Network Standard

Document No.
NS171

Title:
Firestopping in Substations

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Technical Approver		Authorised By			
Name	Joseph Metti	Name		Jacob Bayley	
Designation	Senior Engineer	Designation		Manager - Network Standards & Electrical Safety	

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No	Date	Description	Technical Approver	Authorised By
4	8/05/2025	Update and conversion to the new template.	Joseph Metti	Jacob Bayley

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Scope

This Network Standard sets out the requirements for the installation of firestopping materials in openings in substation walls, floors and ceilings. The openings include holes, slots and other penetrations for electrical services, such as cables, electrical conduits and busbars within an electrical substation.

This Network Standard also sets out the requirements for the fire protection of cables within a substation.

This document does not address the firestopping of other service penetrations.

The requirements of this Network Standard apply to:

- all substations and similar installations, unless indicated otherwise; and
- associated cable installation facilities external to a substation chamber but contained in, or adjacent to, the “host" building. This includes cable risers, cable turning rooms and pits.

In addition to this Network Standard, all buildings shall comply with the National Construction Code (NCC / BCA), Australian Standards and any other relevant codes and standards in respect to fire segregation and firestopping within the building.

All persons including Ausgrid staff, Accredited Service Providers, Contractors and any other persons involved with electrical and/or construction work in substations shall comply with this Network Standard.

Reference Documents

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

Ausgrid Documents

Electrical Safety Rules

Electricity Network Safety Management System Manual

NS181 Approval of Materials and Equipment and Network Standard Variations

NS187 Passive Fire Mitigation Design of Substations

NS211 Working with Asbestos Products

NS212 Integrated Support Requirements for Ausgrid Network Assets

NS259 Requirements for protection system segregation

Other Standards and Documents

AS/NZS 1170 Structural design actions – Series

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

AS 1851 Maintenance of fire protection systems and equipment

AS 2067 Substations and High Voltage Installations exceeding 1 kV a.c

AS 2865 Confined spaces

AS 3600 Concrete structures

AS 4072.1 Components for the protection of openings in fire-resistant separating elements - Service penetrations and control joints

AS 4100 Steel structures

ENA Doc 001-2019 National Electricity Network Safety Code

National Construction Code Series (NCC)

The National Occupational Health and Safety Commission’s NOHSC:3002(1988) and NOHSC:2002(1988)

Underwriter Laboratory Standard UL 1479 ‘Fire Test on Through Penetration Fire Seals’

Acts and Regulations

Electricity Supply (General) Regulation 2014 (NSW)

Electricity Supply (Safety and Network Management) Regulation 2014 (NSW)

Work Health and Safety Act 2011 (NSW)

Work Health and Safety Regulation 2017 (NSW)

Clause	Standard Requirements

1 General

1.1 The objectives of this Network Standard are to:

- minimise the risk of fire spread via electrical services that penetrate substation building elements (walls, floors and ceilings) that are required to have an FRL or a resistance to the incipient spread of fire;
- minimise fire spread and extent of cable damage within the substation due to potential hazards such as arc chutes and HV cable joints;
- reduce the potential impact of a single fire event upon Network supply; and
- document the product performance requirements that suppliers of firestopping products shall meet in order to achieve approval from Ausgrid.

1.2 A list of approved product specific installation details is included in Annexure B.

2 Fire Risk Assessment

2.1 A risk assessment shall be conducted to identify the appropriate stages of construction and/or commissioning that require firestopping to be installed.

2.2 The risk assessment shall be undertaken by persons competent in assessing the fire risks and the findings shall determine the penetrations to be fire stopped. Penetrations that do not have cables shall also be assessed.

2.3 Firestopping in new substations shall be installed in stages in accordance with the risk assessment. The use of easily installed and removable firestopping such as fire pillows are appropriate during construction works.

2.4 The risk assessment shall assess and document the following items:

- Accidents that initiate a fire may occur when commissioning new equipment.
- All non-ventilation openings shall be assessed, not just openings carrying cables.
- Building fire systems may not be fully operational.
- Fire zoning into multiple compartments where substation design permits.
- Fire rated protection to cables by boxing in cables may be necessary in high-risk locations.
- Daily reinstatement of firestopping during installation of equipment.
- Hot work may occur during construction and cable jointing.
- Storage of materials and building refuse may occur during construction.
- The risk and cost associated with equipment loss where a fire occurs prior to or after commissioning.

2.5 During the installation of equipment, the use of temporary firestopping where appropriate shall be assessed.

2.6 Prior to commissioning equipment in new substations, or in modified existing substations, the associated firestopping for that equipment and compartment shall be fully installed.

2.7 Installed firestopping shall be continuously monitored during all phases of construction and commissioning works.

3 Material Safety

3.1 General

Both new and existing firestopping materials may contain harmful ingredients and appropriate measures shall be taken to manage any risks.

3.2 Safety Data Sheets

3.2.1 A copy of current Safety Data Sheets (SDS) shall be readily available when firestopping products are being installed, removed, disturbed or interfered with in any way. These SDS's are required by Work Health and Safety legislation and shall be provided for all products.

3.2.2 Safe Work Method Statements shall be provided and contain the safe method of work to be followed including storage, handling, disposal and clean up after use. All staff, ASPs and contractors shall be trained in the application of the Safe Work Method Statements.

3.3 Existing Seals

3.3.1 Man-Made Mineral Fibres (MMMF)

3.3.1.1 Existing fire seals may contain inhalable Man-Made Mineral Fibres (MMMF). Alternate products that do not contain MMMF shall be used for all new installations.

3.3.1.2 Where existing seals containing MMMF need to be disturbed or removed, precautionary measures shall be used to mitigate against the potential hazards. Refer to Annexure D for the mitigation requirements.

3.3.2 Asbestos

3.3.2.1 Existing fire seals may contain asbestos, in particular old NC compound. Additionally, some duct lines and cable bandage tape may also contain asbestos. Asbestos material shall not be reused.

3.3.2.2 Refer to Ausgrid's Asbestos Location Register for details on asbestos locations. Removal and disposal of asbestos shall be in accordance with NS211 requirements.

4 Firestopping of Penetrations

4.1 General

4.1.1 Except where indicated otherwise by this Network Standard, all services that penetrate building elements that are required to have a Fire Resistance Level (FRL), or a resistance to the incipient spread of fire, shall be sealed to provide compartmentalisation.

4.1.2 Where the requirements for the extent of compartmentalisation is not clear, refer to Ausgrid's Network Standards, Annexure B of this document and Ausgrid Engineering for direction.

4.2 Fire Rating of Penetration Seals

4.2.1 NS187 nominates the minimum FRL required for the various building compartments and elements affected by potential fire sources.

4.2.2 Except where indicated otherwise by this Network Standard, approved penetration seals shall have a FRL which is equivalent to the building compartment for both integrity and insulation.

4.2.3 Ausgrid's approved penetration seals shall achieve a minimum fire resistance period as indicated in Tables 1 and 2 based on the NS187 compartmentalisation requirements.

4.2.4 For some locations in Table 1, a higher FRL is required by NS187 for the associated building elements to maintain building performance and ensure survival and re-use of the structure following a fire.

4.2.5 For existing substations, existing penetration seals which are disturbed by new works shall be reinstated to a level that is equivalent to, or better than, the original seal. Refer to Clause 4.9.

Table 1 – Minimum fire rating of penetration seals – Fire source

Fire Source	Minimum Fire Resistance Period (hours) to protected equipment or building elements[1, 2]			
	CBD Zone	STS	Zone	Distribution & Chambers
Transformer/reactors – oil filled (external & internal)	3[4]	3[4]	3	3

Fire Source	Minimum Fire Resistance Period (hours) to protected equipment or building elements[1, 2]			
	CBD Zone	STS	Zone	Distribution & Chambers
Transformers non-oil filled (external & internal)	3	3	2[3]	2[3]
Distribution centre oil filled	3[4]	3[4]	3	3
Distribution centre non-oil filled	3	3	2[3]	2[3]
Other oil filled equipment	3[4]	3[4]	3	3
Other non-oil filled equipment	3	Not required except for BCA compliance.	Not required except for BCA compliance.	2[3]
Cable marshalling areas (basements etc)[5]	3[4]	3[4]	Not required except for BCA compliance and for Clause 4.3	3
Cable Risers	3[4]	3[4]	3	3
Control Room	3	Not required except for BCA compliance.	Not required except for BCA compliance.	N/A
Battery Room (where provided)	3	Not required except for BCA compliance.	Not required except for BCA compliance.	N/A
Battery Enclosures	Non-combustible	Non-combustible	Non-combustible	N/A
Communication Room (where provided)	3	Not required except for BCA compliance.	Not required except for BCA compliance.	N/A
Capacitors (where provided)	3	3	2[3]	N/A

[1] Penetration seals shall adopt the highest fire rating applicable to either side of the building element being penetrated.

[2] Ausgrid may require a higher fire resistance period than nominated in Table 1 for specific sites where loss of supply and/or safety issues dictate.

[3] Refer to Ausgrid Engineering for suitable penetration seal design details.

[4] Applicable only to the penetration seals installed at these locations. A higher fire resistance period (4 hours) is required by NS187 for the associated building elements to ensure survival and re-use of the structure.

[5] Penetration seals may not be required for conduits in external basement walls under specific conditions. Refer to Clause 4.3.

Table 2 – Minimum fire rating of penetration seals - Function

Fire Source	Minimum Fire Resistance Period (hours)[1, 2]			
	CBD Zone	STS	Zone	Distribution & Chambers
Amenities, foyers and other areas not containing substation equipment	Not required except for BCA compliance.	Not required except for BCA compliance.	Not required except for BCA compliance.	Not required except for BCA compliance.
Audio Frequency Load Control (AFLC)	N/A	Not required except for BCA compliance.	Not required except for BCA compliance.	N/A

[1] Penetration seals shall adopt the highest fire rating applicable to either side of the building element being penetrated.

[2] Ausgrid may require a higher fire resistance period than nominated in Table 2 for specific sites where loss of supply and/or safety issues dictate.

4.2.6 Penetration seals shall also achieve an equivalent temperature (insulation) rating. Where this is not possible due to heat transfer through the cable core, suitable cable fire protection shall be provided over a minimum length of 150mm to prevent the cable from igniting on the non-fire side. Refer to Annexure B for approved penetration seals.

4.2.7 At locations where a higher fire and temperature rating is required by the NCC (BCA) or other relevant specification, code or standard, refer to Ausgrid Engineering for direction.

4.2.8 Where a reduced fire rating is proposed for short-term, temporary penetration seals installed during the equipping and commissioning stages, refer to Ausgrid Engineering for direction.

4.2.9 Where the approved penetration seals are deemed to be unsuitable, the alternative designs shall meet or exceed the performance requirements for approved penetration seals.

4.2.10 Alternative penetration seal designs shall have a relevant local testing certificate for the specific installation configuration and conditions. All alternative designs shall be subject to the written approval of Ausgrid Engineering.

4.3 Basement Penetration Seals

4.3.1 Penetration seals are not required for conduits in external basement walls provided the conduits comply with all the following requirements:

- are buried below ground or fully encased outside the basement wall;
- do not lead to any oil filled equipment enclosures (e.g. transformers);
- do not enter an adjacent cable installation facility within a distance of 10m;
- are clearly identified as external conduits within the basement; and
- have been granted approval by Ausgrid Engineering for deletion of the penetration seal at the specific locations.

4.3.2 All conduits in external basement walls not covered under Clause 4.3.1 shall have appropriate penetration seals applied in accordance with this Network Standard.

4.3.3 Conduits in external basement walls may require the use of water seals to prevent the ingress of water into the basement. Refer to Clause 4.11 for requirements relating to water seals.

4.4 Sealing of Elongated Penetrations

4.4.1 Where penetration seals are required, conduits, ducts and cable risers that penetrate a building element shall be sealed at both ends, unless exempted under Clause 4.4.2. This will ensure that:

- no penetration seals will be missed; and
- a fire cannot spread to other parts of the building via a wall cavity or void between the faces of the walls.

4.4.2 For short penetration lengths, a one-sided penetration seal is permitted where all the following requirements are satisfied:

- the penetration is less than 500mm in length;
- there is no cavity or void in the wall or floor element; and
- the penetration seal is visible from the other side.

4.4.3 Where a one-sided penetration seal is used for a suspended floor, it shall be applied to the underside (soffit or ceiling side) of the floor.

4.5 Structural Adequacy of Floor Penetrations

Pedestrian traffic on fire seals shall be prevented as the seal can be damaged, and a person could fall through a large penetration. Refer to Annexure D for the measures required to protect floor penetration fire seals.

4.6 Provision of Access Points Through Penetration Seals

Access points shall be provided through penetration seals where this is necessary for cable fault location and future cable access. Refer to Annexure D for access point design details.

4.7 PVC Conduits

4.7.1 Exposed internal PVC conduits (e.g. small wiring) provide a fuel source and allow a fire to spread via the conduit or along the cables inside.

4.7.2 To prevent the spread of fire via conduits, an intumescent seal shall be provided for those building elements required to have a FRL. An approved intumescent seal is detailed in Annexure B, Drawing A4-125652.

4.7.3 Where waterproofing of the conduits is also a requirement, certified firestopping and water seal measures shall be used. Refer to Clause 4.11.

4.7.4 Bundled PVC conduits shall not be used through penetration openings.

4.8 Penetrations for Other Services

4.8.1 This Network Standard covers penetrations for electrical services only.

4.8.2 Where penetration seals are required for other services, these shall be installed to provide a minimum fire and temperature rating in accordance with this Network Standard.

4.8.3 The NCC (BCA) requires all services through fire barriers to be fire stopped. In some instances, the NCC or other relevant code or standard may require a higher fire rating than this Network Standard.

4.9 Reinstating Existing Penetration Seals

4.9.1 All existing penetration seals which are disturbed by new works in the substation shall be reinstated to a level that is equivalent to, or better than, the original seal. Refer to Annexure D for details.

4.9.2 Existing penetration seals that are partially disturbed shall be reinstated using the same approved product as the original seal. Where this cannot be achieved, the entire seal shall be replaced using the approved product specific installation details included in Annexure B.

4.10 Protective Coatings for Seals

Where required, a protective coating shall be provided to protect the seal from exposure to moisture such as rain (not full submersion) or to oil. Refer to Annexure B for approved protective coatings.

4.11 Water Seals

4.11.1 Firestopping products shall not be used as water seals unless they form part of a certified water seal system. Conventional firestopping products are not guaranteed to work if submerged for any length of time, and non-porous fire seals may dislodge due to water head pressure.

4.11.2 The installation of water seals within the substation shall be based on a site-specific design and shall be subject to review by Ausgrid Engineering.

4.11.3 The water proofing of substations is not covered in this Network Standard.

4.12 Signage and Identification

4.12.1 Each compartment that has been fire sealed shall be provided with a firestopping sign as detailed in Annexure A.

4.12.2 All penetration seals shall be identified on-site using a suitable system which allows for ease of reference and future maintenance. Refer to Annexure D for details.

4.13 Installation Certification

Certification shall be provided by the approved installer to ensure the firestopping product is installed or applied to the manufacturer's requirements. Refer to Annexure D for details.

4.14 Final Inspection

4.14.1 Ausgrid shall arrange for a final inspection and sign-off following completion of the installation works, to ensure that the extent of the works comply with the requirements and intent of this Network Standard.

4.14.2 The approved installer shall rectify any defects or outstanding items that are identified and shall undertake any additional works as directed by Ausgrid.

5 Cable Fire Protection

5.1 General

5.1.1 The objective of cable fire protection is to remove the ability of a cable to provide a fuel source in a fire.

5.1.2 Cable fire protection shall be in the form of approved cable coating products, approved cable wraps and blankets, or approved flame-retardant cable sheaths.

5.1.3 The extent of approved application of cable fire protection shall be as detailed in this Network Standard. All other applications of cable fire protection shall be assessed on a site by site basis and shall require prior written authorisation from Ausgrid Engineering.

5.2 Protection for Cable Penetration Seals

5.2.1 Cable fire protection for penetration seals shall be installed where it is shown as part of an approved product specific installation detail (refer to Annexure B).

5.2.2 Cable fire protection at these locations is required as a part of a cable penetration seal to prevent the cable from igniting due to heat conduction along the cable core.

5.3 Secondary Cables in Buildings

5.3.1 Control Rooms

5.3.1.1 Secondary cables located within a control room shall not be cable fire protected unless approved in writing by Ausgrid Engineering.

5.3.1.2 Where cable fire protection is deemed necessary and cables enter control or protection panels, the cable fire protection shall not extend into the panel.

5.3.1.3 Cable identification tags shall be kept free of any approved cable coating.

5.3.2 Other Locations

5.3.2.1 This Clause applies to cable basements, trenches, cable risers and other internal locations. Refer to Clause 5.6 for external switchyards.

5.3.2.2 Secondary cables shall be segregated from the following potential hazards where reasonably practicable:

- Arc chutes on internal arc classification (IAC) switchgear which face directly onto, and are in the immediate vicinity of, the secondary cables;
- Major LV cables (exceeding 32Amps) and distribution boards;
- HV cable joints, unless exempted by Clause 5.5; and
- Other site-specific hazards as advised by Ausgrid Engineering.

5.3.2.3 In addition, secondary cables shall be segregated at the following locations where reasonably practicable:

- “A” scheme and “B” scheme secondary cables segregated from each other when they are exposed to a common potential hazard. Refer also to NS259.

5.3.2.4 Segregation of secondary cables shall use one of the following methods:

- Spatial separation sufficient to prevent ignition; or
- A suitably fire rated barrier protecting the secondary cables; or
- Local fire protection of the exposed secondary cables near potential hazards in accordance with Clause 5.3.3.

5.3.2.5 Approval shall be obtained from Ausgrid Engineering where more extensive secondary cable fire protection is proposed. Additional secondary cable fire protection shall require a risk-based assessment of the site-specific hazards.

5.3.3 Local Fire Protection Measures

5.3.3.1 The design of local fire protection measures for exposed secondary cables shall be subject to the review and written approval of Ausgrid Engineering.

5.3.3.2 Local fire protection measures shall aim to shield the exposed secondary cables from the short-term effects of heat and/or flame arising from an arc fault, a failure of a nearby major LV cable, failure of a HV cable joint, or other specific hazard.

5.3.3.3 Refer to Clause 5.5 and Annexure B for requirements and details of secondary cable fire protection measures near HV cable joints.

5.3.3.4 Cable coating shall not be used for cable fire protection of secondary cables unless approved in writing by Ausgrid Engineering.

5.4 HV and Major LV Cables in Buildings

5.4.1 General

The requirements for segregation of HV cables and major LV cables do not apply to distribution substations.

5.4.2 Segregation Requirements

5.4.2.1 This Clause applies to cable basements, trenches, cable galleries and vertical surface mounted cables and other internal locations. Refer to Clause 5.6 for external switchyards.

5.4.2.2 High voltage cables and major LV cables shall be segregated from the following potential hazards where reasonably practicable:

- HV cable joints in adjacent cables, unless exempted by Clause 5.5; and
- Other site-specific hazards as advised by Ausgrid Engineering.

5.4.2.3 Segregation of HV cables and major LV cables shall use one of the following methods:

- Spatial separation sufficient to prevent ignition, or
- A suitably fire rated barrier protecting the HV and major LV cables; or

- Local fire protection of the exposed cables in accordance with Clause 5.4.3.

5.4.2.4 In addition, cable fire protection shall be provided to:

- HV cable joints for a length of cable on either side of the joint; and
- Cable penetration seals as required by Clause 5.2.

5.4.2.5 Approval shall be obtained from Ausgrid Engineering where more extensive HV cable and major LV cable fire protection is proposed. Additional HV and major LV cable fire protection shall require a risk-based assessment of the site-specific hazards.

5.4.3 Local Fire Protection Measures

5.4.3.1 The design of local fire protection for exposed HV cables and major LV cables shall use one of the following measures as applicable:

- Approved flame-retardant cable sheath material for HV cables; or
- Approved cable coating for HV and major LV cables; or
- Approved cable wraps or blankets for HV and major LV cables, subject to an evaluation of the potential cable de-rating impacts.

5.4.3.2 Refer to Clause 5.5 and Annexure B for requirements and details of cable fire protection measures at, and adjacent to, HV cable joints.

5.4.3.3 The use of cable wraps or blankets for fire protection shall assess the potential cable de-rating impacts of the installation. For cable blankets, this method shall be limited to short cable lengths of not more than 3 metres. Approval shall be obtained from Ausgrid Engineering where more extensive lengths of cable blanket are proposed.

5.4.3.4 The application of cable coating to HV and major LV cables shall be in accordance with the manufacturer's requirements and this Network Standard. Protection against overspray is only required for the floor area and for sensitive plant items.

5.4.3.5 Fire protection of HV and major LV cables is not required where there are other effective means of fire protection in the compartment, such as the installation of sprinklers.

5.5 Cable Fire Protection Near HV Cable Joints

5.5.1 General

The requirements for fire protection of cables near HV cable joints do not apply to distribution substations.

5.5.2 Cable Protection Requirements

5.5.2.1 HV cable joints within substation buildings shall be avoided where reasonably practicable to minimise the risk of a joint failure damaging adjacent cables or initiating a fire. Refer to Annexure E for the results of a cost benefit analysis that includes HV cable joints external to substation buildings.

5.5.2.2 Where HV cable joints are required within a building, suitable risk mitigation measures shall be implemented to locally fire protect exposed secondary cables, HV cables or major LV cables that are near the joint.

5.5.2.3 Suitable local cable fire protection measures near HV cable joints shall always be implemented for the following substations:

- All Sub-Transmission Substations (STS);
- All Sydney CBD Zone Substations;
- All new substations under development or recently completed;
- All substations where full fire separation and firestopping is NOT provided to the rooms directly above, or adjacent to, the HV cable joint installation; and
- All other substations, except where exempted by Clause 5.5.2.4.

5.5.2.4 Based on the Annexure E cost benefit analysis, local cable fire protection measures near HV cable joints may be omitted for some specific zone substations, but only where both of the following conditions are satisfied:

- The zone substation is NOT covered under Clause 5.5.2.3; and
- The zone substation is exempted by Table E2 in Annexure E.

5.5.2.5 Annexure E outlines the methodology used for the cost benefit analysis of risks associated with HV cable joints. Table E2 provides a list of exempt zone substations where local cable fire protection is not required near HV cable joints.

5.5.2.6 Annexure E, Figure E1 provides a flowchart which summarises the requirements of this Network Standard for cable fire protection near HV cable joints.

5.5.2.7 Refer to Annexure B for details of approved cable fire protection measures at, or near, HV cable joints.

5.6 Cable Fire Protection in External Switchyards

5.6.1 Cable fire protection shall be provided in the splash zone in front of external oil filled equipment to prevent catastrophic equipment failures also causing cable trench fires. Refer to Annexure B, Drawing A4-128123.

5.6.2 Cable fire protection includes approved cable coating, cable wraps or cable blankets.

5.6.3 Additional site-specific measures to fire protect critical external cables shall be assessed at identified high risk locations, including the following;

- Substations in bushfire prone areas where cables and other equipment is exposed to radiant heat and possible ember attack; and
- Areas adjacent to oil filled transformers which may be subject to oil fire radiant heat effects but are located outside the bunded areas.

5.6.4 NS187 provides guidance on the radiant heat exposure limits for cables and other elements within substations.

5.6.5 Cable fire protection shall not be provided elsewhere for cables in cable trenches, or at other locations in external switchyards, unless approved in writing by Ausgrid Engineering.

6 Ausgrid Approved Products and Product Specific Installation Details

6.1 Firestopping products shall be supplied and installed only by Ausgrid approved suppliers and approved installers.

6.2 Ausgrid's approved product specific installation details are included in Annexure B. These penetration seal details are designed to achieve a fire rating as indicated, and an equivalent temperature rating where possible.

6.3 Where the penetration seal temperature rating is affected due to heat transfer through the cable core, suitable cable fire protection shall be provided in accordance with Clause 4.2.6 to prevent the cable from igniting on the other side.

6.4 Firestopping systems shall be installed using the approved product specific installation details as shown in Annexure B and the manufacturer's instructions.

6.5 Modifications are not allowed to the approved product specific installation details unless prior approval is granted by Ausgrid Engineering, and a relevant testing certificate is provided.

Annexure A: Firestopping Seal Identification and Details Markers

A1 General

The sign in this Annexure shall be applied once the firestopping is completed.

A2 Fire Seal Identification

Fire seal identification markers, as indicated below, shall be A4 size.

Annexure B: Ausgrid Approved Product Specific Installation Details

B1 General

Ausgrid's approved product specific installation details are included in this Annexure. The use of these approved products shall only be accepted by Ausgrid when installed in accordance with the approved product specific installation details.

Modifications are not allowed to the approved product specific installation details unless prior approval is granted by Ausgrid Engineering, and a relevant testing certificate is provided.

Where a suitable approved product detail does not exist for a specific installation, contact Ausgrid Engineering for direction.

Variations and additions to the approved product specific installation details may occur over time. All users of this Network Standard shall refer to the latest amendment.

B2 Approved Products

Table B1 – Approved Products

Product	Manufacturer	Suppliers Product Name	Comments	Contract	Stockline Number	Inhalable MMMF
Cable Mortar	3M	3M Fire Barrier Mortar (Product discontinued)	Tested to Dwg 128080. Not be used where submersion in water is likely	Product is discontinued in Australia. Details retained for reference.		None
	Hilti	CP637 Fire Stopping Mortar	Pending local testing of configuration specified on drawing 128080			
Boards	Promat	Promatec H 25 mm thick	Use two layers. Approved for empty cable slots.			
		Promasil 1100S 60 mm thick	Replaces Vermiculux boards. Approved for cables slots with cables.			
Cable Fire Pillows	Hilti	CP651 Firestop Cushion	Only available for Ausgrid stock number #386262. Tested to Dwg 128080. Not to be used where submersion in water is likely.	CW2223139	185068	None
Cable Bricks	Hilti	CFS-BL Firestop Block	Hilti stock number #20652863. Tested to Dwg 128080. Not be used where submersion in water is likely	CW2223139	185066	None
	Promat	Promastop Cable Bricks	Tested to AS1530 using Dwg 230284.		Not set up yet	None

Product	Manufacturer	Suppliers Product Name	Comments	Contract	Stockline Number	Inhalable MMMF
			Not be used where submersion in water is likely			
Cable Coating	Hilti	CP679A Firestop Cable Coating (To be replaced by another Hilti product)	Approved for all outdoor and indoor areas including wet areas– imminent FM Approved	CW2223139	185067	None
Cable Bandage	Trafalgar / SVT	Pyro-Safe DG	Approved for indoor and outdoor use – IEC tested 120 min.			None
	Promat	PROMA-BLANKET	Made to order. Available for large orders only. Approved for indoor dry area use only – Tested to AS 1530-1999.			None
	Hilti	CFS-P BA Firestop Putty Bandage	For secondary cables or spare conduits only			None
Cable Wrap	Promat	Promaseal Flexi-Wrap	Approved for use with Promasil 1100S seals in cable slots			
Conduit Collars	Promat	Promaseal Conduit Collars	Tested for four hours		None proposed	None
Conduit Plugs	Hilti	CFS-PL Intumescent Firestop Plug	For secondary cables or spare conduits only. Hilti Stock Item - 107 mm #2059530 132 mm #2059531 158 mm #2059532 202 mm #2059533 Approved for indoor and weather protected (rain, UV) outdoor use.	CW2223139	185069 185070 185071 185072	None
Fire Sealant	Hilti	CP611A Intumescent Firestop Mastic	Hilti Stock Item - #220351			None
Protective Coating	Parbury	Emer-Clad & Emer-Seal	Indoor use Colour – Red		None Proposed	None

Product	Manufacturer	Suppliers Product Name	Comments	Contract	Stockline Number	Inhalable MMMF
Fire Seal	Beele Engineering	Beele Engineering NOFIRNO	Pending local testing to drawing 128080. This product is also an effective water seal (up to 2 bar pressure head).			None
	Filoform	FiloSeal+HD FIRE	Under review. This product is also an effective water seal (up to 2 bar pressure head).			None

B3 Standard Installation Drawings

Table B2 – List of Standard Installation Drawings

Title	Drawing Number
Penetrations with more than 60% cable loading	
Refer to Ausgrid Engineering	
Duct penetration	
Mortar and pillow cable duct seals for floor and wall penetrations - indoor	A4-128468
Other small penetrations and frequently disturbed penetrations	
Pillow seal for cables in floors or walls – indoor	A4-128120
Pillow seal for cable and cable trays in floors and walls - indoor	A4-128121
Spare conduit seal for trenches and other large mortar seals.	A4-128118
Conduit penetration	
Conduit collar for small diameter conduits	A4-125652
Outdoor Floor Conduit Penetrations	
Penetration seal for outdoor floors	A4-190509
Penetration seals for secondary cables – bund floors	A3-225716
Cable slots and cable risers	
Mortar seal for new cable slots - indoor	A4-128467
Mortar seal for cable slots and cable risers - indoor	A4-128113
Floor Seal – Spare Switchgear Cable Slot Seal	A4-184895
Mortar seal for transformer tails – outdoor	A4-190509
Spare conduit seal detail	A4-128118
Cable Slot Seal – Cable Openings Through Floor Slabs - indoor	A4-208655
Cable Slot Seal – Alternative Configurations - Cable Openings Through Floor Slabs – indoor	A4-208657
Cable Brick floor penetration seal – Power Cables – indoor	A4-230284
Cable Fire Protection	
Cable Blanket Fire Protection of Power and Secondary Cables near Cable Joints – Plan at Cables on Trays – Sheet 1	A3-252098

Cable Blanket Fire Protection of Power and Secondary Cables near Cable Joints – Section at Cables on Trays – Sheet 2	A3-252099
Cable Blanket Fire Protection of Power and Secondary Cables near Cable Joints – Section at Cables on Trays – Sheet 3	A3-252100
Cable Blanket Fire Protection of Power and Secondary Cables near Cable Joints – Section at Cables on Floor – Sheet 4	A3-252101
Cable Blanket Fire Protection of Power and Secondary Cables near Cable Joints – Section at Cables on Trays – Sheet 5	A3-252111
Cable trenches	
Pillow seal for cable trench	A4-128119
Brick Seal for cable trenches	A4-128473
Cable trench coating near oil filled equipment in external yards	A4-128123
Spare conduit seal detail	A4-128118
Customer substation busbar seal	
Mortar or cable brick busbar seal	A4-128117
Steel busway duct penetration seal	A4-232355

Annexure C: Sealant Properties

C1 General

This Annexure specifies the properties required for cable coating and penetration seals that provide firestopping to substation buildings.

For use in Ausgrid's substations, the products or system of products shall satisfy all of the requirements in this Annexure C. Approved products and approved product specific installation details are listed in Annexure B.

C2 Fire and Temperature Rating Requirements

Fire sealing products shall be capable of achieving the required fire rating and the equivalent temperature rating (where possible) unless they are providing a gas seal only. In some instances, a higher fire and temperature rating may be required by the BCA or other relevant specification, code or standard.

The firestopping fire test, with an appropriate test duration, shall comply with the details for cable loading, cable sizes and cable types shown on Drawing 128080. Details of the proposed product system to achieve Ausgrid's requirements shall be provided by the supplier/manufacturer.

Where the temperature rating for cable penetrations cannot be achieved for cable types shown on Drawing 128080, measures shall be put in place to prevent the cables igniting before the end of the fire test period.

For flame-retardant coatings, product approvals may relate to various international classifications that are not based on fire duration / temperature ratings. For these products, contact Ausgrid Engineering for direction.

C3 Approved Testing Standards

All products used by Ausgrid shall have testing that reflects Ausgrid's requirements in terms of cable loading, sizes and types. Refer to Drawing 128080.

Suppliers and manufacturers shall specify all limitations applicable to their products.

All flame-retardant cable coating products shall be approved by Factory Mutual for use as a flame-retardant coating and shall include a cable de-rating test.

C4 Health and Safety

The product shall not be hazardous to workers during or after application, in its powder form, or when broken out. In the event of a fire, the product shall not emit toxic gases or substances.

Products that contain harmful ingredients will not be approved by Ausgrid where a less harmful alternative product is available.

C5 Further Testing and Compliance

The firestopping product performance shall be supported by test results which are to Ausgrid approved testing standards.

Fire and temperature penetration sealing products shall comply with AS 1530.4 and shall be tested to Factory Mutual and/or Underwriter Laboratory standards (or an Ausgrid approved equivalent).

Sealing products shall be approved for application around cables that are typically found in Ausgrid substations. Compatibility with cable materials shall be demonstrated.

Where the required test results are not available, or where Ausgrid is not satisfied with the level of testing performed, the product(s) shall be further tested to Underwriter Laboratory Standard UL 1479, or AS 1530.4, using Drawing 128080.

Test results shall be inspected by Ausgrid Engineering to ensure that testing has provided for Ausgrid's typical cable types and configurations. Where this has not occurred, Ausgrid may require further testing as detailed in this Annexure.

Where a supplier or manufacturer provides test results that do not satisfy Ausgrid's requirements for testing of products, the supplier/manufacturer shall re-test the products in accordance with

Ausgrid's requirements. Ausgrid will provide the test penetration cables and cable tray only for the test.

C6 Structural Capacity

The cable mortar supplier shall verify that their products are self-spanning for a distance up to 800 mm (without pedestrian loading and without supports).

Where supports are required for pedestrian loading and self-weight, suppliers shall verify that the details in Annexure B are sufficient for the required loading (refer to Annexure D for floor loading details).

C7 Consistency

The consistency of mortar type seals shall be able to be altered to suit various application methods, including pumping where applicable.

C8 Removal

Once in place and set, cable mortar product shall be easily removable with hand tools with minimum effort, to avoid damage to existing cables. Product suppliers shall submit a procedure for the product removal method.

The product removal method shall not require the use of electrically conductive tools, or sharp objects, which could damage cables.

Ausgrid will assess the ease of product removal for each intended application. As part of this assessment, Ausgrid shall give consideration and preference to products that allow the safe removal of product from around energised cables.

Flame-retardant cable coating is required to be non-removable once applied.

C9 Intumescent seals

Cable fire pillows, cable bricks and cable putty shall be intumescent to a minimum of 30% of the original volume of the product when exposed to heat. Products shall not expand below 100°C.

Installation and certification of the product components shall be in accordance with the product specific standard installation drawings listed in Table B2 of Annexure B.

C10 Non-shrink Requirements

Cable mortar shall not shrink when cured.

C11 Weather Resistance

For external applications, all firestopping products shall be weatherproof and UV proof. A system of various products may be used to provide a weatherproof and UV proof seal.

Cable coating products shall be weatherproof, UV proof and resistant to water penetration when submerged.

C12 Resistance to Oil

All firestopping products shall be able to resist exposure to oil and still function as intended. A system of products is permitted to achieve oil resistance.

Where penetrations, including conduits, have openings that are less than 100 mm above floor level (e.g. in a pit), the sealant shall also prevent the spread of any oil spillage.

C13 Vermin and Termite

All firestopping products shall be vermin and termite resistant or shall be provided with other means of preventing attack.

C14 Design Life

The Design Life of firestopping products shall be not less than 30 years.

The Design Life for cable coating systems at internal locations shall be compatible with the substation or cable life, which is typically 50 years. For external environments, refer to Ausgrid Engineering for direction.

C15 Compatibility

The materials and installation techniques of all firestopping and cable protection products shall be physically, chemically, electrically and thermally compatible with the relevant cable materials and other electrical equipment, to ensure that there is no adverse reaction or damage to the cables or other electrical equipment.

Cable coating systems shall not cause any electrical de-rating of the cables.

The use of cable wraps or blankets for fire protection shall assess the potential cable de-rating impacts of the installation. Refer to Clause 5.4.3.3.

Annexure D: Firestopping Design, Certification and Reinstatement

D1 General

Without firestopping, a fire may spread and damage other parts of the substation building simply by finding its way through any penetration no matter how small.

The fire propagation velocity for PVC insulated cable bundles can be 20 m/m (metres/minute) for vertical installation, and 5 m/m for horizontal installation, as determined by the British Central Electricity Generating Board (CEGB). Other types of plastic insulation, such as polyethylene or polypropylene will propagate fire more quickly.

Standard concrete or sand cement is not fire rated when used as a sealant where cables pass through penetrations. A fire that is tracking along a cable may pass through a penetration that has been sealed with standard concrete or sand cement and can burst out the sealant in the process.

In addition to generic fire ignition sources (e.g. human error), fires can also be started when oil filled electrical equipment such as transformers or oil filled switchgear fail. When this occurs, the fire is fuelled by the oil and by any bituminous compound in busbar compartments or end boxes. Other fuel sources include the secondary, HV and LV cables and the low voltage boards.

Importantly, the damage to a substation is not just limited to the spread of flames, but includes the damage caused by fire fighting and the spread of hydrochloric acid and smoke damage from any burning PVC coated secondary cables.

Firestopping limits the extent of cable and equipment damage and the amount of fire spread from burning cable insulation.

D2 Existing MMMF Seals

Where existing seals that contain Man-Made Mineral Fibres (MMMF) need to be disturbed or removed, the required mitigation requirements shall be as follows:

1) Personal protective equipment (PPE) equivalent to "Level 1" under the Work Procedures General of NS211, and consisting of:
    a) half face respirator with P2 particulate filter;
    b) disposable Nitrile gloves or leather gloves; and
    c) gum boots or boot covers.
2) Material shall be wetted down using water or a PVA/water solution prior to removal. The removal procedure shall be designed to minimise and control the generation of dust using a water spray method when applicable and the careful application of hand tools. Power tools shall not be used except under an approved procedure for their use.
3) All waste material shall be single bagged in heavy duty, low density, 200μm thick polyethylene bags. Disposal shall be in accordance with the waste classification of this material.

D3 Structural Adequacy of Penetrations Through Floors

Pedestrian traffic on fire seals shall be prevented. The measures indicated below are required to protect the seal and to prevent pedestrians from falling through:

1) The following are all the requirements for cable penetrations in corridors, passageways or floors where pedestrian loading is possible:
    a) Provide handrails where possible to prevent traffic over the seal or provide trafficable deck plates over seal with a 20 mm gap underneath;
    b) Paint ‘No Step’ on the seal at 1.5 metre intervals and at open sections; and
    c) Provide support underneath for accidental pedestrian loading.
2) The following are all the requirements for cable penetrations greater than 200 mm in width in non-trafficable areas:
    a) Paint ‘No Step’ on the seal at 1.5 metre intervals and at open sections; and

b) Provide support underneath for accidental pedestrian loading

3) The following are all the requirements for cable penetrations less than 200 mm in width in non-trafficable areas:

a) Paint 'No Step' on the seal at 1.5 metres intervals and at open sections; and

b) Provide support underneath for dead weight of the fire seal.

Any structural supports shall conform to relevant Australian Standards including, but not limited to:

- AS/NZS 1170 Structural design actions – Series
- AS 3600 Concrete structures
- AS 4100 Steel structures

The underneath support of fire seals in Items 1 and 2 of this Clause shall be designed for an accidental pedestrian loading of 1 kN point load or 0.25 kPa whichever is greater. Trafficable deck plates shall be designed in accordance with the loading requirements in AS/NZS 1170.

D4 Provision of Access Points for Cable Fault Location

The requirements of this Clause do not apply to distribution substations.

Where floor penetration seals are required below high voltage switchgear, an access point shall be provided near the switchgear group for temporary installation of earth cables during cable fault location.

The access point shall be a 125 mm diameter PVC conduit through the full thickness of the seal. The PVC conduit shall be filled with a fire pillow, which can be removed during fault location, and reinstated afterwards. Where sheeting supports the seal, the 125 mm diameter PVC conduit shall be located over a 50 mm diameter hole in the sheeting.

D5 Access Points for Future Cable Access

Where large mortar seals are provided, and it is envisaged that frequent future access is required, spare conduits shall be placed as needed to allow easy access and resealing for additional cables. Refer to Annexure B, Drawing A4-128118 for details.

This Clause does not apply to switchgear cable slots. Refer to the requirements of Clause D4.

D6 Reinstating Existing Penetration Seals

D6.1 Requirements

The reinstatement of existing firestopping shall be the direct responsibility of the works Project Manager, Project Officer or Supervisor, as applicable. Reinstatement of fire stopping and shall be included as a check item in the routine and final inspections of works on site to be conducted by the Site Manager.

Disturbed penetration seals shall be reinstated prior to leaving the site on a daily basis. During ongoing site works the use of easily removable temporary firestopping such as fire pillows may be appropriate.

Where an entire seal has been removed or disturbed it shall be reinstated in accordance with this Network Standard. See Clause D6.2 for reinstatement requirements for larger penetrations.

Any structural support systems and signs shall be reinstated to this Network Standard and made safe at all times.

D6.2 Reinstating Large Penetration Seals

Where a small amount of disturbance occurs in a large penetration, such as a new cable in a long switchgear cable slot, advice shall be sought from Ausgrid Engineering for requirements on reinstating the seal prior to removing the material.

For large disturbances, the entire seal shall be replaced in accordance with this Network Standard.

D7 Signage and Identification

The identification of each penetration seal, or group of seals, shall include the following information as a minimum;

- A unique number for the site;
- A general location marker (i.e. BA = Basement);
- The date of installation; and
- The product name or material used for the seal.

Where reasonably practicable, the numbering system shall align with the conduit numbering adopted for the substation.

D8 Installation Certification

D8.1 New Installations

It shall be the responsibility of the approved installer to provide certification that all seals are installed to the manufacturer's requirements. The approved installer shall certify that they have undertaken the firestopping in accordance with this Network Standard and the manufacturer's recommendations. Certification documentation shall be provided to Ausgrid Engineering.

D8.2 Cable Slots

Where the top of the penetration seal is not visible (e.g. in a slot between a switch room and a cable basement, where switchgear restricts access to the top of the slot), it will be necessary to measure the seal installation depth by other means, such as by obtaining an Access Permit and opening a panel to test the depth.

The tool used to test the depth shall be non-conductive and not damaging to cable sheaths. A suitable tool may be made from a section of PVC conduit, of diameter not more than 25 mm, and with the end bevelled on the outside at 30□ to the axis of the conduit.

The hole made by the tool shall be restored with penetration seal product equivalent to the original, for the full depth of the seal, promptly after the depth test has been completed.

D8.3 Long Term Management

Regular inspection and maintenance is required in accordance with AS 1851 to ensure the integrity of fire segregation. Refer also to the requirements of the NCC / BCA.

Annexure E: Cable Fire Protection Near HV Cable Joints

E1 General

This Annexure outlines the methodology used for the cost benefit analysis (CBA) of risks associated with HV cable joints. Figure E1 provides a flowchart which summarises the requirements of this Network Standard for cable fire protection near HV cable joints.

E2 Cost Benefit Analysis – Methodology

The CBA was prepared by Ausgrid Asset Standards to assess the following Options in relation to HV cable joints and the use of cable fire protection in substation basements:

- OPTION 1 Do Nothing – No Fire Protection Near Joint
- OPTION 2 Remove Joint from Basement
- OPTION 3 Retain Joint with Fire Mitigation

The CBA approach was based broadly on the methodology used for other Ausgrid equipment (Concord Zn 11kV Switchgear Replacement).

The key data entry and assumptions used in the CBA were as follows:

1) **Single Joint** - The CBA was based on a single new joint at a given substation, the estimated failure risk of that joint, and the cost of various mitigation controls.
2) **Failure Rate** - The cable joint failure rate (fires) for the Base Case was based on the single Ausgrid fire event (Hornsby Zn, Feb 2019).
3) **Fire Event** - The Hornsby Zn fire event indicates 100% of energy was at risk, with an effective switching time of 16hrs (50% of customers on), and a repair time of 216hrs (9 days).
4) **Energy at Risk** - For the Base Case, the CBA assumed 100% of energy at risk to determine the Expected Unserved Energy (EUE) during the effective switching time. The EUE during the post-switching has allowed for the substation effective Load Transfer Capacity.
5) **Risk Costs** - The Total Risk Costs are the sum of annualised values for Expected Unserved Energy, Repair Cost and Safety Impact Cost. The Net Present Value (NPV) of these annual risk costs was used in the CBA calculations.
6) **VCR** - The adjusted NEM Value of Customer Reliability (VCR) applied to the EUE was $40.036 $/kWh for the Base Case.
7) **Safety Impact** - The Safety Impact Cost was based on the Value of a Saved Life with an appropriate disproportionate factor (x10) and exposure rate applied.
8) **Option Costs** – The CBA Option Costs are capital costs (Year 0) for the mitigation controls used under Options 2 and 3. These values were budget estimates for the works, with a suitable range to cover various site conditions.
9) **Residual Risk** - For the Base Case, the CBA assumed a residual total risk cost of 20% for the fire mitigation controls used under Option 3.
10) **Benefit to Cost Ratios** - For the CBA, the Risk Benefit to Cost ratios were based on the level of risk reduction v's cost relative to Option 1 - Do Nothing, namely;

    B/C Ratio 1 [R($) (Option 1 - Option 2)] **/** [($) (Option 1 - Option 2)]
    B/C Ratio 2 [R($) (Option 1 - Option 3)] **/** [($) (Option 1 - Option 3)]

B/C Ratios > 1.0 indicate that the benefits exceed the costs when compared to Option1 – Do Nothing. This indicates when options apart from "Do Nothing" should be implemented.

A summary of the Base Case data entry values for the CBA is provided in Table E1, together with possible alternative low / high values for further sensitivity analysis, as required.

Table E1 – CBA Base Case and Sensitivity Scenarios – Key Data

Key Data		CBA Scenario			Sensitivity		
	Unit	Low Limit	Base Case	High Limit	Switchroom Fire Damaged	NS 171 Scenario 1	NS 171 Scenario 2
Cable Joint Failure Return Period (Fires)	Years	40	20	10	20	10	20
Repair Time (MTTR)	Hrs	72	216	336	1080	216	400
Switching Investigation Time	Hrs	1	2	4	4	2	2
Energy at Risk							
Pre-switching	%	20	100	100	100	125	133
Load Transfer Effectiveness							
Post -switching	%	100	90	80	80	70	60
Value of Customer Reliability (VCI	$/kWh	28	40.036	65	40.036	40.036	40.036
Repair Cost	$	80,000	404,000	600,000	2,000,000	404,000	800,000
Economic Evaluation							
Design Life	Years		20		20	20	20
Discount Rate	%	7	5	4	5	5	5
Option 1 Cost - Do Nothing	$	0	0	0	0	0	0
Option 2 Cost - Remove Joint	$	9,000	35,000	60,000	35,000	35,000	35,000
Option 3 Cost - Retain Joint and Protect	$	4,000	10,000	20,000	10,000	10,000	10,000
Residual Risk - Joint Failure Fire – Option 3	%	10	20	30	20	20	20

E3 Cost Benefit Analysis – Outcomes

The cost benefit analysis (CBA) developed for the use of cable joints within substation buildings compares the level of risk reduction provided by the two alternative controls (elimination of joints v's cable fire protection).

The key data entry and assumptions used in the CBA are outlined in Clause E2, and several alternative low / high values have been provided for sensitivity analysis.

The CBA is sensitive to several of the input variables, including the substation average load, cable joint failure rate, repair time, load transfer capacity and option cost.

Several scenarios were developed to address the key sensitivities, establish the range of possible outcomes, and provide a basis for selection of the most appropriate risk reduction method.

The broad outcomes of the CBA and sensitivity can be summarised as follows:

- The substation Yearly Average Load (MVA) and Load Transfer Capacity (at time of peak load) (MVA) are the key determinants of the B/C Ratio, with other risk factors held constant.

- A sensitivity analysis using a range of input variables and scenarios indicates that B/C Ratios < 1.0, namely “Do Nothing”, can be justified in some circumstances. Generally, this outcome applies where either one of the following conditions can be satisfied:
  - The zone substation peak loading DOES NOT exceed 10MVA, or
  - The zone substation peak loading is between 10MVA and 35MVA and the substation Load Transfer Capacity (at time of peak load) exceeds 5MVA.
- The use of HV cable joints external to substation buildings (Option 2) can remain cost competitive at up to 30% higher capital cost, when compared to HV cable joints within a building using approved cable fire protection measures (Option 3). This is based on a risk-cost assessment considering the likely residual risk of a cable joint fire under Option 3.

The outcomes of the CBA as outlined above have been incorporated into the design requirements of this Network Standard (Clause 5.5 and Table E2).

E4 List of Exempt Zone Substations

Based on the results of the Cost Benefit Analysis, local cable fire protection measures near HV cable joints may be omitted for some specific zone substations.

Table E2 provides a list of exempt zone substations where local cable fire protection is NOT required near HV cable joints. These zone substations are generally lightly loaded, or medium loaded, with adequate load transfer capacity.

In preparing Table E2, other factors such as the zone substation criticality (e.g. supplying a major hospital) and the expected remaining life (e.g. zone substation soon to be replaced) have also been assessed.

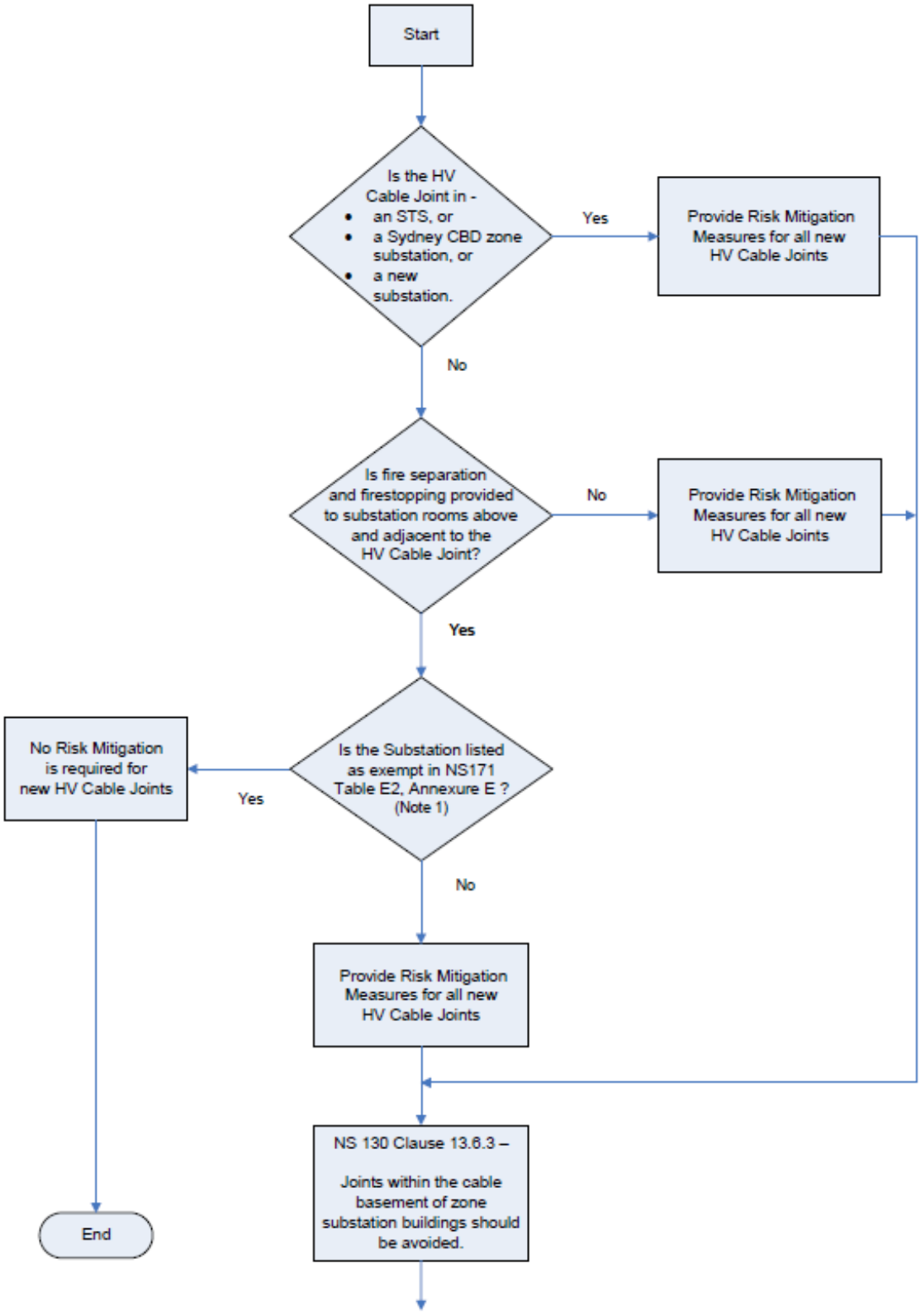
Table E2 will be reviewed and updated as future substation loadings and Network configurations change with the growth in demand.

Table E2 – List of Exempt Zone Substations

Zone Name	Zone Name	Zone Name
Aberdeen	Gateshead	New Lambton
Adamstown	Harbord	Newdell
Avondale	Hurstville North	Newport
Blackwattle Bay	Jewells	Noraville
Blakehurst	Killarney	Nulkaba
Brandy Hill	Maitland	Paxton
Broadmeadow	Maryland	Rouchel
Cardiff	Matraville	Sans Souci
Charlestown	Medowie	Stockton
Croudace Bay	Mitchell Line	Telarah
Denman	Mitchells Flat	Tomago
Dulwich Hill	Moonan	Wamberal
Empire Bay	Mt Hutton	Williamtown
Enfield	Mt Thorley	Woy Woy
Galston	Narrabeen	

E5 Cable Fire Protection – Flowchart

Figure E1
NS171- Fire Protection Near HV Cable Joints



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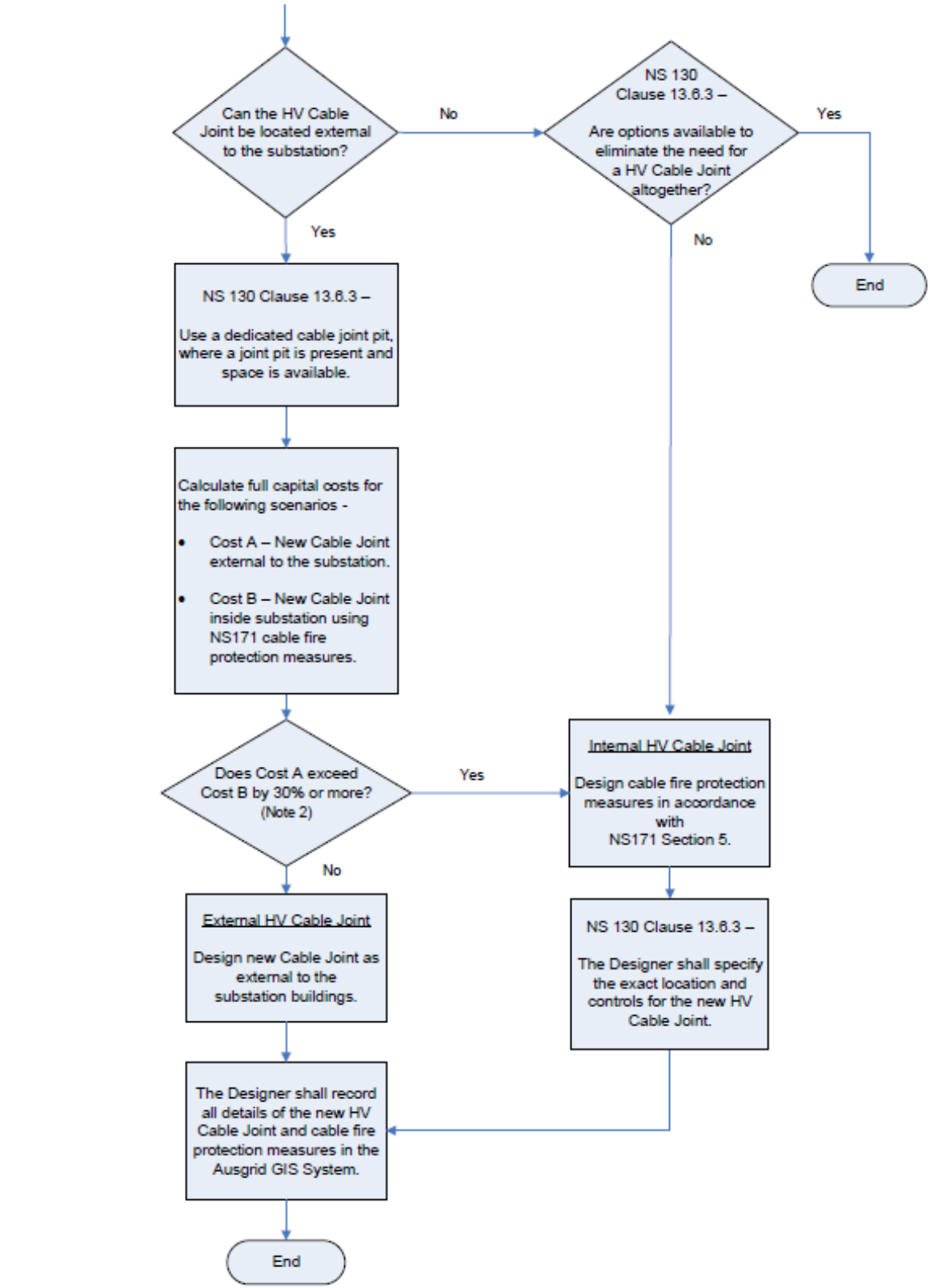

Note 1 – Based on a Cost-Benefit Analysis using reasonable risk-cost assumptions.

Note 2 – Based on a 30% residual fire risk for internal HV cable joints.