

Distribution Design Rules

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1. General

1.1 Purpose

This document sets out rules for standard distribution design on Horizon Power networks. It specifically caters for new installations using the latest standard equipment and not legacy equipment. Designs that do not follow the rules contained herein are considered non-standard, and warrant greater scrutiny when reviewed.

Standardisation of network components also provides benefits to Horizon Power in risk assessment, work practices, and supply chain management.

1.2 Scope

This chapter 1 defines the scope of the Distribution Design Rules both as to its content and application.

The objectives of these Distribution Design Rules are that they:

- 1) apply to the Distribution System (as described in Appendix D);
- 2) are consistent with good electricity industry practice;
- 3) are consistent with Horizon Power standards and relevant Australian Standards; and
- 4) are relevant to written laws and statutory instruments.

1.3 Application

The Distribution Design Rules apply to the design of the distribution system and shall be read in conjunction with construction standards and policies. The design rules concept is to promote the introduction of the latest design standards and equipment thus not perpetuating the use of legacy design standards and equipment.

Where distribution networks are not designed in accordance with these rules, the associated risk with the design must be reviewed by Horizon Power or their authorised representative.

The following activities must be undertaken for distribution system design and construction works:

1.3.1 Planning Report

Every design must have a covering planning report. The report may be specific to the design or general i.e. regional, network, town, or feeder planning report.

The planning report must cover network capacities and detail the:

- 1) network.
- 2) load size.
- 3) load distribution centres.
- 4) load cycle.
- 5) nature of load.
- 6) network impacts (e.g. harmonics).
- 7) required transfer capacity.
- 8) potential interconnection points.
- 9) automation requirements.

Note: The Planning Report shall confirm if the requested load can be connected, the work required to enable the load to be connected.

1.3.2 Land, Environmental, Native Title and Heritage Assessment

Construction of new distribution network assets, or the modification of existing assets must address Horizon Power requirements to consider the land used, the impacts to the environment and to the communities.

Designers must engage the Environmental Sustainability team to determine the best optimal design with the lowest impact.

The Environmental Sustainability team will consider:

- 1) Land - aboriginal communities or other interested parties.
- 2) Environment - sensitive area or impact to fauna and flora.
- 3) Heritage – aboriginal or other sites, geographically/geologically significant areas or ground disturbing impacts.
- 4) Native Title - rights and interests of aboriginal and others.

Note: The Environmental Sustainability team do not wish to receive multiple clearance requests for the same job and would expect to only receive the request once the design has been reasonably finalised, unless this is a major project that may have an extensive impact study.

1.3.3 Risk Assessment

A Formalised Asset Safety Assessment (FASA) is required for every design. The FASA seeks to achieve a consensus on the risk level to the Horizon Power's network from the design.

The FASA is a guided process that identifies, evaluates and mitigates risk and documents all assumptions and decisions relevant to the design that impacts on a built asset during its life cycle. (Refer to *"FASA Procedure" DM# 5381710*).

1.3.4 Safety in Design (External Designers)

Whenever design work is undertaken to construct new distribution network assets, or modify existing assets, demonstration of due diligence with respect to safety is required. A safety in design report must be submitted by designers not directly employed by Horizon Power or under the direct direction of Horizon Power employees. (Refer to *"Safety in Design Guideline" DM# 41460386*).

The safety in design report must cover in detail the following:

- 1) Concept of design.
- 2) Design.
- 3) Installation.
- 4) Commissioning.
- 5) Maintenance.
- 6) Decommissioning.
- 7) Disposal.

1.3.5 Design Submission (Major Projects and External Applications)

Design submissions provide evidence of compliance with *"WA Electrical Requirements"*, *"Horizon Power Technical Rules"*, *"EnergySafety guideline"* for HV installations and *"WA Service and Installation Requirements"*.

All new or modified installations, for major projects and bulk consumers, connected to Horizon Power's network must be assessed by the regional asset managers or their delegates.

- *"HPC-2DJ-17-0001-2015 Guideline –Design Submission Evaluation and Capturing" DM# 3066318* can be used for guidance; whilst
- *"HPC-2DJ-17-0002-2017 Design Submission"* coversheet template *DM# 5097561* can be used as a check sheet for all the required documentation.

Note: The Design Submission process may be used when reviewing complicated connections to LV networks, i.e. BESS, IPP's, Solar Farms, etc. refer to section 3 of the guideline.

1.3.6 Distribution Design Safety Checklist

The "*Distribution Design Safety Checklist (DDSC)*" DM# 11165030 is to be used when assessing all other distribution designs. This checklist provides a comprehensive list of design elements when working on Horizon Power's networks.

1.4 Design Process and Inputs

The steps involved in the design of a network will depend on the individual project and the context in which the design is performed. It is important that designers seek to update existing network assets where possible to align with the latest distribution equipment, especially where the rating of equipment is in question.

It is an iterative process, with the designer making some initial assumptions, e.g. conductor/cable type and rating, which may later be adjusted as the design is checked and gradually refined. The final outcome is an optimum arrangement that meets all constraints. Horizon Power uses Electric Office software to aid the design process.

Note: Designers are required to have an understanding of AS 2067, AS/NZS 3000, AS/NZS 7000 and SA/SNZ HB 331 whilst complying with these rules.

1.4.1 Network Requirements

A design must take into account both present and future network requirements. This information is typically covered in the project planning report, design specification and equipment specifications.

1.4.2 Horizon Power Technical Rules

The Technical Rules set forth the operation requirements for the distribution networks that determine the design parameters for distribution designs. The Technical Rules must therefore be understood for effective designs as the Distribution Design Rules may not capture all of the operational requirements.

1.4.3 Horizon Power Distribution Design Catalogue

The Design Catalogue is a suite of standard equipment combinations that can facilitate the designer. The suite of standard equipment allows quicker selection of design options whilst the standard combinations ensure that critical pieces of equipment are not missed. These combinations are not comprehensive in any way and can be altered as required by the designer.

1.4.4 Horizon Power Distribution Construction Standards

The Construction Standard is a suite of standard design construction drawings that can facilitate the design, i.e. reference can be made to these standard construction drawings without having to create them for each design.

1.4.5 Distribution Network Constraints

Horizon Power's distribution is split into 38 separate networks each with its own source of generation and network constraints. Appendix J covers the maximum allowable transformer size for specific networks whilst Appendix E covers the DADMD requirements.

1.4.6 Distribution Equipment

Design and equipment specifications play a role in capturing requirements that need to be addressed during design. This includes:

- 1) Equipment and cable rating for normal load, emergency load and for fault conditions.
- 2) Equipment or cable operating conditions (e.g. Broome versus Esperance).
- 3) Network tolerance limits (e.g. statutory voltage tolerance limits).
- 4) Standard installation requirements.
- 5) Protection grading requirement.

In special cases, there may be additional requirements such as:

- 6) Consumer request for a higher security supply.
- 7) Coordination with a road lighting design.

2. Overview of the Distribution System

An overview of Horizon Power's distribution system is provided in Appendix D.

3. Distribution System Design and Construction

3.1 MV Distribution System Planning

The *"Horizon Power's Technical Rules" (HPC-9DJ-01-0001-2012)* and *"Pilbara Harmonised Technical Rules"*, set out the criteria for planning the distribution MV network, including:

- 1) Loading and utilisation of MV feeders.
- 2) Voltage control.
- 3) Voltage-drop on network components.
- 4) MV and LV voltage limits.

It is intended that future versions of the *"Technical Rules"* will also contain the requirements for inverter-connected energy sources, such as photo-voltaic panels and battery storage.

3.1.1 Voltage Control

Impedance in each of the following components of the distribution system leads to voltage drop:

- 1) Medium Voltage Feeder.
- 2) Distribution Transformer.
- 3) Low Voltage Network.
- 4) Consumer Service Leads/Cables (from LV distribution mains to point of attachment).

After a distribution system has been constructed, there are only two locations where voltage levels can be adjusted:

- a) at the zone substation (bus-bar voltage set-point and the use of Line Drop Compensators), and
- b) at the distribution transformers (off load tap changers).

Non-adjustable parts of the system must be designed to fully utilise the voltage control equipment at these locations to keep the consumers' voltages within the statutory voltage tolerance limits. Voltage-drop limits that are allowed in distribution system components are provided in Table 1:

Table 1 – Voltage-drop Limits with respect to nominal voltage

Non-Adjustable System Component	Maximum Voltage Drop
Medium Voltage Feeder	5.0%
Distribution Transformer	4.0%
Low Voltage Network	5.0%
Consumer Service Cable	1.0%

3.2 Loading of MV Distribution Feeders

There are two types of distribution feeders:

- Overhead lines, and
- Underground cables.

3.2.1 Interconnection of MV Feeders

Normally-open interconnection points must be provided between adjacent distribution feeders, where it is technically and economically feasible, as specified by the regional asset manager, on a case-by-case basis. Distribution feeders supplying critical loads, such as town centres and hospitals, must have a normally-open interconnection point with spare capacity, as per Section 3.2.3.

3.2.1.1 Switching between Distribution Feeders and Feeder Spurs

With the exception of switching operations, MV feeders in microgrids must not be operated in parallel unless approved by Energy Planning and Engineering & Project Services.

Switching devices must be located to allow sections of the lines to be either isolated or energised (i.e. radial tee-offs from the backbone of network feeders) during fault finding exercises.

Switching of distribution feeders and distribution feeder spurs in microgrids shall be limited to the maximum switching loads given in Appendix J, due to constraints in generator step load response. The generator step load response is predetermined during contract negotiations with Independent Power Producers, as switching too much load in at once may cause the generator to drop out.

3.2.2 Loading Capacity of MV Feeders

Distribution feeder loads must be limited to the values given in the subsections below. The utilisation criteria in Section 3.2.3 must also be considered based on the feeder arrangement. Feeders dedicated to individual consumers can be loaded up to these limits.

Larger loads in the Pilbara Grid need to be connected to the transmission network.

Loads that can be connected to the distribution networks are limited by the capacity of the individual system.

3.2.2.1 6.6 kV Feeders (Only for Murchison Radio Observatory Networks)

6.6 kV networks are no longer supported and where possible should be replaced with 22 kV networks.

3.2.2.2 11 kV Feeders

The following rules apply to 11 kV feeders installed within the Horizon Power network.

- 1) The load attached to 11 kV feeders must not exceed 5 MVA (260 A). Refer to Figure 1.
- 2) Individual consumer loads:
 - must not exceed 4 MVA (80%) per connection point
 - if greater than 4 MVA but less than 8 MVA, require a higher reliability of supply, i.e. must be provided with an alternate redundant supply at an additional cost to the consumer.

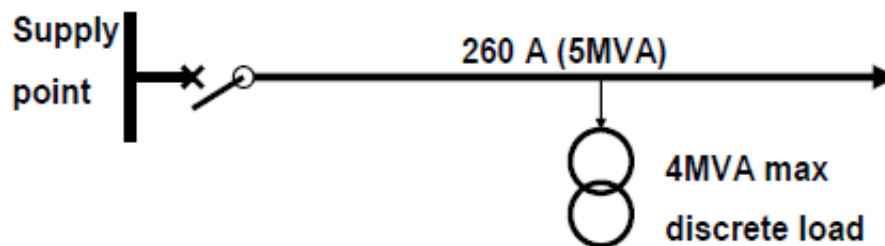


Figure 1 – 11 kV network arrangement

3.2.2.3 22 kV Feeders

The following rules apply to 22 kV feeders installed within the Horizon Power network.

- 1) The load attached to 22 kV shared feeders must not exceed 10 MVA (260 A). A feeder may be split two ways with 5 MVA (130 A) on each split leg. Refer to Figure 2.
- 2) Individual consumer loads:
 - must not exceed 4 MVA (80%) per connection point. Two connection points may be connected to separate legs of a split feeder.
 - if greater than 4 MVA but less than 8 MVA, require a higher reliability of supply, i.e. must be provided with an alternate redundant supply at an additional cost to the consumer.
 - if greater than 8 MVA but less than 15 MVA, must be provided with a dedicated feeder. Consumers requiring a higher reliability of supply must be supplied with a dedicated feeder and reserved capacity on an alternate feeder, at an additional cost to the consumer.

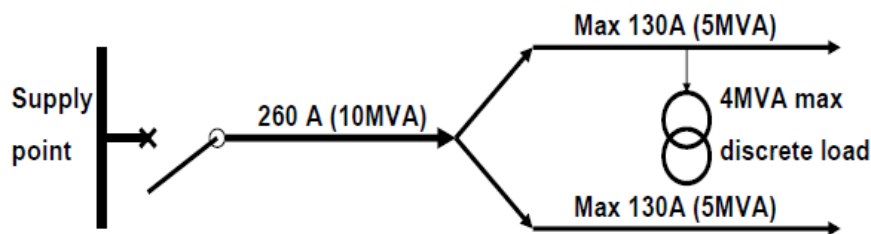


Figure 2 – Shared feeders using a 'Y' arrangement (22 kV)

3.2.2.4 33 kV Feeders

The following rules apply to 33 kV feeders installed within the Horizon Power network.

- 1) The load attached to 33 kV shared feeders must not exceed 15 MVA (260 A). A feeder may be split two ways with 7.5 MVA (130 A) on each split leg. Refer to Figure 3.
- 2) Individual consumer loads:
 - must not exceed 6 MVA (80%) per connection point. Two connection points may be connected to separate legs of a split feeder.
 - if greater than 4 MVA but less than 8 MVA, require a higher reliability of supply, i.e. must be provided with an alternate redundant supply at an additional cost to the consumer.
 - if greater than 8 MVA but less than 15 MVA, must be provided with a dedicated feeder. Consumers requiring a higher reliability of supply must be supplied with a dedicated feeder and reserved capacity on an alternate feeder, at an additional cost to the consumer.

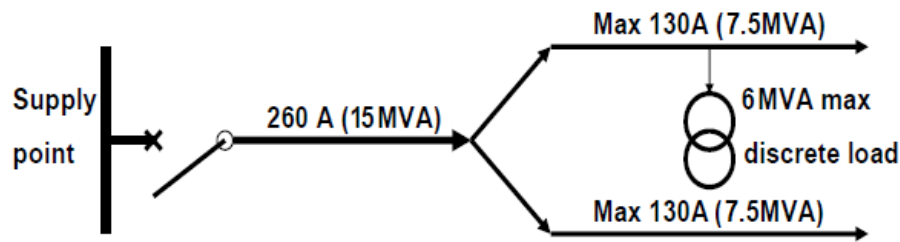


Figure 3 – Shared feeders using a 'Y' arrangement (33 kV)

3.2.2.5 Summary Values

Table 2 summarises the loading capacity for each voltage level, where 'L' is the discrete load in MVA.

Table 2 – Loading of Feeders

Discrete load in MVA		Method of Supply
11 kV	22 kV or 33 kV	
$L \leq 4$	$L \leq 4$	Shared feeder
$4 < L \leq 8$	$4 < L \leq 8$	Load to be split evenly across feeder segments, each of which are supplied from a different feeder
-	$8 < L \leq 15$	Load to be supplied from a dedicated feeder
$L > 8$	$L > 15$	Load must be assessed on an individual basis

3.2.2.6 Single Phase MV Lines

All new single-phase lines must be supplied via an isolation transformer for operation as a single-phase line.

An exception to this is allowed when supplying a single consumer, with load not exceeding 10 A (127 kVA at 12.7 kV and 191 kVA at 19.1 kV). Single-phase lines to such consumers do not require an isolation transformer.

3.2.3 Utilisation Criteria for Loading MV Feeders

The following rules apply to the utilisations of MV feeders within the Horizon Power network. The loading of feeders in Section 3.2.2 must also be considered.

- 1) For radial feeders, without interconnection, 100% utilisation is allowed. However, Horizon Power must be alerted at the design phase so a contingency plan can be considered to minimise the outage duration to less than 12 hours.
- 2) If a distribution feeder is able to be interconnected to one other adjacent feeder, the feeder utilisation limit shall be 60%. If each feeder is loaded to 50% capacity (assuming the feeders have equivalent capacity) then the total load can be carried by one feeder in the event of the loss of a feeder,
i.e. $\frac{1}{2} L + \frac{1}{2} L = \frac{2}{2} L$.
- 3) If a distribution feeder is able to be interconnected to two other adjacent feeders, the utilisation limit shall be 75%. If each feeder is loaded to two thirds capacity or 66% then the total load can be carried by two feeders in the event of the loss of a feeder,
i.e. $\frac{2}{3} L + \frac{2}{3} L + \frac{2}{3} L = \frac{3}{3} L + \frac{3}{3} L$.
- 4) If a distribution feeder is able to be interconnected with three other adjacent feeders, the utilisation limit shall be 85%. If each feeder is loaded to 75% capacity then the total load can be carried by three feeders in the event of the loss of a feeder,
i.e. $\frac{3}{4} L + \frac{3}{4} L + \frac{3}{4} L + \frac{3}{4} L = \frac{4}{4} L + \frac{4}{4} L + \frac{4}{4} L$.

3.3 Low Voltage System

LV distribution mains refer to LV network used to distribute power. Normally open interconnection points must be provided between adjacent distribution mains, where it is technically and economically feasible, as specified by the regional asset manager, and is a case-by-case basis. Interconnection of LV distribution mains must allow for the transfer of loads during the failure of a transformer or LV distribution mains.

All new low voltage service connections and upgrades to existing overhead service cable must be underground where feasible. Where service connections are required to connect to overhead mains, the service connection must be underground again where feasible, using a pole-to-pillar configuration.

3.4 Distribution System Demand Assessment

The size of the load must be determined before commencing the design process. Examples for estimating loads are available in Appendix C of *AS/NZS 3000*.

Design After Diversity Maximum Demand (DADMD) is a special estimate of the electrical load of every consumer connection (at low voltage). When the DADMD of every connection is summed, and multiplied by a diversity factor, the result is the load as seen by the supply transformer. The loads of all distribution transformers connected to a medium voltage feeder contribute to the total load on that feeder.

DADMD values and diversity factors must be used when estimating load for Horizon Power's LV distribution systems. These are provided in Appendix E.

3.5 Overhead Line Design

Overhead lines must be designed to perform at suitable levels of reliability and security for the weather expected in the region it is installed, for the entirety of its intended life. The design methodology must comply with *AS/NZS 7000 – Overhead Line Design* (Detailed Procedures).

The design of an overhead line must consider the loading of the MV distribution system (Section 3.1) and of MV feeders (Section 3.2). Selection of a suitable conductor must consider:

- 1) conductor type to carry load current at designed utilisation.
- 2) insulation requirements.
- 3) structures.
- 4) clearances to conductor, ground and structures.
- 5) easement for overhead lines.

Refer to Appendix F for more details.

3.5.1 Line Security Levels and Wind Return Periods

Horizon Power's overhead distribution lines shall be designed to Level 1 security, except for lines over waterways, railway crossings and lines supplying defined high security installations which shall be designed to Level 2 - security as per *Table 6.1 of AS/NZS 7000*.

The minimum design wind return period shall be:

- a) 50 years for Level 1 security, and
- b) 100 years for Level 2 security.

3.6 Underground Cable Design

The design of an underground cable network as a distribution feeder shall consider the utilisation criteria as defined above. Selecting the appropriate cables must at least consider:

- 1) cable type to carry load current at designed utilisation;
- 2) insulation requirements;
- 3) cable installation inside and outside road alignments;
- 4) cable installation in proximity to other services; and
- 5) easements for underground cables.

Design of networks for subdivisions shall be in accordance with *"Underground Distribution Schemes Manual"* (HPC-5DA-07-0012-2012). Cable installation shall be in accordance with *"Utility Providers Code of Practice"* for Western Australia and Horizon Power's *"Cable Installation Manual"*.

Refer to Appendix G for more design related information. Cables must be installed in ducts for any road or rail crossing and where dictated by a project requirements.

3.7 Substation Design

Distribution substations must be designed in accordance with AS 2067 and the *"Western Australian Service and Installation Requirements"* (WASIR). The substation arrangement must follow one of those provided in the *"Distribution Construction Standard"* substation arrangements (DCS G3 series of drawings). In addition to this, the designer must consider:

- 1) minimum land requirements (refer also to Appendix H).
- 2) installation requirements.
- 3) earthing and minimum separation for earth potential rise hazards (refer also to Appendix H).
- 4) fire safety requirements and fire separation (refer also to Appendix H).
- 5) noise level limit requirements (refer also to Appendix H).
- 6) proximity limits to other services.

3.8 Streetlight Design

Streetlight designs shall comply with the luminance requirements as specified in *AS/NZS 1158.1.1* and *AS/NZS 1158.3.1*. Refer to Appendix I.

LED luminaires must be used for new streetlights and replacement of existing streetlight luminaires. Horizon Power's standard luminaires are double insulated to eliminate the likelihood of any electric shocks.

3.9 Earthing

Earthing of the distribution network must be designed in accordance with the principles in Horizon Power's *"Distribution Line Earthing Standard"*. Earthing system designs must be based on the ALARP (As Low as Reasonably Practical) principle within Horizon Power's risk management framework. Refer to Appendix C.

3.10 Safety Requirements

Safety procedures in accordance with the *"Distribution Construction Standards"*, *"Instructions Manual"* and Horizon Power's *"Health and Safety Management System (The Zone)"* shall be complied with in the design, construction, operation and maintenance of the distribution system.

3.11 Land, Environment, Native Title and Heritage Requirements

An Environmental Clearance Request Form (available at <https://horizonpower.sharepoint.com/sites/Powerlink/operational/Pages/Clearance-request-form.aspx>) is required to be completed prior to any field and project works (including overhead works and inspections) to ensure that legislative and regulatory requirements are fulfilled.

3.12 Location of Distribution Components

Refer to Appendix H for guidance on the location of distribution components.

4. Overhead Network Components

This section describes the core components of the overhead system. Detailed design principles are provided in Appendix F.

4.1 Supports

Historically, Horizon Power has used poles of only four lengths, as shown in Table 3. The required depths and pole lengths for cohesive soils are also shown.

Table 3 – Poles lengths and embedment for cohesive soil

Required height above ground (m)	Use	Embedment depth (m)	Standardised pole length (m)
7.95	Intermediate/Strain/Termination	1.55	9.50
9.30	Intermediate/Strain/Termination	1.70	11.00
10.65	Intermediate/Strain/Termination	1.85	12.50
12.00	Intermediate/Strain/Termination	2.00	14.00

The height above ground should be maintained regardless of the foundation required.

Table 4 lists the standard steel poles.

Table 4 – Rating of Steel Poles

Pole Length (m)	Pole Rating (kN)	Maximum pole tip load, maximum wind condition (kN)	Maximum pole tip load, serviceability condition (kN)
9.50	20	20	12
11.00	20	20	12
11.00	30	30	18
12.50	40	40	24
14.00	35	35	21

4.2 Stays

Generally, the use of stays would be recommended during line design using design software, e.g. Poles'n'Wires.

No stays shall be located within one (1) metre of an existing or planned driveway crossover.

All load is to be taken by the stay, i.e. the load is not shared between pole and stay (pole flexes under load whereas stay is rigid and therefore must be capable of holding the full applied load).

If the stay wire is not attached to the loading point of the pole, the stay wire tension required is further increased. This increased value of the stay wire tension is calculated by taking the original tension (at loading point) multiplied by the height above ground divided by the height of stay attachment.

It is recommended that the design engineer considers reviewing *section 22.5 of SA/SNZ HB 331* when making use of stays.

4.2.1 Equipment for Stays

Stays consist of the following equipment:

4.2.1.1 Anchors

Horizon Power makes use of two types of screw anchors to mitigate the different soil conditions:

- A 200 mm helical anchor head which allows for easier ground penetration, but provides a lower holding capacity, and
- A 300 mm helical anchor head which allows for a greater holding capacity but is harder to install (ground penetration is not that easy),

Both anchor heads have an installation torque capacity of 1356 N-m which connects to rods having a capacity of 160 kN.

The two graphs below provide the holding capacity details:

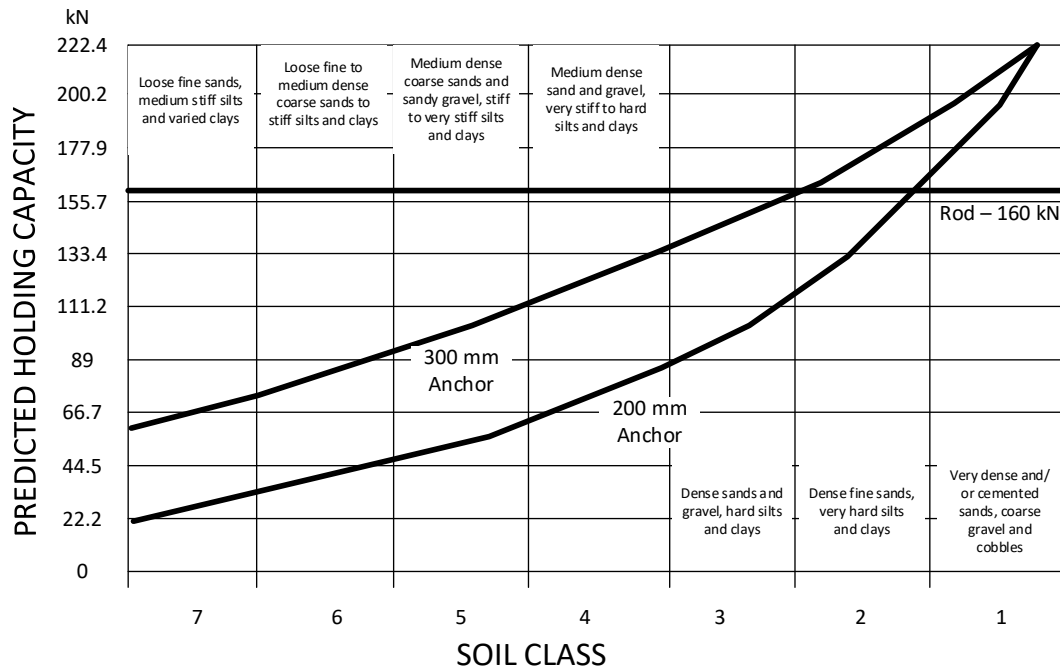


Figure 4 – Soil Class versus Holding Capacity

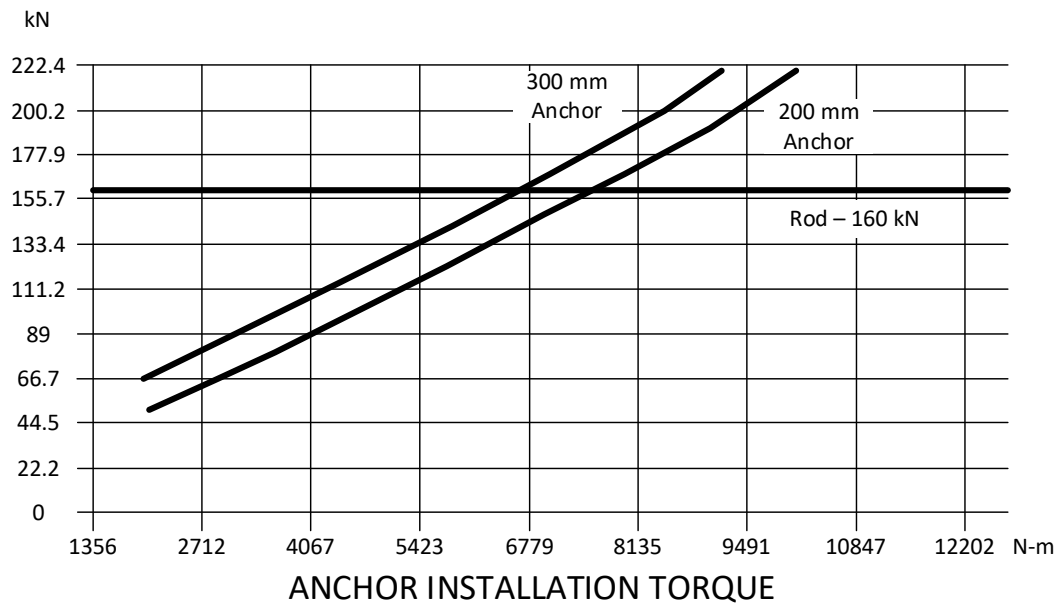


Figure 5 – Installation Torque versus Holding Capacity

4.2.1.2 Stay Wire

To prevent electrical current in the stay wires, or the charging of stay wires from downed overhead conductors, an insulator must be installed approximately 3000 mm from the either the stay attachment point or outrigger (refer to DCS drawings R08.1, R08.2-1, R08.2-2 and R08.3).

Horizon Power makes use of two types of stay wires each having the following capacities with 80% strength reduction factor:

A 19/2.00 SC/GZ conductor rated to 60 kN (74.4 kN x 80%)

A 19/2.75 SC/GZ conductor rated to 113 kN (141 kN x 80%), unfortunately the eyebolt used to connect the stay to the pole limits the load to 86 kN.

4.2.1.3 Outrigger

The outrigger consists of a metal bar approximately 2700 mm long that is used to pivot the stay and allow the installation of the stay closer to the pole.

4.2.2 Ground Stays

The preferred angle range for ground stays is between 45° and 60° to ground. Stay wire 19/2.00 SC/GZ or 19/2.75 SC/GZ (galvanised steel) conductor with a GY3 insulator installed approximately three (3) metres from pole attachment point (refer to DCS drawing R08.1).

4.2.3 Outrigger Stays

Outrigger stays to be used only when ground stays are unsuitable or limited space is available.

Outrigger can either be bolted or strapped to the pole, stay wire is 19/2.00 SC/GZ or 19/2.75 SC/GZ (galvanised steel) conductor with GY3 insulators installed approximately two point seven (2.7) metres from the ground level (refer to DCS drawings R08.2-1 and R08.2-2). Minimum distance between pole and stay anchor point is 2700 mm.

4.2.4 Aerial Stays

Aerial stays are to be avoided and should only be used after all other options have been exhausted. Aerial stays with 1 19/2.00 SC/GZ (galvanised steel) conductor and a GY3 insulator shall be used (refer to DCS drawing R08.3).

4.3 Crossarms

4.3.1 MV Crossarms

Galvanised steel crossarms shall be used on MV overhead lines to support MV conductors on insulators:

- 1.9 m steel crossarm (nominal cross-sectional dimensions of 75 x 75 mm) for strain/termination and with a raiser for intermediate
- 2.4 m steel crossarm (nominal cross-sectional dimensions of 100 x 100 mm) for strain/termination and with a raiser for intermediate
- 3.3 m steel anti-swan crossarm (nominal cross-sectional dimensions of 125 x 75 mm) for strain/termination
- 3.3 m steel anti-swan crossarm (nominal cross-sectional dimensions of 125 x 75 mm), with raisers 250 mm and 720 mm high for strain/termination and with a raiser for intermediate

Note: Double crossarm application (DCS H4-1) may be required for the 3.3 m steel anti-swan crossarm to address loading issues.

4.3.2 LV Crossarms

LV composite cross-arms shall be used only when:

- Installing new LV conductor on existing MV line (long spans where LV ABC cannot be strung) poles and
- Replacing current LV cross-arms on low voltage bare conductor networks.

The 2.1 x 0.1 x 0.1 m composite cross-arm can be used as either strain, termination or intermediate.

Note: LV Crossarms are generally used for replacement of existing installations and where LV ABC is not practical to be used. LV construction standard is to use LV ABC.

4.4 Insulators

- 1) Polymeric post and strain insulators must be used on MV networks. Post type must be used for intermediate poles, and strain type must be used for angle, strain and termination poles.
- 2) LV insulators must be used on wood (legacy cross-arms) or composite cross-arms only for limited applications (refer to Section 4.3.2). Pin type must be used for intermediate poles, and shackle type must be used for angle, strain and termination poles.
- 3) Shackle type LV insulators shall be used for running earth conductors on MV feeders.

4.5 Conductors

The following conductors are standard in the overhead network, refer to Appendix F2.11 for parameters:

Table 5 – Rating of Standard Conductors

Name	Number of strands / strand diameter (mm)	Material	Current rating – Region A (Amperes)	Current rating – Regions C, D (Amperes)	Fault rating (kA for 1 s)
Moon	7/4.75	AAC	380	344	9.12
Neptune	19/3.25	AAC	439	397	11.62
Saturn	37/3.00	AAC	597	537	19.28
Triton	37/3.75	AAC	779	698	30.1
Venus	61/3.75	AAC	1049	935	49.6
Chlorine	7/2.50	AAAC	172	157	2.53
Iodine	7/4.75	AAAC	375	340	9.12
Krypton	19/3.25	AAAC	433	392	11.62
Lemon	30/7/3.00	ACSR	537	483	15.6
Lime	30/7/3.50	ACSR	645	579	21.27
	3/2.75	SC/AC	69	63	1.5
95 mm ² LVABC		Al (XLPE insulated)	216	196	9.3
150 mm ² LVABC		Al (XLPE insulated)	282	256	14.6
2C 6 mm ²		Cu (XLPE insulated)	56	51	0.79

Name	Number of strands / strand diameter (mm)	Material	Current rating – Region A (Amperes)	Current rating – Regions C, D (Amperes)	Fault rating (kA for 1 s)
3C 6 mm ²		Cu (XLPE insulated)	55	50	0.79
4C 6 mm ²		Cu (XLPE insulated)	54	49	0.79
2C 16 mm ²		Cu (XLPE insulated)	100	92	2.1
4C 16 mm ²		Cu (XLPE insulated)	96	88	2.1

4.5.1 Conductor Stringing

The Distribution Construction Standards Package T “DCS Part 12 – T Stringing Charts (DM# 44038291)” to be used for conductor stringing, methodology can be found in the document “Standard – Distribution Stringing Tables (DM# 42708883)”.

4.5.2 Conductor Applications

- 1) Iodine 7/4.75 AAAC conductor shall be used for MV overhead radial feeders from a zone substation (Pilbara Grid) or power generating station (Microgrids).

This conductor has sufficient current-carrying capacity for allowable feeder load; however, feeder length may be limited by voltage drop limits.

Note: Krypton 19/3.25 AAAC conductor must be used as the first segment of feeder from a zone substation (Pilbara Grid) or power generating station (Microgrids) where the faults level exceeds the capacity of Iodine 7/4.75 AAAC conductor (9 kA for 1 s).

- 2) 3/2.75 SC/AC conductor must be used for single phase MV lines.
- 3) Where the running earth is under-slung, the running earth conductor must be the same as the phase conductors.
- 4) Where the running earth is above the phase conductors (providing lightning protection), 3/2.75 SC/AC conductor must be used.
- 5) 150 mm² LV ABC must be used as LV distribution mains conductors.
- 6) LV distribution mains distributed from 315 kVA transformers must be separated as two separate circuits to distribute the load.

- 7) No new bare LV conductor must be installed. Iodine 7/4.75 AAAC conductor must be used for LV only when LV ABC cannot be used (such as when existing poles are spaced for long MV spans).
- 8) 150 mm² LV ABC (with each phase physically separated), must be used as droppers or taps on MV conductors (excluding 3/2.75 SC/AC) to equipment other than pole top transformers.
- 9) 95 mm² LV ABC (with each phase physically separated), must be used as droppers or taps on MV conductors for pole-top transformers (excluding Live Line Clamp arrangements) and pole top equipment connected to 3/2.75 SC/AC conductors.

4.5.3 Conductor Attachments

4.5.3.1 Insulators

- 1) AAC and AAAC conductor:
 - a) Armour rods required on long rural networks.
 - b) Aluminium ties suitable for top and side securing to insulators at MV and LV.
 - c) Aluminium clamps (ICH0091) to Clamp-Top type insulators at MV.
- 2) SC/AC conductor:
 - a) Armour rods required to bulk up conductor size at all insulators.
 - b) Aluminium clad steel preformed ties suitable for top and side securing to insulators at MV and LV.
 - c) Ferrous clamps (ICH0090) to Clamp-Top type insulators at MV.
- 3) SC/GZ conductor:
 - a) Armour rods required to bulk up conductor size at all MV insulators.
 - b) Galvanised steel preformed ties suitable for top and side securing to insulators at MV and LV
 - c) Ferrous clamps (ICH0090) to Clamp-Top type insulators at MV.
- 4) Copper conductor:
 - a) Armour rods required to bulk up conductor size at all MV insulators.
 - b) Ferrous clamps (ICH0090) to Clamp-Top type insulators at MV.

4.5.3.2 Terminations

- 1) At termination poles, aluminium dead end helical terminations must be used to terminate AAAC conductors.

- 2) At termination poles, steel dead end helical terminations must be used to terminate SC/AC and SC/GZ conductors.
- 3) To terminate LV overhead services, strain clamps (wedge clamps) must be used. This is only for replacement of existing services of same capacity.
- 4) For LV ABC at intermediate and angle poles, suspension clamps must be used.
- 5) For LV ABC at termination and in-line strain poles, strain clamps must be used.
- 6) Where LV ABC is connected to LV ABC (as a tee-off) at intermediate and angle poles, strain clamps and suspension clamps must be used.
- 7) Where LV ABC is connected to bare LV distribution mains (as a tee off), strain clamps must be used. Krone fuses must be used, unless LV bare conductors are fused at the transformer.
- 8) Facade mounting of LV ABC is permitted so far as window openings are avoided and non-tensioned construction is used.

4.5.3.3 Joints/Sleeves (Mechanical – Under Tension)

Table 6 – Tension Joints

Conductor material	Joint required
AAC	Full-tension crimp sleeves Mechanical Range 6-14.3 mm
AAAC	Full-tension crimp sleeves Mechanical Range 6-14.3 mm
ACSR	Full-tension crimp sleeves Mechanical Range 6-14.3 mm
SC/AC	Full-tension helical joint
LVABC	Full-tension crimp sleeves

4.5.3.4 Joints/Clamps/Sleeves (Electrical – Not Under Tension)

- 1) Parallel groove (PG) clamps must be used to connect bare conductors that are not under tension.
 - a) The PG clamp must suit the conductor material. Clamps are available for aluminium to aluminium, aluminium to copper (bi-metal), copper to copper, and SC/GZ to SC/AC.
 - b) Two PG clamps must be used for all connections to LV neutral conductors
- 2) Bi-metallic lugs must be used to terminate LV ABC droppers on to equipment.

- 3) Insulation piercing clamps must be used to connect (tee off) to LV ABC, LV services and streetlight services via fuses from LV ABC conductors.
- 4) Pre-crimped aluminium/copper splices (stalk lugs) must be used to connect LV ABC conductors to bare aluminium/copper conductors with PG clamps.
- 5) Live line clamps must be used to connect transformers on the SWEWR system to the single-phase line conductor. The connection must not be made directly onto the line conductor, but instead via a stirrup made up of two PG clamps joined by a stainless-steel stirrup.

4.5.3.5 Running Earth Attachments

Running earth conductors must be attached to poles using:

- 1) LV shackle insulators (Section 4.4 clause 3)) for all conductors at intermediate poles
- 2) Helical preformed terminations with clevis thimbles for all conductors at termination poles

4.5.3.6 Armour Rods and Vibration Dampers

- 1) Armour Rods are designed to protect the conductor at its support points against damage from abrasion, bending, vibration and flash overs in accordance with *Table Y1 in AS/NZS 7000*.
- 2) Spiral vibration dampers (SVD's) are designed to reduce Aeolian vibration on conductors which is generated by wind turbulence. SVD's are made of a solid, non-corrosive high impact strength, UV resistant, PVC rod.

The gripping section should be installed approximately 100 to 120 mm from armour rods, ties or other conductor hardware, as indicated below.



Figure 6 – SVD Installation Location

Vibration dampers are required at intermediate conductor supports and not at -conductor strain/tension attachments. Vibration dampers must be installed on:

- AAAC conductor, tensioned to 18% (in areas falling under “Terrain Category 1” as defined in AS/NZS 1170.2);
- ACSR conductor, tensioned to 18%;
- SC/AC or SC/GZ conductor, tensioned to 17.5% and above

Note: Dampers to be installed on both sides of the post insulator for SC/AC or SC/GZ conductors and doubled up when the bay length is greater than 250 m.

5. Overhead Equipment

5.1 Pole-Mounted Distribution Transformers

Pole-mounted transformers are used only when upgrading existing transformers. Smaller rural supplies may be provided from 25 kVA and 10 kVA transformers. Pole mounted transformers capacities are in Table 7.

Table 7 – Pole Mounted Transformers

MV Voltage	MV Phases	Capacity (kVA)
6.6/11 kV	3	25, 63, 100, 200, 315
	2	10 (2 Bushing-250/500 V)
22 kV	3	25, 63, 100, 200, 315
	2	10, 25 (2 Bushing-250/500 V)
33 kV	3	25, 63, 100, 200, 315
	2	25 (2 Bushing-250/500 V)
12.7 kV	1	10, 25
19.1 kV	1	10, 25

5.1.1 Transformer Installation Constraints

Maximum size of transformers on the Microgrids is given in Appendix J.

5.1.2 SWEWR Isolating Transformers

Refer to Section 3.2.2.6.

5.2 Reclosers

5.2.1 Recloser Purpose

- 1) Reclosers must be used to:
 - segment MV feeders to minimise consumer exposure to faults.
 - prevent prolonged outages to a critical load (e.g. large town) due to faults downstream of its location.
 - prevent temporary (transient) faults (e.g. tree branches short circuiting conductors momentarily) from causing prolonged outages.
- 2) Reclosers must be used to automatically interrupt (trip) and reclose MV feeders during faults, generally this is done according to a predetermined sequence of tripping and reclosing operations. The usual sequence of operation is to trip instantaneously when first identifying the fault (current threshold exceeded) and thereafter trip a further two times using timed delay current operations.

5.2.2 Recloser Application

- 1) Reclosers must be located to ensure planned fault coverage on overhead MV feeders, and located to meet back-up protection requirements.
- 2) Feeder sectionalisation, load breaking and fault breaking requirements must be considered when locating Reclosers on MV feeders.
- 3) Reclosers on MV feeders must be three phase (ganged) and be rated to match the estimated maximum load with allowance for future load increase.
- 4) Single-phase reclosers must be used to protect and install at the beginning of the SWEWR, rather than HV drop-out fuse where MV feeder reliability can be impacted by transient faults.
- 5) Reclosers by themselves must not be used as points of isolation.
- 6) Reclosers set to multiple operations must not be used to protect underground MV cables.
- 7) Switching capability of reclosers is provided in Appendix K.
- 8) Each switching point (where possible) shall be capable of remote operation regardless of the availability of communications, to allow future remote operation when communications are made available.

- 9) The effect of the switched load on the upstream power station or substation must also be considered. The load between two switches must not exceed the maximum switching loads provided in Appendix J for networks in the Microgrids.

5.3 Load Break Switches

5.3.1 Load Break Switch Purpose

Load Break Switches must be used to:

- 1) segment MV feeder by means of planned on-load switching
- 2) switch MV feeders both on-load and under fault conditions (fault isolation and restoration)
- 3) facilitate remote operation when connected to SCADA

5.3.2 Load Break Switch Application

Load Break Switches:

- 1) must be located to segment MV feeders and facilitate switching between feeders or feeder segments to reduce planned and unplanned switching times (refer to clause 3.2.1).
- 2) must be three phase (ganged) and be rated to match the estimated maximum load with allowance for future load increase.
- 3) must be used to replace pole-top switches where:
 - a) remote operation is required and/or
 - b) maintenance of the pole-top switch is costly and inefficient (i.e. location of pole-top switch is more than 100 km from the depot, or within 1 km from the coast).
- 4) may be used as points of isolation, with appropriate work procedures.
- 5) may be used to switch underground MV feeders at point of connection with overhead MV feeders.
- 6) switching capacity of load break switches is provided in Appendix K.
- 7) each switching point (where possible) shall be capable of remote operation regardless of the availability of communications, to allow future remote operation when communications are made available.
- 8) the effect of the switched load on the upstream power station or substation must also be considered. The load between two switches must not exceed the maximum switching loads provided in Appendix J for networks in the Microgrids.

5.4 Pole-Top Switches

Pole-top switches shall be used to segment MV feeders for:

- 1) planned switching, and
- 2) restoring supply after faults.

Note: Refer to Appendix K – Switching Capacity of Overhead and Ground Mounted Devices.

5.4.1 Pole-Top Switch Application

Pole-top switches:

- 1) must be located to segment MV feeders and facilitate switching (refer to Section 3.2.1).
- 2) must be three phase (ganged) and be rated to match the estimated maximum load with allowance for future load increase.
- 3) may be used as points of isolation, with appropriate work procedures.
- 4) may be used to switch (on no-load or load less than 10 A) underground MV feeders at points of connection with overhead MV feeders.

5.5 FuseSaver

FuseSaver's reduce the number of electrical outages caused by the operation of Drop-Out Fuses due to transient electrical faults. Selection of the model of FuseSaver is key for optimum operation noting the following specifications:

- 1) Minimum line current for operation (0.15 A)
- 2) Rated normal current (40 A)
- 3) Rated short-circuit breaking current (1.5 kA_{RMS})
- 4) Rated short-circuit making current (3.75 kA_{peak})

5.5.1 FuseSaver Application on SWEWR Networks

FuseSaver's may be installed almost anywhere on SWEWR networks, though offer the most benefit when:

- 1) located in series with Drop-Out Fuses,
- 2) connected to the HPCC via SCADA to allow operability, and
- 3) selected correctly for network load and fault current at location.

5.6 Drop-Out Fuses

Drop-out fuses installed on MV systems shall be used to electrically protect:

- 1) a single transformer (up to 1MVA).
- 2) single-phase feeder spurs, where transformers aren't individually protected by a drop-out fuse.
- 3) three-phase MV cables to transformers, length limited do to ferroresonance in transformer.

5.6.1 Drop-Out Fuse Application

Drop-out fuses:

- 1) must be located on the same pole as the transformer it protects or on the pole before.
- 2) when used to protect single-phase spurs, must be located either on the tee-off pole or the first pole of the spur.
- 3) must not be installed in series with another drop-out fuse.
- 4) may be used as points of isolation, with appropriate work procedures.
- 5) may be used to protect underground MV cables supplying ground mounted transformers at points of connection with overhead MV feeders, provided the cable length does not exceed values in Table 8 or that the transformer is never energised unloaded.

Note: The use of 3 phase load boxes when energising unloaded transformers with HV fuses would mitigate the need to apply a critical cable length.

Table 8 – Ferro-Resonance – Critical Cable Length

Transformer Rating (kVA)	Critical Cable Length (m)		
	11 kV	22 kV	33 kV
	35 mm ² /22 kV		50 mm ² /33 kV
160	42.6	6.6	4.1
315	35.68	9.1	5.25
630	71.3	15.7	7.5
1000	66.6	15	9.4

Fuses for pole-mounted distribution transformer protection are given in in the Distribution Construction Standard G1-02 drawings.

5.7 MV Disconnectors

MV Disconnectors provide a visible break and are used to isolate, when the recloser is placed in the 'Open' position. MV disconnectors don't have making/breaking capabilities and should therefore not be operated as a switching device or operated under load.

5.8 Surge Arresters

Surge arresters must be installed as close as possible to the electrical equipment to protect from voltage surges due to a lightning strike.

Note: The use of surge arresters on lines is no longer considered acceptable as they do not provide effective measures to protect lines from over voltages.

5.8.1 Surge Arrester Application

Surge Arresters must be installed on:

- 1) Transformers (MV side), reclosers, load break switches, voltage regulators, capacitors and reactors installed on poles.
- 2) MV cable terminations on poles.

5.9 Voltage Regulators

Voltage Regulators must be considered for maintaining a fixed output voltage regardless of the fluctuation of input voltage. Voltage regulators are used on long feeders where voltage drops occur. A voltage regulator has up to 35 steps to 'boost' input voltage to the desired output. Regulators may be connected Star or Delta configuration.

Note: Planning report to recommend placement and locations of voltage regulators.

5.10 Capacitors

Capacitors must be considered for increasing voltage on MV lines particularly when there are large loads at the end of lines that consume reactive power.

Note: Planning report to recommend placement and locations of capacitors.

5.11 Reactors

Reactors must be considered for decreasing voltage on MV lines automatically particularly on very long lightly loaded lines.

Note: Planning report to recommend placement and locations of reactors.

5.12 Fault Indicators

Fault indicators must be installed at locations that facilitate the speedy restoration of normal network conditions following a fault. It enables fault crews to identify a faulty feeder segment beyond a fault indicator.

Note: Operations/work crews to provide optimal locations.

5.12.1 Fault Indicator Application

Fault indicators are generally applied at the following locations:

- 1) At the beginning of spur lines not having a recloser or sectionaliser.
- 2) On MV feeders at key switch positions.
- 3) On the incoming cable of a ring main unit.

5.13 Earthing

The following equipment must be earthed in accordance with Appendix C:

- Steel Pole
- Transformer
- Recloser
- Load-break switch
- Pole-top switch
- MV Cable termination
- Lightning Arrester
- Voltage Regulator
- Capacitor
- Reactor
- Surge Arresters

5.14 Overhead LV Disconnectors

Overhead LV Disconnectors must be used as open points for interconnecting overhead distribution mains from different transformers.

5.15 Overhead LV Spreaders

Overhead LV Spreaders must be used on existing LV overhead bare conductor spans where:

- 1) span length is in excess of 55 m;
- 2) historically there has been known clashing or the installation is within high fire risk area or an area deemed to have high-risk of clashing due to reason such as:
 - a) Heavy vegetation/ overhanging trees;
 - b) Use of dissimilar conductors on same span;
 - c) Separation distance between LV conductors of less than 0.535 m (typical separation distance between LV conductors); and
 - d) Transposition of conductors from a horizontal to a vertical arrangement.
- 3) site assessment has been carried out to ensure that the associated conductors, cross-arms and poles are in good, serviceable condition.

5.15.1 LV Spreader Application

A mid-span clearance assessment shall be performed based on:

- 1) Mid-span separation constant of:
 - a) 0.4 in low fire-risk/non-cyclonic area or
 - b) 0.6 in any other circumstance;
- 2) On-site measurements of attachment points in particular for scenarios with:
 - a) least separation distance between the adjacent conductors; or
 - b) greatest potential difference (voltage) between adjacent conductors.
- 3) Conductor with the greatest sag (where there are dissimilar conductors used within the same span);
- 4) Conductor temperature of 50 deg C.

- 5) On-site verified conductor tension (recommended) or otherwise conductor tension as per the following:
- a) For spans up to 55 m:
 - i. (Old) Copper – 10% tension (7/12)
 - ii. AAC – 10% tension (7/2.75, 7/4.75, 19/3.25)
 - iii. AAAC – 7% tension (7/2.75, 7/4.75, 19/3.25)
 - b) For spans greater than 55 m:
 - i. (Old) Copper – 25% tension (7/12)
 - ii. AAAC – 18% tension (7/2.75, 7/4.75, 19/3.25)

Note: An assessment will be required where transposition of conductor from a horizontal to a vertical arrangement takes place.

5.16 Streetlights

LED luminaires must be used for new streetlights. Horizon Power has five standard luminaire sizes, shown in Appendix I Table 43. Compared with gas discharge lamps, LED lamps are more energy efficient, they have a more even dispersion pattern and a sharper drop-off (i.e. less spill).

Design and further information can be found in Appendix I.

5.17 Distribution Mains Protection

5.17.1 Overhead Line Fuses

- 1) Bare and LV ABC overhead lines must be protected with fuses at the transformer as provided in the Distribution Construction Standard G1-02 drawings.
- 2) Existing unfused bare overhead lines must be fused when lines are extended or when augmentation work is done.
- 3) With 315 kVA transformers, LV distribution mains must be segregated to two separate distribution mains, with load attached to each distribution mains not exceeding 250 A. Each LV distribution main must be separately fused.

5.17.2 Service Cable Fuses

Service cable tapped off the overhead LV network must be protected by fuses, either Flowline HRC fuses (rated 10 A, 30 A, 60 A and 100 A) or Krone HRC fuses (rated 200 A and 315 A) depending on the supply capacity. Fuse rating must be equal or lower than cable rating.

5.17.3 Streetlight Fuses

There are two types of streetlights available for use in the network, both must be protected by a HRC fuses rated at 10 A.

5.17.3.1 Power Pole Streetlights

Power pole streetlights are generally found in urban settings and are attached to power poles supporting LV overhead networks. The streetlights are support on outreaches attached to the power poles and connected to the LV networks by means of a flowline fuse and neutral terminal box. The flowline contains a red-spot fuse-holder and a neutral terminal capable of terminating 16 mm² service wires.

5.17.3.2 Steel Standard Streetlights

Steel standards or streetlight poles are self-supporting streetlights which come in three heights, refer to Appendix I for further details, are supplied by means of 16 mm² LV underground cables from pillars. As well as the 10 A fuse in the streetlight "BILL" cut-out, a "Red-Spot" fuse-holder with a 20 A fuse is required to be installed in the pillar.

6. Underground System Core Components

6.1 Cables

The standard cable used for MV circuits within Horizon Power's network is single core termite proof laid a trefoil formation.

For LV cable circuits a 3-core neutral screened termite proof cable is used, except for 400 mm², where three single core termite proof cables are laid in trefoil.

Termite proofing shall be achieved using a double brass tape (DBT) layer in the cable.

6.1.1 6.6 kV, 11 kV and 22 kV Networks

All 6.6 kV, 11 kV and 22 kV networks will make use of 22 kV rated cables.

- For feeder cables, 185 mm² and 400 mm² aluminium, TR-XLPE/XLPE insulated, copper screen, WBT, DBT, PVC/HDPE sheath.
- For transformer cables, 35 mm² aluminium, TR-XLPE/XLPE insulated, copper screen, WBT, DBT, PVC/HDPE sheath.

Note: 240 mm², 500 mm² and 630 mm² copper, TR-XLPE/XLPE insulated, copper screen, WBT, DBT, PVC/HDPE sheath cables may be used but are not preferable.

6.1.2 33 kV Networks

33 kV networks will make use of 33 kV rated cables:

- For feeder cables, 185 mm² aluminium, TR-XLPE/XLPE insulated, copper screen, WBT, DBT, PVC/HDPE sheath.
- For transformer cables, 50 mm² aluminium, TR-XLPE/XLPE insulated, Copper screen, WBT, DBT, PVC/HDPE sheath.

6.1.3 Low Voltage Distribution Mains Cables

It is preferred that LV distribution main cables be either three-core 240 mm² aluminium conductor with copper neutral screen, or single-core 400 mm² copper. All shall be XLPE insulated, with Nylon and HDP sheath or DBT and PVC sheath.

6.1.4 Service Cables and Minor Branch Cables

Service and minor branch cables must be 25 mm² copper cable, neutral screened, XLPE insulated, WBT, DBT, HPDE sheath.

6.1.5 Streetlight Cables

Streetlight cables must be single core 16 mm² copper cable, neutral screened, XLPE insulated, WBT, DBT, HPDE sheath.

6.2 Cable Markers

Cable markers can be above ground and underground.

- 1) Above ground markers are to be installed as per *section 6.1.3 of the Underground Cable Installation Manual* in locations where:
 - a) cable routes have not yet been captured in DBYD, these markers should be installed along the route, at route deviations and cable joints.
 - b) above ground equipment can be hidden by vegetation, e.g. pillars.
- 2) Below ground markers are to be installed as per *section 11 of the Underground Cable Installation Manual*.

6.3 Conduits

Conduits, as per *section 13 of the Underground Cable Installation Manual*, must be used where cables:

- 1) cross railway lines (conduit to extend 500 mm beyond railway boundaries).
- 2) cross roadways (conduit to extend 500 mm beyond road verge).
- 3) enter and exit distribution substations as per DCS G6-1.
- 4) enter and exit cable pits or any equipment bound by concrete where cables may be, installed, replaced or removed.
- 5) for service and minor branch cables.
- 6) Cables installed outside Horizon Power's alignment (0-500 mm or 2400-3000 mm) as per *section 13.2 of the Underground Cable Installation Manual or the Utility Code of Practice*.

Standard conduits sizes used are 150, 125, 100, 80, 50, 32 and 25 mm. Cables in conduits are derated and AS 3008 should be consulted to determine the effect that conduits have on cable current capacity.

Conduits for cables are generally based on the cable diameter with some allowance for additional cables. The 3 phase trefoil cables in the table below are based on a 60% fill factor.

Table 9 – Three Phase Trefoil Cables in Conduits

Conduit diameter	33 kV Cable	22 kV Cable	LV Cable
150 mm	185 mm ² Al	400 mm ² Al	N/A
125 mm	50 mm ² Al	240 mm ² Cu	N/A
100 mm	N/A	35 mm ² Al	400 mm ² Al or Cu

Note: Cable derating calculation sheets can be obtained from Engineering Services.

6.4 Cable Applications

6.4.1 MV Cable Networks

MV feeder cables from a zone substation (Pilbara Grid) or power generating station (Microgrids) must be as per Sections 6.1.1 and 6.1.2 depending on the voltage level. Cable lengths will be limited by voltage drop exceeding the permitted limits.

The following rules apply to MV cable networks:

- 1) Where current capacity limits are exceeded or voltage limits cannot be achieved and feeder load management is required, this must be done via a RMU.
- 2) Where required, interconnection of feeders must be done via RMU's. This enables load transfers in case of emergency.
- 3) Connections to MV loads must be done via RMU's:
 - a) Transformer ≤ 1 MVA connected with fuse-switch isolators and
 - b) Transformer > 1 MVA (e.g. consumer owned substations) connected with circuit breakers.
- 4) MV cables located on a consumer's property must have additional mechanical protection (as per the Western Australian Service and Installation Requirements) must be installed when located on a consumer's property, this must be kept as short as possible, with MV equipment located at the property boundary.

Note: District and Sole Use substations installed within consumer's property must be within 30 meters of the property boundary.

6.4.2 LV Cable Networks

The following rules apply to LV cable networks.

- 1) LV distribution mains cable from a distribution substation shall be 240 mm² aluminium XLPE insulated cable.
- 2) Extension of LV distribution mains when required, must be via a universal pillar and not by making joints.
- 3) Where interconnection between mains cables from different transformers (open points) is required, this must be via a universal pillar.
- 4) 400 mm² copper, XLPE insulated cables must be used to connect transformer LV terminals to LV Distribution Frames in Non-MPS substations.

- a) One per phase for 160 kVA.
 - b) Two per phase for 315 kVA and 630 kVA.
 - c) Three per phase for 1000 kVA.
- 5) Neutrals must be sized the same as the phase cables in clause 4).
- a) One per phase for 160 kVA, 315 kVA and 630 kVA.
 - b) Two per phase for 1000 kVA.
- 6) LV distribution mains cables must be protected by fuses at the MPS transformer (refer to Section 7.3.2), at the LV Distribution Frame (refer to Section 7.3.1) or at the termination when connecting to overhead networks unless cable goes to a pillar located within 1 metre of the pole base.

6.4.3 LV Cables to Supply Consumer Loads

The following rules apply to LV cables supplying consumer loads.

- 1) Loads greater than 100 A to be supplied by Uni-pillar via a 240 mm² aluminium cable, or a 200 A wall mounted box cable, cables to be neutral screened, XLPE insulated.

Note: Due to space constraints a 240 mm² cable is difficult to install in a 200 A wall mounted box (185 mm² cable is not a stock item).

- 2) Loads up to 100 A supplied by Mini-pillar or in some cases, an Uni-pillar via a 25 mm² copper cable, neutral screened, XLPE insulated.

Note: Where for safety or practical reasons, a BGSP may be used instead of a Mini-pillar.

- 3) Unmetered supplies supplied by a Below Ground Service Pit (BGSP) via single core 16 mm² copper cable, neutral screened, XLPE insulated.

Note: Where for practical reasons a Mini-pillar installed on a consumer's property may be used instead of a BGSP.

6.5 Cable Joints and Terminations

All cable joints must be installed in accordance with details outlined in the *"Underground Cable Installations Manual"* (HPC-5DJ-03-0001-2012), and the manufacturer's instructions supplied with joint kits. Where not published in specific detail clarification will be sought from the supplier.

6.5.1 Medium Voltage Cable Joints and Terminations

All MV joints, including transition types, shall use heat shrink materials, except for 22 kV joints and where otherwise approved.

6.5.1.1 MV Straight Through Joints

Straight through joints are used for joining cable of the same insulation type. Straight through cable joints and bolted cable connectors must be used to join XLPE cables. They can be used to extend cable length with the same size or smaller size cable.

1) Single core 22 kV cable joints are available in the following sizes for jointing XLPE cables.

- 25 mm² to 95 mm²
- 185 mm² to 400 mm²

2) Single core 33 kV cable joints are available in the following sizes for jointing XLPE cables.

- 35 mm² to 95 mm²
- 150 mm² to 300 mm²
- 240 mm² to 400 mm²

6.5.1.2 MV Transition Joints

Transition joints are joints use for joining cables of different insulation. Transition cable joints and bolted cable connectors must be used to join XLPE to PILCSWA cables. They can be used to extend existing PILCSWA cables with XLPE cables of similar current carrying capacity.

Joints are available in the following sizes for use at 22 kV to join 3 x 1 XLPE cables to 3-core PILCSWA cables:

- 50 mm² PILCSWA to 35 mm² XLPE
- 185/240 mm² PILCSWA to 185/400 mm² XLPE

6.5.1.3 MV Terminations

1) Medium voltage terminations suitable to terminate 35 mm², 50 mm², 185 mm² and 400 mm² cables must be used to terminate medium voltage cables on pole tops and to ground mounted transformers supplied from Drop Out Fuses.

- 2) Separable insulated connectors (non-load-break type and rated at 200 A and 630 A) must be used to terminate cables on MPS and non-MPS substation transformers and on ring-main (RMU) switchgear.
- 3) Dead end plugs must be used to protect separable connectors when they are not connected to transformer bushings.
- 4) Dead end receptacles must be used to protect transformer bushings when separable connectors are not connected.

6.5.2 Low Voltage Cable Joints and Terminations

The following types of joints must be used to connect distribution mains and service cables.

6.5.2.1 LV Straight joints:

- 10 mm² to 10 & 16 mm²
- 16 mm² to 16 mm²
- 25 mm² to 25 mm²
- 120 mm² to 120, 185 & 240 mm²
- 185 mm² to 185 & 240 mm²
- 240 mm² to 240 mm²

6.5.2.2 LV Tee joints:

- 10 mm² to 10 & 16 mm²
- 16 mm² to 16 mm²
- 120 mm or 185 mm² to 2 x 25 mm²
- 240 mm² to 2 x 25 mm²

6.5.2.3 LV Breech joints:

- 120 mm² to 240 mm²

6.5.2.4 LV Terminations

LV cable terminations must be used to terminate low voltage cables on to the following equipment:

- Mini pillars (terminate service cables and streetlight cables).
- Uni-pillars (terminate mains cables and large consumer service cables).
- LV distribution frames (terminate mains cables and sole use consumer cables).
- LV bare overhead mains (terminate 240 mm² and 400 mm² cables via Krone switch fuse and pre-crimped aluminium/copper splices).
- LV bare or LV ABC overhead mains (terminate service cables and streetlight cables).

Note: Like for like terminations must be used for aluminium to aluminium, aluminium to copper (bi-metal) and copper to copper.

7. Underground Equipment

7.1 MV Equipment

7.1.1 Ring Main Units (RMU)

22 kV and 33 kV RMU's must be used for switching of the underground medium voltage network. RMU combinations suitable for use are:

- 1) Two switches plus one fuse switch (2+1)
- 2) Three switches plus two fuse switches (3+2)
- 3) Three switches plus one fuse switches (3+1)
- 4) Three switches plus zero fuse switches (3+0)
- 5) Four switches plus zero fuse switches (4+0)
- 6) One switch plus zero fuse switches (1+0) extensible switch disconnecter
- 7) Zero switch plus one fuse switch (0+1) extensible fuse switch

Extensible switch disconnectors (6) and extensible fuse switches (7) shall be used when disconnectors / fuses are required to be added for switching.

7.1.1.1 Outdoor Applications

RMUs must be incorporated into either 4 or 5 way cyclonic kiosks. These kiosks are to be freestanding aluminium bodies mounted on galvanised steel frames. The steel frames are buried in the ground and sit on a concrete pad to provide a firm foundation and allows easy access to the cables and terminations below the switchgear. Refer to DCS G4 – Equipment Installation Guide for further information.

7.1.1.2 Indoor Applications

RMU's must be mounted in compounds comprising of a brick enclosure (building) with a roof, lockable door and natural ventilation. The compound must contain a cable trench and sufficient space to allow access around the RMU and for arc fault venting.

Generally, these installations cater for larger loads (> 630 kVA) where extensible and non-extensible RMUs are used for district and sole use substations. Consumers who own the enclosure must provide access to Horizon Power at all times.

Note: Enclosures may include transformers and LVDF's.

7.1.2 Earth Switches

Earth switches must be used at all RMU cable termination points.

7.1.3 MV Circuit Breakers

MV circuit breakers must be used for connecting (switching) MV feeders from Zone Substations (Pilbara Grid) or Power Generating Stations (Microgrids) to the network.

7.1.4 MV Fuses

MV fuses must be used to protect transformers. The RMU fused switch must be used to connect a RMU to a transformer less than 1000 kVA.

Full range fuses for ground mounted transformer protection are provided in Distribution Construction Standard G1-02 drawings.

7.1.5 Switching Capability of MV Ground Mounted type Switching Devices

The switching capability of ground mounted type MV switching devices is available in Appendix K.

Each switching point (where possible) shall be capable of remote operation regardless of the availability of communications, to allow future remote operation when communications are made available.

7.1.6 MV Switchboards

- 1) Dual fire-segregated switchboards are required for loads in excess of 4 MVA.
- 2) In consumer owned substations where Horizon Power has a bus section switch between two switchboards, operated with the bus section open (i.e. two feeders/feeder legs operating radially), mechanical interlocking or Horizon Power operational locking is required. This is to prevent closed ring operation via the consumer's switchboards while Horizon Power's bus section switch is open.
- 3) Where a consumer is supplied from a dedicated feeder/s, consideration shall be given to Horizon Power's requirement to carry out periodic maintenance of the circuit breaker and busbar at the zone substation, to provide alternative supply to the consumer.

7.2 Ground Mounted Transformers

Ground mounted transformers suitable for use in distribution substations are:

- MPS – 315 kVA and 630 kVA.
- Non MPS District – 315 kVA, 630 kVA and 1000 kVA.
- Non MPS Sole use – 315 kVA, 630 kVA and 1000 kVA.
- SPUD's – 25 kVA and 50 kVA
- THUD – 63 kVA

7.2.1 Transformer Installation Constraints

The following rules apply to transformer installations:

- 1) Maximum size of transformers that must be installed on the Microgrids are given in Appendix J.
- 2) Transformers may only be overloaded as directed by Planning, otherwise transformer is to be loaded to name plate.

- 3) Where transformers are housed within buildings, a maximum of two transformers can be housed in a single two-hour fire rated enclosure. Transformer pairs must be separated by a two-hour fire rated wall.
- 4) Piggy backing of transformers is prohibited.

7.3 Low Voltage Switchgear

7.3.1 LV Distribution Frames (LVDF)

LV distribution frames are connected via cable to the LV bushings of MPS transformers and terminals of the Fuse/MCCB of Non-MPS transformers. The incoming connection of the LVDF busbar is controlled via an underground LV combination link-switch disconnecter. The busbars supply a number of feeder ways which are fitted with LV combination fuse-switch disconnectors.

LVDFs mounted in a metal-clad kiosk are called Public Electricity Network Distribution Assemblies (PENDA) are available in three different configurations suitable for outdoor or indoor installation, these being:

- Type 1 with 630 A/phase busbar, fixed 2000 A combination link-switch disconnecter and four optional combination fuse/link-switch disconnecter slots.
- Type 2 with 1000 A/phase busbar, fixed 2000 A combination link-switch disconnecter and eight optional combination fuse/link-switch disconnecter slots.
- Type 3 with 1400 A/phase busbar, two fixed 2000 A combination link-switch disconnectors and twelve combination fuse/link-switch disconnecter slots.

The arrangement for each PENDA is to be decided by the designer when purchasing the selected PENDA Type through order sheets provided in the Low Voltage Underground DDC (LU):

- LU63 for the Type 1 PENDA
- LU64 for the Type 2 PENDA
- LU65 for the Type 3 PENDA

Note: Slot 3 in the Type 1 and Slot 4 in the Types 2 & 3 can hold two 160A combination fuse/link-switch disconnectors used for streetlight circuits. Further, designers to select fuses/link for the combination fuse/link-switch disconnecter as required.

LV combination fuse/link-switch disconnectors available:

- 160 A combination fuse-switch disconnecter that uses one whole slot, refer to LU69 of the DDC. This has a particular placement requirement in the LVDF, designer to ensure correct placement.
- 630 A combination fuse-switch disconnecter that uses one whole slot, refer to LU69 of the DDC.

- 910 A combination fuse-switch disconnecter that uses one whole slot, refer to LU68 of the DDC. Please note, the 910 A fuse disconnecter is designated for emergency response generator connection. A 500 A fuse is to be used.
- 1260 A combination link-switch disconnecter that uses two slot, refer to LU67 of the DDC.
- 2000 A combination link-switch disconnecter that uses two slots, refer to LU66 of the DDC.

Note: If the connection (cable) between the LVDF and a consumer's main switchboard is not protected, i.e. is not fused, then the consumer's main switchboard must be contiguous with Horizon Power's substation.

7.3.2 LV Non-MPS Fuse/MCCB

Non-MPS transformers have been fitted with LV combination fuse-switch disconnecter/MCCB's according to transformer size to isolate supply to either the Consumer or LVDF:

- 630 A combination fuse-switch disconnecter for 315 kVA transformers
- 1600 A MCCB for 630 kVA transformers, and
- 2500 A MCCB for 1000 kVA transformers.

7.3.3 LV Pillars

LV pillars are used as a point of connection between distribution mains cables and other distribution mains cables, consumer mains cables, service cables streetlight cables and unmetered supply cables.

There are two types of pillars:

- Mini-pillars and
- Uni-pillars.

The mini-pillar is a ground mounted structure with a detachable lid. It is designed to provide a connection point between the service cable and the consumer mains cable. The mini pillar is used to supply consumer's loads of <100 A and has one terminal for an incoming cable (on the bottom side) and three terminals for outgoing cables (on the top side). One service cable (25 mm²) is on the bottom side, with two consumer mains cables (25 mm²) and if required, one streetlight/unmetered cable (16 mm²) on the top side.

The uni-pillar is a larger ground mounted structure with a detachable lid. This pillar will accommodate up to three LV distribution mains cables and four service / streetlight / unmetered supply cables. Three LV distribution mains cables for interconnections or two LV distribution mains cables and one consumer mains cable (185 mm²). It provides options for a fused network connection point via a set of fuses, or can be configured to supply a single consumer with a load >100 A. Additionally, the uni-pillar has all of the mini-pillar's features.

Refer to Appendix C for earthing requirements for LV pillars.

7.3.4 LV Combination Fuse-Switch Disconnecter

LV combination fuse-switch disconnecter must be used on LV distribution frames to switch to protect outgoing LV distribution mains cables from LV distribution frame. They must be suitable for three phase switching (ganged).

7.3.5 LV Circuit Breaker Board (LVCBB)

In sole use substations, the consumer's switchboard (and consumer circuit breaker) must be contiguous with the Horizon Power's substation, unless the supply transformers are of the **Type II** having LV combination fuse-switch disconnecter's or MCCB's, so that the unprotected cable length is short. When the consumer's main switchboard cannot be contiguous with the substation and the consumer's load exceeds 400 A, switching of incoming cables from transformer to consumer service cables must be via a LVCBB.

Withdrawable LV air circuit breakers rated for use at 1200 A or 1600 A, must be fixed onto a LVCBB.

7.4 Consumer Mains Fuses

Consumer mains (for loads greater than 100 A) supplied via Uni Pillars or LV Wall Mounted Boxes must be protected by HRC fuses (rated 63 A, 200 A and 315 A) depending on the cable used.

Note: Only one consumer >100 A per Uni-Pillar, others will need to be <100 A.

7.5 Streetlight Fuses

Refer to Section 5.17.3.

8. MV Metering Units

When connecting to consumer owned substations, metering units are available for use at 11 kV, 22 kV and 33 kV for underground supplies and at 22 kV and 33 kV for overhead supplies.

MV metering units must be installed between two MV switches, one on the consumer's side and the other Horizon Power's side. The consumer's side MV switch must only be operated by Horizon Power. This principle also applies in any common busbar arrangement when connecting to consumer owned substations.

MV metering units must be installed contiguous to a RMU when installed on the ground as standalone units.

APPENDIX A. REVISION INFORMATION

(Informative) Horizon Power has endeavoured to provide standards of the highest quality and would appreciate notification of errors or queries.

Each Standard makes use of its own comment sheet which is maintained throughout the life of the standard, which lists all comments made by stakeholders regarding the standard.

A comment sheet found in **DM# 3754221**, can be used to record any errors or queries found in or pertaining to this standard. This comment sheet will be used when the standard is periodically reviewed and updated.

Date	Rev No.	Notes
24/04/2017	0	Initial Document Creation
25/11/2025	1	Updated to latest template, with changes as per comments sheet
	2	
	3	
	4	

APPENDIX B. GLOSSARY

AAC	All Aluminium Conductor.
AAAC	All Aluminium Alloy Conductor.
CBL	Calculated Breaking Load (of an overhead conductor).
Conductive	Shall include metallic and any reinforced or prestressed concrete parts of an installation.
Consumer mains	Those conductors between the Point of Supply and the consumers main switchboard.
Contiguous	Applicable to Consumer's main switchboard location with respect to a Substation. Contiguous means adjoining or very close to the Substation enclosure to ensure that cable/s connecting the substation equipment to the main switchboard has zero probability of being damaged with consequent risk to safety and reliability. In the case of Sole Use Substations, contiguous means also visible means of isolation.
Consumer (Customer)	Person or entity to which electricity is sold for the purpose of consumption.
Consumer Owned Substation	A substation where the Consumer is on a Medium Voltage tariff and owns and is responsible for all electrical equipment other than Horizon Power's metering equipment and any medium voltage switches connecting the substation to the Horizon Power network. For loads less than or equal to 4 MVA in Urban Area's, Horizon Power's and consumer ground mounted MV switchgear can be installed outdoors (refer to section 14.3.4.2 of the WASIR). For loads greater than 4 MVA in Urban Area's, Horizon Power's and consumer ground mounted MV switchgear must be installed in an enclosed room provided by the consumer (refer to section 14.3.4.1 of the WASIR). For loads in Rural Area's, where Horizon Power's network is overhead and with the approval of Horizon Power, an aerial switchgear option may be considered (refer to section 14.3.4.3 of the WASIR).
DADMD	Design After Diversity Maximum Demand – basic per consumer electrical load used for design on Horizon Power's electrical network.
Distribution Feeder	A medium voltage radial circuit forming part of the distribution system that is supplied from a zone substation.
Distribution Mains	Low voltage conductors emanating from a distribution substation.

Distribution System	Any apparatus, equipment, plant or buildings used, or to be used for, or in connection with, the transportation of electricity at a nominal voltage of less than 35 kV.
District Substation	A substation that has LV connections to the street mains. Horizon Power owns and is responsible for all electrical equipment within the substation. Modular Packaged Substations (MPS) complete with single transformer and LV switchgear, housed in a self- contained metal enclosure for maximum load of 630 kVA. For larger loads Non MPS arrangement comprising one or more transformers plus LV switchgear and MV switchgear as required.
Fire Rated	A minimum fire rating Level of 120/120/120.
Fire Resistant Surface	A surface having a fire rating Level of 120/120/120.
High Voltage (HV)	Steady state voltages greater than 35 kV.
Low Voltage (LV)	Low Voltage is defined as steady state voltages less than 1 kV.
LV ABC	Low Voltage Aerial Bundled Conductor.
Low Voltage Services (also called Service Cable)	Low voltage conductors that connect Distribution Mains to a Point of Supply.
Main Switchboard	A switchboard from which the supply to the whole electrical installation can be controlled (refer to <i>clause 1.4.92 of AS/NZS 3000</i>).
Medium Voltage (MV)	Steady state voltages equal to or greater than 1 kV and less than or equal to 35 kV.
MEN	Multiple Earthed Neutral Installation.
Modular Packaged Substation (MPS)	A District or Sole Use substation where the transformer and/or medium voltage switchgear and/or low voltage switchgear is housed in a self-contained metal enclosure/s connected as a single package.
Microgrids	The isolated networks in: <u>East Kimberley:</u> (Kalumburu, Wyndham, Kununurra, Lake Argyle, Warmun and Halls Creek), <u>West Kimberley:</u> (Derby, Camballin/Looma, Fitzroy Crossing, Yungngora, Bidyadanga, Broome, Beagle Bay, Djarindjin/Lombadina and Ardyaloon), <u>East Pilbara:</u> (Marble Bar and Nullagine), <u>West Pilbara:</u> (Onslow),

	<u>Gascoyne/Midwest:</u> (Exmouth, Coral bay, Carnarvon, Denham, Gascoyne Junction, Meekatharra, Cue, Mt Magnet, Yalgoo, Wiluna and Sandstone) and <u>Esperance:</u> (Esperance, Norseman, Hopetoun, Laverton, Leonora and Menzies).
Pilbara Grid	The interconnected network located in the Pilbara region.
PILCSWA	Paper Insulated Lead Cable Sheath Wire Armoured.
Point of Supply	The junction of the Consumer Mains with conductors of an electrical Distribution System.
Policy	A brief, straightforward statement indicating intention and direction, and enabling the decision-making process.
Preplanning	Means thinking, preparing and deciding about how to get something done before starting on it.
Procedure	Prescribed means of accomplishing policy through a series of steps or processes.
Regions	Horizon Power's Regional Business Units in Broome, Karratha, Carnarvon and Esperance.
Safety in Design	is a process defined as the integration of hazard identification and risk assessment methods early in the design process to eliminate or minimise the risks of injury throughout the life of a structure or system being designed.
SC/AC	Aluminium-clad steel conductor.
SC/GZ	Steel (galvanised) conductor.
Site	All parts of the works that are the subject of the offer and acceptance between Horizon Power and the Consumer for the provision of electrical services.
Sole Use Substation	A substation established for a single consumer and which has no LV interconnection with the street mains. Horizon Power owns and is responsible for all electrical equipment within the substation. Non MPS arrangement comprising one or more transformers plus LV switchgear and MV switchgear as required.
Structural Engineer	A qualified person who is engaged by the Consumer to design and prepare structural documentation for the substation enclosure to resist loads and forces as outlined in AS/NZS 1170.2 where relevant.

Substation (Distribution Substation)	A collection of switchgear and/or a transformer/s on a single site (which may or may not be screened or enclosed) connected to the Distribution System.
SWEWR	Single Wire (with) Earth Wire Return. A single-phase overhead supply. Similar to the 'SWER' (single-wire earth return) used in other utilities, except an under-slung earth wire is used.
Terminal Substation	A bulk transmission point connecting transmission lines at the same voltage level (220 kV) and also step down and distribute power to Zone Substations e.g., Karratha Terminal and Hedland Terminal.
Transmission System	Any apparatus, equipment, plant or buildings used, or to be used, for, or in connection with, the transportation of electricity at nominal voltages of 66 kV or higher, and which forms part of the Pilbara Grid.
WASIR (ex WADCM)	Western Australian Service and Installation Requirements (old Distribution Connections Manual).
WAER	Western Australian Electrical Requirements.
Zone Substation	A substation that transforms electricity from a transmission system voltage to a distribution system voltage. E.g., Murdoch Drive and Pegs Creek.

APPENDIX C. EARTHING REQUIREMENTS

C.1 Earthing Design Objectives

The design of an earthing system must ensure that:

- 1) All conductive parts consisting of metalwork and equipment within the reach of a person standing on the ground are effectively earthed. This is to ensure hazardous touch, step and transfer voltages that can occur during fault conditions are mitigated to satisfactory risk levels;
- 2) A low impedance earth is available to effectively carry power frequency earth fault currents to earth. This facilitates the operation of protective equipment, to isolate faults and also to carry transient currents caused by lightning and switching surges;
- 3) Future increase in network earth fault levels are considered. It is suggested the fault current at the time of design is increased by 20%, capped at the primary plant ratings stated in the *Technical Rules HPC-9DJ-01-0001-2012*; and
- 4) Testing and future modifications, particularly those below ground, can be carried out with minimal interruption to installation operation.

Earth conductors, electrodes and connections (joints) must be designed and constructed to ensure that:

- 5) Fault currents are carried to earth without damage to these components;
- 6) Possibility of inadvertent mechanical damage and interference is minimised; and
- 7) Corrosion is minimised.

C.2 Essential Requirements

In order to achieve the objectives in Appendix C.1, a suitable earth resistance value must be attained to ensure that the probability of fatality from hazardous touch, step and transfer voltages is as low as reasonably practical (ALARP). For boundary calculations a risk level of 1×10^{-6} must be used in the design process.

The risk must be assessed in accordance with Horizon Power's *Distribution Line Earthing Standard: HPC-9DC-08-0001-2012* and *Distribution Power Lines in the Vicinity of Conductive Installations Standard: HPC-9DC-15-0001-2012* and must be acceptable to Horizon Power.

C.3 Combined Earthing System

For distribution substations, a combined earthing system must be used, where the MV and LV earthing systems are interconnected at 'an earth terminal bar' (*DCS G-6-11 and G-6-12*) or a 'grading ring'. Details of earthing connections are provided in G-6.

The combined earthing system must have a resistance sufficiently low (generally ≤ 1 Ohm may be sufficient but the risk level must be estimated) to ensure that the design objectives of Appendix C.1 are fulfilled. In certain cases, an earth resistance > 1 Ohm may provide an acceptably low risk level at low cost.

C.3.1 Ground Mounted Equipment

A grading ring must be installed around ground mounted equipment installations to mitigate hazardous touch voltages. The grading ring is installed around equipment that is earthed and subject to hazardous voltage rise during fault conditions. It is installed around the equipment at a distance of 750 mm (with doors open) and buried at a depth of 500 mm. The grading ring is connected to two earth electrodes which are installed diagonally at opposite ends, which makes up the earthing system.

Two electrodes must be used to ensure that there is adequate redundancy in the event that one electrode is disconnected from the grading ring for some reason including testing. A maximum resistance of 10 Ohms per electrode is permitted to allow upstream protection to operate correctly. The grading ring is to provide an equipotential area for a person touching the equipment only, and protects only against the touch voltage hazard of touching that particular piece of equipment.

C.3.2 Difficulty in getting the required Combined Earth Resistance

The number of consumer installation electrodes associated with the LV MEN system connected to the substation will influence the combined resistance value. Where there are an insufficient number of consumers connected, it may be difficult to obtain a combined resistance value low enough to attain a low risk level.

Low resistance earths can be installed at pillars located away from the substation, where the soil resistivity may be conducive to obtaining a low resistance earth, and may also be beyond the zone of influence of the substation earth. These may be 'deep earths' (typically 30 m) which extend to a depth where there is a lower resistivity layer.

C.4 Separate MV and LV Earthing Systems

Where a combined earthing configuration does not provide for safe touch, step and transfer voltages, segregation of MV and LV earthing systems must be considered, but this is not the preferred option. The separation required can be determined as per *Distribution Power Lines in the Vicinity of Conductive Installations Standard: HPC-9DC-15-0001-2012*.

By separating the MV and LV electrodes, the transfer of EPR from the MV system to the LV system can be controlled. However, the integrity of the separated MV and LV earthing systems must be maintained during the life of the installation. Therefore, they must be captured in Horizon Power's Geospatial Information system (GIS). This will minimise the possibility of other earthed structures being installed within the physical separation distance.

C.4.1 Issues with Separated MV and LV Earthing Systems

Separated MV and LV earthing systems may not be effective in controlling hazardous step and touch voltages in the event of a MV line to LV line contact at the distribution transformer, or on a conjoint MV/LV line section. The following options may be considered for protecting against MV to LV contacts:

- Ensuring the configuration of LV lines at the distribution transformer poles is such that MV to LV contact is unlikely; and
- Replacing bare LV conductors over conjoint MV/LV spans with LV buried cable and LV ABC cable.

When the LV earthing system is segregated from the MV earthing system at a distribution substation, the total earth impedance of the LV earthing system (including associated MEN earths) must be sufficiently low to ensure that the MV feeder protection will operate in the event of a MV winding to LV winding fault.

LV insulation breakdown which can cause the transformer tank to be live will not be cleared by protection and persist until it becomes a hazard. To mitigate this hazard, a low voltage gapless surge arrester must be fitted between the low voltage neutral and transformer tank.

C.5 Size of Earthing Conductors

The size of earth conductors selected must suit the determined Fault Current levels as set out in *Table A 13.1 - Standard Distribution Equipment Ratings* and *Table A 13.2 - Standard Zone Substation Ratings of the Technical Rules*. Specific conductor sizes can be as per *AS/NZS 3008.1.1- Section 5*.

Earthing Conductors:

- 70 mm² – 10.2 kA/1 s or 5.85 kA/3 s
- 120 mm² – 17.1 kA/1 s or 9.86 kA/3 s

C.6 Conductive Structures in the Vicinity of Substations

An earthing design must take into consideration the close proximity of continuous metallic objects that can give rise to transferred voltages. Transferred voltage is the voltage rise of an earthing system during a fault, transferred by means of a connected conductor (for example, a metallic cable sheath, metallic pipelines, metallic fences or rail) into areas with low or no voltage rise relative to earth. This results in voltage difference occurring between the connected conductor and its surroundings.

When the voltage rise on the earthing system is transferred by metallic pipes (water or gas), or a fence earthed at regular intervals along its length, such conductive parts will rise to a voltage somewhere between the maximum and minimum voltage rise affecting it.

When such metallic structures are insulated from the ground, the maximum voltage transferred to the structure will be maintained along the structure.

Such conductive structures must be separated from the substation earth grading ring by at least two metres. Metal bollards installed outside substations must be located at least two metres away from the earth grading ring. If located within two metres, the bollard must be bonded to the grading ring and included within the grading ring.

Telecommunications plant, gas pipelines and metallic fences can be subject to transfer voltages from substation installations. Refer to the *Standard – Power Lines and Cables in the Vicinity of Conductive Installations: HPC-9DC-07-0001-2012*, which provides guidance on calculating the EPR and LFI (Low Frequency Induction) on such conductive structures.

APPENDIX D. DISTRIBUTION SYSTEM OVERVIEW

D.1 System Configuration

Steps in supplying energy to consumers are explained in the clauses below.

D.1.1 Power Generating Stations

Horizon Power manages 38 systems: the Pilbara Grid in the Pilbara and the connected network between Kununurra, Wyndham and Lake Argyle in the Kimberley, and 34 stand-alone systems in regional towns.

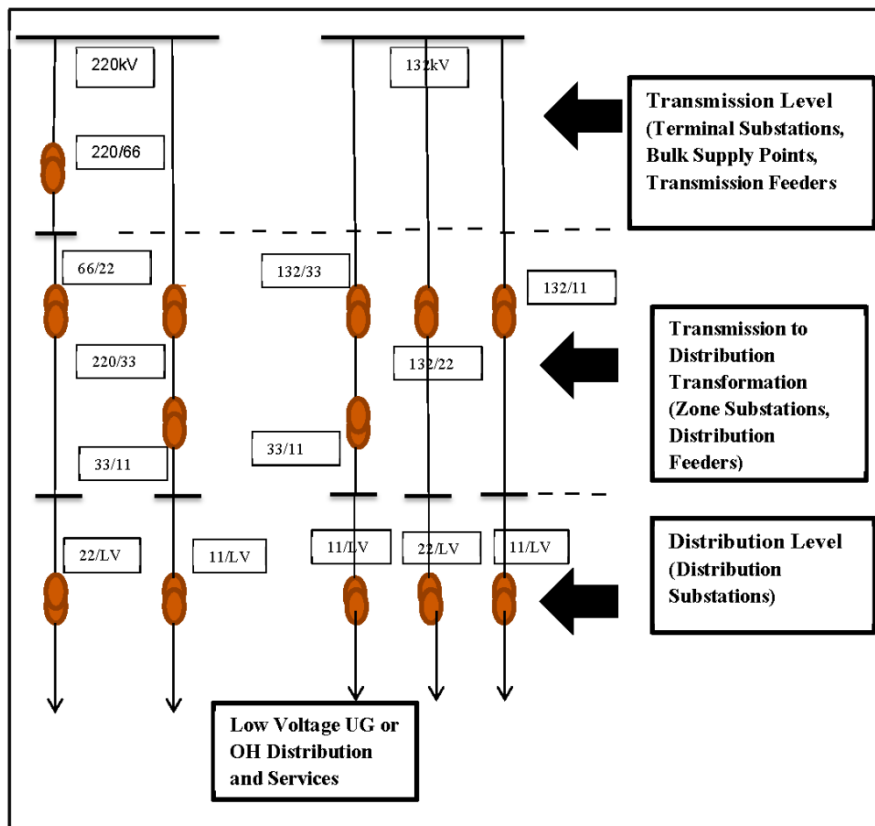
D.1.2 Transmission System

Horizon Power has two transmission systems, the one in Pilbara Grid, and the other between Kununurra, Wyndham and Lake Argyle in the Kimberley. The Pilbara Grid consists approximately 464 km of overhead transmission lines and 10 substations transporting energy from Power Generating Stations to major load centres via transmission line networks that operate at voltages of 66 kV, 132 kV and 220 kV. At major load centres supply may be given directly to a major consumer at transmission voltage (e.g. 66 kV) or transformed at zone substations to medium voltages for distribution purposes.

D.1.3 Distribution System

Energy is taken from zone substations (in the Pilbara Grid) or directly from Power Generating Stations (in the Microgrids) at a voltage of 33 kV, 22 kV or 11 kV and supplied to consumers by a combination of medium voltage feeders, distribution substations and distribution mains. Major consumers may elect to take supply at medium voltage.

Figure 7 shows the Functional Components of a distribution system and their position and role in the overall system.



D.2.3 Distribution Feeders

The distribution feeder is a significant component of the distribution network. In the Pilbara Grid, it is the link between a zone substation and the consumer. In the Microgrids, it is the link between the power generating station and the consumer.

A consumer may be supplied directly from a distribution feeder, or via a distribution substation and the LV network. There are two types of distribution feeder:

- Overhead line
- Underground cable

D.2.4 Distribution Substations

Distribution substations transform medium voltage to low voltage (415/240 V). There are a number of different types of substations in the distribution network.

- 1) Pole mounted substations (limited to 315 kVA capacity).
- 2) Ground mounted substations:
 - District Substations (MV switchgear, transformers and LV switchgear owned by Horizon Power with LV street feeds).
 - Sole use Substations (MV switchgear and transformers owned by Horizon Power with no LV street feeds).
 - Consumer owned substations (MV switchgear connecting to Network owned by Horizon Power with consumer being supplied at medium voltage).

D.2.5 Distribution Mains

Distribution mains or street feeds, distribute power at low voltage.

D.2.6 Low Voltage Services

All new low voltage service connections and upgrades to existing overhead service cables are underground, even if the service cables are to be connected to overhead distribution mains.

APPENDIX E. DADMD FOR TOWNS AND DIVERSITY FACTORS

Table 10 – List of Towns with DADMD Values (extracted from DM# 14298709 – ADMD Review)

Town	Residential DADMD (kVA)	Town	Residential DADMD (kVA)
East Kimberley			
Halls Creek	4	Lake Argyle	4
Kalumburu	4	Warmun	3
Kununurra	7	Wyndham	4
West Kimberley			
Ardyaloon	4	Derby	6
Beagle Bay	3	Djarindjin/Lombadina	3
Bidyadanga	3	Fitzroy Crossing	5
Broome	6	Yungngora	4
Camballin/Looma	3		
East Pilbara			
Marble Bar	3	Port Hedland (Note 1)	8
Nullagine	4	South Hedland (Note 1)	8
West Pilbara			
Karratha - Single lot	8	Onslow	6
- Duplex	7.5	Point Samson	7
- Triplex	5.5	Roebourne	6
- Quadr'ex	3.5		
Gascoyne/Midwest			
Carnarvon	5	Meekatharra	5
Coral bay	5	Mt Magnet	5
Cue	3	Sandstone	3
Denham	5	Wiluna	3
Exmouth	6	Yalgoo	4
Gascoyne Junction	4		

Town	Residential DADMD (kVA)	Town	Residential DADMD (kVA)
Esperance			
Esperance	7	Leonora	6
Hopetoun	5	Menzies	3
Laverton	5	Norseman	4

Note 1: Where multiple occupancy lots are developed in towns with DADMD of 8 kVA, the corresponding DADMD values shown for Karratha apply.

The design DADMD values are based on measured DADMD values with an allowance for potential growth over the life of the cable asset. This allowance reflects the range of climatic zones, socio-economic and expansion potential factors applicable in each town.

The DADMD values (Table 10) and Diversity Factors (Table 11) are applied as follows:

- 1) A diversity factor is applied where there are less than 50 consumers connected to a transformer. In such case the transformer load is estimated as equal to: $\text{<DADMD Value>} \times \text{<diversity factor>} \times \text{<number of consumers>}$.
- 2) When there are 50 consumers or more connected to a transformer, the load is estimated as equal to: $\text{<DADMD Value>} \times \text{<number of consumers>}$.
- 3) For distribution mains emanating from a transformer, the total load on any mains cable is estimated as per clauses 1) and 2) above, taking the number of consumers connected to the distribution mains, the relevant DADMD value and the diversity factor.

Table 11 – Diversity Factors

No of consumers	Diversity factor
1	3.0
2	2.5
3	2.
4	1.75
5	1.6
6	1.5
7	1.43
8	1.38
9	1.33
10	1.3
11	1.27
12	1.25
13	1.23
14	1.21
15	1.2

No of consumers	Diversity factor
16	1.19
17	1.18
18	1.17
19	1.16
20	1.15
21-22	1.14
23-24	1.13
25-26	1.12
27-28	1.11
29-31	1.10
32-35	1.09
36-40	1.08
41-46	1.07
47-49	1.06
≥50	1.0

APPENDIX F. OVERHEAD LINE DESIGN PRINCIPLES

F.1 Design Principles

The main technical aspects in the design of overhead lines must ensure that:

- 1) mechanical load forces do not exceed the strength of structures or other components, and
- 2) clearances are adequate – between the conductors and the ground or from other objects in the vicinity of the line, as well as between the conductors and circuits themselves so that conductor clashing does not occur.

The line must comply with these requirements over the full design range of weather and other load conditions that could reasonably be encountered – when the line is cold and taut, when at its maximum design temperature and consequently when conductor sag is at a maximum, and under maximum wind conditions. The load conditions to be considered for Horizon Power lines are set out in the following sections, where applicable wind pressures, temperatures and load factors are provided.

F.2 Design Basis

The limit state design approach as per *AS/NZS 7000* must be used with a reliability based (risk of failure) approach. This approach matches component strengths (modified by a factor to reflect strength variability) to loads, calculated on the basis of an acceptably low probability of occurrence.

F.2.1 Limit State Design

Limit state design approach takes into account statistical variations in loads, and also variation in material properties of structures such as poles. This variation is matched against a desired level of reliability.

Limit state loads are compared with the limit state strength (which includes a deflection limit state). The limit state strength needs to be greater than the limit state loads for each load combination. Also, the design deflection limits need to be greater than the load effect on deflection.

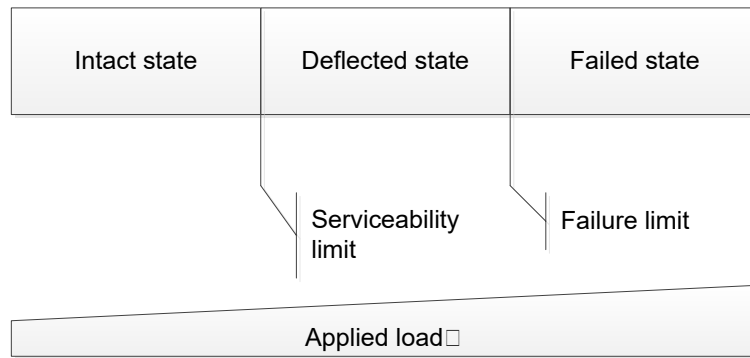


Figure 8 – Application of Conductor Limit States

Limit state principles apply to components of an overhead power line, including poles, conductors and insulators, and also to electrical clearances. All electrical components have properties which vary with manufacturing and weather conditions.

F.2.1.1 Limit State Design Loads

Limit state loads must include variable factors (load multipliers) which account for the uncertainty in the magnitude of the load from various effects such as wind, component weight, etc..

F.2.1.2 Limit State Design Strength

Limit state design strength considers modification factors for durability, processing effects, fatigue, load sharing, temperature effects, duration of load creep etc., as appropriate, as well as the more general component strength factor.

F.2.2 Design Wind Speed

A complete coverage of wind loading is given in *Appendix B of AS/NZS 7000*.

The design site wind speed is taken as –

$$V_Z = V_{50} \times M_d \times M_{Z.cat} \times M_s \times M_t$$

where:

- $M_{Z.cat}$ is the gust wind speed multiplier for terrain category, based on *AS/NZS 1170.2*
- M_d is the wind direction multiplier (taken as equal to 1, for wind in any direction)
- M_s is the shielding multiplier is taken as equal to 1 ignoring the effects of shielding provided by buildings and other structures

- M_t is the topographic multiplier for gust wind speed normally taken as 1
- V_{50} is the basic regional wind velocity for the region corresponding to the 50 year return period (39, 52 and 60 m/s for regions A, C and D respectively). Please note that for V_{100} , the corresponding values are 41, 56 and 66 m/s. (Refer to Table 15 for wind regions)
- **Note:** As per *Appendix B3 of AS/NZS 7000*, cyclonic wind amplification factors are not applicable to Regions C and D.

The design pressure q_z is be calculated as follows:

$$q_z = 0.6V_z^2 \times 10^{-3} \text{ kPa}$$

A few towns such as Marble Bar and Ivanhoe fall into Region B, however considering the small number of assets in these areas, they will be assumed to be located in Region C, for ease in performing calculations.

F.2.3 Wind Loads

Wind loads must be applied to all elements of an overhead line.

The design wind pressure q_z for different types of surfaces can be calculated by multiplying with the drag force coefficient for that particular surface (C_d).

$$q_z = 0.6V_z^2 \times C_d \times 10^{-3} \text{ kPa (Refer to Appendix F.2.4)}$$

The drag force coefficients (C_d), for various equipment, are given in Table 12.

Table 12 – Drag Coefficients for Components

Equipment	Suggested C_d Factor
Round Poles Smooth	1.2
Round Poles Rough (including 12-sided poles)	1.3
Octagonal pole	1.4
Transformers	2.2
Regulators	1.2
Conductors (assumed SRF =1)	1.0
Cross-arms (end/wide face)	1.2/1.6
Insulators (post/pin/strain)	1.2

Table 13 – Terrain Height Multiplier

Terrain Height Multiplier ($M_{z,cat}$)				
Height (m)	Category 1 Region C, D	Category 2 Region C, D	Category 3 Region C, D	Category 4 Region C, D
8	0.98	0.98	0.854	0.854
10	1.0	1.0	0.89	0.89
12	1.028	1.028	0.926	0.914
14	1.056	1.056	0.938	0.938
16	1.084	1.084	0.962	0.962

Note: Terrain Multiplier for Region A is taken as 1 for structures up to 60 m height (*Figure B.4 of AS/NZS 7000*). Terrain Categories are defined in Table 14).

Table 14 – Terrain Categories

Terrain Category	Description
1	Exposed open terrain
2	Open terrain, water surfaces, grassland with few well scattered obstructions having heights generally from 1.5 m to 10.0 m
3	Terrain with numerous closely spaced obstructions 3 m to 5 m high such as areas of suburban housing
4	Terrain with numerous large, 10 m to 30 m high and closely spaced obstructions such as large city centres and well developed industrial complexes

F.2.4 Regional Wind Speeds and Wind Pressures

Regional wind speeds and wind pressures that are used to calculate loads on structural components are given in Table 15. These use 1.0 for all multipliers ($M_{z,cat}$, M_d , M , and M_t).

Table 15 – Regional Wind Speeds and Wind Pressures

Region	Description	Wind Pressure					
		V ₅₀ 50 year return period			V ₁₀₀ 100 year return period		
		(Pa)	(km/h)	(m/s)	(Pa)	(km/h)	(m/s)
A	Esperance, Kununurra and any other area beyond 200 km from the coast	900	140	39	1000	148	41
B	Marble Bar, Wyndham	1200	159	44	1400	173	48
C	Broome, Derby	1600	187	52	1900	202	56
D	Port Hedland, Karratha, Onslow, Carnarvon	2150	216	60	2600	238	66

F.2.5 Span Reduction Factor (SRF)

The span reduction factor takes into account the spatial characteristics of wind gusts and inertia of conductors. When determining wind pressure on conductor, for conductor tension calculations, SRF for the related tension section must be used:

- Region A, where spans are 200 m or less:

$$SRF = 1$$

- Region A, where spans exceed 200 m, calculate SRF using the formula:

$$SRF = \left(\frac{\text{span length} - 200}{1000} \right) \times 0.3125$$

- Regions C and D, calculate SRF using the formula:

$$SRF = 0.59 + 0.41e^{\left(\frac{-\text{span length}}{210} \right)}$$

The calculated result should be checked against the following graphs:

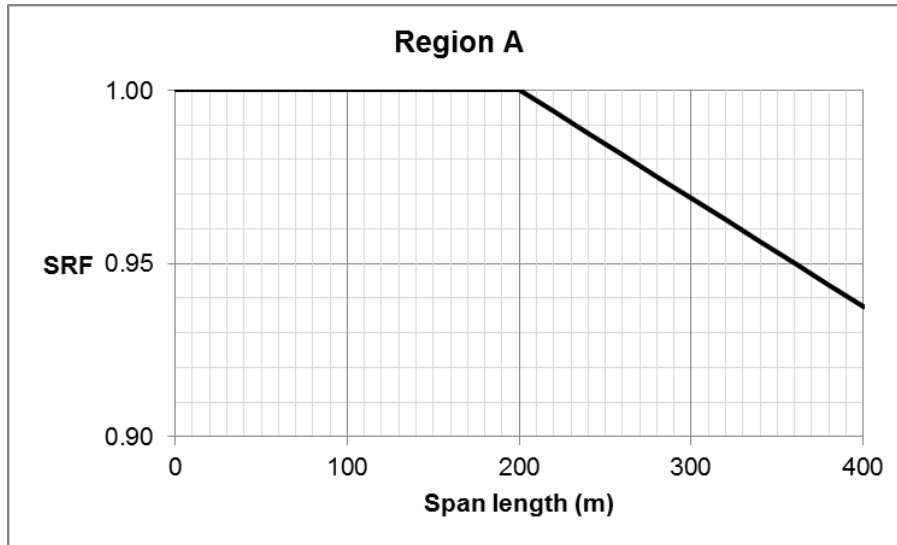


Figure 9 – Span Reduction Factor (Region A)

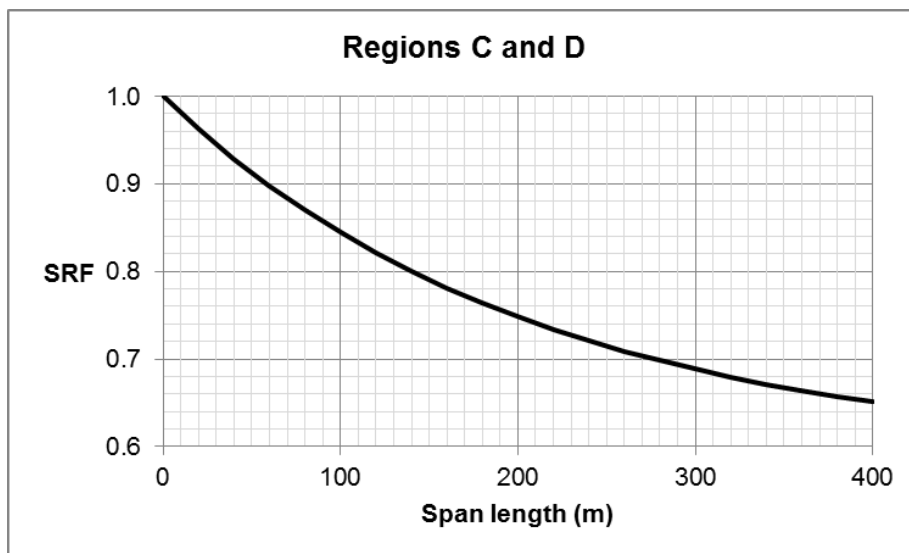


Figure 10 – Span Reduction Factor (Region C & D)

F.2.6 Temperature

Ambient temperature for Region A is 40°C (summer) and 15°C (winter), and for Regions C and D 45°C (summer) and 35°C (winter).

Maximum conductor temperature must not exceed 75°C, to ensure that electrical clearances are maintained.

F.2.7 Strength and Serviceability Limit States

F.2.7.1 Ultimate Strength Limit State

Ultimate limit state is the maximum load carrying resistance of a structure or structural element. It is associated with collapse or other forms of structural failure due to excessive deformation, loss of stability, overturning, rupture or buckling.

F.2.7.2 Serviceability Limit State

Serviceability limit state is the state beyond which specified service criteria for a structure or a structural element is no longer met. In this state, a structure and all its components mechanically function whilst maintaining prescribed electrical clearances.

F.2.7.3 Strength Reduction Factors

The strength reduction factor (ϕ) takes into account variability of material and workmanship for structural components used in overhead lines as well as some modification factors. Table 16 gives strength reduction factors applicable to different components of an overhead line.

Table 16 – Strength Reduction Factors (as per Table 6.2 of AS/NZS 7000)

Component of Overhead Line	Limit State	Strength Reduction Factor (ϕ)
Steel Poles and Cross-arms	Strength	0.9
Bolts, Nuts and Washers	Strength	0.9
**Untreated wood poles and Cross-arms	Strength	0.5
**Untreated wood poles and Cross-arms	Serviceability	0.3
**Fully treated wood poles and Cross-arms	Strength	0.5 to 0.8
**Fully treated wood poles and Cross-arms	Serviceability	0.4
Fittings and pins, forged or fabricated/cast	Strength	0.8
Fittings, cast	Strength	0.9
Porcelain or glass cap and pin string insulator units	Strength	0.8
Porcelain or glass insulators (other than cap and pin string insulator units)	Strength	0.8

Component of Overhead Line	Limit State	Strength Reduction Factor (ϕ)
Synthetic composite suspension or strain insulators	Strength	0.7
Synthetic composite line post insulators	Strength	0.9 (max design cantilever load)
Conductors	Serviceability	0.5 of CBL
Stays	Strength	0.8

** - legacy equipment and should be considered for replacement

F.2.8 Load Combinations

F.2.8.1 General

In the design of an overhead line, a range of loading conditions must be considered. This provides due consideration for all possible service conditions that the line and individual supports may be subjected to, throughout its service life. Load factors are used to reflect the uncertainty in the derivation of the particular load. The value of each load component must be calculated separately for each loading condition.

These must include the potential effects of differential wire tensions across the structure due to the effects of unequal spans and wind pressures that may exist at the structure.

Ultimate and serviceability limit state loads are to be considered in determining structure deflections and strength ratings.

For loadings less than the serviceability limit, the deflections must be limited to a value that ensures that electrical clearances are not infringed.

F.2.8.2 Permanent Loads

Self-weight of structures, insulators, other fixed equipment and conductors resulting from adjacent spans act as permanent loads.

Vertical loads on poles foundations, cross-arms, insulators and fittings is the vertical force due to their own mass plus the mass of all ancillaries and attachments (G_s).

Vertical loads of conductors/cables and attachments such as marker balls, spacers and dampers form the design weight span (G_c).

F.2.8.3 Load Conditions and Load Factors

The following load conditions and factors must be used to determine the loading on structures:

- W_n is the wind load based on a selected wind period.
- F_t is the load on structure due to intact horizontal component of conductor tension in the direction of the line for the appropriate wind load. This tension must be calculated using the appropriate temperature for the load condition.
- G_c is the vertical load due to conductors.
- G_s is the vertical load due to cross-arms, insulators and fittings.

F.2.8.4 Maximum Wind and Maximum Weight

Determined by the equation:

$$W_n + 1.25F_t + 1.1G_s + 1.25G_c \text{ (Table 7.3 of AS/NZS 7000)}$$

The conductor tension must use a temperature of 15°C, as per the short duration load of Table 18.

F.2.8.5 Maximum Wind and Uplift

Determined by the equation:

$$W_n + 1.25F_t + 0.9G_s + 1.25G_c \text{ (Table 7.3 of AS/NZS 7000)}$$

The conductor tension must use a temperature of 5°C as per the sustained load condition of Table 18.

F.2.8.6 Everyday Condition (sustained load)

Determined by the equation:

$$1.1F_t + 1.1G_s + 1.25G_c \text{ (Table 7.3 of AS/NZS 7000)}$$

The conductor tension must use a temperature of 5°C as per the sustained load condition of Table 18.

F.2.8.7 Serviceability (deflection/damage limit)

Determined by the equation:

$$1.0F_t + 1.1G_s + 1.1G_c \text{ (Table 7.3 of AS/NZS 7000)}$$

The conductor tension must use a temperature of 5°C as per the sustained load condition of Table 18.

F.2.8.8 Failure Containment Load

These loads are as a result of the failure of an adjacent structure. For the failure containment condition, supports must be designed for the equivalent longitudinal loads resulting from conductors on the structure being broken with a minimum coincident wind pressure of 0.25 times the ultimate design wind pressure (W_n). The unbalance tension (F_b) resulting from these broken conductors is the residual static load (RSL) in the aerial phase conductors after severance of a conductor, or the collapse of a conductor support system. For aerial conductors supported by suspension insulator strings, an RSL factor of 0.7 must be used, otherwise 0.8 is used.

The unbroken conductors will be subject to the “Intact Conductor Tensions (F_t)”.

F_b and F_t tensions for conductors are based on the temperature corresponding to the everyday load condition with a minimum nominal wind pressure of 0.25 times the ultimate design wind pressure.

The conductor tension must use a temperature of 15°C as per Table 19. Accordingly, total load on a structure is:

$$0.25W_n + 1.25F_t + 1.1G_s + 1.25G_c + 1.25F_b$$

F.2.9 Pole Foundations

Embedment depths have **NOT** been calculated with the Brinch Hansen method as stated in *AS/NZS 7000*. They have been calculated using a Winkler-Spring model (COM624P developed by the US Federal Highway Administration). The Brinch Hansen method in many cases is excessively conservative, and in some cases un-conservative. A strength reduction factor of 0.7 has been used for foundations.

Embedment depth may need to be increased if:

- sloping ground is present, or
- trenches and open excavations are present close to the pole.

The soil parameters defined as ‘cohesive’ are provided in Table 17. These have been used to calculate the required pole embedment.

Table 17 – Assumed Soil Properties

Soil category	Cohesive
Density (kN/m ³)	20
Internal friction angle (°)	0
Cohesion (kPa)	53
SPT blow count	9

The standard foundation will be adequate if the soil is equal or better than the above descriptions, as confirmed by an experienced geotechnical or structural engineer. If the soil condition is worse than the cohesive case, different solutions are required.

Where a geotechnical engineer is engaged to investigate soil properties, they should be given specific requirements to fulfil, corresponding to the parameters above. Failure to give specific requirements may be costly, as the engineer may investigate far more than what is required. The required parameters are:

- Soil description (i.e. medium density sand, stiff clay, etc.),
- SPT blow count at each layer within the expected foundation depth,
- Depth of water table (expected high level)
- If the line is particularly important the following additional measurements are recommended
- Soil internal friction angle (dry & saturated)
- Soil density (dry & saturated)
- Cohesion (dry & saturated)

Backfill should be mechanically compacted in 300 mm layers. If compaction is by hand, it should be done in 150 mm layers. Where concrete backfill is used, it should be mechanically vibrated, and have a minimum strength of 25 MPa. Concrete cures over several days, and poles set in concrete should not be loaded during this period. Where it is required to load poles immediately, an approved polyurethane foam backfill may be used. Foam must have a minimum compressive strength of 750 kPa, and be self-extinguishing.

F.2.10 Conductors

F.2.10.1 Conductor Sag and Tension

Conductor tension will be increased due to wind and reduced due to the following factors causing increase in sag:

- Increase in temperature.
- Creep due to ageing.
- Pole movement due to foundation collapse or stay relaxation.

F.2.10.1.1 Conductor Tension Limits

Tension limits for conductors to consider the following temperature and wind conditions specified in Table 18.

Table 18 – Temperature and Wind Conditions for Limit State Loads

Conductor load conditions	Temp	Wind
Sustained load condition	5°C	0 kPa (no wind)
Short duration load condition	15°C	Maximum Wind for Region
Intact conductor tension under average wind	15°C	0.5 kPa
Failure containment loads	15°C	0.25 times Maximum Wind for Region

F.2.10.1.2 Conductor Stress and Fatigue

Fatigue failure of overhead line conductors occurs almost exclusively at points where the conductor is secured to fittings. The cause of such failures is dynamic stresses induced by vibration combined with high static stresses. It is therefore necessary to limit both the static and dynamic stresses if the conductor is to have acceptable fatigue endurance and thereby provide required life cycle performance.

In order to prolong the life of conductors, design tensions must be limited to below 50% of CBL. By using appropriate clamping of conductors to insulators static stresses can be controlled and dampers are used to control dynamic (vibration) stresses. Table 19 indicates recommended maximum horizontal tension as a percentage of CBL considering both static and dynamic stresses. The following must be considered in the application of Table 19:

- 1) The horizontal tensions are applied at 15°C
- 2) The table is a guide only and need not apply to situations where proven line performance indicates a lower or higher tension as appropriate.
- 3) Smaller diameter conductors will vibrate at higher frequencies and reach their fatigue in a shorter time however such conductors are easier to damp effectively.
- 4) Increased span length requires increased vibration protection.
- 5) Vibration dampers are purpose built devices, that reduce conductor vibration and armour rods are used to reduce damage to conductor caused by vibration.
- 6) For new conductors that are pre-stressed, the tension limits in table may be applied to the after creep (final) tension.
- 7) For new conductors that are over tensioned, the tension limits in table may be applied to the initial stringing tension, especially if the sagging is carried out over the colder months.

Table 19 – Conductor Horizontal Tension – Everyday Load (based on *Table Y1 of AS/NZS 7000*)

Conductor Type	Base Case tension (% of CBL)	Recommended incremental Increase in horizontal tension (% CBL)							Recommended maximum horizontal tension (% of CBS)
		Static Stress Considerations			Dynamic Stress Considerations				
		Clamp Category*			Damping/Terrain Category				
					No Dampers		Fully damped all categories		
					Terrain Category				
A	B	C	1	2	3,4				
AAC	18	0	1.5	2.5	0	2	4	6.5	27
AAAC	15	0	1.5	2.5	0	2	4	6.5	24
ACSR	17	0	1.5	2.5	0	2	4	7.5	27
SC/GZ SC/AC	10	0	2.5	5.0	0	5	10	16	31
Clamp Category	Type A	Short trunnion clamp, post or pin insulator with ties (without armour rods)							
	Type B	Post or pin insulator (clamped or tied) with armour rods or shaped trunnion clamps with armour rods							
	Type C	Helically formed armour grip with elastomer insert or helically formed ties with armour rods							
Terrain Category	As per Table 14								

F.2.10.2 Conductor Span Ratios

Large differences in span lengths of adjacent spans can result in significant tension differences across intermediate structures, which may not be able to be equalised by the movement of the pole top and may cause ties or pins to fail.

- In urban situations adjacent spans must be limited to a ratio of 2:1. For example, on a typical 50 m span length, adjacent spans must not be shorter than 25 m
- In rural situations adjacent spans must be limited to a ratio of 5:4. For example, on a typical 110 m span length, adjacent spans must not be shorter than 80 m for AAAC conductors. For SC/AC conductors, span ratio must be limited to 2:1.

F.2.10.3 Conductor Strain Sections

Strain sections not to exceed 1.5 to 2.0 km for AAC or AAAC and 3.0 km for SC/AC conductors to prevent tensioning errors during construction.

F.2.10.3.1 Ruling Span

Designs must specify the ruling span for each strain section and the distance between each pole on the design.

The ruling span is calculated using the following formula:

$$RS = \sqrt{\frac{(S1^3 + S2^3 + S3^3 + \dots)}{(S1 + S2 + S3 + \dots)}}$$

where S indicates the relevant spans in the strain section, i.e. from strain to strain structure.

Note: The ruling span is not the average span length.

The *Distribution Stringing Table Standard (HPC-9DJ-07-0002-2023 DM# 42708883)* is to be used when determining the conductor stringing tension.

F.2.10.3.2 Slack Span

- 1) Slack Spans are generally used in two (2) scenarios:
 - a) To join a spur line to its main line where:
 - i. staying the main line to support the full tension of the tee-off line, is either not physically possible or very difficult, or
 - ii. reducing consumer's outage time during the construction of the spur line. The spur line is constructed in its entirety, and a slack span used to energise the spur.
 - b) As the last span of a spur line where it is not possible to place a stay on the last pole of the spur. The previous pole before the last pole is changed into a stayed termination pole and a slack span installed to the very last pole.
- 2) There are three possible slack span arrangements:
 - a) HV only, with or without a running earth;
 - b) LV only;
 - c) LV below HV.
- 3) Only strain or termination crossarm configurations to be used on all poles associated with the slack span bay.
- 4) Conductors to be hand tight tensioned only, with consideration of:

- a) conductor ground clearances;
 - b) mid-span clashing:
 - i. HV to running earth,
 - ii. HV or running earth to LV
 - c) pole strengths and length of slack span.
- 5) The take-off angle needs to be kept as close as possible to be in line with the spur line, and / or at right angles to the main line. The maximum line take-off angle is to be between an arc of 45° to 135° from both the main line run and spur line run.
- 6) All equipment is to be so sited on both the take-off pole and the spur line pole so as to ensure that the clearance requirements, electrical, mechanical and physical, are met. For example, drop-out fuses are to have 900 mm vertical clearance below them to allow for the drop-out fuse travel.
- 7) Positioning of poles. Care needs to be taken to allow adequate access around the first pole for stay installation, or for the movement of vehicles, or even if the take/off pole falls over there is no impact on the spur line.
- 8) Running earth considerations:
- a) to be of the same size as the phase conductor;
 - b) terminated using DDC RE3 item arrangements on both stayed pole and end-of-line pole unless there is a possibility that the running earth may foul the stay wires, then DDC RE1 item arrangements to be used.

Note: This may not be required if the take-off angle is such that the 2 wires will not foul each other, in which case use RE3 on the stayed pole.

F.2.10.4 Conductor Clearances

Clearances to structures such as buildings and spacing between conductors of the same circuit or different circuits must be as per *AS/NZS 7000*. Clearances to earthed structures or to ground are extracted from *AS/NZS 7000* and specified below.

F.2.10.4.1 Clearance to Earthed Structures

Minimum clearance to earthed structures must be as follows:

- 11 kV – 160 mm
- 22 kV – 280 mm
- 33 kV – 380 mm

Further the Distribution Construction Standard drawings have incorporated the following clearances:

- 560 mm distance between LV bare and earthed equipment, this entails 200 mm (distance between kingbolt and top of conductor) + 60 mm (electrical distance AS 2067) + 300 mm (ergonomic distance AS 5804.1)
- 370 mm distance between LV ABC and earthed equipment, this entails 70 mm (approximate distance between kingbolt and top of LV ABC bracket) + 300 mm (ergonomic distance AS 5804.1)

Clearance must be increased in locations where bridging of insulators by birds/animals is probable.

F.2.10.4.2 Clearance to Ground

At a phase conductor temperature of 75°C, and a running earth conductor temperature of 50°C, the clearance of a conductor from ground must comply with Table 20.

Table 20 – Conductor Clearance from Ground

Location	Distance to ground in any direction (m)	
	≤ 1000 V	> 1000 V & ≤ 33 kV
Over the carriageway of roads	5.8	7.0
Over the carriageway of designated “Heavy Haulage Route” (MRWA)	7.1	7.7
Over the carriageway of designated “High Wide Load Route” (MRWA)	10.3	10.3
Over land other than the carriageway of roads	5.8	5.8
Over rural agricultural land where tall machinery is used	6.0	6.6
Over land which due to its steepness or swampiness is not traversable by vehicles more than 3 m in height	4.8	4.8
Over the surface at the maximum water level not readily accessible to the ocean (as defined for navigable water)	15.3	15.3
Over rail crossings	9.3	9.3

Notes:

- 1) The distances specified are final conditions for conductors which have aged. When conductors are first erected, an allowance must be made for 'settling in' and 'conductor creep' (refer to Appendix F 2.10.3).
- 2) The distances specified are designed to protect damage to conductors, impact loads on conductor supports and protecting vehicles from contact with conductors.
- 3) When calculating ground clearance, a construction tolerance of 300 mm should be included for long bay lengths and 100 mm for short bay lengths.
- 4) For the purpose of this clause, the term 'ground' includes any unroofed elevated area accessible to plant or vehicles and the term 'over' means 'across and along'.
- 5) The above values are based on vehicles with a maximum height of 4.6 m.

F.2.10.4.3 Clearance for Line Corridors

For a phase conductor temperature of 75°C the clearance of a conductor from structures and vegetation along the line route must comply with Table CC1 in *Appendix CC of AS/NZS 7000*.

- 11 kV – 10 m (edge to edge of 5 m from centre of line)
- 22 kV – 15 m (edge to edge of 7.5 m from centre of line)
- 33 kV – 20 m (edge to edge of 10 m from centre of line)

F.2.10.4.4 Mid-span Conductor Separation

A mid-span separation constant (k) of 0.6 should be used. Where a constant less than 0.6 is used, the following information must be provided and documented for Horizon Power approval:

- 1) Projected worst case fault level (single-phase and three-phase)
- 2) Bushfire risk rating for the area
- 3) Wind condition
- 4) Indication if running disc angle to normal intermediate/strain transition is used as part of the construction

The use of $k = 0.6$ is non-negotiable if:

- Projected worst case fault level exceeds 6 kA
- The design is within close proximity to high or extreme bushfire risk area
- The design is in a cyclonic region
- Running disc angle to normal intermediate/strain transition forms part of a long bay construction.

F.2.11 Ratings for Overhead Line Conductors

Table 5 provides nominal continuous current rating and fault rating for overhead line conductors, whilst Mechanical data for conductors is given in Table 21.

The continuous current ratings are based on *AS/NZS 3008.1.1* with the following operating conditions:

- 1) Maximum conductor temperature 75°C
- 2) Maximum cable temperature 80°C
- 3) Maximum ambient air temperature 45°C (Regions C and D), 40°C (Region A)
- 4) Wind speed 1 m/s
- 5) Emissivity coefficient 0.9
- 6) Solar radiation 1000 W/m²

The fault current ratings are based on *section 5.3 of AS/NZS 3008.1.1* with the following operating conditions:

- a) Initial conductor temperature of 75°C and
- b) Maximum conductor temperatures of:
 - 160°C for AAC & AAAC,
 - 150°C for ACSR/GZ,
 - 400°C for SC/AC,
 - 80°C for LV ABC conductor and
 - 200°C for HDCU conductor.

(Refer to *Horizon Power Environmental Conditions Standard: HPC-9EJ-01-0001-2013*, for temperature conditions in various parts of the network).

Table 21 – Conductor Mechanical Data

Size	Type	Cross Sec. Area (mm ²)	Nominal Diameter (mm)	Min. Breaking Load (kN)	Approx. Mass (kg/km)	Modulus of Elasticity (GPa)	Coef. of Linear Expansion (10 ⁻⁶ /°C)
7/2.50	AAC Leo	34.4	7.5	5.7	94.3	65	23
7/4.75	AAC Moon	124	14.3	18.9	339	65	23
19/3.25	AAC Neptune	158	16.3	24.7	433	65	23

Size	Type	Cross Sec. Area (mm ²)	Nominal Diameter (mm)	Min. Breaking Load (kN)	Approx. Mass (kg/km)	Modulus of Elasticity (GPa)	Coef. of Linear Expansion (10 ⁻⁶ /°C)
37/3.00	AAC Saturn	262	21	42.2	721	64	23
37/3.75	AAC Triton	409	26.3	62.1	1120	64	23
61/3.75	AAC Venus	674	33.8	97.2	1860	64	23
7/2.50	AAAC/1120 Chlorine	34.36	7.50	8.18	94.3	59	23
7/4.75	AAAC/1120 Iodine	124	14.30	27.10	339	59	23
19/3.25	AAAC/1120 Kryton	157.60	16.30	37.40	433	56	23
30/7/3.00	ACSR/GZ 1120 Lemon	262	21	90.4	973	88	18.4
30/7/3.50	ACSR/GZ 1120 Lime	356	24.5	122	1320	88	18.4
3/2.75	SC/AC	17.82	5.93	22.70	118	162	12.9
4 x 150 mm ²	LV ABC	150	45.60	84	2020	56	23
4 x 95 mm ²	LV ABC	95	38.40	53.20	1350	56	23
2 x 6 mm ²	HDCU	6	12.5	4.8	140	112	17
4 x 6 mm ²	HDCU	6	9.6	2.4	290	112	17
2 x 16 mm ²	HDCU	16	16.5	12.2	350	112	17
4 x 16 mm ²	HDCU	16	24.4	6.1	710	112	17

F.2.12 Mechanical Strength Ratings for Cross Arms

Mechanical strength ratings for cross-arms are in Table 22 and Table 23.

Table 22 – Steel Cross-arm Mechanical Data

Cross-arm cross-sectional dimensions, length (mm)	Bending capacity about X Axis (kN.m)	Bending capacity about Y Axis (kN.m)	Section compression capacity (kN)	Member compression capacity (kN)	Tension capacity (kN)	Shear capacity about X Axis (kN)	Shear capacity about Y Axis (kN)
75x75x3, 1900 mm (unitised)*	6.9	5.9	230.8	171.7	241.1	78.2	78.2
100x100x4, 2400 mm	16.4	14.4	420.8	355.68	355.6	139.1	139.1
125x75x5, 3300 mm	19.5	15.9	513.4	199.2	536.2	217.4	122.9

Table 23 – Composite Cross-arm Mechanical Data

Cross-arm cross-sectional dimensions, length (mm)	Bending capacity ultimate (kN.m)	Bending capacity short term (vertical) (kN.m)	Bending capacity long term (vertical) (kN.m)	Bending capacity short term (longitudinal) (kN.m)	Bending capacity long term (longitudinal) (kN.m)	Tension capacity (Mpa)	Shear capacity (Mpa)
100x100x5, 2100 mm	17.7	7.7	3.0	0.75	0.30	600	84

F.2.13 Mechanical Strength Ratings for MV Insulators

Mechanical strength ratings for MV insulators are in Table 24.

Table 24 – MV Insulator Mechanical Data

Type	Voltage (kV)	Specified Cantilever Load (SCL) (kN)	Specified Tensile Load (STL) (kN)	Specified Mechanical Load (SML) (kN)
Line Post Tie Top Insulator	33	12.5	25	N/A
Line Post Clamp Type Insulator	33	12.5	25	N/A
Suspension Strain Insulator	46	N/A	N/A	66.7

F.2.14 Mechanical Strength Ratings for LV ABC Clamps

Mechanical strength ratings for LV ABC clamps are in Table 25.

Table 25 – LV ABC Clamp Mechanical Data

Type	Safe Working Load (SWL) kN
Termination Clamp	15
Suspension Clamp	22
Angle Yoke Insulator	12

APPENDIX G. UNDERGROUND CABLE DESIGN INFORMATION

G.1 Continuous Current Ratings for Underground Cables

The continuous current rating of a cable must be used in cable designs, unless cyclic loading studies have been performed.

The 'cyclic rating' of cables considers the load connected to the cable and is generally 10% - 40% lower than the 'continuous current rating' of the cable.

Table 26 provides nominal continuous current ratings for medium voltage cables:

- Buried direct in ground at a depth of laying of 0.8 m to the top of cable or group of cables
- In a duct with depth of laying of 0.8 m to the top of the duct

The continuous current ratings are based on the following operating conditions:

- 1) Maximum conductor temperature 90°C (XLPE insulated cables)
- 2) Ambient air temperature 46°C
- 3) Ambient soil temperature 30°C
- 4) Soil thermal resistivity 1.5°C.m/W

Table 26 – Medium Voltage Cable Continuous Current Rating

Cable Size	Conductor Material	Voltage (kV)	Current Rating (A) in Ground (Trefoil formation)	
			Direct Buried	In Duct
35 mm ²	Al	22	122	103
185 mm ²	Al	22	296	267
400 mm ²	Al	22	425	393
50 mm ²	Al	33	145	127
185 mm ²	Al	33	296	267

Table 27 – Low Voltage Cable Continuous Current Rating

Cable Size	Conductor Material	Current Rating (A) in Ground (Trefoil formation)	
		Direct Buried	In Duct
25 mm ²	Cu	123	99
120 mm ²	Al	228	187
185 mm ²	Al	290	243
240 mm ²	Al	337	287
*400 mm ²	Cu	543	483
630 mm ²	Al	562	500

*The 400 mm² copper cable current rating has been at 110° conductor temperature.

The cable ratings in Table 27 and Table 28 shall be used only when the cable manufacturer's catalogues are not available.

Refer to *Horizon Power Environmental Conditions Standard (HPC-9EJ-01-0001-2013)* for temperature conditions in various parts of the network.

G.2 Derating Factors for Underground Cables

Cables installed in environments which differ from the conditions outlined in section G.1, must be modified using the formula below:

Continuous current rating = (Current rating in relevant table) x (factor for depth burial) x (factor for thermal resistivity) x (factor for ground temperature) x (other factors) as per tables as appropriate.

The rating modification tables in this section must be used when the cable manufacturer's catalogues are not available.

Table 28 – Rating Factors for Depth of Laying Directly in the Ground

Depth of Burial (m) (to top of cable)	Low Voltage Cables		High Voltage Cables	
	≤ 300 mm ²	> 300 mm ²	≤ 300 mm ²	> 300 mm ²
0.6	1.0	1.0		
0.8	0.98	0.97	1.0	1.0
0.9	0.97	0.96	0.99	0.98
1.0	0.96	0.95	0.98	0.97
1.25	0.95	0.93	0.96	0.95

Depth of Burial (m) (to top of cable)	Low Voltage Cables		High Voltage Cables	
	$\leq 300 \text{ mm}^2$	$> 300 \text{ mm}^2$	$\leq 300 \text{ mm}^2$	$> 300 \text{ mm}^2$
1.5	0.93	0.92	0.95	0.93
1.75	0.92	0.91	0.94	0.91
2.0	0.91	0.90	0.92	0.89

Table 29 – Rating Factors for Depth of Laying Directly in a Duct

Depth of Burial (m) (to top of duct)	Low Voltage Cables		High Voltage Cables	
	$\leq 300 \text{ mm}^2$	$> 300 \text{ mm}^2$	$\leq 300 \text{ mm}^2$	$> 300 \text{ mm}^2$
0.6	1.0	1.0		
0.8	0.97	0.98	1.0	1.0
0.9	0.96	0.97	0.99	0.99
1.0	0.95	0.97	0.98	0.99
1.25	0.92	0.96	0.95	0.97
1.5	0.91	0.95	0.94	0.96
1.75	0.92	0.95	0.92	0.96
2.0	0.89	0.94	0.91	0.95

Table 30 – Rating Factors for Variation in Thermal Resistivity of 3-core MV Cables

Conductor size (mm ²)	Thermal Resistivity (°C.m/W)				
	1.0	1.2	1.5	2.0	2.5
35 to 150	1.07	1.0	0.93	0.84	0.76
185 to 400	1.07	1.0	0.92	0.82	0.74
(Note: Laid directly in the ground)					

Table 31 – Rating Factors for Variation in Thermal Resistivity of 1-core MV Cables

Conductor size (mm ²)	Thermal Resistivity (°C.m/W)				
	1.0	1.2	1.5	2.0	2.5
Up to 150	1.07	1.0	0.91	0.81	0.73
185 to 400	1.07	1.0	0.90	0.80	0.72
(Note: Laid directly in the ground)					

Table 32 – Rating Factors for Variation in Thermal Resistivity of 3-core MV Cables

Conductor size (mm ²)	Thermal Resistivity (°C.m/W)				
	1.0	1.2	1.5	2.0	2.5
35 to 150	1.03	1.0	0.96	0.90	0.85
185 to 400	1.04	1.0	0.95	0.87	0.82
(Note: Laid in duct buried in the ground)					

Table 33 – Rating Factors for Variation in Thermal Resistivity of 1-core MV Cables

Conductor size (mm ²)	Thermal Resistivity (°C.m/W)				
	1.0	1.2	1.5	2.0	2.5
Up to 150	1.05	1.0	0.94	0.87	0.81
185 to 400	1.06	1.0	0.93	0.84	0.77
(Note: Laid in duct buried in the ground)					

Table 34 – Rating Factors for Variation in Ambient Temperature

Air Temperature (°C)	25	35	40	45	50	55
Rating Factor	1.14	1.05	1.0	0.95	0.89	0.84

Table 35 – Rating Factors for Variation in Ground Temperature

Air Temperature (°C)	15	20	25	30	35	40
Rating Factor	1.07	1.04	1.0	0.96	0.92	0.88

Table 36 – Rating Factors for Cable Groups of 3 x 1-core MV Cables

Voltage	No of Cables in Group	Separation				
		Touching	150 mm	300 mm	450 mm	600 mm
Up to 33 kV	2	0.78	0.81	0.85	0.88	0.90
	3	0.66	0.71	0.76	0.80	0.83
	4	0.60	0.65	0.72	0.76	0.80
(Note: MV Single-core cables in trefoil laid directly in the ground)						

Table 37 – Rating Factors for Cable Groups of 3-core MV Cables

Voltage	No of Cables in Group	Separation				
		Touching	150 mm	300 mm	450 mm	600 mm
22 kV	2	0.80	0.85	0.89	0.90	0.92
	3	0.69	0.75	0.80	0.84	0.86
	4	0.63	0.70	0.77	0.80	0.84
33 kV	2	0.80	0.83	0.87	0.89	0.91
	3	0.70	0.73	0.78	0.82	0.85
	4	0.64	0.68	0.74	0.78	0.82
(Note: Laid directly in the ground)						

G.2.1 Cables Buried Partly in Conduit

The current capacity of direct buried cables must be reduced when part of the cable is laid in conduit. Other derating factors shall apply as specified in Appendix G.2.

When the length of cable in conduit is greater than 20 times the cable diameter, the cable must be considered as if laid in conduit. Accordingly, MV direct buried cables greater than 3 m in length and LV direct buried mains cables greater than 2 m in length installed in conduit must be considered as laid in conduit.

If a material such as bentonite that has a thermal resistivity similar to that of ambient soil is used to fill the conduit, the derating factor can be considered to be 1.

G.3 Emergency Rating of Underground Cables

XLPE cables can be operated under emergency conditions up to a conductor temperature of 105°C for periods up to 36 hours, no more than 3 times per year. This is after leaving an allowance for high volume of expansion of XLPE above 100°C and compatibility of terminations. However, where metal tape screens are used, the overload temperature must be limited to 100°C. Refer to *AS/NZS 1429*.

G.3 Short Circuit Rating of Underground Cables

Short circuit current values allow conductor temperature to rise from 90°C to a maximum temperature of 250°C, assuming adiabatic conditions (i.e. neglecting heat loss). Where high fault currents are anticipated in single core cables, consideration must be given to electromechanical forces which will cause the cables to move apart if adequate restraint is not provided.

Cable screens must be rated to withstand 10 kA for 1 second (*AS/NZS 4026*).

APPENDIX H. LOCATION OF DISTRIBUTION COMPONENTS

H.1 General Requirements

H.1.1 Safety

Safety of persons and livestock must be considered when locating distribution equipment. Particular attention must be given to:

- 1) Bushfire initiation
- 2) Electric arc limitation including explosive atmospheres (hazardous areas)
- 3) Touch, step and transfer voltages
- 4) Low frequency induction
- 5) Fire risk to infrastructure in vicinity
- 6) Safe clearances
- 7) Electromagnetic fields
- 8) Hazard to road users
- 9) Hampering accessibility to persons including emergency services
- 10) Restricting accessibility
- 11) Appropriate signage

H.1.2 Environmental

Impact to the environment from distribution equipment and vice versa must consider the following:

- 1) Bird flight paths – striking conductors
- 2) Bird and animal habitats – flashover initiation
- 3) Oil leakage – pollution particularly to waterways
- 4) SF₆ and other gas leakages
- 5) Noise impact
- 6) Proneness to graffiti vandalism
- 7) Visual impact
- 8) Pollution from cement plants, quarries, mine sites, sea and salt lakes

H.1.3 Land Use

In locating distribution equipment consideration must be given to the following:

- 1) Utility Providers Code of Practice regarding alignments and sharing land with other services
- 2) 100-year Flood levels
- 3) Protected wetlands
- 4) Cultural heritage and native title
- 5) Declared rare flora and threatened ecological communities
- 6) Soils, dust, erosion, land entry permits, vegetation clearance permits
- 7) Clearing and removal of native vegetation
- 8) Restrictive covenants where required to maintain safety

H.1.4 Future Requirements

When choosing and locating distribution equipment future requirements must be considered in terms of forecasts for:

- 1) Load growth
- 2) Economic growth
- 3) Land use

H.1.5 Installation and Maintenance

Installation and maintenance issues must be considered when locating distribution equipment including but not limited to the following:

- 1) Access to equipment and vehicles
- 2) Traffic management
- 3) Costs

H.2 Requirements for Overhead Lines

H.2.1 Clearance to Structures and Buildings

Clearance from conductors to any non-electrical infrastructure such as structures and buildings must be as per *clause 3.11.2.1 of AS/NZS 7000*.

H.2.2 Easement Requirements

When considering the width of an easement to provide clearance from structures refer to *clause 3.11.2.2 of AS/NZS 7000*.

H.2.3 Location of Poles

Distribution poles must be located within the designated 2.4 to 3.0 metre alignment, as laid out in the *Utility Providers Code of Practice for Western Australia*. Pole positions must comply with the designated alignment at all times, unless alternative offsets have been arranged with relevant local authority and service providers.

Guidance to setbacks and barriers is also provided in:

- *AS/NZS 1158.1.2 – Lighting for Roads and Public Spaces*
- *AustRoads publications and guidelines* for rural and urban road design
- *AS/NZS 3845.1 – Road Safety Barrier Systems and Devices*

Pole locations and foundations may be affected by the slope in ground, trenches and excavations. Refer to Appendix F2.9 for more information.

Poles should **NOT** be located:

- 1) within 1 m of a driveway crossover
- 2) at road intersections where visibility may be reduced for road users
- 3) in positions that inhibit access to underground services
- 4) within the projection of other utility easements

H.2.3.1 Railway Crossings

Overhead power lines must not cross railways unless it is unavoidable. If crossing railway lines, overhead lines must be designed to:

- 1) the requirements of the railway authority
- 2) have a Level 2 security (refer to Section 3.5.1)
- 3) be strained at both ends
- 4) be unable to fall on the railway tracks under any circumstances

Note: Design of rail crossing to be submitted to Rail Authority for comment.

H.2.3.2 Water Crossings

Overhead power lines must not cross waterways unless it is unavoidable. If crossing waterways, overhead lines must be designed as per the guidelines of *AS 6947 Crossing of Waterways by Electricity Infrastructure* and *SA/SNZ HB 331 Overhead Line Design*.

H.3 Requirements for Underground Cables

H.3.1 Agreed Road Alignments

- 1) Underground cables must be laid in the 0 – 500 mm alignment in accordance with the *Utility Providers Code of Practice for Western Australia*.
- 2) Cables may be laid in the 2.4 m to 3 m alignment, centred on 2.7 m (which is reserved for pole lines) as a first preference when 0 – 500 mm alignment is not available.
- 3) Cables installed outside the 0 – 500 mm alignment must be mechanically protected. When directional drilling is used to install cables, heavy duty conduits must be used as mechanical protection.

H.3.2 Outside Alignments

- 1) In exceptional circumstances, cables may be laid outside the standard alignment (see clauses H.3.1.(1) and H.3.1.(2)) in:
 - a) other utilities' alignment, with their permission
 - b) road reserves, public open spaces, public access ways
 - c) private property
- 2) Cables installed as per clause H.3.2.1) must be mechanically protected by polymeric cable cover with cable marker tapes installed a maximum of 300 mm below final ground level.
- 3) Cables installed as per clause H.3.2.1) by directional drilling must be encased in heavy duty conduit and additional cable protection covers and marker tape are not required.
- 4) Where cables cannot be installed at the required depth due to obstacles such as hard rock, they may be installed at a reduced depth not less than 300 mm in concrete and inside conduits after performing a suitable risk assessment. The concrete must be a minimum thickness of 75 mm and be the upper surface of the ground. Compacted backfill may be used between the surface concrete and the conduit.

H.3.3 Proximity Limits to other Services

All cables must have a minimum clearance of 150 mm to other services.

H.3.4 Railway Crossings

Cables installed within railway boundaries must be designed in accordance with *AS 4799 Installation of Underground Utility Services and Pipelines within Railway Boundaries*.

H.3.5 Water Crossings

Cables installed within waterways must be designed in accordance with *AS 6947 Crossing of Waterways by Electricity Infrastructure*.

H.3.6 Easements

- 1) Horizon Power cables installed within road reserves, public open spaces, public access ways (clause H.3.2.b)) must be protected by an easement under the *Land Administration Act 1997*.
- 2) Horizon Power cables installed within private property (clause H.3.2.c)) must be protected by an easement under *Section 167 of the Planning and Development Act 2005*.
- 3) The minimum width of an easement must be 1 m.

H.4 Requirements for Substations

H.4.1 Site Requirements

Substation sites are to be located on public owned land (e.g. road reserve extension or public open space). Where available, parks are preferred over road reserve. Substation sites must also be located in the 'kink' of road reserve and as close as possible to the road boundary line extension along normal gazetted public road reserve. (refer also to section H.5). When choosing a location to site substations in public open space (POS), the following shall be considered:

- 1) Suitable location of sites within public open space.
- 2) Size, shape, contour and dimensions of public open space.
- 3) Community standards of health, safety and amenity.

H.4.1.1 Minimum Land Requirements

Minimum land requirements for distribution substations are given in Distribution Construction Standard G3. A summary of the requirements are given in Table 38 and Table 39.

Table 38 – Land Requirements for District Substations

Capacity up to	Switchgear	22 kV (mm x mm)	33 kV (mm x mm)
630 kVA	No	4500 x 3800	4500 x 3900
	Yes	4500 x 6600	4500 x 6700
1000 kVA	No	5100 x 4500	5400 x 4700
	Yes	6350 x 6000	6650 x 6000
2000 kVA	No	5300 x 8100	5600 x 8250
	Yes	6550 x 8100	6850 x 8250

Table 39 – Land Requirements for Sole Use Substations

Capacity up to	Switchgear	22 kV (mm x mm)	33 kV (mm x mm)
1000 kVA	No	4500 x 3800	4700 x 4100
	Yes	4500 x 6600	4500 x 6700
2000 kVA	No	3800 x 8100	3800 x 8250
	Yes	6550 x 8100	6850 x 8250

H.4.1.2 Additional Clear Zone

Considering the fire hazard risk (clause H.4.2) and the EPR, (earth potential rise risk, clause H.4.3) a minimum 2 m clearance zone around all substation footprints (Table 38 and Table 39) is required.

H.4.2 Fire Separation

Where transformers are housed outdoors, minimum separation requirements are given in Table 40.

Table 40 – Minimum Separation Distance for Transformer installed Outdoors

Transformer Capacity	Horizontal clearance to other similar capacity transformers or non-combustible Surfaces	Horizontal clearance to combustible surfaces of buildings	Horizontal clearance to 2 Hr fire rated surfaces of buildings	Vertical clearance to 2 Hr fire rated surfaces of buildings
Up to 630 kVA (< 1000 L oil)	1 m	6 m	1 m	4.5 m
Tyree 1 MVA	1 m	6 m	1 m	4.5 m
1 MVA (up to 2000 L oil)	3 m	7.5 m	1.5 m	7.5 m

Transformers in enclosures not fully enclosed, with open roof, must maintain clearance to non-fire rated building surfaces in accordance with Table 40 (details are available in DCS).

H.4.3 Separation for Earth Potential Rise

Medium voltage substations must have a below ground earth grading ring to minimise touch voltage hazards. In certain cases, the grading ring is at the limit of the substation footprint area. Conductive structures must be 2 m clear of the grading ring as per section C.6.

To avoid future (after substation has been built) issues related to encroachment within the hazard zone, a clear zone of 2 m around the substation earth ring footprint is required.

H.4.4 Restricted Usage and Covenants

Suitable easements must be obtained to attain the requirements in clause H.4.1.2.

H.4.5 Proximity Limits to other Services and Hazardous Areas

Services including telecommunications, water and gas must not be installed either on or under or in close proximity to a substation site. Refer to *WASIR Section 14* for clearance to other services.

Horizon Power assets in the vicinity of hazardous areas (explosive atmospheres, such as those near fuel stations, fuel farms, and gas compression stations) should be placed only after checking the hazardous area dossier for that facility. The dossier should show the hazardous area zones in accordance with AS/NZS 60079.10.1 or AS/NZS 60079.10.2, and Horizon Power assets should be placed outside zones 0, 1 and 2, and where economical and practical, a further distance from these zone boundaries.

H.4.6 Environmental Protection

H.4.6.1 Oil Containment

Oil containment of Distribution Transformers is covered in DCS G9-1 & 2 and in the Standard for *Oil Containment of Distribution Transformers: HPC-9DJ-07-0001-2013*.

H.4.6.2 Flood Proofing

Prevention of flooding of Distribution Substations is covered in DCS G9-3 & 4.

H.4.6.3 Noise Regulations

Noise limits are set by the Department of Environment and Conservation (DEC) in Western Australia through *Environmental Protection (Noise) Regulations 1997*.

- 1) The Noise Regulations define Noise Sensitive Premises as:
 - a) Premises occupied solely or mainly for residential or accommodation purposes;
 - b) Rural premises;
 - c) Caravan parks and camping grounds;
 - d) Hospitals with less than 150 beds;
 - e) Rehabilitation centres, care institutions and the like;
 - f) Educational institutions;
 - g) Premises used for public worship;
 - h) Hotels which provide accommodation to the public;
 - i) Premises used for aged care or child care;
 - j) Prisons and detention centres; and
 - k) Any other premises not defined as industrial, utility or commercial premises as per the Noise Regulations.
- 2) The noise level limits for Noise Sensitive Premises are given in Table 41.

Table 41 – Noise Level Limits for Noise Sensitive Premises

Location of Substation	Assigned level (dBA)
Within 15 m from Noise Sensitive Premises	45 +Road Noise Level
Beyond 15 m from Noise Sensitive Premises	60 +Road Noise Level
Beyond 450 m from Noise Sensitive Premises	0

- 3) Road Noise Level is determined as follows:
- 6 dBA for Major Roads within 100 m of Noise Sensitive Premises (more than 15,000 vehicles per day)
 - 2 dBA for Major Roads beyond 100 m of Noise Sensitive Premises (more than 15,000 vehicles per day)
 - 2 dBA for Secondary Roads within 100 m of Noise Sensitive Premises (6,000 - 15,000 vehicles per day)
 - 1 dBA for Secondary Roads beyond 100 m of Noise Sensitive Premises (6,000 - 15,000 vehicles per day)
 - 0 dBA for any other Road or any Road beyond 450 m from noise Sensitive Premises
- 4) Horizon Power Transformers are designed to emit sound levels in accordance with *Figure Z.A.1 of AS 60076.10* and the maximum levels are given in Table 42.

Table 42 – Maximum Transformer Sound Levels

Transformer Capacity (kVA)	Sound level (dBA)
1000	56
630	56
315	56
≤ 200	56

H.4.6.4 Compliance with WA Noise Regulations

To comply with the WA Noise Regulations, the Noise Level Limits for Noise Sensitive Premises should **NOT** be exceeded. Where compliance is not achieved by transformer location with respect to the concerned Noise Sensitive Premises, the following options may be considered:

- Using sound attenuating enclosures or barriers; and
- Providing sufficient clearance to noise sensitive premises.

In the design of substations the following must be considered:

- Impact on the local environment (Regulations/Guidelines);
- Impact on the working environment (Occupational Health & Safety Regulations in WA); and
- Equipment Noise (from Horizon Power's Transformer Specification and in accordance with AS 60076.10 for transformers).

Refer to Figure 11 below for setback requirements from sensitive premises.

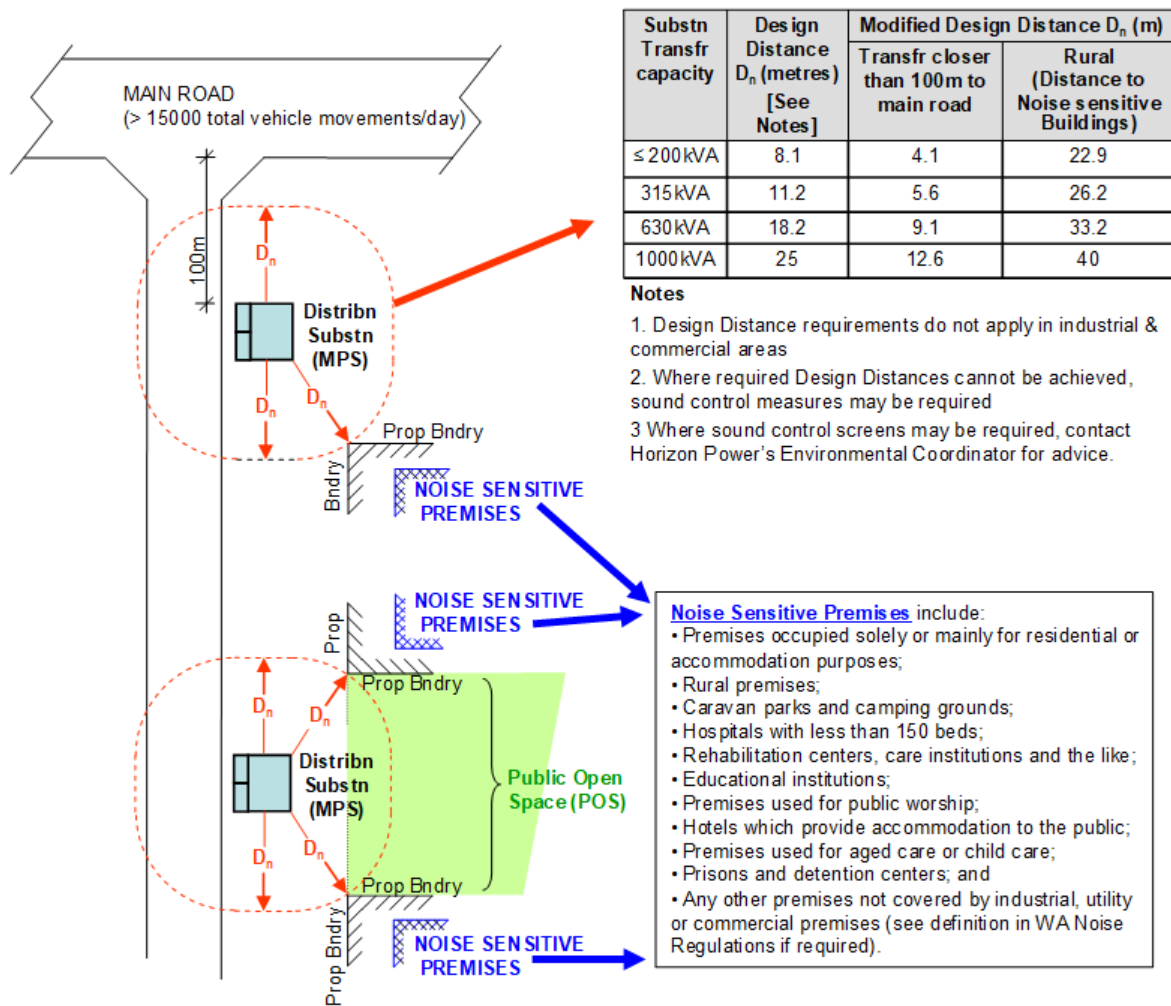


Figure 11 – Noise Setback requirements

H.5 General Considerations in Locating Ground Mounted Equipment (GME)

When locating ground mounted equipment, consideration must be given to the probability of vehicles colliding with equipment and being submerged during flooding events.

H.5.1 GME Inside Road Reserves

Collisions which can cause injury to vehicle occupants, danger to the public, exposure of electrical apparatus, loss of power and environmental damage must all be considered.

- 1) GME must be installed:
 - a) Outside the clear zone relevant for the vehicle speed, traffic volume and road conditions.
 - b) At road truncations provided it is of low enough profile to not impede driver visibility at the intersection, it is not in the clear zone and the relevant council or Main Roads WA has given written approval for the equipment installation.
 - c) In a clear zone only with a high integrity crash barrier designed and installed to provide adequate protection.
 - d) In a car park so that vehicle movement cannot impact it, preferably set back from a curb that shall prevent vehicle overhang of at least 3 m. Otherwise, bollards shall be installed.
 - e) With bollards to protect all MV ground mounted equipment, as required.
- 2) GME must **NOT** be installed:
 - a) In the middle of roundabouts and median strips. Pillars are permitted in roundabouts or median strips when they are 2 metres from a pole.
 - b) So as not to interfere with normal pedestrian movement.

H.5.2 GME Below 100-year Flood Level

Flooding which can cause an electrical shock to the public and loss of power must all be considered.

GME must **NOT** be installed in:

- 1) Drain or stormwater channels
- 2) Floodplains
- 3) Rivers, streams or creeks
- 4) Water basins
- 5) Waterways
- 6) Wetlands

H.6 General Considerations in Locating Switching Devices

It is recommended that the location and type of switching devices should be made in consultation with the local operating personnel who have general knowledge of the area, the operational requirements of the network and consumers.

Switching devices (especially manual types) located on lines near to roads or before entering restrictive areas (i.e. fenced-off, hilly or swampy land), allow operators to easily isolate the associated line.

APPENDIX I. STREETLIGHTS

I.1 Objectives

The objectives of street lighting are to provide safety, security and amenity to road users. In certain areas, where there are turtle hatching grounds, or where there is the prospect of introducing Astrotourism, the impact of street lighting must be limited (refer to *Street Lighting for Turtle Nesting Standard: HPC-9DJ-14-0001-2015* and to *POS-Dark Sky DM# 23223495 for Astrotourism requirements*).

The streetlight asset family consists of:

- Support Structures
- Luminaires; and
- PE Cells

I.2 Streetlight Supports

Streetlight luminaires are supported on:

- 1) Steel streetlight columns, which includes outreaches (single and double) specifically made for supporting luminaires
- 2) Power poles (steel, wood and concrete), using four types of streetlight outreaches. (This is not the preferred standard practice, though is still in use where minor streetlight installations occur).

I.2.1 Steel Streetlight Columns

Steel streetlight columns are of four types:

- 1) Frangible columns
- 2) Cyclone rated columns
- 3) Slip base columns
- 4) Pivot columns

Standard lengths for these columns are 6.5, 10.5 and 12.5 m. The standard embedment depth of these columns is 1.5, 2.0 and 2.2 m respectively.

I.2.1.1 Frangible Columns

Frangible streetlight columns, as discussed in the *Streetlight Poles Standard HPC-9DC-14-0001-2017 DM# 4885108*:

- 1) Must be installed only in Region A (refer to clause F.2.4)
- 2) Look similar to normal streetlight columns except that they remain attached to the base structure and absorb any impact energy by progressively deforming and entrapping the impacting vehicle.
- 3) The deformation of the column is controlled by a 'designed' weakening of the column stem over the lower length.
- 4) The thickness of steel is not more than 3 mm and weakening of steel is visible in the lower part.

Note: Horizon Power no longer stocks frangible streetlight steel columns.

I.2.1.2 Cyclone Rated Columns

Cyclone rated columns as discussed in the *Streetlight Poles standard HPC-9DC-14-0001-2017 DM# 4885108* are:

- 1) Not frangible and required for Regions C and D (refer to clause F.2.4).
- 2) Not recommended for installation in Zone 2 areas as per *AS/NZS 1158.1.2*. However, they may be installed in Zone 2 when the width of Zone 2 is large and the required luminance levels on the road cannot otherwise be achieved.
- 3) Suitable for installation in Zone 3 areas as applicable under *AS/NZS 1158.1.2*.
- 4) Where road lighting designs are done for cyclonic areas, and it is desired to put columns in Zone 2, the use of guard rails (or other equivalent means) is recommended.

I.2.1.4 Slip Base Columns

Slip Base columns are not frangible but are considered suitable for installation in Zone 2 areas as per *AS/NZS 1158.1.2* on roads controlled by Main Roads WA.

Slip Base columns are 13.7 m in height from foundation to luminaire attachment point.

Note: Slip Base columns are installed by Main Roads and are **NOT** maintained or managed by Horizon Power.

I.2.1.4 Pivot Columns

Pivot columns have not been used extensively within Horizon Power and therefore are not standard. Use of these column types will require a structural design evaluation and approval from engineering or the asset manager concerned.

I.2.2 Power Poles (Streetlights)

Streetlight luminaires are attached to power poles using four types of outreaches:

- 1) Major road – LV ABC supply
- 2) Major road – LV Bare supply, no cross-arm
- 3) Major road – LV Bare supply, with cross-arm
- 4) Minor road – LV ABC supply

I.2.3 Streetlight Column Foundations

The installation of streetlight columns in cyclonic areas require concrete collar foundations as per the requirements of the *Distribution Construction Standard* (Drawings in S9-2 and S10-1). The concrete strength must be N20.

Columns in non-cyclonic areas are installed as per the requirements of the *Distribution Construction Standard* (Drawings in S9-1 and S10).

I.3 Streetlight Luminaires

- 1) Streetlight luminaire types currently installed are High Pressure Sodium (HPS), Mercury Vapour (MV), Metal Halide (MH), Compact Fluorescent (CFL) and Light Emitting Diode (LED).
- 2) New streetlight installations must be LED luminaires.
- 3) Existing streetlights must be replaced with LED luminaires when replacement is required.
- 4) Table 43 below provides a list of equivalent LED luminaires, that have replaced gas discharge and first-generation type LED luminaires over time.

Note: All lamps/luminaires containing mercury are no longer accepted within Horizon Power and are to be removed where possible.

Table 43 – Luminaires

LED – ‘L’ Series (3000 K NEW) 2022-	LED – ‘L’ Series (4000 K OLD) 2018-2022	CFL (LEGACY) 2017	LED – ‘U’ Series (LEGACY) 2015-2016	LED – ‘LU’ Series (LEGACY) 2011-2014	Gas Discharge (LEGACY) 2009-2010
16 W HL6601	L2 20 W HL6300	ECO 18 W HL6232	U2 30 W HLH3323	LU2 56 W HLH3320	CFL 42 W HL6231
16 W HL6601	L2 20 W HL6300		U2 30 W HLH3323	LU2 56 W HLH3320	MV 80 W HL0708
28 W HL6607	L2 20 W HL6300		U2 30 W HLH3323	LU2 56 W HLH3320	MH 70 W HL1887

LED – 'L' Series (3000 K NEW) 2022-	LED – 'L' Series (4000 K OLD) 2018-2022	CFL (LEGACY) 2017	LED – 'U' Series (LEGACY) 2015-2016	LED – 'LU' Series (LEGACY) 2011-2014	Gas Discharge (LEGACY) 2009-2010
43 W HL6605	L3 53 W HL6303		U2 30 W HLH3323	LU2 56 W HLH3320	MV 125 W HL6140
70 W HL6610	L4 80 W HL6309		U4 120 W HLH3324	LU4 112 W HLH3321	HPS 150 W HL6145
140 W HL6613	L6 160 W HL6312		U6 180 W HLH3326	LU6 210 W HLH3322	HPS 250 W HL6146
140 W HL6613	L6 160 W HL6312		U6 180 W HLH3326	LU6 210 W HLH3322	MH 250 W HL6138
Purchased from Western Power	Purchased from Western Power	Purchased from Western Power	Purchased from Vendor	Purchased from Vendor	Purchased from Western Power
Phillips	Phillips	Sylvania	Lightsense	Lightsense	Sylvania

I.4 Design of Streetlighting

Streetlight designs must comply with the luminance requirements as specified in *AS/NZS 1158.1.1* and *AS/NZS 1158.3.1*. The lighting scheme must be nominated by the client, usually the shire council. The above standards do not apply where luminaires may be installed at irregular intervals on an otherwise unlit road or when additional luminaires may be installed for increased security.

Table 44 – Streetlight Placement

	Lighting Category	Typical Path/Road Width (m)	Path/Road Width (m)	Max Spacing (m)	Mounting Height (m)	Suitable LED Luminaire
Cycle/foot Pathways	PP3	Any	≤ 6	35	6.5	16 W
			≤ 6	45	10.5	16 W
Local Roads	PR4	15-20	≤ 14	65	6.5	28 W
			≤ 10	85	10.5	28 W
			≤ 18	65	10.5	43 W
			≤ 12	100	10.5	70 W
			≤ 20	85	10.5	43 W
			≤ 18	100	10.5	70 W
			≤ 20	95	10.5	70 W
			≤ 20	105	10.5	70 W
Local Roads	PR5	15-20	≤ 15	75	6.5	43 W
			≤ 20	105	10.5	70 W

	Lighting Category	Typical Path/Road Width (m)	Path/Road Width (m)	Max Spacing (m)	Mounting Height (m)	Suitable LED Luminaire
Major Roads, Commercial & Industrial Precinct	V3	30-40	≤ 10	71	12.5	140 W
			≤ 12	62	10.5	140 W
			≤ 12	65	12.5	140 W
			≤ 14	60	12.5	140 W
Minor & Principal Roads	V4	30-40	≤ 10	63	10.5	140 W
			≤ 14	64	10.5	140 W
			≤ 16	75	12.5	140 W

Note: For V3 & V5 Lighting Categories, lights to be installed on both sides of road or two lights in the middle of the road.

I.5 Replacing Existing Streetlights

When replacing existing luminaires with LEDs on the assumption that the luminaires being replaced have been designed to the requirements of section I.4, replacement LED luminaires must be selected in accordance with Table 43.

I.6 Streetlight Wiring and Electrical Protection

- 1) LED luminaires and associated wiring must be double insulated.
- 2) Notwithstanding clause I.6.1), for steel streetlight outreaches, connection between the neutral and earth terminals of the streetlight cut out must be maintained, with an earth loop conductor connecting the earth terminal with the steel streetlight support frame (streetlight supports must be considered as earthed structures).
- 3) Notwithstanding clause I.6.1), when wood power poles with luminaires are replaced with steel power poles, or luminaires are installed on steel power poles, and there is conductivity between the luminaire and the steel pole, a connection must be established between the luminaire neutral connection and the steel power pole frame.
- 4) Electrical protection of streetlights must be as per clause 5.16.1.

APPENDIX J. MAXIMUM SIZE OF TRANSFORMERS AND SWITCHING LOADS FOR MICROGRIDS

Table 45 – Maximum Size of Transformers and Switching Loads for Microgrids

District	Town	Feeder	Max TX Size	Maximum Switching Load
Kimberley	Ardyaloon	All	100 kVA	250 kVA
	Beagle Bay	All	100 kVA	250 kVA
	Bidyadanga	All	100 kVA	250 kVA
	Broome	Substation Feeders	1 MVA	3000 kVA
		Broome Rd	200 kVA past the Voltage Regulator	
	Derby	All	1 MVA	3000 kVA
	Fitzroy Crossing	All	500 kVA	1000 kVA
	Halls Creek	All	500 kVA	1000 kVA
	Kununurra	22 kV Feeders	500 kVA when the upstream protective device is the Feeder Circuit Breaker	3000 kVA
		Rural	200 kVA when the upstream protective device is a Recloser	1500 kVA (feeders 6 & 7)
	Lake Argyle	All	200 kVA	
	Looma	All	200 kVA	380 kVA
	Warmun	All	100 kVA	200 kVA
	Wyndham	All	315 kVA	500 kVA
Gascoyne	Carnarvon	All	1 MVA – Only for large single consumer installations	3000 kVA
		Lake McLeod	315 kVA on the 33 kV side of the Step Up Transformer	
	Coral Bay	All	315 kVA	500 kVA
	Denham	All	315 kVA	500 kVA

	Exmouth	11 kV	1 MVA	1500 kVA
		33 kV	1 MVA	1500 kVA
	Gascoyne Junction	All	100 kVA	125 kVA
Midwest	Cue	All	100 kVA	250 kVA
	Meekatharra	All	315 kVA	1000 kVA
	Mount Magnet	All	315 kVA	500 kVA
	Sandstone	All	100 kVA	125 kVA
	Wiluna	Thompson Nth Thompson Sth	200 kVA	250 kVA
		Wells St	100 kVA	
	Yalgoo	All	100 kVA	125 kVA
Esperance	Esperance	11 kV Feeder	1 MVA	4000 kVA
		33 kV Feeder (CB)	500 kVA	2750 kVA
		33 kV Feeder (R1)	315 kVA	2750 kVA
		33 kV Feeder (R2)	200 kVA	2750 kVA
		33 kV Feeder (R3)	100 kVA (if installed)	2750 kVA
	Hopetoun	Rural feeders	200 kVA	750 kVA
		Town feeders	315 kVA	500 kVA
	Laverton	All	200 kVA	300 kVA
	Leonora	All	315 kVA	1000 kVA
	Menzies	All	100 kVA	100 kVA
	Norseman	All	315 kVA	750 kVA
Pilbara	Marble Bar	All	100 kVA	250 kVA
	Nullagine	All	63 kVA	100 kVA
	Onslow	All	200 kVA	1000 kVA

APPENDIX K. SWITCHING CAPACITY OF OVERHEAD AND GROUND MOUNTED DEVICES

Determining the loads that can be managed on distribution networks shall take into account the loading capacity of the line equipment. Larger loads warrant individual switching devices. These can be considered for load management, depending upon ease of access.

Load breaking and making capacity of switching devices is provided in Table 46 and Table 47.

Table 46 – Overhead Type Switching Devices

Item	Switchgear Type	Capacity		
		Load	Breaking	Making
1.	Disconnects (should not be used as switching devices)			
1.1	MVDO	Fuse Rating	Fault	Fuse Rating
1.2	S & C Fault Tamer	Fuse Rating	Fault	Fuse Rating
1.3	Stanger – In Line Links	250 A	50 A	50 A
1.4	Siemens - Fusesaver	Setting	4 kA	10 kA
2.	Pole-Top Switch (Air-Break Switch)			
2.1	ALM	400 A	10 A	10 A
2.2	Falcon	400 A	10 A	10 A
2.3	Falcon Ezybreak	400 A	20 A	20 A
2.4	ACCULEC Load Disconnect	800 A	400 A	400 A
3.	Load Break Switch			
3.1	Schneider RL	630 A	630 A	12.5 kA
4.	Sectionalizer (should not be used as switching devices)			
4.1	Haycolec	Load Rating	Fault	Load Rating
5.	Reclosers			
5.1	McGraw Edison RV ACR	400 A	Fault	Fault
5.2	Nulec N24 & U27	630 A	12.5 kA	12.5 kA
5.3	NOJA OSM38	800 A	12.5 kA	12.5 kA
5.4	Reyrolle OYT **	150 A	Fault	Fault

** - equipment is questionable and should be considered for urgent replacement

Table 47 – Underground Type Switching Devices

Item	Switchgear Type	Capacity		
		Load	Breaking	Making
1.	Disconnects			
1.1	Alstom FBA5	630 A	630 A	16 kA
1.2	Alstom FBX	630 A	630 A	16 kA
1.3	Alstom Fluokit M	630 A	630 A	31 kA
1.4	Felten & Guillaume GA2K	630 A	630 A	16 kA
1.5	GEC DDFA **	400 A	Fault	Fault
1.6	Hazemeyer Magnefix MD **	250 A	250 A/Fuse	250 A/Fuse
1.7	Holec SVS	630 A	630 A	40 kA
1.8	Merlin Gerin M6 Vercors	400 A/Fuse	400 A/Fuse	Fault
1.9	Nebb Brown Boveri RGB12	400 A/Fuse	400 A/Fuse	Fault
1.10	Schneider D14	100 A/Fuse	100 A/Fuse	Fault
1.11	Schneider RM6	400/630 A	400/630 A	40 kA
1.12	Siemens 8CK2	400 A/Fuse	400 A/Fuse	Fault
2.	Breakers			
2.1	Alstom HWX	2500 A	40 kA	40 kA
2.2	Email J18	800 A	26 kA	26 kA
2.3	English Electric OLX **	800 A	13.1 kA	13.1 kA
2.4	GEC Alstom SBV 24	1250 A	16 kA	16 kA
2.5	GEC D4XD	400 A	Fault	Fault
2.6	Nilsen JB422/OMI	1600 A	Fault	Fault
2.7	Nilsen GEC OLX	800 A	Fault	Fault

2.8	Reyrolle 2A9T	800 A	Fault	Fault
2.9	Reyrolle LMVP	2500 A	Fault	Fault
2.10	Schneider AD4 MC	2000 A	Fault	Fault
2.11	Schneider RM6	400/630 A	16 kA	40 kA
2.12	Westinghouse J18	800 A	26 kA	26 kA
2.13	Yorkshire YSF6	630 A	Fault	Fault

** - equipment is questionable and should be considered for urgent replacement

APPENDIX L. EXTERNAL REFERENCE DOCUMENTS

L.1 Legislation

- 1) Electricity Act 1945
- 2) Electricity System Safety Regulations 2015
- 3) Electricity (Licensing) Regulations 1991
- 4) Environmental Protection (Noise) Regulations 1997
- 5) Land Administration Act 1997
- 6) Occupational Safety and Health Act 1984
- 7) Occupational Safety and Health Regulations 1996
- 8) Planning and Development Act 2005
- 9) WA Electrical Requirements
- 10) WA Service and Installation Requirements

L.2 Australian Standards and Guidelines

- 1) AS/NZS 1158.1.1:2022 - Lighting for Roads and Public Spaces – Part 1.1: Vehicular traffic (Category V) lighting – Performance and design requirements
- 2) AS/NZS 1158.1.2:2010 - Lighting for Roads and Public Spaces – Part 1.2: Vehicular traffic (Category V) lighting - Guide to design, installation, operation and maintenance
- 3) AS/NZS 1158.3.1:2020 - Lighting for Roads and Public Spaces – Part 3.1: Vehicular traffic (Category P) lighting - Performance and design requirements
- 4) AS/NZS 1170.2:2021 - Structural design actions Part: Wind actions
- 5) AS/NZS 1429.1:2006 - Electric cables – Polymeric insulated
- 6) AS 2067:2016 - Substations and High Voltage Installations exceeding 1 kV a.c.
- 7) AS/NZS 3000:2018 - Electrical Installations (Wiring Rules)
- 8) AS/NZS 3008.1.1:2017 - Electrical installations-Selection of cables – Part 1.1: Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions
- 9) AS/NZS 3845.1:2015 - Road Safety Barrier Systems and Devices – Part 1: Road safety barrier systems
- 10) AS/NZS 4026:2008 – Electric cables
- 11) AS 4799:2000 - Installation of Underground Utility Services and Pipelines within Railway Boundaries
- 12) AS 6947:2009 - Crossing of Waterways by Electricity Infrastructure

- 13) AS/NZS 7000:2016 - Overhead Line Design – Detailed Procedures
- 14) AS 60076.10:2023 - Power transformers – Part 10: Determination of sound levels
- 15) AS/NZS IEC 60079.10.1:2022 - Explosive atmospheres – Part 10.1 Classification of areas – Explosive gas atmospheres
- 16) AS/NZS 60079.10.2:2016- Explosive atmospheres – Part 10.1 Classification of areas – Explosive dust atmospheres
- 17) SA/SNZ HB 331:2020 - Overhead Line Design Handbook