

Network Standard

Document No.

NS187

Title:

Passive Fire Mitigation Design of Major Substations

Approved Date	2/03/2026	Revision	3	
Lifecycle Stage	Design	Internal Use	<input checked="" type="checkbox"/>	External Use <input checked="" type="checkbox"/>
Technical Approver		Authorised By		
Name	Joseph Metti	Name	Murray Chandler	
Designation	Senior Engineer	Designation	Head of Network Strategy and Future Grid	

Revision

No	Date	Description	Technical Approver	Authorised By
3	2/03/2026	Update and conversion to the new template	Joseph Metti	Murray Chandler

DISCLAIMER

This document is bound to the conditions set out in NS002 Network Standards Disclaimer.

Ausgrid maintains a copy of this and other Network Standards together with updates and amendments online at www.ausgrid.com.au. This document is considered uncontrolled once printed.

Table of Contents

Scope	3
Reference Documents	3
Ausgrid Documents.....	3
Other Standards and Documents	3
Acts and Regulations	4
1 General	5
2 Design approach	5
3 Passive fire mitigation design.....	6
4 Passive fire protection systems	6
5 Passive fire protection within buildings	7
6 Passive fire protection external to buildings	7
7 Egress provisions	10
8 Detailed design requirements	11
9 Public safety and Regulatory compliance	11
10 Bushfire	12
11 Design documentation.....	14

List of Annexures

Annexure A : Passive fire mitigation requirements.....	A-1
Annexure B : Active fire protection	B-1
Annexure C : Fire separation walls.....	C-1
Annexure D : Detailed design requirements.....	D-1
Annexure E : Background to passive fire protection design	E-1
Annexure F : Typical properties of combustible liquids	F-1

Scope

This Network Standard provides the minimum requirements for passive fire protection systems at Ausgrid's major substations, as well as the minimum requirements for personnel safety and emergency egress in the event of fire.

The minimum requirements for active fire systems at Ausgrid's substations are provided in Technical Guide T0059.

This Standard applies to new sub-transmission substations, zone substations and switching stations.

This Standard does not include fire protection provisions for equipment located outside of major substations such as:

- kiosk substations (refer to NS141);
- pole top equipment such as transformers, capacitors and reclosers; and
- chamber substations (refer to NS113).

Where this Network Standard is to be applied to proposed works within an existing substation, Ausgrid Engineering will provide further site-specific recommendations on the type and extent of passive fire protection to be applied.

Reference Documents

All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards.

Ausgrid Documents

NS001 Glossary of Terms

Bushfire Risk Management Plan

NS113 Site Selection and Construction Design Requirements for Chamber Substations

NS141 Site Selection and Preparation for Kiosk Substations

NS171 Firestopping in Substations.

NS185 Major Substations Building Design Standard.

NS188 Design for Substation Overpressure

NS189 Oil Containment for Major Substations

NS190 Oil Containment Operational Requirements for Major Substations

NS212 Integrated Support Requirements for Ausgrid Network Assets

T0059 Active Fire Systems for Substations

Other Standards and Documents

AS/NZS 1170.0 Structural design actions - General principles.

AS 1530.1 Methods for fire tests on building materials, components and structures – Combustibility test for materials.

AS 1530.4 Methods for fire tests on building materials, components and structures Fire-resistance tests of elements of building construction.

AS 1530.8.1 Methods for fire tests on building materials, components and structures - Tests on elements of construction for buildings exposed to simulated bushfire attack - Radiant heat and small flaming sources.

AS 1530.8.2 Methods for fire tests on building materials, components and structures - Tests on elements of construction for buildings exposed to simulated bushfire attack - Large flaming sources.

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

AS 2484.1 Fire - Glossary of terms – Fire tests.

AS 3600 Concrete structures.

AS 3700 Masonry structures.

AS 3959 Construction of buildings in bushfire-prone areas.

AS 4072.1 Components for the protection of openings in fire resistant separating Elements – Service penetrations and control points.

AS 4100 Steel structures.

ENA Doc 001 - 2019 National Electricity Network Safety Code

IEC 61039 Ed. 2.0 Classification of insulating liquids

National Construction Code Series (NCC)

NSW Rural Fire Services Guide, Planning for Bushfire Protection

Society of Fire Protection Engineers (SFPE) Handbook of Fire Protection Engineering

Acts and Regulations

Electricity Supply (General) Regulation 2014 (NSW)

Electricity Supply (Safety and Network Management) Regulation 2014

Work Health and Safety Act 2011 and Regulation 2017

Clause Standard Requirements

1 General

- 1.1 Due to the unique fire risks within substations, the requirements in this Network Standard will be over and above the minimum requirements of the National Construction Code (NCC) and other statutory regulations, in some instances.
- 1.2 The minimum requirements that shall apply for the protection of buildings against fire are those contained in the NCC.
- 1.3 All materials and equipment used for construction of Ausgrid's assets shall be free from Asbestos and/or Asbestos related products.

2 Design approach

2.1 General

Passive fire systems shall be the first line of defence for the prevention of fire spread in substations.

2.2 Fire risk zones

- 2.2.1 Where any part of the fire risk zone extends to include other buildings, parts of the same building that house the high voltage installation, fire escape routes, or other fire sensitive locations and facilities, then a potential fire hazard exists.
- 2.2.2 The classification of fire risk zones for high voltage installations such as substations shall be based on a risk assessment that incorporates the provisions of AS 2067 and the additional requirements of this Network Standard including the thermal radiation thresholds.
- 2.2.3 Where a fire hazard exists, high voltage installation enclosures within or adjacent to buildings shall be designed with suitable fire protection to meet the requirements of AS 2067 and this Network Standard.

2.3 Passive fire protection

- 2.3.1 Passive fire systems shall be designed to minimise the risk of damage from the spread of fire from one segregation zone to another. Segregated zones are defined in NS001.
- 2.3.2 Refer to Clause 2.4 for the requirements of active fire protection systems in relation to passive fire systems.
- 2.3.3 Examples of passive fire protection systems include the following items. Refer to Annexure A for the minimum required fire resistance period:
- fire separation walls and fire barriers.
 - fire stopping to penetrations within fire barriers. Refer to Annexure D for the use of fire dampers to openings within fire barriers.
 - self-closing fire doors to openings in fire separation walls and fire barriers.
 - minimum fire separation distances from fire sources.
 - oil containment / bunding.

2.4 Active fire protection

- 2.4.1 Refer to Technical Guide T0059 and Annexure B for information on active fire protection systems.
- 2.4.2 The use of an active fire system as additional protection to supplement a passive system shall have written approval from Ausgrid Engineering.
- 2.4.3 Active fire protection systems shall not be used as a substitute to passive fire protection systems, except where exceptional circumstances apply and subject to the written approval of Ausgrid Engineering.

2.4.4 The Designer shall make allowances for the credible limitations of active systems including any WHS and environmental impacts.

2.5 [Properties of combustible liquids](#)

Annexure F provides information on the typical properties and characteristics of combustible liquids commonly associated with Ausgrid substations.

3 **Passive fire mitigation design**

3.1 [General](#)

Passive fire mitigation design involves the application of a fire rating to fire barriers or fire separation walls and the provision of adequate separation distances.

3.2 [Key design criteria](#)

3.2.1 [Oil fires](#)

3.2.1.1 The following design criteria shall be applied to fire barriers, fire separation walls and other building elements exposed to potential oil fires:

- 1) Fire Intensity - the intensity of the fire (temperature-time curve) shall be equal to the Hydrocarbon Curve specified in AS 1530.4.
- 2) Fire Duration - the duration of the fire shall be based on the amount of fuel available, the energy content of the fuel and the time dependent fire intensity.
- 3) Oil Containment Bund Drainage - any oil containment bunds which are provided with gravity drainage shall:
 - a) be assumed to have a non-functioning (blocked or closed off) drainage system as the base case; or
 - b) alternative scenarios shall be assessed, with the drainage functioning as designed and any spilt oil draining at the design flowrate. Alternative scenarios shall be subject to approval by Ausgrid Engineering (refer to Annexure E).

3.2.1.2 Where fire plume modelling is used, the emissive power and maximum burn rate of the dielectric fluid shall be determined. In the absence of specific information, these properties shall be based on the relevant hydrocarbon fires detailed in the SFPE Handbook of Fire Protection Engineering and shall be subject to approval by Ausgrid Engineering.

3.2.2 [Fire separation walls](#)

In addition to the requirements of Clause 3.2.1, the design criteria in Annexure C shall be applied to fire separation walls (FSW) associated with power transformers and with other equipment exposed to potential oil fires.

3.2.3 [Detailed design requirements](#)

The detailed design requirements provided in Section 8 shall be applied to passive fire mitigation design in substations.

4 **Passive fire protection systems**

4.1 The two methods of achieving passive fire protection in substations are:

- by physical separation distance to prevent ignition or damage to critical equipment or to building elements; or
- by the provision of fire compartments.

- 4.2 Where space availability and site conditions allow, physical separation shall be given priority as the method of passive fire segregation.

5 Passive fire protection within buildings

5.1 Separation distances

- 5.1.1 Where adequate separation distances inside buildings are not reasonably practicable or economical for fire protection, compartmentalisation shall be used as the method of fire segregation internally.
- 5.1.2 For oil fires, calculation of design radiant heat levels shall be based on the relevant design criteria given in Clause 3.2.

5.2 Compartmentalisation

5.2.1 General

Compartmentalisation of substations shall be used to limit the extent of fire damage and reduce restoration times for the building and equipment. On this basis, the Ausgrid design requirements to reduce fire spread in substations may exceed the NCC provisions in some instances.

5.2.2 Compartment fire rating level

- 5.2.2.1 Where effective compartmentalisation is required, a fire rating shall be applied to all walls, floor, ceiling and openings to the compartment. Refer to Annexure A for the minimum required fire resistance period of various building elements within the substation.
- 5.2.2.2 The structural design of building elements for the impact of fire shall ensure the minimum required fire resistance period is achieved for the whole compartment.
- 5.2.2.3 Where a fire barrier is required to prevent ignition, Annexure A provides the minimum required fire resistance period for the barrier.

5.2.3 Linear compartmentalisation in substation buildings

- 5.2.3.1 The need for linear compartmentalisation shall be balanced against the introduction of obstructions in congested areas such as cable basements.
- 5.2.3.2 Linear compartmentalisation requires written approval from Ausgrid Engineering and may include cable coating and other measures as part of the overall linear compartmentation system.

6 Passive fire protection external to buildings

6.1 General

- 6.1.1 For electrical equipment external to buildings, fire segregated zones shall be provided to the substation equipment that are exposed to a fire hazard and that require protection against fire.
- 6.1.2 Where fire segregated zones are required external to buildings, this Section details the requirements for achieving the required level of fire protection.

6.2 Separation distances for buildings and transformers

6.2.1 General

- 6.2.1.1 The main fuel source features in open switchyards are power transformers and, to a lesser extent, oil circuit breakers and smaller earthing and distribution style transformers.
- 6.2.1.2 The separation distances provided between external building elements and adjacent fuel sources shall limit the extent of fire damage and reduce the restoration times for the building.
- 6.2.1.3 The separation distances provided between power transformers and adjacent fuel sources shall ensure significant damage to the power transformer is reduced or eliminated. An assessment shall be made of any long lead-time vulnerable components of a transformer when determining the separation distances.

6.2.2 **Wind factors**

Determination of separation distances shall include a factor of safety of 1.5 to the distance calculated, to allow for prevailing wind effects. Alternatively, the fire plume shall be modelled using a radiant heat analysis with a flame tilt of 45° to the vertical.

6.2.3 **Radiant heat factors**

6.2.3.1 In determining the required separation distances, an assessment shall be made of the fuel source, fire intensity, fire duration, effectiveness of bund drainage and the ultimate transformer size.

6.2.3.2 The radiant heat exposure limits applicable to various fire sensitive elements within a substation are indicated in Table 1.

Table 1 – Radiant Heat Exposure Limits

Item	Maximum allowable radiant heat flux (kW/m ²)	Comment
Cable	12.5	Cables begin to distort and may ignite. Cables may also sustain damage at lower radiant heat levels.
Steel support structure	15.0	To 60% of yield strength.
Porcelain bushing/Insulators	12.5	Damage may occur requiring replacement or in extreme case resulting in catastrophic failure. Refer to Annexure C.
Polymeric bushing/insulators	11	Damage may occur requiring replacement or in extreme case resulting in catastrophic failure. Refer to Annexure C.
Aluminium busbar	12.5	Busbars may undergo significant distortion and impose significant stresses on rigid insulators.
Copper busbar	12.5	Busbars may undergo significant distortion and impose significant stresses on rigid insulators.
Transformer oil	4.5	Auto-Ignition is possible.
Transformer tank	20 (Top) 14 (Side)	Transformers may have more vulnerable components, such as bushings and cables, that are not readily replaceable and have lower exposure limits. Refer to Annexure C .
Conservator	16	Limited by maximum oil temperature.
Combustibles	<12.5 typical	Piloted ignition may occur on timber
Non-combustible	<25.0	
Fire hydrants	3.0	For on-site external fire hydrants that are required for specific firefighting scenarios (e.g. a main transformer fire).
Egress paths	2.5	For emergency egress external to buildings. Refer to Clause 7.2.2

6.2.3.3 Radiant heat levels for oil fires shall be based on the relevant design criteria given in Clause 3.2.

6.2.3.4 The radiant heat exposure limits in Table 1 are not applicable to bushfire events which are of much shorter duration than major oil fires. Refer to Section 10.

6.3 **Minimum separation distances - outdoor transformers**

6.3.1 To establish the required minimum separation distances for outdoor transformers, a radiant heat analysis shall be undertaken wherever reasonably practicable.

6.3.2 Where a radiant heat analysis is not available, the information for segregation of outdoor transformers contained in AS 2067 shall be used to determine the minimum separation distances based on transformer type, insulating liquid volume and type and other factors.

6.3.3 Separation distances which exceed those in AS 2067, and which are not supported by a radiant heat analysis, shall be subject to approval by Ausgrid Engineering.

6.4 Fire separation walls for transformers

6.4.1 General

6.4.1.1 Where fire segregation zones are required and the required separation distances cannot be achieved, fire separation walls (FSW) shall be used.

6.4.1.2 FSWs shall be designed to the relevant design criteria given in Clause 3.2. The design dimensions of the FSW shall prevent fire spread over and around the wall.

6.4.1.3 Fire separation walls are not required between a power transformer and “directly connected” neutral earthing reactors/resistors and/or earthing transformers. Refer to Clause 6.5.3.

6.4.1.4 The design and detailing of FSWs shall take into account the following aspects:

- fuel source;
- fire intensity;
- fire duration;
- the effectiveness of bund drainage;
- ultimate transformer size;
- vertical clearance to buildings; and
- the required horizontal clearance to equipment for safe egress and operational requirements.

6.4.1.5 The radiant heat levels for oil fires shall be based on the relevant design criteria given in Clause 3.2 and the determination of separation distances for exposed elements shall allow for wind effects, in accordance with Clause 6.2.2. The impact of convection, where significant, shall also be assessed.

6.4.1.6 The design methodology and justification for the FSW dimensions shall, where requested, be submitted to Ausgrid Engineering for review and approval.

6.4.2 Vertical separation distances

Vertical separation distances above externally located transformers, or the extremities of oil filled transformer components, shall comply with the following:

- 1) for transformers with less than or equal to 1,000 litres of oil capacity, a minimum vertical separation of 6m shall be provided.
- 2) for transformers with an oil capacity greater than 1,000 litres but less than or equal to 2,000 litres, a minimum vertical separation of 7.5m shall be provided.
- 3) for transformers with an oil capacity greater than 2,000 litres but less than or equal to 20,000 litres, a minimum vertical separation of 10m shall be provided, and:
 - a) this distance shall not be reduced, except where a lesser separation distance can be justified by a comprehensive fire engineering analysis approved by Ausgrid Engineering; and
 - b) an increased distance may be required for specific bund configurations, where advised in writing by Ausgrid Engineering.
- 4) for transformers containing more than 20,000 litres of oil, a comprehensive fire engineering analysis shall be undertaken by Ausgrid Engineering, or otherwise shall be submitted as part of a detailed Design Report approved by Ausgrid Engineering.

6.4.3 Requirements between transformers and buildings

- 6.4.3.1 Where a building compartment (or part thereof) is within the fire risk zone, then a fire hazard exists, and suitable fire protection shall be provided.
- 6.4.3.2 The design of a building wall which is integrated into a single common wall shared with the transformer bay shall be subject to approval by Ausgrid Engineering.
- 6.4.3.3 The building wall facing the transformer shall be of sufficient height and width to ensure fire protection of the entire building compartment including the roof structure.
- 6.4.3.4 Alternatively, where the building has a self-supporting ceiling that provides fire protection, the roof structure does not need to be fire rated provided the self-supporting ceiling can support the collapsed roof structure.

6.4.4 Requirements for boundary fire separation walls

- 6.4.4.1 The Designer shall assess the height and type of construction of neighbouring buildings and the likely fire size within the substation.
- 6.4.4.2 In the event of a fire, the radiant heat emitted from the substation shall comply with the requirements of the NCC. The impact of convection, if significant, shall also be assessed.
- 6.4.4.3 Refer to Clause 9.3 for the maximum heat flux that can be emitted from the boundary of the substation.

6.5 Separation distances for other switchyard equipment

- 6.5.1 This Network Standard is not intended to cover the fire protection of all switchyard equipment and structures. Where fire protection is required, the exposure limits in Table 1 shall be applied.
- 6.5.2 The switchyard equipment and structures which may require fire protection will vary on a site-by-site basis depending on the equipment function and the substation criticality. This equipment may include, but is not limited to, the following items:
 - external cable trenches at specific locations (refer to NS171).
 - manually operated outlet valves associated with outdoor oil containment tanks (refer to NS189).
 - auxiliary transformers deemed to be critical for the partial re-energisation and restoration of service.
 - project specific equipment, where approved in writing by Ausgrid Engineering.
- 6.5.3 Some items of switchyard equipment can be readily replaced in the event of damage during a fire and other items may not be critical for the partial re-energisation and restoration of service. Equipment which does not require fire protection includes, but is not limited to, the following items:
 - power transformer insulated bushings which are deemed to be replaceable items (refer to Annexure C and Annexure E).
 - directly connected neutral earthing reactors/resistors.
 - directly connected earthing transformers.
- 6.5.4 Refer to Ausgrid Engineering for project-specific scopes in relation to switchyard equipment and structures including sealing ends, circuit breakers and AC or DC boards.

7 Egress provisions

7.1 Emergency egress within buildings

- 7.1.1 Access and emergency egress within buildings shall be in accordance with NCC requirements and AS 2067 as a minimum.
- 7.1.2 All compartments containing high voltage equipment in Ausgrid buildings shall have a minimum of two points of safe egress, except where an exemption is allowed under NS185.
- 7.1.3 Flash fires or effects of blasts caused by arc explosions are outside the scope of this standard.

7.2 Emergency egress external to buildings

7.2.1 Radiant heat exposure

Fire emergency egress within switchyards shall allow for the effects of radiant heat exposure from burning oil filled transformers or other oil filled electrical equipment with a similar fire hazard.

7.2.2 Personnel safety and radiant heat

7.2.2.1 The Designer shall make provision for personnel safety and emergency egress within the substation.

7.2.2.2 Ausgrid's minimum requirements for egress in relation to substation fires, allowing for the effect that fires have on human exposure limits, shall be as follows:

- the design of substation egress paths shall assess locations for safe egress points from site, all potential oil and other significant fire source locations, the radiant heat levels along egress paths and the exposure limits on personnel.
- personnel shall not be exposed to a radiant heat flux of level greater than 2.5kW/m² along designated egress paths during evacuation. This radiant heat flux limit shall be further reduced where exposure times greater than 30 seconds are possible.
- egress points in gates shall be positioned such that exposure for personnel shall be limited to 2.5kW/m² for egress where a single action handle is provided on the escape door/gate.
- where there is no single action door/gate, a limit of 1.7kW/m² for indefinite exposure shall be adopted for egress points.
- the Designer shall investigate alternative means of protection, such as refuge areas, where adequate separation distances cannot be achieved.
- the determination of separation distances shall allow for prevailing wind effects, in accordance with Clause 6.2.2.

8 Detailed design requirements

Ausgrid has developed detailed design requirements for passive fire mitigation of substations which are described in Annexure D and cover the following aspects:

- Openings in fire barrier and fire separation walls – doors, vents;
- Minimum clearance to fire doors and fire dampers;
- Switchyard trenches and other locations;
- Firestopping;
- Smoke seals;
- Roof systems - internal and external fire protection;
- Impact resistance; and
- Substation overpressure effects.

9 Public safety and Regulatory compliance

9.1 General

9.1.1 The requirements of the NCC in terms of building element fire ratings, set-backs, services and egresses shall be met as a minimum.

9.1.2 Where an Alternative Solution approach is used to satisfy the NCC provisions, the Alternative Solution shall meet the intent and performance requirements of the NCC and shall comply with Ausgrid's Network Standards.

9.2 Adjacent or adjoining properties and buildings

9.2.1 The main objectives of the NCC with respect to fire safety and fire resistance is to:

- safeguard people from illness or injury due to a fire in a building;
- safeguard occupants from illness or injury while evacuating a building during a fire;
- facilitate the activities of emergency services personnel;
- avoid the spread of fire between buildings; and
- protect other property from physical damage caused by structural failure of a building as a result of fire.

9.2.2 Fire spread to adjoining buildings shall be prevented and other properties protected from damage in the event of a substation fire.

9.2.3 For new substations, buildings shall comply with the relevant fire performance requirements of the NCC. The NCC provides criteria for verification of the performance requirements and places limits on allowable levels of heat flux radiation with respect to distances beyond a property boundary.

9.3 Heat flux limits

9.3.1 In all cases, the maximum potential heat flux between buildings on adjoining allotments, and on the same allotment, shall not exceed those specified in the NCC.

9.3.2 At locations where the building adjoining the Ausgrid substation site is constructed of timber on or near the boundary, a heat flux of less than 25 kW/m² shall be achieved at the boundary. Where flame impingement is possible this value shall be reduced to 12.5 kW/m².

10 Bushfire

10.1 General

10.1.1 This Section provides the minimum requirements for protection of the substation against bushfires.

10.1.2 This Network Standard does not provide requirements for protecting bushfire prone land against fire from an equipment failure.

10.1.3 For bushfire prone land, as a minimum, segregation distances to combustibles (using 12.5 kW/m² where flame impingement is possible) shall be adopted at the boundary, or the switchyard fence, depending on the land use within the boundary.

10.1.4 Substations deemed to be in bushfire prone land shall satisfy all the requirements of AS 3959 and the NSW Rural Fire Services (RFS) guide, Planning for Bushfire Protection (PBP).

10.1.5 This Section does not include the use of fire separation walls to protect external equipment from a bushfire, assuming that sufficient land is available to achieve the required separation distances. Where adequate space is not available, seek further advice from Ausgrid Engineering.

10.2 Approach to bushfire protection

10.2.1 The design of Ausgrid substations shall ensure that they do not contribute to a bushfire and are able to maintain supply at a minimum predetermined level after a bushfire event. If required, the substation shall be able to shut down safely in the event of radiant heat damage.

10.2.2 The criticality of Ausgrid substations, and the level of service required during (and after) a bushfire event, will be site dependent and will vary with location within the network. This aspect will impact upon the type and extent of bushfire protection provided at a given site.

10.2.3 Where bushfire protection is required, the radiant heat exposure limits provided in Table 2 shall be applied to the critical substation elements only. Assessment of element criticality shall be based on the substation importance, reliability of supply, repair / replacement options, potential bushfire exposure and other aspects.

10.2.4 Based on the substation location and criticality, some HV components will need to be protected from bushfire, and some can remain exposed and readily replaced if damaged.

10.3 Buildings

- 10.3.1 At locations where loss of the facility or network supply is unacceptable, in addition to the requirements of AS 3959, further measures shall be applied aimed at preventing a fire from entering through openings, roof systems, or any other means.
- 10.3.2 As a minimum, the building shall be designed for the required fire resistance level (FRL) in Annexure A.
- 10.3.3 All external doors shall match the fire performance FRL of the building and shall be fitted with fire resistant smoke seals at the base of the door to prevent embers from entering under the door.
- 10.3.4 The use of wall penetrations within a zone 400mm above external ground level where embers can accumulate, shall be subject to approval by Ausgrid Engineering.

10.4 Switchyard equipment

- 10.4.1 Radiant heat is the most likely cause of damage to switchyard equipment and structures in a bushfire. All identified critical switchyard equipment shall be sufficiently set back from the boundary or otherwise provided with suitable local heat / fire barriers for protection.
- 10.4.2 Fire spread can be caused by embers igniting combustibles within the switchyard. The Designer shall assess the need for protection of combustible switchyard components against ember damage.
- 10.4.3 Bushfire events can create significant radiant heat flux levels. However, the peak exposure level is of relatively short duration when compared to other fuel source features within a substation. As a result, the allowable radiant heat exposure limits are correspondingly higher for most substation elements based on the short-term exposure.
- 10.4.4 The assumed radiant heat / temperature duration curve applicable to bushfires shall be as follows:
 - peak values are reached after 1 minute;
 - values remain at peak for up to 4 minutes; and
 - values recede to ambient linearly over a further 5 minutes.
- 10.4.5 Refer to Table 2 for the limiting radiant heat flux levels for determining minimum safe separation distances.
- 10.4.6 For bushfires, the NSW RFS PBP is the key reference document in establishing the maximum bushfire intensity at a given location. A flame front length equal to the approach boundary length shall be assumed and a flame height based on the PBP shall be used in the calculations.

Table 2 – Radiant Heat Exposure Limits for Bushfires

Item	Maximum allowable radiant heat flux (kW/m ²)	Comment
Cable (see Note 1)	12.5	PVC Cables begin to distort and may ignite.
	20	Ignition of XLPE cables between 85 and 550 seconds.
Steel support structure	35	To 60% of yield strength after a maximum duration of 5 minutes. Applies where elastic deflections due to elevated temperatures are not critical.
Porcelain bushing/Insulators	>30	Damage may occur requiring replacement or in extreme case resulting in catastrophic failure. (see Note 3).
Polymeric bushing/insulators	>30	Damage may occur requiring replacement or in extreme case resulting in catastrophic failure. (see Note 3).
Aluminium busbar	20	Based on 250°C after a maximum duration of 5 minutes. Comparable to withstand temperature under fault conditions.
Copper busbar	25	Busbars may undergo significant distortion and impose significant stresses on rigid insulators.

Item	Maximum allowable radiant heat flux (kW/m ²)	Comment
Transformer tank	>35 (see Note 2)	Refer to above regarding bushings and cables.
Combustibles	12.5	Piloted ignition may occur on timber.

¹ Exposed external cables that are at or near ground level may need specific protection against ember damage. Refer to Clause 10.4.2.

² Transformers may have more vulnerable components, such as bushings and cables, that are not readily replaceable and have lower exposure limits. Refer to Annexure C.

³ Detailed information on radiant heat exposure limits is not available. However, in-service applications exposed to bushfire indicate a high radiant heat limit and a low risk of damage or failure.

10.4.7 The radiant heat limits provided in Table 2 are applicable to identified critical substation structures and HV components. Critical elements are those deemed to be essential for return to service following a bushfire event.

10.4.8 The location of critical substation elements, their sensitivity to radiant heat and their ease of replacement will each impact upon the potential Asset Protection Zone (APZ) required at a given substation.

10.4.9 APZ widths may potentially reduce where critical exposed elements nearest the boundary are able to be locally protected and/or rapidly replaced following a bushfire event.

10.5 [House keeping](#)

10.5.1 Substations in bushfire prone areas may accumulate leaf matter, adjacent to buildings or in alcoves, that may become an additional fuel source.

10.5.2 Substations shall be inspected and cleaned regularly to prevent the build-up of significant combustible matter.

11 **Design documentation**

11.1 A Design Report shall be prepared by an appropriately qualified engineer practicing in the specific discipline of fire engineering.

11.2 The Design Report shall provide details of the schematic designs developed and demonstrate by calculation how the objectives of passive fire mitigation performance requirements stipulated in this Network Standard are satisfied.

11.3 The Design Report shall be prepared prior to the detailed design of the substation and submitted to Ausgrid Engineering for approval at the completion of the schematic design stage.

11.4 The methodology and calculations for determining all separation distances shall be provided as part of the Design Report prior to detailed design.

Annexure A: Passive fire mitigation requirements

A1 General

- A1.1 Refer to Ausgrid Engineering for scope on the extent of segregation. Table A1 provides the performance requirements when segregation is required.
- A1.2 Table A1 does not include provisions for pole mounted equipment such as transformers and capacitors.
- A1.3 Ausgrid may require a higher fire resistance period than those nominated in Table A1 for specific sites where loss of supply and/or safety issues dictate.

A2 Performance requirements

Table A1 Performance requirements where segregation required

Fire Source	Minimum Fire Resistance Period (hours) to protected equipment or building elements ^{1, 2, 3}			
	CBD Zone Substation	Sub-transmission Substation	Other Zone Substation	Distribution & Chamber Substations
Transformer/reactors – oil filled (external & internal)	4 hours or spatial separation	4 hours or spatial separation (see Note 4)	3 hours or spatial separation (see Note 4)	3 hours or spatial separation
Transformers non-oil filled (external & internal)	3 hours or spatial separation	3 hours or spatial separation	2 hours or spatial separation	2 hours or spatial separation
Distribution centre Oil Filled	4 hours or spatial separation	4 hours or spatial separation (see Note 4)	3 hours or spatial separation (see Note 4)	3 hours or spatial separation
Distribution centre Non-oil Filled	3 hours or spatial separation	3 hours or spatial separation	2 hours or spatial separation	2 hours or spatial separation
Other oil filled equipment	4 hours or spatial separation	4 hours or spatial separation (see Note 4)	3 hours or spatial separation (see Note 4)	3 hours or spatial separation
Other non-oil filled equipment	3 hours or spatial separation	Non-combustible Comply with NCC.	Non-combustible Comply with NCC.	2 hours or spatial separation
Cable marshalling areas (basements etc.) (see Note 5)	4 hours	4 hours	Non-combustible Comply with NCC.	3 hours or spatial separation
Cable Risers	3 hours	3 hours	3 hours	3 hours
Control Room	3 hours	Non-combustible Comply with NCC.	Non-combustible Comply with NCC.	N/A
Battery Room (where provided)	3 hours	Non-combustible Comply with NCC.	Non-combustible Comply with NCC.	N/A
Battery Enclosures	Non-combustible	Non-combustible	Non-combustible	N/A
Communication Room (where provided)	3 hours	Non-combustible Comply with NCC.	Non-combustible Comply with NCC.	N/A
Capacitors (where provided)	3 hours or spatial separation	3 hours or spatial separation (see Note 4)	2 hours or spatial separation	N/A

Fire Source	Minimum Fire Resistance Period (hours) to protected equipment or building elements ^{1, 2, 3}			
	CBD Zone Substation	Sub-transmission Substation	Other Zone Substation	Distribution & Chamber Substations
Amenities, foyers and other areas not containing substation equipment	Non-combustible Comply with NCC.	Non-combustible Comply with NCC.	Non-combustible Comply with NCC.	Non-combustible Comply with NCC.
Audio frequency load control (AFLC)	N/A	Non-combustible Comply with NCC.	Non-combustible Comply with NCC.	N/A

¹ Higher fire resistance periods may be required under the NCC particularly where multi-classifications exist when a substation is incorporated within another building.

² AS 2067 may have additional requirements for fire protection where a fire hazard exists.

³ Spatial separation shall be applied in outdoor applications. Refer to Clause 5.1 for use within buildings.

⁴ The required fire resistance period associated with external power transformers, external capacitors and other external oil filled equipment may be reduced to a minimum of 2 hours where the fire exposure can be demonstrated to reduce significantly during the fire resistance period (due to fuel limitation, effective bund drainage, etc).

⁵ Refer to Annexure E for further information on the fire resistance period of cable marshalling areas. Refer to NS171 for firestopping of penetrations and additional measures for cable fire protection.

Annexure B: Active fire protection

B1 General

- B1.1 This Annexure provides further information on the use of active fire protection systems in relation to passive fire systems.
- B1.2 Active fire extinguishing systems, such as sprinklers and deluge systems, aim to reduce the impact of burning equipment by reducing or eliminating any fire or smoke damage to the remaining substation and equipment.
- B1.3 Active systems assist in reducing the overall fire related damage by:
- providing early warning for Ausgrid and/or Fire Brigade intervention.
 - reducing the duration of a fire and providing a safe means of extinguishing the fire without isolating and earthing.
 - overcoming access problems for firefighting.
 - limiting the spread of fire within a compartment.
 - reducing smoke.
 - providing, in some cases, cooling to adjoining areas.
 - providing a secondary system in the event the primary passive system is compromised prior to, or during, a fire event.
- B1.4 Active systems may also reduce fire damage where linear compartmentalisation is not possible, such as some CBD Zone Substation cable basements. At these locations, however, alternative passive fire protection systems are also available, such as cable fire protection or flame-retardant cable insulation.

B2 Application of active systems

- B2.1 The following active fire systems shall be installed throughout Ausgrid substation buildings unless otherwise specified:
- Thermal / Smoke Detection System (excluding distribution substations); and
 - Fire Extinguishers.
- B2.2 These active fire systems shall comply with the design requirements of Technical Guide T0059. The use of additional or alternative active fire systems shall require the written approval of Ausgrid Engineering.
- B2.3 For substations that require on-site external fire hydrants, a suitable separation distance shall be provided from potential fire sources to reduce the radiant heat exposure to an acceptable level during firefighting. Refer to Table 1 for radiant heat exposure limits.

Annexure C: Fire separation walls

C1 Design Criteria

The following design criteria shall be applied to fire separation walls (FSW) associated with power transformers and with other equipment exposed to potential oil fires:

- 1) **Fire resistance level (FRL)** - the minimum FRL for structural adequacy shall be based on the fire resistance period given in Annexure A using a hydrocarbon fire intensity (see Clause C2.1). For external locations, the FRL may be reduced to a minimum of 2 hours where the fire exposure can be demonstrated to reduce significantly during the fire resistance period, due to fuel limitation, effective bund drainage etc (see Clause C2.2).
- 2) **Bushings on adjacent transformers** - the resin impregnated paper and solid porcelain bushings on adjacent transformers shall be treated as replaceable items if damaged. Specific protection from radiant heat is not required for these items (refer to Annexure E, Clause E4). Where oil filled porcelain bushings are installed, seek further advice from Ausgrid Engineering.
- 3) **Radiant heat on adjacent transformers** - the radiant heat on any oil containing components of adjacent transformers (excluding bushings) shall not exceed the values given in Table 1 of this standard (see Clause C2.3).
- 4) **Fire protection of cables** - exposed power cables in adjacent or nearby locations shall be treated as replaceable items if damaged. Specific protection from radiant heat is not required (see Clause C2.4).
- 5) **Minimum FSW height** - the minimum height of a FSW shall be 0.3m higher than the highest oil containing component of either transformer. The height of the FSW shall not be less than that required to break the line of sight between any oil containing components and the adjacent equipment to be protected.
- 6) **Minimum FSW width** - the minimum width of the FSW shall be 0.3m wider on each side than the widest part of either transformer. In addition, the width of the FSW shall be no less than the width of the widest oil containment bund.
- 7) **Design loadings during fire** - the FSW shall be capable of withstanding the design permanent loads, induced thermal loads and 25% of design wind loads using the combination of actions for fire as given in AS/NZS 1170.0. The expected, fire induced, material temperatures shall be used for FSW strength calculations.
- 8) **Stability during fire** - the FSW shall have sufficient strength, end support and lateral restraint to prevent structural collapse during a credible fire event.
- 9) **Thermal response during fire** - the deflection and load eccentricities arising due to thermal response of the FSW to fire exposure shall be assessed in the design and in the load combinations for strength and shall not cause permanent damage to any adjacent building elements.
- 10) **Loss of structural capacity** - suitable design measures shall be taken to prevent extensive concrete spalling and other significant loss of strength mechanisms. Alternatively, the FSW shall be designed with sufficient residual strength to prevent structural collapse during a credible fire event.
- 11) **Damage due to fire** - the FSW may sustain limited, repairable, damage to the exposed surface materials, joints and connections. Alternatively, a more substantial level of damage can be allowed provided that structural collapse does not occur and the FSW components can be readily removed and reinstated (see Clause C2.5).

C2 Additional design information

- C2.1 The minimum FRL for the integrity of FSW joints and for FSW panel insulation can be reduced to 1 hour (e.g. FRL 180/60/60) provided the FSW is not integrated into a single common wall that is shared with the substation building.
- C2.2 Routine inspection and clean-out of the oil containment flame traps, pipelines and EGOWS tanks is essential for the effective drainage of spilt fuel. Gravity drainage of bunds is not provided where a PPS oil containment system is installed. Refer to Annexure E.

- C2.3 Full de-energisation of the substation including transformers is performed by the Network Control Room. This will typically occur within 30 minutes from the commencement of a major transformer oil fire. Refer to Annexure E.
- C2.4 Low cost, localised radiation shields can be provided to exposed power and control cables where necessary.
- C2.5 Additional temporary support of the FSW can be provided during repair or replacement works.

Annexure D: Detailed design requirements

D1 General

Ausgrid has developed detailed design requirements for passive fire mitigation of substations which are described in this Annexure.

D2 Openings in fire barrier walls and fire separation walls

D2.1 General

Door openings in fire barrier walls and fire separation walls shall only be provided where access and emergency egress requirements dictate. Refer to Section 7 for emergency egress requirements.

Windows are not permitted in substation fire barrier walls or fire separation walls.

Fire dampers shall be provided for any openings in fire barrier walls and fire separation walls that are not otherwise fire rated.

D2.2 Doors

Where a door is located in a fire barrier, it shall be fire rated to the FRL of the wall, as determined from Annexure A. Doors shall not impact on bund integrity.

Doors shall be located such the radiant heat damage of vulnerable equipment or components in adjoining compartments is minimised.

D2.3 Vent openings

Vents in fire barrier walls and fire separation walls facing other fire compartments shall be avoided where reasonably practicable.

All vent openings that are required in a fire barrier wall or fire separation wall shall be fitted with fail-safe automatically controlled fire dampers having a fire rating not less than the required fire rating of the fire barrier wall.

Where vent openings are provided, electrical equipment in the adjoining compartment shall be located a sufficient distance away from the vent fire damper. The design will ensure that, for the duration of a fire event, the equipment is not damaged by heat radiated through, or from, the vent fire damper due to a fully developed fire.

D2.4 Minimum clearance to fire doors and fire dampers

To reduce potential heat damage and ensure the safe operation of a neighbouring compartment's equipment following a fire, a minimum set-back distance of equipment from the fire doors and fire dampers is required.

Ausgrid Engineering will provide direction on the minimum clearance requirements to be applied to a particular substation based on the risks to the network.

The minimum clear distance to electrical equipment shall ensure that radiant heat levels emitted from the fire door or fire damper do not cause greater internal temperatures than the equipment's safe operational limits.

The maximum design temperatures shall be as specified in Table D1. These temperatures shall apply for the duration of the fire event, and only to those components that are deemed to be non-replaceable items.

An additional factor of safety on separation distances, to allow for wind effects, is not required for interior or sheltered environments.

Table D1 – Maximum Design Temperatures of Electrical Equipment

Switchgear	Transformer	Cables
105 ° C	130 ° C	130 ° C

For design purposes, the radiant heat flux emitted from a typical fire door opening can be assumed to be 10kW/m² with the door shut.

D3 Switchyard trenches and other locations

NS171 details the fire protection measures required to protect cable trenches and other locations in switchyards from damage due to transformer oil fires or from bushfire related embers and radiant heat.

Ausgrid Engineering will provide direction on the type and extent of external switchyard fire protection to be applied to a particular substation based on the risks to the network. Refer to Clause 6.5.

D4 Firestopping

Where penetrations exist through fire rated building elements, the penetrations shall be sealed to prevent the passage of fire or smoke to other areas within the substation.

The requirements for substation fire rating are outlined in Annexure A and further details are provided in Annexure E for cable marshalling areas.

Firestopping requirements, properties and installation procedures are detailed in NS171.

D5 Smoke seals

Smoke management systems are detailed in NS171.

D6 Roof systems

D6.1 General

Where fire segregation is required by Annexure A, roof systems shall prevent an internal fire from spreading or prevent external fires from entering the building. External fire sources include transformer fires or bushfires.

Roof structures shall not be constructed of, or contain any, combustible material. Combustible materials are those deemed to be combustible when tested in accordance with AS 1530.1.

D6.2 Internal fire protection

Fire spread through a ceiling void into other compartments of the building shall be prevented. Alternatively, the building design shall ensure that fire is prevented from entering the ceiling void of the compartment.

D6.3 External fire protection

Where there is a risk of exposure to an external fire hazard, the roof structure shall be designed for the appropriate fire resistance level. Alternatively, the requirements of Clause 6.4.3.4 shall be satisfied.

D7 Impact resistance

All fire barrier elements shall have sufficient impact resistance to ensure that fire integrity is maintained following any operational impacts.

D8 Substation overpressure

The Designer shall assess the effects of substation overpressure on all passive fire mitigation systems. Refer to NS188.

Annexure E: Background to passive fire protection design

E1 General

This Annexure provides background information relating to some specific design approaches that have been adopted by Ausgrid for passive fire protection at substations.

E2 Cable marshalling areas

E2.1 Previous versions of NS187 required a fire resistance period (FRP) of 3 to 4 hours for all cable marshalling areas (CMA) in Annexure A. For many substations this would often exceed the minimum NCC requirements for the building overall.

E2.2 Historically, the FRP requirements for CMA's were driven by a number of potential hazards that adversely impacted on fire risk, including:

- the use of oil filled and oil impregnated HV cables in the CMA.
- the use of oil filled switchgear in the switchroom directly above the CMA.
- small and confined basement areas with limited internal space for physical separation of cables.
- congested HV cable paths with multiple cable crossovers.
- a prevalence of HV cable joints with inadequate separation to other cables and negligible cable fire protection.

E2.3 For new substation designs, these potential hazards have been significantly reduced with the use of modern substation equipment, the adoption of XLPE HV cable materials and the selective application of cable fire protection.

E2.4 For modular buildings, the CMA is also open on all sides, and this would effectively prevent the build-up of smoke and heat from a potential fire event.

E2.5 As a result, the internal building fire risk for the CMA has been reduced to the point where a significant FRP is no longer necessary other than at critical substations (CBD zone substations or Sub-transmission substations) or where required by the NCC. This change has been incorporated into Annexure A of this Network Standard.

E2.6 In addition, the treatment of penetrations through the various building elements can be correspondingly reduced to comply with the revised requirements of NS171, the NCC and AS 2067 where appropriate.

E2.7 At locations where the residual fire risk is determined to be significant (e.g. HV cable joints, major LV cables), additional local cable fire protection is applied as outlined in NS171.

E3 Oil containment bund drainage

E3.1 For oil pool fires, this Network Standard requires that oil containment bunds with gravity drainage are assumed to have a non-functioning (blocked) drainage system as the base case (refer to Clause 3.2.1.1). This approach also addresses gravity drainage that is disrupted by the activation of shut-off valves during firefighting activities.

E3.2 For alternative bund drainage scenarios approved by Ausgrid Engineering under Clause 3.2.1.1, any oil which is spilt within the bund is assumed to drain away via the flame trap and pipeline at the design flowrate.

E3.3 For effective gravity drainage of the oil containment bunds, routine inspection and clean-out of the oil containment flame traps, pipelines and EGOWS tanks is essential.

E3.4 Refer to NS190 for the Ausgrid requirements relating to the operation and maintenance of the various oil containment systems.

E3.5 Gravity drainage of bunds is not provided for all types of oil containment systems. Parallel Plate Separator (PPS) and other similar systems rely on a closed (undrained) system which uses pumps to empty the bunds.

E3.6 For closed (undrained) systems, and for blocked gravity drainage systems, all of the spilt oil will be retained within the bund enclosure and hence will be potentially available as fuel for an oil pool fire.

E4 Transformer bushings

E4.1 This Network Standard recognises that the resin impregnated paper and solid porcelain bushings on new power transformers are potentially replaceable items if damaged. On this basis, specific protection from radiant heat due to fire is not required for these items.

E4.2 For resin-impregnated paper, porcelain clad bushings at 132kV and 66kV, Ausgrid retains an inventory of spare bushings for most of its major power transformers. Ausgrid's 33kV and 11kV bushings are readily available from local suppliers.

E4.3 Replacement of damaged transformer bushings can be achieved within an acceptably short timeframe and would typically involve the following key steps:

- Day 1 – removal of HV connections and part drainage of transformer oil
- Day 2 – removal of damaged bushings
- Day 3 – workshop modifications to bushing flanges and connectors if required
- Day 4 – installation of new bushings
- Day 5 – refill transformer with oil
- Day 6 – contingency day
- Day 7 – transformer testing
- Day 8 – transformer testing
- Day 9 – reconnection of HV bars and cables

E4.4 Overall, the bushing replacement process involves 7 to 9 days of work using regular hours and depends on the number of local modifications required.

E4.5 Under emergency conditions, using multiple work crews and extended working hours, the work duration could be reduced to a few days.

E5 Transformer tank

E5.1 This Network Standard allows for a permissible radiant heat flux exposure of up to 20 kW/m² for adjacent power transformers exposed to a fire.

E5.2 The radiant heat flux exposure limits are based upon reasonable values for the key inputs including initial temperature, fire duration, time to de-energisation and temperature gradients. A reduction factor of 20% has been applied to allow for unexpected variations to the key inputs.

E5.3 The radiant heat limits apply to the main transformer tank and other non-replaceable oil filled components but excludes the transformer insulated bushings (refer to Clause E4).

E5.4 For Ausgrid's current 132kV and 33kV power transformer designs, the radiant heat limits enable the equipment to remain within the main limiting design temperatures, as indicated below:

- Transformer HV Winding Temperature Rise (above ambient): 90°C
- Transformer HV Winding Hotspot: 140°C

E6 Response to major fires

E6.1 During a major fire, the adjacent power transformers are likely to remain in service and will continue to be actively monitored by the protection system. Adverse effects caused by heat and smoke (conductor damage, flashover, etc.) are rapidly detected and the protection system will trip the unit off-line as required.

E6.2 Ausgrid's Network Security has developed agreed response procedures in the event of catastrophic events, including major transformer fires. There is recognition that major power transformer fires are rare events, and that the insulated bushings of adjacent transformers are potentially replaceable items that can be changed over if damaged by radiant heat exposure.

- E6.3 Network Security advises that, in the event of a major power transformer fire, full de-energisation of the substation would typically occur within 30 minutes. A worst-case scenario may increase this time to 1 hour, although this would be rare.
- E6.4 De-energisation of the substation is undertaken from the Network Control Room, following a site visit and confirmation by an Ausgrid Operator. Once de-energisation has been confirmed by the Operator on site, the Fire Brigade will then enter the substation and commence their attack on the fire.
- E6.5 During a major fire, the Fire Brigade has control of the site and its perimeter and will determine the safe approach distance and who can access the site. These controls will also apply to any Ausgrid representatives at the site.

Annexure F: Typical properties of combustible liquids

F1 General

F1.1 Table F1 provides information on the typical properties and characteristics of combustible liquids commonly associated with Ausgrid substations.

Table F1 - Properties and characteristics of combustible liquids

Material / Liquid	Property				Characteristic		
	Boiling Point °C	Minimum Flash Point °C	Fire Point °C	Fire Class IEC 61100	Ignition Time	Smoke Production	Heat Release
1. Transformers							
Mineral Oil		140	170	O	Short	High	High
Natural Ester - FR3		>300	>340	K2	Long	Medium	Medium to High
Synthetic Ester – MIDEL 7131		275	322	K3	Long	Low	Medium
Polyol Ester – VG32		269			Long	Low	Medium
Silicone Liquid – KF96-50CS		>310	>370	K	Long	Low	Low
2. Capacitors							
Jarylec – C101		144	154		Short		
Faradol - 810	270	138			Short		

F1.2 The fire class “K Classification” shown in Table F1 is based on IEC 61039 Ed. 2.0 - Classification of insulating liquids, as indicated in Table F2.

Table F2 - Fire point and calorific values of insulating liquids

Class	Fire Point	Class	Calorific Value
O	≤ 300 °C	1	≥ 42 MJ/kg
K	> 300 °C	2	$32 < CV < 42$ MJ/kg
L	Not detectable	3	< 32 MJ/kg