AMSA Aid to Navigation Electrical Installation Standard

Document control

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Revision history

Revision date	Version no.	Description of changes
August 2022	0.0	Issued for Tender
October 2022	1.0	Document control table added, document formatted and section 6.12 updated to include cable identification at the connection point

Record of Amendments:

The AMSA Aid to Navigation Electrical Design Standard has been derived from the AMSA Aid to Navigation Electrical Standard Rev 5 which has been separated into design and installation documents.

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1. Scope

Electrical installations in Australian Maritime Safety Authority (AMSA) Aid to Navigation (AtoN) sites must conform to the requirements of:

a) All applicable Commonwealth, State and Territory legislation, regulations, codes of practice and guidance publications relevant to the State or Territory where the installation is located.

b) All applicable Australian Standards (*Australian Standards*).

c) Local network service provider requirements.

d) Manufacturer guidelines and specifications.

This Standard supplement these requirements and specifies how they must be applied to electrical installations at AMSA AtoN sites.

2. Application

The requirements of this Standard apply to the construction, maintenance and alteration of electrical installations in/on AMSA AtoN sites.

It is not intended that the requirements of this document be applied retrospectively to existing installations, however all modifications or additions to existing installations must comply with this Standard.

Where there is any perceived difference between the requirements specified herein and other AMSA or project documentation, the following order of precedence must apply:

a) The request for tender/quotation or contract that the electrical work is being completed under where the requirements are more specific, greater, or more onerous;

b) Specifications issued by contractors, subcontractors or materials suppliers, where approved by AMSA; and then

c) This Standard.

3. Background

AMSA operates a range of AtoN around the Australian coastline for commercial shipping. Most of these AtoN are situated in remote locations and are either mains or solar powered, with the majority of AMSA sites being solar powered. The provision of a reliable power supply for AMSA AtoN's is critical to ensure that performance targets are met and operating costs are reduced by allowing the AtoN to operate reliably between service visits, which can be up to two years (four years for buoys).

4. Referenced Standards

4.1. Australian Standards

Unless otherwise specified, the applicable issue of a referenced standard must be the issue current at the date of the electrical works.

AS1768	Lightning Protection
AS 2676.2	Guide to the installation maintenance, testing and replacement of secondary batteries in building – Part 2: Sealed cells
AS/NZS 3000	Wiring rules
AS/NZS 3008.1	Electrical Installations – Selection of cables
AS 3011.2	Electrical installations – Secondary batteries installed in buildings – Part 1: Sealed cells
AS 4086.1	Secondary batteries for use with stand-alone power systems – Part 1: General requirements
AS 5139	Electrical installations – safety of battery systems for use with power conversion equipment
AS/NZS 5033	Installation and safety requirements for photovoltaic (PV) arrays
AS 60529	Degrees of protection provided by enclosures
AS/NZS 4509.1	Stand-alone power systems – Part 1: Safety and installation
AS/NZS 4509.2	Stand-alone power systems – Part 1: System Design

5. Definitions

The definitions of terms contained within AS/NZS 3000 shall apply to terms used throughout this AMSA Standard excluding those listed below, which have the meaning stated:

AtoN	Aid to Navigation.
AMSA	Australian Maritime Safety Authority.
AEEL	Approved Electrical Equipment List.
Battery Isolator Board	The enclosure and switching arrangement that provides protection from overcurrent from the batteries.
Contractor	The company or person undertaking electrical works.
DC Distribution Board	The enclosure and switching arrangement that divides the DC electrical supply to subsidiary circuits.
DOD	Depth of Discharge – The amount of charge removed from a fully charged battery expressed as a percentage of the battery's rated capacity.
Enclosure (electrical)	Is a cabinet or box that is used to store and protect electrical or electronic equipment and protect users in the environment in which they are installed.
External	Outside of the building or where there is no building, outside of an enclosure.
Internal	Inside of the building or where there is no building, inside of an enclosure.
OEM	Original Equipment Manufacturer.
PE	Photo electric.
Regulations	All applicable Commonwealth, State and Territory legislation, regulations codes of practice and guidance publications relevant to the State or Territory where the installation is located.
Regulator Board	The enclosure, switching and regulator arrangement that controls the charging of batteries and electrical supply to the DC Distribution Board.
Australian Standards	All relevant Australian Standards.
This Standard	This document.

6. General Requirements

6.1. Layout

The layout of all electrical installations must be considered and planned in advance to ensure the most suitable and practical layout is utilised and take into account access for maintenance and isolation.

As far as reasonably practical:

a) battery modules and other heavy equipment must be installed at ground level

b) equipment and enclosures must be positioned taking into account ease of access and at a height/location that does not require the use of access equipment such as ladders

c) heavy items including batteries must be able to be installed without the use of lifting aids

d) cable runs must not cross pathways or floors.

The orientation and position of solar panels must be chosen to maximise the output of the panel whilst also considering the potential for bird fouling and shading of the panels by nearby structure or vegetation

All isolation points must be positioned outside of the “occupational exposure zone” for sites with electromagnetic radiation sources.

All equipment must be positioned:

a) taking into account its security and where specified must be provided with adequate protection from interference by members of the public;

b) such that members of the public cannot be exposed to radio frequency fields in excess of the general public limits;

c) taking into account electrical and transmit/receive efficiency; and

d) in a position that does not interfere with the functionality of any aid to navigation.

All indicator lamps and maintenance plug/ports must be accessible/visible from the front of the enclosure.

Satellite communication antennas for remote monitoring applications are predominately positioned on the north side of a structure with a clear line of view to the sky.

Orientation of the lantern PE cell must consider the rising and setting of the sun to prevent premature or delayed operation of the lantern. The lantern must be on when it is required as an AtoN.

The orientation of the lantern PE cell will impact on the lux level required for switching the lantern on/off.

The lantern PE cell (light sensor) are predominately oriented to the south and can either be separate to the lantern or be part of the lantern. Further consideration to the orientation must be taken into account, when positioned internally to a light house that have fixed blanking panels to the south.

New modern day LED light sources can have the ability to adjust the ambient light levels (lux levels) to suit site specific conditions. The IALA Guideline 1038 provides further detail into the selection and determination of lux level settings.

As a guide the ambient light levels as which AtoN lanterns should switch on and off is as follows (obtained from IALA Guideline 1038):

- switch on at 50 – 100 lux
- switch off at 150 – 200 lux
- hysteresis of 50 – 100 lux

Lantern switching levels when not known or specified must be tested during commissioning and or monitored afterwards.

Where multiple lights are used to mark a channel, all such lights must switch on and off almost simultaneously.

Some modern day LED lanterns have the PE cell located on the top of the lantern and consideration must be taken when installed in open environments to the effects of bird droppings.

6.2. Solar panels

Monocrystalline panels are used in the AMSA network.

The majority of solar panels used in the AMSA network are either 12 or 24 volt small area PV modules.

With the ever-quick turnaround of small area PV modules, AMSA will advise of solar panels currently utilised in the AMSA network.

PV modules must be selected in consideration of the environment and structure they are being attached to and ideally have a high wind/load rating.

Solar panels must have the following compliances/certifications unless approved otherwise by AMSA:

a) IEC61215
b) IEC61730
c) IEC61701
d) IEC62716
e) AS5033
f) CE and ISO certification

Solar panels are nominally oriented to the north, unless otherwise specified in the design.

Where solar panel racking is used it must be Clenergy T50 or T110 rail system with the appropriate sized end and mid rail clamps applicable to the PV modules being attached.

AMSA's preference is to have the junction box which is affixed to the PV module to be serviceable (i.e., access permitted to replace cabling).

In the first instance AMSA's requirement is to have solar cabling terminated directly into the PV module junction box. Where this is not possible, IP68 rated (or greater) solar plug MC4 connectors must be utilised. The appropriate tool designed for crimping the connectors must be used.

The use of solar plug MC4 connectors are not permitted on buoys.

6.3. Battery clearances

Unless otherwise specified by the battery manufacturer or relevant Australian Standards, the following minimum clearance (whichever is the greater) will apply for VRLA batteries:

- 10mm between each battery
- 25mm between a battery and the outside edge of a rack or enclosure
- 130mm from a battery terminal to the lowest point of the shelf or structure above or half the distance from the front of the battery to the rear most terminal of the battery, whichever is the greater (to a maximum of 200mm).

6.4. Battery protection

Battery protection must be provided in accordance with relevant Australian Standards.

Unless approved otherwise battery protection and isolation must be in the form of a suitable two pole non-polarised DC rated circuit breaker connected to both output conductors of each battery module and rated for the prospective fault current of the battery module.

For the purpose of electrical drawings, the battery protection shall be known as the Battery Isolator Board.

To allow for reduction in battery cabling sizes; battery terminal mounted fuses may be utilised to meet maximum prospective fault current requirements. When utilised, battery terminal fuses must be installed to both the positive and negative terminals of the battery module. Where a battery module consists of more than one string in parallel, each string output will require battery terminal fuses.

Insulation caps /rubbers must be used on all battery terminals and be provided with an allowance to measure battery voltages without removal.

Battery terminal protector paste (or aerosol) must be applied to all battery terminal connections to prevent oxidation and corrosion from occurring.

6.5. Cable sizing

Cabling must be sized to satisfy both voltage drop requirements and current carrying capacity limitations. Cables used in a battery installation must be capable of sustaining the current that can flow as a result of a short-circuit/prospective fault current.

The contractor must undertake voltage drop calculations to confirm that the proposed cable sizing being utilised in DC circuits is suitable to meet the following voltage drop requirements:

a) A maximum voltage drop of 5% from solar panels to batteries;

b) A maximum voltage drop of 5% from battery module to DC load assuming the entire load current is being drawn from a single battery module;

c) A maximum voltage drop of 2% from batteries to the distribution board assuming the entire load current is being drawn from a single battery module;

d) A maximum voltage drop of 2% for any individual cable; and

e) For mains powered sites in accordance with AS/NZS 3000.

The following calculation in accordance with AS3008.1.1 must be used for determination of voltage drop calculations from circuit impedance:

$$V_d = \frac{2ILZ_C}{1000}$$

Where:

- Z_c is the impedance of the cable in ohms/km
- I is the Current in Amps
- L is the length of the cable in metres

The voltage drop calculation must incorporate:

a) all cabling including those inside enclosures/boards

b) voltage drop due to equipment or components such as diodes (a value of 0.3 volts must be used for the voltage drop across a diode unless otherwise specified by the product data sheet)

The minimum cable sizes that must be utilised are as specified in Table 1 below. These are the minimum cable sizes that may be used; however the Contractor must confirm that these sizes are adequate for the voltage drop requirements specified above and potential prospective fault currents.

Cable location	**Minimum size**
Solar panel to Regulator Board	4mm^2
Regulator Board to DC Distribution Board	6mm^2
Batteries to Battery Isolator Board	6mm^2
Battery interconnect cables (Non-OEM)	50mm^2
DC Distribution Board to load/equipment	4mm^2
Buoys – all cabling	2.5mm^2

Table 1: Minimum cable sizes

Battery cabling when used with an inverter/ charger system must be sized in accordance with the minimum requirements specified by the OEM.

6.6. Cable type

The cable type for all solar panel installations (from the solar panel to the regulator board) must be Figure 8 double insulated construction, with class 5, fine stranded tinned copper conductors.

All cables must maintain their outer insulation from point to point. Secondary insulation such as heat shrink must not be utilised without the prior approval of AMSA.

Cable selection must consider the following:

a) proposed cable route and location;
b) potential for mechanical or vermin damage;
c) weathering, abrasion, UV and ozone resistance;
d) acid and alkaline resistance;
e) suitability for permanent outdoor use;
f) contrasting colour from inner to outer sheath; and
g) ability to maintain its double insulation when each conductor is separated.

Tinned copper cable must be utilised for all DC applications and installations in a marine environment.

Automotive cabling must not be used.

6.7. Cable runs

The layout of all cable runs must be considered and planned in advance to ensure the most suitable and practical route is utilised. The requirement for cable runs to cross walking surfaces must be eliminated as far as reasonably practical; where this is unavoidable the cable run must be provided with adequate mechanical protection and high visibility cable covers to the full extent of the walking surface in order to eliminate the trip hazard.

All cable runs to be installed in a high damage risk area must be enclosed in conduit and provided with adequate mechanical protection or installed in a suitable cable tray fitted with a cover. Where cables are installed in conduits, the conduits must be installed in a uniform manner with no kinks and such that the cables can be easily replaced. All cable runs must be neat, easily accessible and installed in an aesthetically pleasing manner. As far as reasonably practical crossover of cable runs and conduits must be avoided.

Conduits must be installed in a manner that prevents the accumulation of water at any point.

All conduits external to buildings must not be reliant upon sealing compounds to prevent the ingress of moisture; conduits must enter junction boxes with the cables leaving via glands or conduits.

All single insulated cables external of an enclosure shall be enclosed in a conduit. All cables must be adequately supported and protected against mechanical damage. Cables must be installed in/on cable trays, conduits, ducts or where suitable for the cable type and approved by AMSA fixed directly to an appropriate component of the structure.

All cables must be a continuous length with the cable outer sheath to enter the equipment intact. In particular there must be no connections/terminations between the solar panels and regulator boards excluding MC4 connectors (where approved for use) installed in close proximity to the solar panel.

Segregation of cables must be provided in accordance with relevant Australian Standards and in accordance with equipment manufacturer recommendations.

6.8. Discrimination

Appropriate discrimination of circuit protection must be provided to ensure a fault on one circuit will not result in a loss of supply to other circuits.

Segregation of cabling/wiring with different voltages must be in accordance with AS3000.

6.9. Main switch and circuit breakers

All main switches must be installed in accordance with AS3000 or the specified design.

The following must be adopted when installing main switches:

- Must provide overcurrent protection
- Must be labelled
- Must be double pole for DC powered installations

All DC circuit breakers must be DC rated and non-polarised and suitable for the applicable maximum prospective fault current and voltage present.

6.10. Earthing

Earthing must be installed in accordance with AS3000 or as detailed in any specification.

Earthing and equipotential bonding must meet any requirements for lightning and surge protection design.

Where a piece of equipment requires an earth or utilises a bonding strap, the earth/bonding strap must be installed in a manner that will not accelerate corrosion. The connection must consider the isolation of dissimilar metals and the effect that the isolation may have on the connection.

6.11. Terminations in enclosures

Where terminal blocks are required to be linked an appropriate OEM link is to be used.

Internal wiring for connection to field must be terminated on one side of terminal blocks leaving the other side free for external cables.

Connections between electrical components within the same enclosure may be looped.

The mounting and orientation of terminal blocks must enable clear access to the terminals for wiring installation, maintenance and fault finding.

All terminations for wires must be provided with insulated crimped lugs suitable for the terminal type or connection point and must be installed utilising the appropriate crimping tool. AMSA requirement is for the use of bootlace type ferrules and ring type lugs with the appropriate size hole for the stud/bolt. Non insulated lug terminals where used for larger conductors must have heat shrink applied denoting the conductor use.

Termination of conductors must not cause stress, tension or deformation/distortion of terminals or their mounts.

Incoming and outgoing cables must be provided with sufficient slack to re-terminate conductors if required overtime e.g., a small service loop within the enclosure if terminating straight into terminals (without ducting).

Internal wiring within ducts must be laid neatly with the shortest route. Sufficient slack must be provided to enable stripping and termination over time e.g., allow minimum 25mm within duct when aligned with terminal. Excessive slack must be avoided to prevent congestion within the duct and additional voltage drop.

6.12. Labelling

All circuit breakers junction boxes and enclosures must be labelled. Circuit breakers must be labelled with their circuit identification (Q number) above and a description of the connected equipment (BM1, Lantern) beneath. Labels for isolation points and circuit breakers must be installed adjacent to the equipment in a clearly visible location to allow change out of the component without disturbing the label. Enclosure labels must be positioned on the front panel in a clearly visible location that does not obscure internal labelling where practical. Labels must be positioned so as not to be obscured by cabling.

Battery modules must be provided with a label fixed to the battery rack, where the complete battery modules is on one level of a rack only one label is required, for battery modules split over two or more levels a label is required on each level.

All labels must be in the form of a Traffolyte etched panel, white face with black lettering, and installed utilising an adhesive or double-sided tape specified as suitable for the label and substrate that it is being adhered to.

For labelling of circuit breakers or devices, unless noted otherwise, the following applies:

- Circuit identification labels must be 10mm high with 4mm lettering and width to match the circuit breaker or device
- Description labels must be 15mm high with 4mm lettering and width to match the circuit breaker or device, 20mm high labels may be used if required to fit three row descriptions
- All wording must be in a horizontal orientation

For stainless steel enclosures labels may be fixed utilising sealed stainless steel pop rivets.

All cables must be labelled at each end with their cable identification (W number). The label must be placed inside the relevant enclosure where practical. The cable identification number (W number) must be provided at each connection point and labelled with + or – to signify polarity (if applicable).

Where the cable insulation is not reflective of its polarity a label with the cable identification and a suitably coloured heat shrink sleeve (e.g., red/black) must be installed on the cable at the termination point.

All internal wiring within enclosures must be labelled at each connection end with their wiring identification number. All wire labelling must be oriented in the same direction, being read from left to right or bottom to top.

6.13. Removal of redundant equipment

All redundant electrical wiring, conduits, and fittings, mounting brackets, anchor points, fixings/fasteners and other electrical equipment generated whilst undertaking electrical works must be removed.

Any holes remaining from the removal of redundant electrical components must be repaired in a manner approved by AMSA.

Painted surfaces must be made good to maintain the protective coating system.

7. Materials and equipment selection

All mains powered electrical products must be electrically safe and have the required Australian safety approval certificate.

All equipment must be selected from either the AEEL or as detailed in a specified design.

7.1. Material and corrosion protection requirements

All materials must be of a suitable marine grade and selected taking into account the environment into which it is to be installed.

All stainless steel must be grade 316 or better.

All aluminium must be marine grade - 6000 series for extrusion and 5000 series for plate.

All plastics must be heavy duty UV resistant.

All dissimilar metals must be provided with complete electrical isolation through use of appropriate gaskets and bolt/fastener isolation kits. Where this is not possible an anti-corrosive paste such as Duralac, Tef-gel etc must be applied to the mating faces during assembly.

All stainless-steel components must be fabricated/constructed in accordance with AS1554.6 Structural Steel Welding – Part 6: Welding Stainless Steels for Structural Purposes.

All surfaces of fabricated stainless-steel components must be:

a) Acid pickled and passivated in accordance with relevant Australian Standards
b) Be free of grinder marks, abrasion, damage etc.
c) Be free from iron and carbon contamination
d) Be free from weld oxides, scale, slag and heat tint
e) Be free of materials that may cause breakdown of the passive layer such as carbon steel, copper, paints, dyes, tapes and other tight or loosely adherent materials.

All stainless-steel components are to be constructed in an area away from steel fabrication to ensure that no contamination of the stainless-steel components can occur. Stainless steel material must not be in contact with carbon steel that may cause contamination including during fabrication, transportation and installation, the Contractor must not utilise carbon steel materials handling or packaging devices/materials.

Material traceability records for all materials used must be maintained by the Contractor.

7.2. Fasteners

All fasteners must be A4-70 grade or better.

As far as reasonably practical all fasteners must be bolts fitted with flat washers under the bolt head and nut. Nyloc nuts must be fitted.

Any non-stainless-steel fasteners supplied with OEM equipment (excluding equipment installed within IP rated enclosures), must be replaced with like for like stainless steel fasteners.

Where a fastener is installed through a dissimilar metal complete isolation of the different materials must be supplied.

Fasteners into concrete or masonry substrates will be reviewed on a case-by-case basis.

The use of Duralac, Tef-Gel or similar must be used on all fasteners with dissimilar metal contact.

7.3. IP Rating

All electrical equipment must be installed in enclosures that offer the following minimum degree of protection:

a) outdoors – IP56;

b) indoors (including vented battery enclosures) – IP44; and

c) equipment installed above batteries – IP65 and non-metallic.

Any equipment that meets or exceeds the above requirements may be installed without an enclosure; however, consideration must be given to the security of the equipment and potential for other environmental concerns such as bird fouling or sun damage.

7.4. Enclosures

Where available in a material suitable for the exposure, standard commercially available off the shelf enclosures must be utilised.

Where a design dictates the requirement for a custom enclosure they must be designed in accordance with relevant Australian Standards and must take into account the minimum IP rating as per clause 7.3 and the environment into which they will be installed.

Custom enclosures must be fabricated of stainless steel, aluminium, or other material approved by AMSA.

Large enclosures must be provided with solid fixed door stays with a fixed opening of 90 degrees or more. Gland plates must be provided at the base of the enclosure to allow cables to exit with allowance for accessing glands in the event they need to be removed or new glands installed.

Enclosures that may be accessed by members of the public must be provided with a locking mechanism or require a tool to open them.

AMSA's preference is for 3-point locking handles on large enclosures with hinged doors. Where such handles are required to be fitted with a lock the handle must be capable of being locked with an AMSA standard lock (10mm diameter staple).

Cable entry to equipment and enclosures must be bottom entry, unless otherwise approved by AMSA.

Top cable entry into a large enclosure will only be considered in an indoor environment. Where cable entry into a large enclosure has been approved, the cables entering from the top must enter into a dedicated cable zone through a gland plate.

Penetrations to walls and enclosures must not impair their structural integrity or IP rating.

Mounting pans must be predrilled and fitted with either thread forming screws or nutserts for mounting equipment. The use of self-drilling screws or nut bolt combination is not permitted.

Enclosures of a large size when used outdoors (e.g., storage of batteries or regulator board) must be provided with weather shields to all exposed surfaces (including rear) and have a sloped roof of 30 degrees.

Where two enclosures (large) are mounted side by side outdoors, the top and rear weather shield will be one piece and the top will extend past any vertical weather shield without creating a hazard or impeding the door from opening.

Mounting pans must be predrilled and fitted with either thread forming screws or nutserts for mounting equipment. The use of self-drilling screws or nut bolt combination is not permitted.

7.5. Battery enclosures

Battery enclosures must be fabricated of stainless steel.

Enclosures for the storage of batteries when used within a building and accessed by members of the public must be provided with vents in accordance with relevant Australian Standards that are vermin proof, oriented and provided with covers to prevent the ingress of water.

Battery enclosures installed outside in a wet (sea) environment, the use of breather/vents with the appropriate IP rating is required to prevent the ingress of sea mist into the enclosure.

Battery enclosures must be supplied with solid shelves constructed of the same material of the enclosure body with either perforated rubber or a cork material laid between the shelf and the battery.

Cable management must be provided in the form of cable trays laid horizontally above the battery terminal across the back of the enclosures and vertically from the top to the bottom of the enclosure. The vertical cable tray is predominately provided on the side of the enclosure and considering the position of the cable entry point. There must be a gap between the vertical cable tray and the shelf of sufficient size to allow cabling to pass through.

7.6. Battery racks

Battery racks must be designed to ensure ease of installation of batteries and access to the terminals for maintenance activities and where applicable in accordance with relevant *Australian Standards* including AS/NZS 3011.2.

Battery racks are utilised within building structures that are not accessible to the public.

Battery racks must be fabricated of stainless steel.

Each shelf within the rack must be supplied with a solid base board constructed of a rot and corrosion resistant material.

A shelf must be provided above the top row of batteries.

Unless specified otherwise each battery rack must be provided with a mounting board above the top row of batteries suitable for the installation of the following enclosures:

a) Regulator Board;

b) Battery Isolator Board;

c) DC Distribution Board; and

d) Remote Monitoring Enclosure.

The mounting board must be constructed of a rot and corrosion resistant material.

A gap must be provided between the top shelf and mounting board of sufficient size to allow cabling to pass through or for the fitment of a cable tray.

7.7. Cable trays, conduits and ducts

All cable trays or ladders must be stainless steel.

Where a stainless-steel tray does not have a factory folded edge the cable tray must be fitted with a rubber cap to all exposed edges installed utilising a suitable adhesive.

All conduits must be specified as suitable for the intended exposure and mechanical protection required.

All rigid conduit bends must be sweep type unless space restrictions require otherwise.

The use of corrugated conduit internally must be limited and permitted only for short runs to allow flexibility to get around corners or sweep into equipment.

Corrugated conduit is not permitted for external use.

All conduit ends must be sealed to prevent vermin or water ingress.

Conduit fittings must be suitable for the conduit type being used and not impact on the IP rating of the enclosure it is connected to.

All external conduits must be sealed with PVC conduit glue.

Slotted PVC ducts are to be used in enclosures.

7.8. Cable ties

For external applications cable ties must be stainless steel; where cables ties are to be secured to a dissimilar metal, PVC coated stainless steel cable ties or a secondary means for isolation (approved by AMSA) of dissimilar metals must be utilised.

PVC cable ties may be utilised for internal applications.

Care must be taken to ensure cable ties are not overtightened causing damage to a cable or coating system.

All cable ties must be installed utilising the correct tool to ensure no sharp edges remain after trimming.

7.9. Glands

All glands utilised must meet or exceed the IP rating of the enclosure or application to which they are being installed. Where glands are being used as a wall penetration or similar they must have a minimum IP56 rating.

All glands must be supplied with the correct sealing sleave/grommet for the installed cable. The sealing sleave/grommet must not be modified.

Glands must be the compression type with metric thread and the material suitable for the location and use.

The use of split glands (with the appropriate IP rating) must be used where a cable fitted with a pre-terminated fitting is unable to fit through a standard gland opening. Split glands suitable for this are KDS Click (by CONTA_CLIP).

On a case-by-case basis AMSA will consider modifying grommets for figure 8 cables passing through pull through junction boxes that do not have any terminations inside.

7.10. Coaxial cable and connectors

All coaxial cable and connectors must be 50ohm.

All external coaxial connection and mil-spec connectors must have amalgamating tape applied to prevent the ingress of moisture.

The application of die-electric grease is required to further assist with moisture ingress to mil-spec connectors.

8. Inspection, testing and commissioning

All electrical works must be inspected, tested and commissioned to the full extent of the requirements specified in AS/NZS 3000, 4509.1 and 5033 and any other applicable Australian Standard or manufacturers requirement.

A commissioning plan must be developed that includes all relevant tests as specified in Appendix A and any additional testing required for the installation being undertaken or recommended by the equipment manufacturer.

The commissioning plan must include logical step by step processes capturing all stages, testing requirements, expected results and results.

As a minimum all coaxial cabling installed must be tested for distance to fault, VSWR and return loss. The results must be interpreted by the Contractor to ensure it is within the parameters of the coaxial / equipment installation.

A detailed record must be maintained for all inspection, testing and commissioning undertaken.

All parameters changed from default values must be recorded and provided in a table format. As a minimum this must show parameter ID, default value and changed value.

Final settings for all programmable and adjustable equipment must be recorded and provided in electronic format. Electronic configurations / source codes must be provided wherever possible.

All configurable electronic devices in the installation must be provided by the Contractor with the as commissioned software configuration files. Programming software licences and hardware accessories required to fault fine and reconfigure the device must also be provided by the Contractor.

Each State/Territory has requirements for ensuring any electrical work for the installation, repair, alteration, and maintenance is electrically safe. In line with the requirements of the relevant State/Territory copies of the electrical safety test certificates or certificates of conformity/compliance must be provided to AMSA.

The minimum commissioning test requirements are outlined in Appendix A, with the format provided as a guide.

9. Heritage requirements

For heritage structures, including those listed on a heritage register and those that may become listed, all works must consider the following:

a) The selection and positioning of equipment must be considered and planned to:
   I. utilise existing penetrations and mounting arrangements as far as reasonably practical;
   II. be undertaken in a manner that is reversible; and
   III. minimise the impact on the visual amenity of the structure or site.

b) Cable trays must be stainless steel and have a folded edge. A flat stainless-steel cover must also be fitted.

c) Equipment/components such as conduits, saddles, ducts, enclosures, support brackets etc that are to be fixed to the structure must be supplied to match the colour of adjacent surface upon which it is to be mounted where possible. Any markings on conduits must face the wall if the conduit remains unpainted.

A detailed installation plan must be submitted which details:

a) all materials to be utilised

b) location and mounting arrangements for equipment

c) cabling paths.

Following the submission of the detailed installation plan, AMSA's Heritage Officer will review the information provided and assess for any heritage impacts. The Heritage Officer may request additional detail be provided so that they may complete the heritage impact assessment.

The heritage impact assessment does not consider and assess the installation in relation to complying with this standard.

At the completion of any works the contractor must update AMSA's heritage fabric documentation, which will be made available on request.

10. Documentation standards

AMSA places considerable importance on the provision of documentation for electrical designs (including drawings and specifications) and due regard must therefore be paid to the detail, completeness and accuracy of such documents. Documentation must be clear, concise and precise.

Where specified in the request for tender/quotation or contract, As-installed/As-built drawings in AutoCAD and PDF format must be provided for all new electrical installations and modifications to existing installations. The drawings must be prepared in accordance with the AMSA Aid to Navigation Drafting Standard.

As a minimum the following drawings must be provided or updated for all electrical works:

a) Cover page/Drawing index;

b) Electrical symbol legend;

c) Single line diagram/s;

d) Equipment layouts for all levels of the structure in which electrical equipment has been installed including sufficient detail to document cable paths between electrical items (this may require a combination of plan and elevation drawings);

e) Wiring Schematics;

f) Overall bill of materials(excluding electrical boards);

g) Cable schedule;

h) Electrical board drawing set for each board and junction box (excludes pull through) consisting of:

   a. Wiring diagrams

   b. General arrangements

   c. Label diagrams

   d. Bill of materials

i) Electrical related structural components such as battery racks, lantern stands, custom ducts, cable support systems and antenna mounting arrangements.

j) Earthing and lightning protection systems.

11. AMSA standard boards

Unless specified or approved otherwise by AMSA, all regulator boards must be manufactured in accordance with the AMSA standard designs.

AMSA has a combination of PWM and MPPT regulator board design used in the network for both 12 and 24 volt systems.

The AMSA standard regulator board designs can be provided from AMSA's drawing register as required.

The regulator board design to be utilised for a particular site will be either specified in the request for tender/quotation or contract that the electrical work is being completed under. Where not specified, the regulator board design must be selected in consultation with AMSA.

Unless specified or approved otherwise by AMSA all Battery Isolator and DC Distribution Boards must be assembled utilising enclosures and two pole circuit breakers as listed in the AEEL.

12. Quality and approved products

All electrical components and materials must be selected and installed to ensure reliable and satisfactory operation in which safety is the first consideration and to facilitate inspection, maintenance and repairs. Materials must be new, of the best quality and class and must withstand the environmental conditions in which they are subjected to and suitable for the purpose specified.

All materials and equipment must be installed in accordance with the manufacturer's recommendations.

Personnel engaged in the installation of electrical works must be accredited, suitably experienced, competent and skilled in the particular field of works.

The Contractor is responsible for ensuring that the electrical equipment and installation is electrically safe in accordance with AS 3000.

To maintain standards between sites, all equipment must be selected from the Approved Electrical Equipment List (AEEL) included in Appendix B.

The Contractor may request approval for use of alternative equipment not listed in the AEEL by submitting written documentation from the supplier or manufacturer demonstrating its suitability for the intended application and is of equal or better quality.

AMSA is under no obligation to approve any product and may reject such applications without providing written cause.

Not all approved equipment in the AEEL may necessarily be appropriate in all installations. The Contractor is responsible to assess the equipment is suitable, and where it is not, propose an alternative product.

Commercial off the shelf products must be used wherever possible. No open source or custom-built components may be used without specific approval from AMSA.

APPENDIX A – Minimum Commissioning Test Requirements

1. PV Array

PRIOR TO WORKS COMMENCING									
PV Module	**Visual**	**Polarity**	**Parallel connection**	**Voc**	**Isc**	**Correct Termination**	**Operating Voltage**	**Operating Current**	**Bird fouling (%)**
PV1									
PV2									
PV3									
PV4									
PV5									
PV6									
PV7									
PV8									
PV9									
PV10									
PV11									
PV12									
PV13									
PV14									
PV15									
PV16									

Weather Observation:
Time:
Photograph to demonstrate bird fouling:

ON COMPLETION OF WORKS								
PV Module	**Visual**	**Polarity**	**Connection Parallel/Series**	**Voc**	**Isc**	**Correct Termination**	**Operating Voltage**	**Operating Current**
PV1								
PV2								
PV3								
PV4								
PV5								
PV6								
PV7								
PV8								
PV9								
PV10								
PV11								
PV12								
PV13								
PV14								
PV15								
PV16								

PV array must be cleaned prior to undertaking commissioning test on completion of works.
Weather Observation:
Time:

2. Battery Modules

For Voltage Load test ensure all battery modules are isolated excluding the module being tested i.e. Each module must be tested individually.

PRIOR TO WORKS COMMENCING						
Battery Module	**Visual**	**Polarity**	**Voltage No Load**	**Voltage Load**	**Correct Circuit Breaker**	**Comments**
BM1						
BM2						
BM3						
BM4						
BM5						
BM6						
BM7						
BM8						
BM9						
BM10						
BM11						
BM12						
BM13						
BM14						
BM15						
BM16						

ON COMPLETION OF WORKS						
Battery Module	**Visual**	**Polarity**	**Voltage No Load**	**Voltage Load**	**Correct Circuit Breaker**	**Comments**
BM1						
BM2						
BM3						
BM4						
BM5						
BM6						
BM7						
BM8						
BM9						
BM10						
BM11						
BM12						
BM13						
BM14						
BM15						
BM16						

3. Individual Batteries

PRIOR TO WORKS COMMENCING								
Battery Module	Battery Voltage							
	Batt 1	Batt 2	Batt 3	Batt 4	Batt 5	Batt 6	Batt 7	Batt 8
BM1								
BM2								
BM3								
BM4								
BM5								
BM6								
BM7								
BM8								
BM9								
BM10								
BM11								
BM12								
BM13								
BM14								
BM15								
BM16								

ON COMPLETION OF WORKS								
Battery Module	Battery Voltage							
	Batt 1	Batt 2	Batt 3	Batt 4	Batt 5	Batt 6	Batt 7	Batt 8
BM1								
BM2								
BM3								
BM4								
BM5								
BM6								
BM7								
BM8								
BM9								
BM10								
BM11								
BM12								
BM13								
BM14								
BM15								
BM16								

4. Regulator Boards

For output voltage load ensure all equipment is operating at time of test.

Reg Brd	PV Polarity @ Terminal	PV Polarity @ Reg	Battery Polarity @ Terminal	Battery Polarity @ Reg	Output Polarity	Output Voltage No Load	Output Voltage Load	Regulators Charging / Correct LED
+RB1								
+RB2								
+RB3								
+RB4								

5. Regulators
Voltage checks at regulator (Morningstar PWM)

Regulator	Array Volts	Battery Volts	Load Volts	Diode voltage drop	Charge status LED	Battery SOC LED
Module 1						
Module 2						
Module 3						
Module 4						
Module 5						
Module 6						
Module 7						
Module 8						
Module 9						
Module 10						
Module 11						
Module 12						
Module 13						
Module 14						
Module 15						
Module 16						

6. Distribution Boards

Dist Board	Polarity	Correct Labelling	Correct Circuits	Voltage
+DCDB1				
+DCDB2				

7. Power Conditioner

Power Conditioner Unit	Polarity	Voltage Setting	Voltage input	Voltage output
+PCU1				

8. Inverter

Model	Polarity	Voltage in	Voltage out	Earth continuity

9. Remote Switching Device

Device No.	IP Address	Polarity	Terminal Voltage	Switched Equipment	Confirm Switching
1					
2					
3					

Use Cycle Power only – Do Not use turn off/On with Router as it will latch in the off state

Cycle time = 10Sec

Setting for ON/OFF/LAST will be “ON”

Username and passwords:

Role	Username (Fixed)	Password (User Set)

10. Freewave/modem

Model	Polarity	Voltage	Status lights

11. AIS

Unit	Polarity	Voltage load	Voltage no load	Current load	Confirm ESS Tech – Date/Time
1					
2					

12. Lantern

Ensure lantern is operating for voltage measurements

Model	Polarity	Voltage load	Voltage no load	Current load	Rotation speed (RPM) or flash character

13. Racon

Model	Polarity	Voltage load	Voltage no load	Current load	Confirm operation by vessel (if possible)

14. Remote monitoring

Model	Polarity	Voltage	Confirm ESS Tech – Date/Time

15. Antenna Coax test

Each coaxial cable must be tested for distance to fault, VSWR and return loss

Antenna	Cable No.	Test Type	Result	Pass/Fail

16. Earth Grid / Lightning Protection

Equipment	Resistance

17. Equipment details

Equipment	Serial number	Model number

APPENDIX B – Approved Electrical Equipment List

Equipment Type	Approved Equipment
Batteries	As specified or approved by AMSA with bolted connection terminals
Battery mounted Fuse	Bussmann CFBAR battery fuse Bar
	Bussmann MRBF fuse
Solar Panels	As specified or approved by AMSA
Solar Regulator	Morningstar Sunsaver PWM L series Victron Smart Solar MPPT
Circuit breakers	ABB S200 and S800 series
	Noark Ex9BP
Battery Isolator and DC distribution Board enclosures	Clipsal 56SB series
	ABB IP65 Mistral series
	ABB IP65 Europa series
	ABB IP65 Fly series
	Hager IP65 Vector series
	PVPower IP65 Consumer Unit series
Enclosures	Fibox
	B&R Polynova PC and PS series
	B&R Pilbara SS (fitted with weather shields)
	B&R Lambert SS (fitted with weather shields)
	Clipsal 265 series adaptable box
	ABB IP65 Waterproof boxes
	ABB IP65 Junction boxes
Terminals	Weidmuller
	Phoenix Contact
PV array connectors	Genuine Multi Contact MC4
Diodes	Schottky