

**Technical Specification**

**Transport and Main Roads Specifications  
MRTS98 Standalone Solar (PV) Powered Lighting**

**July 2017**

## Copyright



<http://creativecommons.org/licenses/by/3.0/au/>

© State of Queensland (Department of Transport and Main Roads) 2017

**Feedback:** Please send your feedback regarding this document to: [tmr.techdocs@tmr.qld.gov.au](mailto:tmr.techdocs@tmr.qld.gov.au)

## Contents

<b>1</b>	<b>Introduction</b> .....	<b>1</b>
<b>2</b>	<b>Definition of terms</b> .....	<b>1</b>
<b>3</b>	<b>Reference documents</b> .....	<b>2</b>
3.1	Standards and specifications .....	2
<b>4</b>	<b>Quality system requirements</b> .....	<b>3</b>
4.1	Hold Points and Witness Points .....	3
4.2	Warranty .....	3
<b>5</b>	<b>Operational requirements</b> .....	<b>3</b>
5.1	General requirements .....	3
5.2	Functional requirements .....	4
5.3	Performance requirements .....	4
<b>6</b>	<b>Mechanical and physical requirements</b> .....	<b>4</b>
6.1	Lighting mount .....	4
6.2	Ducts and pits .....	5
<b>7</b>	<b>Electrical requirements</b> .....	<b>5</b>
7.1	General .....	5
7.2	Protection .....	5
7.2.1	<i>Protection against electrical shock</i> .....	5
7.2.2	<i>Protection against overcurrent</i> .....	5
7.2.3	<i>Protection against earth leakage current</i> .....	5
7.2.4	<i>Protection against effects of lightning and overvoltage</i> .....	5
7.2.5	<i>PV array protection</i> .....	6
7.3	Electromagnetic compatibility .....	6
<b>8</b>	<b>Equipment and installation requirements</b> .....	<b>6</b>
8.1	Selection and installation of electrical equipment .....	8
8.2	PV module .....	8
8.3	PV charger controller .....	8
8.4	Inverter .....	9
8.5	Batteries .....	9
8.6	Battery enclosure and installation .....	9
8.6.1	<i>Above-ground installation</i> .....	10
8.6.2	<i>Below-ground installation</i> .....	10
8.7	Cables .....	11
8.8	Luminaires and lamps .....	11
8.9	Marking and signs .....	11
<b>9</b>	<b>Documentation</b> .....	<b>11</b>
9.1	Design documentation .....	11
9.2	Equipment documentation .....	11
<b>10</b>	<b>Testing and commissioning</b> .....	<b>12</b>
<b>11</b>	<b>Contractor obligations</b> .....	<b>12</b>

12 Training ..... 12  
13 Maintenance ..... 13  
14 Handover ..... 13

## 1 Introduction

This Technical Specification applies to the design, supply, installation, testing and commissioning, performance, documentation, training and maintenance requirements for solar powered lighting at isolated intersections.

Standalone Solar (PV) Powered Lighting is to provide lighting in locations where reticulated electricity is not available or financially viable. It can be used for flag-lighting, to provide a visual alert to approaching motorists to the presence of an intersection, from a safe distance away.

Where full intersection lighting complying with AS/NZS 1158 is deemed necessary, Standalone Solar (PV) Powered Lighting shall only be pursued after a detailed economical assessment, including whole of life costs, confirming viability of solar-powered in comparison to traditional mains connected lighting.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

## 2 Definition of terms

The terms defined in Clause 2 of MRTS01 *Introduction to Technical Specifications* and MRTS201 *General Equipment Requirements* apply to this Technical Specification. Additional terminology relevant to this Technical Specification is defined in Table 2 below.

**Table 2 – Definition of terms**

Term	Definition
Administrator	Principal's representative or superintendent as defined in Clause 14 of MRTS01 <i>Introduction to Technical Specifications</i>
DoD	Depth of Discharge
ELV	Extra Low Voltage
FAT	Factory Acceptance Test(s)
Irradiance	Radiant solar power incident upon unit area of surface
LED	Light Emitting Diode
LFP	Lithium Iron Phosphate
MPPT	Maximum Power Point Tracking
PCE	Power Control Equipment
PSH	Peak Sun Hours
PV	Photovoltaic
PV Module	The smallest complete environmentally protected assembly of interconnected cell
PV Array	Assembly of electrically connected PV Modules
SPD	Surge Protection Device
STC	Standard test conditions
VRLA	Valve Regulated Lead Acid

### 3 Reference documents

#### 3.1 Standards and specifications

The requirements of the referenced documents listed in Table 3 of MRTS201 *General Equipment Requirements* and Table 3.1 below apply to this Technical Specification. The Technical Specifications referred here are the latest version at the time of release of this document. Where there are inconsistencies between this Technical Specification and the referenced MRTS (including those referenced in MRTS201 *General Equipment Requirements*), the requirements specified in this Technical Specification shall take precedence.

**Table 3.1 – Referenced documents**

Document ID	Document Name / Description
AS/NZS 1158	<i>Lighting for roads and public spaces</i>
AS/NZS 1170.2	<i>Structural design actions - Wind actions</i>
AS/NZS 1768	<i>Lightning protection</i>
AS 1798	<i>Lighting poles and bracket arms – Preferred dimensions</i>
AS/NZS 3000	<i>Electrical installations (Australian/New Zealand Wiring Rules)</i>
AS/NZS 3008	<i>Selection of Cables</i>
AS/NZS 3100	<i>Approval and test specification - General requirements for electrical equipment</i>
AS 3996	<i>Access covers and grates</i>
AS 4086.1	<i>Secondary batteries for use with standalone power systems- General requirements</i>
AS 4086.2	<i>Secondary batteries for use with standalone power systems – Installation and maintenance</i>
AS/NZS 4509.1	<i>Standalone power systems - Safety and installation</i>
AS/NZS 4509.2	<i>Standalone power systems - System design</i>
AS/NZS 5033	<i>Installation of photovoltaic (PV) arrays</i>
AS/NZS 5603	<i>Standalone inverters – Performance requirements</i>
AS 60529	<i>Degrees of protection provided by enclosures (IP Code)</i>
AS/NZS 61000.6.1	<i>Electromagnetic compatibility (EMC) - Generic standards - Immunity for residential, commercial and light-industrial environments</i>
AS/NZS 61000.6.3	<i>Electromagnetic Compatibility – General Standards - Emission</i>
EDM	Transport and Main Roads Electrical Design Manual for roadside devices
IEC 61215	Crystalline silicon terrestrial PV modules - Design qualification and type approval
MRTS01	<i>Introduction to Technical Specifications</i>
MRTS50	<i>Specific Quality System Requirements</i>
MRTS61	<i>Mounting Structures for ITS Devices</i>
MRTS91	<i>Conduits and Pits</i>
MRTS94	<i>Road Lighting</i>
MRTS97	<i>Mounting Structures for Roadside Equipment</i>

Document ID	Document Name / Description
MRTS201	<i>General Equipment Requirements</i>
SA/SNZ TS 1158.6	Technical Specification. Part 6: Luminaires - Performance
QTMR RPDM	<i>Road Planning and Design Manual</i>
TRUM Vol 4 Part 4	<i>Traffic and Road Use Management Manual, Volume 4, Part 4: Bell Joint Assembly</i>

## 4 Quality system requirements

### 4.1 Hold Points and Witness Points

General requirements for Hold Points and Witness Points are specified in Clause 5.2 of MRTS01 *Introduction to Technical Specifications*.

The Hold Points and Witness Points applicable to this Technical Specification are summarised in Table 4.1. There are no Milestones defined.

**Table 4.1 – Hold Points and Witness Points**

Clause	Hold Point	Witness Point	Milestone
5.1	1. Inspection of specific locality		
8	2. Inspection of structure mounting	1. Sealing of conduits	
9.1	3. Design documentation		
9.2	4. Equipment documentation		
10	5. Compliance of equipment with standard requirements		

### 4.2 Warranty

Warranty provisions shall meet the requirements of MRTS201 *General Equipment Requirements*.

## 5 Operational requirements

### 5.1 General requirements

The specific site locality for a proposed solar installation shall be investigated prior to the design stage, to ensure the specific locality is suitable. Trees, steep embankments, buildings or other structures that could shadow the PV module shall be identified. **Hold Point 1**

Solar powered lighting:

- a) As a flag light at isolated intersections:
  - i. shall be able to alert approaching motorists to the presence of the intersection
  - ii. Retroreflective Road Pavement Markings (RRPMs), advance warning and guidance shall also be provided.
- b) As V category or P category lighting, shall comply with AS/NZS 1158, and

- c) Non-frangible poles and aboveground battery compartments shall only be installed outside prescribed clear zones.

## **5.2 Functional requirements**

The solar system is to provide the above stated operational requirements, the functional requirements are as follows:

- a) shall be a self-contained unit, that is the mounting column for the luminaire to be utilised as the mounting structure for the solar array, and where used, an underground pit installed within 3 m of the mounting structure
- b) shall be able to provide required illumination level as per AS/NZS 1158
- c) shall be able to operate a minimum four nights without charging (autonomy period)
- d) automatic switching of the light by photoelectric cell integral to the luminaire when site illumination reaches 30 lux, as per the requirements listed in the EDM. This function may be integrated with the solar system/panel
- e) shall be safe and minimise vandalism and likelihood of theft
- f) require minimum maintenance
- g) shall be able to operate in environment conditions listed in MRTS201 *General Equipment Requirements*, and
- h) expected PSH on a winter solstice day shall provide sufficient energy for a minimum one night of service at winter solstice (worst case power demand).

The worst case energy scenario for solar lighting is deemed to be during the shortest days of the year with the shortest period of time for solar power generation and the longest period of time for power consumption during the night. For design calculation purposes the winter solstice day is nominated as the worst case day.

## **5.3 Performance requirements**

The solar powered lighting shall deliver the operational and functional requirements listed above, and operate under all Queensland weather conditions.

The associated solar powered lighting infrastructure shall have minimum life span of 20 years with minimum three years maintenance free operation.

## **6 Mechanical and physical requirements**

The mechanical and physical requirements of the solar powered lighting shall be as defined in MRTS201 *General Equipment Requirements*.

### **6.1 Lighting mount**

Mounting structures shall be as per the requirements defined in MRTS97 *Mounting Structures for roadside equipment*.

Slip base pole construction may be used in high speed environments for mounting the solar powered lights. The decision to use slip base or frangible posts shall be made by an Engineer with the appropriate RPEQ qualification.



The mounting height of the luminaire for flag lighting applications shall be no less than seven metres above ground level.

Non-frangible poles must be located outside the clear zone prescribed in AS/NZS 1158.1.2.

## **6.2 Ducts and pits**

Pits are not permitted in the roadway.

If a pit is to be installed in an area expected to be exposed to tractor drawn mowers or similar, a Class C pit meeting the requirements of AS 3996 shall be used. In all other areas pits shall meet the requirements of MRTS91 *Conduits and Pits*. Pits are to be constructed with anti-theft features.

The design and construction of ducts shall meet the requirements of MRTS91 *Conduits and Pits*.

## **7 Electrical requirements**

### **7.1 General**

All electrical work shall meet the requirements of AS/NZS 3000, AS/NZS 3100 and AS/NZS 3008.

### **7.2 Protection**

All protection and switches to be double pole type.

#### **7.2.1 Protection against electrical shock**

To provide protection against electrical shock, the following shall be adhered to

- a) all wiring shall be installed in accordance with AS/NZS 3000.
- b) all exposed cables, conduits, ducts and system component shall be of a UV resistant type.
- c) If the system's voltage is higher than ELV or lightning flash density is three or more flashes per square kilometre per year at the area of installation, then all exposed metal parts in the PV array and system components shall be bonded and earthed in accordance with the requirements in AS/NZS 5033.

#### **7.2.2 Protection against overcurrent**

Overcurrent protection shall be provided and the protection device shall be installed immediately adjacent to the batteries, on the load side. For underground battery installations, protective devices installed adjacent to the batteries shall be installed in the department's standard junction box in accordance with TRUM Vol 4 Part 4. In the battery system, protection shall be provided to both positive and negative leads. All overcurrent protection devices shall be capable of interrupting the maximum prospective fault current from the battery. Ratings of the overcurrent protection shall be in accordance with AS/NZS 5033. Overcurrent protection devices within the solar powered lighting system shall be able to provide necessary discrimination.

#### **7.2.3 Protection against earth leakage current**

Protection against Earth leakage current is not required, as per the EDM.

#### **7.2.4 Protection against effects of lightning and overvoltage**

Solar powered lighting installed in places where the lightning flash density is three or more flashes per square kilometre per year shall be provided in accordance with Clause 3.5 of AS/NZS 5033:2012, including the following measures:

- a) equipotential bonding of all exposed metal parts
- b) bundling of positive and negative cables of individual circuits together and avoidance of creation of wiring loops
- c) installation of Surge Protection Devices (SPD) in DC circuits shall be DC rated
- d) DC power cable earthing.

Metal Oxide Varistors shall be used instead of gas discharge protection devices/surge protectors.

#### **7.2.5 PV array protection**

PV array shall be protected against reverse bias and consequent hot spot heating by suitable means such as bypass diodes if the system voltage is not ELV. Protection against reverse current leakage from the batteries during nights shall be provided using techniques such as blocking diodes, if not incorporated into the control equipment / regulator.

#### **7.3 Electromagnetic compatibility**

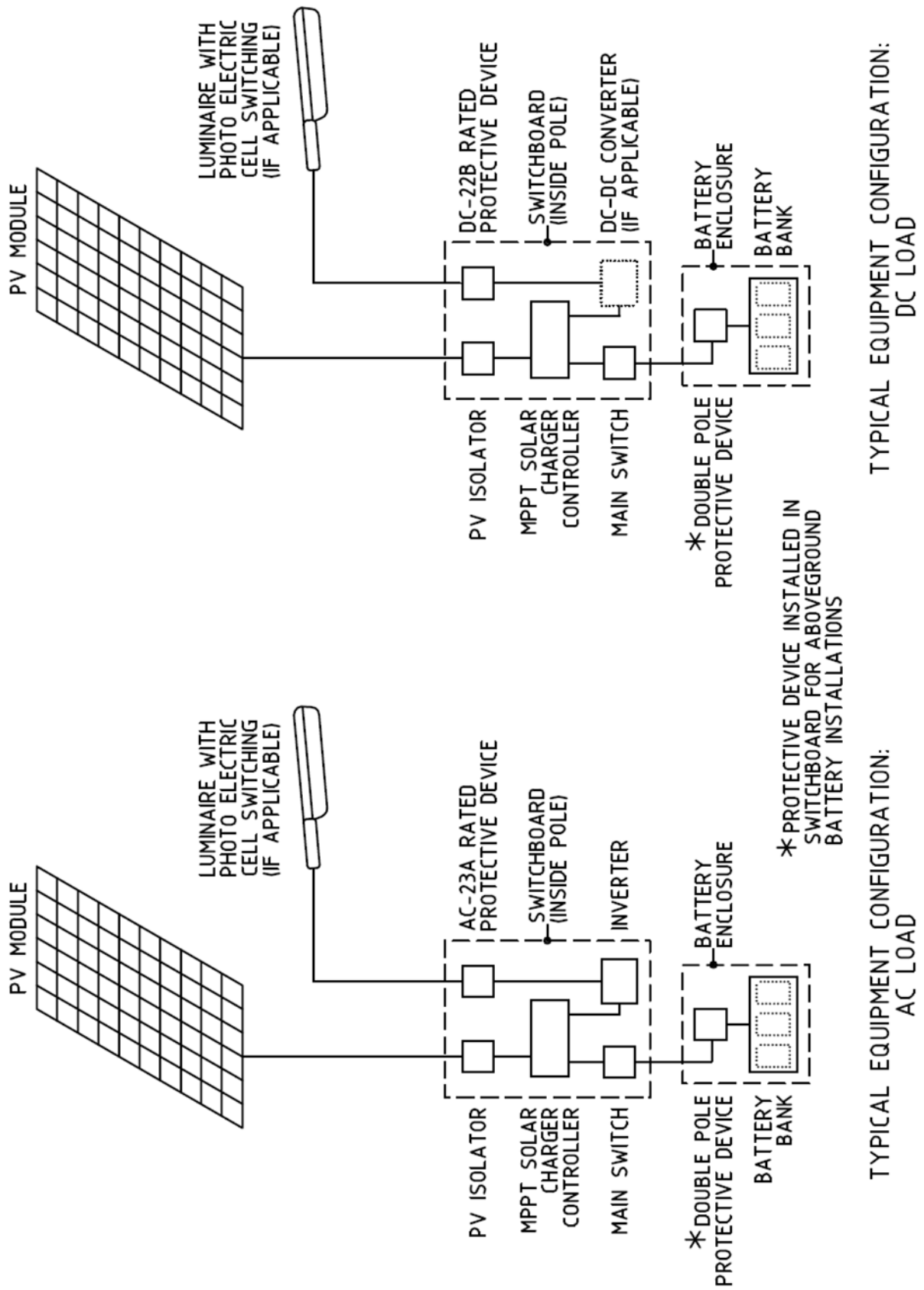
The PV installation shall comply with the electromagnetic compatibility provisions of AS/NZS 61000.6.1 and AS/NZS 61000.6.3 for immunity and emissions respectively.

### **8 Equipment and installation requirements**

The solar powered lighting and the associated infrastructure shall be installed at locations shown on the design documentation. The Contractor shall allow access for inspection of all mounting surfaces by the Administrator prior to installation. **Hold Point 2** See Figure 8 for typical equipment configurations.

After installation of the cables, the conduits shall be sealed to prevent vermin entry. **Witness Point 1**

Figure 8 – Typical equipment configuration for AC and DC loads



### **8.1 Selection and installation of electrical equipment**

All equipment and wiring shall be selected and installed in accordance with the provisions of AS/NZS 3000 and AS/NZS 5033 (where applicable).

A load breaking switch disconnecter shall be fitted adjacent to the PCE, to isolate the array from the application circuit in accordance with the provision of AS/NZS 5033.

All components shall comply with the following requirements:

- a) be rated for DC use (with exception to the luminaire)
- b) have a voltage rating equal to or greater than the PV array maximum voltage corrected for lowest temperature expected at the site
- c) current rating equal or greater than that shown in Table 4.2 of AS/NZS 5033:2014
- d) operational current rated at ambient plus 40°C
- e) the load breaking switch disconnectors non-polarity sensitive, interrupt all live conductors simultaneously and utilization category of at least DC 22 B
- f) circuit Breakers or fuses rated to interrupt full load and prospective fault currents from the PV array and any other connected power sources
- g) circuit Breakers or fuses meet the requirements of the EDM
- h) all equipment exposed to an outdoor environment IP 55 or greater and UV resistant
- i) all junction boxes IP 67 or greater, connection of wiring and associated conduits and glands, orientation and method of connection of wiring shall ensure the IP ratings are retained, and
- j) all components able to withstand maximum operating temperature of the PV array. Generally the maximum operating temperature of PV is maximum ambient temperature plus 40°C.

### **8.2 PV module**

The PV modules shall meet the design qualification and type approval in accordance with IEC 61215 or relevant Australian Standards. PV strings within PV array shall be of same technology and electrical characteristics. Installation of the PV modules shall comply the requirements of AS/NZS 5033.

A bird deterrent device attached to the PV module shall be provided, to stop birds from resting on the solar module, for example small spikes, zig zag sheet metal (preferred), single raised wire or rollers.

### **8.3 PV charger controller**

PV charger controller shall be used to control the battery charging from PV meeting the requirements of the battery manufacturer, to ensure the maximum life of the batteries. The charger controller shall be compatible with the batteries being used. The PV charger controller may also do the energy management functions of the solar light system. Efficiency of the PV charger controller should be not less than 80%. The PV charger controller shall be rated more than 125% of array short circuit current and shall be able to withstand open circuit array voltage at the expected minimum temperature and meet relevant provisions of AS/NZS 4509.2.

If not incorporated in the system design, the PV charger controller should also provide reverse polarity protection for both battery and PV connection, over voltage protection and under voltage cut off.

Temperature compensated Maximum Power Point Tracking (MPPT) type PV charger controller is preferable over other PV charger controller technologies.

The PV charger controller shall be rated IP 56 in accordance with AS/NZS 60529 or installed within an IP 56 rated enclosure.

#### **8.4 Inverter**

Where an AC powered luminaire is specified, the inverter shall conform to the requirements of AS/NZS 5603 or equivalent, and be of performance class A.

#### **8.5 Batteries**

Battery bank of sufficient ampere-hour capacity rated nominally at 48 h rate of discharge (C48), or maximum known hour discharge rate, shall be provided. For all lead acid batteries the maximum DoD during the autonomy period should not exceed 50%. For LFP batteries, the maximum DoD during the autonomy period should not exceed 85%.

The selection of the batteries shall be consistent with AS 4086.1 and AS/NZS 4509.2, and subject to following additional conditions:

- a) batteries shall be rated minimum for 3000 cycles to 30% DoD at 40°C
- b) batteries with liquid electrolyte shall not be used
- c) batteries shall be of the type suitable for solar applications
- d) batteries shall be field replaceable and of standard size and capacity
- e) minimum life span of the batteries is 5 years and guaranteed for a minimum 5 years
- f) batteries capable of sustained operation in an underground pit throughout their lifespan are preferred, and
- g) battery management system, for example cell balancing modules, where recommended by the battery manufacturer shall be installed to protect batteries from premature failure.

#### **8.6 Battery enclosure and installation**

Batteries may be installed above-ground or underground. The decision to choose either option shall be made by taking into consideration other factors such as vandalism and battery technology.

All types of lead acid batteries shall have natural or forced ventilation, the method of ventilation and sizing of ventilation apertures shall meet the provisions of AS 4086.2. Ventilation of batteries other than lead acid shall meet the requirements of the manufacturer.

Ventilation is still required for sealed lead acid batteries as they are still valve regulated (VRLA) to manage gas build up.

Plastic or fibreglass above-ground pillars or battery enclosures are not permitted, due to insufficient protection against theft and damage.

### 8.6.1 Above-ground installation

Where batteries are installed above ground, they shall be installed in IP 56 rated enclosure according to AS/NZS 60529. Arrangement shall be made to avoid vandalism and prevent access by unauthorized persons. Battery enclosures shall be in accordance with provisions in AS/NZS 4509.2.

Installation of the lead acid batteries shall be in accordance with the provisions in AS 4086.2 and relevant installation requirements in AS/NZS 4509.2 are also to be adhered. Installation of other type of batteries shall be in accordance with manufacturer recommendations.

Installation of the battery protection equipment shall meet the requirements of AS/NZS 4509.1.

Above-ground battery compartments are not permitted within the clear zone prescribed in AS/NZS 1158.1.2.

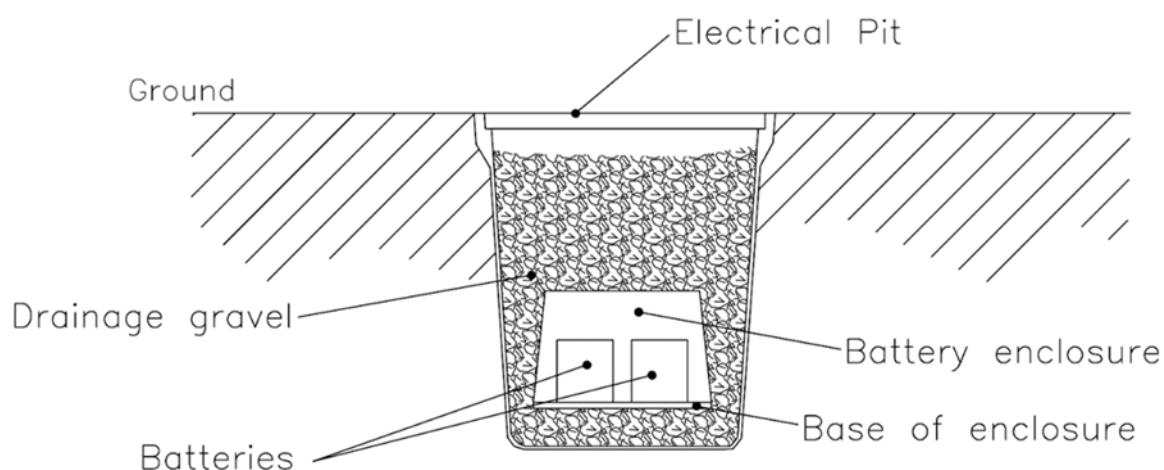
### 8.6.2 Below-ground installation

Where batteries are installed underground, they shall be placed in a pit. If the pit does not have locking or anti-theft features, the pit shall be buried so that the lid is 200 mm ± 50 mm below the surrounding ground level. The pit shall meet the requirements of Clause 6.2.

A bell configured battery enclosure is preferred, this configuration provides an air pocket for the batteries in the event of flooding. Where a bell configured battery enclosure is used, the following items shall be provided, see Figure 8.6.2 for a typical arrangement

- a) loose ballast, for example drainage gravel (up to 20 mm), or similar, to ensure that the bell enclosure does not float in the event of flooding
- b) drilling holes into the battery enclosure is not permitted as this will compromise the air pocket principle. Holes for electrical conduit/venting tube may only be drilled into the base of the enclosure, and
- c) ventilation tubes, where applicable, to connect directly to battery to transport gas from the enclosure

**Figure 8.6.2 – Typical arrangement for underground bell enclosure for batteries.**



### **8.7 Cables**

Selection and sizing of the cables shall be in accordance with AS/NZS 3008, MRTS256 *Power Cables* and MRTS201 *General Equipment Requirements*. The maximum allowable voltage drop between PV array and point of use is 4%.

### **8.8 Luminaires and lamps**

The light output of the luminaire shall be no less than 2200 lumens, and have an overall efficacy of no less than 75 lumens per Watt. The maintenance cycle for luminaires, that is lamp replacement and/or cleaning shall be no less than three years.

The luminaire housing shall be rated to IP 65 or higher, comply with SA/SNZ TS 1158.6 and the spigot entry size shall comply with the relevant clauses of AS 1798.

Dished prismatic or semi cut-off visors shall be used for flag lighting installations, including LED fluorescent and high intensity discharge lamped luminaires. Flat or aero-screen type visors shall only be used where glare or upward waste light parameters are problematic.

Luminaires compatible with DC electrical supply are preferred, reducing electronic componentry in the system.

### **8.9 Marking and signs**

Marking and signs, including shutdown procedure, for electrical equipment and system shall be in accordance with provisions of Section 5 of AS/NZS 5033, AS/NZS 4509 and AS 4086.2.

## **9 Documentation**

The documentation requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification.

### **9.1 Design documentation**

The Contractor shall provide design documentation **Hold Point 3** in a similar format as listed in AS/NZS 4509.2, information including, but not limited to:

- a) system sizing details: PV module, PCE rating/s, battery bank sizing, battery management system, nominated autonomy period, luminaire load, meeting the requirements of Clause 5 in this Technical Specification
- b) PV site specific design: tilt, orientation, insolation/irradiance for site, PSH for winter solstice
- c) de-rating factors: PV oversupply, panel dirt, temperature coefficient, PCE losses, battery losses, discharge losses, and
- d) certificates of compliance where required.

### **9.2 Equipment documentation**

The Contractor documentation shall also include at least the following Technical Specifications and necessary Standard Drawings **Hold Point 4**

- a) PV Array data containing at least manufacturer details, model, voltage, short circuit current, reverse biased withstand current, manufacturer tolerance for current, temperature/voltage and current performance and current at 14 V
- b) circuit protection specifications

- c) switch disconnecter specifications
- d) fuse characteristics curves
- e) charger controller specifications containing at least manufacturer details, model no, current and voltage ratings, protections and maximum charging current
- f) battery specifications including capacity curves at various discharge rates, temperature performance, hydrogen suppression efficiency if battery is lead acid, Coulombic efficiency and prospective fault current for short circuit at the battery terminal
- g) battery ventilation requirements and/or suitability of battery for underground installation;
- h) cable specifications (Voltage, current capacity, maximum temperature, material, calculations indicating justification for selection of cables in accordance with AS/NZS 3008
- i) luminaire specifications
- j) mounting and other associated structures.
- k) fabrication and assembly Standard Drawings, detailing all of the components to be installed
- l) a schematic layout of components, building details and interconnection diagrams
- m) recommendations for routine maintenance tasks, and
- n) recommendations on spare parts

Prior to issue of practical completion, the Contractor shall provide a laminated A3 sized copy of the "As Constructed" electrical schematics and wiring diagrams, together with all FATs, commissioning and operating / maintenance documentation to the satisfaction of the Administrator.

## 10 Testing and commissioning

The testing and commissioning requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification. In addition, test sheets shall demonstrate compliance with the technical requirements of this Technical Specification prior to the delivery of the equipment to site. **Hold Point 5**

## 11 Contractor obligations

The Contractor shall provide to the satisfaction of the Principal/Administrator, the following documents prior to the delivery of the Solar Powered (PV) Lighting to Site:

- a) A statement confirming the warranty provisions associated with the equipment.
- b) Compliance details of all components as required or implied under this document.
- c) Records of tests conducted by the Contractor to demonstrate compliance to this Technical Specification, and
- d) Items listed in nine above.

## 12 Training

The training requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification.



### **13 Maintenance**

The maintenance requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification.

### **14 Handover**

The handover requirements defined in MRTS201 *General Equipment Requirements* apply to work under this Technical Specification.

