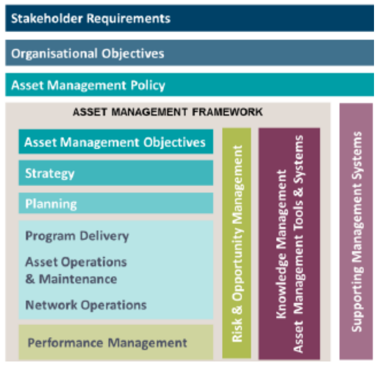
Telecommunications Design

Design Standard



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Contents

Revision Details

Version	Date	Summary of change	Section
0	11/4/2024	Initial release	

1 Introduction

1.1 Purpose and scope

This document specifies the requirements for design of telecommunications systems on Western Power's Telecommunications Network

1.2 Acronyms

See individual chapters for relevant acronym definitions.

1.3 Definitions

Term	Definition
Shall	is to be interpreted as "mandatory".
Should	is to be interpreted as "advisory or discretionary".
'Western Power's Representative'	(Also called 'Liaison Officer' or 'Construction Manager') means the officer appointed by WP as it's representative to whom all site, contractual and technical matters are referred.

1.4 References

See individual chapters for relevant references.

1.5 Conflicts

In the event of conflict between Western Power standards and other regulations, codes or standards, the order of precedence shall be:

1. Statutory Codes and Regulations.
2. Mandatory Codes and Standards (e.g., AS / ACIF S009).
3. Western Power standards, or specifications within the tender or contract.
4. Referenced Australian and International Standards.

2 Networks

2.1 Time Division Multiplexing Network

2.1.1 Introduction

Western Power utilises two types of Time Division Multiplexing (TDM) technologies: Synchronous Digital Hierarchy (SDH) and Plesiochronous Digital Hierarchy (PDH). This chapter describes the design of these networks.

Currently, hybrid multiplexers are used which can provide SDH, PDH and MPLS-TP connectivity. This chapter also describes the design requirements for these multiplexers.

2.1.2 Definitions

Table 1: Definitions

Term	Description
E1	A circuit capacity in PDH (payload 2048kBit/s)
FOBOT	Fibre Optic Break Out Tray
IDF	Intermediate Distribution Frame
MTP®	Muti-fibre Termination Push-on. MTP is a registered trademark of US Conec Ltd
PDH	Plesiochronous Digital Hierarchy
SDH	Synchronous Digital Hierarchy

2.1.3 Australian and International Standards

Telecommunications TDM Network shall be designed in conformance with the following standards.

Table 2: List of Applicable Standards

Standard/Specification	Description
ETSI EN 300 147	Synchronous digital hierarchy multiplexing structure
ETSI EN 300 417-1-1	Generic processes and performance
ETSI EN 300 417-2-1	SDH and PDH physical section layer functions

Standard/Specification	Description
ETSI EN 300 417-3-1	STM-N regenerator and multiplex section layer functions
ETSI EN 300 417-4-1	SDH path layer functions
ITU-T G.707	Network node interface for the synchronous digital hierarchy
ITU-T G.783	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
ITU-T G.803	Architecture of transport networks based on the synchronous digital hierarchy (SDH)
ITU-T G.805	Generic functional architecture of transport networks
ITU-T G.806	Characteristics of transport equipment – Description methodology and generic functionality
ITU-T G.841	Types and characteristics of SDH network protection architectures
ITU-T G.808.1	Generic protection switching – Linear trail and subnetwork protection
ITU-T G.957	Optical interfaces for equipments and systems relating to the synchronous digital hierarchy
ETSI EN 300 417-6-1	Synchronization layer functions
ETSI EN 300 462-1-1	Definitions and terminology for synchronization networks
ETSI EN 300 462-4-1	Timing characteristics of slave clocks suitable for synchronization supply to Synchronous Digital Hierarchy (SDH) and Plesiochronous Digital Hierarchy (PDH) equipment
ETSI EN 300 462-5-1	Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment
ITU-T G.813	Timing characteristics of synchronous digital hierarchy (SDH) equipment slave clocks (SEC)
ITU-T G.825	The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)

Standard/Specification	Description
ETSI EN 300 417-5-1	PDH path layer functions
ITU-T G.703	Physical/electrical characteristics of hierarchical digital interfaces
ITU-T G.704	Synchronous frame structures used at 1544, 6312, 2048, 8488 and 44736 kbit/s hierarchy levels
ITU-T G.775	Loss of Signal (LOS), Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) defect detection and clearance criteria for PDH signals
ITU-T G.805	Generic functional architecture of transport networks
ETSI ETS 300 233	Integrated Services Digital Network (ISDN); Access digital section for ISDN primary rate
ITU-T G.7041	Generic Frame Procedure
ITU-T G.7042	Link Capacity Adjustment Scheme (LCAS) for virtually concatenated signals.
ITU-T G.826	End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections
ITU-T M.2101.1	Performance limits for bringing into service and maintenance of international SDH paths and multiplex section
IETF RFC 1213	Management Information Base for Network Management of TCP/IP-based internets: MIB-II
IETF RFC 2819	Remote Network Monitoring Management Information Base
ITU-T T.50	International Reference Alphabet (IRA) - Information technology - 7 bit coded character set for information interchange

2.1.4 Western Power Standard Designs and Supporting Documents

Telecommunications TDM Network shall be designed in conformance with the following Western Power standard designs and supporting documents.

Table 3: List of Applicable Western Power Standard Designs

EDM/Drawing No.	Description
C52/36/1	Standard Drawing -- Rack Construction -- Keymile XMC20 -- XMC23 Rack Template -- IDF 1, 2, 3 -- Label & Panel Layout
C52/37/1	Standard Drawing -- Rack Construction -- Keymile XMC20 -- XMC25 Rack Template -- IDF 1, 2, 3 -- Label & Panel Layout
C71/30/1 - 13	Standard Drawing series – Keymile XMC20

2.1.5 Network Requirements

When a new site is established, two multiplexers should be installed. One exception is telecommunications-only sites where a single multiplexer installation would meet the diversity requirements for the services carried.

Another exception is customer sites from which there is unlikely to be further telecommunications network extension. At these sites, it is permissible to provision the required telecommunication services as dark fibre services. Therefore, no multiplexers are required at these sites.

Each bearer shall be connected to a multiplexer. These connections shall be SDH unless there is a technical limitation such as an ACMA embargo which prevents establishing a connection of sufficient capacity, or there is an existing PDH interface which is to be maintained.

PDH E1 physical connections should be avoided.

The two multiplexers at the site shall be connected to each other by an SDH link.

In metropolitan areas, or where most sites are interconnected with fibre, it is acceptable to utilise a mix of STM-1 and STM-4 links. The design objective shall be to minimise the number of SDH cards required. In country areas, or where sites are interconnected with microwave bearers, it is preferred to reserve STM-1 ports for microwave links and use STM-4 for fibre links.

Where microwave radio equipment has the capability to perform cross-connections, these should be avoided. That is, microwave radio equipment should only act as a regenerator of the SDH traffic, not as a multiplexer.

2.1.6 Chassis capacity

At Western Power Terminal substations, Zone substations and Telecommunications only sites, the larger XMC25 chassis shall be deployed. The smaller XMC23 chassis shall only be deployed at customer sites.

Cards shall only be installed in the multiplexer if they are to immediately carry active services, or there are known future projects that will carry active services. Where all services are migrated off a card and there are no future plans for the card to carry services, the card shall be decommissioned and removed from the chassis.

2.1.7 Microwave links

Where new microwave links are deployed, the design shall provide enough bandwidth to allow for SDH and MPLS bandwidth requirements, preferably on the same polarisation.

2.1.8 Power Requirements

All multiplexers shall be equipped with dual power feeds.

2.1.9 Housing Requirements

At each site, the multiplexers should not be located in the same rack. Co-locating the multiplexers in the same rack should only be considered at existing relay rooms where there is insufficient room for more racks. During the staging of a project, it is permissible to locate a new multiplexer in the same rack as a multiplexer which is to be decommissioned even though this may temporarily reduce diversity.

Cards shall be installed in the standard slots as defined in the standard drawings unless those slots are occupied.

2.1.10 Network Management Requirements

All multiplexers shall be provisioned with a Network Management Service to monitor and manage the device as per section 3.7.

2.1.11 Cabling

Copper cabling from the cards of the multiplexer sub-rack should terminate in the same rack on an RJ45 patch panel or Krone disconnect module fitted into an Intermediate Distribution Frame (IDF). See section 2.5.5.4 for RJ45 patch panels. It is permissible to terminate prefabricated ethernet patch leads from the multiplexer cards directly to the destination equipment if both are located within the same rack.

Where copper cabling is to terminate in terminal blocks rated to 110V these shall be installed in an existing 110V TPS rack or a dedicated wall-mounted cubicle (e.g., XMC20 TEPI2 card).

Fibre patch leads from the cards of the multiplexer sub-rack shall terminate within the same rack at the destination equipment, or at an MTP FOBOT where the destination equipment is in another rack.

2.2 MPLS-TP Network

2.2.1 Introduction

Western Power is deploying a Multi-protocol Label Switching – Transport Profile (MPLS-TP) network as the successor to its SDH network. This technology is supported by the current generation of hybrid multiplexer in use (ABB Hitachi XMC20) in addition to SDH and PDH.

2.2.2 Definitions

Table 4: Definitions

Term	Description
MPLS	Multi-protocol Label Switching
MPLS-TP	Multi-protocol Label Switching – Transport Profile

2.2.3 Australian and International Standards

Telecommunications MPLS-TP network shall be designed in conformance with the following standards.

Table 5: List of Applicable Standards

Standard/Specification	Description
IETF RFC 3031	Multiprotocol Label Switching Architecture
IETF RFC 3032	MPLS Label Stack Encoding
IETF RFC 3270	Multi-Protocol Label Switching (MPLS) Support of Differentiated Services
IETF RFC 3985	Pseudo Wire Emulation Edge-to-Edge (PWE3) Architecture
IETF RFC 4664	Framework for Layer 2 Virtual Private Networks (L2VPNs)
IETF RFC 5332	MPLS Multicast Encapsulations
IETF RFC 5462	Multiprotocol Label Switching (MPLS) Label Stack Entry: “EXP” Field Renamed to “Traffic Class” Field
IETF RFC 5921	A Framework for MPLS in Transport Networks
IETF RFC 5960	MPLS Transport Profile Data Plane Architecture

Standard/Specification	Description
IETF RFC 7213	MPLS Transport Profile (MPLS-TP) Next-Hop Ethernet Addressing
IETF RFC 2685	Virtual Private Networks Identifier
IETF RFC 3811	Definitions of Textual Conventions (TCs) for Multiprotocol Label Switching (MPLS) Management
IETF RFC 3812	Multiprotocol Label Switching (MPLS) Traffic Engineering (TE) Management Information Base (MIB)
IETF RFC 3813	Multiprotocol Label Switching (MPLS) Label Switching Router (LSR) Management Information Base (MIB)
IETF RFC 5601	Pseudowire (PW) Management Information Base (MIB)
IETF RFC 5602	Pseudowire (PW) over MPLS PSN Management Information Base (MIB)
IETF RFC 5603	Ethernet Pseudowire (PW) Management Information Base (MIB)
IETF RFC 5718	An In-Band Data Communication Network For the MPLS Transport Profile
IETF RFC 6370	MPLS Transport Profile (MPLS-TP) Identifiers
IETF RFC 7331	Bidirectional Forwarding Detection (BFD) Management Information Base
IETF RFC 5586	MPLS Generic Associated Channel
IETF RFC 5860	Requirements for Operations, Administration, and Maintenance (OAM) in MPLS Transport Networks
IETF RFC 5880	Bidirectional Forwarding Detection (BFD)
IETF RFC 6371	Operations, Administration, and Maintenance Framework for MPLS-Based Transport Networks
IETF RFC 6374	Packet Loss and Delay Measurement for MPLS Networks
IETF RFC 6375	A Packet Loss and Delay Measurement Profile for MPLS-Based Transport Networks

Standard/Specification	Description
IETF RFC 6426	MPLS On-Demand Connectivity Verification and Route Tracing
IETF RFC 6428	Proactive Connectivity Verification, Continuity Check, and Remote Defect Indication for the MPLS Transport Profile
IETF RFC 7276	An Overview of Operations, Administration, and Maintenance (OAM) Tools
IETF RFC 7419	Common Interval Support in Bidirectional Forwarding Detection
IETF RFC 4762	Virtual Private LAN Service (VPLS) Using Label Distribution Protocol (LDP) Signaling
IETF RFC 6372	MPLS Transport Profile (MPLS-TP) Survivability Framework
IETF RFC 6378	MPLS Transport Profile (MPLS-TP) Linear Protection
IETF RFC 7324	Updates to MPLS Transport Profile Linear Protection
IETF RFC 7769	Media Access Control (MAC) Address Withdrawal over Static Pseudowire
IETF RFC 4448	Encapsulation Methods for Transport of Ethernet over MPLS Networks
ITU-T G.8113.2	Operations, administration and maintenance mechanisms for MPLS-TP networks using the tools defined for MPLS

2.2.4 Western Power Standard Designs and Supporting Documents

Telecommunications MPLS-TP network shall be designed in conformance with the following Western Power supporting documents.

Table 6: List of Applicable Western Power Supporting Documents

Drawing No.	Description
	Manual – Telecommunications Construction – Installation Practices[1]
	Guideline – Antenna & Feeders Construction[1]

[1] Western Power internal document

2.2.5 Network Requirements

Transmission Terminal Switchyards should form part of the core network and be connected in a ring topology. Where a Terminal Switchyard has multiple relay rooms, the relay room for the higher voltage switchyard shall be the core site. Both multiplexers at the site shall be part of the core network.

A Zone substation or telecommunications only site may need to also be part of the core network, due to optical budget. At these sites, only one multiplexer should form part of the core network.

Otherwise, Zone substations and telecommunications only sites should be connected in sub-rings from the core network.

2.2.6 Microwave links

Where new microwave links are deployed, the design shall provide enough bandwidth to allow for SDH and MPLS bandwidth requirements, preferably on the same polarisation.

2.2.7 Equipment Requirements

All XMC20 multiplexers shall be fitted with CENT2 controller cards to enable MPLS-TP connectivity.

MPLS-TP links in the core network shall be provisioned with 10Gbit/s SFPs, unless limited by optical budget. If limited by optical budget, the designer should identify if an existing Zone substation or telecommunications only site can be included in the core network as an intermediate site. If this is not possible, 1Gbit/s SFPs shall be used instead.

MPLS-TP links outside the core network shall be provisioned with 1Gbit/s SFPs.

2.2.8 Power Requirements

All multiplexers shall be equipped with dual power feeds.

2.2.9 Housing Requirements

At each site, the multiplexers should not be located in the same rack. Co-locating the multiplexers in the same rack should only be considered at existing relay rooms where there is insufficient room for more racks. During the staging of a project, it is permissible to locate a new multiplexer in the same rack as a multiplexer which is to be decommissioned.

2.2.10 Network Management Requirements

All multiplexers shall be provisioned with a Network Management Service to monitor and manage the device. See section 3.7.

2.2.11 Cabling

Copper cabling from the cards of the multiplexer sub-rack should terminate in the same rack on an RJ45 patch panel or Krone disconnect module fitted into an Intermediate Distribution Frame (IDF). See section 2.5.5.4 for RJ45 patch panels. It is permissible to terminate prefabricated ethernet patch leads from the multiplexer cards directly to the destination equipment if both are located within the same rack.

Where copper cabling is to terminate in terminal blocks rated to 110V these shall be installed in an existing 110V TPS rack or a dedicated wall-mounted cubicle (e.g., XMC20 TEPI2 card).

Fibre patch leads from the cards of the multiplexer sub-rack shall terminate within the same rack at the destination equipment, or at an MTP® FOBOT where the destination equipment is in another rack.

2.3 IP/MPLS Network

Western Power’s IP/MPLS based network shall be used for Operational Technology (OT) traffic such as:

- Telecommunications Management Service
- Automation remote access
- distribution Automation SCADA service
- Fault Recorder
- Corporate LAN
- Property and Fleet WAN
- PAX VOIP
- DMR service
- AMI backhaul

The SEAL network carries many of the existing services listed above but the IP/MPLS will replace the SEAL network over time, see chapter 2.5 for SEAL network detail.

The network design shall align with the strategy to move towards IP/MPLS network and only add SEAL network equipment as a last resort.

2.4 Network Synchronisation

2.4.1 Introduction

Synchronisation can be provided at three levels:

- Frequency synchronisation
- Phase synchronisation
- Time of Day synchronisation

Phase synchronisation is not currently utilised in Western Power telecommunications.

Western Power's application of Frequency and Time of Day synchronisation is described in this section.

2.4.1 Definitions

Table 7: Definitions

Term	Description
Clock	A network element which generates an accurate frequency signal.
Credible event	An event that results in failure, and which is considered to be both possible and probable.
Disjoint paths	A set of two or more paths, where a failure of any single network element or link would not lead to failure of all set members.
DNU	Do not use. A synchronisation quality level (15) used to prevent a signal from being used for synchronisation purposes.
Failure	A state where a network element, path or service is either not capable of transporting data, or not capable of transporting data without introducing bit errors at a rate greater than 1 x 10-3. Such a state may occur as a result of synchronisation failure.
Jitter	The short-term variations of the significant instants of a timing signal from their ideal positions in time (where short-term implies that these variations are of frequency greater than or equal to 10 Hz).
Link	A means of interconnecting two network elements, typically achieved through the use of fibre optic or co-axial cable(s), radio propagation, or a path provided a telecommunication network.

Term	Description
Master-Slave synchronisation	Use of a single designated master clock for synchronisation of all other (slave) clocks.
MC	Master clock. A clock (that is not synchronised to another clock, and) that is used for synchronisation of one or more slave clocks.
NE	Network element. A device that may be connected (through one or more links) to other like devices to form a telecommunication network.
Non-credible event	a) An event that results in failure, and which is considered to be possible but not probable. b) Two or more concurrent credible events.
Normal operation	An absence of failure.
Normal synchronisation	An absence of synchronisation failure.
Path	A means of transporting data (through one or more interconnected network elements) between two or more specific points in a telecommunication network.
PRC	Primary Reference Clock. A clock that provides a reference frequency signal compliant with ITU recommendation G.811.
Protected service	A service that utilises disjoint paths to ensure that normal operation (of the Service) is achieved for any single failure.
QL	Synchronisation quality level. An indicator of signal quality for synchronisation purposes, as defined in ITU-T recommendations G.704 (PDH) and G.707 (SDH). *NOTE: Synchronisation quality levels do not reflect any degradation caused by the accumulation of jitter or wander.*
SC	Slave clock. A clock that is synchronised to a master clock, through a synchronisation link or through a synchronisation distribution trail.
SD trail	Synchronisation distribution trail. A series of one or more synchronisation links, connecting a master clock to a slave clock, possibly through one or more network elements.

Term	Description
SEC	SDH Equipment Clock. The logical function, representing the equipment clock of a SDH network element that provides a reference frequency signal compliant with ITU recommendation G.813.
Service	A means of transporting data (through one or more paths) for a specific purpose, typically provided by a telecommunication network operator to a customer.
SSM	Synchronisation Status Message. A four-bit code used to convey a synchronisation quality level.
SSU	Synchronisation Supply Unit. A clock that provides a reference frequency signal compliant with ITU recommendation G.812.
Synchronisation area	Geographic area in which all equipment which needs to operate synchronously is synchronised to one master clock.
Synchronisation failure	A state where all clocks are not synchronised to a single reference signal (thus all clocks may not have the same long-term accuracy).
Synchronisation link	A link that supports the distribution of synchronisation. Synchronisation links may support an exchange of synchronisation status messages.
T0	Internal timing signal used for synchronisation of a SSU / network element (refer to ETSI EN 300 462-2-1 for further definition of T0, T1, T2, T3 and T4).
T1	Timing reference signal derived from a STM-n input signal.
T2	Timing reference signal derived from a 2048kbit/s traffic input signal.
T3	Timing reference signal derived from a 2048kHz or 2048kbit/s (with or without SSM) input signal.
T4	External reference timing output signal, 2048kHz or 2048 kbit/s (with or without SSM).
Timing loop	A network condition where a network element becomes synchronised to its own timing signal a) through a direct loop back b) via other network elements

Term	Description
Wander	The long-term variations of the significant instants of a digital signal from their ideal position in time (where long-term implies that these variations are of frequency less than 10 Hz).

2.4.2 Australian and International Standards

Network synchronisation shall be designed in conformance with the following standards.

Table 8: List of Applicable Standards

Standard/Specification	Description
ITU-T G.703	Physical/electrical characteristics of hierarchical digital interfaces
ITU-T G.704	Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44736 kbit/s hierarchical levels
ITU-T G.707	Network node interface for the synchronous digital hierarchy (SDH)
ITU-T G.781	Synchronisation layer functions
ITU-T G.796	Characteristics of a 64 kbit/s cross-connect equipment with 2048 kbit/s access ports
ITU-T G.797	Characteristics of a flexible multiplexer in a plesiochronous digital hierarchy environment
ITU-T G.803	Architecture of transport networks based on the synchronous digital hierarchy (SDH)
ITU-T G.810	Definitions and terminology for synchronization networks
ITU-T G.811	Timing characteristics of primary reference clocks
ITU-T G.812	Timing requirements of slave clocks suitable for use as node clocks in synchronisation networks
ITU-T G.813	Timing characteristics of SDH equipment slave clocks (SEC)
ITU-T G.823	The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy

Standard/Specification	Description
ITU-T O.171	Timing jitter and wander measuring equipment for digital systems which are based on the plesiochronous digital hierarchy (PDH)
ETSI EN 300 462-2-1	Synchronization network architecture based on SDH networks

2.4.3 Western Power Standard Designs and Supporting Documents

Synchronisation shall be designed in conformance with the following Western Power standard designs.

Table 9: List of Applicable Western Power Standard Designs

Drawing No.	Description

2.4.4 Frequency Synchronisation

2.4.4.1 SDH Synchronisation

Frequency synchronisation of SDH multiplexer equipment shall be achieved through master-slave synchronisation, in accordance with ITU-T G.803 and G.810.

> ***Background Note:***
>
> *As per ITU-T G.803, the architecture employed in SDH requires the timing of all network element clocks to be traceable to a PRC which is compliant with ITU-T Recommendation G.811.*
>
> *As per ITU-T G.810, the master-slave synchronisation system has a single PRC to which all other clocks are phase-locked. Synchronisation is achieved by conveying the timing signal from one clock to the next clock. Hierarchies of clocks can be established with some clocks being slaved from higher order clocks and in turn acting as master clocks for lower order clocks.*

Each network element shall be configured to (a) minimise the number of synchronisation links used for synchronisation distribution trails, and (b) maximise the reliability of synchronisation distribution trails. Synchronisation distribution trail reliability shall be preferred to synchronisation distribution trail length.

Synchronization supply units (SSUs) shall be used to limit synchronisation distribution trails to a maximum of **twenty** synchronisation links (ITU-T G.803, section 8.2.4, N=20) between PRCs/SSUs and SDH equipment clocks.

> ***Background Note:***
>
> *SSUs are used to support reliable network synchronisation through filtering and regeneration of synchronisation signals (to remove higher frequency phase noise).*

Each SDH multiplexer equipment should be connected to a minimum of two synchronisation links (that are capable of distributing synchronisation in both directions) and should not be connected to more than four synchronisation links (that are capable of distributing synchronisation in both directions).

Interfaces that are used for distribution of synchronisation shall be prioritised to assist in the control of synchronisation distribution trails and for prevention of timing loops.

The SDH synchronisation shall be designed such that during periods where a single failure exists, SDH multiplexer equipment of non-linear networks **shall** remain synchronised to a PRC.

The SDH synchronisation shall be designed such that during periods where more than one failure exists, SDH multiplexer equipment **should** remain synchronised to a primary reference clock. It is understood that it may not be possible for all SDH multiplexer equipment to remain synchronised during periods where multiple failures exist.

No failure shall lead to the formation of one or more timing loops.

Links that are known to be unreliable shall not be used for distribution of synchronisation.

ITU-T G.704 (2048 kbit/s) interface signals shall be preferred to ITU-T G.703 (2048 kHz) interface signals for the purposes of synchronisation.

Background Note: *This is because G.703 signal does not carry an indication of the quality level of the source generating the timing information, whereas G.704 can carry an indication of the quality level of the source generating the timing information via the SSM. For further information, refer to clause 5.3 of ITU-T G.781.*

Hybrid multiplexer equipment that (a) contain both SDH and PDH components, and (b) make active use of such SDH components, are considered SDH multiplexer equipment. Such equipment shall be configured to synchronise PDH components to the SDH equipment clock (T0).

2.4.4.1.1 Clock Designation

Clock designations shall be as per the table below.

Clock	Description
Master Clock	For each SDH network, a single primary reference clock shall be configured to operate as a master clock for network synchronisation and shall be presented to the network as a G.811 compliant clock. This clock shall be designated as 'master' clock for the network, and each network element shall be configured to slave to this clock during periods of normal synchronisation.
Alternate master clock	For each SDH network, a second primary reference clock may also be configured to operate as a master clock and shall also be presented to the network as a G.811 compliant clock. This clock shall be designated as 'alternate master' clock for the network, and each network element shall be configured to slave to this clock only during periods where the 'master' clock is unavailable (i.e., a synchronisation distribution trail cannot be formed between the network element and the 'master' clock).

Clock	Description
Ordinary clock	All other primary reference clocks and synchronisation supply units shall be presented to SDH networks as G.811 compliant clocks. Such clocks shall be designated as 'ordinary' clocks and each network element shall be configured to slave to such clocks only during periods where the 'master' clock and 'alternate master' clock (if present) are unavailable (i.e., a synchronisation distribution trail cannot be formed between the network element and either (a) the 'master' clock or (b) the 'alternate master' clock).

2.4.4.2 PDH Equipment

> ***Background Note:***
> *Hybrid multiplexer equipment that (a) contain both SDH and PDH components, and (b) make active use of such SDH components, are **not** considered PDH multiplexer equipment. Refer to SDH section above.*

N/A – No new purely PDH equipment is to be installed in the Western Power.

2.4.5 Time of Day Synchronisation

The 'time of day' of the network devices is required for Telecommunications Operation and Maintenance to monitor the fault reporting and problem analysis from the Telecommunications Control Centre. All servers, PCs, and network equipment that supports logs will need to show the correct time of day.

2.4.5.1 Scope

The scope of this design guide is limited to Telecommunication Environment zones. This includes the following network zones:

- Telecommunications Operations Network (TON) production environment. *[TON details redacted]*
- Telecommunications Network
    - SEAL Network
    - PDH/SDH Network
    - Radio Network (Microwave, Single/Dual Channel Links)
    - IP Network (CBD and DA)
    - MPLS Network
    - Various edge devices
    - Any other network or equipment that form part of the greater Western Power Telecommunications network and is monitored and managed by the TON environment above.

2.4.5.2 Time of Day Network Architecture

The time of day synchronization will allow the computers, systems, and communication equipment to have the correct time with each other. The time of day clock sources are provided within the TON network – an OT classified, secured network and time of day will not be synchronized to any time server that does not reside within a comparable OT zone.

Each network component, that supports time of day synchronization (NTP/SNTP) protocol will synchronize its time of day clock regularly to the nominated time servers. In case where the time servers are not available, the network component will maintain its date/time from its own clock and continues to try establishing synchronization with the timeservers.

[TON details redacted]

2.4.5.3 Design Requirements

[TON details redacted]

For the Telecommunication network devices without time synchronization capabilities, and with local date timestamp history of alarms/events, a regular process (via manual procedure or automatic CLI script) should be implemented to set their time-of-day clock (scope of Comms Implementation and Comms Operations & Maintenance).

For the Telecommunication network devices without a local date/time clock, time-of-day synchronization is not required.

2.4.5.4 Determining Time Sync Methodology for New Devices

The communication network equipment may or may not support the time-of-day clocking and time synchronization. If communication network equipment stores locally the alarm or event history, it may include its own timestamp with the alarm and event in the history log.

Where the event or alarm is forwarded to the Operational Support System (OSS), or the Network Management Systems (NMS), the date & time of the OSS or NMS is normally attached to the received message for display & log purposes. However, it is not always the case. It is important for any new network design should address the following questions and include the time of day synchronization configuration appropriately in the design documentation.

- Does network device support day and time clock?
- Does it have local time stamped of events and history?
- Does it support time of day synchronization using NTP / SNTP or proprietary protocol?

2.4.5.5 Time Distribution Protocol

The Network Time Protocol (NTP) version 3 is adopted as the protocol standard for time-of-day distribution within the TON and Telecommunications Network environment.

Where NTP is not available, devices can use SNTP (Simple Network Time Protocol) as client time synchronization, which will work with the available NTP Servers.

In cases where communication network devices use proprietary protocol to distribute or synchronize the time of day within their respective management domain, the time server within this communication network must synchronize its time of day with the above appointed time distributors.

The following parameters should be used for NTP clients.

Parameter	Recommended Value
Time synchronization Polling interval	600 secs (10 mins) fixed period.
Time change limit	7200 seconds (2 hours in forward and backward change direction)
Acting on broadcast time synch	Yes

2.5 SEAL Network

2.5.1 Introduction

The Substation Equipment Access Link (SEAL) network provides Ethernet access to Western Power sites including substations, depots, and communications facilities.

The SEAL network is being replaced by the IP/MPLS based network (see chapter 2.3) and this transition should be considered when using the SEAL network for new services.

2.5.2 Definitions

Table 10: Definitions

Term	Description
SDH	Synchronous Digital Hierarchy
VC3	Virtual Container 3, a circuit capacity in SDH (payload 49MBit/s)

2.5.3 Australian and International Standards

SEAL network shall be designed in conformance with the following standards.

Table 11: List of Applicable Standards

Standard/Specification	Description
IEEE 802.1	Higher Layer LAN Protocols Working Group
IEEE 802.3	Ethernet
IEEE 1613	IEEE Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations

2.5.4 Western Power Standard Designs and Supporting Documents

The SEAL network shall be designed in conformance with the following Western Power standard designs.

Table 12: List of Applicable Western Power Standard Designs

Drawing No.	Description

2.5.5 Design Requirements

2.5.5.1 Equipment Selection

Equipment selection shall consider the following parameters:

- Expected traffic throughput
- Location of the site within the SEAL topology
- Type and number of interfaces required to meet current requirements

Considering the requirements of the project, the switch shall be sized such that there are at least 20% spare ports for future requirements.

2.5.5.2 Power Supply

All switch subracks that support dual power supplies shall have the dual modules installed. These modules should be supplied by different power feeds, (e.g., Bus A and Bus B).

AC powered applications should be powered from a UPS-backed power supply. At customer sites, including IT drop-offs at WP depots, these units shall use the customer's local UPS. Where there is no UPS solution available at the site, a consumer level surge protection solution shall be fitted between the AC mains supply and the unit. UPS is not mandatory, but the risk shall be considered during the design.

2.5.5.3 Port Isolation

If the Ethernet port on any device deployed in the network is not rated to IEEE 1613 standard, and that copper port is connected to primary-interfacing equipment (such as Fault Recorders), then external surge protection shall be provided to that copper port to prevent a surge from damaging the Ethernet switch or other equipment that is electrically connected to it.

2.5.5.4 RJ45 Patch Panels

When a SEAL switch is installed at a substation or a telecommunications site, one 24 port RJ45 patch panel shall be provided locally for terminating the substation equipment cabling and earth points of the interfacing Ethernet cable's shielding.

When providing Ethernet cabling for a new service from outside the SEAL rack, install the cable to the rear of the allocated port on patch panel, and then jumper to the Ethernet Switch port. When connecting multiple cables between two racks, consider patch panels at each end for better cable management.

Only pre-terminated Ethernet patch leads shall be used between the SEAL switch and the above RJ45 patch panel. Direct patch leads may also be run if the SEAL switch and the target equipment are in the same rack, and the interfaces are readily accessible from the front of the rack.

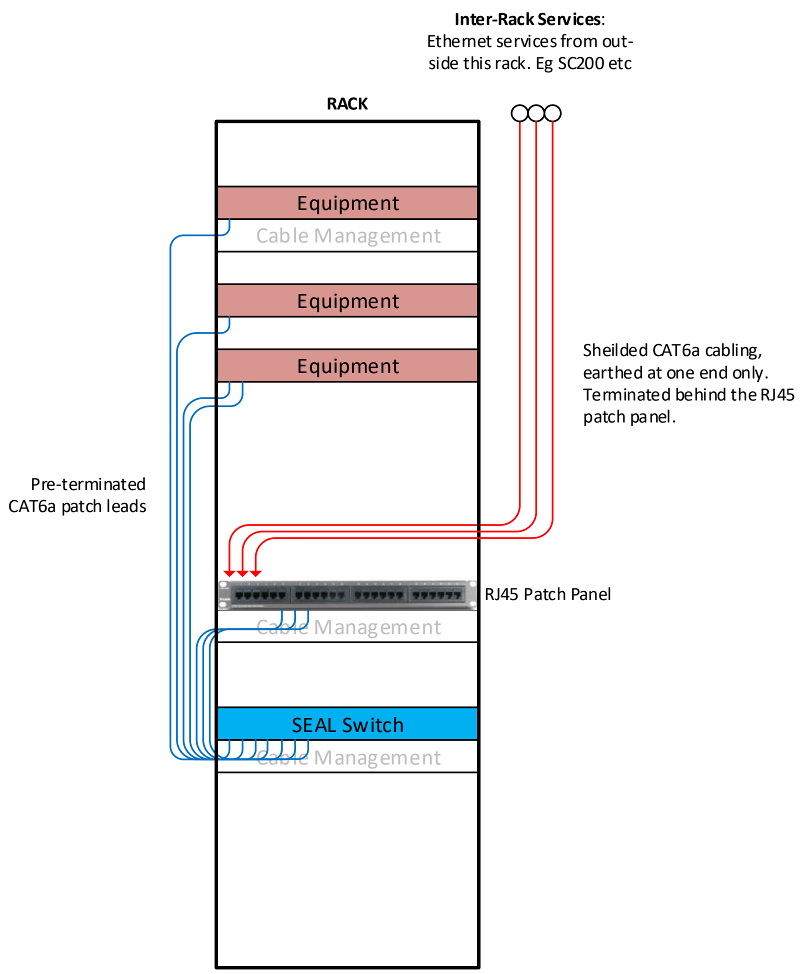


Figure 1 SEAL Patching Arrangement

2.5.5.5 Expansion Beyond Chassis Capacity

There may be instances where the required interface count for a site exceeds the interface count available via the current (or planned) SEAL switch solution on-site. In this case, a secondary SEAL switch can be deployed to expand the interface count accordingly.

These two switches should be inter-linked together on-site. The primary switch should handle all inter-site connections, while the second switch should handle any additional local connections required.

The secondary switch should be from the same manufacturer/product line as the primary switch.

Background Note: *This is to simplify the SEAL deployment at that site, rather than splitting it across multiple vendors and potentially complicating any troubleshooting activities that may arise.*

2.5.5.6 Substation LAN Requirement

For substations, a Substation LAN port shall be supplied which terminates on a wall outlet at the substation control desk.

2.5.5.7 Maintenance Ports

On each SEAL switch, ports shall be reserved to support maintenance activities, such as the following:

- Use interface for emergency restoration of SEAL service due to a faulty interface.
- Use interface for field access to networks, by temporarily setting up interface.
- Use interface for troubleshooting activities (such as port mirroring).

This requirement may be waived for switches with very limited port quantities.

For locations with more than one SEAL switch, this requirement applies to each switch.

The design templates for each type of switch specifies the number of reserved ports for maintenance.

2.5.5.8 Backhaul

SEAL backhaul via fibre is preferred.

Background Note:

This is preferred for several reasons:

- *To segregate SEAL network from other traffic*
- *To reduce risk of loss of network management of the network equipment where the network equipment has a fault (e.g., radios and SDH multiplexers)*
- *To maximize the bandwidth available to the SEAL network*
- *To avoid using bandwidth on the bearer (e.g., SDH STM1 capacity)*

Should this not be possible (e.g., in country regions), then the following Ethernet bearer solutions should be used (where available):

- Ethernet over Microwave Radio
- Ethernet over MPLS/TP (EoMPLS)
- Ethernet over SDH (EoSDH)
- Ethernet over PDH (EoPDH)

Where the SEAL network is transported over SDH, it shall be given a capacity of at least 1x VC3.

2.5.5.9 SFPs

All SEAL fibre links should be specified to be 1Gbps.

Industrially rated SFPs shall be specified for Substation environments where supported by the vendor. These typically have an operating temperature range up to 60°C or higher.

SFPs with digital diagnostics monitoring (DDM) or digital optical monitoring (DOM) should be used for all SEAL fibre links.

2.5.5.10 Datacentre Sites

Where SEAL equipment is installed in third party datacentres, the equipment selection and design shall comply with the relevant datacentre requirements.

2.5.5.11 Security

The SEAL network (or any management service) shall not be carried over un-secure infrastructure, without appropriate security measures put in place to control the risk. Such security measures need to be signed off by the appropriate authority (ICT Security Manager and/or OT Solution Architect). Unsecure infrastructure is defined as any devices/network that are outside the direct control of WP Telecommunications or WP SCADA/Automation, (e.g., the IT or Telstra networks).

All devices shall be physically secured to prevent unauthorised access to the equipment. For customer-controlled sites equipment should be installed in lockable cabinets.

2.6 CBD/DA Network

2.6.1 Introduction

2.6.2 Definitions

Table 13: Definitions

Term	Description
CBD	Central Business District
DA	Distribution Automation
OSPF	Open Shortest Path First
OT	Operational Technology (in contrast to Information Technology)
VRF	Virtual Routing and Forwarding

2.6.3 Australian and International Standards

Telecommunications CBD/DA Network shall be designed in conformance with the following standards.

Table 14: List of Applicable Standards

Standard/Specification	Description
IEEE 802.1	Higher Layer LAN Protocols Working Group
IEEE 802.3	Ethernet
IEEE 1613	IEEE Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations

2.6.4 Western Power Standard Designs and Supporting Documents

Telecommunications CBD/DA network shall be designed in conformance with the following Western Power standard designs and supporting documents.

Table 15: List of Applicable Western Power Standard Designs and Supporting Documents

Drawing No.	Description
	Telecommunications Construction Standard – Optical Fibre Network[2]
	Telecommunications Construction Standard – Optical Fibre Network (Approved Material Listing)[2]
	TOM - SECURITY - Network Diagram (CBD IP Network)[2]

2.6.5 Network Physical Architecture

Background Note: *The OSPF/VRF-lite network is planned to be replaced by an IP/MPLS network. At that time, this chapter will be superseded.* *The existing CBD/DA network comprises of three parts: The 'head end' interface, the OSPF core and the OSPF Area loops.*

The CBD/DA network OSPF core shall interface to field facing systems of the SCADA and Telecommunications OT domains. This interface shall be at the Data Aggregation Sites.

The OSPF core shall comprise Area 0 and all the Area Border Routers (ABRs). The Area 0 Routers shall be connected in a full mesh and interface to the OT domains above. Each ABR shall connect to two Area 0 Routers. All interfaces in the OSPF core shall be 1000MBits/s Ethernet.

The ABRs shall be installed in pairs. Each pair shall serve two OSPF areas. These areas shall have a loop topology. The pair of ABRs shall be directly connected to each other to complete the loop.

For the CBD network, the loop is composed of fibre links between the Data aggregation sites and the CBD substations. All interfaces on the loop shall be 1000MBits/s Ethernet for the CBD network.

The interfaces for the Distribution Automation (DA) network shall be 100Base-T. The loop is provisioned as point-to-point Ethernet over SDH links each assigned a capacity of 5 x VC12.

Each CBD substation shall have its own site router. Where a DA base is not located at a site where a loop topology is possible, a site router shall be instead located on the loop and an Ethernet service shall be extended from the router to the base. This service shall have a capacity of 1x VC12.

This architecture is depicted in Figure 2.

[2] Western Power internal document

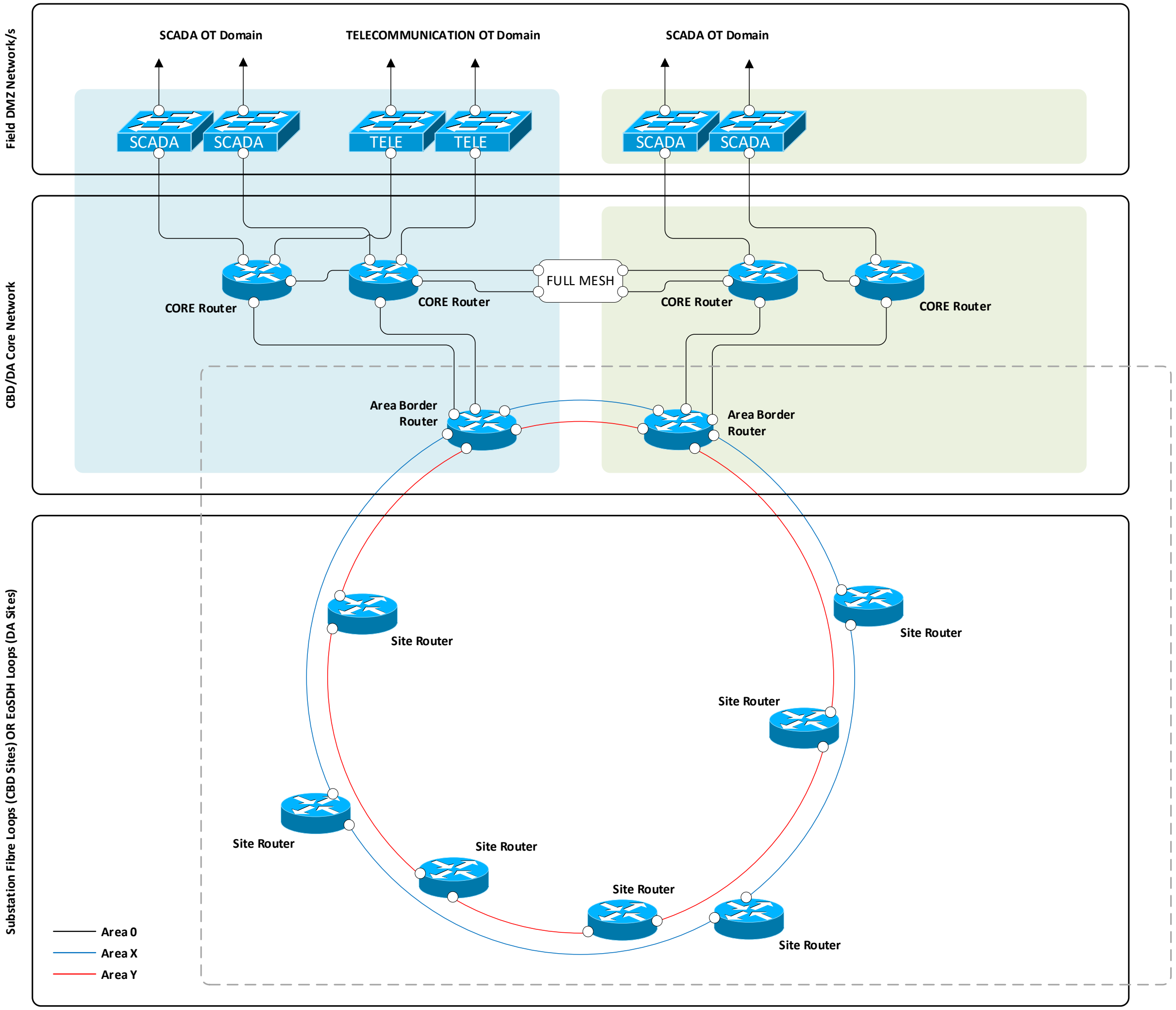


Figure 2 CBD/DA IP Network

2.6.6 Ethernet Architecture

Each physical link between routers in the network shall be allocated a VLAN for each VRF utilising that link.

The VLAN allocated shall not be used in the router for any other purpose.

VLAN number allocation shall be the VRF number x 100 + an index value starting at 50. For example, VLAN 151 may be allocated for VRF 1.

2.6.7 IP Architecture

IP addresses shall be allocated as per the scheme defined in 'TOM - SECURITY - Network Diagram (CBD IP Network)'.

VLANs on physical links between routers shall be configured as sub-interfaces. Other VLANs shall be configured as Switched VLAN Interfaces (SVIs).

2.6.7.1 VRF-lite Requirements

The IP addresses allocated to each VRF instance shall not overlap.

Each VRF instance shall not share interfaces with any other VRF instance, in order to segregate the traffic.

Each VRF instance shall have a loopback IP address allocated, and this address shall be the Router ID for the VRF instance.

VRF-lite indices shall be conserved over the network. The allocated VRF-lite indices are given in Table 16. No further VRF-indices may be added to the network.

Table 16: VRF-lite index allocations

VRF-lite index	Usage
1	Router management
2	CBD Automation traffic
3	CBD Power Supply Unit Management
6	Distribution Automation traffic
7	Radio Management

2.6.7.2 OSPF

Each VRF instance shall run its own instance of OSPF.

The number of participating routing devices in any OSPF area shall not exceed a total of 48.

The number of OSPF areas shall not exceed 20.

All other areas shall connect only to Area 0. For example, Area 1 cannot connect directly to Area 2. ABRs shall not connect to more than three OSPF areas, that is, Area 0 and two others.

The ABRs shall perform route summarisation for Area 0.

Areas 1, 2, 3, 4, 5, 6, 7, 8, 9, 11 and 12 are used for CBD Automation. Areas 96, 97, 98 and 99 are used for Distribution Automation.

2.6.8 Security

This network shall not use infrastructure not under the direct control of Western Power's Telecommunications or Automations teams, without an approved Cyber security risk assessment.

All devices shall be physically secured to prevent unauthorised access to the equipment.

All radio traffic over the air shall be encrypted. GE Orbit radios shall use AES 256 encryption.

2.7 Telecommunications Operational Network

[TON details redacted]

3 Services

3.1 Teleprotection

3.1.1 Introduction

Relay-to-relay protection signalling is one of the main services provided by the telecommunication network. As these services are an integral part of the system protecting primary plant from damage, there is a need for these services to be highly reliable.

3.1.2 Definitions

Table 17: Definitions

Term	Description
TPS	TeleProtection Signalling

3.1.3 Australian and International Standards

Teleprotection shall be designed in conformance with the following standards.

Table 18: List of Applicable Standards

Standard/Specification	Description
ITU-T G.703	Physical/electrical characteristics of hierarchical digital interfaces
IEEE C37.94	N times 64 kbps Optical Fiber Interfaces between Teleprotection and Multiplexer Equipment

3.1.4 Western Power Standard Designs and Supporting Documents

Teleprotection shall be designed in conformance with the following Western Power standard designs.

Table 19: List of Applicable Western Power Standard Designs

EDM/Drawing No.	Description

3.1.5 Communication Path

To comply with the Technical Rules, communications paths for Protection 1 and Protection 2 circuits shall be routed through different parts of the communications network, never passing through the same piece of equipment, and with each piece of equipment supplied by separate power distribution systems.

3.1.6 Differential Protection

The standard communications interface for new protection services is fibre optic IEEE C37.94. Existing protection relays may use ITU-T G.703 interfaces.

The maximum communications channel propagation time shall be less than 10ms.

3.1.6.1 OPIC2

Keymile OPIC2 shall be used for new differential protection channel applications. The OPIC2 shall be used in C37.94 TDM mode, with the individual C37.94 circuit not protected.

3.1.7 Teleprotection Signalling (TPS)

TPS is generally used for legacy transmission line protection and Undervoltage Load Shedding (UVLS).

3.1.7.1 Power Supply

TPS equipment shall be powered by the site Substations DC supply, which is usually nominally 110V DC. At certain sites, the supply voltage may be nominally 230V DC.

3.1.7.2 Location

Standalone TPS equipment should be installed in a separate cubicle to other telecommunication equipment. If space constraints make it impractical to install new cubicles, it is permissible to install TPS units in the same cubicle as other equipment. However, the TPS shall be segregated from other equipment in the rack by use of a physical barrier and separate RDPs. Segregation of 110VDC power and control cabling from other cables shall also be maintained.

3.1.7.3 Trip Transfer Times

Teleprotection systems shall be designed to provide the minimum practicable command transmit times. During the design stage, the TPS transfer time should be calculated using the Protection Timing Tool.

The maximum trip transfer times are as follows:

Digital Teleprotection Systems – 10ms

Where a shorter trip transfer time is required, this shall be detailed and highlighted by Protection Design. It may be desirable to minimise the trip transfer times in some situations by additional communications equipment, especially if a small increase in communications system cost allows significant reduction in trip transfer times.

3.1.7.4 Alarms

Refer to Section 3.7.5.2.1 for alarm requirements.

3.1.7.5 TEPI2

Keymile TEPI2 teleprotection card shall be used to replace standalone TPS on the Western Power network.

Background Note:
Western Power protection preference for new transmission line protection or asset replacement of existing protection is digital differential protection using C37.94 standard. *Asset Performance have proposed replacement of existing teleprotection systems with the TEPIx card for the following reasons:* • *There are a lot of legacy protection relays and schemes using teleprotection equipment. It is likely that the teleprotection equipment will require replacement prior to protection relay replacements due to their lower asset lifespan.* • *Some of the existing TPS units eg: DIMAT and RFL945 are obsolete, and no replacement is available for them as yet.* • *Availability of remote alarms on the TEPIx card thus eliminating the requirement for dry contact alarms* *There are two types of TEPI cards – TEPI1 and TEPI2. TEPI1 converts the electrical signal from the protection relay into an E0 timeslot for transport via the TDM network. TEPI2 converts the electrical signal from the protection relay into an ethernet pack that can be transported as Ethernet over SDH (EoSDH) or Multiprotocol Label Switching (MPLS).*

If both Protection 1 & 2 be TPS-based, only one standalone TPS unit shall be replaced with TEPI2. This is further described in the table below.

Scenario	Replacement
Protection 1 communications is currently differential protection Protection 2 communication is currently TPS-based	Protection 2 communication to be replaced with TEPI2
Protection 1 communication is currently TPS-based Protection 2 communications is currently differential protection	Protection 1 communication to be replaced with TEPI2
Protection 1 communications is currently TPS-based Protection 2 communications is currently TPS-based	Protection 1 communications to be replaced with TEPI2 Protection 2 communications to remain standalone TPS

Note these scenarios assume no protection relay changes are occurring. In most cases, if protection relays are being replaced, then they will be replaced with differential protection relays which would not need TPS.

Each TEPI2 card has two virtual interfaces. Each card shall only be used for the following combination of services:

- One Transmission line (2-ended) tele-protection (P1 or P2) service.
- One Undervoltage Load Shedding Scheme (UVLS) service.
- One Inter-tripping scheme.
- One Transmission line (2-ended) tele-protection (P1 or P2) service AND one UVLS service.
- One Transmission line (2-ended) tele-protection (P1 or P2) service AND one Inter-tripping scheme.

One teed Transmission line (3-ended) tele-protection (P1 or P2) service.

3.2 Automation

3.2.1 Introduction

This chapter provides the requirements for adding new circuits to the SCADA system.

The current electricity network management systems are POF (DMS) and XA/21 (EMS).

These systems require DNP over IP communication from remote sites to central hubs. The IP signals are transported using Western Power's MPLS-TP and SDH/PDH network where possible and using approved data radio's where not.

The change to DNP IP standard design occurred in 2020, so most of the existing installation utilise RS232 signals to be transported from remote sites to central hubs. The RS232 signals are transported using Western Power's SDH/PDH network where possible and using approved data radio's where not. See the end of the chapter for former serial-based design guidelines.

There is a slight difference in how the EMS and DMS handle the data transmission however the basic design philosophy is the same for both systems. That is to provide a system that is robust with no single point of failure causing loss of service.

3.2.2 Definitions

Table 20: Definitions

Term	Description
CBD	Central Business District of Perth
DA	Distribution Automation
DMS	Distribution Management System
EMS	Energy Management System
FEP	Front End Processor
WSOS	Windows Switchgear Operating System

3.2.3 Australian and International Standards

Automation services shall be designed in conformance with the following standards.

Table 21: List of Applicable Standards

Standard/Specification	Description
IEC 61850	Standard series for protocol-based communication between Intelligent Electronic Devices (IEDs) at Electrical Substations

3.2.4 Western Power Standard Designs and Supporting Documents

Teleprotection shall be designed in conformance with the following Western Power standard designs.

Table 22: List of Applicable Western Power Standard Designs

Drawing No.	Description

3.2.5 DMS Circuits

Background Note:

The DMS provides automation and control to all devices in the distribution side of the primary network. The system is comprised of main and backup FEPs. The DMS must be manually switched to utilise the alternative FEP upon connectivity failure between a set of remote devices and the FEP actively monitoring those devices.

It should be noted here that, where possible, CBD distribution device telemetry will be transported to the DMS in the method outlined in the CBD Design Chapter.

This method relies on proximity to CBD Substation Fibre Loops.

Historically, access to all devices, outside of the CBD and some inside the CBD, is provided using remote radio bases. These radio bases each provide connectivity to multiple remote devices located in their coverage area.

The remote radio bases currently used in the Western Power distribution network offer two RS232 channels. The first channel is used to relay DNP3 telemetry to and from the devices in the radio bases' coverage area, the second is currently being provisioned for future potential remote management (for Nulec reclosers, using the application 'WSOS') traffic to those same devices. Telemetry is required to be transported back to both aggregation sites while WSOS traffic should only be transported back to one aggregation site.

DA traffic will only be required to run at 9.6kb/s or 19.2kb/s depending on the remote device connection.

Each individual remote radio base shall have two individual circuits extended to them. These DA circuits should be run entirely over the PDH/SDH network wherever possible.

The first circuit requires diverse cross connection paths to be established from the nearest PDH multiplexer of the remote radio bases to aggregation sites.

The split between the two paths to the different FEP site locations should be implemented using an omni directional conference cross connection. The cross connection should be implemented as close as is practically possible to the site where the remote device is located, if not the remote site itself. The cross connection should only be implemented at a site where the two paths leaving the site will actually be diverse. The method of implementing this cross connection is equipment specific.

The second circuit shall be established between the remote radio base and aggregation site and may follow the same path as the first circuit.

In the case where the remote radio base location does not have PDH network connectivity, the radio's data interface ports shall be extended to the nearest site with PDH network connectivity using appropriate approved data radio links.

3.2.6 EMS Circuits

Background Note: *The EMS provides automation and control to zone and terminal substation RTU equipment in the transmission side of the electricity network. The system is comprised of main and backup FEPs located at Data Centres. Upon connectivity failure between a remote device and the FEP actively monitoring that device, the EMS may require manually switching to poll using the alternative FEP, depending on channel configuration.*   *The RTUs currently used in the Western Power transmission network at terminal and zone substations offer two IP channels to output equipment telemetry. This equipment telemetry is required to be diversely transported from the first RTU IP port to the first aggregation site and from the second RTU IP port to the second aggregation site.*   *No connection point is required for RRST as Automation Design are in the process of installing Telstra Remote Telemetry devices on the transformer units.*

EMS traffic from substations to master stations requires duplicated DNP over IP circuits. The comms solution is to provide MPLS-TP circuits between substations and data aggregation sites.

The Q-in-Q standard is used in the design. This allows SCADA to use their own VLANs inside telecommunication network provided VLAN. The Ethernet ports at the data aggregation site and at the substation are trunk ports, allowing any SCADA VLAN to enter and leave the network.

In instances where MPLS-TP is not available at the remote sites, the DNP IP traffic shall be transported using Ethernet over PDH (EoPDH) or Ethernet over SDH (EoSDH). In these instances, the multiplexers will be configured to only transport the one SCADA VLAN required for that site over the EoPDH or EoSDH circuit.

3.3 Network Reinforcement Schemes

3.3.1 Introduction

This chapter provides the requirements for designing new Network Reinforcement Schemes (NRS).

These schemes are used when a distributed control system is required to carry out operations on the electricity network independently of the EMS or DMS.

3.3.2 Definitions

Table 23: Definitions

Term	Description
Centralized Control System	Control system where logic is executed in a singular device which is then communicated to other devices for subsequent action
Distributed Control System	Control system where logic is executed in several, geographically-separated devices all communicating to each other.
DMS	Distribution Management System, see section 3.2
E0	A circuit capacity in PDH (payload 64kBit/s)
EMS	Energy Management System, see section 3.2
MPLS-TP	Multiprotocol Label Switching – Transport Profile
PDH	Plesiochronous Digital Hierarchy
RSTP	Rapid Spanning Tree Protocol
SDH	Synchronous Digital Hierarchy
VC12	Virtual Container 12, a circuit capacity in SDH (payload 2MBit/s)
VLAN	Virtual Local Area Network

3.3.3 Australian and International Standards

Telecommunications NRS services shall be designed in conformance with the following standards.

Table 24: List of Applicable Standards

Standard/Specification	Description
IEC 61850	Standard series for protocol-based communication between Intelligent Electronic Devices (IEDs) at Electrical Substations

3.3.4 Western Power Standard Designs and Supporting Documents

Telecommunications NRS services shall be designed in conformance with the following Western Power standard Designs.

Table 25: List of Applicable Western Power Standard Designs

EDM/Drawing No.	Description

3.3.5 Network Reinforcement Schemes Requirements

Background Note:
Network Reinforcement Schemes are typically based on IEC 61850 communication protocols, namely GOOSE and MMS. Duplicated Protection relays are provisioned for inputs and outputs to primary plant and to process logic. Inter-site communication between these relays is via an Automation switch. Telecommunication services terminate at the Automation switches at each site to transport the data. The Automation switches run Rapid Spanning Tree Protocol (RSTP) or a similar protocol to prevent Ethernet loops and prevent broadcast storms.

Network Reinforcement Schemes (NRS) communication topology shall be provisioned as point-to-point Ethernet services between each relevant site. The services shall terminate at the NRS Automation switch.

NRS 1 Automation switches shall not be interconnected with NRS 2 Automation switches.

The NRS Ethernet services shall form a ring topology between sites. The NRS 1 ring shall follow the same route through the communications network as the NRS 2 ring (the two rings shall use the same telecommunications equipment).

The NRS Ethernet services shall not be switched by telecommunication equipment, unless tested with the Automation switches. Switching in the telecommunications equipment has the potential to disrupt Automation RSTP. The NRS 1 Automation ring and NRS 2 Automation ring may also use the same VLANs and switching can remove segregation of the services.

The NRS Ethernet services should be transported by SDH or MPLS-TP. When transported by SDH, the service should be provisioned 1xVC12 in capacity. When transported by MPLS-TP the service should be provisioned 10Mbit/s capacity.

If the NRS Ethernet services are not transported by SDH or MPLS-TP, they shall be transported over PDH or as a dark fibre service. When transported as Ethernet over PDH, the service shall be provisioned with 30xE0 capacity.

The NRS Ethernet services shall be designed such that at no point is the ring ‘collapsed’, that is, failure of a single network element or telecommunications bearer shall not cause the loss of all the NRS Ethernet services to any Automation switch.

3.4 Advanced Metering Infrastructure

3.4.1 Introduction

This chapter provides the provisioning requirements for additional Advanced Metering Infrastructure (AMI) coverage.

3.4.2 Definitions

Table 26: Definitions

Term	Description
AC	Alternating Current
AMCM	Advanced Meter Communications Module
AMI	Advanced Metering Infrastructure
NIC	Network Interface Card

3.4.3 Australian and International Standards

Telecommunications AMI network shall be designed in conformance with the following standards.

Table 27: List of Applicable Standards

Standard/Specification	Description
IEEE 80.2.15.4	IEEE Standard for Low-Rate Wireless Networks

3.4.4 Western Power Standard Designs and Supporting Documents

Telecommunications AMI network shall be designed in conformance with the following Western Power standard designs and supporting documents.

Table 28: List of Applicable Western Power Standard Designs and Supporting Documents

Drawing No.	Description
	HTZ Communications – RF Modelling Guideline[3]

[3] Western Power internal document

Drawing No.	Description
	VLAN Allocation drawing[4]

3.4.5 RF Network Design Requirements

The design process for the AMI RF Network, detailed in 'HTZ Communications – RF Modelling Guideline', shall be followed.

3.4.6 Backhaul Requirements

For Access Points located outside Transmission Substations and Telecommunications only sites, a commercial third-party telecommunications network (Telstra) is to be used for backhaul of data.

For Access Points located inside Transmission Substations and Telecommunications only sites, the SEAL network shall be used for backhaul. No more than 20 sites shall be allocated to any one VLAN. The site allocations shall be as per the VLAN Allocation drawing.

Traffic from the AMI network into the SEAL network shall be rate limited to 10Mbit/s.

Traffic shall be classified as critical, priority and normal. Critical traffic should suffer no more than 250ms of latency, priority should suffer no more than 300ms and normal traffic should suffer no more than 1000ms of latency. Critical traffic shall have a Class of Service CS4, priority traffic shall have CS2 and normal traffic shall have CS1.

Background Note:
The Advanced Meter Communications Module (AMCM) otherwise known as a Network Interface Card (NIC) that provides the meter IEEE 802.15.4 communications has a typical delay of 10ms per hop at 2.4Mbps, with a maximum hop count of 15, and a recommended hop count of 10. Note the GEN4 NIC has a documented hop delay of 25ms at 300kbps. The default rate of the NIC5 is 100kbps, typical hop delay for a 250byte packet at 100kbps is 50ms.

3.4.7 Access Point Security

For Access Points located inside Transmission Substations and Telecommunications only sites, the Access Point shall be installed within the relay room or communications building.

[4] Western Power internal document

3.5 Operational Voice/Telephone Requirements

3.5.1 Introduction

Voice communication from Network Operations Centre (NOC) is a critical requirement to ensure the efficient and safe management of Western Power's power network. Critical sites within Western Power require redundant telecommunication paths to be available for voice contact for normal operational and emergency work.

Primary and backup speech paths are a requirement under Western Power's Technical Rules.

3.5.2 Definitions

Table 29: Definitions

Term	Description
Fixed mobile phone	External service provider mobile phone having a normal telephone handset and operation with battery backup.
NOC	Network Operations Control
PABX	Private Automatic Branch Exchange. Carriers out the voice call processing and switching from a PABX telephones onto a limited number of an external carrier circuits. E.g., PABX may control 100 building telephone extensions to 10 external carrier lines.
PAX	Private Automatic Exchange. Carriers out the voice call processing and switching from a PAX telephones onto a limited number of an internal carrier circuits to another PAX switch. Telephone calls between PAX's are made via an internal network independent from any external carrier.
Registered Facility Market Participants	Generators or customers of the Wholesale Energy Market (WEM) who operate a facility registered with the Australian Energy Market Operator (AEMO)
SLS	Straight Line Service. Single analogue telephone line provided by external service provider. Is not switched by any internal machine on a premise (e.g., Telstra line)
Voice path	A communication path for the transmission of speech between two points. May be achieved via an internally switching technology (e.g., PABX/PAX) or external technology (carrier exchange or mobile phone) for a connection to be set up between two points. Connection achieved normally by dialling a telephone number.

3.5.3 Australian and International Standards

Designs shall be in conformance with the following standards.

Table 30: List of Applicable Standards

Standard/Specification	Description

3.5.4 Western Power Standard Designs and Supporting Documents

The following Western Power standard designs are applicable for telephony.

Table 31: List of Applicable Western Power Standard Designs

EDM /Drawing No.	Description
	Technical Rules
C58/13/1	STANDARD DRAWING – PAX – VOIP Telephone Media Converter Cabinet
C58/13/2	STANDARD DRAWING – PAX – VOIP Telephone Media Converter Cabinet
C58/13/3	STANDARD DRAWING – PAX – VOIP Telephone Media Converter Cabinet
C58/13/4	STANDARD DRAWING – PAX – VOIP Telephone Media Converter Cabinet (Power Supply Bracket for 1 Unit.)
C58/13/5	STANDARD DRAWING – PAX – VOIP Telephone Media Converter Cabinet (Power Supply Bracket for 2 Unit.)
C58/13/6	STANDARD DRAWING – PAX – VOIP Telephone Media Converter Cabinet (DIN Rail Bracket)
C58/13/7	STANDARD DRAWING – PAX – VOIP Telephone Media Converter Cabinet (Mounting Bracket)
C58/14/1	STANDARD DRAWING – PAX – VOIP PoE Injector Shelf
C58/15/1	STANDARD DRAWING -- PAX -- PAX VOIP MEDIA CONVERTER -- SHELF LAYOUT

3.5.5 Design Requirements

The table below describes the telephony requirements for difference location types.

Location	Requirement
Western Power – Power Stations & Registered Facility Market Participants (Load or Generator)	Two separate independent voice paths from NOC to Power Station Control Room in Power Station plus contingency. i. Primary Path – PABX or fixed mobile phone via/from external service provider ii. Secondary Path – Internal PAX extension iii. Contingency path – Personnel issued mobile phone or emergency satellite phone. External service provider line not to be used by any secondary services on site e.g., Datastores etc. External services to be protected from Earth potential rises.
Terminal Substations/Power Station Switchyards	Two separate independent voice paths from NOC to Terminal Substation plus contingency. i. Primary Path – Fixed mobile phone from external service provider ii. Secondary Path – Internal PAX extension iii. Contingency path – Personnel issued mobile phone or emergency satellite phone. External services to be protected from Earth potential rises. External service provider line not to be used by any secondary services e.g., Datastores etc. All control/switchroom buildings within a substation compound to be covered by the above requirement.
Independent Power Producers (no despatch)	One voice path from NOC to IPP control room plus contingency. May be via external service provider. i. Primary Path – PABX or fixed mobile phone from external service provider, or via Internal PAX extension. ii. Contingency path – Personnel issued mobile phone or emergency satellite phone. Contingency path may use same external service provider. External services to be protected from Earth potential rises.

Location	Requirement
Zone Substations	One voice path from NOC to Zone Substation plus contingency. May be via external service provider. i. Primary Path – Fixed mobile phone from external service provider, or via Internal PAX extension. ii. Contingency path – Personnel issued mobile phone or emergency satellite phone or Mobile Radio. External services to be protected from Earth potential rises. All control/switchroom buildings within a substation compound to be covered by the above requirement.

Note: SLS may be in use as the primary path for existing substations, but shall not be used for any new installations. Where possible, these shall be decommissioned and replaced with alternatives as per the above table.

3.5.6 Telephone Installation Location

VOIP Telephones shall be placed on the following locations, as applicable.

Location	Preferred Operational Telephone Installation Location
Substation control building with desk	On desk
Substation control building without desk	On wall near main entry door
Standalone comms shelter	On wall
Switchroom	On wall near main entry door – shall not be installed directly in front of switchgear
Third party generator control building	On control desk or adjacent to media converter – as agreed with third party

3.5.7 PAX Services

3.5.7.1 Overview

PAX services shall be provisioned via VOIP. The handsets at the site shall be a Western Power ICT provisioned VOIP handset.

3.5.7.2 SEAL VLANs

The SEAL Network currently transports the PAX VOIP VLANs from the PAX Jump-zone Environment through to the end sites.

The PAX handset shall be allocated to one of the following VLANs depending on the location of the site.

- 1030: Network servicing the Metro Area
- 1031: Network servicing Country North
- 1032: Network servicing Country East
- 1033: Network servicing Country South

3.5.7.3 Sites with Multiple Buildings

At a site where there are multiple main buildings, (relay rooms and switch rooms), there may be a need to provision multiple PAX handsets to service the site.

The design shall cater for the following:

- A VOIP handset shall be installed at each of the building locations.
- A PAX extension shall be allocated for each VOIP Handset.
- A PAX extension shall be allocated for the site.

Background Note:
While it may be preferred to have only a single number for the entire site, each VOIP handset requires its own extension to operate – an extension that will be used for outgoing calls.

3.5.7.4 PAX Provisioning

To provision a PAX service, the following shall be used (in order of preference):

1. Local SEAL switch with PoE capability.
2. Local SEAL switch without PoE capability, using a PoE injector.
3. Media Converter with PoE capability connected to a SEAL switch at an adjacent location via fibre optic cable.

Media converters can be rack mounted, shelf mounted, or mounted within a cabinet depending on the application. The media converter should be mounted within a cabinet at locations with limited or no Western Power rack space (eg. at customer sites).

3.5.7.5 Conversion of Analogue PAX Extensions

When undertaking asset replacement activities at a site involving replacement of multiplexers, analogue PAX extensions should be replaced with VOIP-based services.

The new VOIP-based service shall be allocated a new extension number at the time of design.

Background Note:
A new extension number is required to ensure that the site always has a working phone during the transition between commissioning of new service and retirement of old service.

3.6 Third-Party Services

3.6.1 Introduction

This chapter provides the requirements for provisioning new third-party services. Third-Party Services are those in which Western Power provides telecommunications services between two other parties for purposes unrelated to Western Power's operations.

3.6.2 Definitions

Table 32: Definitions

Term	Description
Customer	The party requesting the provisioning of the service
ODF	Optical Distribution Frame

3.6.3 Australian and International Standards

Telecommunications Third-Party Services shall be designed in conformance with the following standards.

Table 33: List of Applicable Standards

Standard/Specification	Description

3.6.4 Western Power Standard Designs and Supporting Documents

Telecommunications Third-Party Services shall be designed in conformance with the following Western Power standards.

Table 34: List of Applicable Western Power Standard Designs

Drawing No.	Description

3.6.5 TDM services

Third-Party Services should not be allocated on the TDM network.

3.6.6 MPLS-TP services

Third-Party Services should not be allocated on the MPLS-TP network.

3.6.7 SEAL services

The capacity allocated to Third-Party Services on the SEAL network should not exceed 80% of the unused capacity of each link the traffic traverses.

The Third-Party Services should be allocated their own VLAN. Customers with multiple Third-Party Services may be allocated a single VLAN.

3.6.8 Dark Fibre Services

The capacity allocated to a Third-Party Service over Dark Fibre shall only be the fibres presented to the customer equipment. That is, no cores shall be reserved at the ODF without patch-leads installed to the customer equipment.

A new Third-Party Service should not consume the last available cores on a set of fibres (e.g., a tube) between two locations.

3.7 Network Management Services

3.7.1 Introduction

This section covers Network Management Services which enables remote monitoring and configuration of telecommunications devices.

3.7.2 Definitions

Table 35: Definitions

Term	Description
Data Aggregation Sites	Sites which interface the TON and Telecommunications Field network.
HTTPS	Hypertext Transfer Protocol Secure
NMS	Network Management System
NOC	Network Operations Control
Normally Open	An alarm contact which is open when the equipment is de-energised
Normally Closed	An alarm contact which is closed when the equipment is de-energised
Northbound Interface	A logical interface of an NMS providing alarm and logging information to another software system such as an OSS
OSS	Operational Support System
SNMP	Simple Network Management Protocol
SSH	Secure Shell
TPS	Teleprotection System
TPU	Teleprotection Unit

3.7.3 Australian and International Standards

Telecommunications Network Management Services shall be designed in conformance with the following standards.

Table 36: List of Applicable Standards

Standard/Specification	Description

3.7.4 Western Power Standard Designs and Supporting Documents

Telecommunications Network Management Services shall be designed in conformance with the following Western Power standard designs and supporting documents.

Table 37: List of Applicable Western Power Standard Designs and Supporting Documents

Drawing No.	Description

3.7.5 Alarming

3.7.5.1 SNMP

Active telecommunications equipment shall be monitored by SNMP if capable. If not, the equipment shall be monitored using dry alarm contacts to a SNMP capable RTU. Some equipment requires dry contact alarm monitoring in addition to SNMP. Refer to Section 3.7.5.2.

> ***Background Note:***
>
> *Traditionally Western Power has relied heavily on a system of distributed RTUs to monitor onsite equipment. Each RTU would monitor the dry contact alarm outputs of all devices located at its site. All RTUs would be polled in turn and the state of each input would be automatically updated and analysed in a central database.*
>
> *Various changes in technology and availability of equipment have dictated that this is no longer the most efficient way to monitor the state of onsite equipment.*

Equipment monitored via SNMP shall be provisioned with Ethernet connectivity to the TON network via the Data Aggregation Sites.

When a remote device supports SNMP and the site it is located at has access to the SEAL network then this is the preferred method for monitoring that device. The exceptions to this rule are Keymile multiplexers.

Keymile multiplexers form an OSPF network using a combination of Ethernet over SDH links and SEAL VLANs. Each OSPF area shall be connected back to Area 0 at the Area Border Router devices. There shall be a minimum of two such connections between each area and Area 0.

SNMP capable devices that are new to the Western Power telecommunications network, that is, devices that have never been used in the network before, shall have their MIBs verified and incorporated into Western Power's OSS and SNMP manager (CNMS-NG) by the Telecommunications Operations and Maintenance area.

New SNMP equipped devices should be capable of communicating with a minimum of three trap destinations and should support up to SNMPv3.

A new dedicated VLAN shall be established to transport the new devices SNMP traffic across the SEAL network. This VLAN will also serve to provide management access to these devices.

3.7.5.2 RTU

Dry contact alarm outputs shall be aggregated on a device that can monitor the output state and transport it back to an NMS for interpretation.

Most of the available RTU equipment requires specific multiplexer equipment to be present on site to operate. Dry contact alarms should be allocated to existing RTU equipment where possible.

> ***Background Note:***
>
> *The mechanism for information transport back to the NMS requires that the NMS or a vendor specific management system poll each RTU individually to check the state of each RTUs inputs. As it polls, the NMS updates a database of RTU input states and highlights alarms as required. It should be noted this system is opposite to the SNMP system. With RTUs the NMS drives collection of alarms while with SNMP the system relies on the devices to indicate when the status of one of their alarms has changed.*

The below equipment types have specific requirements for dry contact alarms.

3.7.5.2.1 TPS

> ***Background Note:***
>
> *The availability of TPS impacts operational decisions on the electricity network and therefore NOC require accurate knowledge of the current status of TPS.*

All TPUs shall provide to NOC via the Substation's Automation Gateway/RTU a dry contact general TPS Fail that represents a failure of both equipment and/or connectivity failure. This should be provided from the TPU to the Automation RTU via the protection equipment, however at some sites it has been wired to the RTU alarm contact cards directly. When replacing a TPU, the designer should preserve the existing arrangement.

For alarms provided to the Automation RTU, the contact should be open when the alarm is inactive and should close when the alarm is active. Normally Closed contacts should be used for this alarm.

For alarms provided to protection relays, the contact should be closed when the TPS is in service and healthy and should open when the TPS is in a fault condition. Normally Open contacts should be used for this alarm.

The TPU shall also provide alarms to Telecommunications Control Centre. Where the TPU supports SNMP (i.e., Dimat ZIV TPU-1 and Dewar DM2000), and the site has ethernet connectivity, SNMP shall be used to monitor the equipment. DM2000 TPUs are only to be installed into sites with Ethernet connectivity as they are not equipped with the required four dry contact relays.

If the TPU does not support SNMP, the following dry contact alarms shall be provisioned back to NMS via a (telecommunications) RTU:

- Equipment Failure
- Communications Failure
- Command Received

The DM2000 TPUs shall not be installed at sites without Ethernet connectivity for SNMP as they do not support dry contact alarms.

3.7.5.2.2 DC Systems

Eaton DC rectifier systems shall provide the following dry contact alarms to Telecommunications Control Centre via an RTU:

- Mains fail.
- Low Volts.

Where Ethernet connectivity is available, Eaton DC rectifier systems shall also be monitored by SNMP.

Where Eaton DC rectifier systems are not monitored by SNMP, the two following additional alarms shall be provided to Telecommunications Control Centre via an RTU:

- APS6 common alarm.
- MCS3 Common alarm. (If sub-rack is installed)

Other models of rectifier systems that do not have SNMP monitoring shall provide the following dry contact alarms back to Telecommunications Control Centre via an RTU:

- Rectifier Failure.
- AC Failure.
- Circuit Breaker Failure.

All rectifier systems shall provide analogue indications of their real time DC voltage output and AC input voltage by SNMP if able or as an analogue input to an RTU.

3.7.5.2.3 Rack Distribution Panels

All RDPs shall provide one dry contact alarm back to Telecommunications Control Centre to indicate when a circuit breaker trip operation has occurred.

3.7.5.2.4 Other devices

RTUs and other monitoring equipment are not required to provide alarming to indicate their own health.

All other communication devices without SNMP shall provide two dry contact alarms to indicate major (or critical) and minor (or non-critical) equipment failure.

3.7.5.2.5 Buildings

At standalone telecommunication sites, the following alarms shall be provided back to Telecommunications Control Centre via SNMP directly or via an RTU:

- Door Intrusion.
- Smoke Detector Alarm.
- Surge Diverter/Mains Fail.
- Air-conditioner Fail.

Background Note: *At Substation sites, these alarms are captured by Transmission Automation systems and monitored by NOC.*

At all sites, ambient rack temperature measurement shall be provided back to Telecommunications Control Centre via SNMP directly or via analogue input to an RTU.

3.7.6 Remote Management

Where equipment is capable, remote management connectivity shall be provided to active telecommunications equipment. This should be provisioned over the same Ethernet channel used for SNMP.

Within the TON, connectivity to the relevant Network Management System (NMS) or client software (such has SSH or HTTPS) shall be provisioned for new equipment.

Within the TON, all NMS shall have a Northbound Interface to the Operational Support System (OSS).

3.7.7 Other TON Services

The following services shall also be provisioned where the device is monitored using an Ethernet channel and if the feature is supported by the device:

- Authentication
- Logging
- Domain Name Services
- Network Timing (see Chapter 2.3)

Where possible, these services shall be provisioned by the NMS. Otherwise, they should be provisioned by standalone servers in the TON.

4 Bearers/Transport Mediums

4.1 Line of Sight Radio

4.1.1 Introduction

This section covers the design requirements associated with Line-of-Sight radio typically in the microwave radio bands of 6 to 13 GHz (as used by Western Power).

4.1.2 Definitions

Table 38: Definitions

Term	Description
Availability	A measure to indicate the predicted and/or actual period of time that an item is operational, typically expressed as a percentage of total (operational plus non-operational) time.
Refractive Index	The measure of the speed of radio wavefront in air compared to that in a vacuum. The refractive index of air changes with pressure and water vapour content.
Fading	The attenuation of the radio wavefront as it propagates through the atmosphere. Fading can vary with time, geographical position, radio frequency, rain and reflective surfaces over which the wave front travels.
Fade Margin	The difference, expressed in dB, between the signal level at the input to the receiver and the minimum level for acceptable performance under nominal propagation conditions.
Selective Multipath Fades	Fades that result from frequency selective propagation effects acting across the bandwidth of wideband LOS systems.
Flat Fading	The fading mechanisms, excluding Selective Multipath Fading. Flat Fade margin is used in availability calculations for atmospheric multipath and rain attenuation.
Reference System	To define the availability requirements of a single radio path that forms part of a system, a reference system is defined as having 15 hops. This is a number that is unlikely to be exceeded for most Western Power LOS system.
Fresnel Zone	A (theoretically infinite) number of concentric ellipsoids of revolution which define volumes in the radiation pattern of a directional antenna. The cross section of the first Fresnel zone is circular. Subsequent Fresnel zones are annular in cross section, and concentric with the first.

Term	Description
F1	The first Fresnel zone, and is the boundary of the zone which contains all wave components whose distance travelled to the far-end is less than or equal to 1/2 wavelength greater than the direct ray. Path clearance of the ellipsoid defined by the first Fresnel zone produces the first maxima of received radiation. Reflective surfaces along this ellipsoid produce radiation at the receive antenna, which is in phase with the direct path, phase adding and producing an increased level in received radiation.
k Factor	The refractive index of the atmosphere is not constant across the radio wavefront and therefore a radio wavefront travelling through the atmosphere will be bent due to the different speed of propagation through the varying refractive index. The value of k=1.33 is considered to be the Factor under “normal” atmospheric conditions in a temperate climate.
BER	Bit Error Rate, the number of bit errors divided by the total number of bits transferred during a studied time interval.
Space Diversity	A space diversity system uses two receivers per transmitter with the receiver antennas spaced a distance apart that minimises the correlated fading between the receivers. The receiver outputs are combined in order to reduce the impact of multipath and reflection effects using IF Combining.
IF Combining	A technique of combining the output of receivers in phase at the Intermediate Frequency (IF) prior to the receiver demodulation. This process improves the signal to noise ratio of the received signal prior to demodulation.
Main Antenna	The primary antenna in a space diversity system, generally the first of the two receive antenna.
Diversity Antenna	The second antenna in a space diversity system which is “spaced” away from the primary antenna in order to minimise the correlation between the receivers.
ACMA	The Australian Communications and Media Authority (ACMA) plans and manages the radiofrequency spectrum in Australia. It is responsible for compliance with licensing requirements and investigating complaints of interference to services.

4.1.1 Australian and International Standards

Radio systems shall be designed in conformance with the following standards.

Table 39: List of Applicable Standards

Standard/Specification	Description
ITU-R P.530	Propagation data and prediction methods required for the design of terrestrial line-of-sight systems
ITU-R P.837	Characteristics of precipitation for propagation modelling

4.1.2 Western Power Standards

The following Western Power standards are applicable for radio systems.

Table 40: List of Applicable Western Power Standard Designs and Supporting Documents

EDM/Drawing No.	Description

4.1.3 Design Requirements

Licensed radio bands shall be used for all Line-of-Sight radio applications.

A Line-of-Sight survey shall be conducted for all new radio links. A Line-of-Sight survey is not required in the instance of a like-for-like link replacement.

4.1.4 Radio Path Engineering

Radio path engineering shall be conducted in accordance with ITU-R P.530.

Line of sight radio links shall be designed to achieve an availability of 99.999%.

Where new microwave links are deployed, the design shall provide enough bandwidth to allow for SDH and MPLS bandwidth requirements, preferably on the same polarisation.

Path engineering shall consider the effects of RF signal disturbance, including but not limited to diffraction, refraction, and reflection.

Rain attenuation shall be considered for frequencies above 10GHz. Rainfall rates shall be as per ITU-R P.837.

Radio path engineering shall be done using Western Power approved software and radio path engineering practices. Link engineering shall model the specific radio equipment, feeder cables and antennas. The current approved radio path engineering software is HTZ Communications.

To provide acceptable level of multipath and reflection performance, line of sight systems that meet one or more of the following criteria should be designed with Space Diversity using intermediate frequency or baseband combining:

- Link distance over 30km

- Link path over water bodies or parallel to the coast
- Link path through areas susceptible to fog

> ***Background Note:***
>
> *While fog itself does not affect microwave radiation below 10 GHz, mist and fog often co-occur with thermal inversion in the air column. This is when cold air is trapped below warm air, which can cause microwave ducting. This can also occur when a sea breeze is present near the coast.*
>
> *As cold air has a lower index of refraction, this phenomenon can cause ducting, where microwave radiation is trapped in the region of cold air by total internal reflection, reducing the receiver signal level.*

When selecting potential radio paths, line of sight radio systems in areas known to suffer from ducting should be avoided. This includes but is not limited to:

- Paths that are adjacent and run parallel to the coast.
- Paths between sites on the coastal plain with approximately the same height above sea level.

Where space diversity is employed, a minimum separation between the main antenna and diversity antenna shall be 200 times the wavelength. This corresponds to 10m for 6GHz and 8m for 8GHz links.

4.1.5 Structure Design

Refer to Section 5.5.

4.2 Fibre Optics

4.2.1 Introduction

The Western Power Optical Fibre Network exists primarily to carry critical and operational services to support the supply of electricity to Western Power's customers. These services ranged from protection, SCADA, operational voice, distribution automation, OT and IT zone networking, and other management traffic.

The following chapter provides the minimum requirements and criteria for the design of the Western Power Optical Fibre Network.

It is encouraged that these are read in conjunction with the Optical Fibre Network Construction Standard and the Approved Material Listings.

4.2.2 Definitions

Table 41: Definitions

Term	Description
Adaptor	Device for connecting two similar Optic Fibre Connectors, e.g., Front interface of Optical Line Cards and the Interconnect points on an Optical Patch Panel. Also known as bulkhead adaptor and through adaptor.
ADSS	All Dielectric Self-Supporting Fibre Optic Cable
Alignment	Means the longitudinal centre line of a Conduit run. Often measured from a property boundary.
AS	Australian Standard
Attenuation	Reduction of the optical power induced by transmission through a medium such as optical fibre; this is sometimes called insertion loss. The decrease in power level is expressed in decibels (dB) or as a rate of loss per unit distance (dB/km)
CBD	Central Business District.
Conduit	A tube or pipe that physically accommodates cables and offers mechanical protection for cabling, allowing them to be drawn in and/or replaced. The terms Pipe, duct and Conduit are used interchangeably in this document. All are used in industry and for the purposes of this document mean the same thing.
Contractor	Means a person or persons engaged in work on assets for which this standard can be applied.
DBYD	Dial Before You Dig
High Voltage (HV)	Nominal voltage exceeding 1,000V AC or 1,500V DC.
HMR	Hazard Management Register

Link Loss	For a fibre optic span, the effects of passive components and connection losses must be added to the inherent attenuation of the fibre in order to obtain the total signal attenuation. This attenuation (or loss), for a given wavelength, is defined as the ratio between the input power and the output power of the fibre being measured. It is expressed in decibels (dB).
Low Voltage (LV)	Nominal voltage exceeding 50V ac or 120V dc but not exceeding 1000V ac or 1500V dc.
MPO	The MPO connector is a multi-fibre connector that is defined by IEC-61754-7.
MRWA	Mains Road Western Australia
MTP	Multi-fibre Termination Push-on. MTP is a brand name for an improved MPO connector.
ODF	Optical Distribution Frame. The generic name for all FOBOTs, patch panels and splice enclosures.
OPGW	Optical Power Ground Wire (OPGW), is a type of cable that is used in the construction of electric power transmission and distribution lines. Such cable combines the functions of grounding and communications.
Optic Fibre Videoscope	Electronic microscope using a small video camera to record images of connectors. Can be fitted with probes to allow the inspection of a connector at the rear of a Through Adaptor.
OTDR	Optical Time Domain Reflectometer is the equipment used for the characterisation of fibre attenuation, dispersion, uniformity, splice loss, breaks, and length.
Patch Cord (or Patch Lead)	Length of Optic Fibre with flexible protective sheath and connectors at either end.
Performance Criteria	For optical fibre, including connectors and splices, means the criteria by which a Permanent Link or Channel is deemed to pass or fail.
PE	Polyethylene
Pigtail	Length of Optic Fibre with flexible protective sheath with a connector at one end and spliced directly to the cable/device at the other.
PVC	Poly Vinyl Chloride
SCADA	Supervisory Control and Data Acquisition
SEEPL	Security Equipment Evaluated Products List
SiD	Safety in Design

4.2.3 Australian and International Standards

Design shall be in conformance with the following standards.

Table 42: List of Applicable Standards

Standard/Specification	Description
AS/CA S009:2020	Installation Requirements for Customer Cabling (Wiring Rules)
AS 4836:2023	Safe working on or near low-voltage electrical installations and equipment
AS/CA S008:2020	Requirements for Customer Cabling Products
AS/NZS 2967:2014	Optical fibre communication cabling systems safety
AS/NZS 14763.3:2017 + Amd 1:2018 (ISO/IEC 14763.3:2014)	Information Technology – Implementation and Operation of Customer Premises Cabling - Testing of Optical Fibre Cabling
AN/NZS 2032:2006 + AMDT 1	Installation of PVC Pipe Systems
AS/NZS 2566.2:2002 + Amd 3:2018	Buried Flexible Pipelines - Installation
CA C524:2013	External Telecommunication Cable Networks
CA G591:2006	Telecommunications in Road Reserves – Operational Guidelines for Installations
AS 4799-2000	Installation of Underground Utility Services and Pipelines within Railway Boundaries
AS 2648.1:1995	Underground Marking Tape – Non-detectable Tape
	Utility Providers Code of Practice for Western Australia (MRWA)
	Restoration & Reinstatement Specification for Local Governments in WA
	Western Australia Code of Practice: Excavation 2005
	Safe Work Australia Excavation Work Code of Practice 2013

4.2.4 Western Power Standard Designs and Supporting Documents

The following Western Power standards are applicable for fibre optic systems.

Table 43: List of Applicable Western Power Standard Designs and Supporting Documents

EDM/Drawing No.	Description
	Safety in Design Guidelines[5]
	Hazard Risk Register Template[6]
	Telecommunications Drawing Guidelines[6]
	Telecommunications Construction Standard – Optical Fibre Network[6]
	Telecommunications Construction Standard – Optical Fibre Network (Approved Material Listing)[6]
	Master Dark Fibre Register (Telecommunications and ICT)[6]
	Master Dark Fibre Register (Telecommunications and Protection/Automation)[6]
	CBD/DA IP Network – Loop Tube and Fibre Patching Drawings[6]
	Telecommunications - Optical Engineering Calculator[6]
	Aerial Cable Guidelines (Draft)[6]
C22 Series	Drawings associated with the CBD Loop installations[6]
C60 Series	Drawings associated with Optical Fibre Installations[6]
C990 Series	Drawings associated with the Perth Fibre Network, showing route details[6]
	Electrical System Safety Rules (ESSR)

4.2.5 Purpose and Scope

This chapter applies to all designs that have an optical fibre component.

The objectives are to provide users with an acceptable approach, rules for design, performance, and functional requirements of optical fibre solutions.

The document provides the technical standards for optical fibre design.

[5] Western Power internal document

4.2.6 Design Approach

4.2.6.1 Safety in Design

4.2.6.1.1 Working in Vicinity of Electricity (overhead)

Overhead hazards may be present along the intended path of the planned optical fibre service. These come into play during the construction phase of the project when operating earth moving equipment. They are to be determined, considered, and documented in the associated HMR for the project.

4.2.6.1.2 Working in Vicinity of Traffic

Traffic hazards may be present along the intended path of the planned optical fibre service. These come into play during the construction and maintenance stages of the asset. They are to be determined, considered, and documented in the associated HMR for the project.

4.2.6.1.3 Working in Vicinity of High-Pressure Gas, High Voltage and High-Pressure Water Mains

A DBYD query is expected to be conducted during the design phase to identify all underground assets along the intended path of the optical fibre civil works. This is only applicable if the work involves civil underground works, (i.e., “pit and pipe” works).

High risk assets, such as high-pressure gas, high voltage and high-pressure water mains, are to be highlighted as part of the design. The design should minimize disruption to these services where practicable. Where they cannot be avoided, then they shall be entered in the HMR associated with the project.

4.2.6.1.4 Environment

Western Power SEQT must be consulted for all optical fibre Construction works. This is recommended to be performed early in the Design stage, with any responses being fed back into the Design.

The Project Manager shall be responsible for engaging SEQT. To support this activity, the Designer must provide enough information to review. This shall (at a minimum) include a brief scope of works (pit, pipe, excavation techniques etc) and a GIS marked up sketch.

Environmental Design Considerations:

- Extent of vegetation clearing. Protection of established trees.
- Aboriginal Heritage and Cultural considerations.
- Environmental Sensitive Areas (ESA).
- Noise generated during Construction, and its impact on local business or residences.
- Soil conditions.
- Acid Sulphate soils.
- Disposal of contaminated soil and other Construction debris.
- Biosecurity.
- Water table and dewatering requirements.

4.2.6.2 Security in Design

Western Power is now classified as a critical infrastructure corporation. As operational traffic is reliant on these optical fibre assets, all due physical security considerations are required to be included in the design.

All new pit enclosures shall be lockable with an approved padlock supplied by Western Power. Please consult the Approved Materials Listing for suitable pit enclosures and padlocks.

Consultation with the Security Equipment Evaluated Products List (SEEPL) may be required when selected new products, to be proposed and endorsed, outside the list of approved materials.

Refer to the Physical Security Chapter for more information.

As optical fibre asset is a physical medium, it doesn't impact the cyber-security controls of the networks and services is carries. As such, it is not expected to consider cyber-security with the Security in Design review of the design.

4.2.7 Design Considerations

4.2.7.1 Civil Considerations (Above Ground)

4.2.7.1.1 Optical Power Ground Wire (OPGW)

OPGW installations are expected to be bundled with the associated "Lines and Cables" design documents. As such, the design of OPGW installations are outside the scope of "Telecommunications" design, other than providing the Telecommunication design requirements.

Some examples of telecommunication design requirements:

- Where OPGW joints are to be required, (preferred pole/structure).
- Where the above to underground transitions are required, such as within compound of end Substations, or where the existing Fibre Network needs to join into the OPGW installation.
- Approved Materials to be used for the OPGW joint enclosure.

The exception to this is the "last mile" section of the installation, from the OPGW's point of presence to the end site/s. This "last mile" section of the network is expected to conform to the Under-Ground considerations below.

OPGW joints and enclosures are required to be placed above 3m, to avoid the general public having access to the equipment, and below the MAD with respect to the primary assets.

A Pit enclosure shall be installed near any above-ground to under-ground transition to support the transition.

4.2.7.1.2 All Dielectric Self Supporting (ADSS)

ADSS installations are expected to be bundled with the associated "Lines and Cables", or "Distribution" design documents. As such, the design of the ADSS installations are outside the scope of "Telecommunications" design, other than providing design requirements.

Some examples of design requirements:

- Where ADSS joints are required, (e.g., preferred pole/structure)

- Where the above to underground transitions are required, such as within compound of end Substations, or where the existing Fibre Network needs to join into the ADSS installation.
- Approved Materials to be used for the ADSS joint enclosure.

The exception to this is the “last mile” section of the installation, from the ADSS’s point of presence to the end site/s. This “last mile” section of the network is expected to conform to the Under-Ground considerations below.

ADSS joints and enclosures are required to be placed above 3m, to avoid the general public having access to the equipment, and below the MAD with respect to the primary assets.

A Pit enclosure shall be installed near any above-ground to under-ground transition to support the transition.

4.2.7.2 Civil Considerations (Under Ground)

4.2.7.2.1 Underground Conduits

All new conduits shall be P100 where open trenched, or PE110 where directionally drilled.

The age and congestion of existing and occupied conduits must be considered for new cable installations. A new conduit section may be required to be installed as part of this design, if the existing conduit is determined to be too congested, or its condition is expected to be degraded. If using an existing conduit, this risk should be clearly outlined in the design document, and accepted by the project sponsor, or the project manager.

Unless approved by the asset owner, (Asset Performance, Automation & Control Team), all new cable installations shall be within conduits. There shall be no direct buried assets introduced into the network as part of new builds.

4.2.7.2.2 Sub-Ducting Conduits

In some designs, sub-ducting within electrical conduits, or third-party conduits, may be required. This is usually an option of last resort, where Western Power has restrictions crossing railways, bridges, or entering third party sites.

The requirement for sub-ducting shall be captured as part of the design, and associated construction scope of works.

4.2.7.2.3 Pit Enclosures

All new pit enclosure shall be selected from the Approved Materials Listing.

At time of writing, the current approved pit enclosures to use are the PITLOK Polycrete J8 and J10, or equivalent, enclosures. The J8 enclosures shall be used for all hauling pits, and most FIST/Joint pits. Where there is expected to have additional congestion within the pit, (due to T2C, blown assets, 2nd FIST etc) the J10 enclosure may be used.

The steel lids that accompany the J8 and J10 enclosures shall be used, unless council requirements dictate different lids, (e.g., in-fill lids with brick or granite pavers).

In situations (e.g., CBD) where there is proof of congestion of underground assets, a plastic “P” pit of suitable size may be used with an appropriate PITLOK collar and lid.

4.2.7.2.4 Hauling Activities

All pit enclosures are to be located to support current and future roping and hauling activities.

All joints are to be located to support cable length limitations (see fibre considerations).

As such, the following design requirements have been defined:

- Maximum of 450m conduit length between pit enclosures. This distance shall be reduced to 300m where there are additional changes of direction (i.e., road crossings and corners).
- Where there is a road crossing, one pit enclosure must be within 50m of the crossing. The crossing must be perpendicular to the roadway.
- Where there is an underground to above ground transition, a pit enclosure must be within 10m of the transition point.
- Avoid excessive conduit changes of direction between pit enclosures. No more than two 90°, or 4x 45°, changes of directions between pit enclosures.

4.2.7.2.5 Alignment

As per the Optical Fibre Network Construction Standard document.

4.2.7.2.6 Depth

As per the Optical Fibre Network Construction Standard document.

4.2.7.2.7 Diversity

The traffic that this optical fibre asset is carrying must be considered with respect to any additional diversity and segregation requirements. Consider other bearers (fibre or other medium) exiting a site and ensure an appropriate level of separation is included in the design.

Once within a Western Power site, the separation of diverse lead-ins must be as large as practicable. This may be either side of a driveway or either side of a cable trench. The separation shall be considered on a site-by-site basis, as part of the design.

4.2.7.2.8 Pit and Conduit Locations

There shall not be any conduits or pit enclosures installed within private property, unless a formal agreement has been established between Western Power and the associated landowner.

There shall be no pit enclosures installed within roadways, or driveways. A trafficable pit shall only be used, and installed within a roadway or driveway, as a measure of last resort. Such an installation will need to be endorsed by the asset owner (Asset Performance) and/or design owner (Automation & Control Team) prior to finalizing the design.

The locations of the pits shall be selected based on approved alignment, cable length limitations, hauling distances & activities, and other underground assets.

Where possible pits shall be located as close as practical to the property boundary of two adjacent allotments.

To support lead-ins into a site, a pit enclosure is expected to be located within 100m of the boundary of that site.

TABLE 4

Clearance from other Underground Utility and Carrier Services

Underground Plant Item	Minimum Radial Clearance from Underground Telecommunications Cable in mm (Notes 1, 4)
Gas Pipe	
Large Main (Over 110 mm diameter)	300
Small Main (75 mm diameter or less)	100
Power Line and Service Lines	
HV	300 (Note 2)
LV	100 (Note 3)
Water Main	
High Capacity Main	300
Local Reticulation	150
Sewer	
Mains	300
Connections to Mains	150 (Note 3)
Other Carriers' Telecommunication Cables	100

NOTES:

1. Lesser separations may be used where all the parties involved concur.

2. Where protective covering/barriers have not been provided over HV Power Lines, a minimum separation should be 450 mm.

3. LV Customer Leads and Service Lines housed in appropriately coloured pipes may share a common trench or bore on private property and under roadways without specified separation.

4. Telecommunication Cable includes non-conductive or passive communications cables such as self-supporting fibre optic cable.

Figure 3 Extract of Table 4 from C524:2013 showing required clearances.

4.2.7.2.9 Ingress/Egress Building Considerations

When designing building lead-ins, the preference is to use existing ingress paths to minimize construction costs. If a new ingress point is required, then document this requirement within the design, and refer to the Optical Fibre Network Construction Standard document.

The scope of works required to establish the new lead in must be summarized as part of the design.

4.2.7.2.10 Bollards

When selecting pit enclosure locations, attempt to avoid locations that shows evidence of vehicle parking, or vehicle transiting. While the pit may not be placed on a road or driveway, there are many examples of people regularly parking on the kerb or road reserve.

If the pit must be located within an area that has evidence indicating regular vehicle parking (including heavy vehicles), and/or transiting, then an appropriate hazard to the asset/s must be registered in the project's HMR.

If the risk is not deemed acceptable from the Asset Owner (Asset Performance) and/or Maintenance, then Bollards may be installed post project to protect the asset/s. This is outside the scope of design.

Alternatively, the pit may be upgraded to be trafficable with the approval of the Asset Owner, (Asset Performance), and/or Design Owner, (Automation & Control Team), as an option of last resort.

4.2.7.3 Civil Considerations (Above to Under Ground Transitions)

4.2.7.3.1 Earthing

For pit enclosures that support above ground to underground transitions, these are not to be designed within the vicinity of electrical power earths due to Earth Potential Rise hazards. Such a pit enclosure must be located outside the hazard zones, without an EPR Hazard assessment. Typical hazard zones associated with HV power poles and towers are those defined in AS/CA S009:2013.

The pit enclosure shall be located a minimum of 3m away from the pole and in the designated telecommunications alignment.

If a pit enclosure is required to be located within the EPR hazard zone distance outlined in AS/CA S009, the design is required to be certified by a Qualified Electrical Engineer as complying with the principles of AS/NZS 3835.1 in accordance with Clause 6.1.3 of AS/CA S009.

Please note that the EPR hazard zone may extend several hundred meters from Western Power transmission assets. Contact Western Power Lines and Cable Design Team for pit clearance requirements in such instances.

4.2.7.3.2 Riser Locations on the Pole or Structure

Risers are communication conduits attached to the pole that allows underground to overhead (UGOH) transition of communication cables. Typical riser sizes are 32mm and 50mm.

The riser location should optimise the use of the pole to shield against potential traffic collisions. Risers should only be located between 45° and 225° when 0° is facing the road carriageway.

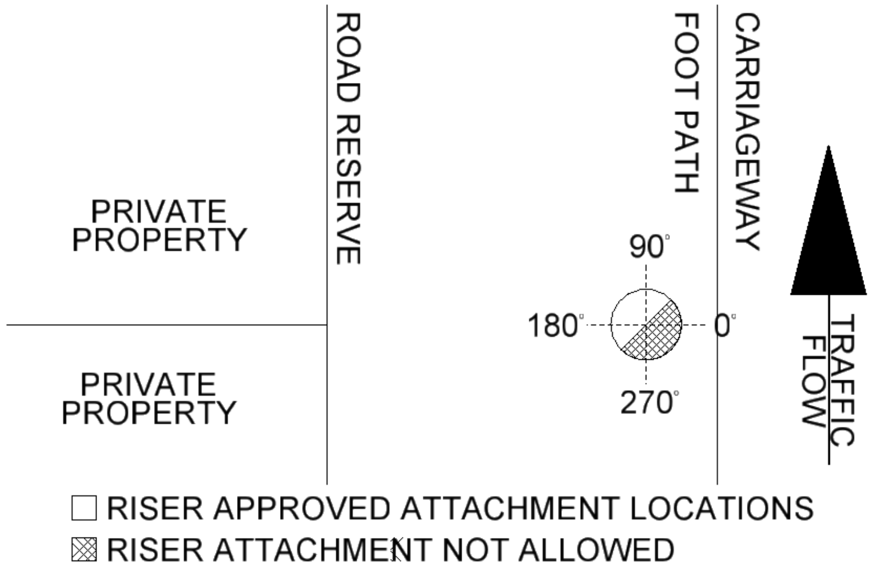


Figure 4 Riser approved attachment locations

4.2.7.3.2.1 Riser Allowable Poles

A riser may only be used on LV Poles and the HV poles types shown below. In general risers are not permitted on HV poles that have a HV Earth installed on it.

HV Pole Type	Riser Acceptable
Intermediate	Yes
Tee off	Yes
Termination	Yes
DOFS poles without down earth	Yes
RDA	Yes
HV Cable termination	No*
Transformer	No
Pole Top Switch	No*
Recloser	No*
Load Break Switch	No*
Surge Arrester/Down Earth	No*
* Riser is allowed if there is no communication earth installed within 15m	

Table 44 Riser acceptable structure

4.2.7.3.2.2 Riser Clearance to Existing Pole Equipment

The below shows the minimum separation permitted between any new proposed riser to any existing risers, LV UGOH, pole reinforcements, and streetlight brackets (where the communication attachment is above the streetlight attachment).

Equipment	Separation
Riser to Pole Reinforcement	50mm
Riser to Riser	50mm
Riser to Streetlights	100mm
Riser to LV UGOH	100mm

Table 45 Riser separation

4.2.7.3.3 Attachment Locations

Communication cables are required to be attached to the pole on the same side as any existing single sided circuit (e.g., LVABC, running earth, switch-wire, pilot cable, Telstra/Optus, etc.), to avoid the pole being “boxed-in” between two or more cables.

If there is no single sided circuit attached to the pole and the overhead powerline has a deviation angle at that pole the communications cable must be placed on the inside of the deviation angle pole to facilitate pole changes.

4.2.7.3.4 Steel and Concrete Poles

Securing of communication cables onto steel and concrete poles is to be undertaken using stainless steel strapping. Steel mains poles rarely occur within Western Power distribution network. However, when it is required to attach aerial communication cables onto a steel mains pole, a layer of mastic tape shall be installed between the pole and the steel strapping to prevent trapping of moisture and galvanic corrosion.

4.2.7.4 Relocation Works

For relocation projects, the design shall minimize the outage window required to resplice from the old section of the network to the new section of the network. This may mean pre-running new optical fibre cable assets in the new section of the network to reduce the cutover event to just re-splicing activities. A small amount of pull back and re-hauling is also acceptable.

The new cable asset shall be spliced onto existing joints, (FISTs), even if the new cable asset needs to be overhauled along the existing cable asset for a distance to achieve this. The introduction of new joints into the network due to relocation works is discouraged.

The new cable asset shall be comparable to the old cable asset in length and optical properties.

The above ensures minimal impact to existing services across that part of the network as well as minimizing any optical re-engineering and equipment changes at the far ends.

For raising of ground level, existing pits may be raised using pit riser collars compatible with the existing pit enclosure, to raise the lid/s to the new ground level. This may change the definition of the pit enclosure to a “confined space”. This must be considered as part of the design and recorded appropriately.

For lowering of ground level, the pit enclosure shall be re-installed, flush with the new ground level. If the existing pit enclosure is not of the latest standard, or no viable to be re-used, then a new pit enclosure shall be installed in its place.

4.2.7.5 Fibre Considerations

4.2.7.5.1 Cables

Optical Fibre cable sections that are expected to be used as part of the Western Power fibre network, (whether part of this design, part of a future roadmap), shall be Loose Tube 144 core cable.

Optical Fibre cable sections that are to be overhauled with existing blown cable assets shall be sized to with spare capacity to support the retirement of the blown cable asset (part of future roadmap). This may require the use of Loose Tube 288 core cable in some section around the central Metro area.

Optical Fibre cable sections that are used as lead-ins into a site shall be Loose Tube 48 core cable. An exception may be made to install 144 core cable into a site, if the expected capacity (current and future) dictates that requirement (e.g., Data Centres, or Head Office).

For ADSS and OPGW, refer to above sections.

Optical Fibre cable sections that pass through a Substation or Power Station environment shall be sub-ducted in a suitably sized flexible conduit from where the lead-in conduit is presented through to the rack or wall enclosure.

The bending radius for all cables shall be 20 times it’s respective diameter. This should be considered as part of the design when selecting the cable path through a site, associated racks and cable tray infrastructure.

The maximum length of optical fibre cable installed shall be 4.5km. An exception may be made for longer continuous cable section within rural installations but must be authorized by the Asset Owner, (Asset Performance), and/or Design Owner, (Automation & Control Team).

All Optical Fibre cables between sites shall be Single Mode.

All Optical Fibre cables between buildings within a site shall be defined in the design scope, as this may vary. It is common for multi-mode to be used within a Substation to transport the Substation Network. However, it is also common for single-mode to be used within depots to transport IT and OT networks between buildings.

4.2.7.5.2 Rack Mounted Enclosures

Consult the Optical Fibre Network Construction Standard, and Approved Materials List for the latest approved ODF enclosures.

The ODF enclosure must be sized to the cable, as the entire cable shall be presented at the ODF. All cores are to be terminated on available pigtails and presented in the ODF for use (current and planned).

For example, a 48-core cable must land on a 48-core ODF and be spliced to 48x pigtails.

4.2.7.5.3 Wall Mounted Enclosures

Consult the Optical Fibre Network Construction Standard, and Approved Materials List for the latest approved wall mounted enclosures.

These are likely to be used within CBD environments, where a Telecommunications rack is not available. The wall enclosure and associated splicing trays shall be sized to the landing cable. All cores are to be presented to the splicing trays.

Only whole tubes are expected to be spliced to pigtails; the design shall determine which tubes.

4.2.7.5.4 Connectors

All new connectors shall be standardised to LC (Duplex).

Please note that there is a range of connector type on the network at present. This need to be considered when scoping out patch lead procurement and associated scopes of works.

4.2.7.5.5 Patch Leads

For new installations, it is expected that fibre patch leads are only used within rack enclosures. Any patching that is required between racks is expected to be via structured cabling (MTP).

An exception may be made where there is only one fibre service to an end location, (such as protection relay or other such racks). In this case, a Ruggedized patch lead may be used.

For existing installations that have the Warren & Brown yellow fibre ducting infrastructure installed, new patch leads should not be installed in the ducting. Install rugged patch leads on cable trays outside of the yellow ducting.

4.2.7.5.6 Structured Optical Fibre Cabling (MTP)

Structured cabling (MTP) shall be installed between Telecommunication racks at new sites, or site where there is no Warren & Brown yellow fibre ducting, to facilitate the reticulate of fibre services within a building. MTP installation shall only be installed between racks that require optical fibre connectivity.

All MTP cables shall be “ruggedized” and may be run alongside other cabling on a cable tray, or under-floor, between racks.

4.2.7.5.7 Separation Requirements

All Western Power approved fibre cables are metal free and are generally exempt from any separation requirements in AS300 and AS/CA S009.

Similarly, there is no requirement for a physical barrier (duct) unless it is to support or protect the cable, such as passing through a Substation environment (cable trench, cable gallery/basement etc).

It is considered good practice to group fibre cables together on a cable tray/ladder unless physical diversity is required.

4.2.7.5.8 Fibre Paths

When establishing fibre paths between sites, whole bundles (12 cores) must be allocated. Bundles must not be split out mid-way between sites.

In the situation where a site needs to break into an existing fibre path, all 12 cores must be re-directed into and out of the new site. If required, associated services may be patched through to restore the original paths.

An exception to this design rule is for CBD sites and their installations. See associated CBD sections in this Design Guidelines document for more information.

4.2.7.5.9 Splicing

The splicing of underground optical fibre cables shall only be performed in a Fibre Infrastructure System Technology (FIST) enclosure, within a Pit enclosure. There shall be no buried joints.

The splicing of overhead optical fibre cables shall only be performed within a suitable Joint enclosure, secured to a suitable structure (e.g., transmission or distribution pole or tower).

When 2 “network” optical cable segments are presented to the same enclosure, all cores are to be spliced through. All splices shall be one for one.

When 3 or more “network” optical cable segments are presented to the same enclosure, only the tubes/bundles that are required to be spliced shall be spliced. All splices shall be one for one.

When a “network” optical cable segment must be spliced onto a “lead-in” optical cable segment, only the tube/bundles that are required to be spliced shall be spliced. All splices shall be one for one.

As stipulated in the fibre paths above, only whole tubes/bundles shall be splices. No partial tubes/bundles shall be permitted, except for the CBD sites and their installations.

4.2.7.6 Colour Standards

The Optical Fibre Construction Manual[6] provides details on optical fibre colour standards.

This standard lists legacy exceptions to the colouring standard.

4.2.7.7 Optical Engineering

The Optical Engineering Calculator[7] shall be used to determine the fade margin of proposed links.

The best available estimate of the optical length, number of splices and number of connectors along a run, at the time of design, shall be used as a basis calculations.

Each link shall be designed to provide at least 6dB fade margin. For fade margin calculations, the Transmit Power shall be the minimum transmit power specified in the manufacturer datasheet.

Each link shall be designed to avoid receiver saturation. For receiver saturation calculations, the Transmit Power shall be the maximum transmit power specified in the manufacturer datasheet.

Optical attenuators should not be used without approval. Some transceivers have a wide range of transmit power values. In these cases, using the minimum transmit power to calculate the fade margin may result in an oversized transceiver being required to meet the 6dB requirement. This would then result in receiver saturation without the use of an optical attenuator. In these cases, the Designer shall request dispensation to use an alternative transmit power value in their calculations (typically, the average transmit power figure provided in manufacturer datasheets).

See Dark Fibre Services[8] for optical engineering requirements associated with them.

4.2.7.8 Joining New Optical Fibre Assets into Existing Network

There are times where a new section of the network will need to join to the existing network. The optical fibre documentation (inventory, drawings, GIS system) should be heavily consulted to understand the physical topology around the area where the new network section shall meet the existing network.

Consideration needs to be given as to how the new section shall be spliced onto the network, while minimizing the impact to the existing network services.

[6] Western Power internal document
[7] Western Power internal document
[8] Western Power internal document

- Does it establish a new fibre path through the network to a target site? Define what splicing and pits are required to be worked on to establish this? Are there spare fibres, or abandoned tube services with "Emtelle" fibre bundles, available to use to reduce Construction costs?
- Does it "cut" into an existing tube service? If so, what is the impact of that event? Does the tube service present itself in the joining pit, or is additional work needed to be completed to present it in the joining pit? This additional work needs to be articulated within the design.
- Does it need to "cut" into an existing loose tube cable? If so, what is the impact of the event? Does the cable present itself in the joining pit, or is additional work needed to be completed to present it in the joining pit? This additional work needs to be articulated within the design. It is preferred to use existing FIST enclosures, if practicable to do so, to avoid adding additional joints and associated optical loss points, to the network.
- If it is only a short distance (<500m) to the next joint that presents the tube service, or cable service, then overhauling the cable back along the network may be acceptable.
- Does a "cut-in" present a single point of failure? Is this acceptable?
- Does a "cut-in" present an unacceptable impact to existing services? Can it be staged to reduce this impact?
- What clean-up activities are required? Re-labelling of splice trays in FIST enclosures? Removal of retired blown fibres (don't abandon them in the tubes, unless they are presented at both ends to a splice tray) (FIST or ODF); if so, then re-label accordingly. Relabelling of cables if the cables have been cut into, which will require visits to multiple pits, (not just the pit the splicing works at taking place in); this needs to be defined by the design.

Consider how these changes impact Constructability and Maintainability. Are you using up "hauling" loops which may limit Maintenance response in that part of the network? Are you proposing works at several pit locations when works at only 2-3 pit locations would achieve the same result?

These works require a judgement call, as it is heavily dependent on the situation being presented within the design. The above are just some consideration points.

4.2.8 Dark Fibre Services

There are situations where the Designer is engaged to provision a dark fibre service to an internal customer (e.g., ICT, Protection, SCADA). This section outlines the considerations associated with designing a dark fibre service.

A dark fibre service to an internal customer is commonly linked with an operational agreement between Asset Owner, (Asset Performance), and the associated customer. As such, there are clear boundaries to the design to align with this agreement.

4.2.8.1 Additional Design Considerations

The service shall be designed to the first point of presence at a site.

4.2.8.2 Optical Engineering

Consult with the internal customer as to the expected transceivers to be used on their equipment, and the expected optical fibre loss that the customer is "guaranteed". While Telecommunications is not responsible for transceiver selection, this may have an impact on the final fibre path and associated design.

The following terms for optical loss are defined below.

Design Optical Loss: the expected optical loss as calculated through the optical engineering component of the design.

Service Optical Loss: the “guaranteed” optical loss that Telecommunications is delivering to the internal customer. This is the above design optical loss plus an additional 6dB of loss, (our fade margin). The internal customer should be designing their associated links based on this level, as a “guaranteed” level, (i.e., They should not be adding any additional fade margins of their own).

4.3 CBD Sites and Designs

This chapter shall be read in conjunction with Section 2.6 (CBD/DA Network). The CBD/DA chapter focuses on the logical network and equipment, while this section focuses on the underlying fibre infrastructure that supports it.

4.3.1 Fibre CBD Loops (Existing)

The CBD network is made up of physical fibre loops (12 cores each) that service an area of the CBD environment.

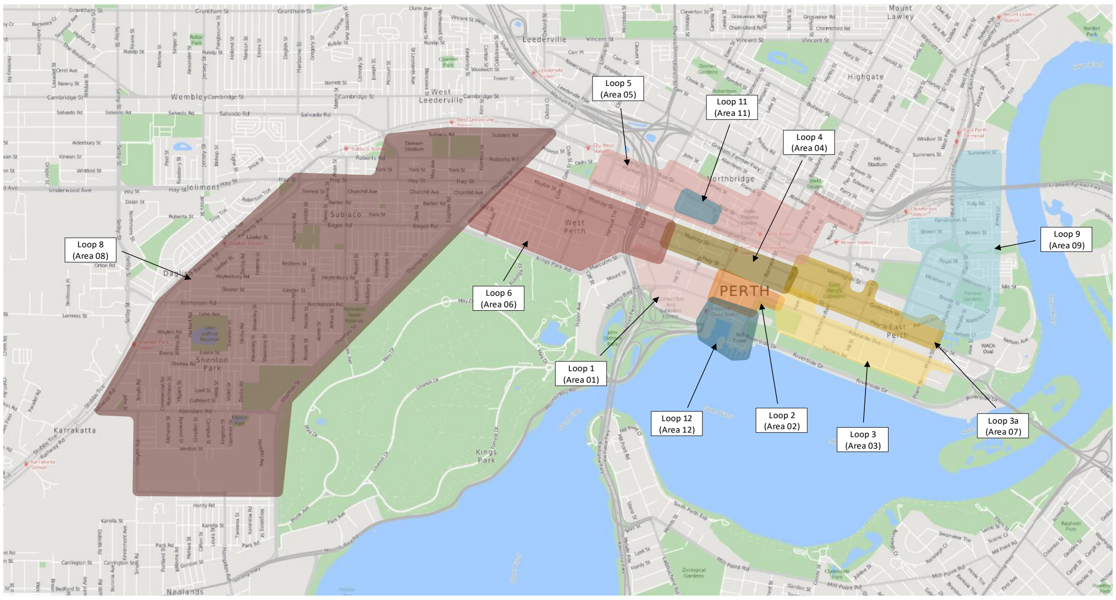


Figure 5 Overview of CBD Fibre Loop Regions

When establishing a new site, the fibre lead-in must be linked through to the appropriate fibre loop, (usually the closest physical loop available).

The location of the lead-in and its “cut-in” of the existing tube service for that loops, defines the new site’s location within the logical topology of that CBD loop and greater network.

Some of the CBD Loops are logically 2x strings. This needs to be considered when selecting the location of the new site within the logical topology of the network.

4.3.2 CBD Fibre Loops (New)

There may be project situations where the development of a new CBD Fibre Loop makes more sense than expanding an already large loop. The Estimating and Concept Design usually captures this requirement before the Detailed Design stage of the Project.

If this occurs, then a 12-core tube service loop will need to be established within the targeted area.

See CBD Core Fibre Network section below for information on extending this new fibre loop back to the Data Aggregation Sites.

See CBD chapter for information on establishing the head end connections at the Data Aggregation sites.

4.3.3 Fibre Lead-ins

The standard optical fibre lead-in for a CBD site is a 48c loose tube optical fibre cable. See Approved Material Listing for latest approved cable asset.

Within the CBD network, it is acceptable to install only a single lead-in cable, even though this presents a single-point of failure.

4.3.4 Splicing Exception

This is the one part of the network where the rule for splicing all 12 cores of a tube service, and all splices must be 1 for 1, is exempted.

Only the cores that are required to be diverted to the new site can be spliced. The remainder of the cores can remain untouched.

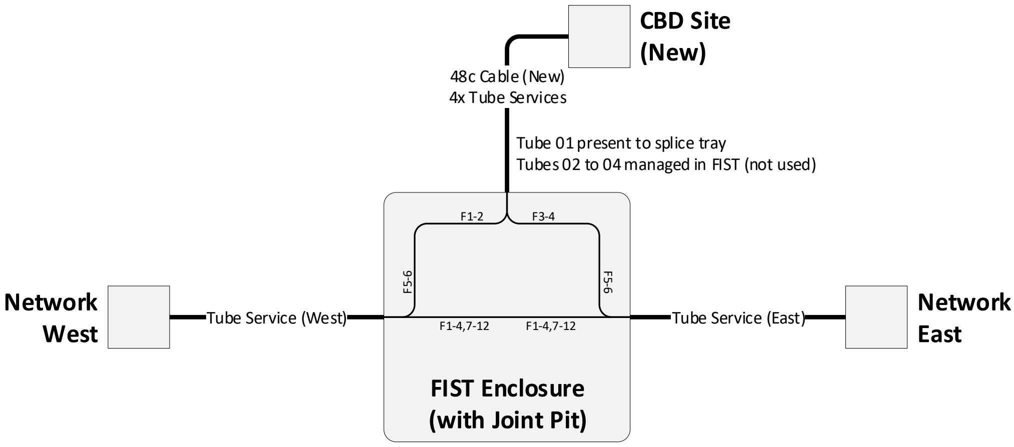


Figure 6 - Splicing Arrange for Standard New CBD Lead-in

It is acceptable to use a single tube on the new cable; no need to provide tube diversity on the same cable asset.

4.3.5 Tube Extensions within FIST Enclosures

Within the CBD Loops, when blown cables were still being installed, it was acceptable to blow the fibre bundle (“Emtelle” 12c bundle) from site to site. The lead-in cables were also often 7DI cables which landed within the FIST enclosures, (as opposed to the T2C enclosures). To achieve the blow, the tubes of the network cable and the lead-in cable were often joined using a tube connector within the FIST enclosure.

Please be aware of this type of installation when planning works, as the drawings and inventory may indicate that the tube service is available for re-splicing within a FIST enclosure, when this may not be the case. If in doubt, an audit may be required to confirm the existing installations.

The standard has changed since the above installations. As such, new lead-in cables shall not be blown cable assets **and** no new installation shall introduce a tube joint within a FIST enclosure. The joints must be presented to a splice tray and spliced through.

4.3.6 CBD Core Fibre Network

The CBD Core Fibre Network is a 48-core fibre network loop that connects the CBD Fibre Loops to the Data Aggregation Sites. The Data Aggregation Sites, which is where the Area Border Routers and Area 0 Routers reside, are located at Western Terminal Substation and Head Office.

The CBD Core Fibre Network also allows the two Data Aggregation Sites to communication to each other, by provisioning the fibre links for the Area 0 Routers and the Area Border Routers.

This Fibre Network was introduced as part of the Network Operations Transition Program (NOTP) to relocate services from East Perth to Western Terminal. It is intended to be the basis to support any future projects.

The CBD Core Fibre Network is outlined in this document as a resource to use to establish additional CBD Fibre Loops if the need arises. See CBD Core Network and Patching Diagram document for more information.

4.3.7 Substation Zone Fibre Network

The Substation Zone Fibre Network is a fibre network that connects Joel Terrace Substation, Head Office, QV1 and Hay St Substations.

The Substation Zone Fibre Network provides fibre services for the Westermo and Keymile Linerunner installations within the CBD Loops. As these are replaced, and HAY and QV1 is exited as primary hubs, the Substation Zone Fibre Network is expected to be retired, (or re-purposed).

The Substation Zone Fibre Network also carries SCADA for Wellington St Substation using Keymile Linerunners from Joel Terrace and Head Office. This service only resides on the East Perth to Head Office fibre path of the Substation Zone Fibre Network.

4.4 Pilot Cable

N/A – legacy technology

4.5 Power Line Carrier

N/A – legacy technology

5 Site Engineering

5.1 Coordinate System

The coordinate system **GDA 1994 MGA Zone 50** shall be used for any work within Western Power.

> ***Background Note:***
>
> *Most of Western Power source GIS data is GDA 1994 MGA Zone 50.*
>
> *Datum and coordinate system are different concepts. GDA 1994 is the datum (which is essentially a reference point), MGA Zone 50 is the projection (one of many algorithms to transform a 3D world into 2D coordinates). Those two things combine to make a coordinate system (sometimes referred to as CRS, or coordinate reference system) called GDA 1994 MGA Zone 50.*
>
> *It is worth mentioning that most of what you see in SPIDAWeb is different – we transform the source data to WGS 1984 Web Mercator Auxiliary Sphere, which is the global standard for web mapping. In this case, WGS 1984 is the datum and Web Mercator Auxiliary Sphere is the projection. We do this so we can smoothly plug in other external services like Nearmaps and the MDS basemap.*

Datum references from older designs shall be converted to GDA 1994 MGA Zone 50.

> ***Background Note:***
>
> *Older designs may have used older datum references and may cause mistakes when re-used in current designs.*
>
> *To determine the location of the communication sites, the coordinates are entered into the system using either latitude/longitudes or easting/northing figures. These coordinates are provided by either a global positioning system (GPS) or from paper based maps purchased by Western Power over a period of time. The paper based maps are based upon an old datum, namely ANS, using the AGD84 projection. Most new digital maps, including GPS, are based upon a worldwide datum termed GRS80, using the GDA94 projection. These two systems have a linear difference of approximately two hundred metres in a north easterly bearing as represented in the figure below.*

5.2 Communication Racks and Equipment

5.2.1 Introduction

This section relates to requirements for communication rack and equipment placement.

5.2.1 Definitions

Table 46: Definitions

Term	Description

5.2.2 Australian and International Standards

Designed shall be in conformance with the following standards.

Table 47: List of Applicable Standards

Standard/Specification	Description
	Engineering Design Instruction: Substation Secondary Systems Design

5.2.3 Western Power Standard Designs and Supporting Documents

Designs shall conform to the following Western Power standard designs and supporting documents.

Table 48: List of Applicable Western Power Standard Designs and Supporting Documents

Drawing No.	Description
	Manual – Telecommunications Construction – Installation Practices[9]

5.2.4 Rack Placement

Communication racks should be placed together in contiguous suites. Note that in is understood that this may not be possible in existing sites with space constraints.

Communication racks shall not be placed directly under equipment that may develop condensation (eg. air conditioners).

Communication equipment racks shall be placed in locations which will allow front and rear access.

Communications DC rectifier and battery expansion racks may be placed in locations without rear access.

[9] Western Power internal document

Rack locations shall allow for adequate egress with doors open. For communication equipment within substations, refer to the Substation Designer and Engineering Design Instruction: Substation Secondary Systems Design.

Communication racks in standalone comms sites shall be supplied without doors.

5.2.5 Equipment Placement

Standard installations shall be accommodated in racks as per standard drawing C52/2/1.

For non-standard installations, these general guidelines should be applied:

- Maintain RDP access space at top of rack (2RU)
- Maintain exclusion zone at bottom of rack (see below)
- Fill rack from top to bottom, except ODFs, which should be placed towards the bottom of the rack.
- Do not leave more than 1RU space between equipment unless there is a manufacturer requirement (eg. passive heat dissipation)
- Provide appropriate cable management for each equipment

The exclusion zone is an area at the bottom of the rack which shall not be used for equipment installation. The exclusion zone shall be as follows:

- Where the bottom-most equipment in a rack **is** an ODF: Bottom 7RU of a rack
- Where the bottom-most equipment in a rack is **not** an ODF: Bottom 9RU of a rack

Deviations to the exclusion zone requirement must be agreed as part of the Constructability, Operability and Maintainability review.

> ***Background Note:***
> *The exclusion zone is intended to avoid manual handling strain and injuries while working at the bottom of the rack.*

For operational telephone installation requirements, refer to Section 3.5.6.

5.2.6 Equipment Asset Replacement

Where existing communication equipment is being replaced with new communication equipment, the design shall be optimised to result in fewer racks being needed where possible. Equipment should not be spread out across multiple existing racks if not necessary for diversity or staging reasons.

> ***Background Note:***
> *In general, legacy equipment usually uses more rack space than newer equipment. Therefore, in asset replacement projects, it is expected that in most cases, there will be a lower rack space requirement. Removal of unused racks allows for a reduction in maintenance expense.*

5.2.7 Rack Numbering

For new sites, generally the following naming convention shall be used for rack numbering:

- Comms Rack 1 – DC Supply Rack

- Comms Rack 1A – DC Expansion Rack (if applicable)
- Comms Rack 2 – Comms Equipment Rack (containing multiplexer #1, SEAL switch, temperature sensor and/or RTU)
- Comms Rack 3 – Comms Equipment Rack (containing multiplexer #2)
- Comms Rack 4 – Comms Equipment Rack
- …

For existing sites, the next available number shall be used for new comms racks. Rack numbers of racks that were removed shall not be reused for new racks.

DC expansion racks shall follow the DC rectifier rack number, followed by A, B, C etc. For example, if the DC rectifier rack at a site is Comms Rack 6, then the first battery expansion rack shall be Comms Rack 6A, the second battery expansion rack shall be Comms Rack 6B

5.2.8 Equipment Numbering

Equipment at a site shall be allocated numbering on a per-site or per-rack basis as follows.

Per-rack basis:

- Patch panels
- IDFs

Per-site basis:

- All active equipment
- ODFs
- MTPs

ODF numbers shall be uniquely allocated from the OSS database.

5.2.9 Cable Numbers

Multiple repositories of cable numbering exist. Cable numbers shall be allocated from the appropriate cable schedule:

Scenario	Format	Cable Schedule
Radio microwave feeder cable	Destination substation code or R-code followed by dash and single digit (starting from 1)	N/A
Radio AMI feeder cable	"AMI" followed by dash and single digit (starting from 1)	N/A
DA/DMR feeder cable	"DA/DMRRX" and "DA/DMRTX" followed single digit (starting from 1)	N/A

Scenario	Format	Cable Schedule
Cable between comms racks	C followed by 3 digits	Comms cable schedule
Cable between comms rack to standalone comms equipment	C followed by 3 digits	Comms cable schedule
Cable between comms equipment and non-comms equipment	C followed by 4 digits	Substations cable schedule allocation for Comms, typically C8050 to C8099
Cable from Comms Site to Perth Fibre Network	C followed by 3 digits	Comms cable schedule
Cable from Substation to Perth Fibre Network	C followed by 4 digits	Substation cable schedule

Some existing sites may not follow this standard. In those cases, the above standard shall be used for any new cables.

Cable numbers shall not be reused once a cable has been decommissioned.

Background Note: *This is to avoid confusion during installation. Cables with old cable numbers may be remaining due to staging and/or due to incomplete completion of previous projects.*

5.3 Site Requirements

5.3.1 Introduction

This section relates to requirements for standalone communication sites.

5.3.2 Definitions

Table 49: Definitions

Term	Description

5.3.3 Australian and International Standards

Designed shall be in conformance with the following standards.

Table 50: List of Applicable Standards

Standard/Specification	Description

5.3.4 Western Power Standard Designs and Supporting Documents

Designs shall conform to the following Western Power standard designs and supporting documents.

Table 51: List of Applicable Western Power Standard Designs and Supporting Documents

EDM/Drawing No.	Description

5.3.5 General requirements

Site selection shall take into consideration the following aspects:

- Ability to satisfy project requirements (establishing required point-to-point connectivity and/or providing coverage at the right locations)
- Accessibility (near roads, minimising length and construction difficulty of access track)
- Power source availability (nearby distribution line, avoiding use of Standalone Power System where possible)
- Elevation (High enough to meet current and future radio path and coverage needs)
- Construction risks (eg. Rocky soil types)
- Distance from aerodromes (which may limit tower height)
- Avoiding Bushfire Prone Areas
- Environmental concerns (eg. Avoiding environmentally sensitive areas and regions with dieback)
- Heritage and community concerns

- Landowner requirements (eg. Avoid impinging on landowner’s usage of land)

5.3.6 Compound Size

The telecommunications fenced compound shall be 10m x 20m unless there are specific constraints with the particular site.

5.3.7 Shelter Requirements

Western Power currently has two approved shelter sizes:

- 5 x 2.5m
- 3 x 2.5m

The 5 x 2.5m shelter size shall be used in most instances. Consult Asset Performance should 3 x2.5m shelter be preferred for any particular project.

Refer to 5.4.8 for shelter selection considering bushfire risk.

5.3.8 Alarm Requirements

Refer to Section 3.7.5.2.5.

5.3.9 Structure Requirements

Refer to Section 5.5.

5.4 Bushfire Protection

5.4.1 Introduction

This section relates to requirements for bushfire protection.

5.4.2 Definitions

Table 52: Definitions

Term	Description
APZ	Asset Protection Zone. A low fuel area immediately surrounding a building.
BAL	Bushfire Attack Level. A means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact, using increments of radiant heat expressed in kilowatts per metre squared, and the basis for establishing the requirements for construction to improve protection of building elements from attack by bushfire.
FRL	The nominal grading period, in minutes, that is determined by subjecting a specimen to the standard time temperature curve regime as set out in AS 1530.4, to specify (a) structural adequacy, (b) integrity, and (c) insulation, which are expressed in that order.

5.4.3 Australian and International Standards

Designed shall be in conformance with the following standards.

Table 53: List of Applicable Standards

Standard/Specification	Description
AS 3959:2018	Construction of buildings in bushfire prone areas
AS ISO 31000:2018	Risk management – Guidelines
	Department of Planning, Lands and Heritage & Western Australian Planning Commission – Guideline for Planning in Bushfire Prone Areas version 1.4, December 2021

5.4.4 Western Power Standard Designs and Supporting Documents

Designs shall conform to the following Western Power standard designs and supporting documents.

Table 54: List of Applicable Western Power Standards

Drawing No.	Description
	Enterprise Risk Assessment Criteria

5.4.5 General Requirements

As per AS 3959:2018, a Bushfire Prone Area is defined as "an area that is subject, or likely to be subject, to bushfire attack."

The Map of Bushfire Prone Areas developed by the Department of Fire and Emergency Services (DFES) shall be used to identify Bushfire Prone Areas.

Background Note:

This has several advantages over Western Power's Fire Risk maps in Spidaweb:

- *Guidelines for Planning in Bushfire Prone Areas developed by the Western Australian Planning Commission refers to the Map of Bushfire Prone Areas to identify the bushfire prone areas.*
- *The Map of Bushfire Prone Areas is used as a generally accepted environmental consulting practice.*
- *The Map of Bushfire Prone Areas has better resolution and therefore provides more accurate information than the Western Power Fire Risk maps.*

Where possible, telecommunication site should be located away from Bushfire Prone Areas. If this is unavoidable, the following shall be considered in the design of communications infrastructure in Bushfire Prone Areas:

- Provision of telecommunication shelter constructed in accordance with Australian Standard AS 3959 Construction of Buildings in Bushfire Prone Areas
- Provision of an Asset Protection Zone (APZ) around the facilities (tower and shelter)

5.4.6 Bushfire Risk Management Plan

A Bushfire Risk Management Plan (BRMP) shall be developed for every site with new shelter/tower installations, including shelter/tower installations within Western Power substations or depot sites.

Background Note:

The BRMP development process optimises the site location to minimise bushfire risk, sets out the requirements of an APZ, and derives the required type of shelter for the particular location.

5.4.7 Asset Protection Zone

APZ shall be measured from the outer edge of proposed assets (i.e., communication shelter, tower and guy ropes), be established around the proposed infrastructure.

The APZs need to be maintained on a regular and ongoing basis to achieve a low threat minimal fuel condition in accordance with acceptable solution A2.1 of the Guidelines for Planning Bushfire Prone Areas.

Requirements for the APZs include:

- Fine Fuel Load: combustible dead vegetation matter less than 6 mm in thickness reduced to and maintained at an average of 2 t/ha. A leaf litter depth of 5 mm from the top of the layer to then mineral earth beneath is indicative of approximately 2.5 t/ha.

- Trees (>5 m in height): lower branches should be removed to a height of 2 m above the ground, tree canopies at maturity being a minimum distance of 10[1] m from the communication buildings, towers and guy wires to mitigate the risk of trees falling on these assets. Canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 meters apart as to not form a continuous canopy.

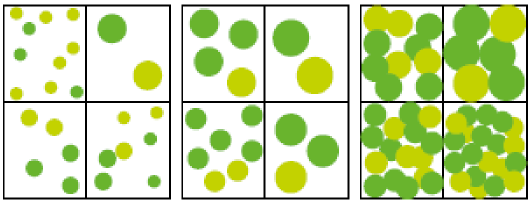


Figure 7 Tree Canopy Cover - ranging from 15% to 70% at Maturity

- Shrubs (0.5 m to 5 m in height): should not be located under trees, clumps of shrubs should be separated from each other by at least 10 m

- Groundcovers (<0.5 m in height): can remain under trees but must be properly maintained to remove dead plant material and any parts within 3 m of a structure

- Grass: should be managed to maintain a height of 10 cm or less.

- For the maintenance purposes clear a 6m border around the outside of the site fence and/or areas, as defined in site access drawings.

Notes:

1. The objective of providing a 10 m separation from tree canopies at maturity is to mitigate the risk of tree falling on the communication assets during a bushfire. However, in case of taller trees this separation shall increase to an appropriate length to mitigate the risk.

2. In addition to above requirements, there shall be no assets constructed within 1m inside of the site fence. This will ensure minimum of 7m clearance from any type of vegetation to Western Power assets.

5.4.8 Infrastructure Construction

The Australian Standard AS 3959 Construction of Buildings in Bushfire Prone Areas is intended to minimise damage to buildings from the effect of ember attack, radiant heat and direct flame contact, associated with bushfires.

The standard AS 3959 defines Bushfire Attack Levels (BAL) which is the measure of severity of a building's potential exposure to ember attack, radiant heat and direct flame contact and uses this as a basis for establishing the requirements for construction.

Western Power uses three types of communication shelters, namely, BAL-FZ, BAL-40 and BAL-LOW (non-bushfire rated).

5.4.8.1 Construction and Design Management Measures for BAL-FZ

The following construction and design management measures shall be implemented where BAL-FZ rated communication shelter is used:

- Building is constructed to minimum BAL-FZ standard in accordance with AS 3959
- Additional building specifications:
  - concrete slab on ground (no sub-floor or gaps)
  - roof installation complies with Appendix I of AS3959 for sheet metal roof construction where possible
  - door to have hot fire rated seal
- For building penetrations:
  - gland plates at penetrations to be fire rated to the same tested Fire Resistance Level (FRL) as the wall (Fyrebox or similar)
  - any PVC conduit penetrations to be fire-stopped in accordance with Building Code of Australia (BCA)
- Consideration shall be given to an external application to provide critical cable runs with some level of protection.

5.4.8.2 Construction and Design Management Measures for BAL-40

Following construction and design management measures shall be implemented where BAL-40 rated communication shelter is used:

- Building is constructed to minimum BAL-40 standard in accordance with AS 3959
- Additional building specifications:
  - enclose any sub-floor spaces in accordance with BAL-40 standard
  - door to have hot fire rated seal
- For building penetrations:
  - stainless steel gland plates and fire pillows at penetrations
  - any PVC conduit penetrations to be fire-stopped in accordance with Building Code of Australia (BCA)
- Consideration shall be given to an external application to provide critical cable runs with some level of protection.

5.4.8.3 Construction and Design Management Measures for BAL-LOW (Non-Bushfire Rated)

The following construction and design management measures shall be implemented where BAL-LOW communication shelter is used:

- Building is constructed to BAL-LOW standard in accordance with AS 3959

- For the maintenance purposes clear a 6m border around the outside of the site fence and/or areas, as defined in site access drawings.

5.5 Structures

5.5.1 Introduction

This section relates to the design of new telecommunications radio structures.

5.5.2 Definitions

Table 55: Definitions

Term	Description

5.5.3 Australian and International Standards

Telecommunications DC supplies shall be designed in conformance with the following standards.

Table 56: List of Applicable Standards

Standard/Specification	Description
AS 1170.0:2002	Structural design actions: General principles
AS 1170.1:2002 (R2016)	Structural design actions: Permanent, imposed and other actions
AS 1170.2:2021	Structural design actions, Part 2: Wind actions
AS 4100:2020	Steel structures
AS 3600:2018	Concrete structures
AS 3995-1994	Design of steel lattice towers and masts
AS/NZS 4677:2010	Steel utility service poles

5.5.4 Western Power Standard Designs and Supporting Documents

Designed shall be in conformance with the following Western Power standard designs and supporting documents.

Table 57: List of Applicable Western Power Standard Designs and Supporting Documents

EDM/Drawing No.	Description
	Technical Specification – Telecommunication Structures
	Telecommunications Design Standard – Aircraft Warning Light Systems for Telecommunications Structures

5.5.5 Design Requirements

Telecommunication structures shall be designed in accordance with Technical Specification – Telecommunication Structures.

New telecommunications structures should be self-supporting.

Structure height shall consider current requirements as well as requirements for future project with a high probability of proceeding. In addition to this, the following allowance for future antennas should be made:

- Quantity: 4
- Type: Parabolic "ultra high performance" (characterised by radiation patterns with ultra-low side lobes)
- Nominal Size: 1.8m
- Location: Two (2) dishes at the highest mounting location of the proposed structure and two (2) dishes 8m down.
- Azimuth: Any

The structure orientation shall be determined considering the expected azimuths of the initial proposed antennas and any know future antennas.

The radio tower should be connected to the associated building via overhead cable tray/gantry where possible. Underground conduit shall only be used in situations where the tower is not adjacent to the building containing the radio indoor equipment. If underground conduit is used, it should run directly into the building. Feeder cables running within substation cable trenches shall be provided with mechanical protection (eg. conduit

5.5.6 Regulatory Notification

Airservices Australia and CASA shall be notified of any new telecommunication structure installation.

5.5.7 Aircraft Warning Light (AWL) System

A new structure may require an Aircraft Warning Light (AWL) system. Refer to Telecommunication Standard – Aircraft Warning Light (AWL) Systems for Telecommunication Structures.

5.5.8 Structural Assessments

Importance Level 4 as per AS 1170.2 shall be used for structural assessment of Western Power communication structures.

> ***Background Note:***
>
> *Importance Level 4 is used due to the multi-use of structures and the possibility that structure use may change during its lifetime.*

The application of a reduced Importance Level may be considered when a reduction in design life or reliability of the structure is tolerable.

The cost to modify an existing structure to comply with this Standard may be considered excessive in some instances, especially when the structure has survived quite well for some years. In these cases, and where the reliability of the structure has been proven, it is acceptable to introduce a reduced Importance Level concept into the evaluation of existing structures.

A reduced Importance Level is also acceptable for staging purposes (eg. in a scenario where new antennas are installed prior to removal of old antennas).

5.6 ACMA Compliance

5.6.1 Introduction

This section relates to requirements for ACMA compliance.

5.6.2 Definitions

Table 58: Definitions

Term	Description

5.6.3 Australian and International Standards

Designed shall be in conformance with the following standards.

Table 59: List of Applicable Standards

Standard/Specification	Description
	Radiocommunications Act 1992
	Radiocommunications Licence Conditions (Apparatus Licence) Determination 2015
	Standard for Limiting Exposure to Radiofrequency Fields – 100 kHz to 300 GHz (Rev. 1) (2021)
13268061	ACMA publication "Human Exposure to Radiofrequency Electromagnetic Radiation – Information for licensees of radiocommunications transmitters"

5.6.4 Western Power Standard Designs and Supporting Documents

Designs shall conform to the following Western Power standard design and supporting documents.

Table 60: List of Applicable Western Power Standard Designs and Supporting Documents

EDM/Drawing No.	Description

5.6.5 Background

The conditions of Radiocommunications Apparatus Licenses issued by the ACMA are set out in the *Radiocommunications Licence Condition (Apparatus Licence) Determination 2015*.

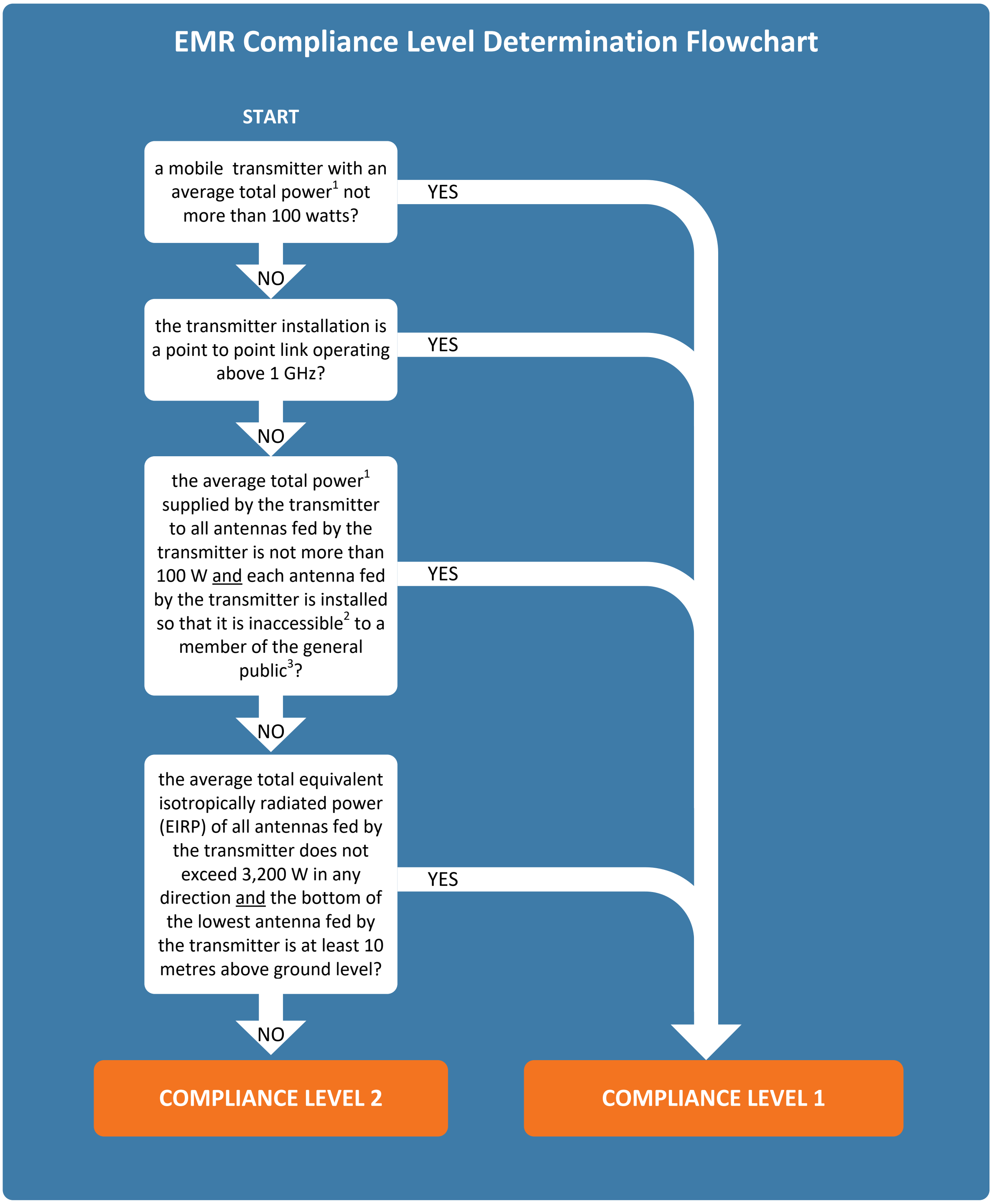
Part 3 of the Determination defines the conditions relating to Electromagnetic Radiation (EMR):

The RF field produced by a transmitter operated under the licence must not exceed the reference levels for general public exposure at a place accessible to a member of the general public.

Reference levels are defined in the ARPANSA standard *Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields – 3kHz to 300 GHz*.

Transmitter installations can be categorised into one of two levels – known as Compliance Level 1 or Compliance Level 2 categories.

The compliance level determines what site assessments and record keeping is required.



[1] *average total power* is calculated by multiplying the transmitter power by the transmission time ratio. For example, a 210W transmitter that transmits only 10% of the time = 21W.

[2] *accessible* examples include private residences, public parks and building rooftops where a transmitter antenna is located on the rooftop and access is not restricted by the site manager or operator.

[3] a *member of the general public* means all persons with the exception of those who may be exposed to radiofrequency fields under controlled conditions, in the course of and intrinsic to the nature of their work.

5.6.6 Design Requirements

For each new transmitter, it shall be determined as part of design whether Compliance Level 1 or Compliance Level 2 is required. Transmitters requiring Compliance Level 2 shall not be introduced into the Western Power network without consultation with Western Power's Asset Performance function.

For transmitters deemed to be Compliance Level 1, no further action is needed as part of design.

For transmitters deemed to be Compliance Level 2, the RF fields shall be calculated in accordance with AS/NZS 2772.2 as part of design.

5.7 Power Supply

5.7.1 Introduction

Telecommunications DC Secondary supplies are used to power communications equipment. The voltage, reliability and standby time of the secondary supply is driven by this equipment requirement, but supplies should generally comply with the standards defined below.

5.7.2 Definitions

Table 61: Definitions

Term	Description
Ampere Hour	Ampere hours (Ah) is the measurement used to indicate the battery's capacity. Therefore, the capacity of a battery is derived by multiplying a certain current in amps (A) with the time in hours (h) for which the battery can supply that current
Discharge Rate	The discharge rate is the rate at which electrical current is taken from the cell or battery
Duty Cycle	The load (in Amperes or Watts) that a battery is expected to supply for a specified time period(s) over the duration of the battery's life
Float Voltage	The float voltage is a charge voltage, set slightly higher than the cells nominal voltage in order to offset the internal losses whilst performing a float charge
RDP	Rack Distribution Panel
Valve-regulated lead-acid (VRLA)	A lead-acid cell that is sealed except for a valve that opens to the atmosphere when the internal pressure in the cell exceeds atmospheric pressure by a preselected amount. VRLA cells provide a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption

5.7.3 Australian and International Standards

Telecommunications DC supplies shall be designed in conformance with the following standards.

Table 62: List of Applicable Standards

Standard/Specification	Description
AS/NZS 3000:2018	Electrical Installation (Wiring Rules)
AS/NZS 3015:2022	Electrical installations - Extra-low voltage d.c. power supplies and service earthing within public telecommunications networks

Standard/Specification	Description
AS/NZS 5000.1:2005	Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 kV
AS 60038-2012	Standard voltages
AS/NZS 61000.2.2:2023	Electromagnetic compatibility (EMC) - Environment - Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems
AS 3011.2:2019	Electrical Installations – Secondary Batteries installed in buildings – Part 2: Sealed Cells

5.7.4 Western Power Standard Designs and Supporting Documents

Telecommunications DC supplies shall be designed in conformance with the following Western Power standard Designs and supporting documents.

Table 63: List of Applicable Western Power Standard Designs and Supporting Documents

EDM/Drawing No.	Description
	Electrical System Safety Rules (ESSR)

5.7.5 AC Supply

5.7.5.1 Mains Supply

The mains supply shall meet the following requirements:

- Nominal AC supply is 240V as per Technical Rules for the South West Interconnected Network.
- Harmonic distortion as per Australian Standard AS 61000.2.2.
- Frequency between 49.8 and 50.2 hertz

5.7.5.2 Rectifier Supply at Western Power Substations

AC Supply to the Telecommunications rectifiers shall be three single phase supplies from the 415V Distribution board. Each cable between the Distribution board and the rectifier rack should be protected by a 32A fuse or MCB. If 32A is not available, a 20A three phase supply should be used.

5.7.5.3 Rectifier Supply at Comms Shelter

AC supply to the Telecommunications shelter shall be a single-phase supply. The rectifier shall be internally fed by six 10A feeds from the distribution board.

AC power shall be from a mini-pillar near the proposed site. The AC power feed to the mini-pillar (if one does not already exist) shall be requested via a Small Commercial Connection request to the Western Power distribution team.

In remote areas where a nearby distribution line is not available, a Standalone Power System (SPS) may be requested via the Small Commercial Connection request. An AC mains distribution line is preferred over a SPS, as a SPS has a lower design life.

5.7.6 DC System

The standard voltage for telecommunications supplies is as follows:

- Nominal -48 V DC for all telecommunications equipment unless otherwise indicated below
- Nominal +12V DC for mobile radio equipment
- Nominal -24V DC for legacy telecommunications equipment only

For installation of legacy equipment where a -24V DC supply does not already exist, DC/DC converters should be used to provide the required voltage.

5.7.6.1 Standby Time and Supply Reliability

Availability and Battery Reserve requirements shall be as per the table below.

Table 64: Availability and Battery Reserve Time

Site	Availability	Battery Reserve (hrs)
Substation Bearer End Site	99.99%	12–24
Substation Bearer Repeater Site	99.999%	48–72
Mobile Radio and General Repeater Site	99.99%	48–72
Depots	99.9%	8–12
PLC/TPS (from Substation Supply)	99.99%	6–10

5.7.6.2 Battery Type

Valve Regulated Lead Acid (VRLA) batteries shall be used.

Background Note:

The advantage of using VRLA batteries are as follows:

- *Low hydrogen gas venting (except during overcharge)*
- *Smaller footprint which allows them to be stacked vertically*
- *Acid containment system not required*

Since space in Western Power Substations and telecommunications sites is at a premium, these advantages make the use of VRLA batteries the most economical. Since VRLA batteries are heavy, the rectifier rack where the batteries are installed is supported by jacks when installed in sites with computer flooring.

Western Power does not use Vented Lead Acid (VLA) batteries. Although these batteries have a longer life, they require additional inspections, gas vents and an acid containment system. Furthermore, their larger footprint makes very expensive over the life cycle of the rectifier system.

5.7.6.3 Rectifier System

Rectifiers used in telecommunications applications shall be equipped for N+1 redundancy, operated in parallel and setup for load sharing. The rectifier system capacity shall be large enough not only to operate the load equipment, but simultaneously recharge the batteries in the desired time.

Refer to Section 3.7.5.2.2 for alarm requirements.

5.7.6.4 Maximum Short Circuit Current

The maximum short circuit current for any installed system shall be less than 20kA. If the system capacity requirement would lead to the short circuit current exceeding 20kA, the following solutions are approved:

- Provision of a separate DC system such that the maximum short circuit current for each individual system is less than 20kA; or
- Provision of a DC system with an explosion venting system. See AS 3011.2-2019 clause 3.3.3

5.7.6.5 Rack Distribution

Each full-size rack with DC powered equipment shall have a Rack Distribution Panel (RDP) of the corresponding voltage.

The A and B bus of a dual bus RDP (-48V DC) shall be fed from the A and B bus of the Rectifier system.

Where DC powered equipment is capable of accepting a dual power feed, the equipment shall be fed from the A and B bus of the RDP.

5.8 Earthing

5.8.1 Introduction

Earthing procedures for telecommunications equipment at Western Power sites are intended to ensure adequate protection of personnel and equipment in the event of Earth Potential Rise (EPR) and differences in potential due to:

1. Lightning strikes
2. Fault conditions (particularly where telecommunications facilities are associated with HV substations)

This section describes the requirements for the earthing and lightning protection of Western Power telecommunications installations.

5.8.2 Definitions

Table 65: Definitions

Term	Description
AC	Alternating Current
ACMA	Australian Communications and Media Authority
DC	Direct Current
ENA	Energy Networks Association
EPR	Earth Potential Rise (with respect to remote earth)
HV	High Voltage (voltages above 1 kV)
IDF	Intermediate Distribution Frame
LV	Low Voltage (voltages below 1 kV)
MEN	Multiple Earth Neutral
MEN Earthing System	Earthing system incorporating the multiple earthing of the distribution LV neutrals, including any local earth electrode installed to earth the incoming LV supply neutral.
PSTN	Public Switched Telephone Network

Term	Description
Remote Site	A site which is not within or adjacent to a substation.
RF	Radio Frequency
SRF	Surge Reduction Filter
Step Potential	The difference in surface potential experienced by a person, without contact with any grounded object, standing with feet 1 m apart.
Touch Potential	The voltage between the feet of a person standing 1 m away from a metallic object and the hand of the person in contact with the object.
Telecommunications Building	Any building or hut (dedicated to telecommunications or shared with control equipment) housing telecommunications equipment within a telecommunications or substation site.
Telecommunications Equipment Earth Bar	Earth busbar fitted to the inside of the telecommunications building for the purposes of earthing telecommunications equipment and achieving equipotential bonding.
Telecommunications Earthing System	The combination of Tower Earthing System and MEN Earthing System.
Telecommunications Service Earth	A connection to the general mass of earth provided by the telecommunications carrier in a way that provides a functional requirement for the telecommunications equipment and cabling. Conductors used in a telecommunications service earthing system do not normally carry battery return current.
Tower Earthing System	The interconnected earthing systems covering the tower (or monopole) earthing, guy earthing, trench earth electrodes, RF cable earthing and the site fence earthing. For sites adjacent to, or part of a substation, this shall include the connections to the substation earth grid.

5.8.3 Australian and International Standards

Telecommunications earthing shall be designed in conformance with the following standards.

Table 66: List of Applicable Standards

Standard/Specification	Description
AS 2067:2016	Substations and high voltage installations exceeding 1 kV a.c.

Standard/Specification	Description
AS 2239-2003	Galvanic (sacrificial) anodes for cathodic protection
AS/NZS 3000:2018	Electrical installations (Australian/New Zealand Wiring Rules)
AS 3015:2022	Electrical installations - Extra-low voltage power supplies and service earthing within telecommunications networks

5.8.4 Western Power Standard Designs and Supporting Documents

Telecommunications DC supplies shall be designed in conformance with the following Western Power standard designs and supporting documents.

Table 67: List of Applicable Western Power Standard Designs and Supporting Documents

Drawing No.	Description
	Manual – Telecommunications Construction – Installation Practices[10]
	Guideline – Antenna & Feeders Construction[11]
	Technical Specification – Telecommunications Structures
	DS (P) - Substation - Substation Earthing Design

5.8.5 Earthing of Standalone Telecommunication Sites

Background Note:

Earthing for lightning surge dissipation is, in some ways, different to HV substation power frequency earthing. In lightning protection earthing, the primary aim is to dissipate a lightning strike into the greater mass of earth. In the main, this is achieved by minimising the surge impedance on the path from the lightning conductor to the greater mass of earth. The lightning conductor can be an antenna support mast, an RF feeder conductor on its way to the telecommunications building, a guy wire or any other conductive part of the telecommunications site.

The greater mass of earth may be defined as the surface soil, the subsoil, the embedded rock, and the underlying water table. Low frequency 50 Hz currents may be conducted to earth via low resistance conductors without regard to their length and consequent inductance; however, high frequency lightning currents require low impedance conductors.

Typical earth grid configurations for standalone telecommunications sites can be found on drawing C76/3/1 (for sites with a guyed mast) and drawing C76/5/1 (for sites with a self-supporting lattice tower).

[10] Western Power internal document

5.8.5.1 Earth Electrode Configurations

The following configurations are approved:

Soil Type	Configuration
Deep, Low Resistivity Soil	Deep driven steel-cored copper clad earth rods. This is the preferred method for remote telecommunications site earthing. The depth of the earth rods shall be calculated based on the soil resistivity and the required resistance to earth. Attempt to drive the rods into the water table. Interconnect guy and tower earths via trench electrodes.
Rock or Sandy Soils	The following options are approved: 1. Use short electrodes interconnected by short lengths of conductors. 2. Install long earth electrodes to a depth of several metres and backfill the holes with a low resistance earthing compound such as calcium bentonite mixed in accordance with AS 2239:2003. 3. Consider a design using plate electrodes instead of rod electrodes. The preferred arrangement is to use a 6-pointed star configuration of trench electrodes buried to a nominal depth of 2.4 metres. Vertical rods should be driven at the centre point and at least two other points on each radial. Each radial shall be approximately 10 metres long. The horizontal separation between earth rods shall preferably be at least equal to twice the depth of each rod. However, where space is limited or there are physical restrictions on site, a horizontal separation equal to the depth of the rods is acceptable. Interconnect the earth rods for the tower and the guys with trench electrodes where practicable.
Bare Rock	Use deep driven steel covered copper clad earth rods. Holes for these rods shall be drilled to a depth of at least 15 metres and have a diameter of not less than 75 mm. The holes shall have been back filled with calcium bentonite or similar conductive cement.

5.8.5.2 Equipotential Bonding of Building and Site Fence to Earth Grid

All earth rods in the vicinity of the telecommunications building shall be bonded to each other as shown in drawing C76/3/1 (for sites with a guyed mast) or drawing C76/5/1 (for sites with a self-supporting lattice tower) using trench electrodes.

Site compound fencing shall be provided with a buried earth ring which is bonded to alternate fence posts and connected to the Tower earthing system at a minimum of two points. Refer also to drawings C76/5/1 and C76/3/1 for typical fence earthing connections.

Equipotential bonding shall be provided in the telecommunications building in accordance with drawing C76/8/1.

5.8.5.3 Maximum Resistance of the Earthing System

The maximum resistance of the tower earthing system on its own is given in Table 5.1 of AS/NZS 3015:2022.

This is a guide to design only – any earth system that is subject to HV faults (such as a radio site connected to a tower earth), must be designed to ensure that the touch and transfer potentials which would occur on the earth system are within the allowable limits of AS/NZS 2067.

Step potentials which would occur on the earth system should be within the allowable touch potential limits of AS/NZS 2067, to ensure a conservative approach is applied.

It is expected that there will be sites with poor soil conditions (rock and/or very high resistivity soils) where there will be difficulty achieving this figure. In this case, the earthing system shall be designed to achieve the lowest resistance practicable, and checks shall be made as the voltage gradients and touch potentials under lightning strike conditions.

The connection to the MEN earthing system will have the effect of reducing the resistance of the communication site earthing, but a significant reduction will largely be due to the MEN earthing network extending over some distance. Under lightning strike conditions, the impedance of this extended earthing network will be high. Hence the reduction in earth resistance due to the connection to the MEN earth must not be considered when determining the maximum resistance of site earthing.

5.8.6 Earthing of Telecommunications Sites in vicinity of Substations

> ***Background Note:***
> *Where telecommunications sites are situated near terminal or zone substations, and telecommunications cables run between them, the earthing design should be considered carefully. There is the need to protect against the lightning strikes as well as the earth potential rise due to fault currents at the zone or terminal substation. The earthing objectives are to minimise danger to personnel and equipment without compromising the operation of the telecommunications network.*

5.8.6.1 Design Requirements

5.8.6.1.1 Telecommunications Sites Within or Adjacent to Substations

Where telecommunications sites are situated adjacent to substations and share a common boundary fence, the substation HV earth grid shall extend to completely cover the telecommunications site. Steps taken to ensure safety of equipment and personnel within the substation shall also be applied to the telecommunications site. In this regard attention shall be paid to the installation of an earth grid and measures to ensure the safety of personnel contacting the boundary fences and gates. If the safe design of the substation HV earthing design depends on the substation having a high resistivity surface layer, this high resistivity layer will also have to be applied in the telecommunications site (refer to Western Power Engineering Design Standard – Earthing Installation Guidelines). The two earthing systems shall be bonded a minimum of 3 locations using copper conductors or straps of at least the same size as the larger of the two earth systems. In addition, 5 m long earth electrodes shall be provided to each of the tower legs, with a direct connection between each electrode and its associated tower leg.

Any conductors entering the telecommunications site shall be considered to be entering a substation and appropriate measures shall be implemented to provide electrical isolation between the incoming cables and the substation area. This will also include the need to isolate water pipes entering the sites.

Under these circumstances the safety and lightning aspects of earthing for telecommunications assets fall within the scope of the substation design. The earth potentials at each end of any telecommunications cable will be the same.

In substations where there may be more than one earth grid and the grids are interconnected, the integrity of the interconnections needs to be carefully investigated. Should there be any uncertainty and the telecommunications facilities are located above separate earth grids and telecommunications cabling traverse the grids, the earthing provisions need to be carefully considered. From a telecommunications perspective an equipotential bond shall be provided between the antenna support structure and the telecommunications building. This may be achieved by providing a minimum of two physically separate connections using copper conductor or strap.

Where new facilities are under consideration this is the preferred arrangement.

Any earthing design carried out in a telecommunications facility that is connected to the earth grid of a Western Power substation shall be approved by Substations Design team.

5.8.6.1.2 Telecommunications Sites Near (But Not Adjacent To) Substations

Where the telecommunications site is situated within three hundred metres of the substation and outside of the substation boundary fence, determine whether isolation of the telecommunications and substation sites, or a commonly bonded site system is the most cost-effective approach to implement. Isolation between sites may be achieved by use of fibre optic links.

Where the two sites do not share a common boundary fence, the substation design must not provide any earthing facilities for the telecommunications site (i.e., the earthing systems for the substation and the telecommunications facility must be kept separate).

Background Note:
Where the sites are connected by an uninsulated earth cable there is a danger to nearby pedestrians since the uninsulated cable can be at very high potentials during fault conditions. Additionally, this high voltage may be conducted to points of low earth resistance encountered along the route causing local potential rises (e.g., a metal fence).

Any data communications between the substation and the comms site shall only be via all dielectric fibre optic cable.

5.8.7 Earthing of Antenna Support Structures

Earthing of antenna support structures shall comply with Technical Specification – Telecommunications Structures.

5.8.8 Radio Frequency Feeders

Earthing of radiofrequency feeders shall comply with Guideline – Antenna & Feeders Construction.

5.8.9 Earthing of Telecommunication Buildings

The 400/230V AC mains power supply to the telecommunications building shall be earthed in accordance with the requirements of AS/NZS 3000.

The Telecommunications Services Earth Bar provided as part of the transportable telecommunications shelter shall be connected to the telecommunications structure Earthing System using 2 off 70 mm^2 PVC insulated copper conductors.

5.8.10 Surge Protection for External Cables Entering

Power cables entering a Telecommunications Site is protected by surge arrestors in the standard design.

5.8.11 Earthing of Telecommunications Equipment Within Cubicles

Telecommunications equipment within cubicles shall be earthed as per the following supporting documents:

- Manual – Telecommunications Construction – Installation Practices[11]
- Guideline – Antenna & Feeders Construction[12]

[11] Western Power internal document

5.9 Physical Security

5.9.1 Introduction

This chapter captures the telecommunications requirements to accommodate physical security.

5.9.2 Definitions

Table 68: Definitions

Term	Description
AS	Australian Standard
Brownfield Site	Site with existing or previous assets
Greenfield Site	New site with no previously installed assets
HMR	Hazard Management Register
SiD	Safety in Design

5.9.3 Australian and International Standards

Telecommunications Physical Security shall be designed in conformance with the following standards.

Table 69: List of Applicable Standards

Standard/Specification	Description

5.9.4 Western Power Standard Designs and Supporting Documents

Telecommunications Physical Security shall be designed in conformance with the following Western Power standard Designs and Supporting Documents.

Table 70: List of Applicable Western Power Standard Designs and Supporting Documents

EDM/Drawing No.	Description
	COMMUNICATION ACCESS SIGN - RF Radiation and Restricted Access[12]

[12] Western Power internal document

5.9.5 Property & Fleet WAN Service

The Property & Fleet WAN service to connect to site security networks shall be transported using the SEAL network.

> ***Background Note:***
>
> *Historically, Telecommunications Design was responsible for the design of electronic security systems however this has been handed over to Property & Fleet. The provision of the WAN service above is the limit of Telecommunications Design responsibility for Electronic Security.*

5.9.6 Security Requirements for Telecommunications Sites

The telecommunications equipment shelter layout shall include provision of space for a security rack.

All new sites buildings and mast/tower base shall be enclosed by a chain link fence with barbed wire at the top as detailed in drawing C74/5/1, suitably installed to prevent access by lifting the lower portion of the fence.

A double gate to allow vehicle access to the compound shall be included in the perimeter fence.

Where guy wires are used for masts, the footings and lower guys shall be protected by bollards or low-level fencing around them to prevent accidental damage to the guy wires by vehicular traffic or livestock.

Where a high risk of vandalism is known to exist or is considered possible then a more secure fence/locking system shall be considered and deployed if agreed to by Western Power Asset Performance.

Air-conditioning units shall be protected from vandalism by suitable metal cages.

These metal cages shall be either constructed of steel which has then been “hot dip galvanised” or constructed of metal which does not corrode.

Communications sites shall have suitable signage to act as a deterrent to no authorised users. Drawing C66/46/1 outlines the standard signage required for buildings. Additional signage outlining site hazards may also be required.

5.9.7 Locks

Compound gates shall be secured with a standard Western Power padlock type NK6.

Buildings shall be secured with the following types of locks:

Site Description	Building Lock Requirement
Sites carrying distribution network traffic only	NK6 lock
Sites carrying Transmission network traffic	R series lock to suit GMKRK key system, and swipe card electronic lock if applicable for the site]