables in these tunnels, damage could spread quickly if a fire wasn't detected early. In addition, with the long tunnel lengths and confined spaces involved, personnel need an early warning of a fire as soon as possible.

Subject to risk analyses, detection systems and automatic fire suppression systems should be considered for full height cable tunnels and other restricted locations where personnel could be at risk in the event of a fire. Personnel safety shall be the primary concern in the design of cable tunnels and associated suppression systems. Cable tunnels must be assessed to determine if they are confined spaces, and if so, all requirements of confined spaces must be met.

Where automatic sprinkler systems are not installed, portable fire extinguishers shall be installed in full height cable tunnels at not more than 20 metre intervals.

10.6 General Site Requirements

Outdoor areas of a substation contain limited combustible material and the majority of the site is covered in non-combustible surfacing such as blue metal or bitumen. This, combined with the low likelihood of equipment fires, means the risk of fires and their spread through a substation is low.

The substation layout shall provide for adequate access for Western Power and specialist firefighting personnel (e.g. FESA) and equipment. In larger substations, consideration may be given to the provision of multiple vehicular entrances to avoid congestion in an emergency

10.6.1.1 Mobile extinguishers

Mobile extinguishers are similar to hand held units except they are on wheeled trolleys because of their bulk and are designed for fires which are beyond the capability of hand held extinguishers.

They are only installed in terminal substations and consist of 75kg dry chemical powder units, with a 6m discharge hose, all housed in a suitably labelled cabinet in a conspicuous location near the building.

In terminals with more than one switchyard, there shall be a mobile unit for each switchyard.

Travel paths shall be arranged such that there are no obstacles (steps, fences, banks etc) to interfere with the free travel of the unit when being propelled by a single operator. For stepped sites, a separate extinguisher may need to be considered for each level.

10.7 BESS System Requirements

Battery Energy Storage Systems are installed to reinforce the network in certain positions.

Requirements for fire detection and / or suppression for BESS should be determined by means of a fire risk assessment performed in consultation with the BESS manufacturer.

10.8 Fire Wall Requirements

10.8.1 Between transformers[16]

Where firewalls are required between transformers, they shall:

- comply with the minimum height and separation from transformer requirements as per AS 2067:2016 Table 6.1 and Figure 6.1. Minimum separation clearances are much less for ester filled transformers than for mineral oil transformers. Note that these are the minimum requirements and the fire risk assessment undertaken for the site may impose more onerous requirements.
- have a FRL of at least 120/120/120 (2 hours). AS 2067:2016 specifies 2 hours as a minimum but suggests that it may be increased if there is a high likelihood of a fire lasting longer. A FRL higher than 2 hours may be required based on a Fire Risk Assessment.

10.8.2 Between transformers and other infrastructure:

Where the required separation distance (see Section 10.2.2) cannot be achieved between a transformer and other equipment and infrastructure, the following actions shall be taken:

a) for combustible buildings and switchyard equipment not associated with the transformer, suitably rated fire walls or other fire barriers shall be installed. The FRL of the firewall must be a minimum of 2 hours, a higher FRL may be required based on a Fire Risk Assessment.

b) for switchyard equipment associated with the affected transformer, fire protection is not normally necessary because repair of the transformer should allow time to replace/repair the other equipment.

10.8.3 Construction Material

The preferred construction materials are self-standing pre-fabricated concrete panels incorporated into the transformer bund. The installation of the panels must be considered, including the method of lifting and required space and clearance for the walls. The space requirements for accommodating the large crane must also be considered.

[16] See Western Power Internal Document

An alternative to this is to use a steel framed structure with fire rated, fibre reinforced cement core cladding. This method requires a smaller crane but may need a longer outage for installation.

The fire wall construction method of poured in situ, reinforced concrete is no longer used for firewalls.

See Engineering Design Instruction – Substation Structures and Foundations for design and construction requirements.

11 Fire Detection System Requirements

11.1 System Requirements

Where a fire detection system is required it shall meet the following requirements:

- Aspirating smoke detection systems shall be used, such as VESDA, since the early detection of smoke provides the best indication of an incipient fire. See Appendix B for more information on VESDA systems
- When the fire detection system fire alarm is activated, or the manual fire alarm call point is pressed, this shall automatically:
  - initiate local audible and visual alarms for the building in which the fire has been detected
  - send a remote alarm to NOC (and FESA if required as per building regulations)
  - show a local alarm on the Sub Indicator Panel and extended to the main Fire Indication Panel in the relay room
  - shut down any ducted air conditioning and mechanical ventilation systems to minimise the potential spread of smoke and fire through the building. Note split system type air-conditioning systems do not need to be shut down.
- In areas where bushfires are common, the detection system shall be a VESDA differential system with a detector located outside the building to provide a reference point. This ensures that smoke entering from outside the room does not cause an incorrect operation of the detection system.
- Fire alarms shall be connected directly to the Western Power SCADA system (and not routed via any 3rd party equipment).

11.2 System Design

11.2.1 Designated site entry point

The designated site entry point shall be the main entry into the substation switchyard.

A visual strobe alarm which is able to be seen from the designated site entry point shall identify the building in which the fire alarm has operated.

The Fire Authority must be able to easily access the building where the alarm has operated from this point.

11.2.2 Designated building entry point

Each building shall have a nominated designated building entry point which will be chosen by Western Power.

11.2.3 Alarm Zone limitations

All locked areas or areas to which fire service access is restricted, shall be separate alarm zones. The detection system is not required for the toilet and other sanitary spaces unless the floor area is equal to or greater than 3.5 m^2. See 0VESDA for more information.

11.2.4 External and Internal Fire Alarm Indication and Warning Sounders

External fire alarm indication installed on the outside wall of each building shall be one red strobe light and sounder combination unit. The electronic sounder shall be an integral component within the red strobe light unit.

The external strobe light shall also be visible from the designated site entry point.

The internal fire warning sounder must comply with AS 1670.1-2018, Clause 3.22.

11.2.5 Logic

A fire alarm from the SIP or FIP shall only operate the strobe and sounder on the building which it is monitoring.

If the SIP is transmitting a fire alarm it shall extend the fire alarm to the FIP. The FIP will activate its indoor sounder(s) only.

If a Fire Alarm is transmitted from the FIP to the SIP, then the SIP shall only activate the indoor sounder(s).

The fire system design shall include provision of a cause-and-effect matrix detailing all system interface functions compliant with AS1670.1 – 2018.

11.2.6 Location of Indicator Panels

A substation site shall have only one Fire Indicator Panel (FIP). This FIP shall be located in the relay room.

A Sub Indicator Panel (SIP) shall be installed in each separate switchroom building. Separate SIPs are not required in switchrooms which are part of the same building as the relay room.

The FIP and SIPs shall be installed inside the relevant building, adjacent to the designated building entry point.

11.2.7 Sub Indication Panel

This panel shall comply with AS 7240.2-2018 as a minimum.

Each SIP will have an alarm zone facility (AZF) for transmitting a signal to the FIP and up to eight maximum, alarm zone circuits (AZC) for connection to detector devices, such as VESDA and point type detectors.

Furthermore, each SIP will be fitted with control and indicating equipment (CIE) for the following functions:

- indication of alarms, internal faults and zone isolation,
- monitoring of power supply faults; and
- control of auxiliary devices and interlocks.

The SIP shall supervise external warning sounders, strobes and accept an input from manual call points.

It shall be fitted with onboard automatic test facility.

Each separate switchroom building shall be serviced by one SIP which will report as one separate alarm zone to the FIP. Each SIP shall separately report: zone fault, zone isolate and defective (which includes the power supply fail) signals to the FIP and Western Power's SCADA system.

Any indications of fire alarms, faults and zone isolation shall be possible to reset or restore only from the SIP, whose AZC are connected directly to detectors transmitting the alarms.

11.2.8 Fire Indication Panel

The Fire Indicator Panel shall comply with AS 7240.1-2018 and be designed to the requirements of AS 4428.1-1998.

It will monitor, accept and transmit to a remote monitoring centre the following alarms, using one signal path from each SIP:

- fire alarm,
- zone fault and supply fault combined; and
- zone isolate.

11.2.9 Isolation Facilities

The fire detection system shall include isolation facilities to allow for work to be carried out in a substation without the risk of false alarms.

When the fire detection system is put in the isolated state a remote alarm shall be sent to NOC.

11.2.10 Multi Point Aspirating Smoke Detector Requirements

A single VESDA device shall be installed in each relay and switch room. This VESDA device should also monitor any cable basement below as a separate zone. They should not be installed in zones with locked areas. See 0VESDA for more information and preferred VESDA models.

11.2.11 Point Type Smoke Detector Requirements

Point type smoke detectors shall be used in the battery room. The smoke detector(s) shall be connected via an MTL5061 Fire / smoke detector interface unit required for detectors in hazardous areas. The MTL5061 interface unit shall provide a separate zone alarm to the FIP. See 0VESDA for more information.

Point type smoke detectors may also be used in other rooms where required. These detectors may be connected directly to the SIP/FIP as a separate zone.

11.2.12 Manual Call Points

All manual call points shall consist of a surfaced mounted push button with a breakable glass cover.

The cover plate of the manual call point shall be engraved with red filled letters "Fire Alarm – Break Glass – Push Button".

A manual call point button shall be surface mounted to the front of the fire indicator panel and any sub-indicator panels, and on the wall near the entrance door to each zone.

The manual call points shall comply with AS 1603.5, and AS 1670.1-2018 Clause 3.14.

11.2.13 Fire Alarm Zone

Each fire alarm zone shall consider all fire detectors and manual call points within that zone.

Interface cards on the fire detection system shall be used to operate other systems (such as air conditioning) within the zone.

11.2.14 External Doors

All external doors shall have a door open alarm sent to NOC.

11.2.15 Defective Alarm

When the fire detection system is in the defective state a remote alarm shall be sent to NOC via Western Power's SCADA system. See Section 11.3 for the wiring requirements for the defective alarm.

11.2.16 Site Plan

A plan showing all buildings, roads and access points shall be located at the Fire Indicator Panel. Included on this plan shall be information on how to access the other buildings. The muster point shall also be noted on the site plan. The site plan shall be approved by Western Power before it is printed onto a traffolyte label and installed on site.

11.2.17 Air Conditioning and Ventilation System Interface

A relay contact to the ducted air conditioning and ventilation system control circuit shall be provided for automatic shutdown when the fire detection system is activated (excludes non ducted reverse cycle airconditioning).

The incoming supply connecting into CIE on a SIP or a FIP, required for air conditioning shutdown relay – control, shall not exceed ELV rating of 120V ripple free D.C. For control voltages exceeding ELV a separate and compliant intermediate relay(s) shall be installed outside CIE enclosure in order to comply with AS 1670.1-2018, clause 3.24.1.

11.2.18 Key Diagram - Fire indicator Panel Zone Layout

A traffolyte label shall be fitted on the Fire indicator Panel and Sub-Indicator panel showing the areas covered by each zone.

The zone block plan shall comply with AS 1670.1-2018 Clause 3.10.

11.2.19 Escape Route Plans

At each exit door an escape route plan is to be provided on the wall next to the door. This is to also include cable basement exit doors.

The escape route plan is to be mounted at eye level.

The escape route plans shall be approved by Western Power before installation.

11.2.20 Power Supplies

The fire detection system power source shall comply with AS 1670.1-2018 Clause 3.15 and specifically to AS 4428.5-1998 power supply units design.

A separate ventilated compartment at the bottom of the fire indicator panel and the sub-indicator panel shall be provided for the batteries.

The batteries shall be maintenance free, rechargeable with a suitable corrosion proofing housing.

The power supply to the fire detection system will be from the substation 415V supply. The 415V power supply failure signal is monitored. The 415V supply is duplicated and considered reliable. Therefore, the battery capacity shall be calculated based on a 24 hour standby time.

The power supply to the fire detection system must comply with AS3000 section 7.2.4. Specifically the supply for the fire system must be derived from upstream of the main switch of the AC distribution board from which it is supplied.

11.3 SCADA

The alarms provided by the fire detection system shall have the following states:

Table 11.1: Alarms provided by the Fire Detection System

Alarm Name	Alarm State
Fire Alarm Operated	Normally open contact, Closed in alarm state
Fire Alarm Defective	Normally open contact, Closed in alarm state
Fire Alarm Isolated	Normally open contact, Closed in alarm state

11.4 Operations

When NOC receives an alarm from the fire detection system they will follow their required procedures.

If a fire alarm is received from a substation the Network Operations Controller (NOC) shall ensure that the appropriate personnel attend the site to establish whether the fire is genuine, and to provide access to the fire service if required.

Table 11.2: Actions taken by Control Room for Fire Detection System Alarms

Alarm Name	Action
Fire Alarm Operated	Send a switching operator to site to investigate. If there is a fire upon arrival notify the Fire Authority and attempt to perform primary isolation of electrical equipment if deemed safe. Notify DC Maintenance Technician if the Automatic Fire Detection and Alarm-System has false alarmed.
Fire Alarm Defective	Notify the on-call DC Maintenance Technician.
Fire Alarm Isolated	Ensure if someone on site is working on the Automatic Fire Detection and Alarm system or working in the vicinity of the installation and carrying out tasks that may cause false alarms. If no one is on site, then notify the on-call DC Maintenance Technician.

12 Fire Suppression Systems

Fire suppression systems shall aim to contain the fire to the affected equipment and attempt to extinguish the fire.

12.1 Passive Systems

12.1.1 External intervention for firefighting

A major transformer fire can be expected to burn for a long time and specialist knowledge and equipment would be required to extinguish it within a reasonable period.

Because of their expertise and firefighting equipment, Western Power relies on FESA, together with local firefighting authorities in regional areas, to extinguish transformer fires.

12.1.2 Influences on design

FESA has summarised their approach to fighting fires in Western Power substations as follows:

- a substation must be proven totally de-energised before FESA will commence any firefighting
- FESA do not require any assistance from Western Power
- water for firefighting in substations is available to FESA across the metropolitan area
- in regional areas, there may not be water available because of the remoteness from town water
- FESA would spray a foam blanket over a bund area to extinguish any pool fire
- If necessary, FESA will keep adjacent transformers cool with a water spray. Because FESA will continuously drain these bunds, or even if they overflowed, it would only be clean water so there doesn’t need to be any special allowance in bund design volumes to account for this water.

12.2 Active Systems

Active suppression systems are required for some indoor installations subject to a Fire Risk Assessment. The system shall meet the following requirements:

- The designs shall meet AS 2118.1 and all other relevant Australian Standards
- Dual activating systems shall be used (smoke and thermal detectors)
- The suppression medium shall not damage the equipment it is protecting
- The system shall be maintained to comply with relevant Australian Standards
- The system shall have the ability to be deactivated whilst personnel are working in the area with a warning to evacuate the area for an activation of the system

12.2.1 Water System

A water extinguishing system shall be designed to meet the requirements of a particular site, as identified in the fire risk assessment for the site. High velocity water spray systems are designed to evenly distribute a fine but broken stream of water over the area covered by the projectors. The impact of water in this form onto an oil surface creates an emulsion that will not burn.

12.2.2 Gas System

A gas system shall be designed to AS 4214-2018 and specifically to meet the needs of the particular site. Western Power shall provide a specification for the system prior to the start of design when new applications are developed.

FM-200 is widely used in electrical applications and may be considered for use in a gas flooding system. Other types of gas suppression systems may also be considered as part of the risk assessment. Since gas suppression systems are not common within the Western Power network, their use must be supported by a Fire Risk Assessment and the design, documentation and training of relevant personnel must be developed in consultation with the Substation Design area and other Western Power stakeholders when new applications are designed.

13 Brownfield Policy

For any major work in brownfield sites (including transformer replacement, new transformer, new building projects) a fire risk assessment must be undertaken. This is a fundamental requirement of AS 2067:2016. See Section 9 for more information.

Any new work completed in brownfield sites must meet the requirements of the current Australian Standards and the requirements of this standard. This includes the installation of an oily water separation system for new transformers installed in brownfield sites.

A decision not to bring existing non-conformances up to standard shall be supported by a risk assessment that recognises the relevant risks involved and is endorsed by the relevant stakeholders. The sponsor shall be the owner of this risk assessment.

13.1 Oil Containment

When a transformer is replaced in a brownfields substation, the existing bund shall be upgraded to the current standard as described in this document.

Where existing bunds are replaced in brownfield sites, the following order of preference must be followed:

- Design each bund to hold the required oil volume
- Design a separate holding tank to hold the difference in oil volume between the transformer oil volume and the maximum bund capacity
- Connect the bunds such that the adjacent bunds share the oil volume. In this case, the pipework shall be levelled such that one bund fills completely before starting to fill the next bund, to reduce the clean-up effort required. For this scenario, all bunds sharing the oil volume must be separate, fully sealed and firetraps must be fitted on pipework connecting the bund. This option must be fully justified in the fire risk assessment and approved by the Principal Electrical Design Engineer before finalising the design.

13.2 Fire Protection

At brownfield sites, for clearances between transformers and buildings, it is preferred to meet the G1 clearance wherever possible. If it is not possible to meet G1 distance, then using the G3 distance may be considered, however extra measures are required, such as a fire wall or parapet wall or a 2 hour fire rating of the building roof. See AS 2067:2016 Section 6.7.4.4 and Table 6.1. See Section 10.2.2 for more information.

In older substations with oil filled circuit breaker switchboards, consideration shall be given to the value of retrospective installation of fire detection and/or suppression facilities. See Section 10.4.2 for more information.

Appendix A: Mobile and hand held portable fire extinguishers

Portable fire extinguishers are classified by contents. The two types used in Western Power substations are:

1. Dry Chemical Powder (DCP) – Outdoor use only
2. Carbon Dioxide (CO2) – Indoor use.

A.1 Dry Chemical Powder

These extinguishers are effective and suitable for use on electrical fires but can damage sensitive equipment. They also leave significant quantities of fine powder residue which is intrusive and difficult to clean up. They shall therefore not be used in control rooms because of potential damage to protection and other sensitive equipment.

Monammonium phosphate (general purpose powder) types shall be used.

A.2 Carbon Dioxide (CO2)

These extinguishers are suitable for use on electrical fires and do not produce the residue seen with dry chemical types. As such they shall be the only types used inside substation buildings.

Appendix B: VESDA

The VESDA system is essentially a precision air sampling device. A fan is incorporated in the unit and a detector head optically samples filtered air drawn through a system of piping in which small holes are drilled at intervals. Different adjustable alarm levels are available, the sensitivity of which can be adjusted to suit the operating environment.

Due to the limited quantity of combustive material, the amount of heat generated in control room fires is relatively small. The VESDA system will readily detect the products of combustion of PVC at relatively low fire temperatures.

In remote installations, where long delays may occur in rectifying an out of service VESDA system, consideration should be given to the installation of supplementary conventional point smoke detectors (photo-optical light scatter type).

B.1 VESDA System Detailed Design Requirements

B.1.1 Locked areas and concealed spaces

All locked areas or areas to which <u>fire service access is restricted</u>, shall be <u>separate alarm zones</u> as per AS 1670.1-2018 requirements, Clauses 2.3 and 3.27. The detection system is not required for the toilet and other sanitary spaces unless the floor area is equal to or greater than 3.5 m^2 as per AS 1670.1-2018, Clause 3.28.

Protection of concealed spaces not exceeding 500 m^2 shall be connected to the alarm zone on the same storey of a building, providing that the total protected area and the number of detectors comply with AS 1670.1-2018, Clause 2.3 and detector remote indicators are compliant to Clause 3.16.

B.1.2 Buildings

For building with a single zone, only a single multipoint aspirating smoke detector shall be installed.

For buildings with locked or restricted areas (such as a cable basement) within the same building, a multi-zone aspirating smoke detector shall be installed with the two rooms monitored separately as separate zones.

For other rooms, protection shall be provided with thermal or smoke point type detectors, each room being monitored as a separate zone.

B.1.3 External and Internal Fire Alarm Indication and Warning Sounders

External fire alarm indication installed on the outside wall of each building shall be one red strobe light and sounder combination unit. The strobe shall be compliant to AS 1603.11-2018 and AS/AS ISO 7240 and installed as close as practicable to Designated Building Entry Point specified in 11.2.2 above and compliant to AS 1670.1-2018, clause 3.8.

The external strobe light shall also be visible from the designated site entry point.

The electronic sounder shall be an integral component within the red strobe light unit. The sounder nominal output shall be 99 dB (A) and no more than 105 dB (A). The vendor must note that electromechanical fire bells and warning devices shall not be accepted.

The FIRE sign shall be fixed adjacent to both external strobe light and sounder combination unit and also to internal Fire warning sounder inside the building. The sign with word FIRE in lettering not less than 25 mm high on red background and white letters, shall be weather and ultraviolet resistant as per AS 1319, Appendix D4(b).

The internal Fire warning sounder shall have an output of between 65 dB (A) and 75 dB (A) and must comply with AS 1670.1-2018, Clause 3.22.

The external strobe and sounder combination unit and the internal sounder shall be supervised for both open and short circuit for each building. Both strobe and sounder units shall be protected with appropriate semiconductor blocking diodes for an accidental reversal of wiring or polarity of supply. The fault alarm shall be reported to the building SIP and the FIP.

B.1.4 Detector Requirements

The following detector types shall be used in the fire protection installation:

B.1.5 Multi-point Aspirating Smoke Detectors

VESDA units should be installed in all contiguous zones with mutual access between areas, hence shall be installed in relay and switch rooms. They should not be installed in zones with locked areas as per 11.2.3.

The installation design shall comply with AS 1670.1-2018, clause 5.2.2 and must be performed with the aid of design tool, ASPIRE 2 program.

Detectors shall be installed to comply with AS 1670.1-2018 Clauses 3.7 and 3.27. They shall be located and spaced on the ceilings as per AS 1670.1-2018 Clause 5.1.2 and between deep inter-beams as per AS 1670.1-2018 Clause 5.1.2 and Figure 5.1.1(F).

For areas of high air flow such as air-conditioned or ventilated relay rooms, the spacing of multi-point aspirated or smoke type detectors depends on the number of air changes per hour. The vendor shall request this information from Western Power and determine the distance between detectors from AS 1670.1-2018, Clause 5.1.5 and Table 5.1.5.

B.1.6 Point Type Smoke Detectors

Point type smoke detectors shall be installed in non-contiguous zones with locked areas and are suitable for clean concealed spaces.

Photoelectric type detectors are required and shall have an obscuration sensitivity of at least 4% per meter.

The construction and design requirements of the detector shall comply with AS 1603.2-1997.

The location and spacing of detectors shall be compliant with AS 1670.1-2018.

AS 1670.1-2018 Clause 5.15 must be adhered to for areas of high airflow.

A smoke detector shall be used in the battery room. The smoke detector(s) shall be connected to a MTL5061 Fire / smoke detector interface unit. The MTL5061 interface unit shall provide a separate zone alarm to the FIP.

Appendix C: Relationship with FESA

The sources of risk of the most serious fires in a substation are the power transformers. Even though these fires are extremely rare, their consequences can be disastrous. The requirements of this Engineering Design Instruction and standard substation layouts are intended to ensure a transformer fire is confined to itself with no consequential damage to other plant, equipment or buildings.

However, a major transformer fire can be expected to burn for a long time and specialist services would be required to extinguish it within a reasonable period. Western Power would rely on FESA, and local firefighting authorities in regional areas, to extinguish such a fire.

FESA has indicated that within the metropolitan area, there are sufficient fire hydrants to ensure adequate water supplies available for firefighting at any location using FESA equipment for pumping. Therefore Western Power should not need to arrange the installation of fire hydrants for locations within the metropolitan area.

However, in rural areas, some sites can be remote from town water supplies and FESA (or local firefighting authorities) may request Western Power to arrange for a hydrant to be installed outside the substation fence.

To ensure FESA is aware of the issues associated with fighting fires in substations, and at the request of Western Power's insurers, some FESA personnel have been provided with familiarisation tours through selected substations.

Appendix D: Preferred Equipment

All new installations shall use equipment from the following preferred equipment list unless otherwise approved by Western Power.

D.1 FIP / SIP

- Notifier CFP-16 – Where 16 or less zones are adequate for the installation
- Notifier AFP-3030 – Where more than 16 zones are required.

D.2 VESDA

- VLF-250 – Where a single zone is required to be monitored (where no cable basement exists)
- VES-A00-P – Where multiple zones are required to be monitored (eg. Cable basements)

D.3 Point Type Smoke Detectors

- Notifier 2151BAUS

D.4 Manual Call Point

- Notifier MCP

Appendix E: Approval Record and Document Control[17]

[17] See Western Power Internal Document