WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Company Directive

ENGINEERING EQUIPMENT SPECIFICATION 25/6

110V Batteries, Chargers, Distribution Boards & Associated Auxiliary Cabling For Metering Circuit Breaker Type Primary Network Substations

Author:	**Graham Brewster**
Implementation Date:	**October 2018**
Approved by	[signature]
	Policy Manager
Date:	12 October 2018

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IMPLEMENTATION PLAN

Introduction

This Engineering Equipment Specification (EE SPEC) defines the requirements for substation 110V batteries, battery chargers, battery controllers, dc distribution boards & associated auxiliary cabling which are to be deployed at “metering circuit breaker” type primary network substations.

Main Changes

The main changes from the previous specification are as follows:

- Inclusion of particular GNB Marathon M FT monoblocs on the list of WPD Approved Monoblocs
- Amended temperature correction factor for Enersys monoblocs
- Revised Battery Calculator to include GNB Marathon M FT monoblocs

Impact of Changes

This EE SPEC is relevant to all staff involved with the planning, design, installation and modification of 110Vdc systems at “metering circuit breaker” type primary network substations.

This EE SPEC is also relevant to Independent Connection Providers.

Implementation Actions

Managers should notify relevant staff of this EE SPEC and brief them on its requirements.

Implementation Timetable

The requirements of EE SPEC 25/6 shall apply to any project which is sanctioned on or after 1st October 2018.

REVISION HISTORY

DOCUMENT REVISION & REVIEW TABLE		
Date	**Comments**	**Author**
October 2018	EE SPEC 25/6 Issued The main changes from the previous specification are as follows: • Inclusion of particular GNB Marathon M FT monoblocs on the list of WPD Approved Monoblocs • Amended temperature correction factor for Enersys monoblocs • Revised Battery Calculator to include GNB Marathon M FT monoblocs and amended temperature correction factor for Enersys monoblocs	Graham Brewster
March 2015	EE SPEC 25/5 Issued EE Spec 25/4 has been split into two separate specifications, namely EE Spec 23 and EE Spec 25/5. EE Spec 25/5 (this document) relates to 110Vdc systems at "metering circuit breaker" type primary network substations. The main changes from the original specification are as follows: • Title changed • A modified battery duty cycle • Guidance on methodology for sizing batteries included • Cabling requirements included	Graham Brewster
January 2011	EE SPEC 25/4 Issued	Andy Hood
December 2007	EE SPEC 25/3 Issued	Andy Hood

CONTENTS

1.0 INTRODUCTION

The operational security of the distribution network is dependent upon reliable and secure dc auxiliary supplies. 110V dc systems are used to power protection and switchgear control equipment, and a “no-break” supply is required.

This Engineering Equipment Specification defines the requirements for substation 110V batteries, chargers and dc distribution boards which are to be deployed at “metering circuit breaker” type primary network substations.

2.0 DEFINITIONS

For the purpose of this Engineering Equipment Specification the following definitions apply:

WPD	Western Power Distribution
Primary Network Substation	A 132kV, 66kV, 33kV or 25kV substation including directly associated 66kV, 33kV, 25kV, 11kV and 6.6kV switchboards at transformer stations
“Metering Circuit Breaker” Substation	A substation constructed for the sole purpose of supplying a single customer via a single metering circuit breaker
Cell	The basic electro-chemical unit used to generate or store electrical energy
Monobloc	A multi-compartment container housing a number of separate, but electrically interconnected cells. 12V monoblocs are typically employed
Battery	Multiple cells or monoblocs electrically interconnected in an appropriate series / parallel arrangement to provide the requisite level of operating voltage and current
Battery Duty Cycle	The load a battery is expected to supply for a specified period following loss of output from the battery charger (for whatever reason)

3.0 REFERENCES

This document makes reference to, or should be read in conjunction with, the documents listed below. The issue and date of the documents listed below shall be those applicable at the date of issue of this document, unless stated otherwise.

3.1 British Standards

BS 88-2	Low Voltage Fuses
BS 381C	Specification For Colours For Identification, Coding And Special Purposes
BS 5467	Electric cables – Thermosetting insulated, armoured cables for voltages of 600/1000V and 1900/3300V
BS 6121-1	Armour glands – Requirements and test methods

BS 6121-5	Code of practice for selection, installation and inspection of cable glands and armour glands
BS 6290: Part2	Lead-Acid Stationary Cells And Batteries
BS 7671	Requirements For Electrical Installations
BS EN 50014	Electromagnetic Compatibility – Requirements For Household Appliances, Electric Tools And Similar Apparatus
BS EN 50272-2	Safety Requirements For Secondary Batteries And Battery Installations Part 2: Stationary Batteries
BS EN 60051	Direct Acting Indicating Analogue Electrical Measuring Instruments And Their Accessories
BSEN 60255	Electrical Relays
BS EN 60269	Low Voltage Fuses
BS EN 60309-1	Plugs, Socket Outlets And Couplers For Industrial Purposes: General Requirements
BS EN 60309-2	Plugs, Socket Outlets And Couplers For Industrial Purposes: Dimensional Interchangeability Requirements For Pin And Contact Tube Accessories
BS EN 60529	Degrees Of Protection Provided By Enclosures (IP Code)
BS EN 60694	Common Requirements For High Voltage Switchgear And Control Gear Standards.
BS EN 60896-21	Stationary Lead Acid Batteries Part 21 – Valve Regulated Types: Methods Of Test
BS EN 60896-22	Stationary Lead Acid Batteries Part 22 – Valve Regulated Types: Requirements
BS EN 60947-3	Low Voltage Switchgear And Controlgear: Switches, Disconnectors, Switch-Disconnectors & Fuse Combination Units
IEC TS 61000-6-5	Electromagnetic Compatibility – Generic Standards: Immunity For Power Station And Substation Environments
BS EN 61006-4	Electromagnetic Compatibility – Generic Emission Standards Industrial Environment

3.2 Energy Networks Association Technical Specifications

ENA TS 48-4	DC Relays Associated With Tripping Function In Protection Systems
ENA TS 50-18	Design And Application Of Ancillary Electrical Equipment
ENA TS 50-19	Standard Numbering For Small Wiring

3.3 Institute Of Electrical & Electronic Engineers (IEEE)

IEEE 485	Recommended Practice For Sizing Lead Acid Batteries For Stationary Applications

4.0 GENERAL REQUIREMENTS

4.1 Substation DC Supply Arrangements

The 110V batteries, chargers & distribution boards will be employed at “metering circuit breaker” type primary network substations. Each of these substations will provide electricity to a single customer via a single metering circuit breaker. However, if the connection to the network is “looped” rather than “teed”, the WPD switchboard may consist of up to three circuit breakers (two feeder and one metering circuit breakers). The 110Vdc systems are used to drive protection and switchgear control equipment associated with these power circuits.

110Vdc systems shall be designed to provide “no-break” supplies at all times, in particular whilst routine maintenance, repair or replacement activities are undertaken on batteries & chargers, or the charger ac incoming supply. This is because it is, or may, be unacceptable for:

a) DC supplies to protection and switchgear control equipment to be depleted whilst the associated power circuit is energised

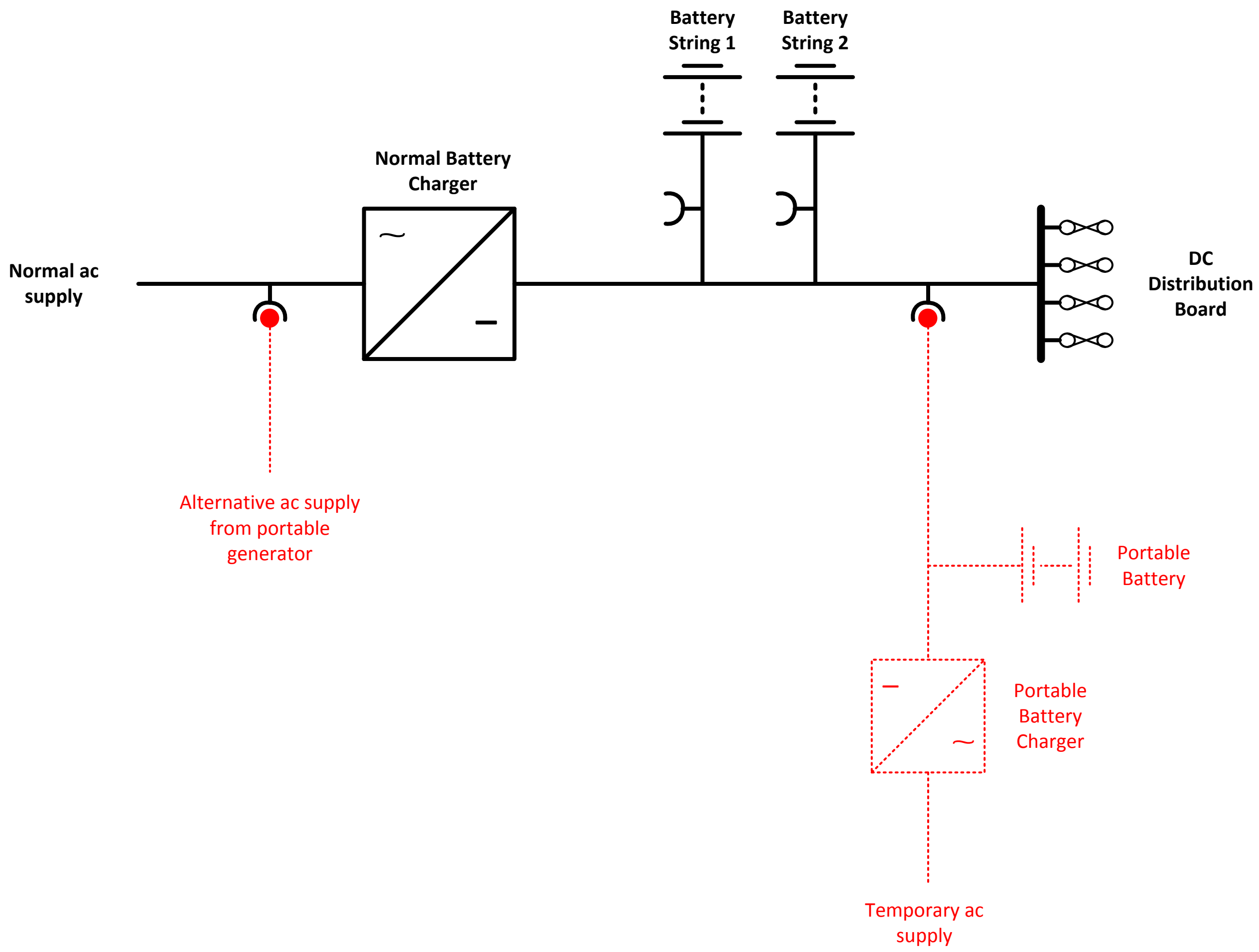
b) All power circuits to be made dead concurrently whilst activities of this type are undertaken

A sustained shutdown of an entire primary network substation (including the site ac auxiliary power supply) as a consequence of either a localised or widespread event will result in the 110V battery slowly discharging due to the standing load. The shutdown could last for 72 hours (worst case scenario).

Accordingly, the DC supply arrangements shall include the following facilities:

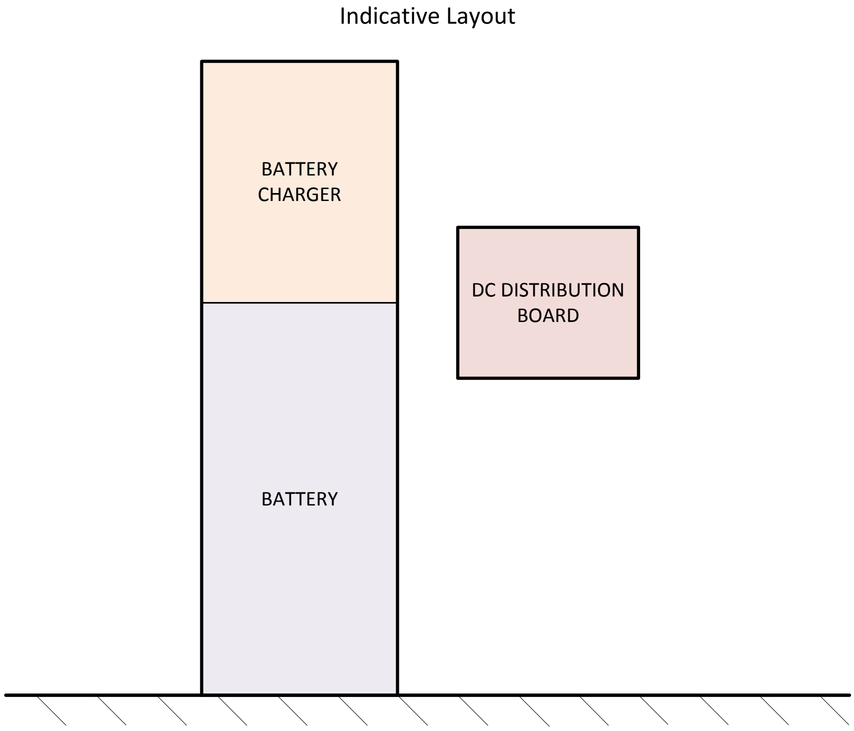
- A means of supplying the battery charger from a portable generator whilst the normal fixed ac supply is being maintained, repaired or replaced
- Two parallel-connected strings of batteries arranged in a manner such that dc supplies can be maintained whilst one battery string is being maintained, repaired or replaced
- A means of connecting a portable battery & portable battery charger whilst the battery charger or battery cubicle is being repaired or replaced

A block diagram of the battery, charger and dc distribution board is shown below.



BLOCK DIAGRAM OF BATTERY, BATTERY CHARGER & DC DISTRIBUTION BOARD

4.2 Schematic Diagram of Battery, Charger & DC Distribution Board



4.3 Environmental Conditions

All equipment shall be suitable for operation in ambient conditions as defined in ENA Technical Specification 50-18.

Suppliers shall, unless otherwise specified in the Schedules, assume:

a) An average air change rate for the room containing the battery of 0.25 air changes per hour
b) A temperature of 15ºC shall be assumed for the purposes of rating the battery system

If there are any special environmental conditions to be met these are defined in the Enquiry / Ordering Schedule.

4.4 Electromagnetic Compatibility

The battery, charger & dc distribution board system shall comply with requirements of the Electromagnetic Compatibility Regulations.

Emission requirements shall satisfy the requirements of BS EN 61000-6-4.

Immunity requirements shall be in accordance with IEC TS 61000-6-5: Electromagnetic compatibility – Immunity for power station and substation environments.

4.5 DC System Earthing

110Vdc systems shall not be directly connected to earth, but earthed via the high impedance of an insulation monitoring (i.e. earth leakage) device. In other words, 110Vdc systems shall be IT systems (I=Isolated, T=Earth) as described in BS 7671.

4.6 Wiring and Terminations

All interconnecting control wiring, terminations and terminal blocks shall be in accordance with ENA Technical Specification 50-18.

Terminal blocks for alarm facilities shall be screw clamp type, to ENA Technical Specification 50-18, with a hinged link for isolation purposes.

Identification marks (ferrules) shall be fitted to each wire in every auxiliary cable. The ferruling shall comply with the requirements contained in ENA Technical Specification 50-19. Its purpose is to facilitate tracing through equipment for function checking and fault-finding and consequently this numbering shall be shown on schematic and wiring diagrams.

Manufacturers may apply identification marks to small wiring complying with other standards, or to their own convention, at terminals which are not located at the point of interface to auxiliary cabling.

4.7 Construction Requirements for Enclosures

Enclosures shall:

- Have a design life of 40 years
- Satisfy the requirements of ENA Technical Specification 50-18
- Be constructed from sheet-steel
- Include cable entry facilities on both the top and bottom sides via un-drilled, removable gland plates
- Include provision for connection to the substation earth-bar. The earthing arrangement shall comply with ENA Technical Specification 50-18
- Be fitted with protective bushes or similar protection, where wiring is taken through division sheets, shelves or side walls

Where an enclosure is in the form of a freestanding cubicle the following additional requirements apply:

- Cubicles shall have a maximum height of 2100mm
- Vermin proofing shall be provided where cubicles are to be located above cable trenches / ducts
- Bottom entry gland plates shall be situated not less than 100 mm above vermin proofing level
- Provide unrestricted access to the battery and battery connections via either, front mounted hinged and lockable doors or via easily removable, bolted panels

Enclosures shall be painted throughout in semi-gloss paint in light grey shade 631 to BS 381C.

4.8 Drawings and Instructions

Drawings shall bear the substation name and/or the WPD contract reference, as appropriate.

All final copies of the schematic / circuit / general arrangement drawings shall be provided in *.dwg (CAD) format.

All final copies of the installation / commissioning / maintenance instructions shall be provided in *.pdf (Adobe Reader) format.

A paper copy of the schematic / circuit / general arrangement drawings and the installation / commissioning / maintenance instructions shall be supplied with each battery, battery charger and dc distribution board.

5.0 REQUIREMENTS FOR BATTERIES

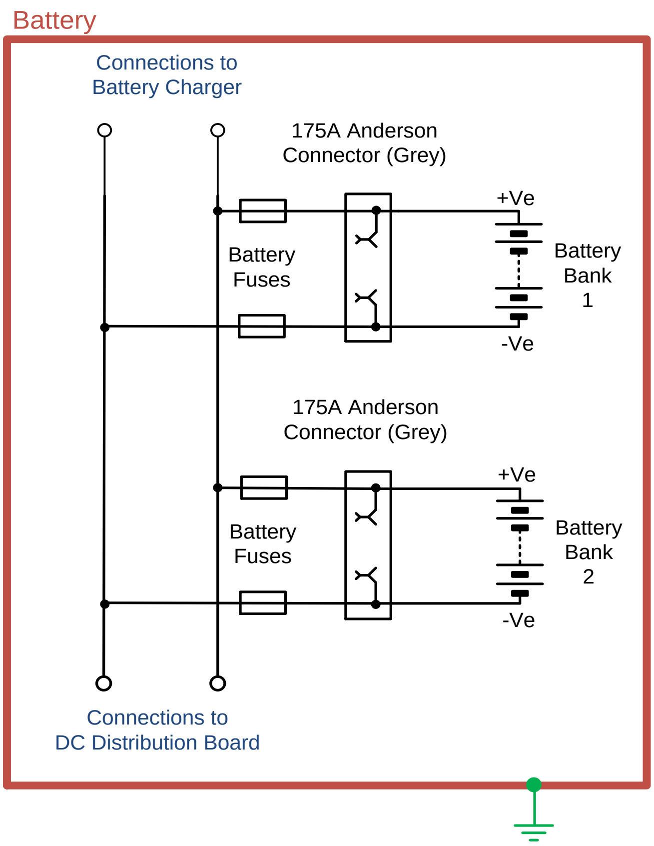
Batteries will be employed in a float charge application (i.e. permanently connected to a load and to a dc power supply) and in a static location (i.e. not generally intended to be moved from place to place). The load will comprise of protection relays and switchgear control equipment i.e. a utility switching application.

The battery is required to supply the dc power requirements when the following conditions occur:

- The load on the dc system exceeds the maximum output of the battery charger
- The output of the battery charger is interrupted
- The ac power supply to the charger is lost

5.1 Schematic Diagram of Battery

A schematic diagram of the battery employing two parallel-connected strings of cells or monoblocs (i.e. a dual battery) is shown below.



5.2 Monobloc Type

Batteries associated with 110V systems shall employ valve regulated lead-acid monoblocs complying with BS EN 60896-21 and BS EN 60896-22.

The monoblocs are to be installed in cabinets and consequently shall be preferably be equipped with front-facing terminals in order to facilitate maintenance and testing activities.

5.3 Monobloc Performance, Durability & Design Life

The design life of the battery shall be at least 10 years, which shall be calculated using an average ambient temperature of 20°C.

Monoblocs shall have a service life in excess of 1100 days at an operating temperature of 40°C and shall maintain their capacity for in excess of 350 days at a stress temperature of 55°C when tested in accordance with BS EN 60896-21.

Monoblocs shall be classified as “12 years & longer – Very Long Life” according to Eurobat Guide 2015.

5.4 WPD Approved Monoblocs

The following monoblocs are approved for use on Western Power Distribution’s network:

Enersys Powersafe SBS EON Technology Thin Plate Pure Lead range, types:

- SBS B14F
- SBS C11F
- SBS 170F

GNB Marathon M FT, types:

- M12V60FT
- M12V100FT
- M12V190FT

5.5 Battery Arrangement

The battery shall consist of two parallel-connected strings of monoblocs.

Each string shall consist of a number of series-connected monoblocs (as appropriate for the battery voltage). Each string shall be identical i.e. employ the same number and type of monobloc and contain 50% of the overall battery capacity.

5.6 Battery Duty Cycle

The battery system shall, in the event of a failure of either the charger or its ac supply, be capable of supporting:

- The standing dc load for a period of 72 hours, followed by
- The simultaneous opening (tripping) of 3 circuit breakers, followed by
- The sequential closing of 3 circuit breakers

> *Guidance*
> *If the connection to the network is “teed” the WPD switchboard will consist of a single metering circuit breaker. Where the connection is “looped” the WPD switchboard may consist of up to three circuit breakers (two feeder and one metering circuit breakers). In all cases three circuit breakers shall be assumed for determining the battery duty cycle.*

5.7 Battery Sizing

The battery system shall be sized in accordance with the requirements of this section and the methodology described in Section 11.

5.7.1 110V Systems

The following requirements apply to all 110V batteries:

NOMINAL VOLTAGE	108V	(54 cells @ 2V per cell)
NORMAL WORKING VOLTAGE	123.7V	(54 cells @ 2.29V per cell)
MINIMUM PERMISSIBLE VOLTAGE AT THE BATTERY TERMINALS AT THE END OF THE DUTY CYCLE	99.9V	(54 cells @ 1.85V per cell)

5.7.2 Battery Design Margin

It is prudent to provide a margin to allow for unforeseen additional load on the dc system or for ambient temperatures being lower than expected. A battery design margin of 1.1 shall be applied to the battery sizing calculation.

5.7.3 Temperature Correction Factor

A temperature of 15ºC shall be assumed for the purposes of rating the battery system.

The available capacity in a monobloc is affected by its operating temperature and rated capacity is typically based upon an ambient temperature of 20ºC or 25ºC. Manufacturer's data on the effect of battery temperature on the electrical discharge performance shall be used to determine a temperature correction factor to be applied to the battery sizing calculation.

Guidance
Battery capacity shall be assessed using a temperature of 15°C whereas design life shall be assessed using 20°C (see 6.3 above).

The rating of Enersys Powersafe SBS EON monoblocs are based on an ambient temperature of 20°C and a temperature correction factor of 1.04 shall be applied to the battery sizing calculation to correct for a temperature of 15ºC. The temperature correction is based upon a 1 hour discharge rate.

The rating of GNB Marathon M FT monoblocs are based on an ambient temperature of 20°C and a temperature correction factor of 1.04 shall be applied to the battery sizing calculation to correct for a temperature of 15ºC.

5.7.4 Ageing Factor

End of service life shall be deemed to be the point at which the battery's actual capacity has reached 80% of the nominal capacity. The battery shall perform the full specified discharge duty cycle throughout its service life, and consequently a 1.25 factor for age shall be applied to the battery sizing calculation.

5.8 Battery Accessories

The battery shall be supplied with accessories and/or tools appropriate for the battery type.

5.9 Battery Connections

All connections up to the battery fuse shall be insulated so that a short circuit cannot occur under all feasible conditions.

Insulation should be resistant against the effects of ambient influences like temperature, dust and mechanical stress.

Monobloc terminal covers shall allow maintenance, measurement and test activities to be undertaken whilst minimising the exposure of live parts.

5.10 Protection and Testing Facilities

Each battery string shall be protected by two fuses (one in the positive circuit and one in the negative circuit).

Battery fuses shall comply with BS EN 60269-1, BS EN 60269-2 and BS 88-2 reference A or B.

A 175A Anderson type connecter shall be installed between each battery string and its associated fuses for battery testing purposes.

5.11 Enclosure

Construction requirements for the enclosure are specified in Section 4.7 above.

The battery shall be provided in a separate compartment of the same enclosure housing the battery charger. The enclosure shall be a free standing cubicle type design capable of being placed against a back wall.

The battery enclosure shall provide a degree of protection to at least IP2X or IPXXB classification in accordance with BS EN 60529.

The battery enclosure shall be lockable and shall be sized such that:

- There is adequate access to monobloc terminals to allow maintenance, measurement and test activities to be undertaken (e.g. for voltage & impedance measurements, discharge tests and the like)
- A single battery string or an individual monobloc can be replaced without dismantling or removing other equipment
- There is a physical gap between neighbouring monoblocs, and between monoblocs and the sides of the enclosure. The gap shall be in accordance with the manufacturer’s recommendations

Monoblocs shall be arranged in a single row per tier. Each row shall run parallel with the enclosure door and the monoblocs shall be orientated such that their terminals face towards it. Alternative arrangements may be submitted to WPD’s Policy Section for approval; however, these are only likely to be countenanced when substantial clearance is available for accessing monoblocs positioned at the rear of others.

The enclosure floor and shelves (where fitted) shall be designed to take the load of the monoblocs.

Whilst the volume of gas emitted by valve regulated lead-acid cells or monoblocs is very small under normal charging conditions, it increases significantly in the event of overcharging. Sufficient natural ventilation shall be provided to prevent the formation of an explosive hydrogen concentration within the enclosure under fault conditions, specifically, in the event of an overvoltage condition of 2.40V per cell. Ventilation requirements shall be calculated in accordance with BS EN 50272-2 and the average air change rate for the room containing the battery declared in section 4.3.

5.12 **Labelling**

5.12.1 Monobloc Labelling

Each monobloc shall be provided with a durable and easily visible alphanumeric identification to enable specific maintenance records to be kept and faulty monoblocs to be identified unambiguously. The identification shall commence with a letter which identifies the string, followed by a number which identifies the monobloc. Numbering shall start at the positive pole, with each monobloc being consecutively numbered all the way to the negative pole.

For example: **A5**

A label shall be placed on the front of each monobloc specifying the replacement date. The date shall be 8 years from the date of supply (to the nearest month).

5.12.2 Battery Identification Label

The battery cubicle shall be provided with a durable and easily visible alphanumeric identification label mounted on the exterior of the enclosure.

The alphanumeric identification shall be **110V BATTERY (WPD)**

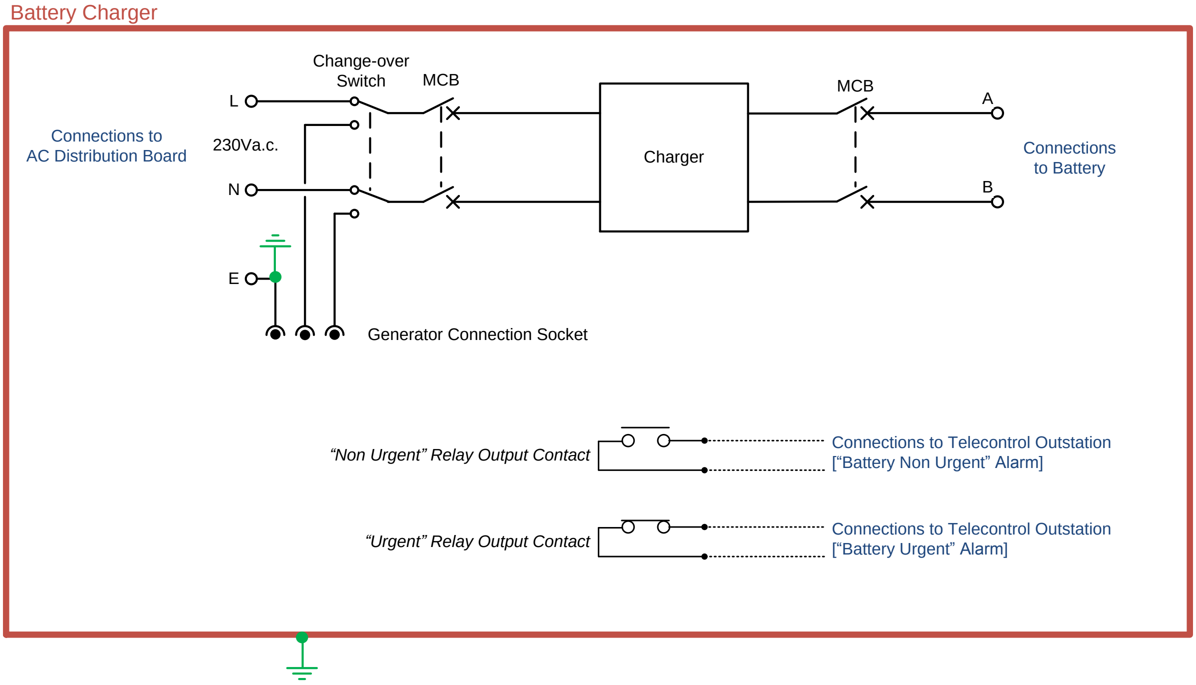
5.12.3 Manufacturer's Information Label

The exterior of the cubicle shall be provided with a durable and easily visible information label showing the following details:

- Name of manufacturer or supplier
- Manufacturer's or supplier's type reference
- Nominal battery voltage
- Nominal or rated capacity of the battery

6.0 REQUIREMENTS FOR BATTERY CHARGERS

6.1 Schematic Diagram of Battery Charger



NOTES:
"Urgent" and "Non-Urgent" relays shown in the de-energised state

6.2 General

The charger shall be an automatic constant voltage charger utilising thyristor controlled rectifier technology.

The charger shall be constructed so that the thyristor controlled rectifier unit can be easily removed and replaced.

6.3 Design Life

The design life of the battery charger shall be at least 20 years.

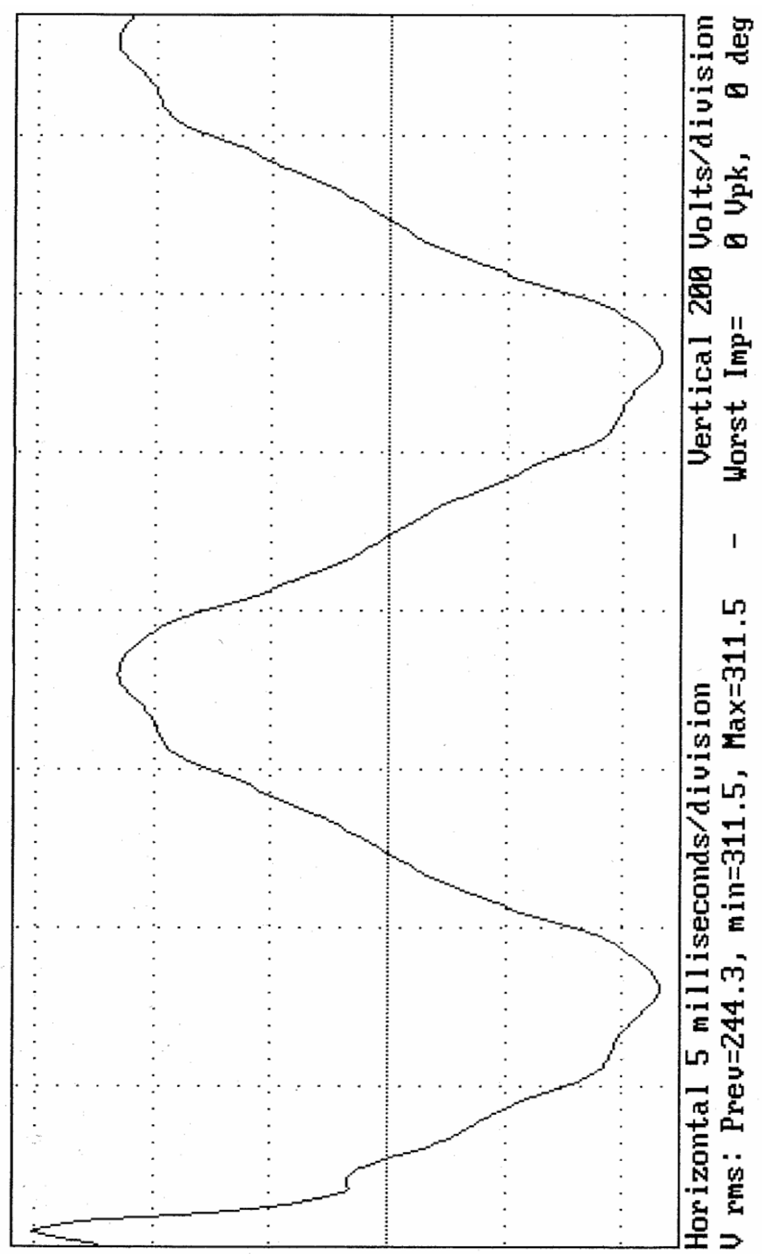
6.4 AC Circuits and Maintenance Facilities

The battery charger shall operate from a 230Vac single phase 50Hz supply.

The battery charger shall include current and voltage limiting circuitry, along with frequency interference suppression to comply with BS EN 55014-1 under all operating conditions.

The battery charger shall not be damaged by temporary over-voltages of the type shown below lasting for 3 seconds.

TEMPORARY OVERVOLTAGE ON CHARGER INPUT



A 230V phase, neutral & earth socket to BS EN 60309-1 and BS EN 60309-2 plus a suitable ac change-over switch shall be provided to allow a mobile generator to be connected.

All 230Vac terminals shall be fully shrouded.

6.5 DC Output Current Rating

The charger dc output current rating shall be not less than:
C_{10} current for the battery + (Charger Design Margin x Standing Load Current)

It is prudent to provide a margin to allow for unforeseen additional load on the dc system. A charger design margin of 1.1 shall be employed in the charger sizing calculation.

6.6 DC Output Voltage Control

The float voltage setting shall be adjustable about the set value, accommodating the range of float voltages recommended by the battery manufacturer.

Boost charging facilities shall not be provided.

6.7 DC Output Current Control

The charger output current shall be adjustable between 20% and 100% of the current rated output current.

6.8 Performance

On float charge, the output voltage shall not vary by more than +1% to -1% under the following conditions:

a) Frequency varying between +1% and -1% of 50 Hz.

b) AC input voltage varying between +10% and -6% of 230V or 400V (as appropriate).

c) Charger DC current output varying between 0% and 100% of the nominal rating.

The AC ripple permitted on the battery system output shall not exceed 2% of rated voltage and shall not exceed levels that have an adverse effect on battery life.

The charger shall be designed to prevent, as far as possible, transient voltages or spikes above 137.5V occurring on the DC output.

6.9 Charger Input / Output Protection

The input and output of the charger shall be protected by suitable miniature circuit breakers (MCBs). Residual current devices (RCD) shall not be used.

6.10 Charger Control Module and other Electronic Components

All electronic components shall be chosen such that they should not require replacement during the design life of the system.

6.11 Instrumentation Requirements

The battery charger shall include instrumentation which displays the charger dc output voltage and current.

6.12 Battery & Charger Monitoring Requirements

The following battery and charger monitoring functions shall be provided:

a) Mains supply monitoring
b) Charger monitoring
c) Low voltage monitoring
d) High voltage monitoring
e) Battery impedance monitoring
f) Earth fault monitoring

The monitoring scheme shall include LEDs for local alarm / indication purposes, and output relays with volt-free contacts for remote (telecontrol) alarm purposes.

LEDs shall be flush mounted on the front of the charger door and shall be clearly visible.

Three separate output relays shall be provided, “Urgent”, “Non-Urgent” and “Common Fault”. Two sets of changeover contacts shall be available on each relay. The “Urgent” relay shall be normally energised and will de-energise if an abnormal condition is detected (i.e. a fail-safe arrangement). The “Non-Urgent” and “Common Fault” relays shall be normally de-energised and will energise if an abnormal condition is detected.

LEDs and output relays shall operate after a user-settable time delay whenever an abnormal condition is detected. The user-settable time delay is to avoid alarms being generated for transient faults and shall encompass the range 0 to 60 seconds. It shall normally be set to 30 seconds.

A normally closed contact on the “Urgent” relay will initiate a “Battery Urgent” telecontrol alarm. A normally open contact on the “Non-Urgent” relay will initiate a “Battery Non-Urgent” telecontrol alarm. The wetting current for telecontrol alarm contacts is typically in the range 3 to 6mA.

6.12.1 Mains Supply Monitoring

The status of the incoming 230Vac supply shall be continuously monitored and alarms / indications shall be triggered in the event the mains supply fails.

The mains supply monitoring function shall self-reset.

Mains Supply Healthy	Mains Supply Failed
• A green “Mains Supply Healthy” LED shall be illuminated • The “Urgent” relay shall be energised • The “Common Fault” relay shall be de-energised	• A green “Mains Supply Healthy” LED shall be extinguished • The “Urgent” relay shall be de-energised • The “Common Fault” relay shall be energised

6.12.2 Charger Monitoring

The status of the charger shall be continuously monitored and alarms / indications shall be triggered in the event the charger becomes faulty.

The charger monitoring function shall be hand-reset i.e. latches once operated.

Charger Healthy	Charger Failed
• A green “Charger Healthy” LED shall be illuminated • The “Urgent” relay shall be energised • The “Common Fault” relay shall be de-energised	• A green “Charger Healthy” LED shall be extinguished • The “Urgent” relay shall be de-energised • The “Common Fault” relay shall be energised

6.12.3 Low Voltage Monitoring

The charger output / battery voltage shall be continually monitored and alarms / indications shall be triggered in the event the DC voltage falls below a user-settable limit.

The user-settable voltage limit shall be adjustable between 99 - 125V. The limit shall be set to operate at 111V (54 cells @ 2.06V per cell).

The low voltage monitoring function shall have built in hysteresis i.e. a pick-up / drop-off differential. Once picked-up, the function shall not drop-off until the voltage is at least 0.5% higher than the pick-up value.

The low voltage monitoring function shall be hand-reset i.e. latches once operated.

DC Voltage Normal	DC Voltage Low
• A red or amber "DC Voltage Low" LED shall be extinguished • The "Urgent" relay shall be energised • The "Common Fault" relay shall be de-energised	• A red or amber "DC Voltage Low" LED shall be illuminated • The "Urgent" relay shall be de-energised • The "Common Fault" relay shall be energised

6.12.4 High Voltage Monitoring

The charger output / battery voltage shall be continually monitored and alarms / indications shall be triggered in the event the DC voltage rises above a user-settable limit.

The user-settable limit shall be adjustable between 125 - 145V. The limit shall be set to operate at 127V (54 cells @ 2.35V per cell).

The high voltage monitoring function shall have built in hysteresis i.e. a pick-up / drop-off differential. Once picked-up, the function shall not drop-off until the voltage is at least 0.5% lower than the pick-up value.

The high voltage monitoring function shall be hand-reset i.e. latches once operated.

DC Voltage Normal	DC Voltage High
• A red or amber "DC Voltage High" LED shall be extinguished • The "Urgent" relay shall be energised • The "Common Fault" relay shall be de-energised	• A red or amber "DC Voltage High" LED shall be illuminated • The "Urgent" relay shall be de-energised • The "Common Fault" relay shall be energised

6.12.5 Battery Impedance Monitoring

Approximately once in each 24 hour period the battery shall be actively tested (using an automatic routine) to detect faulty cells and poor connections. The test should, where at all possible, be carried out in the morning (say 8:00am) so that in the event a problem is detected any remedial work can be carried out during normal working hours.

The test method shall not adversely affect the life of the battery.

The preferred method of carrying out this test is to reduce the charger output for a short period of time during which the battery voltage is monitored. If the drop in battery voltage is above appropriate limits a possible high impedance condition is indicated. Alarms and indications shall be triggered in the event high impedance conditions are detected during two consecutive tests.

Details of their test method / routine shall be submitted to WPD for approval.

The battery impedance monitoring function shall be hand-reset i.e. latches once operated.

Battery Impedance Normal	Battery Impedance High
• A red or amber "Battery Fault" LED shall be extinguished • The "Urgent" relay shall be energised • The "Common Fault" relay shall be de-energised	• A red or amber "Battery Fault" LED shall be illuminated • The "Urgent" relay shall be de-energised • The "Common Fault" relay shall be energised

6.12.6 Earth Fault Monitoring

The charger shall continually monitor the integrity of the connections to dc equipment / wiring, and alarms / indications shall be triggered in the event the earth leakage current rises above a pre-determined value.

The earth fault monitoring shall function as follows:

a) No more than 5 mA earth fault current shall flow when either the positive or negative pole is directly connected to earth

b) With battery voltage at its normal float voltage, an alarm shall be given when the insulation resistance of the wiring connected to one pole drops to 50,000 ohms or less with the insulation resistance of the wiring connected to the other pole at 1,000,000 ohms.

c) With battery voltage between the minimum and maximum levels an alarm shall be given when the insulation level on either pole drops below +10% or -10% of the set value.

The earth fault monitoring function shall be self-reset.

No Earth Fault	Battery Earth Fault	
	Positive Pole	Negative Pole
• A red or amber "Earth Fault - Positive" LED shall be extinguished • A red or amber "Earth Fault - Negative" LED shall be extinguished • The "Non-Urgent" relay shall be de-energised • The "Common Fault" relay shall be de-energised	• A red or amber "Earth Fault - Positive" LED shall be illuminated • The "Non-Urgent" relay shall be energised • The "Common Fault" relay shall be energised	• A red or amber Earth Fault - Negative" LED shall be illuminated • The "Non-Urgent" relay shall be energised • The "Common Fault" relay shall be energised

6.13 **Charger Burden**

The following details shall be provided:

- The continuous load imposed by the charger control module, monitoring scheme etc, (but excluding the connected DC load)

- The load imposed by the charger on the ac supply system

6.14 **Enclosure**

Construction requirements for the enclosure are specified in Section 4.7 above.

The battery charger shall be provided in a separate compartment of the same enclosure housing the battery. The enclosure shall be a free standing cubicle type design capable of being placed against a back wall.

The battery charger enclosure shall provide a degree of protection to at least IP2X or IPXXB classification in accordance with BS EN 60529.

The battery enclosure shall be lockable and shall be sized such that there is sufficient space to enable:

- The thyristor controlled rectifier to be replaced without dismantling or removing other equipment

- Maintenance activities to be carried out, such as adjusting float voltage and output current settings, cleaning heat sinks and fans, testing battery alarms etc.

6.15 **Labelling**

6.15.1 Battery Charger Identification Label

The battery charger shall be provided with a durable and easily visible alphanumeric identification label mounted on the exterior of the enclosure.

The alphanumeric identification shall be **110V BATTERY CHARGER (WPD)**

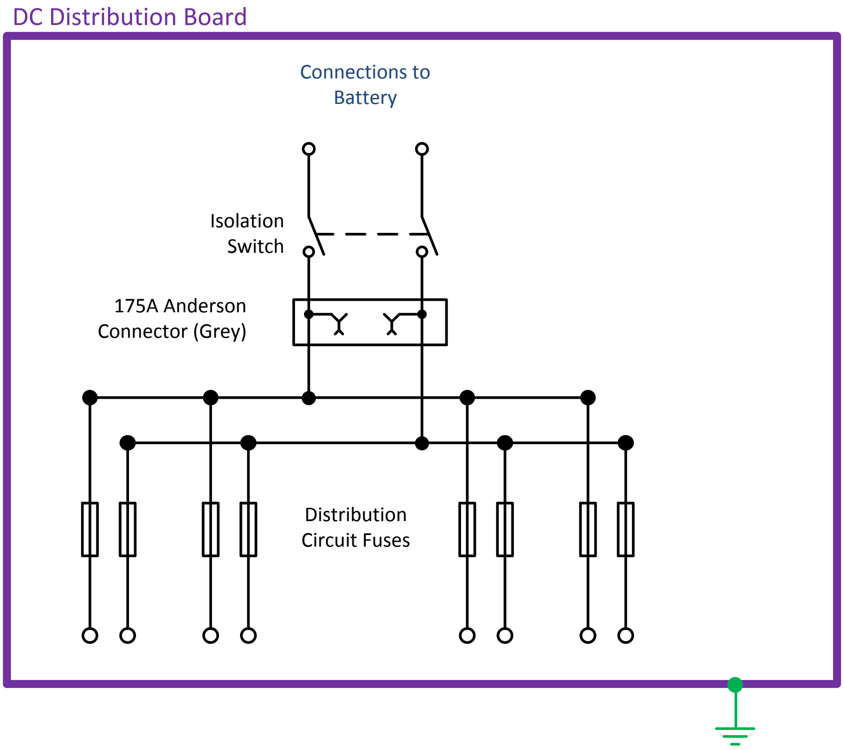
6.15.2 Manufacturer's Information Label

The battery charger shall be provided with a durable and easily visible information label showing the following details:

- Name of manufacturer or supplier
- Manufacturer's or supplier's type reference
- Rated ac input voltage
- Rated ac input current
- Rated dc output voltage
- Rated dc output current
- Date of manufacture

7.0 REQUIREMENTS FOR DC DISTRIBUTION BOARDS

7.1 Schematic Diagram of the DC Distribution Board



7.2 Design Life

The dc distribution board shall have a design life of 40 years.

7.3 Circuits and Maintenance Facilities

The incoming circuit (from the battery & charger) shall be terminated on a double pole isolation switch with a rating of not less than 100A.

An Anderson Type 175A connecter shall be provided on the outgoing side of the isolation switch to enable a temporary battery and/or charger to be connected.

Each outgoing distribution circuit shall comprise two black fuse carriers and bases which shall have a current rating of 32A and be suitable for use with fuse links to BS 88-2, reference A. Fuse carriers shall be equipped with a fuse link with a 32A rating.

7.4 Enclosure

The distribution board shall be contained within a wall mounted enclosure which is physically separate from the cubicles associated with the battery & charger.

The enclosure will be mounted immediately adjacent to the battery & charger and will be interconnected with it by short lengths of cable.

The rationale behind this approach is that it facilitates the preservation of substation dc auxiliary supplies during the replacement of the battery, charger or associated cubicle, which have a much shorter design life than that of the distribution board.

The enclosure shall be equipped with a front mounted hinged and lockable door.

Construction requirements for the enclosure are specified in Section 4.7 above.

7.5 Labelling

All labelling shall be in accordance with ENA Technical Specification 50-18.

7.5.1 Distribution Board Identification Label

The DC distribution board shall be provided with a durable and easily visible alphanumeric identification label mounted on the exterior of the enclosure.

The alphanumeric identification shall be **110V DC DISTRIBUTION BOARD (WPD)**

7.5.2 Manufacturer's Information Label

The exterior of the enclosure shall be provided with a durable and easily visible information label showing the following details:

- Name of manufacturer or supplier
- Date of manufacture

7.5.3 Fuse-holder Identification Labels

Each fuse-holder shall be provided with a durable and easily visible alphanumeric identification label mounted immediately adjacent denoting its function.

The alphanumeric identification shall be in the form **X Y Z**, where:

X =	**DC+** or **DC-**	**(**as appropriate)
Y =	***CIRCUIT NAME***	
Z =	**(*A)**	**(**where * is the fuse link current rating)

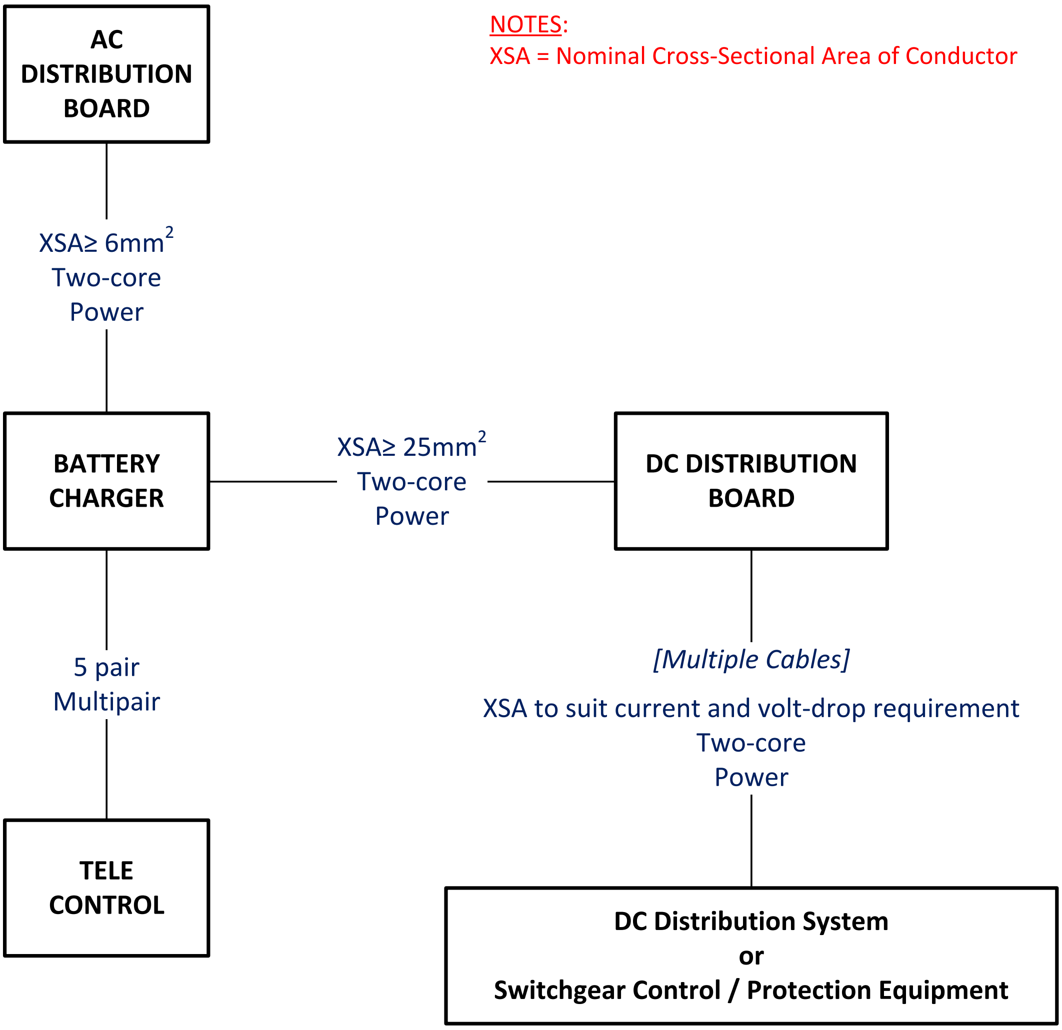
For example: **DC+ SWITCHGEAR (32A)**

7.5.4 Component Identification Labels

The Anderson connector shall be provided with a durable and easily visible alphanumeric identification label mounted immediately adjacent denoting its function.

8.0 REQUIREMENTS FOR AUXILIARY CABLING

8.1 Schematic Diagram of Auxiliary Cabling



8.2 Auxiliary Cables - Power

Auxiliary power cables shall be in accordance with the requirements contained in British Standard BS 5467: Electric cables – Thermosetting insulated, armoured cables for voltages of 600/1000V and 1900/3300V.

Cables shall be rated for voltages of 600/1000V and have annealed stranded copper conductors.

DC and single-phase ac circuits shall employ two-core cable. The cores of all cables shall be identified by colour. Two-core cables shall employ brown and blue coloured insulation.

The armour shall consist of a single layer of galvanised steel wire.

The nominal cross sectional area of the conductor shall be in accordance with the schematic diagram in 8.1 above. Outgoing cables from the DC distribution board shall have a nominal cross-sectional area to suit the load current and to satisfy the following volt-drop requirements:

- 110V systems maximum volt-drop = 6V

8.3 Auxiliary Cables – Multicore

Multicore auxiliary cables shall comply with the requirements contained in WPD Engineering Equipment Specification 80: Specification for Multicore Cables.

The nominal cross sectional area of the conductor shall be in accordance with the schematic diagram in 8.1 above.

8.4 Auxiliary Cables – Multipair

Multipair auxiliary cables shall comply with the requirements contained in WPD Engineering Equipment Specification 79: Specification for SCADA Multipair Light Current Control Cables.

8.5 Auxiliary Cables – Glands

Cable glands for use with auxiliary multicore, multipair and power cables shall be in accordance with the requirements contained in British Standard BS 6121:

- Part 1: Armour glands – Requirements and test methods
-
- Part 5: Code of practice for selection, installation and inspection of cable glands and armour glands

Cable glands installed at an indoor or outdoor location shall be of type designation “BW” and “CW” respectively.

The cable gland earth tag shall be connected to the enclosure earth bar / stud using a green/yellow sheathed earth cable. The cable shall have a cross sectional area which is sufficient to carry the earth fault current and in any instance shall be not less than $2.5mm^2$.

9.0 WPD STANDARD CONFIGURATIONS

WPD requires batteries, battery chargers and dc distribution boards to be ordinarily supplied in a number of standard configurations. This does not preclude the need for other configurations, but they will be subject to special order.

9.1 Batteries

WPD will require batteries to be provided in one of the following forms:

REF	VOLTAGE	STRINGS	MONOBLOCS PER STRING	NOMINALC_{10} CAPACITY	INCLUSIONS
110 - BA120	110V	2	9 * 12V	120Ah	– Monobloc labels – Battery Identification Label – Manufacturer's Information Label
110 - BA180	110V	2	9 * 12V	180Ah	

9.2 Battery Chargers

WPD will require battery chargers to be provided in one of the following forms:

REF	AC INPUT	DC OUTPUT VOLTAGE	DC OUTPUT CURRENT	INCLUSIONS
110 - CH120	230V Single Phase	110V	20A	– Battery Charger Identification Label – Manufacturer's Information Label
110 - CH125	230V Single Phase	110V	25A	

9.3 Integrated System

WPD will require integrated systems to be provided in one of the following forms:

WPD REF	BATTERY	CHARGER	INCLUSIONS
110 - IS - BA120 - CH120	110 - BA120	110 - CH120	– Monobloc labels – Battery Identification Label – Battery Charger Identification Label – Manufacturer’s Information Label
110 - IS - BA180 - CH125	110 - BA180	110 - CH125	

9.4 Distribution Boards

WPD will require distribution boards to be provided in one of the following forms:

WPD REF	WAYS		FORMAT	INCLUSIONS
DB - 4W32	4 Double Pole	RS32/32A	Wall Mounted	– Distribution Board Identification Label – Manufacturer’s Information Label – Fuse-holder Labels – Component Identification Labels
DB - 6W32	6 Double Pole	RS32/32A	Wall Mounted	

10.0 PERFORMANCE DATA FOR WPD APPROVED MONOBLOCS

Note the following data presumes two identical strings of monoblocs are connected in parallel.

Nominal capacity and nominal current are based upon a temperature of 20°C and an end of discharge voltage of 1.80V per cell.

Discharge current values are based upon a temperature of 20°C and an end of discharge voltage of 1.85V per cell.

Enersys Monobloc	Nominal C_{10}		Discharge Current (Amperes)	
	Capacity (Ampere-Hour)	Current (Amperes)	5 Min	72 Hrs
SBS B14F	123.4	12.34	386.0	1.84
SBS C11F	183.0	18.3	496.0	2.90

GNB Monobloc	Nominal C_{10}		Discharge Current (Amperes)	
	Capacity (Ampere-Hour)	Current (Amperes)	5 Min	72 Hrs
M12V60FT	117.4	11.74	304.0	1.76
M12V100FT	200.0	20.0	490.0	3.00

11.0 SIZING OF LEAD ACID BATTERIES & CHARGERS

Lead acid batteries shall be sized in accordance with IEEE Standard 485: Recommended Practice for Sizing Lead Acid Batteries for Stationary Applications.

11.1 WPD Battery Sizing Calculator

WPD has prepared a Microsoft Excel spreadsheet for calculating the size of a lead acid battery in accordance with the methodology described in the following sections.

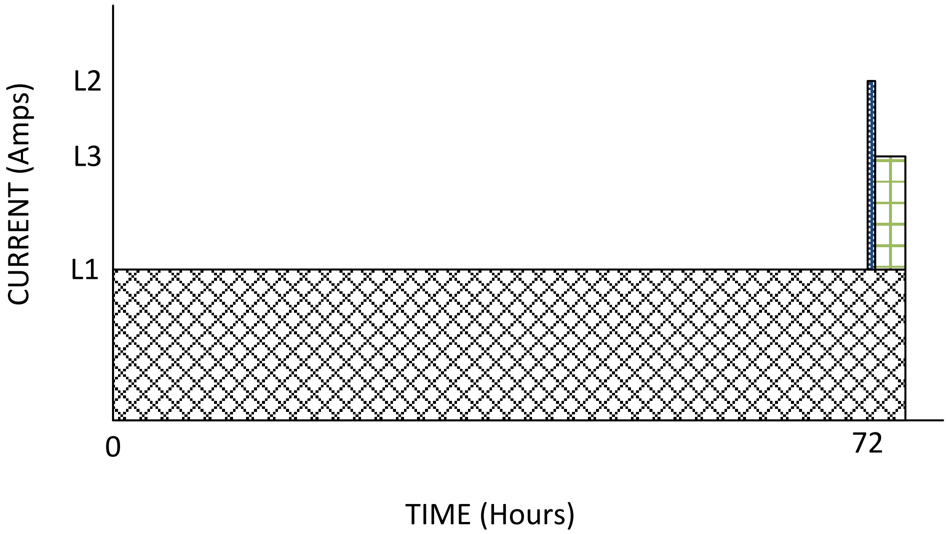
Battery Calculator (EE SPEC 25/6)

11.2 Battery Duty Cycle

A diagram of the duty cycle, based on the requirements of Section 5.6 above, is shown below.

- L1 is the standing continuous load current
- L2 is the transient load current due to the simultaneous tripping of 3 circuit breakers (after 72 hours) plus the standing continuous load current
- L3 is the transient load current due to the sequential closing of 3 circuit breakers (following their aforementioned tripping) plus the standing continuous load current

DIAGRAM OF BATTERY DUTY CYCLE



11.3 Preliminary Selection of Cell / Monobloc Type

The battery sizing calculation requires the use of discharge characteristics for a particular cell / monobloc and consequently a preliminary selection of the likely cell / monobloc type has to be made.

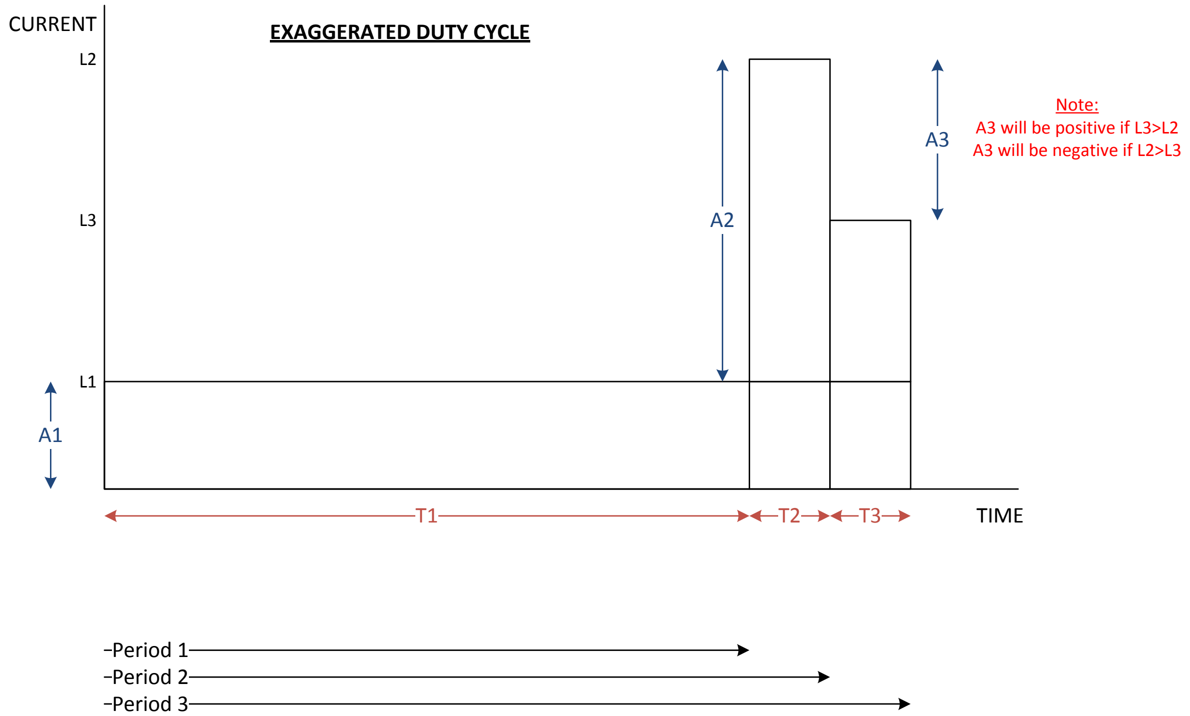
A cell / monobloc type shall be selected which has a 72 hour discharge current capability in excess of 1.43x the standing load current

For example, if the standing load current is 0.55A, then 1.43 x 0.55 = 0.79A. Using the table in Section 9 above, SBS B14F or M12V60FT monoblocs could be selected as they have a 72 hour discharge current capability of 1.84A and 1.76A respectively.

Note that if the battery sizing calculations prove unfavourable for this cell / monobloc type then it will be necessary to repeat the calculations using a different cell / monobloc type.

11.4 Battery Sizing Methodology

Consider the battery duty cycle drawn to an exaggerated scale:



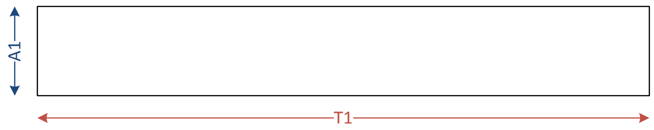
A1 = L1
A2 = L2 – L1
A3 = L3 – L2 *(Note: The sign of A3 is important i.e. whether it is +ve or –ve)*

The battery must have enough capacity to carry the combined loads during the complete duty cycle. In order to verify this it is necessary to break the duty cycle down into a number of discrete periods, and for each one to calculate the maximum capacity required. This iterative process is continued until all periods have been considered, and the worst case (highest) capacity is chosen.

This method ensures that the average cell voltage does not drop below the specified minimum (1.85V) at any point in the duty cycle.

Period 1 is considered first. When Period 2 is analysed it is assumed that the current for Period 1 continues. The capacity is then adjusted for the change in current between the two periods. The same approach is followed for Period 3. In other words:

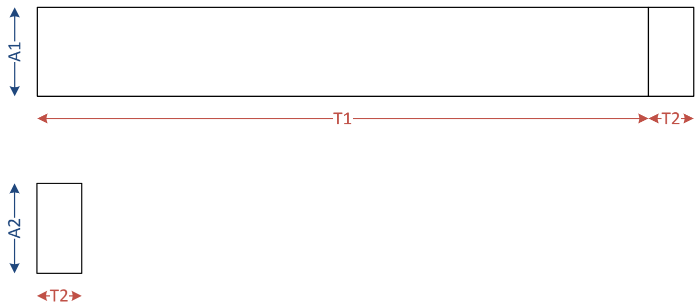
<u>Period 1</u>



Capacity for Period 1 =

$$\frac{\text{A1 * Nominal } C_{10} \text{ Capacity}}{\text{Discharge Current}_{[T1]}}$$

<u>Period 2</u>



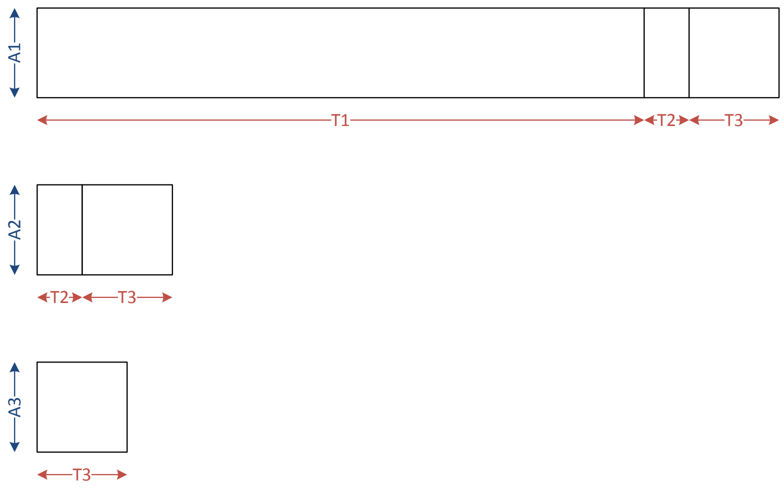
Capacity for Period 2 =

$$\frac{\text{A1 * Nominal } C_{10} \text{ Capacity}}{\text{Discharge Current}_{[T1+T2]}}$$

Plus

$$\frac{\text{A2 * Nominal } C_{10} \text{ Capacity}}{\text{Discharge Current}_{[T2]}}$$

<u>Period 3</u>



Capacity for Period 3 =

$$\frac{\text{A1 * Nominal } C_{10} \text{ Capacity}}{\text{Discharge Current}_{[T1+T2+T3]}}$$

Plus

$$\frac{\text{A2 * Nominal } C_{10} \text{ Capacity}}{\text{Discharge Current}_{[T2+T3]}}$$

Plus

$$\frac{\text{A3 * Nominal } C_{10} \text{ Capacity}}{\text{Discharge Current}_{[T3]}}$$

(nb polarity of A3 is important!)

11.5 Example Calculation

A 110V battery & charger system is required for a new 33kV substation constructed to connect a solar farm. The substation is to be connected using a “looped” connection to the network and the 33kV switchboard consists of two feeder circuit breakers and one metering circuit breaker.

Each circuit breaker requires 200 watts for 60 milliseconds for tripping purposes. Each circuit breaker is equipped with a spring charging motor which requires 300 watts for 7 seconds for closing purposes.

The standing continuous load has been assessed as 75 Watts.

In other words,

T1 = 72 hours
T2 = 60 milliseconds
T3 = 21 seconds (i.e. 3 x 7 seconds)

Loads expressed in watts should be converted to a current equivalent. Minimum cell voltage should be used for the purpose of this conversion.

L1 = 75W / (54 cells * 1.85V per cell) = 0.75A
A1 = L1 = 0.75A

L2 = L1 + simultaneous tripping burden
= L1 + (3 * 200W) / (54 cells * 1.85V per cell) = L1 + 6.01A
A2 = L2 – L1 = 6.01A

L3 = L1 + sequential closing burden
= L1 + (300W) / (54 cells * 1.85V per cell) = L1 + 3.00A
A3 = L3 – L2 = (L1 + 3.00A) – (L1 + 6.01A) = -3.01A

Note that A3 is negative in this instance.

11.5.1 Preliminary Selection of Monobloc Type

A cell / monobloc type shall be selected which has a 72 hour discharge current capability in excess of 1.43x the standing load current

The standing current is 0.75A and therefore 1.43 x 0.75A = 1.07A.

Enersys SBS B14F and GNB M12V60FT monoblocs are capable of supplying 1.84A and 1.76A for 72 hours respectively and consequently either could be utilised. In this particular instance it was decided to use Enersys monoblocs and consequently the discharge characteristics for the SBS B14F monobloc is used for the detailed calculations.

11.5.2 Period 1 Calculation

T1 = 72 hours

Enersys SBS B14F monoblocs (from Section 10)

- 72 hour discharge current = 1.84A
- Nominal C_{10} capacity = 123.4Ah

Current A1 = 0.75A
T1 = 72 hours

Capacity $= \frac{0.75 * 123.4}{1.84} = 50.3Ah$ [1A]

Capacity for Period 1 = [1A]
= 50.3Ah

11.5.3 Period 2 Calculation

T2 = 60 milliseconds
T1 = 72 hours T1+T2 = 72 hours 60 milliseconds

Enersys SBS B14F monoblocs (from Section 10)

- 60 milliseconds discharge current = 386.0A *{use 5 minute value}*
- 72 hours 60 milliseconds discharge current = 1.84A *{use 72 hour value}*
- Nominal C_{10} capacity = 123.4Ah

Current A1 = 0.75A
T1+T2 = 72 hours 60 milliseconds
Capacity = $\frac{0.75 * 123.4}{1.84}$ = 50.3Ah [2A]

Current A2 = 6.01A
T2 = 60 milliseconds
Capacity = $\frac{6.01 * 123.4}{386.0}$ = 1.9Ah [2B]

Capacity for Period 2 = [2A] + [2B]
= 50.3Ah + 1.9Ah
= 52.2Ah

11.5.4 Period 3 Calculation

T3 = 21 seconds
T2 = 60 milliseconds
T1 = 72 hours T1+T2+T3 = 72 hours 21.060 seconds

Enersys SBS B14F monoblocs (from Section 10)

- 21 seconds discharge current = 386.0A *{use 5 minute value}*
- 21.060 seconds discharge current = 386.0A *{use 5 minute value}*
- 72 hours 21.060 seconds discharge current = 1.84A *{use 72 hour value}*
- Nominal C_{10} capacity = 123.4Ah

Current A1 = 0.75A
T1+T2+T3 = 72 hours 21.060 seconds
Capacity = $\frac{0.75 * 123.4}{1.84}$ = 50.3Ah [3A]

Current A2 = 6.01A
T2+T3 = 21.060 seconds
Capacity = $\frac{6.01 * 123.4}{386.0}$ = 1.9Ah [3B]

Current A3 = -3.01A
T3 = 21 seconds
Capacity = $\frac{-3.01 * 123.4}{386.0}$ = -0.96Ah [3C]

Capacity for Period 3 = [3A] + [3B] + [3C]
= 50.3Ah + 1.9Ah – 0.96Ah
= 51.2Ah

11.5.5 Highest Capacity Period

The period with the highest capacity is Period 2 = 52.2Ah.

11.5.6 Battery Design Margin

A battery design margin of 1.1 shall be applied in accordance with 5.7.2
1.1 * 52.2Ah = 57.4Ah
1.2

11.5.7 Temperature Correction Factor

A temperature correction factor of 1.04 shall be applied in accordance with 5.7.3
1.04* 57.4Ah = 59.7Ah

11.5.8 Ageing Factor

An ageing factor of 1.25 shall be applied in accordance with 5.7.4
1.25* 59.7Ah = 74.6Ah

11.5.9 Overall Assessment

A battery with a nominal C_{10} capacity not less than 74.6Ah is required.

Enersys SBS B14F monoblocs have a nominal C_{10} capacity of 123.4Ah and therefore are adequate for the intended application.

11.5.10 Charger Sizing

The charger dc output current rating shall be not less than (see section 6.5 above):
C_{10} current for the battery + (charger design margin * standing load current)

Enersys SBS B14F monoblocs have a nominal C_{10} capacity of 123.4Ah and nominal C_{10} current of 12.34A (from Section 10).

Standing load current = 0.75A

Consequently the charger dc output current rating must not be less than:
12.34A + (1.1 * 0.75A) = 13.2A

Therefore select a charger with a 20A dc output current rating.

APPENDIX A

SUPERSEDED DOCUMENTATION

This document supersedes EE:SPEC 25/5 dated May 2015 which has now been withdrawn

APPENDIX B

ANCILLARY DOCUMENTATION

EE SPEC 23/1 110V and 220V Batteries, Chargers, Controllers, Distribution Boards & Associated Cabling For Primary Network Substations Other Than Metering Circuit Breaker Type

APPENDIX C

KEY WORDS

Batteries; Chargers; Distribution; Boards; 110V; DC; Primary. Metering;