ROADS AND MARITIME SERVICES

TRAFFIC SYSTEMS

SPECIFICATION NO. TSI-SP-016

GENERAL REQUIREMENTS FOR OUTDOOR ELECTRONIC EQUIPMENT

Issue: 2.0
Dated: 30/03/2017
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## RECORD OF AMENDMENTS

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1 PRELIMINARIES

1.1 Scope

This specification covers general requirements related to the design, construction and manufacture, including overall quality and reliability, of electronic equipment for outdoor use in association with roads, bridges, tunnels and other road transport infrastructures in the State of New South Wales.

NOTE: Equipment covered by this Specification includes electronic road signs, traffic control, monitoring and management equipment, and intelligent transport system (ITS) equipment, and their associated communication equipment.

This specification also covers commercial off the shelf (COTS) electronic equipment supplied as components of intelligent transport systems intended for road transport infrastructures.

NOTE: Refer to Clause 1.5 for definition for COTS equipment.

NOTE: Requirements applicable to COTS electronic equipment are covered in Section 6.

This specification is intended to be used only as a reference document to other RMS ITS or traffic related equipment specifications that explicitly make reference to this specification, and in the manner the references are made. This specification shall always be read in conjunction with these referencing documents (known as dedicated equipment specifications).

If this specification is referenced in a general way, rather than from an equipment specification (e.g. only as a general standard referenced by or included in a contract), then the contents of this specification shall be assessed by the Contractor for applicability to the equipment. This assessment shall be on a clause-by-clause basis with acceptable justification provided subject to approval by the RMS Representative.

NOTE: Manufacturers and/or suppliers are expected to demonstrate that their equipment is fit for purpose. RMS QA Specifications TS201 and TS202 provide guidance on the approval of equipment for generic use or specific project applications respectively.

1.2 Precedence

In the event of any conflict between this Specification and other referenced specifications and standards, the order of precedence shall be as follows:

(a) The dedicated equipment specification, or other referencing documents (known as Referencing Specifications);

(b) This Specification;

(c) Standards referenced by this Specification.
1.3 Application

This Specification is intended to be used as a supplement to dedicated equipment specifications and requirements documents, and sets out the technical requirements for the following:

(a) Design, reliability and durability;
(b) Minimum quality of components;
(c) Workmanship and quality assurance of printed circuit boards and electronic assemblies;
(d) Test procedures, including environmental tests;
(e) Pre-delivery inspection;
(f) Documentation.

1.4 Standards and Specifications

1.4.1 National and International Standards

This Specification calls up Australian and international Standards that are listed in Appendix A.

The equipment shall be designed and manufactured to comply with relevant standards. The order of precedence for standards is as follows:

(a) Australian Standards;
(b) IEC, ISO and ITU-T Standards;
(c) ANSI, IPC, and UL Standards;
(d) Any other standards referred to.

1.4.2 Specifications

This document is to be read in association with the following specifications:

(a) The dedicated equipment specification;
(b) Other applicable Referencing Specifications.

1.4.3 Regulations

Equipment, including components and assemblies, shall comply with all applicable statutory requirements affecting the design, construction and operation of the equipment.

1.5 Definitions and Glossary of Terms

a.c. – Alternating current
ACMA – Australian Communications and Media Authority

ANSI – American National Standards Institute

approval – Where stipulated in this Specification, approval shall be sought by the Supplier in writing from the RMS Representative, unless the context explicitly refers to approval by or from another authority

approved – Means approval has been duly sought, and has been given in writing by the RMS Representative, unless the context explicitly refers to approval by or from another authority

cabling – This category includes cabling that is separate from modules such as inter-module cables, and wiring between other components, such as transformers

CD ROM – Compact Disc Read-Only-Memory

components – Means the discrete devices forming part of the equipment. They include electronic components such as resistors, transistors and integrated circuits, and mechanical components such as fasteners

Contract, or the Contract – The contract that uses this Specification as a specification for the contract

Contractor – The contractor of the contract under which this Specification is a part of the contract document

COTS – Commercial off the shelf

COTS equipment – Equipment that is commercially available, self-contained and operating independently of other equipment, and with which the Supplier and Contractor has no association other than as a buyer of the equipment

custom-designed equipment – Equipment designed to RMS requirement(s)

d.c. – Direct current

dedicated equipment specification – The main RMS equipment specification applicable to the equipment and to which this Specification is supplementary

A dedicated equipment specification is also a Referencing Specification

DIN – The German Institute for Standardization

electronic equipment – Means equipment that incorporates one or more electronic device or component;

Also known as electronics equipment.

electronics equipment – Means electronic equipment

ELV – Extra-low voltage, as defined in AS/NZS 60950.1

ESD – Electrostatic discharge
failure – Inability to perform the function(s) required
hazardous voltage – Means a voltage that meets the definition for hazardous voltage in AS/NZS 60950.1
IC – Integrated circuit
IEC – International Electrotechnical Commission
IEEE – The Institute of Electrical and Electronics Engineers
IPC – The Institute for Interconnecting and Packaging Electronic Circuits
ISO – International Standards Organisation
ITS – Intelligent transport system; also known as intelligent transportation system
ITU-T – International Telecommunication Union – Telecommunications Division
LED – Light emitting diode
LV – Low voltage (as defined in AS/NZS 3000)
manufacturer – The manufacturer of equipment covered by or under this Specification
module – A removable assembly of components which may comprise a single printed circuit board, or a cluster of boards, contained within a single chassis
MTBF – Mean Time Between Failures
natural failure voltage – The on-load voltage of a secondary battery below which further discharge of the battery may damage the battery and shorten its service life
NSW – New South Wales
PCB – Printed circuit board
PIDG – Pre-insulated double grip
PROM – Programmable Read Only Memory
RCM – Regulatory Compliance Mark (administered by ACMA)
Referencing Specification – The document or specification that is applicable to the contract works and stipulates or requires compliance with this Specification (TSI-SP-016) in full or in part
reliability – The probability that the function(s) will be performed for the period in question, or when required for one-shot functions
RMS – Roads and Maritime Services, which is a New South Wales Government agency
RMS Representative – The person appointed by Roads and Maritime Services to carry responsibility on behalf of Roads and Maritime Services for the execution of the Contract
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoHS Directive</td>
<td>The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC made by the European Union</td>
</tr>
<tr>
<td>this Specification</td>
<td>Means Specification TSI-SP-016</td>
</tr>
<tr>
<td>Supplier</td>
<td>The supplier of equipment covered by or under this Specification; Where the supply of equipment is under a contract, it means the contractor of the contract.</td>
</tr>
<tr>
<td>TIA</td>
<td>Telecommunications Industry Association</td>
</tr>
<tr>
<td>UL</td>
<td>Underwriters Laboratories</td>
</tr>
<tr>
<td>USB</td>
<td>Universal Serial Bus</td>
</tr>
<tr>
<td>UV-A</td>
<td>Near ultraviolet radiation with wavelength in the region 315 nm - 400 nm</td>
</tr>
<tr>
<td>UV-B</td>
<td>Mid ultraviolet radiation with wavelength in the region 280 nm - 315 nm</td>
</tr>
</tbody>
</table>
2 ENVIRONMENTAL REQUIREMENTS

2.1 General

The equipment shall, without any further manual adjustment after initial commissioning, give the specified performance, design life and durability with any combination of power supply voltage, temperature, or humidity herein specified.

The environment in which the equipment will operate is generally of extreme temperatures, dusty, and with both high and low humidity and corrosive airborne substances.

The design of the equipment shall be such that the constituent components and assemblies operate within the environmental limits of voltage, frequency, temperature and humidity set by the following parties:

(a) The component manufacturer; and

(b) As nominated in this Specification, subject to explicit alternative limits specified in the dedicated equipment specification.

NOTE: Refer to Clause 1.5 for definition for dedicated equipment specification.

Where equipment is mounted on structures or in any way subject to vibration or shock, measures to mitigate the possible resultant induced mechanical failure shall be included in the design, manufacture and construction of the equipment.

2.2 Ambient Conditions

The minimum requirements for the equipment shall be as shown in Table 2.2

<table>
<thead>
<tr>
<th>Condition</th>
<th>Range</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperatures - General</td>
<td>-10°C to 55°C</td>
<td>Operation within Specification</td>
</tr>
<tr>
<td></td>
<td>-15°C to 60°C</td>
<td>Operation without malfunction or damage</td>
</tr>
<tr>
<td>Operating temperatures – Special equipment</td>
<td>-15°C to 70°C</td>
<td>Operation within Specification</td>
</tr>
<tr>
<td>(see NOTE 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperatures (see NOTE 2)</td>
<td>-20°C to 70°C</td>
<td>Storage without adverse effect</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Up to 98% within the temperature range 5°C to 55°C</td>
<td>Operation within Specification</td>
</tr>
<tr>
<td>Dust and rain (see NOTE 3)</td>
<td>Driving dust and rain at regional design wind speed</td>
<td>Operation without malfunction or damage</td>
</tr>
</tbody>
</table>
Wind | Regional design wind velocity and gusts as per AS/NZS 1170.2 | Operation without malfunction, damage or any permanent physical misalignment; and also without any dynamic physical misalignment greater than the maximum permitted value

NOTE (1): Special equipment is equipment that has been identified as such in the dedicated equipment specification that makes reference to this Specification for operating temperature requirements.

NOTE (2): Storage may not be always in a warehouse environment. Spares are routinely transported to sites in vehicles where temperatures may be raised.

NOTE (3): This requirement applies only to equipment that is directly exposed to the environment.

[Drafting Note: Table 2.2 has been changed as shown above by removing “insolation” requirement and changing “free air temperature” to “operating temperature”. With these changes, compliance testing is simplified by doing a standard ‘temperature with the specified humidity’ endurance test, instead of a combined temperature, humidity and insolation test.]

### 2.3 Atmospheric Pollutants

Adequate anti-corrosion measures shall be taken in the design of the equipment so that the equipment is suitable for use in fume and salt laden atmospheres over the design life. In particular the equipment shall tolerate continuous exposure to high levels of motor vehicle exhaust gases, and salt laden atmospheres as found in coastal environments.

Atmospheric pollutants and typical values for their concentrations are indicated in Table 2.3 that was compiled from information supplied by the NSW Pollution Control Commission:

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total suspended Particles 30-50 µm</td>
<td>23 – 300 µm/m³</td>
</tr>
<tr>
<td>Dust deposit &gt;30 µm</td>
<td>0.5 – 5 g/m²/month</td>
</tr>
<tr>
<td>Sulphur Dioxide</td>
<td>0.005 – 0.05 ppm (vol)</td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>0.001 – 0.3 ppm (vol)</td>
</tr>
<tr>
<td>Hydrogen Sulphide</td>
<td>0.001 – 0.02 ppm (vol)</td>
</tr>
<tr>
<td>Airborne salt (NaCl) deposited</td>
<td>2 – 30 g/m²/month</td>
</tr>
</tbody>
</table>
2.4 Power Supply Conditions

2.4.1 General

Unless otherwise specified in the dedicated equipment specification, the prime power supply to the equipment shall be the mains supply as nominated in Clause 2.4.2.

2.4.2 Mains Powered Equipment

Mains powered equipment shall operate from a nominal 230 V 50 Hz supply.
The equipment shall operate correctly and reliably within specification over the voltage range 216 – 264 V r.m.s. and for any variations in frequency in the range 48 – 52 Hz.
The equipment shall not be damaged by mains supply voltages over the range 0 – 280 V r.m.s. and for any variations of frequency in the range 45 – 55 Hz.

2.4.3 Battery Powered Equipment

Battery powered equipment shall operate within specification between the upper voltage limit when the battery is on-charge and fully charged, and the lower limit set by the natural failure voltage of the battery specified by the battery manufacturer.
Battery powered equipment shall not be damaged by battery voltages from 0 V (zero volt) to the nominal battery voltage plus 25%.
Battery powered equipment shall be protected against reversal of the polarity of the supply voltage.

NOTE: Refer to Clause 4.15 for requirements for batteries.

2.5 Shock and Vibration

2.5.1 Shock

All removable sub-assemblies, in an unpacked condition, shall be capable of withstanding the bump test to AS 60068.2.29 Eb with severity 1000 bumps acceleration 10g (98 m/s²) with a pulse duration of 16 ms.

2.5.2 Module Mounting

The mounting of modules and sub-assemblies shall be of sufficient strength to prevent permanent distortion during handling and transport. Tests, if applicable, will be nominated in the dedicated equipment specification.

2.5.3 Vibration

Equipment for some applications may be subject to tests for compliance with AS 60068.2.6 Test Fc Vibration (Sinusoidal). The severity of the test will be nominated in the dedicated equipment specification.
2.6 Electromagnetic Compatibility

2.6.1 Immunity to Surges and Electromagnetic Radiation

The equipment shall comply with AS/NZS 61000.6.1 as a minimum if no relevant product or product family EMC immunity standard exists.

The equipment shall provide immunity to the following:

(a) Electrostatic discharge;
(b) Fast transients on the mains supply;
(c) Surges on the mains supply;
(d) Radiated radio frequencies;
(e) Conducted radio frequencies;
(f) Voltage dips, short interruptions and voltage variations;
(g) Power frequency magnetic fields (where applicable);
(h) Radio disturbances (where applicable).

Unless otherwise specified in the dedicated equipment specification, the respective performance criterion for these immunity items in AS/NZS 61000.6.1 shall be used.

2.6.2 Electromagnetic Emissions

The equipment shall be provided with radio interference suppression to comply with the ACMA’s Electromagnetic Compatibility (EMC) regulatory arrangement under the Radiocommunications Act 1992.

NOTE: Refer to the ACMA document “ACMA mandated EMC standards” (dated 4 July 2016, at the time of release of this version of Specification TSI-SP-016), which lists the mandatory standards under section 162 of the Radiocommunicaitons Act 1992.

The generic standards that apply to equipment not covered in Part 2 of this ACMA document are stated in Part 1 of the document. For equipment intended for use in a residential, commercial, or light industrial environment, the Australian standard applicable is noted to be AS/NZS 61000.6.3 at the time of release of this version of Specification TSI-SP-016.

Equipment designed to emit electromagnetic radiation shall be fitted with screens and safety devices to prevent operator exposure to radiation levels in excess of those nominated in AS/NZS 2772.

2.7 Wind Loading

Unless otherwise stated in the dedicated equipment specification, the complete equipment, including all mounting brackets and provisions, shall have adequate strength and rigidity for the wind loading conditions set down in AS/NZS 1170.2 for Terrain Category 1.5, Region B.
2.8 Environment Protection

2.8.1 General

The design, composition and manufacture of the equipment shall be such that there is no or minimal risk to health and the environment relating to the manufacture, transportation, use, operation, maintenance, collection, treatment, recycling and disposal of the equipment. For the purpose of this requirement, the requirements in this clause (Clause 2.8) shall be considered as minimum.

Where required by the RMS Representative, the Supplier shall provide documentation (e.g. certificates, test reports) to substantiate compliance with the requirements in this clause.

2.8.2 Hazardous Substances

The equipment shall not contain an unsafe amount of hazardous substances in any part of the equipment subject to technical and economic feasibility. For the purpose of this requirement, established international and regional standards, practices and limits shall apply.


2.9 Condensation

Adequate anti-condensation measures shall be taken in the design of the equipment, and any requirements for mounting, so that the equipment is not adversely affected by the build-up of condensate within the enclosure housing the equipment, or within the equipment itself.
3 EQUIPMENT CONSTRUCTION

3.1 Mechanical Protection

All equipment, including parts and components, shall be adequately protected against incursion of vermin, termites and insects, and incursion of dust and moisture which may affect performance.

All equipment shall be supplied with an external finish suitably treated and coated or plated to inhibit rust and corrosion in the environmental conditions stated in Section 2.

3.2 Susceptibility to Vandalism

In general, the exterior of the equipment housing shall be designed to resist or discourage vandalism, avoiding openings and features that offer break-in or leverage points.

Particular attention shall be given to the design of equipment housings to preclude, or otherwise minimise the effects of, the following:

(a) Forcibly opening the access door;
(b) Opening the access door(s) by simple tools or implements, such as by screwdrivers or pliers, or similar common tools being used to open the door locks or part of the hinges;
(c) Forcibly pushing the housing from its mountings; and
(d) Damage to the housing or door or mounting base by kicking or pushing.

3.3 Dissimilar Materials

All metallic parts, including screws, nuts and washers, shall be plated or manufactured of material such that dissimilar metals in contact shall have an electro-chemical potential difference not exceeding 0.5 V.

Where this condition cannot be met, an alternative design that eliminates this condition shall be provided.

3.4 Use of Fire-Resistant Materials

Materials and components used in the equipment shall be selected so as to minimise the risk of fire. In this respect the requirements for resistance to heat and fire in AS/NZS 3100 shall apply.

The exterior parts of housings shall use materials which are inherently fire-resistant.

Fire resistant materials shall be non-toxic and halogen free.
4 EQUIPMENT DESIGN

4.1 Reliability and Maintainability

4.1.1 General Requirements

In many cases, public safety depends on the efficient and reliable operation of equipment manufactured under this Specification. A high standard of reliability and fail-safe operation over the specified life of the equipment shall be provided for the equipment.

The Supplier shall ensure that the equipment meets the general objectives implied in this clause. Unless specified otherwise in the Contract or project deed, all equipment shall be designed for a minimum life of 15 years of reliable operation, subject to the replacement or maintenance of identified parts on a regular or as required basis.

Electro-mechanical parts that are required for frequent or continuous operation, such as ventilation fans and magnetic disc drives, shall not be used in roadside or remote environments.

4.1.2 Design Life

The equipment shall provide a minimum useful design life of 15 years unless specified otherwise in the dedicated equipment specification.

Choice of components, technology and solution direction shall reflect this design requirement.

4.1.3 Reliability

The dedicated equipment specification will define the target. Where the dedicated equipment specification does not, the equipment supplier shall define what constitutes failure. In the absence of any definitions, any defect shall be considered a failure.

For COTS equipment, the Contractor/Supplier shall provide MTBF calculations or historical reliability records from the equipment manufacturer/supplier in support of a claim of compliance.

For custom-designed equipment, the Contractor/Supplier shall provide MTBF calculations that are based on component failure rates and/or other relevant data in support of a claim of reliability performance.

Dedicated equipment specifications may provide for primary functions which are used less often, but require greater reliability in addition to secondary functions which have higher usage requirements with a lesser reliability requirement.

4.1.4 Maintainability

The equipment should be designed to minimise the impact of maintenance tasks. Consideration should be given to the provision of facilities to aid technicians in the detection, diagnosis and repair of failures.

Equipment suppliers shall provide detailed fault diagnosis, either automatic or using manuals, and fault correction instructions. Preventive maintenance activities required to
ensure that the equipment remains in a fully operational state shall be clearly identified in the maintenance manual.

Specific maintenance design criteria that should be considered are:

(a) ease of access for all maintenance tasks, including minimisation of need to remove any item to access a defective part (see Clause 4.2);
(b) minimise the complexity of maintenance (corrective and preventive) tasks;
(c) minimise the frequency of preventive maintenance dictated by design;
(d) minimise the maintenance support costs;
(e) minimise the maintenance personnel skill requirements;
(f) minimise the potential for maintenance errors;
(g) elimination of need for specialised physical tools;
(h) provide continuous monitoring of circuits, input and outputs to provide for early indication of faults/failures;
(i) provide for ease of access and changeability of replaceable items.

4.1.4.1 Spares

The Contractor or equipment suppliers shall clearly identify all items that can be replaced in the field. Clear, unambiguous and complete instructions for the replacement process shall be given in the maintenance manual.

For any item that can be repaired in the field clear, unambiguous and complete instructions for the repair process shall be given in the maintenance manual.

For items that are to be replaced in the field, the Contractor or equipment supplier shall clearly define whether the item can be:

(a) repaired in a workshop (instructions for repair shall be provided in the equipment manuals), or

(b) returned to the equipment supplier for repair (instructions on information to be provided with defective item shall be provided in the equipment manuals).

4.2 Equipment Layout and General Arrangement

4.2.1 General

Equipment layout within a roadside housing shall be designed for ease of access during operation, maintenance and service. Access to individual modules shall be provided for replacement of the module without the need for removing other components or wiring. The access to and replacement of modules shall not require the removal of fasteners that are not reusable.

4.2.2 Ergonomic Factors

The equipment design and construction shall take account of ergonomic factors relating to operation, and maintenance and operator safety.
Where applicable the equipment shall comply with AS 1470. Equipment designed for extended periods of use by operators, e.g. control panels or communications facilities, shall take account of industry standards for ergonomic design.

### 4.3 Electrical Stability

The equipment shall remain electrically stable and operate within specification when subassemblies, circuit cards or modules are mounted on extension units or when covers have been removed to gain access for adjustments.

### 4.4 Power Consumption

The equipment shall be designed such that it achieves the highest electrical efficiency and lowest power consumption commensurate with its required functions.

Where alternative technologies could be used, preference shall be given to the compliant technology that provides acceptable performance and reliability with matching low power supply demand.

Equipment suppliers shall declare the power consumption figures (i.e. VA and power factor values) for their equipment, where appropriate, as follows:

(a) Operating – no load;
(b) Operating – half load;
(c) Operating – full load.

Where equipment configuration differs depending on purchasers’ particular requirements, power consumption figures shall be provided for each standard supply configuration as defined in the dedicated equipment specification.

### 4.5 Cooling

Heat radiating devices shall be adequately spaced from printed circuit boards and other parts liable to suffer damage from heat.

All devices shall be mounted so as to promote maximum air circulation.

Air-conditioners, fans and similar electro-mechanical devices shall not be required for cooling.

### 4.6 Acoustic Noise

#### 4.6.1 Complete Equipment

The peak noise level emitted in any direction shall not exceed 40 dB(A) when measured at a distance of 5 m from the equipment under free-field (anechoic) conditions. The measuring equipment shall be set for fast response.

#### 4.6.2 Power Converters

Power supplies (e.g. d.c. to d.c. converters) and similar devices shall operate at inaudible frequencies.
4.7 Electrical Safety

4.7.1 General

The equipment shall comply with the relevant electrical safety provisions of AS/NZS 3000, AS/NZS 3100, AS/NZS 60950.1 and the requirements of the NSW Work Health and Safety Act as applicable.

Suitable protection shall be provided to preclude accidental contact of live parts by personnel engaged in operation or maintenance of the equipment.

Prominent warning labels and Danger signs complying with AS 1319 shall be affixed at appropriate locations on and within the equipment to provide warning about the presence of hazardous voltages.

NOTE: Refer to Clause 1.5 for the definition for hazardous voltage.

4.7.2 Printed Circuit Boards

Protection from contacts with hazardous voltages shall be provided on printed circuit boards where a hazardous voltage is present.

A prominent and durable warning notice(s)/label(s) shall be affixed on or adjacent to semiconductor devices and/or their heat-sinks in all cases where the heat-sink or device casing is not at chassis potential.

4.8 Fasteners

4.8.1 Reusable Fasteners

A durable combination of reusable fasteners shall be used for all applications in which parts may be separated for inspection, test, repair, replacement or to gain access to other parts.

Threaded fasteners shall not be used with tapped holes in plastic materials unless the material is graded to support this long-term use.

Thread cutting screws shall not be used to tap into sheet metal with thickness less than 3 mm.

4.8.2 Lubrication and Locking

When fasteners rely on tapped holes in metal castings, the threads shall be coated with a suitable sealant, unless the fastener is intended to be permanently locked in position, when a suitable compound may be used.

4.9 Surface Temperature

Unless otherwise specified, all components and devices shall be rated so that the maximum surface temperature of any external part of the equipment subject to handling does not exceed 15°C above ambient.
4.10 Modules

4.10.1 Module Replacement

Modules and circuit boards intended for field replacement shall be securely held in position, but should also be capable of removal or replacement by technical personnel without a need for special tools.

Normally modules and circuit boards should be incapable of being replaced or inserted into incorrect positions, and mating connectors shall be polarised accordingly. Where correct placement cannot be assured, electrical connections shall be arranged so as to prevent damage to any part of the equipment, if modules are plugged into incorrect positions.

4.10.2 Module Removal

It shall not be necessary to disturb permanent wiring, or soldered or crimped connections to remove any plug-in module or circuit board.

4.10.3 Module Mounting

Circuit boards and modules shall be supported to prevent harmful distortion and to allow the removal of plug-connected components without stressing either components or wiring.

Plug-in boards and modules are to be constructed to avoid damaging strain on components when inserted or removed from the rack or housing. Mounting shall be such that, under conditions of vibration and shock normally encountered, there is minimal flexing of the modules or circuit boards. Any such expected flexing shall not cause damage to the modules or circuit boards.

All plug-in units that are intended for removal and installation by the user (e.g. RMS) shall have suitable provision for their removal and reinstallation. Insulated guides to tracks shall be provided to ensure that the plug-in units are securely retained in and aligned with the mating sockets. Unless otherwise specified in the dedicated equipment specification, all plug-in units shall be provided with a retaining device or equivalent means to ensure that the connector cannot disengage in normal service.

4.11 Power Cabling

4.11.1 Rating

All mains voltage wiring shall have minimum ratings in accordance with AS/NZS 3000.

4.11.2 Segregation

Adequate separation shall be maintained between LV and ELV wiring such that it complies with AS/NZS 3000. All wiring shall be supported or retained in such a manner that a dislodged conductor in either circuit cannot bridge into other power or electronic circuits.

Segregation/separation of LV wiring and communications cables shall comply with AS/ACIF S009.
4.12 Electronic Cabling

4.12.1 Flexible Wiring

Conductors of flexible wiring shall have no fewer than seven strands and no strand shall be larger than 0.3mm diameter, and shall comply with AS/NZS 1125.

Flexible wiring enclosed in a sheath shall be used wherever cable forms are to flex in operation or maintenance.

4.12.2 Support

All wiring shall be organised such that there is no undue stress on the on any electrical connection.

The point of entry to wander leads shall provide a smooth, flexible and insulated lead-in and flexible cables shall be all securely anchored at the points of entry.

Adhesive-mounted cable supports shall not be used.

4.12.3 Protection

Edges against which cables might come into contact with shall be protected by grommets or other form of fixed insulation.

Cable forms shall not exert pressure against any unprotected edge of metal equipment when in normal use.

4.12.4 Insulation Displacement

The use of insulation displacement terminations is not encouraged, and each specific application shall be clearly identified in equipment technical information supplied for approval.

Where wires are to be terminated by insulation displacement, the type and thickness of insulation and wire dimension shall conform to the specification for the terminating device. Connectors shall be of a type that provides strain-relief. The termination shall not be less than 10mm from the cut end of the cable.

Wires shall only be terminated using tools and techniques recommended by the original manufacturer.

4.12.5 Provision for Re-termination

Sufficient slack cable shall be provided at each terminating point to allow the cable to be re-terminated twice.

4.12.6 Cable Lugs

Where more than one lug is clamped at a terminal point, the lugs shall be of similar size and mechanically compatible to ensure that all the lugs are held equally securely.

A maximum of two separate cables may be terminated in a single lug, and only provided that the following conditions are met:
(a) The lug is designed to accommodate two conductors; and
(b) The two cables are of the same gauge and number of strands.

4.12.7 Cable Core and Wire Identification

The requirement of this clause shall apply to wiring between modules of equipment, modules to terminal strips and connectors, and modules to indicators and control devices.

All such individual wiring and cables shall each be labelled with durable wire and cable ferrules with colour coded numbers. Each wire or cable core shall be labelled at both ends of the run. Where cable cores are colour coded (e.g. ribbon cables) and are terminated on the same multi-terminal connector or terminal strip, it is acceptable for core ferrules to be applied only to a number of cores provided that all cores are properly and clearly colour-coded and the colour-coding scheme used is logical and detailed in both the installation and maintenance manuals.

4.13 Terminals and Connectors

4.13.1 General

It shall not be possible to mate a connector into an incorrect socket. Connectors of different types or sizes, or connectors with polarizing barriers, shall be used in places where there is possibility of confusion with the correct mating position.

All connectors shall be rated for a minimum of 500 insertion-withdrawal cycles.

Where normally unused connectors are provided on the external surfaces for assemblies, these shall be protected by suitable covers.

4.13.2 Low Voltage (LV) Connectors

LV multi-pin connectors shall be of a polarized type capable of being readily locked or clipped in position. All pin and socket inserts in each connector shall be individually self-aligning.

The connector pins shall be rated for continuous operation for the maximum peak currents that will pass through them, and with a minimum rating not less than 500 V a.c., 5 A.

The connectors shall provide adequate sealing against the ingress of dust.

External connectors shall be weatherproof.

The plug or socket section attached to a wander-cable shall be of a type that firmly clamps the cable other than by its electrical connections.

Metallic casing of both plug and socket sections shall be earthed to a special earth pin in the connector in accordance with AS/NZS 3000.

LV and ELV circuits shall not be taken through common connectors unless all wiring insulation is at LV standards.
4.13.3 Extra Low Voltage (ELV) Connectors

4.13.3.1 General
The mating contacts of all connectors operating at extra low voltage (ELV) level shall be gold plated over nickel with a minimum of 0.7 µm thickness of gold.

ELV and LV circuits shall not be taken through common connectors unless these connectors, and all connections to them including wires and circuit tracks are rated at LV standards.

4.13.3.2 DTE/DCE Type
Where 9-pin, 15-pin, 25-pin and 37-pin, D Type connectors are used, these shall be of the type specified in IEC 60807-3, ISO 4903, AS 2748 and ISO 4902 respectively.

4.13.3.3 Printed Board
Printed circuit boards interconnections to other PCBs and/or back panels shall be provided to ensure ease and speed of module replacement, at the level of replacement identified in the maintenance manual. This would generally suggest the use of two-piece PCB connector sets.

4.13.4 IC Sockets
Preference should be given to integrated circuit devices without mounting sockets. Refer to Clause 5.10.1.2 for requirements for direct soldering of certain semiconductors into printed-circuit boards.

Where IC sockets are used, all mating contact areas of the sockets shall be gold plated over nickel with a minimum of 0.7 µm thickness of gold.

4.13.5 Terminals for the Connection of External Wiring

4.13.5.1 Terminals for Incoming Mains Supply
Where connection to incoming mains (grid) supply is required, appropriate terminals compliant with AS/NZS 3000 shall be provided.

4.13.5.2 Terminals for Field Wiring
Unless otherwise specified, terminals for the connection of external field wiring shall be of the rail-mounted, screw clamp types with spring-loading. The voltage rating shall be not less than 500 V r.m.s. and the continuous current rating shall be not less than 30 A r.m.s.

All terminals for field wiring shall be capable of accepting conductors with cross-sectional areas from 0.5 mm² to 4 mm².

The terminals shall be designed to accept PIDG crimp type lip-blade terminal lugs.

Each terminal shall be clearly and indelibly identified.

The terminal assembly shall be arranged in the following manners:

(a) The connecting cables can be formed in a neat manner,
(b) The individual conductors can be connected or disconnected without disturbing other connections;

(c) The cables do not obscure the terminal identification.

4.14 Interfaces

Wherever equipment incorporates internal or external interfaces between differing technologies for which there are either national or international standards (e.g. ITU-T, TIA, IEEE), these standards shall be used. Examples of such situations include the connection of telecommunication lines, test equipment, or radio equipment, with either analogue or digital circuits.

4.15 Integral Batteries for Support of Mains Powered Equipment

Integral batteries for the purpose of this Specification shall be defined as batteries built into the equipment to provide support of the volatile functions stated in this clause.

The use of integral batteries is not preferred and is permitted only where the battery used is suitable for the required environmental conditions for the equipment.

NOTE: The use of high capacity capacitors (also known as supercapacitors) that are provided with appropriate external equalisation and current limiting is preferred over integral batteries due to the former’s wider operating temperature range and longer service life. Refer to Clause 5.8 for requirements for capacitors.

The use of integral batteries shall be restricted to the support of essential but otherwise volatile functions which must be retained for operation of the equipment, but would otherwise be lost by power failure or board removal. These functions include real-time clocks and battery backed RAM. Operation of the equipment shall not be dependent upon the presence of an integral battery.

The equipment shall provide monitoring of integral batteries, including but not be limited to remaining charge state and warning alarm for low life remaining.

Where an integral battery is of the rechargeable type, the battery shall operate in a float-charge mode using an in-built charger incorporated in the equipment. The battery charging circuit shall be regulated to ensure that the battery is insensitive to power supply harmonics and distorted waveforms and is not damaged by other excursions of mains voltage.

Provision shall be made to ensure that an in situ integral battery that is flat or otherwise cannot supply the required operating voltage and current to its load does not affect the normal operation of the equipment.

All batteries shall be clearly marked with date of manufacture or a use-by date.

4.16 Duty Cycle

The equipment shall be capable of operating continuously 24 hours per day, every day unless otherwise specified in the dedicated equipment specification.
5 COMPONENTS USED IN ELECTRONIC CIRCUITS

5.1 General

Components used in electronic circuits shall be selected for their suitability to provide the circuit function, and their long term performance and reliability commensurate with the minimum equipment design life required in Clause 4.1.

The equipment design shall ensure that the following minimum conditions apply to all electronic components used:

(a) The worst-case peak voltage impressed on the electronic component shall not exceed 70\% of the component manufacturer’s maximum rating at 70\(^\circ\)C ambient temperature, other than the following:
   (i) The maximum voltage impressed on transformers, contactors and relays shall be the rated voltage of the device, including supply voltage tolerances;
   (ii) The maximum voltage impressed on capacitors shall be in accordance with Clause 5.8.1.2;

(b) The worst-case current through the electronic component shall not exceed 70\% of the component manufacturer’s maximum rating at 70\(^\circ\)C ambient temperature;

(c) The maximum power dissipated by the electronic component shall not exceed 50\% of the component manufacturer’s maximum rating at 70\(^\circ\)C ambient temperature.

NOTE: Refer to other clauses of this section (Section 5) for additional or special requirements applicable to specific types of electronic components.

5.2 Mounting of Electronic Components

Electronic components shall be installed within modules (see Clause 4.10) or circuit boards inside an enclosure.

Unless purposely designed for such (e.g. DIN rail mounted relays), electronic components shall not be mounted on terminal strips or DIN rails.

5.3 Power Transformers and Inductors

Throughout this clause (including subclauses), a reference to transformers shall include inductors and transductors (magnetic amplifiers) where applicable. The requirements of this clause shall also apply to special transformers (e.g. current or instrumentation transformers) in low voltage circuits.

The transformers shall comply with AS/NZS 61558.2.6, AS/NZS 61558.2.16 and AS/NZS 61558.2.17.

On normal full-load the efficiency of the transformer shall be at a maximum, and the full-load temperature of the transformer winding when mounted in its normal position shall be appropriate for the temperature conditions specified in Clause 2.2.

The voltage regulation of power supply transformers shall be kept as low as possible having regard to the application.

Where a short-circuit fault could cause damage, the transformer secondary winding shall be protected by a fuse, thermal device or cut-out.
5.4 Switches

The requirements of this clause apply to manual switches of all types, such as toggle switches, push button switches, PCB-mounted switches and rotary switches.

All switch contacts shall be of a type giving a wiping action in operation, and conservatively rated for the duty performed. The contacts shall be of a material that will not corrode or tarnish with exposure to the environments defined in Clauses 2.2, 2.3, 2.4 and 2.5.

The switch mechanism shall be of a reliable, approved type having definite stops in each switching position, and designed such that it cannot be left in an intermediate position between adjacent stops.

All switches shall be appropriated rated for the power, voltage, current, electrical surges and transients required for the application.

Rotary switches shall be rated at a minimum of 10,000 cycles of operation.

All other switches shall provide for a minimum of 1,000 cycles of operation or 15 years of normal use whichever is the greater.

All power switches shall be rated to comply with the requirements of AS/NZS 3000.

Unless otherwise permitted in the dedicated equipment specification, all front panel switches shall be capable of manual operation without the need for special tools.

5.5 Contactors (Power Relays)

5.5.1 Construction

All ac operated contactors shall have accurately ground mating surfaces and operate without audible hum, chatter or vibration.

All contacts shall be of a metal that is resistant to burning, pitting or tarnishing in use or on exposure to the environment of stated in Clauses 2.2, 2.3, 2.4 and 2.6. The contacts shall have a slight wiping action in operation.

The contactor coils shall be rated for continuous duty at the maximum applied operating voltage and maximum ambient temperature.

5.5.2 Mounting

All contactors shall be mounted in such a manner that their operation can be conveniently observed in situ. They shall be mounted strictly in accordance with the manufacturer's instructions and with the contact faces in a vertical plane. They shall be mounted such that every contactor is accessible, and it shall not be necessary to unsolder wires or remove adjacent components to change a contactor or clean or adjust contacts.

5.5.3 Interlocking

Contactors used for safety-related applications and switching, shall have an effective mechanical interlock between all contacts such that no contact can be operated (or released) without all other contacts being operated or released as the case may be.
5.5.4 Rated Number of Operations

Unless otherwise specified, all contactors shall have a minimum mechanical life of $10^7$ operations.

5.6 Relays

5.6.1 Electromagnetic Relays

All electromagnetic relays shall be of dust sealed construction.

NOTE: Refer to Clause 5.1 for applicable minimum conditions relating to the required ratings for the relay contacts.

All electromagnetic relays, except reed relays, shall be rated for a minimum of $10^6$ cycles of operation or 20 years of normal use whichever is the greater.

Reed relays shall have a guaranteed functional life rating of not less than $10^7$ cycles of operation, or in excess of twice the expected number of operations over a nominal 20 year life period, whichever is the greater.

5.6.2 Solid State Relays

Solid-state relays shall be rated to carry full load current continuously with natural convection cooling.

Solid-state relays used for motors, lamps and inductive loads shall have high surge current capabilities, with the peak current rating at least ten times the rated continuous current.

Solid-state relays shall be protected against damage and false switching due to transient voltages with a rate of change of voltage (i.e. $dv/dt$) up to 100 V/µs.

Solid state relays shall withstand at least 1500 V a.c. between input and output, and between output and case; or 3500 V a.c. in applications where the switched circuit contains a human-machine interface device.

The relays shall provide isolation between input and output of not less than $10\,\text{M\Omega}$.

5.7 Fixed Resistors

5.7.1 Rating

In addition to the minimum conditions specified in Clause 5.1, the power rating of any fixed resistor shall be such that the maximum surface temperature of the resistor, or its heat-sink where fitted, does not exceed $20^\circ\text{C}$ above ambient. This requirement does not apply to resistors that are purpose-built heating elements.

5.7.2 Mounting

All resistors shall be mounted on printed-circuit cards, insulated tag-boards or properly designed standoffs in such a manner that maximum use can be made of natural ventilation.

Resistors rated at 1 W or greater shall be mounted on insulated standoffs to provide a minimum of 3 mm clearance from the surface of the printed circuit board or mounting panel.
Resistors shall be mounted with adequate clearance from other components likely to be affected by the heat dissipated from the resistor.

Wire-wound resistors rated at 20 W or more shall be mechanically supported other than by their electrical connection.

**5.7.3 Type**

All through-hole resistors rated below 1 W other than those for special purposes (e.g., current sensing) shall be of the metal film or metal glaze approved quality type with suitable protective covering.

Where resistors are mounted over circuit tracks, the resistor shall be of a fully insulated type.

Notwithstanding the above, the type of resistors used shall be appropriate for the application, (e.g. circuits requiring low thermal noise may use carbon resistors).

**5.7.4 Resistor Networks**

Resistor networks may be used provided that the package power dissipation and the power dissipation in any resistor element does not contravene the requirements in Clause 5.1.

**5.8 Capacitors**

**5.8.1 General**

**5.8.1.1 Quality**

All fixed capacitors shall be of assessed quality as specified in IEC 60384.

**5.8.1.2 Applied Voltage**

The maximum voltage impressed on any capacitor shall not exceed 85% of the limit specified by the original manufacturer.

For the purpose of this clause, the maximum voltage shall be the sum-total of all steady and peak (transient) voltages, including voltage fluctuations/variations, applied simultaneously.

**5.8.1.3 Series Connection**

Capacitors shall not be connected in series for the purpose of creating an equivalent capacitor with a higher rated voltage, except where the equivalent capacitor is used in place of a battery.

Where multiple capacitors are connected in series to simulate an equivalent single capacitor, an appropriate voltage and leakage current equalisation network shall be included to ensure that the voltage across individual capacitors comply with Clause 5.8.1.2 over the full required operating temperature range.
5.8.1.4 Mounting
All capacitors shall be mounted strictly in accordance with the original manufacturer's recommendations.

5.8.2 Electrolytic Capacitors
The operating temperature rating of electrolytic capacitors shall be not less than 105°C.
All electrolytic capacitors shall have a low rated equivalent series resistance.
All electrolytic capacitors other than power supply filter capacitors shall be of a type which does not require reforming within 5 years and is not subject to significant degradation (e.g. drying out) over a nominal 15 year life period.

5.8.3 Non Polarized Capacitors
It is preferred that all capacitors other than electrolytics should be of the synthetic film dielectric type.
Capacitors having other dielectrics such as ceramic or mica may be used, provided that these are of a type recommended by the original manufacturer for the application and are used strictly in accordance with the manufacturer's recommendations.
Paper dielectric capacitors shall not be used for other than LV power circuits, and shall be of the self-healing type.

5.8.4 Adjustable Capacitors
Adjustable capacitors (e.g. trimmers) shall be of a type which is sealed from dust and provides stable capacitance before and after adjustment, and consistent varying capacitance during adjustment.
Adjustable capacitors shall be rigidly mounted so that there is negligible movement during adjustment, and the mounting pins and surface are unstressed.
Adjustable capacitors shall be protected from any adverse effects of dust precipitation under normal operating conditions (Clauses 2.2, 2.3, 2.4 and 2.5).
Adjustable capacitors shall be rated at a minimum of 1000 adjustment cycles or 20 years of normal operation, whichever is the greater.

5.9 Potentiometers

5.9.1 Construction
All potentiometers and variable resistors shall be of the fully enclosed type.
Adjustable resistors used for calibration purposes shall be of the multi-turn type, suitable for adjustment by a screwdriver or similar tool.
The spindle shall be sealed after calibration if there is no friction device to prevent loss of calibration due to vibration.
Panel-mounted multi-turn potentiometers shall be provided with a turn counter or similar appropriate position indicator.
The resistance element shall be of cermet or other high stability material approved by the RMS Representative.

5.9.2 Mounting

All potentiometers and variable resistors shall be mounted in accessible positions such that any adjustments can be made with the sub-unit in position in the housing (if necessary using a suitably designed extender device) and with power applied.

5.10 Semiconductor Devices

5.10.1 General

5.10.1.1 Source

The prior approval of the RMS Representative shall be required for all single-source semiconductor devices that are to be used in equipment to be supplied. For the purpose of this requirement, the Contractor/Supplier shall in their submission to the RMS Representative list all single-source semiconductor devices proposed to be used in the equipment, together with the device manufacturer's name, device type number and a brief description of the application.

5.10.1.2 Mounting

With the exception of programmable memories and microprocessors, all semiconductor devices shall be soldered directly into/onto printed circuit boards, or mounted directly into/onto panels without the use of sockets.

Programmable memories and microprocessors may be either soldered directly into/onto printed circuit boards, or with the prior approval from the RMS Representative, mounted in sockets.

NOTE: Refer to Clause 4.13.4 for requirements for IC sockets.

5.10.2 Programmable Memory Devices

Fusible link PROMs shall be of proven stability with zero regrowth of fused links within the operational life of the equipment.

Where memory technologies storing the values of two or more bits in a single memory cell are used, the supplier shall be required to demonstrate to the RMS Representative how their design mitigates against the problems that this technology suffers from.

5.10.3 Optical Couplers

Optical couplers shall provide effective isolation of 3,000 V r.m.s. between their inputs and outputs.

Optical couplers have a wide range of variations in optical output and detection sensitivity due to production variations and long term degradation. Circuits using optical couplers shall be designed to accommodate the range of coupler sensitivity and allow for degradation of up to 50% in current transfer ratio whilst maintaining performance within specification.
5.10.4 Light Emitting Diodes (LEDs) used as Light Source

5.10.4.1 General

The requirements of this clause (Clause 5.10.4) apply to light emitting diodes (LEDs) used as the light source for message display equipment (e.g. variable message signs, variable speed limit signs, in-pavement lights) and signalling equipment to be used on roads or similar environments.

5.10.4.2 LED Technology

LEDs used as the light source for message displays or signals to be used on roads or similar environments shall provide a minimum 100,000 hours of cumulative switched-on life expectancy with a light output depreciation of not more than 30% when operating within the temperature range specified in Clause 2.2.

NOTE: At the time of release of this Specification, Ø3 mm and Ø5 mm AlInGaP red light output LEDs, AlInGaP yellow light output LEDs, InGaN green light output LEDs and InGaN white light output LEDs are known to be able to meet the above requirements when driven at a current of not more than 20 mA peak.

The output colour(s) of the emitted light from the LED(s) in normal operation of the equipment, expressed as chromaticity co-ordinates on a CIE 1931 chromaticity diagram, shall be as specified in the dedicated equipment specification, or applicable Australian or international Standard.

5.10.4.3 LED Selection

The Contractor (or Supplier as relevant) shall ensure that an LED selection process appropriate to meeting the following requirements is adopted by the equipment manufacturer and this process shall be documented in both the Contractor’s (or Supplier’s as relevant) and manufacturer’s Quality Management Systems:

(a) LEDs shall be selected and graded to provide the required uniformity of output across all LEDs for the same display;

(b) LEDs shall be selected for their ability to provide the required luminous intensity without the need to drive them beyond 70% of the original manufacturer’s maximum device ratings for current, power, and operating and junction temperatures, or in a way that may result in a reduction of the nominal life of the LEDs or a degradation of the luminous intensity over time in excess of that permitted in Clause 5.10.4.6.

The encapsulating epoxy of all LEDs used shall contain ultraviolet light inhibitors to reduce both UV-A and UV-B absorption by at least 80%.

5.10.4.4 LED Arrangement

This clause applies to applications that require display panels.

LEDs should be installed in such a way that ensures that their mechanical axes in the direction of their optical output are normal to the printed circuit board and their bezels are at a uniform height from the printed circuit board, and to provide maximum light output on the optical axis.

NOTE: Where the required output optical axis is not in the mechanical direction of the display front face, it is preferred that the LED circuit boards be so aligned to provide the required angular offset to the required output axis.
5.10.4.5 LED Drive Current and Output

In addition to the requirements in Clauses 5.1 and 5.10.4.3(b), where each individual LED is in a Ø5 mm, Ø3 mm, or similar size package, no peak magnitudes of the drive current shall exceed 20 mA. In addition, it is not acceptable to achieve the required output intensity by pulsing LEDs with current values higher than the drive current specified herein.

5.10.4.6 Long Term Performance

Each LED device in the equipment shall have a rated minimum service life and associated maximum light output depreciation as stated in Clause 5.10.4.2.

The initial value of the output light intensity of the LED (pixel) element shall be the value measured in laboratory tests prior to the equipment being put into operation, or the equipment manufacturer’s specification value, whichever is larger.

The initial value shall be not less than the appropriate “minimum” output luminous intensity/luminance value specified in the dedicated equipment specification.

NOTE: Refer to the dedicated equipment specification for other photometric and test requirements.

5.10.5 Visual Indicators

5.10.5.1 General

Unless otherwise specified in the dedicated equipment specification, visual indicators shall be provided by light-emitting diodes with clear body packages.

LED indicators shall provide unambiguous indication output with good visibility in direct sunlight and at angles up to 30 degrees to the indicator axis.

5.10.5.2 Displays

The equipment shall be designed to automatically switch off user displays (but not equipment alarm or status indicators) approximately 10 minutes after the last operator action (e.g. keystroke).

5.10.5.3 Liquid Crystal

Where the dedicated equipment specification requires the use of a liquid crystal display(s), the liquid crystal display shall provide a minimum contrast ratio of 7 to 1 under the prevalent conditions of illumination at the intended location of use. The display shall be readily replaceable without removal of unrelated parts of the equipment and without the need to disconnect soldered, wire-wrapped or other permanent types of connectors.

NOTE: Conditions of illumination include day, night, and bright and overcast days in NSW.

NOTE: Refer to Clause 2.2 for operating temperature requirements.

NOTE: Refer clause 4.1 for reliability requirements.

Back-lighting of the liquid crystal displays shall be provided by LED lamps.
6 REQUIREMENTS FOR COTS EQUIPMENT

6.1 General

For the purposes of this Specification, in addition to the definition of COTS equipment in Clause 1.5, the following applies to all references to COTS equipment:

(a) Equipment that is of a type of, or provides substantially similar functions to, equipment that is already covered by an RMS specification shall not be classified as COTS equipment;

(b) COTS equipment shall have established performance and reliability records that are acceptable to RMS;

(c) COTS equipment shall be of an auxiliary nature in the project or contract work that uses it.

The following sections and clauses in this Specification apply to COTS equipment:

(a) Section 1 ‘Preliminaries’;

(b) Section 2 ‘Environmental Requirements’;

(c) This Clause (Clause 6) in its entirety;

(d) Section 9 ‘Electrical Protection’;

(e) Section 12 ‘Statutory Certification and Approval’;

(f) Section 13 ‘Quality Assurance’;

(g) Section 15 ‘Warranties and Spares’.

6.2 Reliability and Maintainability

The requirements in Clause 4.1 shall apply to COTS equipment.

6.3 Acoustic Noise

The requirements in Clause 4.6 shall apply to COTS equipment.

6.4 Electrical Safety

The requirements in Clause 4.7 shall apply COTS equipment.

6.5 Labelling Requirements

COTS equipment shall be clearly marked by means of a durable label on its external face with the following information:

(a) Manufacturer’s identification;

(b) Equipment description and code;

(c) Date of supply;

(d) A unique serial number;

(f) ACMA C-Tick / RCM certification marking;
(g) ACMA A-Tick certification marking (where applicable);
(h) ACMA certification for radio communication equipment (where applicable);
(i) The RMS type approval number (where applicable).

6.6 Software

The requirements in Clause 8.4 shall apply to COTS equipment.

6.7 Documentation

Unless otherwise specified in the dedicated equipment specification or the Contract, an operations and maintenance manual(s) shall be supplied for each model of COTS equipment in the following format:

(a) Two sets in prints;
(b) One set in the portable document format or other file formats agreed to by the RMS Representative, submitted by means of email, or on an ISO 9600 compliant CD ROM or a USB flash drive.

The manual(s) shall include the following information:

(a) Full description of the equipment functions and interface connections;
(b) Set up procedures;
(c) Inspection and maintenance requirements and information, covering both preventive and repair activities;
(d) Software update procedure where applicable;
(e) Recommended spares where relevant.
7 MARKING AND LABELLING

7.1 General
Markings shall be provided on the equipment in accordance with this Specification, the dedicated equipment specification and other applicable specifications and standards.

All identification markings shall be in English and the type numbers and name shall be the same as those used in the equipment manuals.

All markings shall be capable of withstanding mechanical abrasion and environmental stresses without adverse deterioration.

Labels shall not include any advertising material (such as material associated with the brand, manufacturer or others).

7.2 Housings
Where the equipment is fitted within a housing which has a switchboard(s), the housing shall be clearly marked on the inside in a durable manner with the following information:

(a) Manufacturer’s identification;
(b) Equipment code or type number;
(c) Date of supply;
(d) A unique serial number;
(e) ACMA C-Tick / RCM certification marking;
(f) ACMA A-Tick certification marking (where applicable);
(g) ACMA certification for radio communication equipment (where applicable);
(h) The RMS type approval number (where applicable).

7.3 Modules
All removable modules, printed-circuit cards and other plug-in sub-assemblies shall be clearly and indelibly marked with the following information:

(a) Title, describing the function of the unit;
(b) Manufacturer’s identification;
(c) Equipment code or type/model number;
(d) Date of supply;
(e) A unique serial number.

This information shall be marked on the cover of the unit so that it is readily visible, preferably without removing the module from its mounting. If the cover is mechanically separate from the chassis or main assembly of the unit, the same information shall be marked on the main assembly.

In addition, the month and year of supply may also be duplicated on a non-separable section of the module, to assist with identification of items covered by warranty.
7.4 Components and Controls

All switches, adjustment facilities, indicator lights, push buttons, fuses, cable sockets and plug-in components shall be neatly and clearly marked to indicate their function and/or to what they are connected.

Switches shall show “ON” and “OFF” positions where applicable, and selector switches shall be provided with calibrated dials clearly marking each position.

All connectors and sockets shall be clearly and permanently marked with the relevant circuit or functional identification. All connectors shall be uniquely identified at each of the mating sections.

7.5 Type of Label

7.5.1 Approval by RMS Representative

Where not specified, the Supplier shall obtain the approval of the RMS Representative regarding the selection of suitable marking text and the size and position of labels or legends.

7.5.2 Front Panels, Covers and Chassis

In no case shall legends be written or painted on the body of the units, but engraved, anodised, permanently silk-screened or indelibly stencilled markings will be permitted.

7.5.3 Adhesive Labels

Adhesive labels may be used subject to approval by the RMS Representative, having due regard to durability of both the adhesive and the printing process. However, adhesive labels shall not be used on module front-panels or on the exterior of the equipment housing.

Approval for use of adhesive labels is subject to proven long-term suitability of the adhesive material having regard to environmental and operational factors. Paper labels are not permitted.

Adhesive labels shall not cover tracks or solder pads on printed circuit boards.

7.5.4 Layout Diagrams

In lieu of individual markings, the use of a layout/assembly diagram is permissible, subject to approval by RMS, provided such a diagram is affixed within the equipment in a durable manner and in such a position that it can be readily related to the components in question. Furthermore, where the information relating to positioning of modules and the like may vary from site to site, the diagram shall be appropriately water-proofed and attached to the housing rather than to a removable sub-assembly.

7.5.5 Options and Programming Identification

Equipment capable of supporting either hardware or software options shall display details of the facilities actually provided, including workshop programmable features.
Data on such options shall be displayed inside the equipment for the information of service personnel.

Subject to the approval of the RMS Representative, in lieu of the above, the information may be provided in the form of a field manual.
8 MONITORING AND TEST FACILITIES

8.1 Metering and Test Points

Where setting-up, adjustment or checking of the equipment is required in the field, any test points which are needed for monitoring of voltage, current, signals and other circuit state parameters shall be clearly marked on the relevant circuit boards and equipment parts. The measurement of performance characteristics and in-service monitoring shall be by means of commercially available test equipment or that provided as part of the equipment supply.

All test points shall be identified in the maintenance manual and shall be accompanied by clear instructions on the procedures for use.

8.2 Alarm Conditions

Where a field equipment is capable of self-monitoring for the purpose of fault diagnosis and reporting alarm conditions, the equipment shall be fitted with a readout or indicator of any such alarm or off-normal condition, whether or not this condition is made available on a remote monitoring equipment/system.

8.3 Access

Access to test facilities shall be unimpeded by cables, fixed components or hardware, and test and monitoring points shall be suitable for the attachment of test probes without risk:

(a) to the technician;
(b) of mechanical damage; or
(c) electrical malfunction of the equipment.

8.4 Software

Where a microprocessor forms part of the equipment and it is a requirement of the dedicated equipment specification or the supply contract, the Supplier shall provide a set of test programs which shall adequately exercise and automatically test the processor and the related circuits. In the event that the test program detects a fault, an automatic diagnostic display, log or file shall be generated.
9 ELECTRICAL PROTECTION

9.1 General

All equipment shall be protected against the effects of component failure, accidental short circuits and equipment malfunction by the provision of circuit breakers, fuses, or current-limiting devices.

9.2 Modules and Circuits

Protection for modules and circuits shall be non-destructive such that in the event of an electrical fault or other abnormal electrical conditions occurring, the modules and circuits would not be damaged and can resume operation when the abnormal condition has disappeared.

Notwithstanding, it is permissible that where the protection circuit includes a sacrificial component, such as a fuse, the replacement of the sacrificial component is required for resumption of operation.

9.3 Power Systems

Graded protection shall be provided for both a.c. and d.c. supplies to all major portions of the equipment.

Power system protection shall be graded such that only the protective device nearest the fault is activated. Grading shall apply for both short circuit and high resistance fault conditions.

9.4 Protection from Electrostatic Discharge

The handling, packaging, storage and shipment of electronic components and assemblies shall take account of the risk of damage by electrostatic discharge (ESD).

Levels of device susceptibility to ESD may vary from 30 V to 1000 V, and the Supplier shall take measures during manufacture, testing, storage and shipping to eliminate damage or degradation caused by ESD. As a minimum, these measures shall include the handling and transport of all static-sensitive devices in accordance with IEC 61340-5-1 and IEC/TR 61340-5-2.

9.5 Earthing

All equipment shall be earthed in accordance with AS/NZS 3000, AS/NZS 3100 and AS/NZS 60950.1.
10 PRINTED CIRCUIT BOARDS AND ASSEMBLIES

10.1 Standards

Printed circuit boards shall conform to Class 3 (or its equivalent if a new set of classification notations is applicable) of IPC-A-600 "Acceptability of Printed Boards".

The following design approaches for printed circuit boards have been found to provide reliable performance. Where alternative approaches are used, evidence should be supplied to show how the alternative approaches provide equivalent or better reliability, or are sufficient for the application:

(a) Printed circuit cards should employ glass fibre/epoxy laminate of at least 1.6mm thickness, and a minimum conductor thickness of 35 µm.;

(b) For circuits with peak voltage differentials of less than 50 V, the minimum spacing between adjacent printed conductors should be:
   (i) 0.3 mm for boards with an approved conformal coating; and
   (ii) 0.5 mm for uncoated boards.

Conductor spacing should be greater than the above minima where the board layout permits;

(c) For circuits with peak voltage differentials of 50 V or greater, the minimum spacing between adjacent printed conductors shall be appropriate for the applied voltages, and should not be less than 0.5 mm. The board should be coated with an approved solder mask (refer to Clause 10.3);

(d) For printed tracks required to carry peak currents less than 100 mA, the design minimum track width should be 0.5 mm. Where board space is restricted the track width may be reduced to an absolute minimum of 0.3 mm;

(e) For printed tracks required to carry peak currents of 100 mA or greater, the following requirements should be noted:
   (i) The conductor should not fuse before any associated protective device operates;
   (ii) The temperature of the printed track should not rise more than 10ºC due to resistive losses;
   (iii) The conductor width should be not less than 0.5 mm.

*NOTE:* Refer to IPC-2221 for track current carrying capacities and for track spacing versus voltage breakdown ratings.

10.2 Soldering

The solder used shall be lead-free. The solder flux used shall be bromide-free.

Soldered connections shall conform to Class H of IPC J-STD-001 “Requirements for Soldered Electrical and Electronic Assemblies”.

All residues of solder flux shall be cleaned from PCBs after soldering.
10.3 Solder Mask

PCBs shall have solder masks over topside and bottom side tracking layers. The solder masking of printed circuit boards shall conform to Class H of IPC-SM-840 “Qualification and Performance Specification of Permanent Solder Mask and Flexible Cover Materials”.

10.4 Conformal Coating

For all applications where components with (tin plated) iron leads are used in equipment which is not intended to be continuously energised, or where otherwise specified, electronic assemblies shall be provided with a conformal coating for additional protection or spray-on lacquer designed for this purpose. All parts and components that are to remain uncoated such as switches, fuse holders, edge connectors, and IC sockets shall be masked prior to coating to prevent contamination.

The coating shall be transparent to enable marking and colour coding of components to be clearly visible. The coating shall be of the solder-through type; that is, it shall not char, burn or discolor when a hot soldering iron is applied to a coated joint.

The conformal coating material shall conform to the requirements of IPC-CC-830 “Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies”.

10.5 Printed Board Assemblies

Printed board assemblies shall conform to Class 2 of IPC-A-610 “Acceptability of Electronics Assemblies”, unless otherwise required by the dedicated equipment specification.

10.6 Board Marking

All printed circuit boards shall show component coding corresponding to designations shown on the circuit or schematic diagram. If possible, component outlines should also be shown. Such markings shall be applied by silk-screen printing or a similar process on the side where the components are mounted.

Component and test point identifications shall be legibly marked on the circuit boards.

10.7 Protection

It is preferred that all printed circuit boards used as independent modules be mechanically protected by removable covers. Where required for safety reasons, metal covers shall be effectively earthed.

10.8 Flammability

Printed circuit boards and assemblies shall be capable of passing the flammability test UL 94V-1 in UL 94.
10.9 Modification or Repair

When printed circuit boards are either modified or repaired as part of production or after failure subsequent to delivery, all work shall be in accordance with IPC-7711/7721 “Rework, Modification and Repair of Electronic Assemblies”.

11 EQUIPMENT TESTING AND INSPECTION

11.1 General

The requirements of this section (Section 11) apply to equipment for which RMS type approval is a requirement, and the dedicated equipment specification requires compliance with the testing and inspection requirements of this Specification.

NOTE: The procedure for gaining type approval is not covered by this Specification. Refer to the dedicated equipment specification or other applicable RMS documents for requirements for type approval.

11.2 Routine Production Tests

11.2.1 Purpose

Each unit of equipment shall be tested by the equipment manufacturer to prove that the equipment performance complies with specified requirements. The RMS Representative shall have right of access to the testing areas to enable inspection and to witness all phases of the production tests, or to request the repetition of these tests if there is no evidence of such tests having been properly carried out.

11.2.2 Type of Test

As a minimum, the manufacturer shall carry out the following production tests on each item of equipment:

(a) Following assembly, all printed-circuit boards shall be pretested at appropriate voltage levels to exercise every available function.

(b) Each electronic assembly with associated interfacing shall be subjected to a heat test under normal operating conditions in the following sequence:

(i) Place in an oven and raise to within ±2°C of the upper storage temperature in Table 2.2 in Clause 2.2;

(ii) Once the unit reaches temperature, it is to remain at that temperature for 20 minutes;

(iii) Allow the unit to cool rapidly to ambient temperature (below 30°C);

(iv) Repeat steps (i), (ii) and (iii) twice more (making a total of three cycles);

(v) The equipment shall be soak tested at an ambient temperature of 60°C ±2°C with power applied for 24 hours, and tested after soaking for correct operation.

If failure occurs during any cycle, then the whole procedure steps (i), (ii), (iii), (iv) and (v) shall be repeated. During the heat test, the assembly and the associated interfacing shall be fully exercised and its performance monitored.

11.2.3 Test Status

The performance and status of each item of equipment under production tests shall be fully documented by the equipment manufacturer in accordance with the requirements of AS/NZS
ISO 9001. This documentation shall be made available for inspection at any time upon request by the RMS.

11.3 Pre-delivery Inspection

Unless otherwise specified in the dedicated Contract or dedicated equipment specification, the requirements in this clause shall apply.

The manufacturer shall provide a Compliance Certificate to cover the batch of equipment to be delivered, and access to all quality records related to the batch.

The Compliance Certificate shall be a formal document stating that the equipment has been fully tested in accordance with an Inspection and Test Plan approved by the RMS and meets all specified requirements. The Compliance Certificate shall clearly identify the equipment, the batch information and the purchasing order number. The Compliance Certificate shall be personally signed and dated by the designated representative of the manufacturer.

NOTE: The Inspection and Test Plan for the equipment is an integral part of the Type Approval issued by RMS. Subject to the approval of the RMS manager for type approval, the Inspection and Test Plan may be revised from time to time to suit the needs of the manufacturer's quality management system.

After production equipment has passed the manufacturer’s inspections and tests and ready for delivery, the equipment may be subjected to a pre-delivery inspection at the manufacturer’s works or Supplier’s premises in the Sydney area before delivery.

The pre-delivery inspection will be conducted by an RMS inspector and shall include an examination of the goods and a check of the manufacturer’s Compliance Certificate and quality records. Before leaving the manufacturer’s / Supplier’s premises the RMS inspector will issue the Supplier with documentation to confirm that the goods:

(a) have been inspected and are cleared for delivery; or

(b) have been rejected for stated reasons; or

(c) are subject to further verification for stated reasons.

The Supplier shall give the RMS inspector at least two working days’ notice of the availability of the goods for pre-delivery inspection.

Requests for pre-delivery inspection are to be directed to the RMS Representative responsible for ordering the type approved equipment. Copies of all records associated with a pre-delivery inspection shall be forwarded to the RMS Helpdesk (email: ITSHelpdesk@rms.nsw.gov.au) for the attention of Manager, Traffic Equipment & Standards Group, RMS Intelligent Transport Systems.
12 STATUTORY CERTIFICATION AND APPROVAL

The equipment shall comply with the following statutory requirements as applicable and be certified as such:

(a) Statutory requirements for electromagnetic compatibility;
(b) Statutory requirements for public telecommunications equipment;
(c) Statutory requirements for radio communications equipment.

For the purpose of this requirement, all supplied equipment shall be compliant with the applicable standard(s) promulgated by ACMA. All compliant equipment shall be individually labelled with the applicable compliance label.

NOTE: The compliance label specified by ACMA for the above certifications at the time of release of this version of Specification TSI-SP-016 was the Regulatory Compliance Mark (RCM).

NOTE: Refer to Clause 2.6 for requirements for electromagnetic compatibility.
13 QUALITY ASSURANCE

13.1 General

The Supplier and the manufacturers of equipment and software provided by the Supplier shall each operate a quality management system complying with AS/NZS ISO 9001 or ISO 9001. This quality management system shall be certified by a quality management system certifying body either accredited under the criteria laid down in the Joint Accreditation System of Australia and New Zealand (JAS-ANZ), or listed in the International Standards Organisation ISO Directory of ISO 9000 and ISO 14000 Accreditation and Certification Bodies.

13.2 Traceability of Equipment

All items of equipment shall be marked with a batch code, serial number, or other marking to provide traceability under the manufacturer’s quality management system.

NOTE: Refer to Clause 6.5 for labelling requirements for COTS equipment.

NOTE: Refer to Clause 7.2 for labelling requirements for housings.

NOTE: Refer to Clause 7.3 for labelling requirements for modules.

13.3 Quality Audits

The RMS Representative shall have the right to examine records of internal and external quality audits carried out on the Supplier’s and the equipment manufacturers’ quality management systems. As a result of such examinations, or in addition to them, RMS or the RMS Representative may carry out an independent quality audit concerning equipment or software.
14 DOCUMENTATION

14.1 General

Unless otherwise specified in the dedicated equipment specification or the Contract, the requirements in this Section 14 shall apply.

Documentation required under this Section shall be provided in the following format:

(a) Two sets in prints;
(b) One set in the portable document format or other file formats agreed to by the RMS Representative, submitted by means of email, or on an ISO 9660 compliant CD ROM or a flash drive or other agreed medium.

14.2 Test Certificates

Certified test results of factory tests and measurements shall be provided before or at the time of pre-delivery inspection. Where pre-delivery inspection is not required, these shall be supplied to the RMS Representative for acceptance before delivery of the equipment.

14.3 Quality Plan

The Supplier shall submit a quality plan to the RMS Representative at least twelve (12) weeks prior to the scheduled delivery date or at a time agreed with the RMS Representative.

The quality plan shall include details of all tests and checks to be performed during and at the end of the manufacturing process.

14.4 Installation Information

This information shall contain all data necessary for the placement and connection of the equipment. It shall include the following:

(a) Dimensioned mechanical drawings showing mounting points, access to cable terminations, test points, meters and controls, removable panels and doors;
(b) Cable termination details, e.g. lug dimensions and preferred routing for external cables within the equipment;
(c) Requirements for site preparation or equipment mounting.

14.5 Equipment Handbooks

The Supplier shall provide equipment handbooks as nominated in the dedicated equipment specification. Separate handbooks shall be provided for each type of equipment supplied. Handbooks shall be provided at least six (6) weeks prior to delivery or as nominated by the RMS Representative.

Each handbook shall include the following as a minimum:

(a) Overview of features and description of functions;
(b) Specifications of internal components with data sheets;
(c) Wiring schedules, including terminal block layouts;
(d) Drawings (e.g. assembly and construction, functional and/or physical block diagrams, circuit schematics, connection diagrams);

(e) Setup instructions;

(f) Operations instructions;

(g) Maintenance instructions, including diagnostic procedures and maintenance procedures covering restorative and preventive actions;

(h) Shut-down instructions;

(i) Description of indicators, monitoring points and service connections;

(j) Specifications for external connections, both mechanical and electrical;

(k) Occupational and health instructions.

14.6 Software Documentation

Where the equipment employs any form of software, the Supplier shall supply sufficient information to operate, maintain and modify the configuration parameters of the operating programme of the equipment without reference to the Supplier or original designer.

Software documentation shall include a software configuration management datasheet which details the version number of all operating software and updates.

Source code developed specifically for RMS or the Contract shall be delivered to RMS or placed into Escrow, or otherwise made available to RMS in accordance with an arrangement agreed to by RMS.

NOTE: Refer to the dedicated equipment specification or other contract documents for additional requirements for software and software documentation.
15 WARRANTIES AND SPARES

15.1 Work Health and Safety

The Supplier shall warrant that the equipment and equipment handbooks identify risks, in accordance with the Work Health and Safety Act 2011, for:

(a) technicians in their installation, commissioning and maintenance of the equipment; and

(b) road users in their exposure to the equipment when using the NSW Road Network.

The warrant does not apply in cases where risks eventuate due to misuse or mistreatment of equipment by technicians or the public, unless that misuse or mistreatment could have been reasonably foreseen.

15.2 Warranties

The requirements in this clause apply unless other warranty conditions are specified in the dedicated equipment specification or other part(s) of the Contract.

The Supplier shall provide, for each item of equipment supplied, a warranty period of 12 months after equipment installation or 24 months after equipment delivery to the RMS store, work site or other locations required, whichever occurs first.

Any equipment failed in service or found to be defective within the warranty period shall be made good by the Supplier. For the purpose of this requirement, the following shall apply:

(a) The Supplier shall rectify all defects in situ within 48 hours of receiving notification of occurrence of an anomaly;

(b) Where the Supplier is unable to fulfil the requirement in (a), with the consent of RMS, the Supplier shall forthwith replace the defective unit with a temporary replacement within 72 hours. The Supplier shall rectify the defects on the original unit within seven days and arrange with RMS for a suitable time to reinstate the original unit on site.

It is expressly understood that any equipment damaged as a result of a traffic accident, abuse or act of vandalism after delivery to RMS will not be covered by warranty provisions.

Notwithstanding the warranty obligation stated above, the Supplier shall rectify any latent defects at the Supplier’s own cost when such a defect is detected and reported to the Supplier within five (5) years of the equipment delivery.

15.3 Spares

The Supplier shall maintain a reasonable supply of spare parts and modules for a minimum period of fifteen (15) years to allow the equipment to be maintained in service.

The Supplier shall give notice to the Authority prior to the last manufacturing run before cessation of manufacture for the particular spares type. The Supplier shall maintain spares for a minimum period of five (5) years after cessation of manufacture for the particular spares type.

Spare parts and modules for maintenance purposes shall include the following as applicable:

(a) Mechanical assemblies;

(b) Electrical assemblies;
(c) Electronic assemblies;
(d) Optical assemblies; and
(e) Electrical and electronic components.
APPENDIX A
REFERENCES AND APPLICABLE DOCUMENTS

A.1 AUSTRALIAN STANDARD SPECIFICATIONS
The following standards have been referred to in this Specification:

AS/NZS 1125 – Conductors in insulated electric cables and flexible cords
AS/NZS 1170.2 – Structural design actions - Wind actions
AS 1319 – Safety signs for the occupational environment
AS 1470 – Health and safety at work – Principles and practices
AS 2748 – Information technology – Data communication – 25-pole DTE/DCE interface connector and contract number assignments
AS/NZS 2772 – Radiofrequency fields – Maximum exposure levels – 3 kHz to 300 GHz
AS/NZS 3000 – Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3100 – Approval and test specification – General requirements for electrical equipment
AS/NZS ISO 9001 – Quality management system - Requirements
AS 60068.2.6 – Environmental testing - Tests - Test Fc: Vibration (sinusoidal)
AS 60068.2.29 – Environmental testing - Tests - Test Eb and guidance: Bump
AS/NZS 60950.1 – Information technology equipment – Safety – General requirements
AS/NZS 61000.6.1 – Electromagnetic compatibility (EMC) – Generic standards – Immunity for residential, commercial and light-industrial environments
AS/NZS 61000.6.3 – Electromagnetic compatibility (EMC) - Generic standards - Emission standard for residential, commercial and light-industrial environments
AS/NZS 61558.2.6 – Safety of power transformers, power supply units and similar – Particular requirements for safety isolating transformers for general use
AS/NZS 61558.2.16 – Safety of transformers, reactors, power supply units and similar products for voltages up to 1100V – Particular requirements and test for switch mode power supply units and transformers for switch mode power supply units
AS/NZS 61558.2.17 – Safety of power transformers, power supply units and similar – Particular requirements for transformers for switch mode power supplies

AS/ACIF S009 – Installation requirements for customer cabling (Wiring Rules)

A.2 RMS SPECIFICATIONS AND DOCUMENTS

The following RMS specifications (as amended) and documents (as amended) have been referred to in this Specification:

QA Specification
TS201 – Approval of ITS Field Equipment

QA Specification
TS202 – Approval of ITS Solutions for Projects

A.3 OTHER STANDARD SPECIFICATIONS

The following standards have been referred to in this Specification:

IEC 60384 – Fixed capacitors for use in electronic equipment

IEC 60807-3 – Rectangular connectors for frequencies below 3 MHz - Part 3: Detail specification for a range of connectors with trapezoidal shaped metal shells and round contacts - Removable crimp contact types with closed crimp barrels, rear insertion/rear extraction

IEC 61340-5-1 – Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements


ISO 4902 – Information Technology – Data Communication – 37–pole DTE/DCE Interface Connector And Contact Number Assignments

ISO 4903 – Information technology - Data communication - 15-pole DTE/DCE interface connector and contact number assignments

ISO 9660 – Information processing; volume and file structure of CD-ROM for information interchange

IPC-2221 – Generic Standard on Printed Board Design

IPC-7711/7721 – Rework, Modification and Repair of Electronic Assemblies
IPC-A-600 – Acceptability of Printed Boards
IPC-A-610 – Acceptability of Electronics Assemblies
IPC-CC-830 – Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies
IPC J-STD-001 – Requirements for Soldered Electrical and Electronic Assemblies
IPC-SM-840 – Qualification and Performance Specification of Permanent Solder Mask and Flexible Cover Materials
ISO 9001 – Quality management systems - Requirements
UL 94 – Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

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