WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

Company Directive

ENGINEERING SPECIFICATION
EE SPEC : 23

110V and 220V Batteries, Chargers, Controllers, Distribution Boards & Associated Auxiliary Cabling for Primary Network Substations Other Than Metering Circuit Breaker Type

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Implementation Date: May 2015

Approved by

Policy Manager

Date: 8 May 2015

IMPLEMENTATION PLAN

Introduction

This Engineering Equipment Specification (EE SPEC) defines the requirements for substation 110V and 220V batteries, battery chargers, battery controllers, dc distribution boards & associated auxiliary cabling which are to be deployed at primary network substations other than “metering circuit breaker” type.

Main Changes

EE SPEC 25/4 has been split into two separate specifications, namely EE SPEC 23 and EE SPEC 25/5.

EE SPEC 23 (this document) relates to 110Vdc and 220Vdc systems at primary network substations other than “metering circuit breaker” type. The main changes from the original specification are as follows:

- A means of disconnecting the dc distribution board from the battery and battery charger (i.e. the battery controller) in the event of a sustained shutdown of the entire substation
- A modified battery duty cycle
- 220Vdc included in order to sustain legacy 220Vdc systems
- Revised requirements for larger DC distribution boards
- Guidance on methodology for sizing batteries included
- Cabling requirements included

Impact of Changes

This EE SPEC is relevant to all staff involved with the planning, design, installation and modification of 110Vdc and 220Vdc systems at 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.

This EE SPEC introduces a means of disconnecting switchgear control and protection equipment from the battery in the event of a sustained shutdown of the entire substation (i.e. a Battery Controller). The specification for the Battery Controller includes an automatic battery disconnect feature. There are equipment failure modes / network running conditions which have the potential to trigger an unwarranted automatic disconnection sequence. Should this situation arise, manual intervention is required in order to prevent the unjustified disconnection of switchgear control and protection equipment at a live substation. Accordingly, Battery Controllers must only be operated in bypass mode until WPD has prepared and implemented suitable and sufficient Operation & Control policies and procedures.

Implementation Timetable

The requirements of EE SPEC 23 shall apply to any project which is sanctioned on or after 1st May 2015.

The requirements of EE SPEC 25/4 shall apply to any project which is sanctioned on or before 30th April 2015.

DOCUMENT REVISION & REVIEW TABLE		
Date	**Comments**	**Author**
May 2015	Initial issue	Graham Brewster

CONTENTS

1 FOREWORD

This Engineering Equipment Specification introduces a means of disconnecting switchgear control and protection equipment from the battery in the event of a sustained shutdown of the entire substation (i.e. a Battery Controller).

The specification for the Battery Controller includes an automatic battery disconnect feature. There are equipment failure modes / network running conditions which have the potential to trigger an unwarranted automatic disconnection sequence. Should this situation arise, manual intervention is required in order to prevent the unjustified disconnection of switchgear control and protection equipment at a live substation. Accordingly, Battery Controllers must only be operated in bypass mode until WPD has prepared and implemented suitable and sufficient Operation & Control policies and procedures.

2 INTRODUCTION

The operational security of the distribution network is dependent upon reliable and secure dc auxiliary supplies. 110V and 220V 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 and 220V batteries, battery chargers, battery controllers, dc distribution boards and associated auxiliary cabling which are to be deployed at primary network substations other than “metering circuit breaker” type.

110V dc systems are the norm on WPD’s network; however, a limited number of sites are equipped with 220V dc systems. 110V will be utilised for all new systems and 220V will be gradually phased out as the protection systems and switchgear at the relevant substations are replaced. In the meantime it is necessary to sustain these legacy 220V systems.

3 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, 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. 6V or 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 Controller	A device for disconnecting and reconnecting DC supplies to switchgear and protection equipment in an electricity substation with the aim of conserving battery capacity in the event of a sustained shutdown on the distribution network
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)

4 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.

4.1 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

4.2 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

4.3 Institute Of Electrical & Electronic Engineers (IEEE)

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

5 GENERAL REQUIREMENTS

5.1 Substation DC Supply Arrangements

The 110V and 220V batteries, battery chargers, battery controllers, dc distribution boards & associated auxiliary cabling will be employed at primary network substations other than “metering circuit breaker” type. Each of these substations will typically provide electricity to several thousand customers and will be made up of a number of discrete power circuits. The 110Vdc and 220Vdc systems are used to drive protection and switchgear control equipment associated with these power circuits.

110Vdc and 220Vdc 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, battery chargers, battery controllers or the charger ac incoming supply. This is because it is unacceptable for:

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

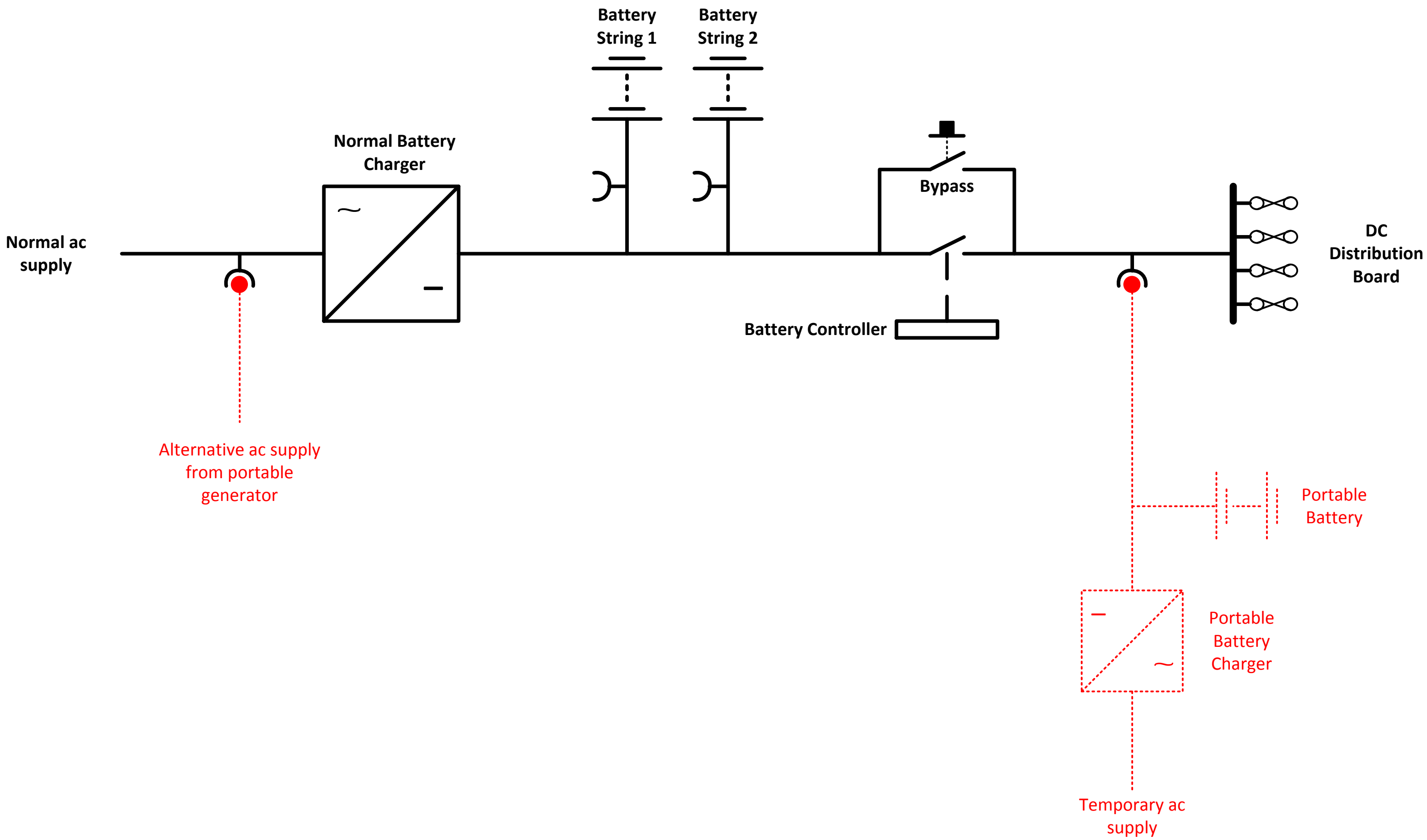
b) All power circuits to be made dead concurrently (i.e. all customers off supply or supplied by other means) whilst activities of this type are undertaken

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 or 220V battery slowly discharging due to the standing load. The shutdown could last for 72 hours (worst case scenario). Instead of sizing batteries for a 72 hour standby period (cost, space & weight issues) it is proposed to size them for a 24 hour standby period and to disconnect the standing load whilst the primary network substation is dead i.e. when protection and switchgear control systems are not required.

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 disconnecting the dc distribution board from the battery and battery charger (i.e. the battery controller) in the event of a sustained shutdown of the entire substation
- A means of by-passing the battery controller whilst it is being maintained
- A means of connecting a portable battery & portable battery charger whilst the battery charger, battery controller or battery cubicle is being repaired or replaced

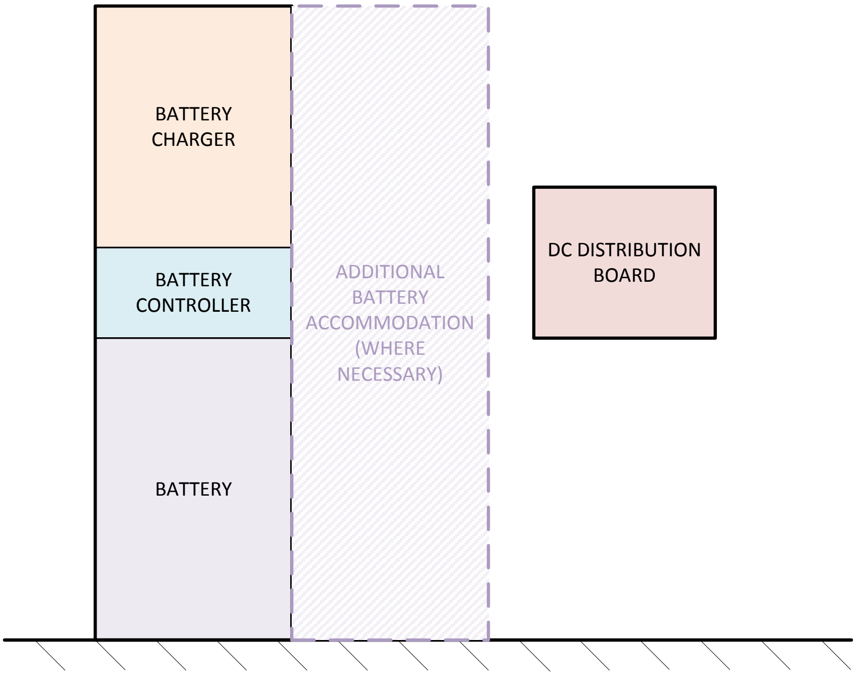
A block diagram of the battery, battery charger, battery controller and dc distribution board is shown below.



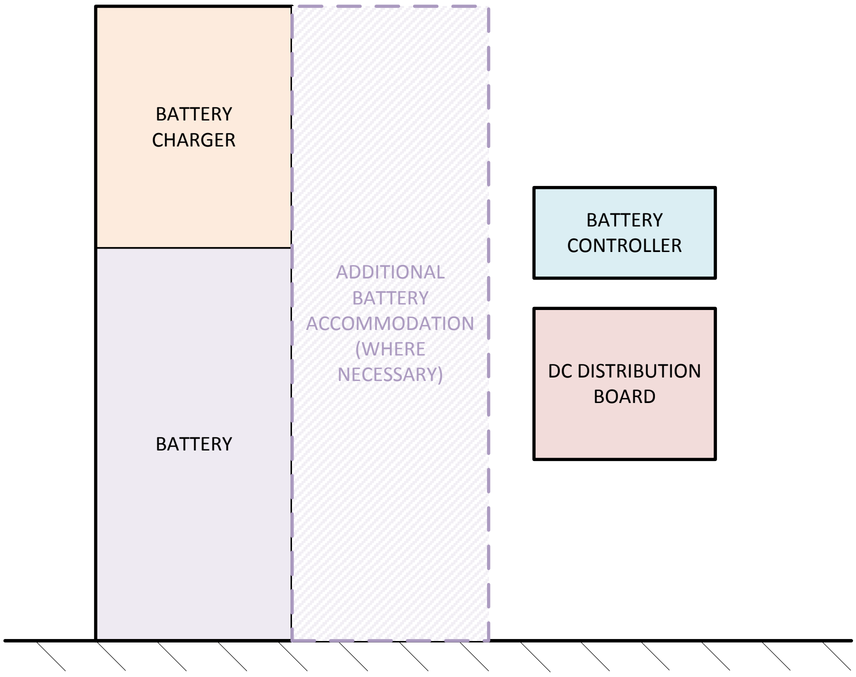
BLOCK DIAGRAM OF BATTERY, BATTERY CHARGER, BATTERY CONTROLLER & DC DISTRIBUTION BOARD

5.2 Schematic Diagram of Battery, Battery Charger, Battery Controller & DC Distribution Board

Indicative Arrangement With Integral Battery Controller



Indicative Arrangement With Separate Battery Controller



5.3 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.

5.4 Electromagnetic Compatibility

The battery, battery charger, battery controller & 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.

5.5 DC System Earthing

110Vdc and 220Vdc 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 and 220Vdc systems shall be IT systems (I=Isolated, T=Earth) as described in BS 7671.

5.6 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.

5.7 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 as follows:

- The battery controller enclosure shall be painted traffic yellow shade 381c631 to BS 4800
- All other enclosures shall be painted light grey shade 631 to BS 381C

5.8 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.

6 REQUIREMENTS FOR BATTERIES

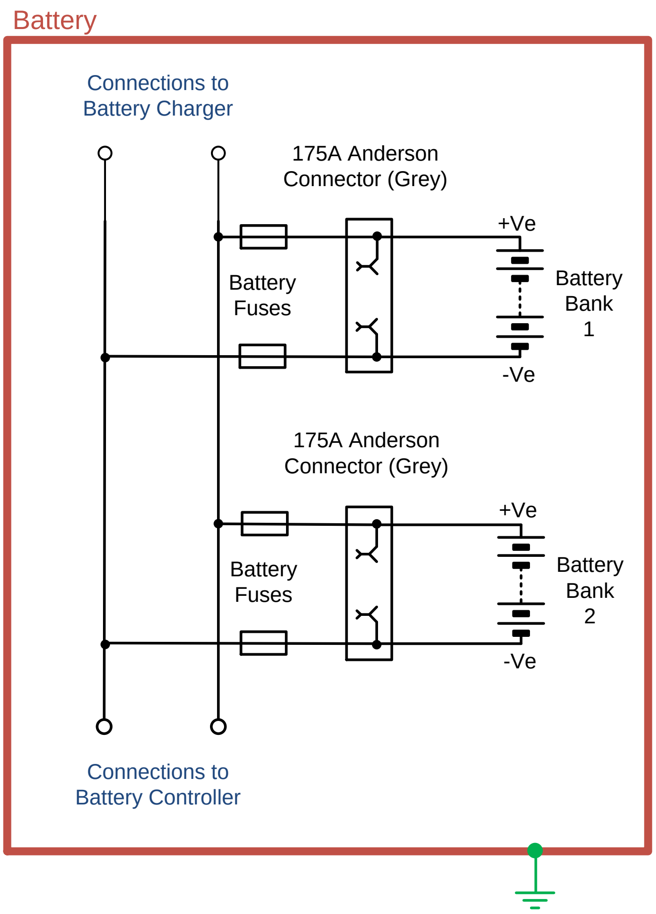
Batteries will be employed in a float charge application (i.e. permanently connected to a load and to a dc power supply) and in a static location (i.e. not generally intended to be moved from place to place). The load will comprise of protection relays and switchgear control equipment i.e. a utility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

6.1 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.



6.2 Monobloc Type

Batteries associated with 110V and 220V 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.

6.3 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.

Monoblocs shall be classified as either “10-12 years – High Performance” or “12 years & longer – Long Life” according to Eurobat Guide 2006.

6.4 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

6.5 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.

6.6 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 24 hours, followed by
- The simultaneous opening (tripping) of “X” circuit breakers, followed by
- The sequential closing of “X” circuit breakers

The number of circuit breakers “X” depends on the power system fault condition which results in the tripping of the most circuit breakers associated with the battery system, and in any event shall be not less than 6.

Guidance

Consider a fault on a single section of busbar, a single mesh corner, a single feeder or a single transformer.

6.7 Battery Sizing

The battery system shall be sized in accordance with the requirements of this section and the methodology described in section 13.

6.7.1 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)

6.7.2 220V Systems

The following requirements apply to all 220V batteries:

NOMINAL VOLTAGE	216V	(108 cells @ 2V per cell)
NORMAL WORKING VOLTAGE	247.3V	(108 cells @ 2.29V per cell)
MINIMUM PERMISSIBLE VOLTAGE AT THE BATTERY TERMINALS AT THE END OF THE DUTY CYCLE	199.8V	(108 cells @ 1.85V per cell)

6.7.3 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.

6.7.4 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.

The rating of Enersys Powersafe SBS EON monoblocs are based on an ambient temperature of 20°C and a temperature correction factor of 1.09 shall be applied to the battery sizing calculation to correct for a temperature of 15ºC.

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).

6.7.5 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.

6.8 Battery Accessories

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

6.9 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.

6.10 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 BSEN60269-1, BSEN60269-2 and BS88-2 reference A or B.

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

6.11 Enclosure

Construction requirements for the enclosure are specified in Section 5.7 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 5.3.

6.12 Labelling

6.12.1 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).

6.12.2 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 in the form **X Y Z**, where:

X = **110V or 220V**, as appropriate

Y = **BATTERY**

Z = **1**, **2**, **3**, etc. and is only required when multiple batteries with the same nominal voltage will be present on a particular substation site

For example: **110V BATTERY 1**

6.12.3 Manufacturer’s Information Label

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

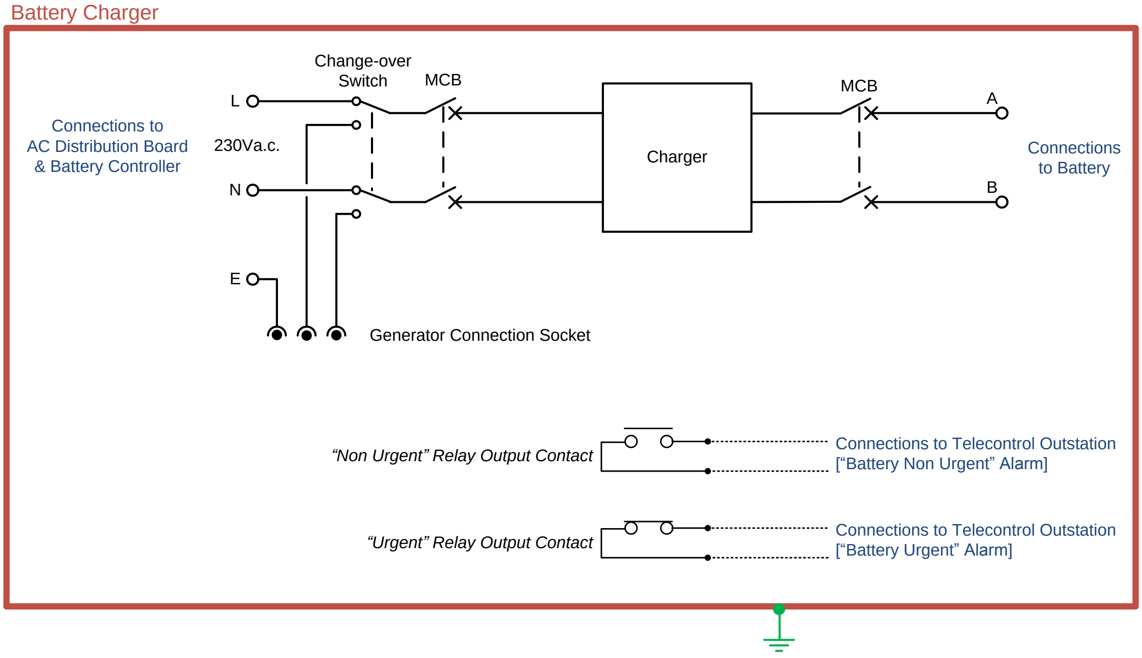
- Name of manufacturer or supplier

- Manufacturer’s or supplier’s type reference
- Nominal battery voltage
- Nominal or rated capacity of the battery

7 REQUIREMENTS FOR BATTERY CHARGERS

7.1 Schematic Diagram of Battery Charger

Note: Single phase battery charger shown.



7.2 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 maintained, removed and replaced.

7.3 Design Life

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

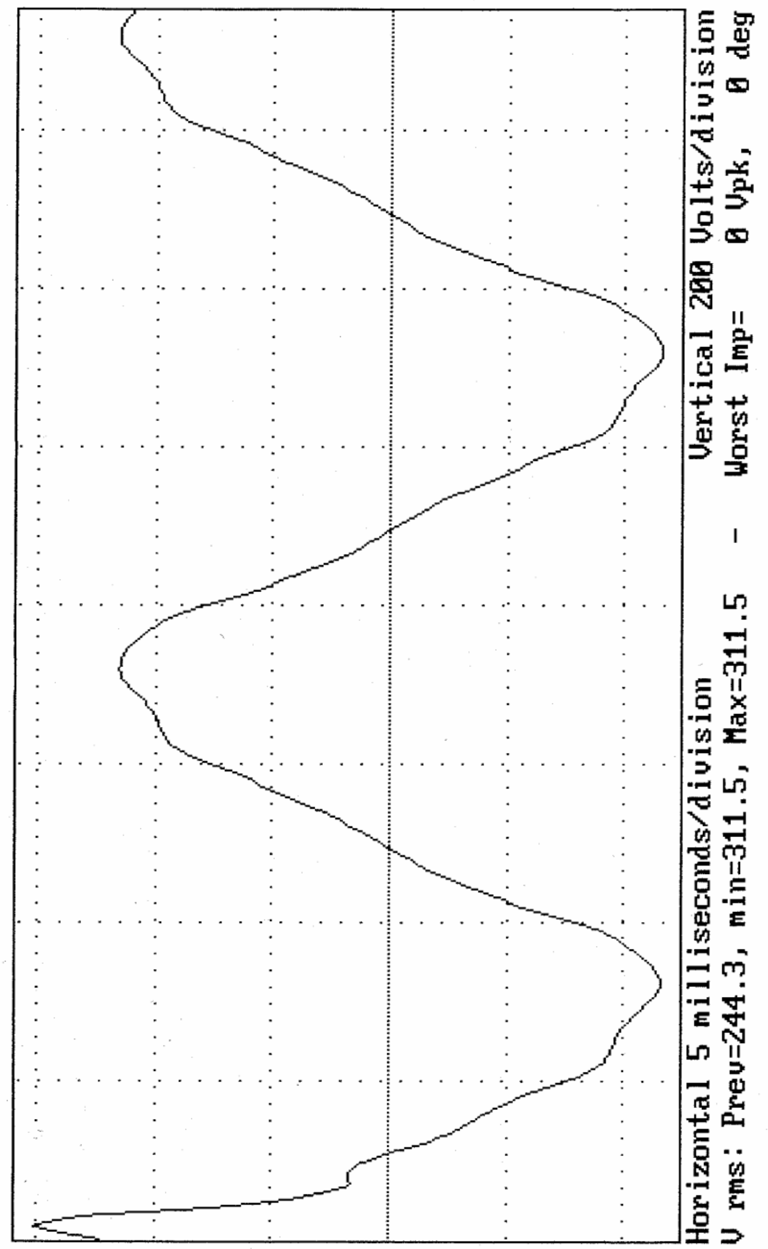
7.4 AC Circuits and Maintenance Facilities

Battery chargers shall operate from a 230Vac single phase 50Hz supply as a norm, however, high capacity chargers (i.e. greater than 35Adc) shall also be available as a 400Vac three phase 50Hz supply option for use at substations with a relatively weak ac supply system.

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 or 400V three-phase, neutral & earth socket (as appropriate) 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 400 / 230Vac terminals shall be fully shrouded.

7.5 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.

7.6 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.

7.7 DC Output Current Control

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

7.8 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 and 275V occurring on the DC output of 110V and 220V chargers respectively.

7.9 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.

7.10 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.

7.11 Instrumentation Requirements

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

7.12 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.

7.12.1 Mains Supply Monitoring

The status of the incoming 400Vac or 230Vac supply (as appropriate) 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

7.12.2 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

7.12.3 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 on 110V systems and between 198 - 250V on 220V systems. The limit shall be set to operate at 111V for 110V systems (54 cells @ 2.06V per cell) and 222V for 220V systems (108 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

7.12.4 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 on 110V systems and between 250 - 290V on 220V systems. The limit shall be set to operate at 127V for 110V systems (54 cells @ 2.35V per cell) and 254V for 220V systems (108 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

7.12.5 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

7.12.6 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

7.13 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

7.14 Enclosure

Construction requirements for the enclosure are specified in Section 5.7 above.

The battery charger shall be provided in a separate compartment of the same enclosure housing the battery (and battery controller where integral). 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.

7.15 Labelling

7.15.1 <u>Battery Charger Identification Label</u>

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 in the form **X Y Z**, where:

X = **110V or 220V**, as appropriate

Y = **BATTERY CHARGER**

Z = **1**, **2**, **3**, etc. and is only required when multiple battery chargers with the same nominal voltage will be present on a particular substation site

For example: **110V BATTERY CHARGER 1**

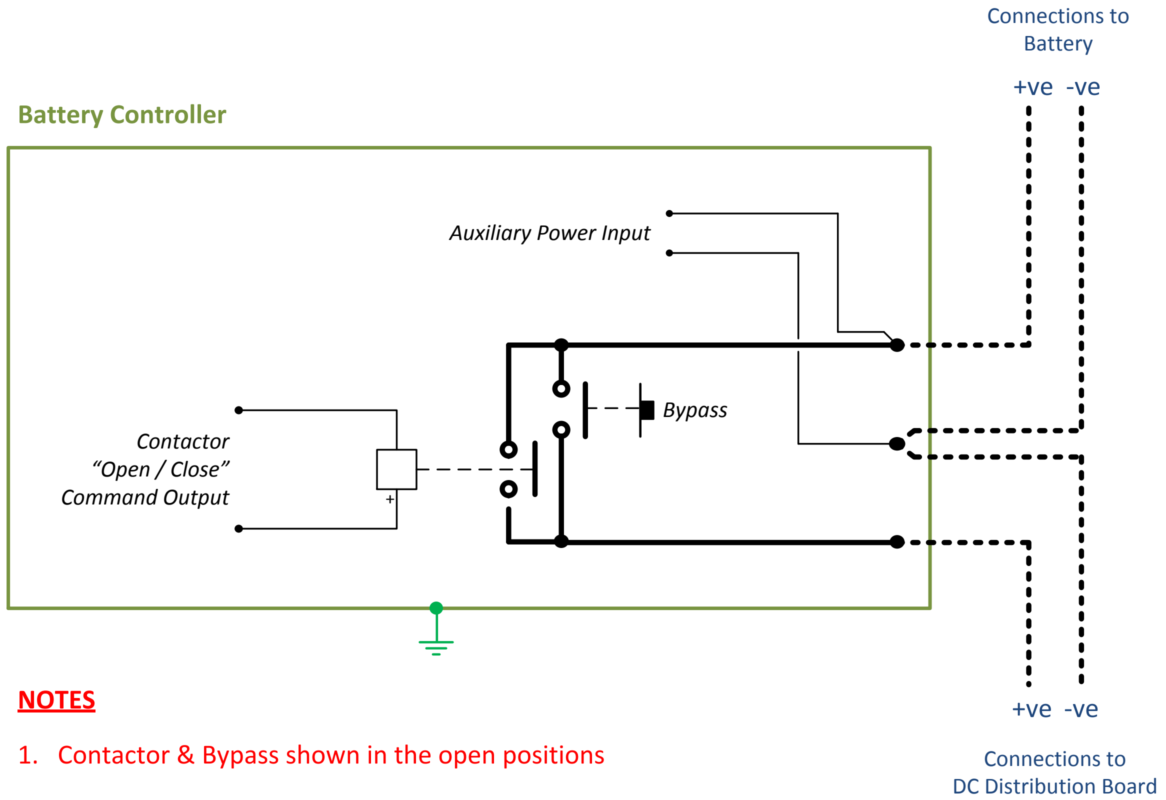
7.15.2 <u>Manufacturer's Information Label</u>

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

8 REQUIREMENTS FOR BATTERY CONTROLLERS

8.1 Schematic Diagram of Battery Controller – Main Connections

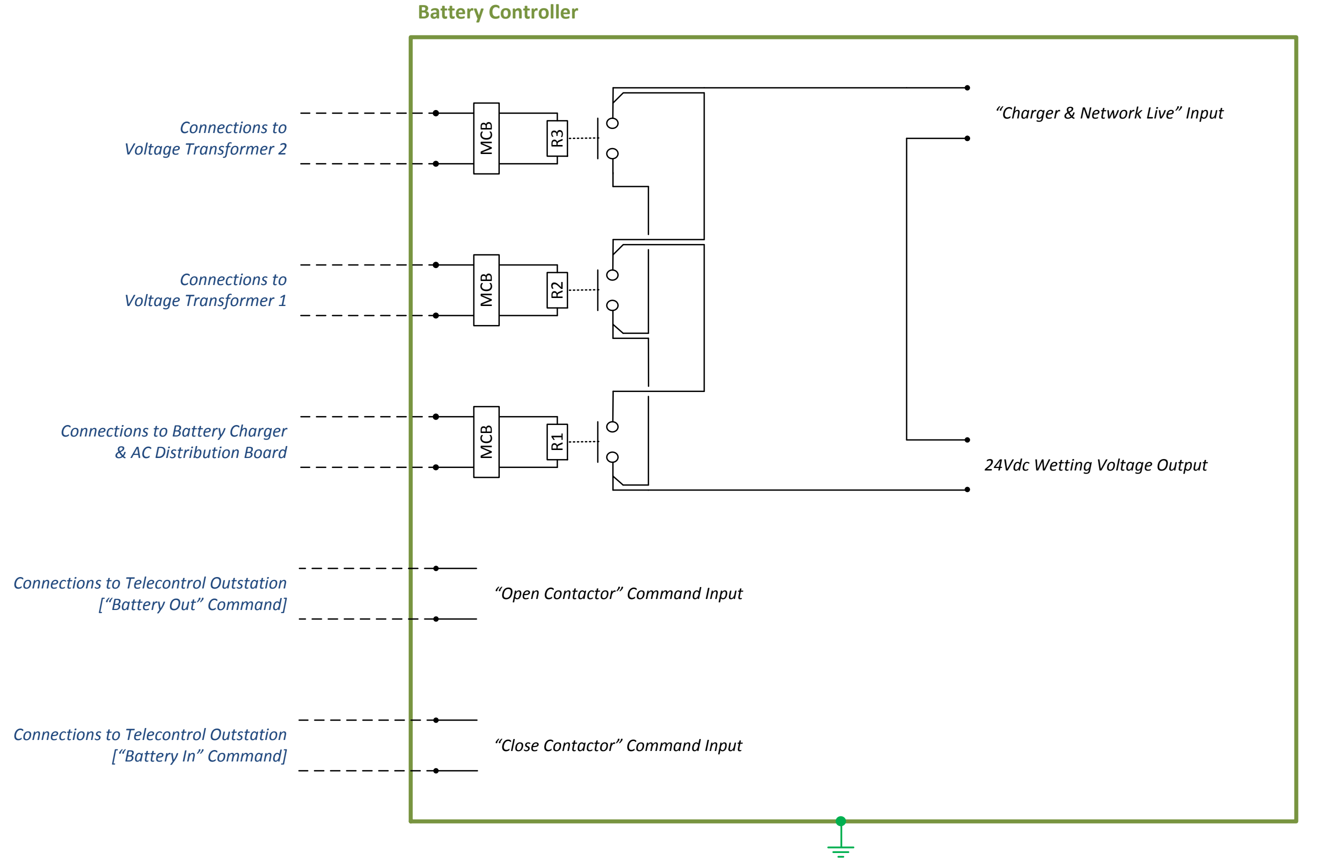


NOTES

1. Contactor & Bypass shown in the open positions

2. Wetting voltage for contactor open/close coils assumed to be derived internal to the battery controller

8.2 Schematic Diagram of Battery Controller - Inputs



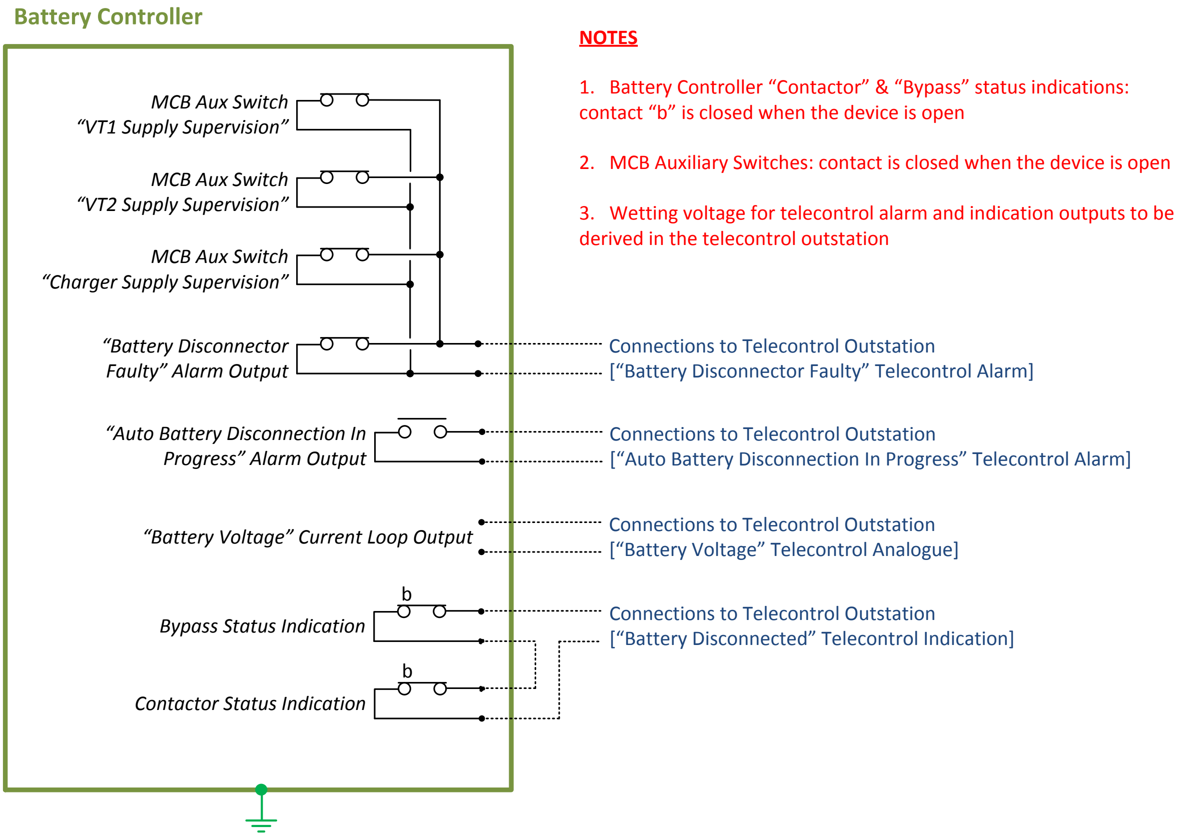
NOTES

1. R1 = Charger Supply Supervision Relay
2. R2 = VT1 Supply Supervision Relay
3. R3 = VT2 Supply Supervision Relay

4 Wetting voltage for "Charger & Network Live" input to be derived internal to the battery controller

5. Wetting voltage for "Open Contactor" and "Close Contactor" Command inputs to be derived in the telecontrol outstation

8.3 Schematic Diagram of Battery Controller - Outputs



8.4 General

The battery controller shall be designed to facilitate the disconnection and reconnection of DC supplies to switchgear control and protection equipment in an electricity substation.

The battery controller shall comprise a magnetically latched contactor plus the associated electronic control circuits, and shall be connected between the battery and the dc distribution board.

The contactor shall consume no power, produce no heat and generate no noise when in either the open or closed position. The application of a momentary signal to the operate coil shall close the contactor and a permanent magnet shall hold it in this state. The application of a momentary reverse polarity signal to the operate coil shall open the contactor. The contactor shall be inherently fail-safe i.e. it shall maintain its position in the event of any control circuit power failure or fault.

Normally the contactor will be in the closed position with the load connected to the battery and charger. The contactor shall be designed for prolonged operation (i.e. 20 years plus) in this state.

Under certain specified circumstances the contactor will be opened in order to disconnect the switchgear control and protection equipment from the battery and charger. The aim is to conserve battery capacity in the event of a sustained shutdown on the distribution network.

The battery controller shall incorporate a bypass switch which circumvents the contactor in order all to facilitate maintenance and testing of contactor without interrupting power to the switchgear control and protection equipment.

8.5 Control Functionality

The control functionality to be executed by the battery controller shall be as follows:

8.5.1 Battery Disconnect – Remote Manual

Remote manual battery disconnection shall be effected by the WPD telecontrol system momentarily energising the "Open Contactor" command input (typically for a 2 second period). The wetting voltage will be derived from the WPD telecontrol outstation and will be either 24Vdc or 48Vdc.

> *Guidance*
> *A problem with the 24Vdc wetting output voltage, or an associated wiring fault, would result in the "Charger & Network Live" input de-energising, thereby triggering an automatic disconnection sequence.*
>
> *If telecontrol interposing relays were employed (as per conventional practice) then it would not be possible to override the disconnection sequence because the wetting voltage for energising the "Open Contactor" command input would be derived from the faulty 24Vdc system.*
>
> *If telecontrol interposing relays are omitted then the wetting voltage for energising the "Open Contactor" command input would be derived from the telecontrol outstation.*

Upon energisation of the "Open Contactor" command input the battery controller shall open the contactor in order to disconnect the load from the battery and charger provided that:

- The Contactor is in the closed state, and
- The "Charger & Network Live" input has been continuously de-energised for a period longer than a user-settable time delay (settings to encompass the range 0.2 to 5.0 seconds in steps of not more than 0.1 seconds. Normally set at 5.0 seconds), and
- The "Open Contactor" command input is energised for a period longer than a user-settable time delay (settings to encompass the range 0.2 to 5.0 seconds in steps of not more than 0.1 seconds. Normally set at 1.0 seconds)

8.5.2 Battery Disconnect – Local Manual

The Battery Controller shall include a means of locally opening the contactor.

Local manual operation of the contactor shall only be possible when the Contactor Bypass Switch is in the closed state.

8.5.3 Battery Disconnect – Automatic

When battery disconnection is required the intention is for this to ordinarily be carried out by the "Remote Manual" method described in 8.5.1 above. However, the battery controller shall also incorporate a means of automatically disconnecting the battery.

Upon de-energisation of the "Charger & Network Live" input the battery controller shall open the contactor in order to disconnect the load from the battery and charger provided that:

- The Contactor is in the closed state, and
- The "Charger & Network Live" input has been continuously de-energised for period longer than a user-settable time delay (settings to encompass the range 1 to 16 hours in steps of not less than 1 hour. Normally set at 6 hours)

8.5.4 Battery Connect – Remote Manual

Remote manual battery connection shall be effected by the WPD telecontrol system momentarily energising the "Close Contactor" command input (typically for a 2 second period). The wetting voltage will be derived from the WPD telecontrol outstation and will be either 24Vdc or 48Vdc.

> *Guidance*
>
> *A problem with the 24Vdc wetting output voltage, or an associated wiring fault, would result in the "Charger & Network Live" input de-energising, thereby triggering an automatic disconnection sequence.*
>
> *If telecontrol interposing relays were employed (as per conventional practice) then it would not be possible to override the disconnection sequence because the wetting voltage for energising the "Close Contactor" command input would be derived from the faulty 24Vdc system.*
>
> *If telecontrol interposing relays are omitted then the wetting voltage for energising the "Close Contactor" command input would be derived from the telecontrol outstation.*

Upon energisation of the "Close Contactor" command input the battery controller shall close the contactor in order to connect the load to the battery and charger provided that:

- The Contactor is in the open state, and
- The “Close Contactor” command input is energised for a period longer than a user-settable time delay (settings to encompass the range 0.2 to 5.0 seconds in steps of not more than 0.1 seconds. Normally set at 1.0 seconds)

8.5.5 Battery Connect – Local Manual

The Battery Controller shall include a means of locally closing the contactor.

Local manual operation of the contactor shall only be possible when the Contactor Bypass Switch is in the closed state.

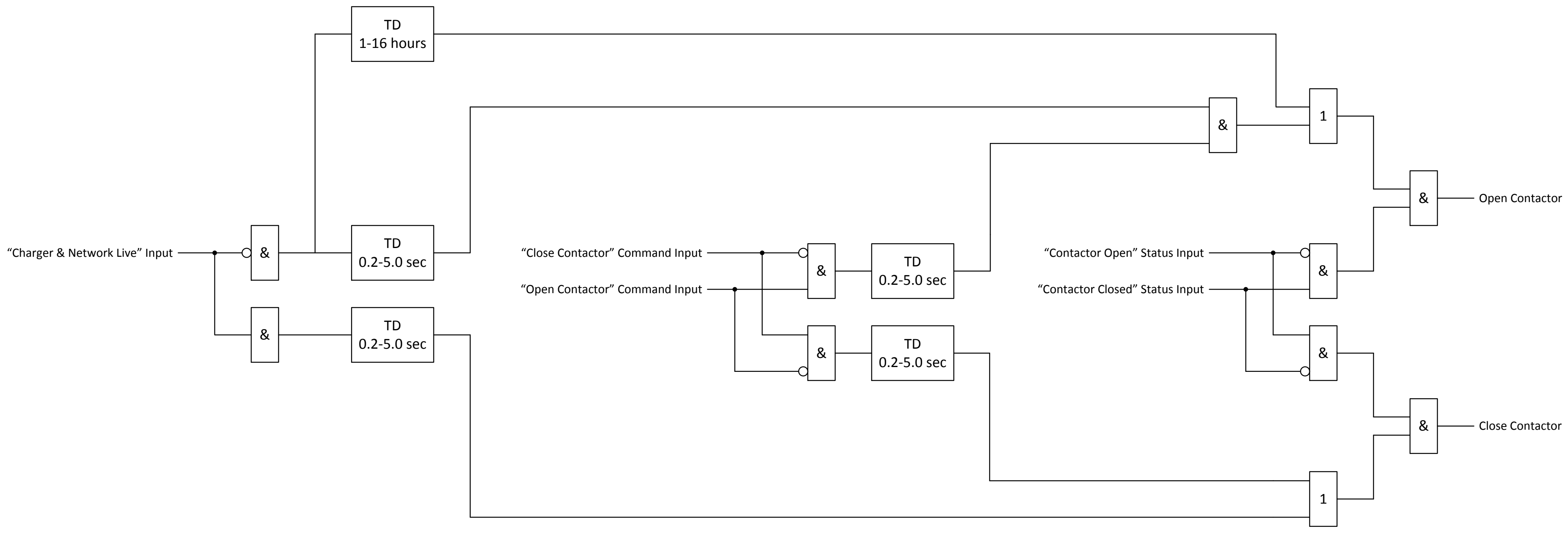
8.5.6 Battery Connect – Automatic

When battery connection is required the intention is for this to ordinarily be carried out by the “Remote Manual” method described in 8.5.4 above. However, the battery controller shall also incorporate a means of automatically connecting the battery.

The battery controller shall continuously monitor the status of the “Charger & Network Live” input. The battery controller shall close the contactor in order to connect the load to the battery and charger provided that:

- The Contactor is in the open state, and
- The “Charger & Network Live” input has been continuously energised for a period longer than a user-settable time delay (settings to encompass the range 0.2 to 5.0 seconds in steps of not more than 0.1 seconds. Normally set at 5.0 seconds)

8.5.7 Logic Diagram of the Battery Controller



8.6 Design Life

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

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

8.7 Auxiliary Power

The battery controller shall be powered the battery i.e. from a $110V_{dc}$ or $220V_{dc}$ supply as appropriate. The auxiliary power supply connections shall be on the battery side of the contactor.

The battery controller shall continue to function with the DC auxiliary power supply input voltage varying within the following range:

- 77V and 137.5V on 110V nominal systems
- 154V and 275V on 220V nominal systems

The battery controller shall consume less than 8W of power. Details of the continuous load imposed by the battery controller shall be provided.

8.8 Contactor Rating

The contactor shall be able to carry $200A_{dc}$ continuously and $450A_{dc}$ for one minute.

The contactor shall be able to interrupt a current of $200A_{dc}$.

8.9 Contactor Bypass Switch

The bypass switch shall have a key-operated lock to avoid unauthorised or accidental operation. The switch shall have a mushroom head type design and the switch contacts shall open when the head is pushed and shall close (to bypass the contactor) when pulled.

The bypass switch shall be able to carry $200A_{dc}$ continuously and $450A_{dc}$ for one minute, and be able to interrupt a current of $200A_{dc}$.

8.10 Auxiliary Relays

The following auxiliary relays shall be provided and mounted internally within the enclosure:

- “Charger Supply Supervision” Relay
  (Relay R1 in 8.2 above)
- “Voltage Transformer 1 Supply Supervision” Relay
  (Relay R2 in 8.2 above)
- “Voltage Transformer 2 Supply Supervision” Relay
  (Relay R3 in 8.2 above)

The relays shall comply with ENA TS 50-18 and the following requirements:

8.10.1 Charger Supply Supervision Relay

The relay shall be suitable for use with the battery charger ac supply voltage specified on the Ordering Schedule.

The relay specification is as follows:

Relay Function:	“Charger Supply Supervision” Relay
Relay Coil:	• 230Vac or 400Vac (as specified on the Ordering Schedule) with an extended voltage range of +25%, -30% • Designed to allow continuous operation even in high ambient temperatures • Equipped with a transient overvoltage suppression varistor
Relay Type:	Self-reset
WPD Approved Relays:	• Manufacturer: Arteche • Manufacturers Ref. No: – 230Vac: RD-2-SYV-FF-230VAC-OP-01000 – 400Vac: RD-2-SYV-FF-400VAC-OP-01000 • Relay Socket: DN DE IP10 • Relay Retaining Clip: E41 Alternative relays that can be demonstrated, to be adequate by the Tenderer, at the time of tender, may be acceptable subject to agreement prior to placement of the contract.

8.10.2 Voltage Transformer (VT) Supply Supervision Relays

The relays shall be suitable for use with the VT secondary output voltage specified on the Ordering Schedule.

The relay specification is as follows:

Relay Function:	“VT1 Supply Supervision” or “VT2 Supply Supervision” Relay
Relay Coil:	• 63.5Vac or 110Vac (as specified on the Ordering Schedule) with extended voltage range of +25%, -30% • Designed to allow continuous operation even in high ambient temperatures • Equipped with a transient overvoltage suppression varistor
Relay Type:	Self-reset
WPD Approved Relays:	• Manufacturer: Arteche • Manufacturers Ref. No: – 63.5Vac: RD-2-SYV-FF-63.5VAC-OP-01000 – 110Vac: RD-2-SYV-FF-110VAC-OP-01000 • Relay Socket: DN DE IP10 • Relay Retaining Clip: E41 Alternative relays that can be demonstrated to be adequate, by the Tenderer, at the time of tender, may be acceptable subject to agreement prior to placement of the contract.

8.11 MCBs

MCBs shall be provided for protection of the Charger, VT1 and VT2 Supply Supervision relay circuits and to facilitate testing of the battery controller. They shall be mounted internally within the enclosure.

The MCBs shall comply with BS EN 60898, be double pole devices, and have a 2A rating.

A normally closed auxiliary contact (i.e. closed when the MCB is open) shall be provided per MCB for alarm purposes. Each alarm contact shall be wired in parallel with the “Battery Controller Faulty” alarm contact (as shown in the diagram in 8.3 above).

8.12 Monitoring Requirements

The following monitoring functions shall be provided:

(a) Contactor status monitoring

(b) Bypass switch status monitoring

(c) Auto battery disconnection status monitoring

(d) Battery controller monitoring

(e) Battery voltage monitoring

The monitoring scheme shall include LEDs and/or LCD displays for local alarm / indication purposes and volt-free contacts for remote (telecontrol) alarm / indication purposes for (a), (b) and (c). LEDs shall be flush mounted on the front of the battery controller and shall be clearly visible.

The wetting current for telecontrol alarm / indication contacts is typically in the range 3 to 6mA.

8.12.1 Contactor Status Monitoring

The position status of the contactor shall be continuously monitored.

A "Contactor Open" LED shall be illuminated whenever the contactor is open, regardless of the state of the bypass switch.

A volt-free contact for remote indication purposes shall be provided. The volt-free contact should preferably be an auxiliary switch which is mechanically driven by operation of the contactor. The contact shall be closed when the contactor is open (and vice-versa).

This contact shall be wired in series with the equivalent contact from the bypass. Concurrent opening of the battery controller contactor and bypass will initiate a "Battery Disconnected" telecontrol indication (as shown in the diagram in 8.3 above).

8.12.2 Bypass Switch Status Monitoring

The position status of the bypass switch shall be continuously monitored.

A "Bypass Closed" LED shall be illuminated whenever the bypass is closed, regardless of the state of the contactor.

A volt-free contact for remote indication purposes shall be provided. The volt-free contact should preferably be an auxiliary switch which is mechanically driven by operation of the bypass switch. The contact shall be closed when the bypass is open (and vice-versa).

This contact shall be wired in series with the equivalent contact from the contactor. Concurrent opening of the battery controller contactor and bypass will initiate a "Battery Disconnected" telecontrol indication (as shown in the diagram in 8.3 above).

8.12.3 Auto Battery Disconnection Status Monitoring

The status of the automatic battery disconnection function shall be continuously monitored. Auto battery disconnection commences when the "Charger & Network Live" input de-energises and concludes upon expiry of the user settable time delay when the contactor is opened (see 8.5.3 above).

A volt-free contact for remote indication purposes shall be provided. The volt-free contact shall close when auto battery disconnection is in progress (and vice-versa).

An LCD display shall show the time remaining until auto battery disconnection is to be executed.

8.12.4 Battery Controller Monitoring

The battery controller shall incorporate continuous self-monitoring.

A “Battery Controller Faulty” LED shall be illuminated whenever the battery controller is in a faulty condition, for example, when a contactor anomaly occurs or when the battery voltage is low.

A “Battery Controller Faulty” relay shall be energised whenever the battery controller is in a healthy condition. The relay shall have a normally-closed volt free contact for remote alarm purposes. In other words, the contact shall open when the relay energises (battery controller healthy) and close when the relay de-energises (battery controller faulty) i.e. a “fail-safe” design. Contact closure will initiate a “Battery Controller Faulty” telecontrol alarm.

8.12.5 Battery Voltage Monitoring

The battery controller shall incorporate continuous monitoring of the battery voltage.

The battery voltage shall be presented on a liquid crystal display mounted on the battery controller to a resolution of not less than 0.25 volts.

A 0-10mA current loop output shall be provided, which shall have an output current which varies linearly with battery voltage as per the following table.

OUTPUT CURRENT	0mA	10mA
BATTERY VOLTAGE: 110V SYSTEMS	80V	140V
BATTERY VOLTAGE: 220V SYSTEMS	160V	280V

The current loop shall drive a “Battery Voltage” telecontrol analogue.

8.13 Enclosure

Construction requirements for the enclosure are specified in Section 5.7 above.

The battery controller shall be available in two discrete formats, as follows:

8.13.1 19” Rack Mounted Enclosure

The battery controller shall be available in a 19 inch mounted format for all new installations, and for retrofitting at sites where the existing battery and charger is accommodated in a 19 inch rack format cubicle and sufficient free space is available.

8.13.2 Wall Mounted Box

The battery controller shall be available in a wall mounted box for retrofitting at sites where the existing battery and charger:

- Is not accommodated in a 19 inch rack format cubicle, or
- Is accommodated in a 19 inch rack format cubicle but where insufficient free space is available

8.14 Labelling

8.14.1 Battery Controller Identification Label

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

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

X = **110V or 220V**, as appropriate

Y = **BATTERY CONTROLLER**

Z = **1**, **2**, **3**, etc. and is only required when multiple battery controllers will be present on a particular substation site. The battery controller shall have the same number as the associated battery control box (see 8.8.1 below).

For example: **110V BATTERY CONTROLLER 1**

8.14.2 Manufacturer's Information Label

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

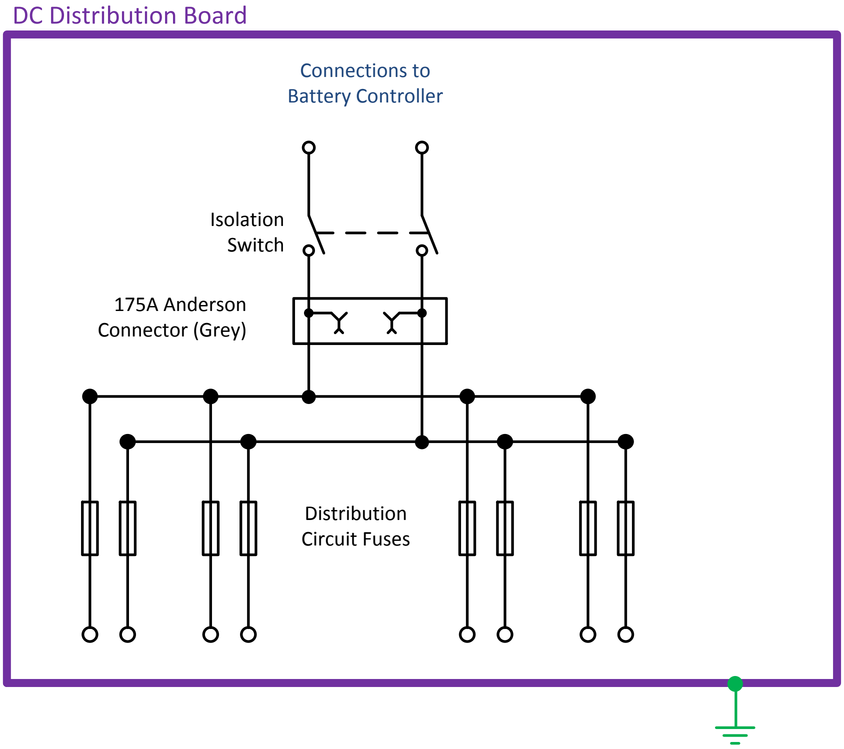
- Name of manufacturer or supplier
- Manufacturer's or supplier's type reference
- Nominal operating voltage
- DC current carrying capacity
- DC current interrupting capacity
- Date of manufacture

8.14.3 Component Identification Labels

The Contactor Bypass Switch, MCBs and auxiliary relays shall be provided with a durable and easily visible alphanumeric identification label mounted immediately adjacent denoting its function.

9 REQUIREMENTS FOR DC DISTRIBUTION BOARDS

9.1 Schematic Diagram of the DC Distribution Board



9.2 Design Life

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

9.3 Circuits and Maintenance Facilities

The incoming circuit (from the battery controller) 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 63A or 100A as per the schedule and be suitable for use with fuse links to BS88-2, reference A. Fuse carriers shall be equipped with a fuse link with a rating as per the schedule.

9.4 Enclosure

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

The enclosure will be mounted immediately adjacent to the battery, battery charger & battery controller and the individual items of equipment will be interconnected by short lengths of cable (to be supplied).

The rationale behind this approach is that it facilitates the preservation of substation dc auxiliary supplies during the replacement of either the battery, battery charger or battery controller, 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 5.7 above.

9.5 Labelling

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

9.5.1 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 in the form **X Y Z**, where:

X =	**110V or 220V**	as appropriate
Y =	**DC DISTRIBUTION BOARD**	
Z =	**1**, **2**, **3**, etc.	only required when multiple DC distribution boards with the same nominal voltage will be present on a particular substation site

For example: **110V DC DISTRIBUTION BOARD 1**

9.5.2 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

9.5.3 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)

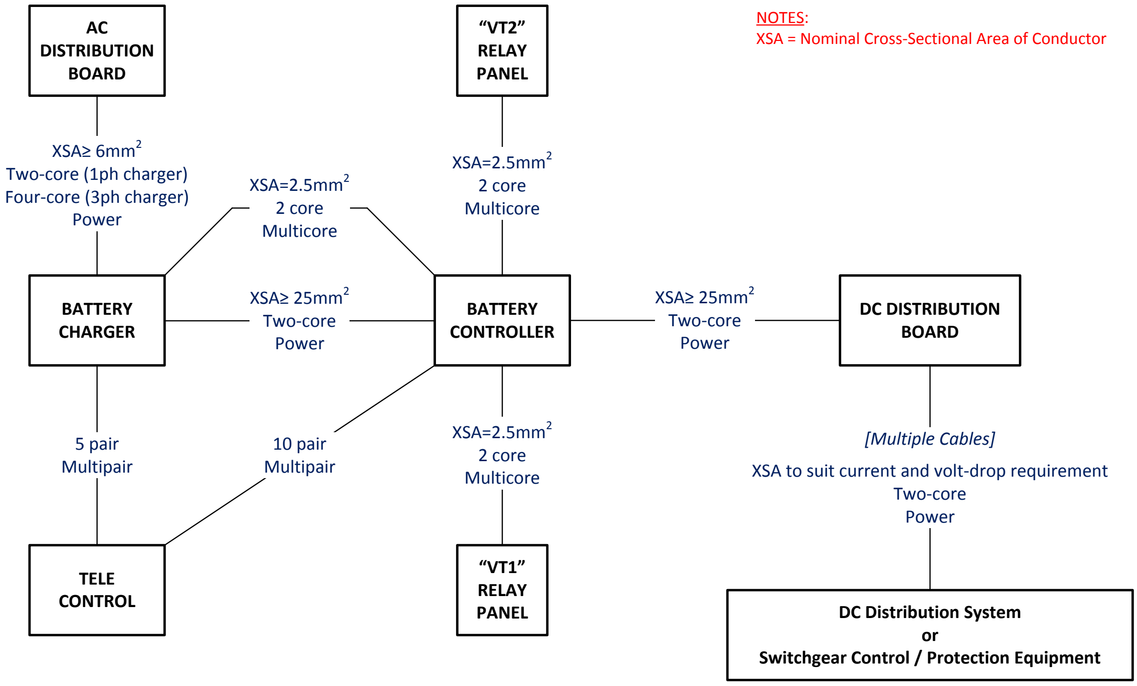
For example: **DC+ RELAY CUBICLES (63A)**

9.5.4 Component Identification Labels

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

10 REQUIREMENTS FOR AUXILIARY CABLING

10.1 Schematic Diagram of Auxiliary Cabling



10.2 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, and three-phase ac circuits shall employ four-core cable.

The cores of all cables shall be identified by colour. Two-core cables shall employ brown and blue coloured insulation, and four-core cables shall employ brown, grey, black 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 10.1 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

- 220V systems maximum volt-drop = 12V

10.3 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 10.1 above.

10.4 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.

10.5 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 $2.5mm^2$.

11 WPD STANDARD CONFIGURATIONS

WPD requires batteries, battery chargers, battery controllers 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.

11.1 Batteries

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

REF	VOLTAGE	STRINGS	MONOBLOCS PER STRING	NOMINAL C_{10} CAPACITY	INCLUSIONS
110 - BAB14F	110V	2	9 * Enersys SBS B14F	123.4Ah	– Monobloc labels – Battery Identification Label – Manufacturer's Information Label
110 - BAC11F	110V	2	9 * Enersys SBS C11F	183.0Ah	
110 - BA170F	110V	2	9 * Enersys SBS 170F	340.0Ah	
220 - BAB14F	220V	2	18 * Enersys SBS B14F	123.4Ah	
220 - BAC11F	220V	2	18 * Enersys SBS C11F	183.0Ah	
220 - BA170F	220V	2	18 * Enersys SBS 170F	340.0Ah	

11.2 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	
110 - CH150	230V Single Phase	110V	50A	
110 - CH350	400V Three Phase	110V	50A	
220 - CH120	230V Single Phase	220V	20A	
220 - CH125	230V Single Phase	220V	25A	
220 - CH150	230V Single Phase	220V	50A	
220 - CH350	400V Three Phase	220V	50A	

11.3 Battery Controllers

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

REF	VOLTAGE	FORMAT	INCLUSIONS
110 - COR**	110V	Rack Mount	– Controller Identification Label – Manufacturer's Information Label – Component Identification Labels
110 - COW**	110V	Wall Box	
220 - COR**	220V	Rack Mount	
220 - COW**	220V	Wall Box	

**	CHARGER SUPPLY SUPERVISION RELAY	VT SUPPLY SUPERVISION RELAYS	INCLUSIONS
21	230V	110V	
26	230V	63.5V	
41	400V	110V	
46	400V	63.5V	

e.g. 110 - COR21 is a 110V rack mounted battery controller equipped with a 230Vac charger supply supervision relay and two 110Vac VT supply supervision relays.

11.4 Integrated System

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

WPD REF	BATTERY	CHARGER	CONTROLLER	INCLUSIONS
110 - IS - BAB14F - CH120 - COR**	110 - BAB14F	110 - CH120	110 - COR**	– Monobloc labels – Battery Identification Label – Battery Charger Identification Label – Controller Identification Label – Component Identification Labels – Manufacturer's Information Label
110 - IS - BAC11F - CH125 - COR**	110 - BAC11F	110 - CH125	110 - COR**	
110 - IS - BA170F - CH150 - COR**	110 - BA170F	110 - CH150	110 - COR**	
110 - IS - BA170F - CH350 - COR**	110 - BA170F	110 - CH350	110 - COR**	
220 - IS - BAB14F - CH120 - COR**	220 - BAB14F	220 - CH120	220 - COR**	
220 - IS - BAC11F - CH125 - COR**	220 - BAC11F	220 - CH125	220 - COR**	
220 - IS - BA170F - CH150 - COR**	220 - BA170F	220 - CH150	220 - COR**	
220 - IS - BA170F - CH350 - COR**	220 - BA170F	220 - CH350	220 - COR**	

11.5 Distribution Boards

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

<table>
<tr><th>WPD REF</th><th colspan="2">WAYS</th><th>FORMAT</th><th>INCLUSIONS</th></tr>
<tr><td>DB-4W63</td><td>4 Double Pole</td><td>4 No. RS63/63A</td><td>Wall Mounted</td><td rowspan="5">– Distribution Board Identification Label
– Manufacturer’s Information Label
– Fuse-holder Labels
– Component Identification Labels</td></tr>
<tr><td>DB-6W63</td><td>6 Double Pole</td><td>6 No. RS63/63A</td><td>Wall Mounted</td></tr>
<tr><td>DB-12W63</td><td>12 Double Pole</td><td>12 No. RS63/63A</td><td>Freestanding</td></tr>
<tr><td>DB-11F63</td><td>11 Double Pole</td><td>1 No. RS100/100A
2 No. RS63/63M80A
8 No. RS63/63A</td><td>Freestanding</td></tr>
<tr><td>DB-23F63</td><td>23 Double Pole</td><td>3 No. RS100/100A
6 No. RS63/63M80A
14 No. RS63/63A</td><td>Freestanding</td></tr>
</table>

12 PERFORMANCE DATA FOR ENERSYS SBS POWERSAFE 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	24 Hrs
SBS B14F	123.4	12.34	386.0	5.4
SBS C11F	183.0	18.3	496.0	8.3
SBS 170F	340.0	34.0	600.2	15.1

13 SIZING OF LEAD ACID BATTERIES

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

13.1 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.

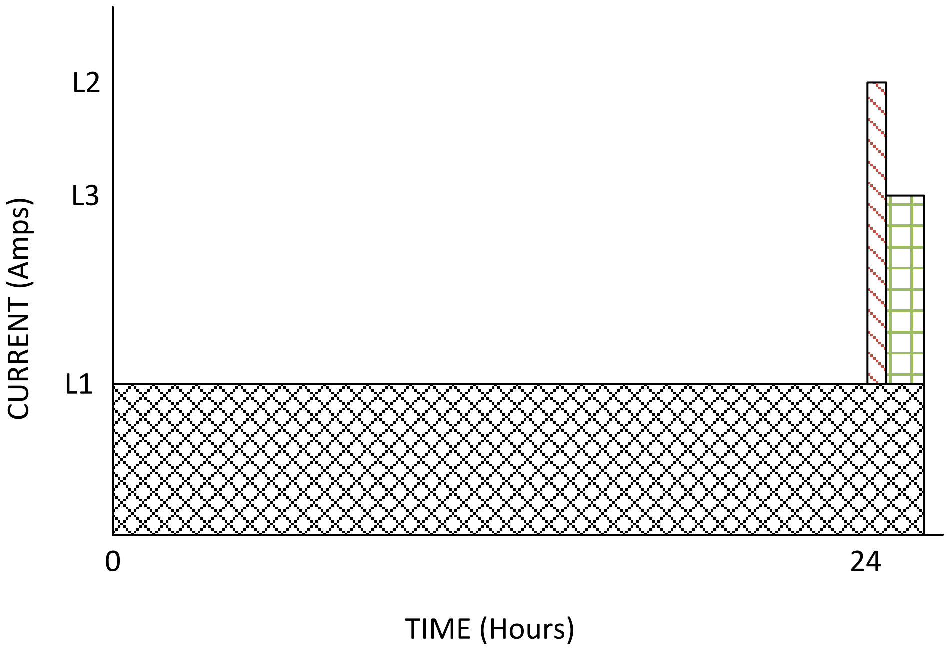
Battery Calculator (EE SPEC 23)

13.2 Battery Duty Cycle

A diagram of the duty cycle, based on the requirements of Section 6.6 above, is shown below.

- L1 is the standing continuous load current
- L2 is the transient load current due to the simultaneous tripping of "X" circuit breakers (after 24 hours) plus the standing continuous load current
- L3 is the transient load current due to the sequential closing of "X" circuit breakers (following their aforementioned tripping) plus the standing continuous load current

DIAGRAM OF BATTERY DUTY CYCLE



13.3 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.

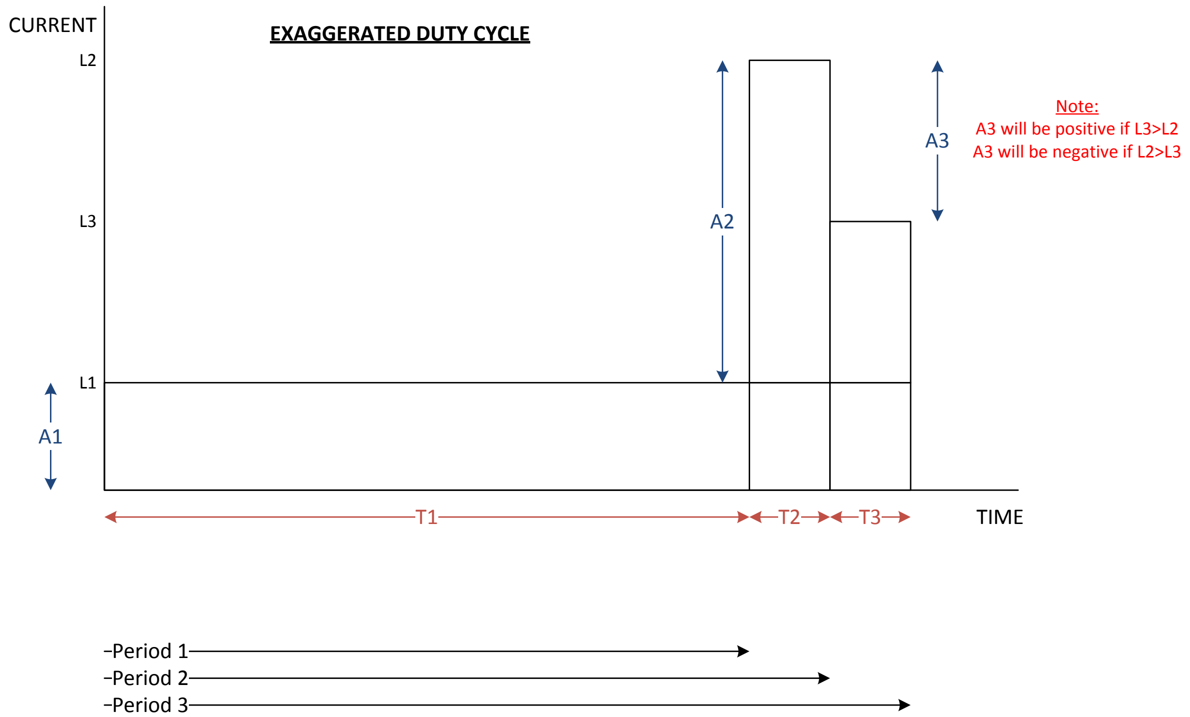
A cell / monobloc type shall be selected which has a 24 hour discharge current capability in excess of 1.5x the standing load current.

For example, if the standing load current is 5.2A, then 1.5 x 5.2 = 7.8A. Using the table in Section 12 above, SBS C11F monoblocs would be selected as they have a 24 hour discharge current capability of 8.3A.

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.

13.4 Battery Sizing Methodology

Consider the battery duty cycle drawn to an exaggerated scale:



A1 = L1

A2 = L2 – L1

A3 = L3 – L2

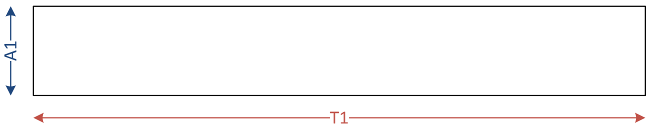
Note that the sign of A3 is important. A3 will be positive if L3>L2 and negative if L2>L3.

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 the next period (2) is analysed it is assumed that the current for the preceding period (1) continues. The capacity is then adjusted for the change in current between the two periods. This process is repeated until all periods have been considered. In other words:

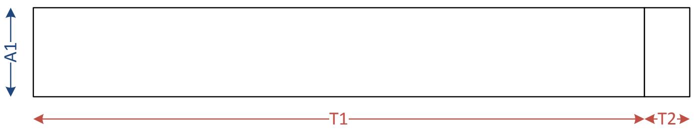
<u>Period 1</u>

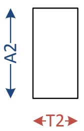


Capacity for Period 1 =

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

<u>Period 2</u>





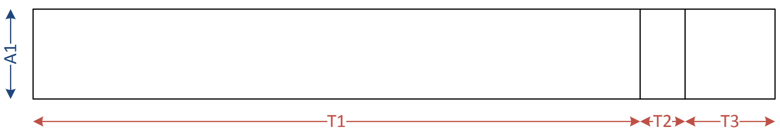
Capacity for Period 2 =

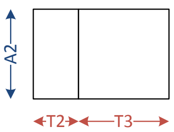
$$\frac{\text{A1 * Nominal } C_{10} \text{ Capacity}}{\text{Discharge Current}_{[T1+T2]}}$$

Plus

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

<u>Period 3</u>





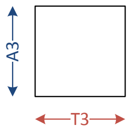
Capacity for Period 3 =

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

Plus

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

Plus



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

(nb polarity of A3 is important!)

13.5 Example Calculation

A 110V battery & charger system is required for a new 33/11kV substation. The 11kV switchboard consists of two incoming circuit breakers, one bus section circuit breaker, and 10 outgoing feeder circuit breakers (five per busbar section). The switchboard is equipped with differential busbar protection.

“X” = 7 circuit breakers
(one incomer plus one bus section plus five feeders need to trip for a busbar fault).

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 420 Watts.

In other words,

T1 = 24 hours
T2 = 60 milliseconds
T3 = 7 * 7 seconds = 49 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	= 420W / (54 cells * 1.85V per cell)	= 4.2A
A1	= L1 = 4.2A	
L2	= L1 + simultaneous tripping burden	
	= L1 + (7 * 200W) / (54 cells * 1.85V per cell)	= L1 + 14.0A
A2	= L2 – L1 = 14.0A	
L3	= L1 + sequential closing burden	
L3	= L1 + 300W / (54 cells * 1.85V per cell)	= L1 + 3.0A
A3	= L3 – L2 = (L1 + 3.00A) – (L1 + 14.0A)	= -11.0A

Note that A3 is negative in this instance.

13.5.1 Preliminary Selection of Monobloc Type

A cell / monobloc type shall be selected which has a 24 hour discharge current capability in excess of 1.5x the standing load current.

The standing current is 4.2A and therefore 1.5 x 4.2 = 6.3A. Enersys SBS C11F monoblocs are capable of supplying 8.3A for 24 hours and consequently the discharge characteristics for this type of monobloc shall be used for the detailed calculations.

13.5.2 Period 1 Calculation

T1 = 24 hours

Enersys SBS C11F monoblocs (from Section 12)

- 24 hour discharge current = 8.3A
- Nominal C_{10} capacity = 183.0Ah

Current A1 = 4.2A
T1 = 24 hours
Capacity = $\frac{4.2 * 183.0}{8.3}$ = 92.6Ah [1A]

Capacity for Period 1 = [1A]
= 92.6Ah

13.5.3 Period 2 Calculation

T2 = 60 milliseconds
T1 = 24 hours T1+T2 = 24 hours 60 milliseconds

Enersys SBS C11F monoblocs (from Section 12)

- 60 milliseconds discharge current = 496.0A *{use 5 minute value}*
- 24 hours 60 milliseconds discharge current = 8.3A *{use 24 hour value}*
- Nominal C_{10} capacity = 183.0Ah

Current A1 = 4.2A
T1+T2 = 24 hours 60 milliseconds
Capacity = $\frac{4.2 * 183.0}{8.3}$ = 92.6Ah [2A]

Current A2 = 14.0A
T2 = 60 milliseconds
Capacity = $\frac{14.0 * 183.0}{496.0}$ = 5.2Ah [2B]

Capacity for Period 2 = [2A] + [2B]
= 92.6Ah + 5.2Ah
= 97.8Ah

13.5.4 Period 3 Calculation

T3 = 49 seconds
T2 = 60 milliseconds
T1 = 24 hours T1+T2+T3 = 24 hours 49.060 seconds

Enersys SBS C11F monoblocs (from Section 12)

- 49 seconds discharge current = 496.0A *{use 5 minute value}*
- 49.060 seconds discharge current = 496.0A *{use 5 minute value}*
- 24 hours 49.060 seconds discharge current = 8.3A *{use 24 hour value}*
- Nominal C_{10} capacity = 183.0Ah

Current A1 = 4.2A
T1+T2+T3 = 24 hours 49.060 seconds
Capacity = $\frac{4.2 * 183.0}{8.3}$ = 92.6Ah [3A]

Current A2 = 14.0A
T2+T3 = 49.060 seconds
Capacity = $\frac{14.0 * 183.0}{496.0}$ = 5.2Ah [3B]

Current A3 = -11.0A
T3 = 49 seconds
Capacity = $\frac{-11.0 * 183.0}{496.0}$ = -4.1Ah [3C]

Capacity for Period 3 = [3A] + [3B] + [3C]
= 92.6Ah + 5.2Ah – 4.1Ah
= 93.7Ah

13.5.5 Highest Capacity Period

The period with the highest capacity is period 2 = 97.8Ah.

13.5.6 Battery Design Margin

A battery design margin of 1.1 shall be applied in accordance with 6.7.3
1.1 * 97.8Ah = 107.6Ah

13.5.7 Temperature Correction Factor

A temperature correction factor of 1.09 shall be applied in accordance with 6.7.4
1.09* 107.6Ah = 117.3Ah

13.5.8 Ageing Factor

An ageing factor of 1.25 shall be applied in accordance with 6.7.5
1.25* 117.3Ah = 146.6Ah

13.5.9 Overall Assessment

A battery with a nominal C_{10} capacity not less than 146.6Ah is required.

Enersys SBS C11F monoblocs have a nominal C_{10} capacity of 183.0Ah and therefore are adequate for the intended application.

13.5.10 Charger Sizing

The charger dc output current rating shall be not less than (see section 7.5 above):

C_{10} current for the battery + (charger design margin * standing load current)

Enersys SBS C11F monoblocs with a nominal C_{10} capacity of 183.0Ah and current of 18.3A (from Section 12).

Standing load current = 4.2A

Consequently the charger dc output current rating must not be less than:
18.3A + (1.1 * 4.2A) = 22.9A

Therefore select a charger with a 25A dc output current rating.

APPENDIX A

SUPERSEDED DOCUMENTATION

EE SPEC 25/4 Substation 110V Battery Systems

APPENDIX B

ANCILLARY DOCUMENTATION

EE SPEC 25/5 110V Batteries, Chargers, Distribution Boards & Associated Cabling For Metering Circuit Breaker Type Primary Network Substations

APPENDIX C

KEY WORDS

Batteries; Chargers; Distribution; Boards; Controllers; Black; Start; 110V; 220V; DC; Primary.