AS 7703:2020

Railway Signalling – Power Supply Systems

Train Control Systems Standard

Please note this is a RISSB Australian Standard® draft

Document content exists for RISSB product development purposes only and should not be relied upon or considered as final published content.

Any questions in relation to this document or RISSB's accredited development process should be referred to RISSB.

RISSB Office

Phone:	Email:	Web:
(07) 3724 0000 Overseas: +61 7 3724 0000	info@rissb.com.au	www.rissb.com.au

AS 7703:2020 **Assigned Standard Development Manager**

Name:	Phone:	Email:
Cris Fitzhardinge	**0419 916 693**	cfitzhardinge@rissb.com.au

This Australian Standard® AS 7703 Railway Signalling – Power Supply Systems was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

Rio Tinto	PTA WA	Metro Trains
Rail Assurance Consulting	Transport for NSW	Queensland Rail
Aurizon	Public Transport Victoria	Wabtec
Novaris	V/Line	Hitachi Rail STS
KiwiRail	JMD Railtech	

The Standard was approved by the Development Group and the Train Control Systems Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

Choose the type of review

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.

Deb Spring
Exec. Chair / CEO
Rail Industry Safety and Standards Board

Keeping Standards up-to-date

Australian Standards developed by RISSB are living documents that reflect progress in science, technology and systems. To maintain their currency, Australian Standards developed by RISSB are periodically reviewed, and new editions published when required. Between editions, amendments may be issued. Australian Standards developed by RISSB could also be withdrawn.

It is important that readers assure themselves they are using a current Australian Standard developed by RISSB, which should include any amendments that have been issued since the Standard was published. Information about Australian Standards developed by RISSB, including amendments, can be found by visiting www.rissb.com.au.

RISSB welcomes suggestions for improvements and asks readers to notify us immediately of any apparent inaccuracies or ambiguities. Members are encouraged to use the change request feature of the RISSB website at: http://www.rissb.com.au/products/. Otherwise, please contact us via email at info@rissb.com.au or write to Rail Industry Safety and Standards Board, PO Box 518 Spring Hill Qld 4004, Australia.

Notice to users

This RISSB product has been developed using input from rail experts from across the rail industry and represents good practice for the industry. The reliance upon or manner of use of this RISSB product is the sole responsibility of the user who is to assess whether it meets their organisation's operational environment and risk profile.

AS 7703:2020

Railway Signalling – Power Supply Systems

Document details

First published as: Enter first publication identifier (AS XXXX:yyyy)

ISBN Enter ISBN.

Document history

Publication Version	Effective Date	Reason for and Extent of Change(s)
PC Draft	Select Board approval date	Draft for public consultation

Approval

Name	Date
Rail Industry Safety and Standards Board	Select Board approval date

Copyright

Published by SAI Global Limited under licence from the Rail Industry Safety and Standards Board, PO Box 518 Spring Hill Qld 4004, Australia.

This Standard was prepared by the Rail Industry Safety and Standards Board (RISSB) Development Group AS 7703 Railway Signalling – Power Supply Systems. Membership of this Development Group consisted of representatives from the organisations listed on the inside cover of this document

Objective

The objective of this Standard is to provide an approach to the use of the electrical equipment throughout the system life cycle in achieving the functional signalling safety inherent with the hazards associated with the use of electricity. This standard specifically covers the signalling power supply and the manner in which it supports the other signalling equipment.

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

1. Requirements.
2. Recommendations.
3. Permissions.
4. Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term 'should'.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term 'may'.

Constraints - provided by an external source such as legislation. Constraints are identified within the text by the term 'must'.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organisations where the risk may be shared.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix A

Commentary

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by 'C' preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

Contents

Appendix Contents

1 Scope and general

1.1 Scope

This Standard covers the use of the electrical equipment as part of a signalling system to achieve vital and non-vital functions. The signal power supply is a critical aspect for safe operation of signalling systems. This Standards scope includes the functional requirements of electrical equipment performing signals safety applications. The scope of this Standard covers the range of environmental conditions signals are likely to be exposed to when operating in Australasian rail networks. The scope also details standard requirements for electrical equipment that is used in signalling systems to aid standardisation of supply and interoperability of equipment across railway networks.

This Standard also covers the use and safety throughout the system life cycle. This includes:

(a) design;

(b) construction;

(c) test and commission;

(d) operation;

(e) maintenance;

(f) modification;

(g) decommission and disposal.

Because of the inherent hazards with electricity there are legislative requirements for its application. Appendix G provides further information. .

The hazards associated with the electrical equipment and the railway signalling functions have been considered and documented to aid users in determining the SFAIRP application of this standard to a railway network or electrical signalling equipment.

1.2 Exclusions

High voltage and railway traction power supplies are excluded from this standard. Where the signalling power supply is derived from these sources the standard only covers the transformer secondary and protection circuits and all downstream equipment.

Railway traction return current circuits and associated equipment are excluded from this standard. This also includes the associated equipment for electrolysis protection.

On board signalling system power supplies are excluded from this standard.

1.3 Demarcation between application of AS/NZS 3000 and AS 7703 requirements

For clarity in applying the correct requirements, a hard line of demarcation is defined between supply authority system or similar power systems and the signalling power system. The line of demarcation is at the low-voltage output terminals of the isolating / transformer supplying the signalling power system.

All installation upstream of these terminals, including the transformer itself, shall comply with the MEN protection system and the customary interpretation of AS/NZS 3000. All installation downstream of these terminals shall comply with the IT system of protection and this Standard.

1.4 Normative references

The following referenced documents are indispensable for the application of this Standard:

- AS 7664 Signals Cable Route
- AS 7702 Rail Equipment Type Approval
- AS 7708 Signalling Earthing and Surge Protection
- AS/NZS 3000 Wiring Rules
- AS/NZS 60898.1:2004 Electrical accessories—Circuit-breakers for overcurrent protection for household and similar installations Part 1: Circuit-breakers for a.c. operation
- IEC 60364-1 Low voltage Electrical installations – Part 1 - Fundamental principles, assessment of general characteristics, definitions.
- IEC 61557-8 Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. - Equipment for testing, measuring or monitoring of protective measures - Part 8: Insulation monitoring devices for IT systems

1.5 Terms, definitions and abbreviations

For the purposes of this document, the following terms and definitions apply:

1.5.1
active

notional supply side of the a.c. circuit, and location of control contacts in single-switched circuits (labelled as Bx)

1.5.2
alternating current

a.c.
type of electrical current, in which the direction of flow of electrons switches back and forth in a regular pattern or cycles. In Australasia this is typically 50 cycles per second and of a sine wave pattern

1.5.3
common

notional return side of the a.c. circuit; may include few or no control contacts and may be shared between a number of control circuits (labelled as Nx)

1.5.4
direct current

d.c.

electrical current that flows consistently in one direction

1.5.5
extra low voltage

less than 50 volts RMS a.c. or 120 volts ripple free d.c..

1.5.6
fault

any unintended connection between two conductors or a live conductor to earth, which is capable of passing current of a magnitude that can result in unsafe operation, damage to equipment or injury to personnel

1.5.7
graceful degradation

when there is a failure of an item of equipment, the functionality and performance of the power supply system is able to achieve a degraded level which is designed to allow some critical signalling functionality to operate

1.5.8
GPO

general purpose outlet for 240 volt power

1.5.9
high voltage

> 1,000 volts RMS a.c. or > 1,500 volts d.c.

1.5.10
IT

'I' means all live parts isolated from earth, or one point connected to earth through high impedance and 'T' means direct electrical connection of exposed conductive parts to earth, independently of the earthing of any point of the power system[1]

1.5.11
low voltage

LV

a.c. RMS voltage 50 volts to 1,000 volts or ripple free d.c. volts 120 to 1,500

1.5.12
MEN

multiple earth neutral or defined as TN-C-S in IEC 60364

1.5.13
OCPD

over current protection device

1.5.14
power supply

device that transforms, modifies or produces the alternating current or direct current supply for the signalling power system from the primary power source

[1] IT code as per IEC60364-1

1.5.15
rail infrastructure manager

RIM

rail transport operator that also manages rail infrastructure

1.5.16
return

notional return side of the circuit and may include few or no control contacts and may be shared between a number of control circuits (labelled as NX)

1.5.17
RMS

root mean square

1.5.18
SELV

system of extra low voltage electrical circuit that is separated from other circuits. It is isolated from earth and from the protective earth conductors of other electrical circuits

1.5.19
SPD

Surge protective device

1.5.20
supply

notional supply side of the circuit and location of control contacts in single switched circuits (labelled as BX)

General rail industry terms and definitions are maintained in the RISSB Glossary: https://www.rissb.com.au/products/glossary/

2 Fundamental principles

2.1 General safety principles

Electrical systems are inherently hazardous to people and other equipment. AS/NZS 3000 provides requirements and recommendations that are designed to reduce risks with regards to electrical installation. This Standard compliments those requirements and recommendations.

To reduce the risks associated with electrical installations in railways, the following fundamental principles, in accordance with AS/NZS 3000, apply:

(a) Electrical installations shall be provided with control and isolation devices. See clause 4.2.5

(b) Electrical installations shall be designed to prevent electric shock. See clause 5.1.1

(c) Personnel working on live equipment shall be protected against contact with live parts within the installation. See clause 5.1.1

(d) Personnel working on equipment shall be protected against contact with parts that couldbecome live in fault conditions. See clause 5.1.1

(e) Electrical installations shall be designed so that in normal operation there is no risk of persons or equipment suffering burns or fire due to high temperature or arcing. See clause 5.1.1

(f) Electrical equipment shall be protected from or designed to withstand environmental and other influences that would reasonably be expected to occur. See appendix B.

2.2 Licencing requirements

Within Australia extra low voltage circuits do not require specific licenses or training. However, circuits operating at low voltage have legislated requirements for the design, installation, operation, maintenance and disposal of electrical equipment and systems. These requirements are state based and there can be specific state-based exemptions and conditions for working on railway signalling circuits.

In accordance with *Rail Safety National Law* all personnel must have the required training, qualifications and competency to perform rail safety work, which includes work on railway electrical installations. The training and licencing requirements for electrical workers shall be clearly defined within a RIMs safety management system (SMS).

The RIM shall have standards and procedures that are consistent with the legislated requirements for persons that work on electrical installations.

These should include documented:

(a) procedures covering the relevant legislative requirements for the respective state or territory to work on electrical systems;

(b) records for the training and competency of personnel who are required to work with the signalling power supply systems;

(c) procedures for undertaking work on the systems including maintenance and operation of the system;

(d) procedures for undertaking changes to the systems including the construction, testing, modification and de-commissioning of the signalling power supply systems;

(e) procedures for recording the design of signalling power supply systems and as-built configuration of the systems;

(f) procedures for recording of the condition and status of the signalling power supply systems.

The RIM shall identify in procedures the requirements applicable for working on:

(g) extra low voltage;

(h) low voltage.

2.3 General principles of railway signalling power supplies

Due to the nature of the railway signalling power supply the following principles shall apply:

(a) The operation or failure of the power distribution system shall not cause a wrong side failure of the signalling equipment.

(b) The power supply installation shall be designed to be electrically safe for workers and the public who can interact with the system.

(c) The system shall be tolerant of faults to ensure a very high availability of signalling systems.

(d) The system shall not allow traction return current from the traction power system to be transmitted to the local supply authority.

2.4 Operational safety considerations

The signalling system uses electrical devices to provide the functional operation for the safety of railway operations. This includes items such as level crossing lights, signal lights, point motors and interlockings where a failure of the signalling electrical power supply will prevent the functional operation. This can lead to degraded modes of operation including manual working that are inherently less safe than the engineered systems. Evaluation of these safety impacts should be included in the design functional requirements to achieve fail-safe operation.

Signalling functions and circuits that have specific functional safety performance requirements also rely upon electrical power to maintain the logic function. This logic function can be based on a sequence of events or a set of conditions. The loss of electrical power can interrupt the retention of that status of the preceding operational events. The loss of electrical power can result in the signalling system responding in an unsafe manner.

2.5 Earthing

The signal power supply system is used to provide logic switched circuits which can extend over multiple physical locations for the functional safety of the railway. The safety requirement and performance is achieved by having the circuits with logic switching in both ac live conductors of the circuit.

Railway signalling power systems used for all supplies, alternating current and direct current shall be designed in conformance with IT system of earthing (isolated from earth) as detailed in IEC 60364.

The outputs of signalling power supply systems shall not be earthed.

All metallic cases and conductive materials supporting or including signalling power supply systems shall be earthed to a signalling earth. The outputs of the railway signalling power supply systems shall be continuously monitored for an earth connection and provide an alarm upon detection of a fault to earth. This function is generally performed by an earth leakage device (ELD).

An equipotential mat may also be installed at a signal equipment location to improve the earth performance for lightning, surges and fault from railway traction systems. The equipotential mat may be achieved by welding a connection to the steel reinforcing of the equipment location and connecting this to the signalling earth. All metallic surfaces in the equipment location are also bonded to this earth.

The requirements of AS/NZS 3000 shall be implemented for all supplies where a neutral-earth connected system is implemented.

C2.5 Commentary

The use of an MEN scheme does not provide a sufficient level of fault tolerance where in the event of an earth fault on the active leg of the circuit the OCPD is triggered, nor does it permit the 'double cutting' of a signalling functional circuit. The use of the IT system of distribution (unearthed) ensures that the safety performance is achieved.

The IEC 60364 standard requires a continuous earth monitoring system. This includes a provision that disconnects power on the occurrence of an earth fault. This is not applied as the total loss of signalling power would pose a greater overall risk than the electrical risk to an individual working on the signalling power electrical system.

This latter risk is managed by system design, work practices, competency of staff with access to the system, scheduled maintenance plans and work practices for response to a first earth fault alarm and working while an earth fault persists.

2.6 Railway traction power systems

Railway signalling power systems shall have separation and isolation from railway traction power systems.

2.7 Safety in design

The safety in design approach allows for the identification of the electrical hazards and the implementation of controls to manage the hazards safe so far as is reasonably practical. The safety in design outcomes canbe different for different parts of the rail network and for different rail operations.

The RIM shall develop standards, procedures and work instructions for the systems and work activities associated with the signalling power supply systems to achieve the required level of safety throughout the system life cycle. This shall include safe work method statements

(SWMS) for activities covering construction, testing, commissioning, operation and maintenance for the railway signalling power supply systems.

The RIMs standards and SWMS should be evaluated as suitable for the level and type of rail operations.

2.8 Signalling performance requirements

The signalling system should be designed to meet a range of performance requirements. In rail network areas with high train frequency, the impact of electrical power failure is greater than for other areas with low frequency of trains. The performance requirements for a signalling system should evaluate the impact of loss of electrical power on the functional performance and on the degraded mode system safety.

The signal power system performance contributes to the overall signalling system operation and availability. The requirements for the signal power system should be appropriate to meet the overall signalling system performance. Appropriate electrical back up performance should evaluate this and the mean time to repair the failure.

To determine the signalling system performance requirements a RIM should evaluate:

(a) fall back to manual operation or degraded mode and its safety hazards;

(b) hazards associated with repairing electrical power within an operating rail network;

(c) quiescent power load and dynamic power load when the power is restored;

(d) delays for systems to reboot or otherwise commence normal operation after power failure;

(e) the impact of initial inrush current for a power supply with exhausted batteries (transient and dynamic);

(f) change over to alternate back up power supplies and the impact of a momentary interruption to electrical power;

(g) the impact of manual entry of train information when restarting the system after a power failure.

2.9 Quality of signalling power supply

The requirements for the quality of the power supplied to interlockings, signalling devices, control, indication and communication devices using information from the device manufacturers shall be detailed by the RIM.

Quality requirements shall include static and dynamic operation.

Power quality assessment shall include:

(a) voltage variations;

(b) harmonic interference;

(c) transient voltages and currents from the primary power source;

(d) signalling system operation;

(e) signalling system fault behaviour and induction from other systems;

(f) lightning.

This information and other nominated requirements should be detailed in the signals functional specification. Appendix D provides further information on signal equipment tests and data sheets.

2.10 Signal power systems overview

2.10.1 General

The signalling power system has the following main components:

(a) Primary power source that provides the electrical power for signalling functions. This may also power other functions on the railway.

(b) Secondary or back up power source that maintains signalling functionality in the event of a failure of the primary power source.

(c) Switching system to allow for change over to the secondary power source and back to the primary power source when it is again reliably available.

(d) Distribution system to allow for the electrical power to be available at multiple signalling equipment locations along the rail network.

(e) Transformation components to other voltages to allow for input or distribution at higher voltages and transformation to the operating voltage of the signalling equipment.

(f) Conditioning for power quality and power factor to ensure that the electrical power meets the interface requirements of the source network and of the signalling equipment.

(g) Protection against surges and lightning which can arise due to the nature of the electrical power and its distribution and the location of the equipment in the harsh railway environment by the use of SPDs.

(h) Protection against overload or faults caused by the signalling equipment being powered by the use of OCPDs and other devices.

(i) Protection against overload caused by an event that leads to damage to the signalling equipment such as a derailment, motor vehicle crash into signalling equipment, storm or other catastrophic action.

2.10.2 Approval conditions

The approval of individual components of the signalling power supply system shall be on the basis of their contribution to the complete system. Approval conditions for the individual components should consider the interaction of the component with the other components and the complete system. These conditions should be documented as part of the equipment and design requirements.

2.11 Signal power supply system life cycle

The system life cycle phases include:

(a) requirements definition;

(b) system design;

(c) construction;

(d) testing and commissioning;

(e) operation;

(f) maintenance;

(g) upgrade or modification;

(h) decommissioning and Disposal.

It is the responsibility of the RIM to manage the signalling power system so that it is safe so far as is reasonably practicable throughout the system life cycle.

The signalling power system can be expected to have changes over the system life cycle. These changes shall be evaluated in the design, operation and maintenance of the system. The RIM should also include provision for review of the above issues as part of the standard procedures for managing the design, maintenance and operation of the signalling power supply systems.

These include evaluation of the following:

(i) Changes to external systems contributing to the power system.

(j) Changes to the rail network.

(k) Changes to the specification of signalling equipment being powered.

(l) Changes to the amount of signalling equipment being powered

(m) Changes to the rail operations that can affect the total load on the system.

(n) Degradation of system components over time and the need to replace the equipment.

(o) Ongoing maintenance requiring secondary or alternate systems be operational while the primary system is being maintained;

(p) How changes to regulatory framework for power systems and the materials used in the power system impact on the need to update the system.

2.12 Safety of personnel working on signalling power systems

Signalling power supply systems operate at electrical voltages and currents that could cause significant injury to staff and damage to equipment. The RIM has obligations that personnel working on the system or operating the system are safe in all situations. The RIM shall implement practices and procedures to ensure the safety of all staff who interact with the signalling power supply system.

This should include documented requirements and procedures for:

(a) meeting the relevant legislative requirements for the respective state or territory to work on electrical systems;

(b) training and competency-based assessments for personnel undertaking the work;

(c) establishing and maintaining records for the training and competency of personnel who are required to work with the signalling power supply systems;

(d) undertaking work on the systems including maintenance and operation of the system;

(e) undertaking changes to the systems including the construction, testing, modification and de-commissioning of the signalling power supply systems;

(f) recording the design of signalling power supply systems and as-built configuration of the systems;

(g) recording the condition and status of the signalling power supply systems.

In considering the electrical hazards, the issue of touch potential between separate equipment and power supplies under normal conditions and fault conditions should be evaluated and mitigated.

2.13 Personnel training and competency

The legislative requirements and AS/NZS 3000 identify different training and competency requirements for personnel working on electrical systems based on the voltage rating of the system. The RIM shall identify in procedures the different requirements for working on:

(a) extra low voltage;

(b) low voltage.

3 Signalling power supply equipment

3.1 Primary power source

3.1.1 General

The suitability and reliability of any power supply shall be evaluated as part of the power supply design requirements.

The primary power source is sometimes referred to as the main supply.

There are a range of primary power sources that may be used for railway signalling.

(a) Supply authority mains supply.

(b) Railway mains supply such as supplies from railway traction substation or other substation.

(c) Motor alternator systems.

(d) Solar supply direct current.

(e) Solar supply with Inverter or convertor.

(f) Wind generators.

The primary supply could have variability or other issues that need to be addressed as part of meeting the signalling system requirements which include:

(g) storage of power;

(h) redundant power supplies;

(i) power quality.

The criticality of the above issues can also be dependent on the type of signalling equipment that is being operated at the location.

3.1.2 Secondary or alternate supplies

A secondary or alternate supply may be designed and installed to meet the signalling power system performance requirements. This is sometimes referred to as the emergency or standby supply.

This secondary supply provides power when the primary source is not available. A means of change over between the supplies shall be provided, which may be automatic or manual. The secondary supply may be any of the same types as used for the primary supply.

The change-over between supplies shall isolate between the primary and alternate supply and not permit inadvertent energisation of one supply by the other.

The primary and alternate supplies should be designed to achieve a level of independence to address common mode of failures to meet the signalling system required performance. This includes evaluation of the source of the supply within other party electrical grids.

3.1.3 Remote area power supplies

In remote areas the available sources of primary power can be limited. The distance to the power source can also be extensive. Innovative solutions that reduce the amount of equipment and installation effort couldbe appropriate for remote area power supplies.

3.2 Power distribution

There can be a need to distribute the power from the source signalling location to other signalling locations. The following shall be evaluated when designing a suitable power supply distribution system:

(a) Some signalling equipment that is microprocessor based can be more sensitive to power fluctuations.

(b) Some equipment such as point motors and boom gate motors can have very high initial and momentary inrush currents followed by high operating currents and then low currents for other sustained operation.

(c) The distance from the location will affect the voltage drop along the cables.

(d) There can be a need to separate out distribution mains for different types of equipment.

(e) Cables for distribution can have limiting factors including voltage drop, temperature rise, surge protection.

Appendix E provides further information regarding power sensitivities to be evaluated.

3.3 Power systems protection

3.3.1 General requirements

The power system can be affected by other external systems or effects. The following shall be evaluated for the impact on the signalling system performance including:

(a) harmonic induction from other systems including railway traction systems;

(b) surges from start-up of the signalling power system;

(c) surges from start-up of external systems on the same grid;

(d) surges from other systems induced into the power mains;

(e) surges from lightning storms;

(f) surges or over currents from equipment failures;

(g) black start of system;

(h) faults which compromise the insulation integrity of the system, introducing the risks of unsafe operation of the signalling equipment or electric shock to persons working on the signalling system.

3.3.2 Discrimination of separate sub-systems

Signalling systems could have many different signalling systems at a location. These should be able to be powered and protected as individual sub-systems to reduce the risk of a single fault removing power from all other sub-systems. The power feeds to separate signal equipment locations from a common signalling power supply location should be separately protected.

3.4 Power system monitoring

The signalling power system shall be monitored remotely to ensure that any faults or failures are brought to the attention of maintenance and/or network control personnel in a timely manner. This should be done by:

(a) monitoring of power at individual locations or groups of locations;

(b) separating power voltages or separate supplies at the same location being separately monitored and indicated;

(c) selected monitored items having both warning indications and alarm indication depending on the immediate impact on signalling functionality;

(d) back-up power supplies also being monitored and indicated to control systems.

The network control or signal control centre power indications should have consistent meaning.

A failure modes analysis may be used to assist in the determination of the scope and functionality of the power system monitoring.

3.5 Signals safety systems

The signalling system functions cover the status at a particular point in time and the associated safe control functions. In some situations the signalling system stores the system status for a number of events or scenarios. In these cases continuous signal power should maintain the intended control functions based on the previous changes in state of the inputs and functions. This includes:

(a) issues like special requirements for approach locking circuits and route holding circuits;

(b) any other functions that require continuity of power supply;

(c) impact of momentary or longer interruption of power supply to signalling functions;

(d) interruptions to train operations resulting from a loss of signal power supply.

The use of voltages greater than 120 volt a.c. (nominal) should be restricted to power supply distribution and shall not be used for switched signal control functions.

3.6 Approval of signals power supply equipment

3.6.1 General

Electrical systems are hazardous and are covered by various legislative requirements. The following issues should be addressed when approving electrical equipment as part of the signal power supply system:

(a) Power equipment and sub-systems meets regulatory requirements.

(b) Equipment meets the RIMs standards and requirements.

(c) Equipment is compatible with other equipment to which it is connected.

(d) Design or performance limitations for the equipment are identified and addressed.

(e) Requirements for installation or construction for the equipment are addressed.

(f) Equipment meets the environmental conditions of installation location.

AS 7702 covers processes that may be applied when undertaking the assessment and approval of equipment for use on railway infrastructure.

3.6.2 Approval conditions

The documentation of the approval of the power equipment should include conditions relating to:

(a) limitations of the equipment including design, installation and maintenance;

(b) purposes for which it can be used;

(c) any special requirements for disposal after de-commissioning.

3.7 Approval of generic power supply equipment

As well as the power equipment that is custom designed and manufactured for railway signalling use, there is also power supply equipment that is generic and can be used for railway signalling power supplies.

The following should be evaluated for this equipment:

(a) That the usage is not different from that in other applications.

(b) That the design or performance of the equipment does not change over time without specific advice from the supplier/manufacturer.

(c) That the equipment is able to be maintained and that spares and technical support is available.

The following are typical voltages for signalling equipment:

(d) 110 volt or 120 volt a.c.for main signalling supply. This is also used for distribution from the main signalling power location to other signalling equipment locations. This is also used for the operation of point motors and signals.

(e) 600 volt a.c. is often used for the distribution of main signalling power supply to other signalling locations.

(f) 415 volt a.c. is sometimes used for distribution mains to reduce volts drop between signalling equipment locations

(g) 50 volt d.c. is used for signalling logic and interlockings and associated equipment. It is also the common voltage for operating signalling logic relays for various functions.

(h) 24 volt d.c. is used for signalling electronic equipment including computer based interlockings. This is also used for non-vital signalling equipment including telemetry systems and control panels.

(i) 12 volt d.c. – 15 volt d.c. is commonly used for level crossing equipment. This is also often used in legacy signalling interlocking equipment.

3.8 Power supply for test equipment and location lighting

The signalling power supply system is designed for signalling equipment which is predominantly at voltages less than the standard domestic supply. There is a need to provide power for test equipment that operates at the standard domestic supply voltage. This supply should be in the signalling apparatus locations. This test equipment may be designed for standard MEN earthing arrangements. Notwithstanding that this equipment may conform to the double insulation requirements, the GPO circuit shall comply with AS/NZS 3000.

The RIM shall determine which signalling locations require the provision of a standard socket -outlet for test instruments and related equipment. Signal location case and signal equipment room lighting should be with 240 volt a.c. luminaires with double insulation.

Power and lightning circuits of 240 volt a.c. shall be wired as MEN circuits in compliance with AS/NZS 3000. It is preferable that these power and lighting supplies are derived directly from the 240 volt a.c. services supply, downstream from the UPS and ECO equipment.

4 Design

4.1 Signalling system power loads

A RIM should establish and document typical power loads for signalling equipment

The process for determining the nominal power load for an item of signalling equipment includes:

(a) a review of data sheet for the equipment;

(b) determining the standing or quiescent load;

(c) determining the dynamic load. Examine this for transient operation;

(d) assessing the impact of multiple items of load simultaneously;

(e) actual testing of the load at a location under various operating scenarios;

(f) validation of the load ratings by other means;

(g) determining the equipment tolerance for interruptions of power supply when there is a change over from one source supply to another source supply;

(h) calculating the power factor.

This information should be documented as a guideline for all signal design engineers to use in a consistent manner.

Further information on calculation of power loads can be found at Appendix C.

4.2 Signalling equipment performance requirements

4.2.1 General

A RIM should determine the power limitations of the signalling equipment individually including:

(a) minimum voltage requirements;

(b) maximum voltage requirements;

(c) inrush current;

(d) hold up time following input power loss;

(e) harmonic distortion tolerance;

(f) susceptibility to transients.

4.2.2 Power quality requirements

The RIM shall determine whether power conditioning is necessary to meet the power quality requirements of the signalling equipment. The RIM shall determine the power factor requirements for the complete signalling power system. The RIM shall ensure that the design requirements for power factor are compatible with and consistent with the power factor requirements of the primary power source and any external power sources.

The power supply shall meet the voltage, current, power quality, power factor, frequency, phase requirements determined necessary to supply the signalling equipment.

The signal power system designer shall demonstrate how these requirements have been achieved. This should include calculations, reference to equipment and reference to external power system supply interfaces.

4.2.3 Solar power design requirements

The design of solar power systems and other intermittent systems including wind generators shall evaluate the nature of the intermittent supply and the load performance requirements. For solar systems, the available daylight hours shall be evaluated together with Bureau of Meteorology data on cloud cover in calculating the solar power generated. This evaluation should be for the specific location and not a generalised value. The evaluation should also evaluate the maximum number of contiguous cloudy days. The battery storage requirements shall be calculated to ensure that power will be available for the total period required. The availability and reliability shall also be calculated. Where battery systems are used to provide availability during the intermittent supply, then the degradation of capacity of the batteries over their service life shall also be included in the evaluation and design.

4.2.4 Power system interruption

The design of the signalling power system secondary or alternate supply should also evaluate the requirement at changeover between the supplies. The emergency change over contactor shall be a break before make operation. In other operational scenarios the length of time for the break could impact on the operation of the signalling equipment.

4.2.5 Power system serviceability

The equipment elements of the signalling power supply will require servicing while maintaining the availability of power to the signalling equipment. The design shall include isolation and bypass switches to allow for an item of equipment to be offline for servicing. The design of UPS systems should include an external bypass switch to allow the equipment and batteries to be serviced or replaced.

The isolation should operate in both legs of the supply simultaneously where this is required to fully isolate the supply for signalling safety or personal safety requirements.

4.3 Primary power source

A RIM should evaluate when designing a primary power source for a signalling system a range of issues including:

(a) availability of supply;

(b) reliability of supply;

(c) diversity of supply;

(d) control of the supply for managing other works and interruptions;

(e) any contractual arrangements with external organisations for the supply;

(f) future needs for railway supply;

(g) consolidation of railway supply needs;

(h) impact of other major electrical users on the supply reliability.

A decision on the requirements and the selection of a supply to meet these requirements should be documented in the signalling functional specification for a new project or major alteration to signalling. This should include the electricity supply authority connection box and meter.

4.4 Power conditioning

A RIM should document the power conditioning requirements in the signal functional specification. The proposed design solution requirements should also be documented.

4.5 Power transformation

The electrical power will normally be provided at a lower or higher voltage than that required for the signalling equipment. Various items of equipment can operate at different voltages. In this case the electrical power shall be transformed into each of the required voltages.

The required input and output voltages at each of the power supply locations should be defined and documented as part of the signal power system design.

Transformation to a higher voltage may also be used as part of the distribution network to reduce the losses due to voltage drop.

4.6 Power distribution

The signalling equipment load for each voltage type at each location is detailed as part of the design activity. From this information the electrical power distribution architecture can be designed.

After the architecture design has been finalized the power mains cables can be designed. These should evaluate the impact on volts drop on each item of equipment. The subsequent design could require the separation of items such as computer-based signalling equipment that are sensitive to voltage fluctuations from point motor mains that could have a short transient voltage drop for motor inrush currents. Appendix E provides further information regarding sensitive equipment.

The required equipment current loads at each of the power supply locations should be defined and documented as part of the signal power system design. This should cover standing load and transient load when equipment is operating.

The voltage drop across the distribution system shall be within limits to meet the performance of the end equipment. For equipment operating mode changing from static to dynamic could induce a voltage change in the supply voltage to the load which can impact other connected equipment. This voltage change should be assessed. This may be referred to as the voltage regulation of the circuit.

The power load of the system shall meet the power factor requirements of the primary and secondary supply.

The RIM shall determine and document the voltage drop performance requirements for the power distribution cables. This shall include details on the cable types and materials, the temperature rise in different installation configurations and the cross-section area of the cables.

The RIM shall determine and document the range of cable insulation types and performance ratings that may be used in the design of the signalling power system.

4.7 Design Issues

The signalling power systems design should be evaluated as a total system and how it meets the signalling system performance requirements. Graceful degradation techniques should be evaluated and applied to the overall design of the signalling power system. These should ensure that critical functions are operational even if other functions are not operational.

For example, the indication of the condition of signal equipment to a remote control centre is important even if there is not sufficient power to operate the equipment.

A failure modes effects and criticality analysis (FMECA) may be undertaken to evaluate the design. The FMECA may also be used to support the graceful degradation features of the signalling power system design.

The use of voltages greater than a nominal 120 volts a.c. should be restricted to power supply distribution and shall not be used for switched signal controls. All wiring that is not part of the signalling IT power scheme should be segregated from the IT wiring. Labelling should be used to identify wiring at greater than a nominal 120 volts.

The signal power system design should include graceful degradation of performance to ensure the safety of operation of the signalling system and train operations. This may include providing preference of the availability of supply to some functions only. Alarms and warning indicators should be in the higher priority functions.

4.8 Power protection

4.8.1 Power protection requirements

The signalling power supply shall be provided with three forms of protection:

(a) Protection against insulation faults.

(b) Protection against overload currents.

(c) Protection against damaging voltage surges and spikes.

4.8.2 Protection against insulation faults

In a signalling system, removal of power supply will result in the partial or complete loss of signalling protection. The resulting need to resort to manual systems of train control will introduce a degree of risk to trains and passengers which far exceeds any individual risk which could result from an insulation fault on the signalling power system.

For this reason, insulation/earth fault protection of the signalling power supply shall not include automatic disconnection of the affected power supply.

Insulation fault protection shall be provided by:

(a) continuous earth fault detection;

(b) indication and alarms to a network control centre;

(c) work procedures requiring response to earth fault alarms; and

(d) safe methods of working on power systems with earth faults.

Requirements for earth leakage detection are detailed in Clause 4.8.4

4.8.3 Protection against overcurrent

Signalling power supplies shall be protected against the effects of excessive currents being drawn.

In typical TN-C-S mains supplies, circuit conductors are designed to operate near their thermal current limits, and overcurrent protection is designed to protect against the effects of overheating due to sustained currents in excess of the conductor ratings. Individual circuit lengths are short, normally not exceeding tens of metres overall.

Signalling power systems, in contrast to this, typically involve circuits hundreds of metres in route length, resulting in conductor sizes determined principally by complying with voltage drop limits; the individual circuit currents are significantly less than the thermal current limits of the circuit conductors used.

For the reasons stated above, overcurrent protection for any signalling power supply shall be rated to protect the supply source against overcurrent.

Overcurrent protection devices shall be circuit breakers compliant with AS/NZS 4898. To maintain constant tripping currents, circuit breakers should not include a thermal tripping element, which can cause the tripping level to vary with ambient temperature. Where an OCPD that has a thermal tripping element, then it shall be specified considering the ambient temperature impact i.e. is by derating.

The normal circuit breaker response time shall be AS/NZS 60898 Curve 'C'.

Where a supply is subject to high short-term currents caused by motor starting currents or transformers with high inrush currents, the circuit breaker design shall ensure that the circuit is protected from an overload but not trip due to a short spike of current at time of inrush by use of curve 'D' circuit breakers.

Individual circuits supplied from a common supply may be protected by fuses. Fuses on individual circuits shall be rated to provide reliable operation of the end circuit, while ensuring that a fault on an individual circuit will be disconnected rather than the complete supply.

An OCPD for UPS batteries may operate on bi-directional current. This OCPD shall not be polarised.

4.8.4 Protection against damaging voltages, surges and spikes

In signalling systems, traditional electrically robust electromechanical equipment has become increasingly replaced by electronic equipment which is far more sensitive and prone to damage from excessive voltages.

Surge and lightning protection should be included as part of the signalling power system distribution design.

Lightning and surge protection shall be in accordance with the requirements of AS 7708.

In a.c. traction territory, this requires the use of sectionalising power cut section transformers to limit mutual coupling from the 25 KV inducing unsafe voltages greater than 50 volts a.c. onto the signalling distribution feeders.

High voltage distribution feeders should also be limited to the distance that they run parallel to the railway corridor and signalling distributions feeders. The mutual coupling resulting shall not induce unsafe voltages greater than 50 volts a.c. onto the signalling distributions feeders or a signalling circuit.

4.8.5 Earth Leakage Detector

Earth leakage detectors (ELD) should be specified on all floating a.c. and d.c. signalling supplies, including extended voltage mains.

ELDs, where specified, shall indicate the occurrence an earth fault on either leg of the supply bus.

The detection arrangement shall be such that any earthing caused by the detector cannot under any circumstances cause interference to the signalling circuits.

ELD sensitivity shall be set to detect a fault condition at a level less than that which would result in both an electrical and functional safety hazard this being defined as:

(a) earth leakage currents of such a magnitude that could hold a vital signalling relay in the energised position.

(b) earth leakage currents that could result in physiological harm i.e. >30mA.

The ELD response time for alarms shall be more than 2 seconds and less than 10 seconds.

The ELD response time for alarms should be less than 5 seconds, to detect faults during point operation.

The ELD shall be capable of operating with a system leakage capacitance of 1uF or higher. The ELD maximum measuring current shall be less than 3 mA.

Resistance response value shall be set in accordance the ELD sensitivity given in Table 1.

Table 1. Earth Leakage Detector Sensitivity Settings

Leakage Detector Sensitivity Settings					
Busbar volts (nominal)	12 d.c.	24V d.c.	50 d.c.	120 a.c.	415 a.c.
ELD sensitivity	15 kΩ	15 kΩ	40 kΩ	40 kΩ	100 kΩ
Equivalent earth Leakage current	1 mA	1.5 mA	1.3 mA	3 mA	4.2 mA

Resistance response values for busbar voltages other than those listed in Table 1 shall be set to have an equivalent earth leakage current not to cause electrical and functional safety hazard as per 4.8.5 (a) and (b).

The ELD should be an insulation monitoring device in accordance with IEC 61557-8 selected for the type of IT power supply system being monitored a.c., d.c. or a.c./d.c.

A visual indication only for the local warning is acceptable with the audible indication not required as part of the device. A visual and/or audible alarm shall be provided in accordance with the RIM design principles and/or standards.

Indication of an earth fault is an accepted method of indicating that the ELD is unable to perform its function.

The ELD should not indicate an earth fault at “power on”.

Maintenance practices should include the checking of the ELD status upon first entry to a signalling location to ensure that the signal maintainer is aware of any existing faults on the signalling system.

4.9 Design documentation

The RIM shall ensure that the designer of the signalling power supply systems produces design drawings and documentation of the systems including the details below. The following designs should be checked and verified to the same level as other elements of the signalling design:

(a) Schematic circuits of the power distribution for the installation.

(b) Schematic circuits of the earthing conductors for the installation.

(c) Plans of the earth stakes and mat and identification of the location of the earth system against a permanent visible structure.

(d) Protection schedule for all electrical protective devices.

(e) Evidence of protection discrimination applied to the distribution system.

(f) Specified earth resistance.

(g) Plans, elevations and cross sections describing the location of all components of the signalling power supply systems.

(h) Voltage drop calculations.

(i) Cable run and size schedule.

(j) Any further details of the design and installed signalling power supply systems as required by the RIM standards and procedures.

The signal power system designer shall provide a design report that details all of the design requirements and demonstrates how the requirements have been achieved.

At the completion of the construction, testing and commissioning, the drawings and documentation should be updated to as-built status.

4.10 Design checking and competency

The RIM shall determine the requirements for the competency of people who undertake the design of the signalling power system. This standard should not be considered as a prescribed standard for the purposes of determining the required qualifications of a person undertaking the design and the requirements of state legislation for registration of engineers for professional engineering work.

The design of the signals power system does impact on the safety of its operation and shall be checked and or verified in accordance with requirements determined by the RIM.

5 Constructability requirements

5.1 Safe separation of equipment and touch potentials

The signals power supply includes different busbars at different voltages. The signalling power is not connected to earth because of its use for signalling safety logic functions.

A surge protection earth should be provided. An SPD is used in conjunction with the surge protection earth to protect the signalling circuit.

The various signals power supplies shall only have one earth.

Typically, there is also an external power from a supply authority which is connected under the MEN configuration. This MEN earth shall be kept separated from the signalling surge protection earth.

The signals power supply equipment shall also be physically separated and isolated from the external MEN based power supply. This separation shall ensure that a person cannot inadvertently touch both sets of power supply when arms are outstretched. Where space is limited an insulated protective cover over the external power supply should be used to provide the physical separation.

Where space is limited or the distance between the separate earths can be compromised by an earth potential rise due to a surge then additional requirements including surge protection should be provided. Refer to AS 7708 for guidance.

Any SPD connected to a signalling power circuit for safety applications shall not have any mechanism to cause an un-revealed fault to earth.

5.1.1 Protection against electric shock, burns or fire

The signals power system shall be designed so that it can be constructed, operated and maintained while protecting against the risk of electric shock, burns to staff or fire.

The following are suitable means to achieve this requirement:

(a) Physical separation of equipment so that a person cannot reach and touch between the dangerous items.

(b) Insulation coverings for the equipment (these may be transparent to allow for viewing of indicators).

(c) Provision of test points that are protected from electric shock.

(d) Physical locking of the equipment in cases with restricted access and protocols for gaining access.

(e) Restricted access to the rooms or cupboards that contain the equipment.

(f) Detection equipment for fire and alarms.

The RIM shall determine which of the above shall be used and in what circumstances.

5.2 Earthing and Bonding

To provide an electrically safe installation and effective lightning and surge protection, all metal work within an installation shall be equipotentially bonded to the signalling earth.

Earthing and bonding shall be installed in accordance with AS 7708.

5.3 Layout construction for earthing, protection, heat and clean/dirty wiring

Power supply equipment will typically generate heat which is conducted upwards. This equipment should not be placed underneath other equipment such as computer based signalling items or electronic items that are susceptible to performance issues when there are elevated temperatures.

The signalling power supply connects to multiple signalling circuits. It is susceptible to impact from surges and lightning strikes. The wiring to and from the power supply should be mounted to be consistent with the principles of separation of clean and dirty wiring (see clause 5.5) in locations cases and relay rooms.

The power supply equipment requires a connection to the signalling earth. This should be a low resistance and a low impedance path to the signalling earth. The earth connections should not have sharp bends which inherently have a high impedance. A minimum radius of 50mm on all bends on the earth wire should be applied.

5.4 Segregation of earthing systems

The signalling power system earthing shall be segregated from other earthing systems infrastructure installed in the rail corridor. The rail corridor could have different earthing arrangements for signalling, signalling ELD test, telecommunications, electrical LV, electrical HV and electric traction and other services installed in the rail corridor or crossing the rail corridor.

The different earthing arrangements shall be either co-ordinated or effectively independent. The arrangements for this are detailed in AS 7708.

Separation of the local supply authority's earth from railway traction and earthing shall be achieved by using an isolation transformer at the railway interface.

The separation shall be ensured by providing:

(a) a minimum 5 metre separation between the local supply authority point of supply and the signalling installation;

(b) a dedicated isolating transformer within the signalling installation. This shall be situated between the point of supply and the safety earth of the installation.

5.5 Clean and dirty wiring

Dirty wiring is cabling that enters a signal equipment location or case from external is susceptible to noise and induction from external power supplies including. This cabling is protected at the point of entry by surge protection and suppression devices. Signalling power system cables entering (or departing) the location/case are similarly protected.

The cable and wires on the internal side of the protective devices is clean of these induction and surge effects. These are termed clean wires. There is the possibility that the cable or wires between the point of entry and the protective device can cause induction of surge effects onto other internal cables and wires. These are also termed dirty wires.

To prevent the transfer of electrical noise from dirty to clean wiring, there should be physical separation between the clean and dirty wires in the ducting within the signal equipment location or case. The clean and dirty wiring should not be in the same ducting. This physical separation prevents the induction of surge effects between the dirty wiring and the clean wiring.

5.6 Ergonomic issues for equipment position

Power supply equipment can be bulky and heavy. In addition to the issues in clause 5.3 evaluation should be given to where the equipment is mounted on the floor or on equipment racks. Two person lifts could be required for heavy and bulky equipment.

The positioning of the equipment should also allow for ongoing maintenance and fault finding without stressing single person maintenance teams.

5.7 Cable Route

The requirements of AS 7664 should be evaluated in determining the design and constructability of the power distribution.

6 Test and commissioning

6.1 Inspection of new power systems

Following the installation of new power systems, they should be inspected for the following issues:

(a) Installed in accordance with the design requirements.

(b) Installed in accordance with the relevant standards, procedures and good practice.

(c) Installed in a manner that will not adversely impact on other signalling equipment.

(d) That all equipment is identified as to its design identification and all power terminals are clearly labelled as to voltage and identity.

(e) That danger labels are applied as appropriate.

6.2 Testing of new power systems or modifications

All signalling equipment including signalling power supplies shall be inspected and/or tested in accordance with the standards and procedures of the RIM. This includes and is not limited to:

(a) all wiring is as per the design;

(b) all wiring is free from earth where required;

(c) no additional wires have been added that are not on the design;

(d) all voltages are tested to be within the required voltage range;

(e) for unique design configurations confirm OCPDs will operate when required and correctly discriminate circuits under failure conditions;

(f) earthing is installed as per the design and the earth resistance is within the required range;

(g) all surge protection devices are of the correct type and are installed correctly.

6.3 Test records

The results of all tests and inspections shall be recorded as part of the new works testing and commissioning records. These records shall be kept after the commissioning in accordance with the SMS of the RIM.

6.4 Commissioning of signalling power systems

Prior to commissioning into service of the signalling power supply system should:

(a) have all inspections and tests completed;

(b) have output side equipment isolated;

(c) be checked to ensure the input voltages are set and are within the design range

(d) be powered up and final check of output voltages;

(e) then have the output busbars connected to the live output.

6.5 Equipment not in service

All signalling power supply equipment that is installed and not in service should be tagged with a label that it is not in service. The input fuses for the equipment should be removed and any circuit breakers switched off and tagged.

6.6 As-built drawings and documentation

At the completion of the construction and commissioning activities, the design drawings and documentation detailed in section 4.9 shall be updated to as-built status. Copies of the drawings and documentation with marked up changes should be available for maintenance staff immediately after the system is brought into service. The completed as-built drawings and documentation should be issued to maintenance staff as soon as practicable.

7 Operation

7.1 Operational reliability of signals power systems

The safety of train operations is higher under engineered systems. In the event of power failure there is a fall back to manual systems that are inherently less safe.

The operational reliability of the signal power system contributes significantly to the operational reliability and safety of the signalling system. The primary electrical power system by itself will not meet the operational reliability requirements. The design should include provision for secondary or back-up power supply systems. The amount and independence of the back-up systems shall be evaluated to be proportional to the operational criticality of the signalling system.

7.2 Changes to train operations and power supply impacts

A RIM shall evaluate the impact of changes to train operations when designing or redesigning signalling power supplies. These changes include, but are not limited to:

(a) significant increase or decrease in number of trains travelling through the location;

(b) significant increase or decrease in train speeds travelling through the location.

To assist future assessments a RIM should detail the train operations that the signalling power system was designed to accommodate. Where there is a significant change in railway operations the changes should be compared to the original design specifications and the signalling power system assessed for suitability.

In some specific cases a change in the length of the trains will impact on the signalling power supply capability. The length of a train travelling over a level crossing will directly impact on the load of the level crossing power supply.

7.3 Monitoring of signals power systems

The operation of the signalling system requires the availability of the power system. Where there are secondary or back-up systems there should be remote monitoring of the backup system. Monitoring of power systems operating at normal state assists signal maintenance staff when there is a signal failure to do an initial diagnosis of the cause of the fault.

This monitoring may also provide a remote indication of good power availability or power failure prior to an impact on rail operations. Main incoming SPDs should be monitored. Consistency of items being monitored and displayed to remote operators can also reduce ambiguity of interpretation of warnings and alarms.

The items being monitored should be documented in standard design practices or guidelines by the RIM. This should include a suitable response action to the different failure scenarios and modes.

8 Maintenance

8.1 Safe maintenance of power supply systems and equipment

Electrical power supplies are inherently dangerous. The procedures for maintenance of the equipment should evaluate both the electrical hazard, working in a live railway corridor and the safety of the signalling system.

Where it is possible to isolate the signal power supply without disrupting the operation of the signalling system, then this should be undertaken before undertaking the maintenance activity. Where it is not possible to isolate the power supply system, then appropriate safety measures shall be applied to control the risk of electric shock.

8.2 Signal personnel safety

The personnel working on the signal power supply system shall have the training and competency to ensure their safety when undertaking work. See section 2.8.

Physical restriction to access to equipment with dangerous voltages is a suitable control. It may be implemented together with restricted access to signalling safety equipment.

8.3 Power supply maintenance records

The signalling power system can vary in performance over time. The RIM should maintain a record of the voltages and currents of the powers supply equipment to allow any trends to be identified and appropriate action taken. The following should be recorded:

(a) Voltages for each individual power supply unit or busbar.

(b) Loads for each individual power supply unit or busbar.

(c) Earth leakage values.

(d) All maintenance service items.

It is advantageous to have history cards to record the voltages and current for each item of power supply equipment. The incoming supply voltages should be recorded at the time of installation / commissioning. These may be referenced and checked as required during the system life cycle and at maintenance activities.

8.4 Preventative maintenance

The signalling power system should be maintained under a process of routine and periodic services. The items to be examined and the regularity of the examinations should be documented as part of the signalling maintenance procedures. These should address the following issues:

(a) Recording of voltages and loads at each service action.

(b) Inspection of batteries that they are in good condition.

(c) Inspection of all equipment for signs of stress or overheating.

(d) Inspection of all fuses, circuit breakers.

(e) Inspection of surge protection equipment and related earth rods.

(f) Inspection of secondary or back up power supply equipment and test of its availability.

(g) Running of motor generators with a load to ensure correct operation.

(h) Testing of earth leakage devices.

(i) Periodic testing / sampling of power supply insulation resistance.

The above items may be covered by different service schedules with different periods.

All maintenance service items should be recorded.

It is advantageous to have history cards to record the voltages and current for each item of power supply equipment.

8.5 Corrective maintenance

When electrical power equipment for the signalling system fails, corrective maintenance shall be required. Following the completion of the corrective task, the power supply and the signalling system should be tested for correct operation and recorded on the power supply history card or other record.

When an earth fault monitor / earth leakage detector indicates the existence of an insulation fault, investigation, identification and correction of the fault shall be addressed as soon as practicable; until such time as the fault has been rectified, the power supply shall be treated as lacking the inherent risk mitigation afforded by an IT protection system.

8.6 Isolation for maintenance activities

The signalling power supply system is typically distributed over multiple physical locations. When maintenance activities are being undertaken, where practicable, the equipment should be isolated. Where isolation is applied, then a process of identifying the person who has implemented the isolation should be implemented. This should include a process that limits who and under what conditions that the power can be restored. These processes should be documented by the RIM and applied consistently.

9 Modifications and alterations

9.1 Changes to signals systems

A change to the signalling system can have an impact on the overall signalling power supply for the location or the interlocking. Before any proposed change to a signalling system is implemented the characteristics and capacity of the signalling power supply system supplying the signalling system shall be reviewed and assessed as meeting the requirements of the signalling system.

9.2 Changes to signalling equipment

In the system life cycle of a signalling installation there will be occasions when individual items of equipment are replaced with a similar or like item. These changes could cause:

(a) increase in power consumption (e.g. motors with different windings);

(b) reduction in power consumption (e.g. LED units);

(c) less tolerance to voltage fluctuations than previous equipment;

(d) less tolerance to unfiltered d.c. supply.

Where there is provision of alternate equipment the design should ensure that it is suitable for the specific circuit. Tests for correct operations should be recorded as part of maintenance records.

9.3 Changes to signalling primary power supply

The following items should be reviewed on each occasion of a change to the signalling primary power supply:

(a) Recalculation of the standing load and the transient load of the signalling system.

(b) Recalculation of voltage drop on distribution cables.

(c) Review of the surge protection of the power system.

(d) Review of the design and selection of the fuses and circuit breakers.

Following this review the RIM should determine whether changes to the design of the signalling power supply are required. An assessment shall be made of the impact of the proposed change on the installed signalling system and the requirements for design and modifications to maintain or enhance the functionality, reliability and resilience of the system.

9.4 Changes to power supply equipment components

Power supply equipment can have many individual components. The ratings printed on the component do not always cover all of the technical specifications. For example:

(a) electrolytic capacitors are rated for voltage and capacity which is marked on the case. They are also rated for the inrush current which is usually not marked on the case. Insufficient inrush current performance could lead to the item failing and even catching fire;

(b) surge protection devices are rated for voltages and currents and should be of the correct value for the equipment being protected.

Changes to a component should only be undertaken after evaluation by a suitably qualified person and the evaluation recorded and checked.

10 Decommission and/or disposal

10.1 General

The RIM shall evaluate the disposal of life expired and surplus to requirement power supply system assets in accordance with its asset management scheme.

10.2 Disposal of environmentally sensitive materials in power equipment

Power supply equipment can contain a number of environmentally sensitive chemicals. These shall be disposed of in accordance with legislation and RIM standards and procedures. These include:

(a) battery chemicals;

(b) transformer chemicals;

(c) rare earth or radioactive materials;

(d) hazardous materials such as insulation materials and the thermal conducting paste on heatsinks.

The decommissioning of such materials shall include work instructions for the disposal of the environmentally sensitive materials.

10.3 Partial de-commissioning of signals power equipment

The signalling power equipment can operate multiple individual circuits. It is possible to de-commission all of the circuits without de-commissioning the power source. This leaves a number of hazards:

(a) There is an active power supply that is connected to busbars and could potentially cause a false energisation of a circuit.

(b) The power supply is not monitored or maintained and creates a hazard in its continued operation.

(c) There is a fault to earth or other system which could adversely impact on signalling functions.

The decommissioning of signalling circuits should evaluate the source of the power to the busbars as well as the downstream circuits. If all downstream circuits are decommissioned then the power source should also be decommissioned unless required for future stagework. Power supplies not in use should be evaluated for isolation.

Where changes to the signalling equipment or the signalling power supply systems is required, all circuits formerly supplying the removed equipment shall be removed from the point of supply. For clarity, the cables from the point of supply to the various signalling equipment shall be completely removed and discarded. The supply points shall be suitably labelled to indicate that the circuit is no longer in place.

Where all circuits supplied by a power supply are removed, the power supply and all associated cables shall be removed from the location.

Appendix A Hazard register

(Informative)

Hazard	Applicable clause
Power supply is unsafe	2.1, 2.11,
Injury to person from signal power supply	2.1, 2.11, 2.12,
Loss of power supply to signalling	2.3, 2.4,
Loss of power supply – lack of redundancy	3.1.2,
Loss of power supply – failure of redundancy	3.1.2, 3.4,
Overload on power supply	4.8,
Low voltage on equipment (during operation)	3.2, 4.6,
Surge on power supply	3.3,
High load at turn on of power supply	4.2,
Power supply not able to be maintained	4.9
Signal system safety issue from power supply fault	2.5, 2.7, 3.5, 4.7, 7.1,
Earth potential rise	2.5, 5.2, 5.3,
Touch potential between equipment hazardous to person	2.5, 5.1,
Earth leakage fault	4.8.5
Unidentified electrical fault in signalling power system	5.4, 7.1,
Equipment damaged by electrical surge	2.8,
Equipment operating beyond its rating	3.6,
Signal Power supply meets Regulatory requirements	2.2, 2.7,
Approval of power supply equipment	3.6, 3.7,
Untrained person makes contact to electrical hazard	2.12, 8.2,
Power supply design by person not competent	2.11, 4.7, 4.9, 4.10, 8.2
Work on Power supply equipment by person not competent	2.1, 2.11, 2.12, 8.1,

Appendix B Environmental condition ranges for signaling and power supply equipment

(Informative)

In Australasia there is a wide variety of environmental conditions where signalling equipment could be installed. This covers:

(a) elevated locations;

(b) dry locations;

(c) locations with high rainfall and consistently high humidity;

(d) locations with high temperatures;

(e) locations with high radiant energy.

The RIM should determine and document the environmental conditions under which the signalling power equipment is required to operate. The equipment location can also have an internal temperature higher than the ambient temperature due to heat generated within the location or solar energy absorbed by the location. These requirements should be used in defining the performance requirements for the signalling power equipment.

The power supply equipment will generate heat and the placement should ensure that the heat does not impact other signalling equipment on the same rack or in the same location. It is recommended that signal power equipment generating heat be placed at the top of a rack unless there are other issues to be evaluated.

Specific locations and the associated equipment could also be subject to the occasional ingress of ground water. The equipment should be rated to operate in these conditions.

Appendix C Signaling power calculation tools and results

(Normative)

Some RIMs have available a signalling power supply calculator. These included the power load consumed by a wide variety of signalling equipment items. They can also include the dynamic load of devices including point motors and all credible operating scenarios. The calculators will assist in determining the power load for a signal equipment location based on the installed equipment. They also include a volts drop calculator for the cables running to the location from the power source.

The use of these calculators will provide consistent outcomes for signalling design of power equipment and the distribution network. Typically, the power loads only vary by a small amount for the number of trains.

In the case of a level crossing, the number and type of trains can have a significant impact on the level crossing operating power requirements. This is particularly so because of the general need to have a battery back up to the power supply for 24 to 48 hours and to up to 7 days for remote locations.

The load on the level crossing power supply with no trains can be low. The presence of a train causes the track circuits to draw current, and the operation of the lights and boom gates if installed. A 1800 metre freight train will cause more power consumption than a 200 metre self-propelled passenger train. The speed of the train will also impact on the total power consumption.

A level crossing power calculation should evaluate the number and type of rail traffic for the particular location and not be a standard allowance. Evaluation of future changes in rail traffic levels should also be taken into account. The power supply calculations should be part of the design that is checked and verified.

The input and output results of all power calculations should be fully documented and form part of the design documents handed over with the as-built drawings and data. This should also include detailing any special evaluations for the signalling location.

Appendix D Signaling equipment testing and data sheets

(Normative)

D.1 Signals equipment testing

Items of signalling equipment undergo assessment and testing to allow for project approvals and rail equipment type approvals. This testing should verify the electrical power load under various static, dynamic and operational scenarios. This verified information should form part of the approval documentation and used as the source of power load requirements.

D.2 Data Sheets

Supplier data sheets shall include information on the electrical power load under static and dynamic operational scenarios.

D.3 Test equipment

Test equipment for signalling power supply systems shall be calibrated in accordance with the test equipment manufacturers documented requirements.

Appendix E Signaling equipment sensitivity to power fluctuations

(Normative)

Many signalling electrical equipment items are sensitive to the voltage level for correct operation. Review of data sheets and testing should confirm the minimum voltage at which the equipment will perform appropriately. This information should be recorded as part of the equipment approval documents.

The following parameters should be evaluated and performance requirements documented for equipment and sources of power supply:

(a) Voltage ranges that the equipment will satisfactorily operate within. Show the nominal voltage and maximum and minimum voltages.

(b) Dynamic range with varying load of the equipment when operating. This should include inrush currents that occur within the initial 250 m/sec of commencing operation.

(c) Equipment sensitivity to power supply fluctuations. This should include the maximum length of time of power interruptions that the equipment will satisfactorily continue to operate.

(d) Brown outs. This should include the impact of a brown out on the continued operation of a device. (For example some contactors could overheat in a brown out).

(e) Frequency and phase range for the equipment.

(f) Motor Alternator set frequency drift for output supply.

(g) Power factor requirement and power factor sensitivity of the supply as detailed by the supply authority or manufacturer for independent equipment supplying power.

Appendix F Suitable controls for electrical hazards

(Informative)

Suitable controls for electrical hazards cover the following range of issues:

(a) Training and qualifications and licences for the people who are permitted to work on the signals power systems.

(b) Procedures under the SMS covering the safe work on the signals power systems.

(c) Procedures under the SMS to ensure that the signals power systems are maintained in good order to prevent electrical hazards.

(d) Procedures under the SMS to ensure that the signals power systems are tested as safe before they are commissioned into operational service.

(e) Engineering standards covering the equipment approval processes before the equipment is incorporated into the signals power systems.

(f) Engineering standards covering the performance requirements of the signals power systems.

(g) Engineering standards covering the design of the signals power systems to meet safety and performance requirements.

Appendix G Legislative documents

(Informative)

There are legislated requirements covering safety and electrical systems that need to be addressed by the Rail Infrastructure Manager. The requirements vary across Australia due to state based legislation..

The legislations cover the following subjects:

(a) Rail Safety legislation for all operations to be safe so far as is reasonably practicable

(b) Rail Safety legislation for people to be competent for the work that they are undertaking

(c) Rail Safety legislation for all equipment to be approved as safe for its function

(d) Work Health & Safety legislation for all systems and activities to be safe so far as is reasonably practicable

(e) Work Health & Safety legislation for safety in design responsibilities

(f) Electrical Safety legislation for the installation and operation of electrical infrastructure

(g) Electrical Safety legislation for equipment to be compliant to standards

(h) Electrical Safety legislation for the competence and licensing of people working on electrical systems

(i) Registered Engineer legislation for the competence and licensing of persons undertaking engineering work.

Appendix H Bibliography

(Informative)

The following referenced documents are used by this Standard for information only:

(a) AS 2676.2 Guide to the Installation, Maintenance, Testing and Replacement of Secondary Batteries in Buildings – Sealed Cells

(b) AS 3011.2 Electrical Installations – Secondary batteries installed in buildings – sealed cells

(c) AS 3015 Electrical installations – extra low voltage

(d) AS 3017 Electrical Installations – Verification Guidelines

(e) AS 61558 Safety of Power Transformers, Power Supplies, Reactors and combinations thereof

About Rail Industry Safety and Standards Board

The Rail Industry Safety and Standards Board is a not for profit company limited by guarantee. Wholly owned by its funding members, RISSB is required to apply the whole of its income and assets to achieving the objects listed in its constitution.

RISSB is responsible for the development and management of Standards, Rules, Codes of Practice and Guidelines for the Australian rail industry.

For further information, visit www.rissb.com.au

RISSB Australian Standards Development Process

The Standards development process is rigorous and transparent.

Authors work with RISSB's Standards Development Managers and Development Groups to ensure that products are acceptable to industry. Standing Committees oversee this work and ensure that proper governance and process is followed. The products are exposed to the public and industry for comment and validated by an independent validator.

Once agreed by the Development Groups, Standing Committees and Validator, the drafts are passed to the RISSB Board for approval.

The same process is used in developing other RISSB products, although Guidelines are not exposed to the public for comment or validated, given their non-binding nature.

Standards Development and Accreditation Committee

RISSB is accredited by the Standards Development and Accreditation Committee (SDAC), and all Standards produced by RISSB since 31 July 2007 are published as Australian Standards.

The Standards Development and Accreditation Committee audits RISSB annually to ensure that RISSB's processes are in accordance with SDAC accreditation requirements.

Sales and distribution

Australian Standards developed by RISSB are sold and marketed through SAI Global. For further information, please visit www.saiglobal.com.

Financial members of RISSB are granted access with membership.

ABN 58 105 001 465

For information regarding the development of Australian Standards developed by RISSB contact:

Rail Industry Safety and Standards Board

Brisbane Office
Level 4, 15 Astor Terrace
Brisbane, QLD, 4000

Melbourne Office
Level 4, 580 Collins Street,
Melbourne, Vic 3000

PO Box 518
Spring Hill, QLD, 4004

T +61 7 3274 000
E Info@rissb.com.au

For information regarding the sale and distribution of Australian Standards developed by RISSB contact:

SAI Global Limited
Phone: 13 12 42
Fax: 1300 65 49 49
Email: sales@saiglobal.com
http://infostore.saiglobal.com/store

ISBN: Enter ISBN.