AUSTRALIAN RAIL TRACK CORPORATION LTD

Discipline: **Engineering (Signalling)** **Category:** **Specification**

Signalling Power Systems

ESD-09-01

Applicability

ARTC Network Wide	✓	**RIC (NSW CRN)**	

Primary Source

SC 07 01

Document Status

Version	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
1.0	12 Oct 09	Standards	Signal Standards Engineer	Manager Standards	Exec Mgr Stds, Sys & Perf 12/10/2009

Amendment Record

Version	Date Reviewed	Clause	Description of Amendment
1.0	12 Oct 09		SC 07 01 v1.0 renumbered to reflect approved numbering scheme. References to other renumbered standards updated.

Contents

1 General

1.1 Scope

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.

Except as otherwise noted in the Particular Specification**,** all items of equipment and all materials required for installation shall be supplied and installed by the Contractor as part of any Contract.

This Specification shall be read in conjunction with all other relevant Signalling Standard Specifications referenced within this document and the Particular Specification.

1.2 Safety

The Contractor shall at all times ensure the safety of employees, not cause danger, delay, obstruction or stoppage to railway traffic and not interfere with the business of ARTC or its Operators.

The Contractor shall ensure that all staff working on the Contract including sub-contractors staff is appropriately accredited for work on or about Rail corridors in accordance with ARTC network Operational Safeworking requirements.

1.3 Occupational Health and Safety

The Contractors and sub-contractors, if any, shall comply with the relevant safety legislation of the Occupational Health and Safety Act.

1.4 Drawings

The documentation and drawings to be used in the execution of the works shall be the relevant approved Contractors drawings plus any other drawings nominated in the Particular Specification.

1.5 Definitions

In this document, the following definitions of terms shall apply:

ARTC – Australian Rail Track Corporation

Contractor – A person, company or authority nominated by ARTC or ARTC's primary contractor to manage a specific contract.

ARTC's Representative – A person, company or authority nominated by ARTC to make engineering determinations on ARTC's behalf.

1.6 Quality

The standard of materials and workmanship shall ensure that the installed system is fit for purpose, over the lifetime of the asset in its physical and operational environment, in terms of safety and reliability.

All material and equipment shall be manufactured and assembled to provide a minimum service life of 20 years when maintained and/or overhauled at the manufacturer's recommended intervals.

Quality of materials and workmanship shall be such that life cycle routine maintenance of the asset is minimised.

All material and equipment supplied to this specification shall be warranted free of defect in manufacture or assembly for a period of twenty four (24) months from delivery.

All of the equipment, including consumables, shall be warranted as complying with this or any referenced specification and as being fit for purpose.

1.7 Submissions for Approval

Where alternatives or new equipment types are proposed, the matter shall be submitted by the Contractor with documented justification in writing, in accordance with ARTC's PP122 acceptance process for "New Equipment and Systems" approval.

1.8 Referenced Documents

The following documents are referenced in this specification:

1.8.1 Australian Standards

AS1099.2Z/AD - Composite temperature/humidity cyclic test

AS2374 - Power transformers

AS3000 - SAA Wiring Rules

AS3100 - General requirements for electrical equipment

1.8.2 ARTC Specifications

ESC-11-01	Construction of Cable Route & Associated Civil Works
ESC-07-04	Install Equipment Racks & Termination of Cables & Wiring
ESC-07-03	Small Buildings, Location/Terminal & General Purpose Cases
ESC-09-02	Lightning and Surge Protection Requirements
ESA-11-01	Cables for Railway Signalling Applications – General Requirements

1.8.3 International Standards

DIN 41576/CEE

1.8.4 Drawings

N/A

1.9 Special Conditions

When working in the vicinity off or adjacent to overhead electrified areas Special Conditions shall apply.

2 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	Status
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
ESC-09-02	Earth electrode resistance	F/C
LEGEND	N/C Non-compliant with AS3000 F/C Fully compliant with AS3000	

3 Environmental Considerations

All equipment covered by this Specification shall be capable of continuous operation at its maximum ratings in the conditions and environment in which it is installed.

Enclosures and buildings must be designed to achieve these results through passive ventilation only, without reliance on mechanical cooling or air conditioning systems.

4 General Design Requirements, Power Supply Systems

4.1 General

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

4.2 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 can be obtained either from available Supply Authority grids, motor-alternator plant or, 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:

- Supply Authority normal, alternator standby
- Supply Authority normal, battery / inverter standby
- Supply Authority normal, battery 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.

4.3 AC Mains Supplies

4.3.1 Supply Authority Supplies

'Supply Authority' refers to mains provided by local electrical supply authorities.

These are available at the majority of locations across the ARTC Network. In some areas however, the cost of providing an extension from the nearest existing supply point may prove prohibitive, and an alternative source of power may be considered.

Provision of the appropriate switchboard and transformer is the responsibility of the party carrying out the installation. This switchboard shall be fitted with lightning/surge diverters. These lightning/surge diverters are to be rated in accordance with ESC-09-02 Lightning and Surge Protection Requirements and are to have local electrical supply authority approval.

4.3.2 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.

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.

4.3.3 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.

4.3.4 Uninterruptible Power Supply (UPS) Systems

Uninterruptible power supplies (UPS) shall be provided where a source of continuous AC power is required for loads which cannot 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.

4.3.5 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.

4.3.6 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.

4.4 DC Supplies – General

4.4.1 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 generally derived from the 120 volt mains by means of simple transformer- rectifier sets (unfiltered).

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 are generally 24 volt DC, full wave rectified, filtered.

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

4.4.2 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 bus-bar 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.

4.5 No-Break DC Supplies

A no-break supply shall be used to feed those circuits for which a momentary de-energisation would affect the operation of stick circuits resulting in unacceptable disruption to operations, requiring the time-out of time delay relays and the re-setting of routes.

The use of no-break supplies shall be provided only where the traffic density and operator workload is such as to produce an unacceptable number of train delays in the event of a power changeover.

The requirement or otherwise for No-Brake DC supplies will be as contained in the Signalling design and/or nominated in the Particular Specification.

4.5.1 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, 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.

4.5.2 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 may be used.

4.6 Battery Supplies

4.6.1 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 active Level Crossing installations. These are generally, high-reliability, long life batteries whose capacity is such that the level crossing equipment will operate correctly for at least 48 hours under normal operating conditions.

The normal rating used currently is 140 Ampere Hours (AH) for Flashing Light installations and 200AH for Flashing Lights and Boom Barriers.

Level crossing batteries can be:

- Nickel Cadmium
- High performance sealed gel cell

Chargers designed to match the particular batteries' operating requirements shall be provided in all cases.

General purpose 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 bus-bar.

4.6.2 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.

4.6.3 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.

4.6.4 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 suitable track feed rectifier set. This arrangement should only be used where a solar supply (Section 4.6.2) is considered unsuitable.

5 AC Mains Supply – Design

5.1 Provision of Supply

Where existing supply points are to be used these will be nominated in the Particular Specification.

Two independent power supplies are required at each supply point.

Wherever possible these will consist of a Normal Supply and Stand-by supply and be consistent with the arrangements identified in Section 4.2.

5.2 Existing Supply Points

Where existing supply points are to remain, the Contractor shall be responsible for carrying out any necessary supply upgrading work.

Where the existing power supply building or enclosure is too small or unsuitable, the Contractor shall be responsible for the provision of a new building and/or modifications to existing power enclosures.

5.3 New Supply Points

Where supplies are provided from Supply Authorities or other Grid Systems and unless otherwise stated in the Particular Specification, the Contractor 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 the required supplies available.

The Contractor shall make all the necessary arrangements for the provision of any supply required, and for its final inspection and connection by the relevant Supply Authority.

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

5.4 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 luminaries.

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

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

Where a 240 volt supply is unavailable, or not sufficiently reliable, the lighting circuit shall be supplied by 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.

6 AC Mains Supply – Distribution

6.1 General Requirements

Reticulation of Signalling AC supplies will normally be at 415volts or 120Volts AC unless specially authorised.

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 auto transformers 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 or ARTC's representative.

Cable route installation shall be in accordance with Specification ESC-11-01 'Construction of Cable Route and Associated Civil Works.

6.2 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 of 415 volts, run in accordance with the following principles may be permitted.

a) Signalling supply at all load points shall be nominal 120V.

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

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.

d) The 120 volt supply to each extended voltage mains shall be controlled by an individual two-pole circuit breaker. The circuit breaker shall have provision to be secured in the 'open' position while work is being carried out on the mains.

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 step-down 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 an orange coloured outer sheath.

6.3 Reticulation Design

This section sets the basic parameters for the design of power reticulation schemes for Signalling works carried out on ARTC's Network

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.

Not withstanding 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.

6.3.1 Definitions - Types of Loading

6.3.1.1 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.

6.3.1.2 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.

6.3.1.3 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.

6.3.2 Power System Loading

6.3.2.1 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.

6.3.2.2 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.

6.3.3 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.

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

6.3.3.1 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

6.3.3.2 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 that 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

6.3.4 Allowances

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

6.3.4.1 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.

6.3.4.2 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.

6.3.5 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.).

6.3.6 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.

6.3.7 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:

ARA Standard Specification "Cables for Signalling Applications – General Requirements"

6.4 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.

6.4.1 Voltage Drop Calculations

Two sets of voltage drop calculations shall be carried out, namely;

a) One for static loading conditions as defined in Section 6.3.3.1.

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

6.4.2 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 Section. 6.3.4.1.

6.4.3 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 turned 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) 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

6.4.4 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.

6.5 Mains Reticulation Design

The completed mains reticulation design shall include the following information:

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

b) Location loading sheets, showing the details listed in Section 6.3.2.

Voltage drop calculation sheets, showing how the estimated voltage drops was arrived at Section 6.3.6.

6.5.1 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:

6.5.1.1 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

Simplified distribution switching

Cable details:

a) Active and Common cables

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

c) Cable size in each section

d) Load location terminals.

6.5.1.2 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).

6.5.2 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.

7 Surge Protection

The Power Supply Systems and the equipment shall be provided with protection against lightning and high voltage surges in accordance with the ESC-09-02 ‘Lightning and Surge Protection Requirements’.

8 Mains Transformers

All transformers shall be of the double wound air-cooled type conforming to Australian Standard AS2374. Additionally all terminals shall be shrouded to prevent accidental contact.

9 Emergency Changeover Equipment (ECO)

9.1 ECO Panels - General

At locations where two independent mains supplies are available, an automatic emergency changeover panel system shall be installed by the Contractor.

At locations provided with engine driven alternators as standby supply, the changeover equipment shall be incorporated in the mains failure plant control panel.

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 10% below a predetermined level and return to normal supply when it is above the preset level.

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 the preset level 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, the ECO may be replaced with a suitable 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.

10 Mains Failure Plant (Engine Driven Alternators)

Where engine driven alternator sets are to be provided they shall include all control gear and automatic supply changeover equipment.

The preferred arrangement for engine-driven mains failure plant is that described as a 'portable' installation.

Any buildings constructed to house these units must conform to the requirements of ESC-07-03 ‘Small Buildings etc’.

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.

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 consistent with the requirements of ESC-07-03 ‘Small Buildings etc’.

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.

11 Switchboards

11.1 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 bus-bars

c) Remote AC submains

d) AC supply to each DC power supply unit

e) DC supply to each DC bus-bar

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 supply voltmeter (continuously metered).

b) 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 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.

11.2 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.

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.

11.3 Switchboard Facilities - 240 volt Supplies

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

12 Circuit Protection

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.

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.

Where fuses are used they shall provide visible indication of rupture wherever possible.

The required current rating of protection equipment shall not be obtained by connecting lower rated components in parallel e.g. circuit breakers, fuses, contacts etc.

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.

13 Circuit Breakers

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.

Where the Signalling load consists of numerous transformers 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 3) 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

Any circuit breakers which include thermal tripping will not be considered for use on Signalling supplies.

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.

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

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

14 Earthing Of Equipment

14.1 Earthing at Signalling Supply Locations

At each power supply location, a Signalling earth system shall be installed in accordance with Specification ESC-09-02 ‘Lightning and Surge Protection Requirements’

14.2 Earth Electrodes

Effective separation must be maintained between the Signalling Earth (S&CES), Council supply (MEN) earth (CE), ELD test earth, and any other earth system at the Signalling supply location.

For effective separation, a distance equal to at least twice the depth of the longer electrode must separate each earth electrode from any other earth electrode or earth conductor. This spacing requirement for the earth electrodes applies even though the Signalling earth may be bonded either directly or via a transient earth clamp to another earth system via the earthing bus-bars in accordance with. ESC-09-02 'Lightning and Surge Protection Requirements'.

14.3 Signalling Supplies

All 120 Volt AC Signalling supplies, and all DC supplies, must be kept strictly free of earths, to maintain circuit integrity and safety in the event of any individual earth fault on a supply bus-bar. This requirement is specifically noted as a departure from AS300 requirements.

14.4 Exposed Metal Racking

All relay racks and equipment cabinets shall be bonded to the Signalling earth with not less that 4mm2 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.

14.5 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 to a separate earth electrode.

15 Earth Leakage Detectors

Earth leakage detectors shall be installed on all vital Signalling supplies inclusive of the 50volt DC supply. 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 bus-bar 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.

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 - i.e. 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 Alarms and Indications

16.1 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 main Control Centre console.

16.2 Alarm Indications - General

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

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

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.

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.

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.

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.

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

16.3 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 also be provided for those.

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

Location	Indication	LED Bezel Colour	Relay
(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
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 Supply to ECO available	Green	------
	AC Emergency Supply to ECO available	Green	------
	AC Load Supply ex ECO available	Green	------
	AC Bus bar Supply Available (each Int, Ext, Points supply)	Green	------
	120 v Supplies available	------	3 C/O
	DC Bus bar Supply Available (Each B24, B50, Int, Ext bulbar)	Green	------
	DC Supplies available (24v, 50v Int, Ext separately)		3 C/O
	DC Supply Unit Channel fail (Each B24, B50, Int, Ext bulbar)	Yellow	
	AC bus bar supply lost	Red	
	DC bus bar supply lost	Red	
	Battery Charger Output Fail (not loss of AC) (each battery supply)	Yellow	
	AC Emergency 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.

Indicating lamps shall give clear and unambiguous indications under their normal ambient lighting.

17 Housings

17.1 General

Multiroom buildings built at power supply locations shall conform to ESC-07-03 “Small Buildings etc”.

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 staff.

Engine driven alternators shall be housed to conform with Section 10.0 of this Specification and ESC-07-03 “Small Buildings etc”.

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 conforming with

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.

17.2 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 conform to ESC-07-03 ‘Small Buildings etc’ and take into particular account 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

18 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 Supply Authority 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.

19 Separation of Signalling and General Purpose Supplies

120 volt Signalling supplies shall be isolated from other voltages by means of transformers.

Where a 240 volt 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.

240 volts Supply Authority 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.

20 Appendix 1: Standard Unit Load Values

120 Volt Unit Load Values for Power Distribution Calculations

Device	Load (va)
Colour light signal (1 head)	40
Colour light signal (2 head)	80
Low speed light	40
Shunt light	40
Marker light	40
'Band of Lights'	120
Stencil route indicator	60
Multi-lamp route indicator	200
Dwarf position light	120
Shunt, colour light	120
Guards indicator	40
Points machine – electric	1000
(For Point Machine VA calculation see paragraph 6.3.3)	
Track feed DC	20
Track feed DC-AC immune	20
Transmitter CSEE	60
Receiver CSEE	30
Transmitter Jeumont Schnider	50
Rectifier – Typical Level Crossing	750
Staff call light	100
Location light - incandescent	60
- fluorescent	40
(For Location Light see paragraph 6.3.3)	

21 Appendix 2: Standard Cable Resistances and Preferred Cables Sizes for Main Reticulation

Conductor Size mm	Normal Conductor Arrangement	Maximum Current	Voltage Drop mV/A.m (loop)	Conductor Resistance/Km at 20
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 #	0.972

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 0.6/1kV PVC power cables published by Olex Cables.

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

22 Items to be specified in the Particular Specification

Items to be specified in the Particular Specification shall include but is not limited to:

1) 1.1
2) 1.4
3) 4.5
4) 5.1
5) 5.3
6) 11.1