AUSTRALIAN RAIL TRACK CORPORATION LTD

This document has been adopted by the ARTC with the permission of the NSW Government and will continue to apply under the authority of the ARTC General Manager Infrastructure, Strategy & Performance until further notice

Discipline

Engineering Standard – NSW

Category

Signalling

Title

Specification - Signalling Power Systems

Reference Number

SCP 03 – (RIC Standard: SC 00 16 00 00 SP)

Document Control

Status	Date	Prepared	Reviewed	Endorsed	Approved
Issue 1 Revision 2	Mar 05	Standards and Systems	Standards Engineer	GM Infrastructure Strategy & Performance	Safety Committee
		Refer to Reference Number	H Olsen	M Owens	Refer to minutes of meeting 12/08/04

DISCLAIMER

Australian Rail Track Corporation has used its best endeavors to ensure that the content, layout and text of this document is accurate, complete and suitable for its stated purpose. It makes no warranties, express or implied, that compliance with the contents of this document shall be sufficient to ensure safe systems of work or operation. Australian Rail Track Corporation will not be liable to pay compensation in respect of the content or subsequent use of this document for any other purpose than its stated purpose or for any purpose other than that for which it was prepared except where it can be shown to have acted in bad faith or there has been willful default.

DOCUMENT APPROVAL

The technical content of this document has been approved by the relevant ARTC engineering authority and has also been endorsed by the ARTC Safety Committee.

DOCUMENT SUPPLY and CONTROL

The Primary Version of this document is the electronic version that is available and accessible on the Australian Rail Track Corporation Internet and Intranet website.

It is the document user's sole responsibility to ensure that copies are checked for currency against the Primary Version prior to its use.

COPYRIGHT

About This Standard

This Specification describes the general requirements for power supply systems for railway signalling installations.

Reliable power supply equipment and systems are fundamental to the operation of the signalling systems and hence to the safety and on-time running of the trains. This document describes the technical requirements for a signalling power supply system to provide the required high reliability.

For Contract Works, this document shall be read in conjunction with the Particular Specification, which refers to it.

Document History

Primary Source – RIC Standard SC 00 16 00 00 SP Version 4.1

List of Amendments –

ISSUE	DATE	CLAUSE	DESCRIPTION
1.1	31/08/2004		▪ Reformatting to ARTC Standard
1.2	14/03/2005	Disclaimer	▪ Minor editorial change ▪ Footer reformatted

Contents

1. Introduction

This Specification describes the general requirements for power supply systems for railway signalling installations.

Reliable power supply equipment and systems are fundamental to the operation of the signalling systems and hence to the safety and on-time running of the trains. This document describes the technical requirements for a signalling power supply system to provide the required high reliability.

For Contract Works, this document shall be read in conjunction with the Particular Specification, which refers to it.

2. Applicable standards

2.1 International Standards

This Specification refers to the following international Specifications and Standards:

IEC 60364 *Electrical Installations in Buildings*

DIN 41576/CEE

2.2 Australian Standards

This Specification refers to the following Australian Standards:

AS1099.2Z/AD - composite temperature/humidity cyclic test
AS2374 - Power transformers
AS3000 - SAA Wiring Rules
AS3100 - General requirements for electrical equipment
ACIF S009:2001 - *Installation requirements for Customer cabling (wiring rules)*

2.3 ARTC Specifications

This Specification refers to the following Australian Rail Track Corporation Signalling Specifications

SPS 23	Single Phase Air-Cooled Isolation Transformer
SPS 26	Mains Failure Plant
SC 05150000 SP	Non-vital Relays for Signalling Applications
SPS 05	Electronic Components - Rating and Construction Requirements
SCP 21	Construction of Cable Route Associated Civil Works and Cable Laying
SCP 20	Cable jointing, terminating and wiring of signalling systems

SCP 22	Small Buildings
SCP 04	Lightning and Surge Protection Requirements
SPS 24	Emergency Change-Over Contactor Panels
SPS 02	Environmental Conditions
SPS 40	Cables for Railway Signalling Applications - General Requirements
SPS 44	Single and Twin Conductor Cables
SPS 47	Fire-safe Single and Twin Conductor Cables
SPS 22	Power Supply Units for Signalling Equipment - General Requirements
SPS 27	DC Unfiltered Rectifier Units
SPS 28	DC Filtered Rectifier Units
SPS 29	DC Track Feeds
SPS 30	DC, Regulated and Filtered Rectifier Units
SPS 31	Battery Chargers
EP 90 10 00 04 SP	ARTC Electrical Systems Requirements specification "Co-ordination of Signalling and Power Systems - Earth Potential Rise"

3. General

3.1 Compliance with standards

AS/NZS 3000:2000 Clause 5.3 allows systems of earthing other than the MEN system to be used providing that they meet the general safety and functional requirements of AS/NZS 3000.

The MEN system of earthing detailed in AS/NZS 3000 is based on the TNC-S (earthed neutral, with distributed protective earth) system of earthing detailed in IEC 60364 *Electrical Installations in Buildings.*

ARTC Signalling power distribution generally conforms to the IT system of earthing (unearthed) as detailed in IEC 60364 *Electrical Installations in Buildings.*

Therefore the ARTC Signalling power distribution meets the requirements of Clause 5.3 of AS/NZS 3000 as well as providing a “safer” and more reliable power supply for the signalling safety system.

The basis for the alignment of the signalling power supply to the IT system of earthing is:

1. *By maintaining a high impedance to earth, any fault currents to earth are limited and this in turn prevents false operation of signalling safety equipment, and allows power to be maintained whilst faults are found and corrected.*
2. *By maintaining a high impedance to earth, body shock currents due to contact with live conductors are limited. The use of a permanent insulation monitor with the IT system allows detection and correction of any compromised insulation prior to a hazardous situation*

occurring.

Protection against direct contact is based on preventing direct contact by the normal means of Insulation, Access, Enclosures, Separation, and Barriers for non-qualified personnel.

Protection against indirect contact is based on limiting prospective touch potentials to less than 50VAC or 120V ripple free DC as required by the standard unless this creates, or increases another hazard.

3.2 Limiting Transferred earth potentials

Under conditions where two earth faults have occurred, transferred earth potentials due to a conductive path from one site to another could exist, which then may allow the touch potentials to exceed the limits for touch potentials.

Items that need to be considered to prevent the possibility of transferred touch potentials include:

- Galvanised Steel Troughing between equipment locations.

  Maintain two insulated joints in the Galvanised Steel Troughing between any signalling locations so that the touch potential across any insulated joint will not exceed the limits.
- Cable ladders between equipment locations.

  Maintain two insulated joints in the Cable ladders between any signalling locations so that the touch potential across any insulated joint will not exceed the limits.
- Metallic pipes for Air Lines or cables between equipment locations.

  Maintain two insulated joints in the Air Lines between any signalling locations so that the touch potential across any insulated joint will not exceed the limits.
- Metallic cable sheaths, or protective layers.

  Only provide Arrestors to earth from metallic cable sheaths at one end only. The end to have the arrestors installed will be the end of the cable will be the end away from the power supply distribution points.
- Metallic cable sheaths, or protective layers for Telecommunications cables.
  Insulated both ends.
- Metal fences.
  Maintain two insulated sections in the metal fencing between any signalling locations if the fence is within 2 metres of the location at both locations so that the touch potential across any insulated joint will not exceed the limits.

Insulated joints shall be rated to 2500VAC for 1 second. A 5mm air gap, and or at least 25mm insulated creepage distance is an accepted practice for providing the insulated joint.

Prevention of transferred touch potentials also addresses the issue of electrolysis and the prevention of circulating stray currents in the area with electric trains.

3.3 Risks whilst Earth Leakage Faults are present

The standard requiring protection against indirect contact is based on limiting prospective touch potentials to less than 50VAC or 120V ripple free DC however due to the hazards introduced by earthing field equipment or disconnecting power to the signalling system touch potentials may reach 120VAC for field equipment under some conditions.

Personnel working on the un-earthed signalling power supply must perform a risk assessment and identify safe work practices whilst an earth fault is present on the signalling power supply.

3.4 Non-compliance with IEC 60364 Electrical Installations in Buildings

The signalling power supply is non-compliant with IEC 60364 IT distribution because the design will not automatically disconnect for a second fault as:

- The fire risk is contained by design.
- The indirect contact risk is addressed by design, and work practice.
- Direct contact risk is addressed by design and work practice.
- Loss of power to the signalling equipment introduces other hazards.

3.5 SAA Wiring Rules

Except where special signalling considerations either contradict or exceed the Standard's requirements, all signalling power supply installations shall be designed and installed in compliance with AS3000 - SAA Wiring Rules.

Sections relevant to AS3000 compliance will be found in:

Paragraph	Subject	statu
5.5	Inspection of new supply installation	F/C
8	Transformers	F/C
6.2 (f)	Signalling sub-mains - permissible voltage drop	N/C
11.2	Switchboard construction	F/C
12.5	Provision of RCD (ELCB) protection	F/C
14.3	Earthing of Signalling Supplies not permitted	N/C
14.4	Bonding of exposed metal racking	F/C
14.5	Earthing of power and lighting circuits	F/C
18.1	Access to power room shall be restricted	F/C
Spec SC 00410000 SP	Testing and Inspection	X/C
Spec SCP 04	Earth electrode resistance	X/C

N/C	Non-compliant with AS3000
F/C	Fully compliant with AS3000
X/C	Exceeds requirements of AS3000

4. Environmental Considerations

All equipment covered by this Specification shall be capable of continuous operation at its maximum ratings in the conditions met within New South Wales. Applicable ambient conditions are described in Specification SC 00220000 SP. Enclosures and buildings must be designed to achieve these results through natural ventilation only, without reliance on mechanical cooling or air conditioning systems.

5. General Design Requirements, Power Supply Systems

5.1 General

This document sets out the standard practices followed in designing and installing signalling power supply equipment for the Australian Rail Track Corporation network.

5.2 Sources Of Supply

The main form of electrical power used for signalling applications is 50Hz AC, at a nominal voltage of 120 Volts.

AC power for signalling is obtained either from the railway or public distribution grids, motor-alternator plant and, in a very few cases, inverters operating from battery standby supplies.

For general signalling purposes, AC supplies shall be duplicated, with separate supplies derived from independent high voltage feeders, or other sources. In order of preference, the common main / standby arrangements are:

a) Railway normal, railway standby

b) Railway normal, Council standby

c) Railway normal, alternator standby

d) Council normal, alternator standby

e) Council normal, battery / inverter standby

In areas where AC supplies are not available or where it is not justifiable to install AC power for a small load, DC power may be supplied either from solar photovoltaic cells or from primary cells.

5.3 AC Mains Supplies

5.3.1 Railway Supplies

The ARTC electrical distribution network incorporates sections operating at three different supply voltages, namely 2.2KV, 11 KV and 33KV. The voltage for signalling supplies is transformed down for use at 120 Volts.

5.3.2 Council Supplies

'Council supply' refers to mains provided by local electrical supply authorities. These are available at almost any location in the state. In some areas, the cost of providing an extension from the nearest existing supply point may prove prohibitive, and an alternative source of power may be considered.

Although there are isolated instances of supplies at 415V, 480V and even at 11 KV, the Council power is generally supplied at 240 Volts, single phase.

Provision of the 240 volt switchboard and transformer is the responsibility of the party carrying out the installation. This 240V switchboard shall be fitted with lightning/surge diverters. These lightning/surge diverters are to be rated in accordance with SC 00170000 SP Lightning and Surge Protection Requirements and are to have local electrical supply authority approval.

5.3.3 AC Supply Voltage Limits

The signalling supply point voltage, at the output of the supply transformers, shall be maintained within the range of 120 to 127 volts. This has been agreed to, as a range achievable in practice.

With the conversion of the ARTC high-voltage electrical distribution in the metropolitan area to 11 kV and higher, there is a requirement on signalling projects to reduce the number of points at which signalling supplies are taken. Consequently, signalling low-voltage distribution mains have to feed over much greater distances. The supply voltage limits specified are necessary to achieve the required equipment operating volts, subject to the 10% load regulation and voltage drop allowance.

Where the electrical supply system is not sufficiently well-regulated to maintain supply within the voltage limits, such voltage regulation equipment shall be provided as is necessary to achieve the supply voltage limits.

5.3.4 Motor-Alternator Sets (Mains Failure Plant)

Where the mains power requirement exceeds a few hundred VA, and only a single reliable mains supply is available, the alternate AC supply shall be provided with a Diesel powered Motor-alternator set fitted with automatic start-up and power transfer facilities.

This mains failure plant shall be equipped with a number of status and alarm indications which require to be repeated to and displayed at the nearest staffed operating point. Mains failure plant shall comply with Specification SPS 26 ‘Mains Failure Plant’.

5.3.5 Uninterruptible Power Supply (UPS) Systems

Uninterruptible power supplies (UPS) shall be provided where a source of continuous AC power is required for loads which can not tolerate even a momentary interruption when a mains changeover or extended loss of power occurs.

UPS output shall remain continuous during transfer from Normal to UPS supply, and during return from UPS to Normal supply.

The signalling power supply is subject to significant phase shifts due to automatic change-over of supply. All UPSs used shall be immune to phase changes on incoming supply, and slowly resynchronise the load supply to the incoming supply so that the UPS load does not experience any significant disruption.

5.3.6 Supplies for Computer-Based Interlocking Systems

Computer-based interlocking systems from various manufacturers have different requirements in terms of their ability to handle momentary power supply interruptions, and the time taken to return to normal operation after a disruption. The acceptable recovery time will depend on the density and importance of traffic at the location in question.

Power supply systems may need to incorporate special arrangements such as transient protection, power conditioning, UPS or high-speed electronic changeover switches, for all or part of the CBI installation.

Such special arrangements shall be provided as are necessary to provide the level of operational availability specified for the particular installation.

Power supply arrangements for SSI central interlocking cubicle installations shall comply with the current *Signalling Circuit Design Standards* SDS 25 Cubicle Power Supply Arrangement circuit sheet.

SSI Mark2 & Mark3 Trackside Functional Modules (TFMs) supplied by Westinghouse Signals Australia and ALSTOM Australia are susceptible to harmonics and noise on the 120V AC Signalling supply. All 120V AC Signalling power supplies, which operate SSI TFMs, shall be fitted with power supply filters designed to remove harmonics and noise above 300Hz. The filter shall provide a 10 fold or higher attenuation of harmonics centred around 1000Hz. These power supply filters shall be fitted at the load side (output) of the power supply changeover unit (Static Switch or High Speed ECO).

5.3.7 Supplies for Signalling Electronic Systems (Non-vital)

Signalling electronic and computer-based systems, including telemetry, train describers, passenger information systems and event loggers, are each different in terms of their operating supply requirements and ability to handle power supply interruptions. This may be determined both by the design of the equipment itself, and the effects on rail operations of a disruption to its functions. Although a system is non-vital in a signalling sense, its failure can have a significant safety effect, in that it may force the railway to be operated in a less-safe fall-back mode.

Power supply systems may need to incorporate special arrangements such as power conditioning, UPS or high-speed electronic changeover switches, for all or part of the installation.

Such special arrangements shall be provided as are necessary to provide the level of operational availability specified for the particular installation.

5.4 DC Supplies - General

5.4.1 DC Signalling Supplies

For conventional relay-based signalling installations, the usual supply for all control circuits is 50 volts DC, full-wave rectified, unfiltered. This is derived from the 120 volt mains by means of simple transformer- rectifier sets, in accordance with Specification SPS 27 'DC Unfiltered Rectifier Units'.

At all relay interlocking locations, separate 50 volts DC supplies shall be provided for internal and external circuits. The internal supply shall not be used for circuits, which extend outside the relay room.

Diagram and non-vital supplies shall be 24 volt DC, full wave rectified, filtered.

12 volt DC control circuits are generally not used, except where signalling controls are included at a level crossing location.

5.4.2 Duplication of DC Supplies

Generally in interlockings, and where a power supply failure will affect the operation of a non-permissive signal, the outputs of two supply units shall be connected in parallel to the supply busbar to provide availability in case of the failure of a unit. This is not normally required in automatic signalling territory where regulations permit for a failed signal to be passed at Stop.

More than two units may be paralleled to achieve the required supply rating. The units shall be rated such that, when one unit fails, those remaining shall not be loaded above 75% of their rated capacity

Where supply units are wired in parallel, power supply alarms shall be arranged to indicate the failure of any individual unit.

Duplicated supply units shall be fitted with isolating diodes to allow the units to be paralleled without cross-feeding. Duplicated DC supply units shall be so designed and connected that it is possible to replace a failed unit without disturbing the other unit, or affecting the operation of the equipment powered by them.

5.5 No-Break DC Supplies

A no-break supply shall be used to feed those circuits for which a momentary de-energisation would produce the de-energisation of stick circuits and an unacceptable disruption to operators while time delay relays operated and routes were reset.

The use of no-break supplies is recommended only where the traffic density and operator work load are such as to produce an unacceptable number of train delays in the event of a power changeover. Unless otherwise stated in the Particular Specification no-break supplies are only required in the area bounded by Maitland, Lithgow, Picton, Unanderra and Sydney.

5.5.1 No-Break Supplies - Capacitive

Where duplicate AC mains supplies are provided, the emergency changeover equipment will switch between supplies in less than one second. In this situation, a completely adequate no-break function is provided by using DC power supply units having highly capacitive filtered outputs.

The rating of the transformer - rectifier is determined by the designed DC voltage and load, and the filtering capacitors shall be sized to provide an output voltage not less than 45 volts DC (for a 50 volt DC nominal supply) over a period of one second at the rated output current. The bus voltage from such a supply shall not exceed 55 volts at any time.

These units shall be fitted with output isolating diodes, and installed in redundant pairs in the same manner as standard transformer-rectifier sets in an interlocking.

For 50 volts DC supply, units complying with Specification SPS 28 ‘DC Filtered Rectifier Units’, such as the Store 92 (7 Amp rating), shall be used.

5.5.2 No-Break Supplies - Battery

In cases where the alternate AC supply is provided by a motor-alternator set, the changeover period will be up to one minute in duration. This is beyond the capabilities of a capacitive no-break supply. An arrangement shall be provided with low capacity batteries providing the standby power.

This comprises duplicate transformer-rectifier supplies in parallel with a single 50 volt battery, with diode isolation between them. A battery charger specifically designed for float-charging shall be provided for the standby batteries. The batteries shall be rated for their short term continuous current rating.

A combined power supply unit / battery charger such as the Store 96, or similar in accordance with Specification SPS 31 ‘Battery Chargers’ may be used.

5.6 Battery Supplies

5.6.1 Battery Standby - Secondary Cells

In some smaller installations with single AC mains supplies of limited reliability, DC standby power may be provided, with a secondary battery rated for continuous operation of the installation and supplied by a charger designed to provide optimum charging for long battery life.

The principal application of secondary cells is in Level Crossings. These shall be provided with high-reliability, long life batteries whose capacity shall be such that the level crossing equipment shall operate correctly for at least 48 hours under conditions of mains failure. The normal rating used currently is 140 Ampere hours. Level crossing batteries are normally Nickelcadmium, but other designs (eg. high performance sealed gel cell batteries) may be acceptable if the installer can demonstrate significant benefits in reliability, cost and maintenance requirements.

Nickel-cadmium level crossing batteries shall be provided with high-reliability Store 74 chargers, in accordance with Specification SPS 31 ‘Battery Chargers’. For alternate battery types, chargers designed to match the batteries’ operating requirements shall be provided.

General purpose lead-acid cells may be used where it is desired to provide battery standby for general signal circuits and signal lighting. Special housing and ventilation arrangements shall be made to prevent the escape of corrosive materials from these cells causing damage to any signalling equipment.

Where batteries and chargers are used the chargers shall be capable of supplying the full load within voltage tolerances with the batteries removed and also recharging fully-discharged batteries while supplying the normal operating load. The recovery time required under these conditions, to restore a fully-discharged battery to at least 75% of full capacity, shall not exceed 10 hours.

Wiring shall be arranged so that either the charger or the batteries may be disconnected without interrupting the supply voltage to the busbar.

Nicad battery standby is also required for telemetry systems and some computer systems.

5.6.2 Photovoltaic Cells (Solar)

Solar cells may be used at a location where ready access to AC mains is not available and average power requirement is low. Typical applications are track circuits and signal lamps.

A typical solar power supply consists of an array of solar cells on a suitable elevated mount, a regulator or charge controller and a secondary battery of special design rated to have a storage capacity equivalent to ten days' normal loading.

The sizing of a solar power installation shall be carried out in accordance with an approved sizing calculation method which takes into account the latitude and solar radiation of the location, the battery charging and discharging characteristics, and the voltage/current characteristics of the solar panels. The sizing calculations shall be subject to approval by the ARTC Corridor Manager or nominated Signalling representative before the installation of the equipment.

5.6.3 Primary Cells

DC power supply from primary cells alone has been used only where small power requirements exist at locations where it is uneconomical to provide AC mains or solar power. Apart from track circuit feeds, few such locations exist today.

The standard primary cell in current use is the Air-depolarised alkaline cell. The preferred design of primary cells shall be such that they provide a means for gauging the state of discharge of the cell at any stage of its life cycle.

5.6.4 DC Track Circuits

The most common use for primary cells is in DC track circuit feeds.

In some country areas where Council mains are available, but the level of reliability is not considered adequate, DC track circuits may be used with a primary battery feed supplemented with a Store 70 track rectifier (Specification SPS 29 ‘DC Track Feeds’).

6. AC Mains Supply - Design

6.1 Provision of Supply

Where existing supply points are to be used these will be detailed in the Particular Specification, otherwise the distribution system shall be designed and supply points and loading where power supply is required nominated, as required by the Particular Specification.

Two independent power supplies are required at each supply point. Wherever possible these will consist of two independent supplies from the ARTC supply network, or else a supply from the ARTC's electrical distribution system and a Council supply from the local electrical supply authority.

Wherever only one supply is available an engine-driven alternator standby unit shall be provided.

6.2 Existing Supply Points

Where existing supply points are to remain the ARTC Corridor Manager or nominated Signalling representative will carry out any necessary upgrading work on supplies derived from the ARTC's power distribution network up to the 120 volt terminals on the supply transformer, provided that the locations and maximum loading requirements are defined in the Tender and subsequent Contract documents.

Where the existing power supply building or enclosure is too small or unsuitable, provision of a new building or enclosure shall be the responsibility of the party carrying out the installation.

6.3 New Supply Points

Where supplies are provided from the ARTC's power distribution system the ARTC Corridor Manager or nominated Signalling representative will provide and install all transformers and switchgear required to make 120V 50Hz supplies available.

Where supplies are provided from Council or other systems and unless otherwise stated in the Particular Specification, the installer shall supply and install or negotiate with the supply authority to supply and install all poles, transformers, meter boxes, earthing, switchgear, surge protection, cables and trenching etc. required to make 120V 50Hz supplies available.

All necessary arrangements shall be made for the provision of any Council supply required, and for its final inspection and connection by the supply authority.

Where engine driven alternators are provided all work associated with their supply and installation shall be the responsibility of the installer.

Where any building or housing is provided or extended to accommodate power supply equipment, this shall include adequate space to house any power supply equipment being provided by the Corridor Manager or nominated Signalling representative. Normally the required accommodation will be incorporated in buildings provided to house signalling equipment.

6.4 Power and Lighting Circuits

At all relay rooms, a 240V 50Hz supply of at least 3600W capacity shall be provided and distributed to GPO's situated strategically in all rooms of the building.

Building illumination shall be provided by means of a 240 volt lighting circuit, with double-insulated luminaires.

Power and lighting circuits in signalling locations shall be wired as MEN circuits, in accordance with AS3000.

Where a Council or Railway 240 volt supply is available, these power and lighting supplies shall be derived directly from the 240 volt supply.

Where a 240 volt supply is unavailable, or not sufficiently reliable, the lighting circuit shall be supplied a step up transformer from the 120V supply, downstream from the ECO equipment. Depending on the capacity of the signalling supply, the power circuit may also be supplied from the same source.

Relay rooms are defined to be locations that significant interlocking functionality is provided or has telecommunications interface to the interlocking.

6.5 AC Power Factor Correction

Most of the loads connected to the signalling mains supply are inductive. This can result in some problems with power distribution, and also present the supply authority with a load of unacceptable power factor.

At each power supply location, the means shall be provided for power factor correction, such that the power factor of the standing signalling load does not fall below 0.8.

The power factor correction equipment shall be installed between the ECO panel and the Switchboard, so that it remains effective, whichever supply is in use.

The power factor correction equipment shall be provided with circuit protection, to rapidly isolate it from the signalling supply in the event of a failure. An indicating lamp and a remote indicating relay shall be provided on the unit, as stated in Clause 18.3, to indicate that the power factor correction circuit is connected to the signalling supply.

When an installation is being commissioned, and after all normal loads have been connected, the power factor shall be checked, any corrections necessary shall be applied, and the final standing power factor value shall be recorded.

7. AC Mains Supply - Distribution

7.1 General requirements

Reticulation of signalling AC supplies will normally be at 120V or 415. Reticulation of 50V DC supplies will be allowed for small loads.

All power cables shall be capable of handling a 15% increase in the estimated standing load to allow for future expansion. All voltage drop calculations shall make allowance for this increase.

The voltage at any point along a pair of mains shall not vary more than 10% from the nominal supply voltage under any static or dynamic load condition, when the supply bus bar is set at nominal voltage under normal operating load conditions.

Booster transformers in mid run or autotransformers at any location shall not be used for mains distribution. Step up transformers shall not be used on mains distribution unless specifically approved by the ARTC General Manager ISP or nominated Signalling representative.

Cable route installation shall be in accordance with Specification SCP 21 ‘Construction of Cable Route Associated Civil Works and Cable Laying’

The reticulation of signalling AC supply from a circuit breaker at the Power supply point to a first location, then a second location, etc is accepted practice.

Segregation of signalling power supply cabling from other signalling cabling, and other signalling power supply cabling is not required as all of the approved cabling meets the standards for double insulation, or reenforced insulation.

7.2 Extended Voltage Mains

Where a mains distribution run is of such a length as to make distribution at 120 volts impracticable the installation of a higher voltage distribution run in accordance with the following principles may be permitted, subject to the express approval of the ARTC GM ISP or nominated Signalling Manager. Such an installation is referred to as an ‘extended voltage’ mains.

Extended voltage mains configuration may also be utilised to provide galvanic isolation for paths between the signalling earths at different signalling locations. This is particularly important when 11 kV or higher High Voltage sub-stations are installed in close proximity to signalling locations.

If the signalling location is with-in the 430V Earth Potential Rise (EPR) contour for the High Voltage installation then extended voltage mains should be used to provide immunity from the High Voltage EPR faults by having transformer isolated power distribution.

a) Signalling supply at source and at all load points shall be nominal 120V 240V, or 415V supply sources are allowed.

b) The extended distribution voltage shall be 'low voltage' as defined in AS3000, but not less than 240 volts and 415V preferred.

c) Outgoing extended voltage mains shall be stepped up to the distribution voltage immediately prior to leaving the supply location and stepped down to 120 volts at each load point. Step-up and step-down transformers shall comply with Specification SPS 23 'Single Phase Air-Cooled Isolation Transformer'

d) The 120 volt supply to each extended voltage mains shall be controlled by an individual two-pole circuit breaker as specified in paragraph 14. The circuit breaker shall have provision to be secured in the 'open' position while work is being carried out on the mains. 240V, or 415V supply sources are allowed.

e) At each load point two, two-pole isolators or circuit breakers, housed within the transformer enclosure, shall be provided to isolate the input to the stepdown transformer and the outgoing mains to downstream locations. The isolator or circuit breaker shall have provision to be secured in the 'open' position while work is being carried out on the mains.

f) Extended voltage distribution mains shall be provided with earth leakage detection (ELD). ELD alarm status shall be indicated in the supply location power supply alarms.

g) All extended voltage wiring shall be double-insulated. Transformers, terminals, isolators or circuit breakers and surge protection of the extended voltage distribution shall be enclosed in suitable earthed metallic housings clearly identified with labels stating "Caution XXX Volts". Isolators and circuit breakers shall be mounted so that they can be operated from outside the housing.

h) Buried cable carrying extended voltage mains shall be identified by a orange coloured outer sheath.

7.3 Reticulation Design

This section sets the basic parameters for the design of power reticulation schemes for signalling works carried out for the Australian Rail Track Corporation of New South Wales.

It describes preferred methods for:

- Estimation of total location loading

- Allowances for design variation and future expansion
- Determination of mains cable sizes
- Preparation of Mains Distribution plans

The requirements listed in this section should be interpreted as representing the minimum requirements for any mains reticulation system.

The designer and installer shall ensure that any new or modified mains supply and distribution system will meet the specified requirements for voltage drop under all static and transient load conditions, with an adequate reserve capacity for future additions.

Notwithstanding any prior approval of system designs and calculations, the installer shall ensure that the final installed power distribution system complies with the specified requirements for loadings, supply regulation and voltage drops.

The following sections define an acceptable method of calculating mains system design parameters and performance.

7.3.1 Definitions - Types of Loading

7.3.1.1 Static Loads

These are devices presenting a continuous and essentially constant value of load, over extended periods

e.g. Signal lights, and all transformer / rectifier sets

7.3.1.2 Occasional Loads

These devices are not normally on, but may be switched on at times for extended periods, generally not exceeding an hour.

e.g. Location lighting, and maintenance call lights.

7.3.1.3 Transient Loads

These devices are also not normally on, but when switched on, present significant loads for brief periods, generally of several seconds.

e.g. Train stops and points machines.

7.3.2 Power System Loading

7.3.2.1 Standard Unit Loads

A table of standard devices and their rated unit loads is provided in Appendix 1 of this document. This need not be reproduced by the Contractor, but the values listed must be used for all calculations submitted, subject to the exceptions noted in the following paragraph.

7.3.2.2 Non-Standard Unit Loads

Unit loads for non-standard items shall be actual measured values, for identical equipment under normal operating conditions. Test documentation shall be submitted to substantiate any such values used in calculations.

Alternatively, for transformer-input devices, the rated load shall be the full rated VA output, plus a loss allowance equal to 33% of the full rated output.

If the device concerned is to operate at less than full rated output, then its unit load shall be the calculated output VA rating, plus the loss allowance equal to 33% of the full rated output.

Where DC supply units are duplicated and operate in parallel, their equivalent AC loading is the calculated output VA rating as before, plus the full loss allowance for each unit.

Where it is proposed to allow reduced load ratings in accordance with this paragraph, full details shall be submitted of the calculations used to determine the reduced rating, for each instance.

A list of all non-standard unit loads shall be included with the power reticulation design submitted for approval, showing for each device :

a) the full rated output, in VA

b) the rated mains loading, in VA

Additionally, for any item for which it is known that the actual mains loading exceeds or varies significantly from the standard unit load value listed in Appendix 1, and a different value is proposed to be used in the calculations, that device, with its rated loadings as proposed, shall be included in the table of non-standard loads. Where an alternative load value is used, empirical test data shall be submitted to substantiate the value used.

7.3.3 Location Loadings

To estimate the total current in each section of a mains feeder, first estimate the total loading at each location fed by the mains in question.

Only devices actually connected to the AC supply system should be included in AC mains calculations. DC loadings from relays, etc should not be calculated directly into AC mains calculations, but instead be used to estimate the AC loading effect of the DC supply unit feeding them (See the previous paragraph).

For each location to be supplied by the mains in question, a location loading sheet shall be prepared, showing the following items:

7.3.3.1 Static Loads

For each type of device, list :

a) the total number in use at the location
b) the unit VA load of the device
c) the resulting total VA load due to the device

For the location, note :

a) the total static load, in VA

b) the total static load, in Amperes

7.3.3.2 Dynamic Loads, occasional and transient.

For each type of device, list :

a) the total number of such device at the location
b) the maximum number which can operate simultaneously
c) the unit VA load of each
d) the maximum transient VA load

For the location, note :

a) the maximum total dynamic VA load
b) the maximum total dynamic load, in Amperes

7.3.4 Allowances

The following allowances shall be made, before calculating reticulation voltage drops:

7.3.4.1 Location Loads

Unless otherwise specified, the following additional load shall be allowed for future expansion, at each location:

a) 15% of the estimated static load ; plus
b) One points machine, at the most remote points feed location, on each mains run which includes points feeds. Where separate points mains are provided, this does not apply to the non- points mains.

7.3.4.2 Cable Lengths

Cable lengths between locations shall be as determined on the site, and shall include suitable allowances for route deviation and cable termination. They shall be not less than the exact measured length along the actual cable route, plus 10 metres.

7.3.5 Cable Resistance Values

The values of cable resistance used to calculate feeder voltage drops shall be the millivolt drop/A/metre values specified in AS3000, Table B2. (Reproduced in Appendix 2 of this document.)

7.3.6 Maximum Voltage Drops

The power supply reticulation system shall be designed to meet the following voltage drop criteria, under the defined load conditions:

a) On 120 volt signalling mains, the maximum voltage drop shall not exceed 10% of the nominal supply voltage for static and dynamic loads combined.

b) On mains with less than 20% difference between end-to-end voltage drops under static and dynamic loading conditions, the maximum voltage drop may be up to 15% of the nominal supply voltage. Provided that it does not exceed the input voltage rating of equipment installed near the supply point, the supply point voltage may be increased to give a static end-point voltage within 10% of the nominal supply voltage.

c) Mains incorporating extended voltage distribution, shall meet the above requirement, applied to the nominal 120 volt supply and end-use points.

d) On mains provided specifically for the supply of point machines, the maximum permissible voltage drop may, subject to specific approval, exceed that normally specified for general mains supplies, up to a limit of 15% of the nominal supply voltage.

7.3.7 Selection of Cable Sizes

Cable sizes shall be selected such that the final total voltage drop from the feed location to the extremity of each feeder does not exceed the specified limits. A list of cable sizes, current ratings, and voltage drops, with preferred cable sizes highlighted, is given in Appendix 2.

The minimum cable size used in a nominal 120 volt mains shall be 7/1.70 mm

No cable may feed into a cable of greater cross-sectional area.

Cables used for power supply purposes shall comply with the following Signalling Specifications :

SPS 40	Cables for Signalling Applications -General Requirements
SPS 44	Single and Twin Conductor Cables
SPS 47	Firesafe Single and Twin Conductor Power Cable

7.3.8 Allowable capacitive coupling to earth

Normal power cables will be double insulated singles or be a double insulated paired cable with a copper shield. The copper shield will not be directly earthed.

A value of 250?F/km is considered appropriate for capacitive coupling for each leg of the power system to earth based on manufacture's typical specifications for the types of cables used.

Signalling AC power distributions should to be limited to 1µF capacitive coupling from each leg to earth.

This means that each AC power distribution bus must be limited to 4 km cumulative length of cabling for each isolated supply, although concessions can be granted based on the use of cable route construction methods that limit the capacitive coupling to earth. For example conduit and versilux lined GST.

7.4 Calculations

Calculation of estimated voltage drops shall be carried out as described below, using the current loadings and cable lengths estimated above, selected cable sizes, and cable voltage drop values as specified in Appendix 2

7.4.1 Voltage Drop Calculations

Two sets of voltage drop calculations shall be carried out and submitted for approval:

a) One for static loading conditions as defined earlier (para. 7.3.3.1).

b) One, for `maximum demand' static and dynamic loading, as described below.

7.4.2 Static-loaded Voltage drop

The static loaded voltage drop calculation shall be carried out with all locations at their estimated static load, plus the 15% load allowance specified in para. 7.3.4.1.

7.4.3 Dynamic-loaded Voltage drop

For the dynamic-loaded volt-drop calculation, the effective loading shall be calculated as follows:

a) Full static loading including 15% allowance, at all locations; plus

b) Location lighting : `on' at the two most remote locations on each feeder, plus at every second location towards the feed point. (If door-operated cut-out switches are provided at all locations then only the two most remote locations need be included); plus

c) Any `occasional' load : `on'; plus

d) Trainstops, where provided: one operating on each feeder, being the trainstop located farthest from the feed point ; plus

e) Point machines: On each feeder, allow the greatest possible combination of machines that can operate as the result of a single `push-push' route setting action by the signaller. (Include in this any normalisation of pre-existing conflicting routes, in going from one route to the `worst' opposite one, and both route setting and trapping.); plus

f) The one extra point machine allowance shown in paragraph 7.3.4.1(b)

7.4.4 Calculation of Voltage Drop, and Cable Size

The preferred approach to the selection of cable sizes is for each section of cable to be chosen to give a resulting voltage gradient along its length, which most closely approximates the average voltage gradient (volts per metre) for the complete cable run in question. This `target' voltage gradient is obtained by dividing the total permissible voltage drop for the cable run, by the length of cable in the run.

The size of each individual cable may be first approximated by selecting the cable size, which under the estimated current loading yields a voltage gradient nearest to, but less than, the `target' value. In a second pass, some cable sizes can be reduced to reduce the overall cable cost. Within any cable run, occasional sections may have a gradient, which exceeds the `target', so long as the end voltage falls within specified limits.

Subject to the limitations on the range of cable sizes available for use, and the desire to limit the number of cable sizes used in any one cable run, in an optimum design the individual location voltages will also lie close to a line conforming to the `target' voltage gradient, with some location voltages being `below' the target line.

The end-point target voltage is the nominal supply voltage, less the 10% permissible voltage drop.

7.5 Mains Reticulation Design

The completed mains reticulation design shall be submitted for approval including the following information:

a) A mains distribution plan, showing the completed distribution scheme.

b) Location loading sheets, showing the details listed in para 4.2.

c) Voltage drop calculation sheets, showing how the estimated voltage drops were arrived at.

7.5.1 Mains Distribution Plan

The completed mains reticulation design should be submitted on a copy of the track plan/s for the project, bearing the following information:

7.5.1.1 Permanent Data

(to form part of the final permanent track plan) :

a) Feed location details (diagrammatically, using standard symbols), showing:

b) Sources of supply

c) Emergency changeover equipment

d) Surge protection

e) Simplified distribution switching

Cable details:

a) Active and Common cables

b) Identification of cable function (eg.WG Bx120, WG Nx120)

c) Cable size in each section

d) Load location terminals.

7.5.1.2 Temporary Data

This is for approval purposes only :

a) Location load currents (Static and Dynamic)

b) Total current in each cable section (Static and Dynamic)

c) Calculated length of each cable section.

d) Estimated voltage drop in each cable section (Static and Dynamic).

7.5.2 Circuit Book

The diagrammatic representation of all the above information including temporary data shall be included as separate sheets in the Circuit Book.

The diagrams are not required to have a lateral scale.

8. Surge Protection

The Power Supply Systems and the equipment shall be provided with protection against lightning and high voltage surges in accordance with the Specification SCP 04 ‘Lightning and Surge Protection Requirements’.

9. Mains Transformers

All transformers shall be of the double wound air cooled type conforming to Specification SPS 23 ‘Single Phase Air-Cooled Isolation Transformers’, and Australian Standard AS2374. Additionally all terminals shall be shrouded to prevent accidental contact.

Supply transformers rated at 3kVA or over are subject to approval by the ARTC GM ISP or nominated Signalling representative.

10. Emergency Changeover Equipment (ECO)

10.1 ECO Panels - General

At locations where two independent mains supplies are available, an automatic emergency changeover panel system complying with Specification SPS 24 ‘Emergency Change-Over Contactor Panels’ shall be installed.

At locations provided with engine driven alternators as standby supply, the changeover equipment shall be incorporated in the mains failure plant control panel, as specified in Specification SPS 26 ‘Mains Failure Plant’.

For supplies rated at over 50 Amperes, the preferred type of changeover contactor is a bar type, with single actuating coil energised when the Normal supply is available. The changeover contacts shall be set to guarantee 'break before make' operation, to prevent the momentary interconnection of the two AC supplies.

The ECO panel shall use AC coils for the main contactor. DC coils using bridge rectifiers are not to be used.

The ECO panel shall incorporate voltage sensing, to force the ECO to standby supply if the normal supply voltage drops below 105 volts and return to normal supply when it is above 115 volts. The preferred circuit arrangements are shown in *Signalling Circuit Design Standards* Power Supply Emergency Change-Over Contactors circuit sheets.

Where the supply feeds electronic equipment, which may be sensitive to repeated switching of the supply, the return to normal supply shall be made only after it has been continuously above 115 volts for a period of at least 10 seconds.

Circuit breakers shall be provided in both the inputs and the output of the ECO panel for protection and isolation purposes.

Where special load requirements exist, approval may be given to replace the ECO with an approved high-speed electronic changeover unit. This shall incorporate guaranteed means to prevent any backfeed into an isolated supply line resulting from the short circuit failure of one or more electronic switching elements.

Static switches, whether installed as stand-alone devices or as part of a UPS system, shall isolate both active and neutral legs of the off-line supply.

11. Mains Failure Plant (Engine Driven Alternators)

1. Where engine driven alternator sets are to be provided they shall be in accordance with Specification SPS 26 ‘Mains Failure Plant’ including all control gear and automatic supply changeover equipment.

2. The preferred arrangement for engine-driven mains failure plant is that described as a 'portable' installation (refer to paragraph 10 of Specification SPS 26 ‘Mains Failure Plant‘).

3. Any buildings constructed to house these units must conform to the requirements of Specification SCP 22 ‘Small Buildings’.

4. Engine cooling air outlets shall be ducted to vent outside the building or enclosure. Adequate ventilation shall be provided to allow for continuous full load running of the set under the hottest ambient conditions given in Specification SPS 02 ‘Environmental Conditions’.

5. The room or enclosure must be of sufficient size to house the relevant switchboards, lightning and surge protection, batteries, battery chargers, fuel tanks etc. and still retain adequate circulating and working room. The proposed design, layout and construction details shall be subject to approval by the ARTC GM ISP or nominated Signalling representative.

6. All engine driven alternator sets shall be fully run in, under full rated load, to the manufacturer's specification prior to the commissioning of the equipment.

12. Switchboards

12.1 Switchboard Facilities - Signalling Supplies

Unless otherwise specified in the Particular Specification, each power supply location shall be provided with a switchboard including the following facilities:

A switching panel incorporating individual circuit breakers for

a) Incoming AC supply to switchboard

b) Local AC busbars

c) Remote AC submains

d) AC supply to each DC power supply unit

e) DC supply to each DC busbar

f) One spare circuit breaker of each size and type used on the switchboard, installed on the switchboard ready for immediate use.

A metering panel incorporating the following facilities:

a) Main 120 volt supply voltmeter (continuously metered).

b) 120V main supply ammeter showing total load on the supply (continuously metered).

c) Voltmeter and ammeter to measure voltages and current of all other AC supplies. (Separate meters giving a continuous indication of each supply or common switchable meters may be provided.)

d) Voltmeter and ammeter to measure voltages and current of all DC supplies. (Separate meters giving a continuous indication of each supply, or common switchable meters may be provided.)

e) Meters and approved spring-return switches to measure the voltage to earth of each leg of the 120V AC and of the 50V DC internal and external supplies.

Note : Where switchable meters are provided the contacts must be arranged to maintain isolation between different supplies at all times.

12.2 Construction

The switchboard shall be designed and constructed in accordance with the relevant parts of AS3000.

The arrangement for switchboards shall be as a wall mounted cabinet, with all components, wiring and terminations easily accessible from the front by means of one or more opening front panels. Cable entry should be through the top or bottom of the housing. Provisions for securing cables as they enter the switchboard enclosure are to be provided. Blanking plates are to be provided for all unused cable entries. All hinged panels shall be bonded to the switchboard housing with flexible braided straps.

Wiring of a typical switchboard is shown in *Signalling Circuit Design Standards* Power Supply section.

The switchboards shall be designed to have 20% useable spare space for future requirements. Panel openings for additional circuit breakers shall be fitted with appropriate blanking plates.

Switchboards shall not contain/incorporate emergency changeover equipment, transformers or DC power supply units.

All switchboard components shall be readily available in Australia. Each item shall be so mounted and connected that it can be readily removed without having to disconnect or disturb other supplies or other components not involved with the component and its immediate circuit.

All components shall be firmly supported to withstand vibration without damage to connections or terminals.

12.3 Switchboard Facilities - 240 volt Supplies

Switchboards provided for 240 volts supplies derived from Council supply, shall be normal commercially-available load centres fitted with standard commercial circuit breakers.

13. Circuit Protection

1. DC signalling control circuits shall be Individually protected by 2A fuses to Specification DIN41576/CEE. Other DC circuits shall be protected by fuses rated at 4A, 6A, 10A, and 15A. in rail mounted (`Klippon' type) holders, rated for the expected loading.
2. AC signalling circuits shall be protected by fuses rated at 4A, 6A, 10A, and 15A. in rail mounted (`Klippon' type) holders, or by approved circuit breakers.
3. Where fuses are used they shall provide visible indication of rupture wherever possible
4. The required current rating of protection equipment shall not be obtained by connecting lower rated components in parallel eg. circuit breakers, fuses, contacts etc.
5. 240 volt power (GPO) and lighting circuits in signalling locations, whether derived directly from the Council supply or from the 120 volt signalling supply, shall be provided with residual current device (RCD) protection and be fully compliant with AS 3000.

14. Circuit Breakers

1. Circuit breakers used in signalling supplies shall be double pole magnetic type, with standard current/time operating curve. They shall be designed to indicate, by lever position, whether they have tripped or have been switched off. The preferred circuit breaker for general signalling applications is the Heinemann CF2, Standard curve (Curve 2), in the 'standard mount, standard connection' form.

2. Where the signalling load consists of numerous transformers (eg. SSI installation or a high number of track circuits) it is possible that a standard curve circuit breaker may trip due to the high inrush currents at turn on or during an ECO transfer. In these instances Slow curve (Curve 1) circuit breakers should be substituted for the Standard curve (Curve 2) circuit breaker and shall be selected to prevent openings for normal circuit conditions while providing protection against abnormal damaging conditions

3. Circuit breakers for normal usage on the signalling power distribution shall not include thermal tripping. The circuit breakers for particular loads, or purposes may include thermal tripping. A separate type approval for the use of circuit breakers including thermal tripping is required for each type of load or purpose.

4. All protection shall be rated to protect the equipment and cables. Discrimination shall be applied to rating such that the circuit breaker or fuse closest to the fault shall be the one to open circuit so that a minimum of equipment is disconnected.

5. On supply busbars where the individual circuits are protected by DIN fuses, the rating of the busbar circuit breaker shall be at least equal to the standing load, plus a current equal to the highest-rated fuse on the busbar.

6. Normal loadings are not to exceed 75% of the rated value of any circuit breaker or fuse.

7. Signalling 120 VAC loads are regarded for the purposes of interpretation of the standards as fixed, stationary equipment. A 5 second disconnection time for the circuit breakers, or fuses is acceptable for faults that would exceed the rating of the cabling.

15. Earthing Of Equipment

15.1 Earthing at Signalling Supply Locations

At each power supply location, a signalling earth system shall be installed in accordance with Specification SCP 04 'Lightning and Surge Protection Requirements'

15.2 Earthing co-ordination

The signalling earth shall be separated from any High voltage earths so that any earth potential rises due to High voltage faults shall be less than 2500VAC and preferably less than 430VAC.

ARTC Electrical Systems Requirements document "Co-ordination of Signalling and Power Systems - Earth Potential Rise" EP 90 10 00 04 SP details how to determine the separation required for the management of the High Voltage and Signalling earths.

Electrical and communications codes of practice may require warning signs concerning EPR hazards to be installed where the EPR exceeds 430V. The *Signalling Surge Protection installation guidelines* detail accepted separation distances.

If a low voltage power earth is provided at the signalling location, then the low voltage power earth and signalling earth shall be bonded via a Transient earth clamp (or Differential earth clamp) with a break down voltage of 290 volts, surge rating of 100kA or more, and a 50Hz current rating of at least 50 amps for one second.

Communications Earth System shall be equipotentially bonded to the power earth as per method 1 of figure 2 of ACIF S009:2001 if the location has a power earth.

Communications Earth System shall be equipotentially bonded to the signalling earth as per method 1 of figure 2 of ACIF S009:2001 if the location only has a signalling earth.

15.3 Signalling Supplies

All signalling supplies, whether AC or DC, must be kept strictly free of earths, to maintain circuit integrity and safety in the event of any individual earth fault on a supply busbar.

This requirement is specifically noted as a departure from AS3000 requirements.

15.4 Exposed metal racking

All relay racks and equipment cabinets shall be bonded to the signalling earth with not less that $4mm^2$ earthing conductors

Any exposed metal racking or cable tray which is carrying AC mains wiring that is not double-insulated shall be bonded to signalling earth with earthing conductors sized to comply with AS3000, Table 5.1, with regard to the maximum size of the mains conductors carried by the racking or tray.

Metalwork shall be bonded to the protective earth used by the power source for the majority of the equipment mounted on it. Preference shall be given for bonding to the low voltage power protective earth, rather that the Signalling earth. Earth bonding resistance shall be less than 2 ohms from the bonded metalwork to the earthing system.

15.5 General Purpose Power and Lighting Circuits

240 volt power (GPO) and lighting circuits in signalling locations shall be installed as MEN circuits, in accordance with AS3000.

Where the power and light circuit is supplied by a step-up / isolating transformer fed from the signalling 120 volt supply, the MEN neutral link shall be earthed. The earth can be connected to the Signalling Earth

16. Earth Leakage Detectors

16.1. Earth leakage detectors shall be installed on all 120V AC and 50V DC vital signalling supplies and on the extended voltage mains. The detectors shall indicate the occurrence of a momentary or continuous earth fault, on either side of the supply bus.

On an extended voltage mains installation, where 120 volt ELD protection is required at load locations, individual ELDs shall be installed on the 120 volt busbar at each location.

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

16.2. The earth leakage detectors shall be continuously indicating and self proving. A failure of the supply being monitored shall not produce an alarm indication.

The detection sensitivity should be adjustable by the manufacturer or by means of an external control, which can be sealed after adjustment.

The detector shall be designed such that, once having operated to a "fault" indication it will remain in that condition until deliberately reset. Terminals shall be provided for a remote reset by an external voltage-free contact.

A "test to earth" spring return switch shall be provided on the unit to facilitate checking of the unit's effectiveness. The earth connection shall be through a resistance valued at the maximum earth leakage resistance the unit will detect, to an independent test earth.

The unit shall provide the means by which to simply identify which side of the supply is subject to the detected earth fault. This shall be done by means of indicator lights on the detector. One green light shall be provided to indicate that each bus is normal - ie clear of earth fault.

Each detector shall incorporate its own built in "clear" and "fault" indications and have an output contact to accommodate an externally fed remote alarm circuit.

16.3. Earth Leakage Detector sensitivity

Earth Leakage Detector sensitivity is set to detect a fault condition at a level less than that which would cause a safety hazard.

Earth Leakage Detectors are set to detect a resistive path to earth and must operate with both legs of a monitored AC supply having 1 µF capacitive coupling to earth.

The earth leakage detector **must not** detect an earth fault greater than the set sensitivity level that occurs for a duration of less than 2 seconds

The earth leakage detector **must** detect an earth fault greater than the set sensitivity level that occurs for a duration of 5 seconds or more.

Earth Leakage Detector Sensitivity settings					
Busbar volts (nominal)	**12 DC**	**24VDC**	**50 DC**	**120 AC**	**415 AC**
ELD sensitivity in K ohms	**15**	**15**	**40**	**40**	**100**
Equivalent earth Leakage current in mA.	1	1.5	1.3	3	4.2

17. Phase Detectors and Alarms

In areas signalled with 50Hz track circuits, phase angle detectors shall be provided at locations between power supply points where two AC mains abut. In these areas, the changing of a power supply's phase may result in the loss of phase reversal between abutting track circuits fed from different supplies, with the consequent possibility of a wrong-side failure of one or other of the track circuits.

The detector shall be arranged to indicate if the phase angle of one mains supply varies by more than 60 degrees with respect to the other. It shall be provided with the means to be connected to indicate a clear 'condition' initially, whatever the initial relative phasing of the AC mains may be (the track circuits will have been correctly phased for this initial supply condition.)

The detector shall incorporate an indicating relay, arranged to be energised in the 'correct phasing' condition. The relay shall have at least one changeover contact for external indications. This shall be included in the local power supply alarm circuit.

18. Alarms and Indications

18.1 General

Each transformer location and relay room shall be provided with power supply indications and alarms as described below. In addition, an alarm monitoring panel shall be provided in each main relay room. Specified alarms shall be displayed on the local emergency control panel and on the main signal box control console.

18.2 Alarm Indications - General

Generally, alarm indications shall be in accordance with the following principles:

a) A green light shall indicate a 'Normal' status, indicating that a supply is operating normally

b) A yellow light shall be used to indicate a 'Warning' status, indicating that part of a supply has failed, and the supply is operating in its standby mode, or that a standby supply has failed and is unavailable in the event of a loss of normal supply.

c) A red light shall be used to indicate an 'Alarm' or ‘Fail’ status, indicating that a supply has failed completely, with consequent loss of function in part of the signalling equipment, and the possible existence of a dangerous condition.

d) At staffed control locations, an audible alarm shall sound whenever any indication changes status, from 'Normal' to 'Warning' or 'Alarm', or back to 'Normal'. The alarm shall operate continuously until silenced by the console operator entering a command to acknowledge the change of status.

e) Indication lights shall be Light Emitting Diode (LED) bezels of the appropriate colour. These LED bezels must be rated for continuous operation at the maximum working supply voltage. Indication lights shall not use incandescent globes.

f) Indication circuits shall be wired so that they produce no interconnection of supplies.

18.3 Power Supply Indications

The power supply indications listed below shall be provided, as applicable, for any signalling power supply installation. Where other types of power supply or control equipment are provided, an equivalent level of indication shall be provided for those also.

Location	Indication	LED Bezel Colour	Relay
TRANSFORMER ROOM	120 v Normal supply to ECO available	Green	------
	120 v Emergency supply to ECO available	Green	------
ECO PANEL	120 v Normal supply to ECO available	Green	2 C/O
	120 v Emergency supply to ECO available	Green	2 C/O
	120 v Load Supply Available	------	2 C/O
POWER FACTOR CORRECTION	PF Correction unit on line	Green	2 C/O
PHASE DETECTOR	Correct phasing between adjoining AC supplies	------	2 C/O
DC Supply Unit (each unit individually)	DC output available	Green	2 C/O
DC Battery Charger	Charger output available	Green	3 C/O
	Battery low voltage alarm (Critical battery supplies only)		2 C/O
DC Supply Busbar (50v and 24v supplies)	DC bus supply available	------	3 C/O
AC Supply Busbar	AC bus supply available	------	3 C/O
(Ext, Points, LV supplies)			
M/A Control Panel	AC Normal supply available	-------	3 C/O
	M/A operating & supply on line	Yellow	3 C/O
	Engine low oil pressure	Red	3 C/O
	Engine overheating	Red	3 C/O
	Fuel low - 12 hours supply	Yellow	3 C/O
	Fuel low - 30 minutes supply	Red	3 C/O
	M/A output circuit breaker tripped	Red	3 C/O
Earth Leakage Detector	Bus 1 Clear	Green	------
	Bus 2 Clear	Green	------
	ELD clear/tripped	------	1 C/O

Location	Indication	Lamp	Relay
Control Panel / Console	Power supplies Normal	Green	
	Power supplies Warning	Yellow	
	Power supplies Fail	Red	
	ELDs clear ELD operated	Green Yellow	
	Power supplies - status change	Audible Alarm	
RELAY ROOM ALARM PANEL	AC Normal Suplly to ECO available	Green	------
	AC Emerg Supply to ECO available	Green	------
	AC Load Supply ex ECO available	Green	------
	AC Busbar Supply Available (each Int, Ext, Points supply)	Green	------
	120 v Supplies available	------	3 C/O
	DC Busbar Supply Available (Each B24, B50, Int, Ext busbar)	Green	------
	DC Supplies available (24 v, 50v Int, Ext separately)	------	3 C/O
	DC Supply Unit Channel fail (Each B24, B50, Int, Ext busbar	Yellow	
	AC busbar supply lost	Red	
	DC busbar supply lost	Red	
	Battery Charger Output Fail (not loss of AC) (each battery supply)	Yellow	
	AC Emerg M/A set on line	Yellow	
	M/A Set - 12 hours fuel warning	Yellow	
	M/A set fail to start or shut down	Red	
	Battery low volts alarm operated	Red	
	ELD tripped (all ELD's grouped)	Yellow	
	AIr pressure below set minimum	Red	

The indicating relay types shown in the list ("2C/O" and "3C/O") refer to plug-in non-vital relays equivalent in form and pin-configuration to 'Fuji' HH22PW-T and HH23PW-T types. Refer to Specification SC 05150000 SP 'Non-vital Relays for Signalling Applications', for details. Indicating lamps shall give clear and unambiguous indications under their normal ambient lighting.

19. Housings

19.1 General

Multiroom buildings built at power supply locations shall conform to Specification SCP 22 ‘Small Buildings’.

Disposition of power supply equipment shall be generally in accordance with Drawing E9980.

AC power supply equipment of over 120V including HV switchgear, regulators, transformers etc. shall be housed in a separate room with separate external access.

Access to the power room shall be restricted to properly qualified and authorised Signals and Electrical staff.

Engine driven alternators shall be housed as in paragraph 11.2 of this Specification.

Signalling and Communications batteries shall be housed in a separate battery room or in a battery cupboard well ventilated to the outdoors, unless they are of a fully-sealed design requiring no ventilation.

Low voltage equipment including incoming surge protection panels, emergency changeover panels, battery chargers etc. may be mounted on the wall of the relay room adjacent to the AC power room and/or battery room or on free standing racks.

19.2 Alternative Housings for Power Supply Equipment

In sections of automatic signalling, where there is no central relay room provided, the signalling power supply equipment may be housed either in a self-contained building or else a more compact housing of suitable design.

Any such alternate housing shall be subject to specific approval, especially in relation to the following items:

a) Protection of the equipment from the elements, dust and vermin

b) Resistance to vandal attack

c) Service life of materials and construction; any special maintenance requirements

d) Free maintenance access

e) Ease of access to wiring, and ease of replacement of the equipment housed

f) Ease of installation of additional equipment

20. Disposition Of Equipment

All high and low-voltage control and supply equipment shall be housed in a room or enclosure, referred to in this document as the 'power room', separated from the signalling relay equipment room.

The power room shall house, at least, all equipment down to the 120 volt isolating / step-down transformers and any supply surge protection panels with open terminals.

Any 240 volt lighting and GPO supply circuit breakers should be housed, with the Council signalling supply breaker, in a distribution panel in the power room.

120 volt ECO panels may be located either in the power room or in the relay room adjacent to the switchboard.

Where the ECO is not mounted in the power room, the outgoing 120 volt Normal and Emergency transformer feeds shall be provided with isolating switches (non-tripping circuit breakers), to permit isolation of supply equipment by Electrical maintenance personnel.

21. Separation of Signalling and General Purpose Supplies

120 volt signalling supplies shall be isolated from other voltages by transformers as specified on Paragraph 9 of this Specification.

Where a 240 volts general purpose lighting and power circuit is derived from the 120 volt reliable supply, the 240 volt circuit shall be installed as an MEN circuit, with its own isolated earth and neutral link. The isolating transformer case and frame shall be bonded to the same earth. The MEN neutral link shall be made on the isolating transformer, from neutral connection to transformer frame, then to the earth electrode or to the Signalling Earth.

240 volts council supplies and derived general purpose supplies shall comply with AS 3000 and be subject to the applicable inspection requirements. The limit of compliance shall be at the 120 volt terminals of the isolating transformer.

22. APPENDICIES

22.1 APPENDIX 1 - STANDARD UNIT LOAD VALUES

120 Volt Unit Load Values for Power Distribution Calculations

Device	Load (va)
LED colour light	20
Train stop - electric	360
- electro-hydraulic	360
(For Train Stop VA calculation see para 6.3.3)	
Points machine - electric	1000
(For Point Machine VA calculation see para 6.3.3)	
Track feed AC	200
Track relay AC	120
Track feed DC	20
Track feed DC-AC immune	20
Transmitter CSEE	60
Receiver CSEE	30
Transmitter J-S	50
Rectifier - Store 74	750
Staff call light	100
Location light - incandescent	60
- fluorescent	40
(For Location Light see para 6.3.3)	
SSI - TFM (not including signal etc loads)	35
SSI - DLM	20

22.2 APPENDIX 2 - STANDARD CABLE RESISTANCES and PREFERRED CABLE SIZES for MAINS RETICULATION

Conductor Size mm ,	Normal Conductor Arrangement	Maximum Current	Voltage Drop mV/A.m (loop)	Conductor Resistance^{e} /Km at 20^{c}
1.5	7/0.50 *	15	29	13.3
2.5	1/1.78	20	18	7.14
4	7/0.85 *	25	11	4.52
6	7/1.04	32	7.5	3.02
10	7/1.35	50	4.5	1.79
16	7/1.70 *	63	2.8	1.13
25	19/1.35	80	1.6	.660
35	19/1.53	105	1.3	.514
50	19/1.78 *	125	0.96	.379
70	19/2.14	155	0.67	.262
95	37/1.78 *	210 #	0.54 #	.195
120	37/2.03	250 #	0.44 #	.150
150	37/2.25	280 #	0.38 #	.122
185	37/2.52	325 #	0.32 #	.0972

Notes:

a) Preferred cable sizes are marked with an asterisk (*)

b) Voltage drop values and maximum currents are taken from AS3000-1991, Table B2.

c) Current ratings are those applicable for single-phase circuits, protected by circuit breaker or HRC fuse, and enclosed in air.

d) Values marked (#) are taken from the selection chart for 0.6/1 kV PVC power cables published by Olex Cables.

e) Conductor resistance values are taken from AS3000-1986, Table B1.

22.3 APPENDIX 3 - AMENDMENTS TO RELATED SPECIFICATIONS

This Specification introduces a number of items, which require supporting amendments to other ARTC Signalling Specifications. The related documents affected will be amended under ARTC's ongoing standards development programme.

In the interim, until those documents are amended to suit, the following requirements shall apply. As each of the documents is amended, the relevant requirements listed below will lapse.

Document reference	Amended requirement
Spec	Definitions
SC 11200000 SP/1.4	*These changes are made to align the definitions of "extra low", "low" and "high" with those in AS3000.*
para 1.4.11	"extra low voltage" means not exceeding 32V ac or 115V dc.
para 1.4.12	"high voltage" means greater than low voltage
para 1.4.17	"low voltage" means exceeding extra low voltage, but not exceeding 1000V ac or 1500V dc
new para 1.4.x	"standard voltage" means voltage used for railway signalling purposes, up to nominal 120V ac.
new para 1.4.y	"extended voltage" means voltage used for railway signalling purposes, within the low voltage range but higher than standard voltage