www.redflow.com

Redflow

Installation and Operation Manual

ZBM2 (3kW/10kWh)

ORIGINAL INSTRUCTIONS

V4.0

CE

redflow

advanced energy storage

Redflow's ZBM2 represents the state-of-the-art in zinc-bromine flow battery technology.

It is designed as a modular battery to be integrated into electricity storage systems.

For Sales and Technical Support, Redflow can be contacted at:

Redflow Limited

ABN 49 130 227 271

27 Counihan Road
Seventeen Mile Rocks
Brisbane
QLD 4073

Australia

W: www.redflow.com

T: +61 7 3376 0008

F: +61 7 3376 3751

E: tech.support@redflow.com

sales@redflow.com

Office hours: 8:30am to 5:00pm, Brisbane, Australia
Monday - Friday

Table of Contents

List of Figures

List of Tables

1. Introduction

This manual is for Redflow's DC flowing electrolyte battery product, the Zinc-Bromine Module 2 (ZBM2). It provides information on this battery's installation, operation and maintenance for nominal 48VDC systems. Installation of the ZBM2 must only be done by trained installers.

1.1. About the ZBM2

Redflow's ZBM2 is a DC flow battery with in-built electronic management. With appropriate ancillary circuitry, multiple ZBM2s can be connected together in parallel. The ZBM2 is ideally suited to daily cycling of its full capacity and offers long cycle life energy storage in such applications.

ZBM2 main components:

- Tanks (including electrolyte)
- Electrode Stacks
- Module Management System (MMS)
- Analog Loom
- Pumps (Zinc and Bromine)
- Cooling Fan
- Cooling Tubes
- Gas Handling Units
- Energy Extraction Device (EED)

Battery operation is controlled and managed by the MMS. Operation of ZBM2s must be kept within the boundaries of the operating envelope set out in Table 1 to ensure correct operation and also to comply with warranty conditions; failure to keep within the boundaries will void the warranty. It should be noted that in applications where one ZBM2 would not be able to remain within the envelope, adding another ZBM2 may bring the performance of each ZBM2 back within the envelope.

Table 1: ZBM2 Electrical Operating Envelope

Power Rating *	Continuous charge power: 2.5kW Continuous discharge Power: 3kW Peak discharge Power: 5kW *Note: Refer to Section 9.4.3 for more information about peak power.*
Usable Capacity/Energy *	200Ah / 10kWh
Minimum Ah Output (end of life)	200Ah (standard cycle) Note: Standard test cycle is defined in Appendix E and is used for warranty claims.
DC Voltage Operating Range	40 to 58V DC
Absolute Voltage Range	0 to 70V DC *Note: ZBM2 have a terminal voltage = 0V on initial start-up and after maintenance cycles*
Auxiliary Power	180W maximum @ 40V DC minimum
Circuit Protection Maximum Rating	125A Note: Each ZBM2 must have a fuse or circuit breaker between the ZBM2 and the Power Control System DC bus.
Short Circuit Fault Current Rating	600A
Battery Operating Temperature Range 0-1000m above sea level**	10 to 50 °C (50 to 122 °F) Charging 15 to 50 °C (59 to 122 °F) Discharging The battery temperature is the electrolyte temperature.
Allowable Ambient Temperature Range	Operation: 5 to 45 °C (41 to 113 °F) Storage and Transportation: -5 to 45°C (14 to 113 °F) Contact Redflow for advice if outside this range.
Self-Maintenance Cycle Frequency	Optimally every full discharge. A minimum of once every 72 hours of zinc pump operation. For warranty to be valid and battery performance to be maintained users must not override ZBM2 internal automatic self-maintenance procedures.
Stack Energy Efficiency*	80% DC-DC maximum
EMC Compliance	*Emissions:* EN61000-6-3:2007; *Immunity:* EN61000-4-2, 3, 4, 5, 6:2007
Approvals	CE (A copy of the EC Declaration of Conformity is available on Redflow's website and is attached in Appendix B.) RCM

* At beginning of life

** For altitudes between 1000m and 2000m upper temperature limit is 45.5°C (113.9 °F)

For altitudes between 2000m and 3000m upper temperature limit is 42°C (107.6 °F)

Contact Redflow to adjust the ZBM temperature limit to the correct setting if above 1000m

It should be noted that any voltage exceeding the absolute maximum voltage specified in Table 1 will damage the electronics in the MMS if connected to the ZBM2. Devices connected to the battery that produce voltages outside the allowable range and damage the ZBM will void battery warranty e.g. voltage spikes. For connected component compatibility contact Redflow.

The physical and communications characteristics of the ZBM2 can be found in Table 2.

Table 2: ZBM2 Physical and Communications Characteristics

Dimensions (ZBM2)	840 L x 825 H x 400 W (mm) 33.1 L x 32.5 H x 15.7 W (in)
Mass (ZBM2)	240 kg (529.1 lb) ZBM2 with electrolyte 90 kg (198.4 lb) ZBM2 without electrolyte
Dimensions (crated)	1080 L x 1040 H x 660 W (mm) 42.6 L x 41.0 H x 26.0 W (in)
Mass (crated)	320 kg (705.4 lb) Redflow crated ZBM2 with electrolyte 170 kg (374.8 lb) Redflow crated ZBM2 without electrolyte
Orientation	The ZBM2 must be kept in an upright position (orientation shown in Figure 9) at all times of operation, storage, handling and transportation. This is a warranty condition.
Electrolyte Volume	100 L (26 US Gal)
Module Geometry	Two parallel stacks of 30 cells
Dangerous Goods Class	DG Class 8 for electrolyte or ZBM2s containing any trace of electrolyte
Weather Protection	The ZBM2 must be installed indoors (out of weather) or in a weather-proof enclosure. This is a warranty condition.
Installation Requirements	ZBM2s must be installed for stationery applications only on flat, level and fully-supported base surfaces. This is a warranty condition.
Transportation Requirements	ZBM2 must be transported in an original supplied Redflow crate/enclosure. This is a warranty condition.
Ventilation	During operation the ZBM2 must be adequately ventilated with minimum airflow of 50l/s (180 m^3/h) per ZBM2 not opposing the direction of ZBM2 cooling fan airflow. This is a warranty condition. During storage the storage area must be dry and appropriately ventilated. This is a warranty condition.
Humidity Conditions	5%-95% humidity, non-condensing. This is a warranty condition.
Explosive Environments	The ZBM2 is not intended for use in explosive environments. This is a warranty condition.
ZBM2 Bus Terminal Connection	Positive: 8mm (approx. 5/16 inch) eyelet Negative: 8mm (approx. 5/16 inch) eyelet
ZBM2 Bus Terminal Torque	10 Nm (7.4 ft-lb) (applies to nuts fitted to MMS studs)
Communications	RS-485 MODBUS RTU

2. ZBM2 Safety

STOP

All low voltage (LV) wiring must be performed by licensed electrical personnel who are responsible for ensuring that all local and government regulations and applicable standards are complied with. This is a warranty condition and failure to comply will void the warranty.

The following safety rules apply for any operation of the ZBM2 batteries.

- Use tools with suitably rate insulated handles to make connections.
- No smoking near ZBM2s.
- Check that cable connections between the ZBM2 and the rest of the Energy Storage System are tightened to the recommended torque value in Table 2 (10Nm), and torqued nuts and MMS are marked.
- Check DC cabling polarity to the ZBM2 is correct prior to powering the system up. Defects caused by reversed polarity void the warranty.
- Even when disconnected, a ZBM2 battery can remain charged and have voltage on the battery terminals.

There are also four main areas of safety specifically relevant to the ZBM2 battery.

- Electrolyte characteristics
- ZBM2 battery voltage
- ZBM2 fire safety characteristics
- ZBM2 safety labelling

These are explained in detail in the sections below.

2.1. Electrolyte Characteristics

STOP

Ensure local government regulations and applicable standards are complied with when working with ZBM2 electrolyte.

The ZBM2 is a flowing electrolyte battery containing approximately 100 litres (26 gal) of water-based zinc-bromide electrolyte.

The ZBM2 electrolyte is an aqueous (water-based) solution of zinc-bromide salt including additional supporting salts and complexing agents.

The electrochemical process of charging a ZBM2 battery alters the electrolyte. Zinc ions are plated out as metallic zinc, and bromide ions become linked with the complexing agents in the electrolyte to form a separate dense Bromine Complex phase.

Electrolyte is yellow to orange in colour, while the Bromine Complex phase is dark red (see Figure 1). This complex phase has a higher density and readily separates (sinks) from the aqueous electrolyte phase and can be described as “oil-like”.

Figure 1: Electrolyte phase and bromine complex phase

Personnel responsible for handling the ZBM2’s electrolyte, including when cleaning up an electrolyte spill, must be aware of the content of the Safety Datasheet (SDS) provided in Appendix F of this manual and published on the Redflow website, and the following safety information.

2.1.1. Bromide and Bromine Complex

ZBM2 electrolyte contains Bromine ions, which are complexed with a quaternary ammonium salt (N-ethyl-N-methylpyrrolidiniumbromide, or MEP) to form the separate dense bromine complex phase, as the battery is charged.

MEP maintains the concentration of elemental Bromine in the aqueous electrolyte at very low levels, of approximately 0.04 mol/L. MEP also reduces the vapour pressure of Bromine above the liquid to levels well below that of pure bromine.

Figure 2 shows the significantly lower vapour pressures of bromine complex (with 1500g/l of Bromine) and charged aqueous electrolyte (with 15g/l of Bromine), compared to pure Bromine.

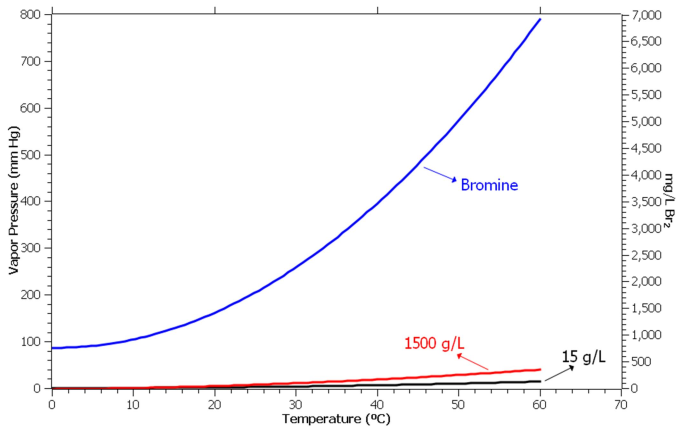

Figure 2: Vapour pressures for charged bromine complex, battery electrolyte and pure bromine

Studies of both small and large leaks of Bromine complex have shown that the concentration of Bromine evaporation in the air is well below the safe long-term working level of 0.1 ppm (as specified by the Occupational Safety and Health Administration and National Institute of Occupational Safety and Health in the United States). In this complexed form, Bromine is:

- Easy to detect early via its chlorine-like smell
- Easy to neutralize (e.g. with sodium bicarbonate or ammonia)
- Poses no fire risk (Bromine is used in many fire retardants)

Despite the fact that there is a very low risk of being exposed to unsafe Bromine gas levels, all personnel involved in opening a ZBM2 to fill it with electrolyte, clean up an electrolyte spill, or empty electrolyte from a ZBM2, must wear the appropriate Personal Protective Equipment (PPE) (refer to Section 2.1.4).

Bromine has a chlorine-like smell and if this is detected the user should investigate whether there are any electrolyte leaks. If you have any questions contact Redflow.

2.1.2. Gas Emissions

Low levels of gas may be emitted during operation of the ZBM2 via the ZBM2's low pressure relief valve. This gas enters the ZBM2's Catch Can, which traps gases using activated carbon, reducing the concentration of any emissions that exit the ZBM2. Regardless, energy storage systems containing ZBM2s must be located in areas designed to ensure adequate ventilation. Refer to Section 9.2.3 for more information about ventilation requirements. Standards such as AS4086.2 (Section 2.7) also provide guidelines about battery room ventilation. Failure to provide adequate ventilation during both operation and storage will void the warranty.

2.1.3. Electrolyte Leaks

The presence of liquid electrolyte in the ZBM2 means that there is potential for a spill to occur. Any electrolyte leak or spill must be cleaned up in accordance with Appendix C.

Spills and leaks of ZBM2 electrolyte must be cleaned up as soon as possible by trained personnel. Until trained personnel are present, the area around the spill or leak should be quarantined.

It should be noted that the ZBM2's own electrolyte tanks are able to store a small amount of electrolyte in the case of a minor leak. However, to prevent electrolyte spillage during major leaks, readily available polyethylene-lined containers or bunding should also be used to contain any spilled electrolyte. This is the same material that the electrolyte tanks are made of.

2.1.4. Personal Protective Equipment (PPE)

The following, or equivalent, PPE must be worn when handling electrolyte or cleaning up an electrolyte leak.

Respirator: Moldex half-face pre-assembled respirator with multi-gas/vapour cartridges (available from Protector Alsafe (www.protectoralsafe.com.au), product code 8602A, part number 0109 0268)

Goggles: Bollé Blast Duo goggles (available from Protector Alsafe, product code 1669211, part number 0708 2904)

Gloves: Prosafe Premium 806 Blue PVC Gauntlets (available from Protector Alsafe, part number 0784 1563)

Spill kits should be kept on hand at all times, e.g. 62 litre Hazchem spill kits can be sourced from Global Spill Control at: http://www.globalspill.com.au/?gclid=CMTvvobp-64CFYJLpgodSBzjwQ.

It should be noted that there is approximately 100L of electrolyte in each ZBM2, and while any leak would be unlikely to result in more than a few millilitres of electrolyte escaping, there is potential for a leak of up to 100L to occur.

Redflow's contracted global emergency contact can also provide additional details on how to clean up an electrolyte leak. Contact details are provided in the SDS in Appendix F.

2.2. ZBM2 Battery Voltage Hazard

A single ZBM2 can have between 0V and 58V DC on the battery terminals during operation. The voltage across the battery terminals will be 0V when it is fully discharged and it is not connected to any other power source. See Figure 11 to identify the battery terminals. While the ZBM2 should be fully discharged (terminal voltage at 0V) during transportation or storage, care must be taken in case the terminals are live.

In addition, there are internal voltages in the ZBM2 of 141V that can reach up to approximately 160V. As a result, all safety guards and covers (see Section 4.13) must always be kept secured on the ZBM2 unless it has been de-energised and these guards need to be removed for maintenance purposes by Redflow trained technicians.

2.3. ZBM2 Fire Safety Characteristics

The ZBM2 is an inherently low fire risk battery as its electrolyte is non-flammable and has many characteristics of a fire retardant (see Section 5 in the SDS in Appendix F).

As a failsafe measure, the ZBM2 firmware automatically turns the electrolyte pumps off if it detects a leak. This prevents further electrolyte from being introduced into the battery's stack. This means that the battery cannot self-sustain an energy discharge. While there will be a slight increase in temperature, these measures help prevent stack overheating.

2.4. ZBM2 Safety Labels

2.4.1. ZBM2 Label

The ZBM2 label is located on top of the electrode stack and the tank at the MMS-end. Figure 3 shows the ZBM2 label and the information it conveys.

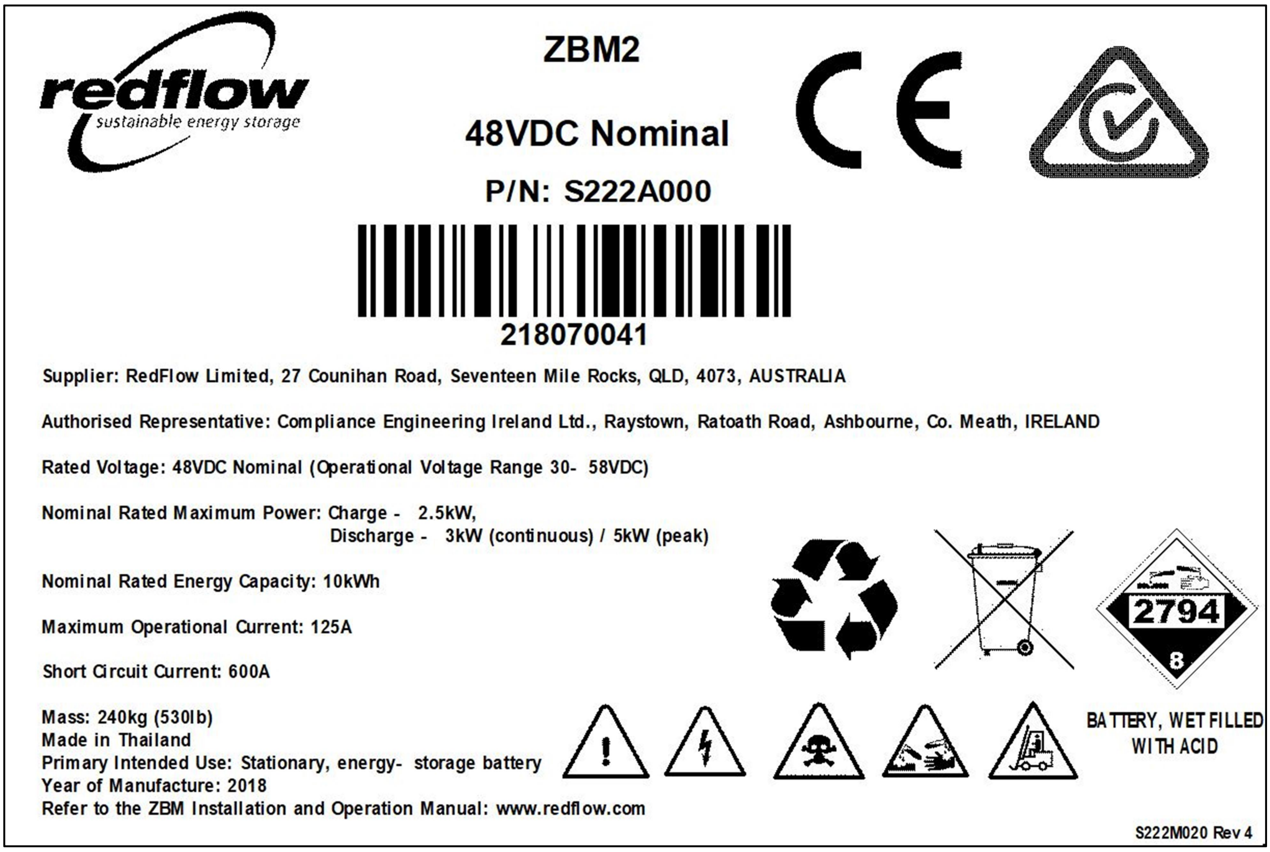

Figure 3: ZBM2 label

2.4.2. Hazard Label

The electrical hazard label shown in Figure 4 is located on:

- the top of the MMS box
- the top of the Zinc Pump Cover
- the top of the Bromine Pump Cover
- on top of the Terminal Collar

Figure 4: Hazard label

3. ZBM2 Handling

STOP

- **The ZBM2 must always be operated, handled, stored and transported in the upright position.**
- **Transportation and lifting devices must be appropriately rated.**
- **The ZBM2 must always be discharged before transportation.**
- **The ZBM2 must never be lifted or manhandled via the battery stack. Always lift and manhandle the ZBM2 from the bottom tank.**
- **Green strapping that loops around stack and tank is not to be removed.**

3.1. ZBM2 Weights & Dimensions

Dimensions (ZBM2)	840 L x 825 H x 400 W (mm) 33.1 L x 32.5 H x 15.7 W (in)
Mass (ZBM2)	240 kg (529.1 lb) ZBM2 with electrolyte 90 kg (198.4 lb) ZBM2 without electrolyte
Dimensions (crated)	1080 L x 1040 H x 660 W (mm) 42.6 L x 41.0 H x 26.0 W (in)
Mass (crated)	320 kg (705.4 lb) Redflow crated ZBM2 with electrolyte 170 kg (374.8 lb) Redflow crated ZBM2 without electrolyte

The ZBM2 is delivered from Redflow in a wooden crate. The crate can be moved using an appropriately rated forklift or pallet jack.

3.2. Lifting Straps

STOP

The ZBM2 is supplied with two lifting straps to enable safe handling of a ZBM2 when it is not in an enclosure. The straps are rated to handle lifting of a ZBM2 filled with electrolyte and must be used to move a ZBM2 in an upright orientation using only a suitably rated lifting device for the ZBM2's weight.

Lifting requirements:

- Lifting of the ZBM2 must not be done manually.
- Any handling of the ZBM2 must involve the use of the 2 lifting straps supplied with the ZBM2 with two personnel on hand.
- Lifting straps must not be removed from the ZBM2 when installed as they will be required for use in removal of the ZBM2.

3.3. ZBM2 Crate Removal Process

The ZBM2 is to be removed from its crate using the following procedure:

1. Confirm that the lifting devices can handle the weight of the ZBM2 and a crated ZBM2.
2. Remove the 4 bolts at the base of the box using a 15mm (9/16”) socket.

Figure 5: Crate bolt points

3. Remove the crate lid with one person lifting at each end.

Figure 6: Lifting crate lid

4. Undo the plastic bag and remove the foam.

Figure 7: Plastic bag and foam

5. Ensure the two straps are positioned around the sides of an upright ZBM2 (not front to back) approximately 1/3 and 2/3 along the ZBM2's long side. The parts of the straps that go under the ZBM2 must be located in the recessed section of the ZBM2 to prevent slippage.

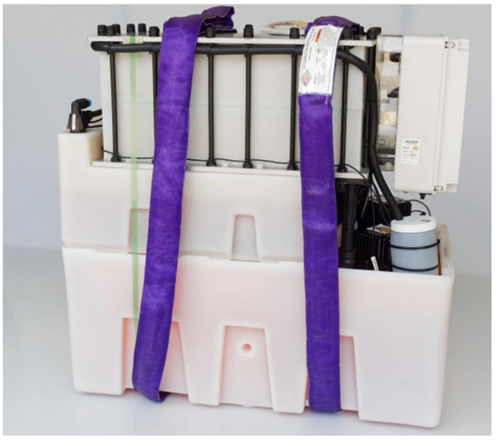

Figure 8: Lifting Strap location

6. Continue with the instructions given in Section 5 to install and connect the ZBM2.

3.4. Dry ZBM2s

The ZBM2 will in most cases be delivered filled with electrolyte (wet), but in some cases (via air freight), the ZBM2 will be delivered without electrolyte. When delivered dry, the electrolyte will be delivered in separate transport containers. This requires the ZBM2 to be filled with electrolyte prior to use. Please contact Redflow or the appropriate Systems Integrator for an additional guide for this procedure.

3.5. Transporting ZBM2s

A ZBM2 filled with electrolyte, as well as a ZBM2 that once contained electrolyte, must be handled, stored and transported as an item with a Dangerous Goods Classification of 8, see Appendix F for the Safety Datasheet.

ZBM2s that have never contained electrolyte do not require a Dangerous Goods rating or similar considerations during handling.

When transporting a ZBM2, the following is required:

- ZBM2 must be transported in an upright position on a flat, fully-supported base surface.
- If not using the original Redflow crating, construct a crate to handle the weight of the ZBM2 and securely hold down the ZBM2 with support packaging to match or better the original crating.
- Transport of ZBM2s must also conform to local and/or international regulations.

- Where possible, transport ZBM2s in an area that has secondary containment, for example, a catchment tray or bunding.
- Storage temperature conditions apply during transportation. Exposure to temperatures outside the specified storage temperature range voids the ZBM2's warranty.

Failure to comply with transportation requirements will void the warranty.

3.6. Storing ZBM2s

ZBM2s can generally be stored for up to 12 months in their wet state, but must always be fully discharged. Wet ZBM2s are classified as Dangerous Goods Class 8.

In all cases, ZBM2s must be stored on a flat, stable and fully-supported base surface in an upright position. The storage area must be dry and ventilated; closed cycle air-conditioned spaces are not suitable. ZBM2s must be stored in areas that do not receive direct sunlight, as ultraviolet rays can breakdown ZBM2 components.

The ambient temperature should adhere to the storage temperature range specified in Table 1. Storage for longer than 12 months or in conditions that do not conform to the above will void the ZBM2 warranty.

It is recommended that secondary containment, such as a catchment tray or bunding (not provided with the ZBM2) is used to reduce the spread of electrolyte in the event of an accidental leak or spill during storage and transportation.

4. ZBM2 Components

See Figure 9, Figure 10 and Figure 11 for the components of the ZBM2.

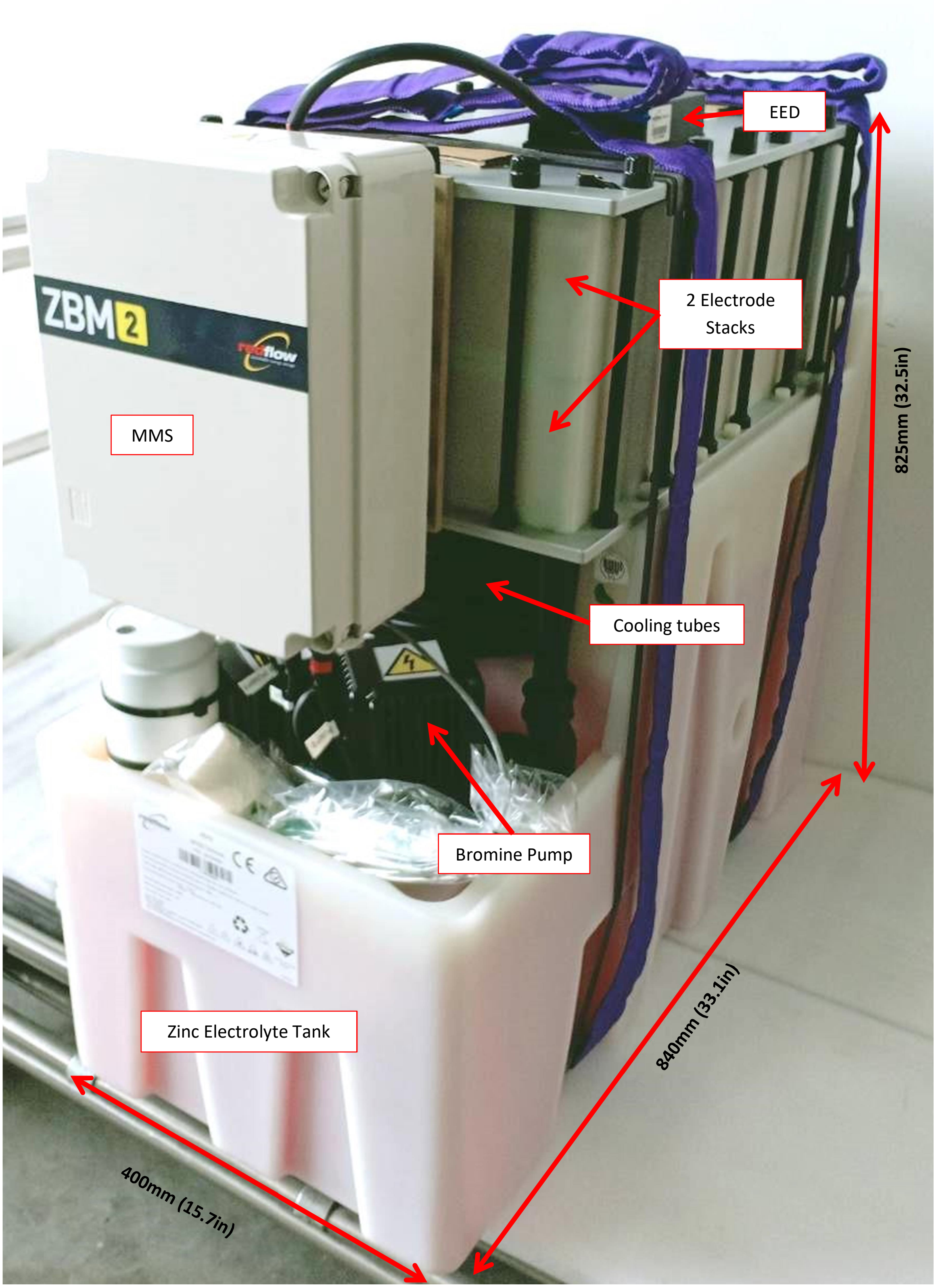

Figure 9: ZBM2 components (front and side view)

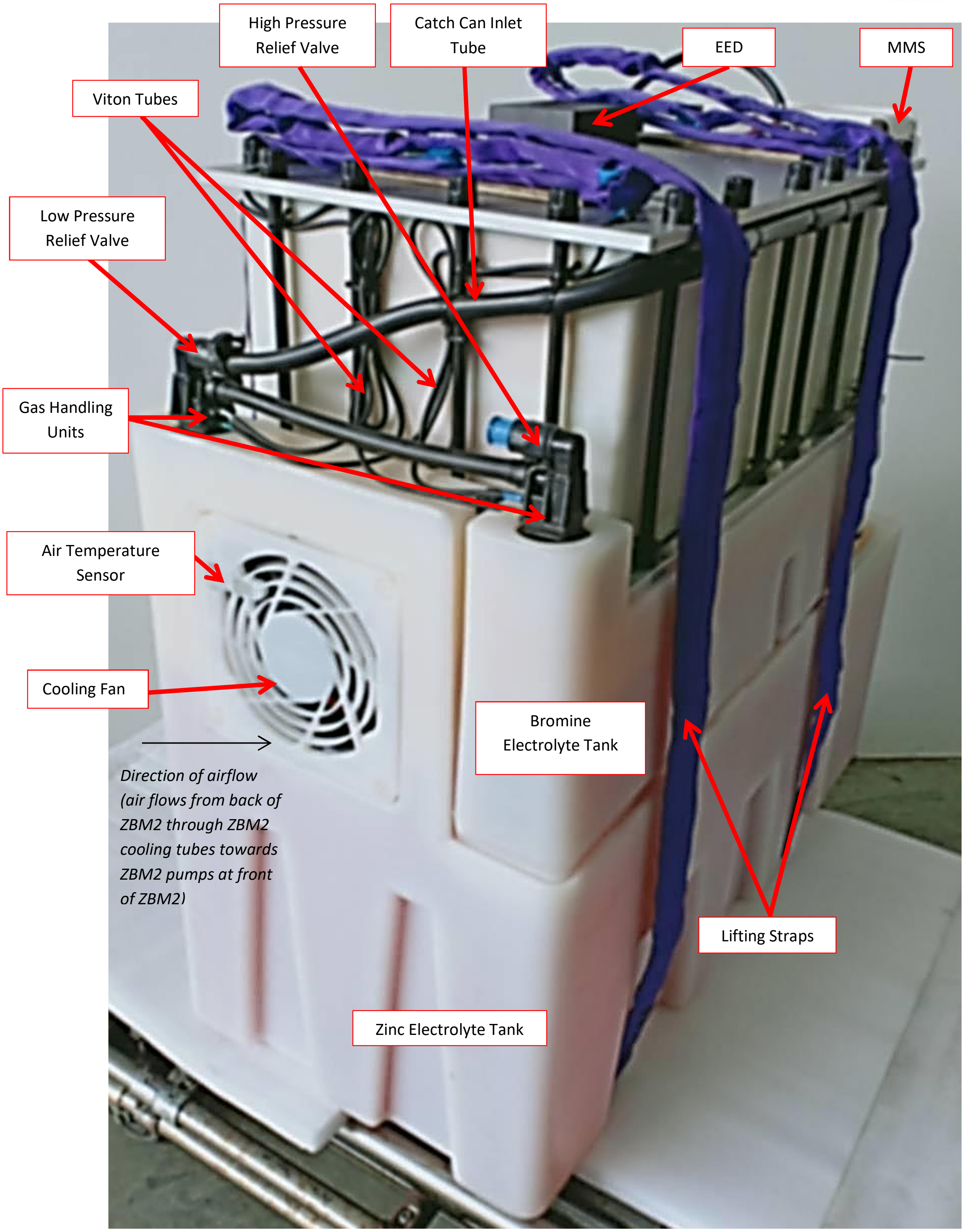

Figure 10: ZBM2 components (back and side view)

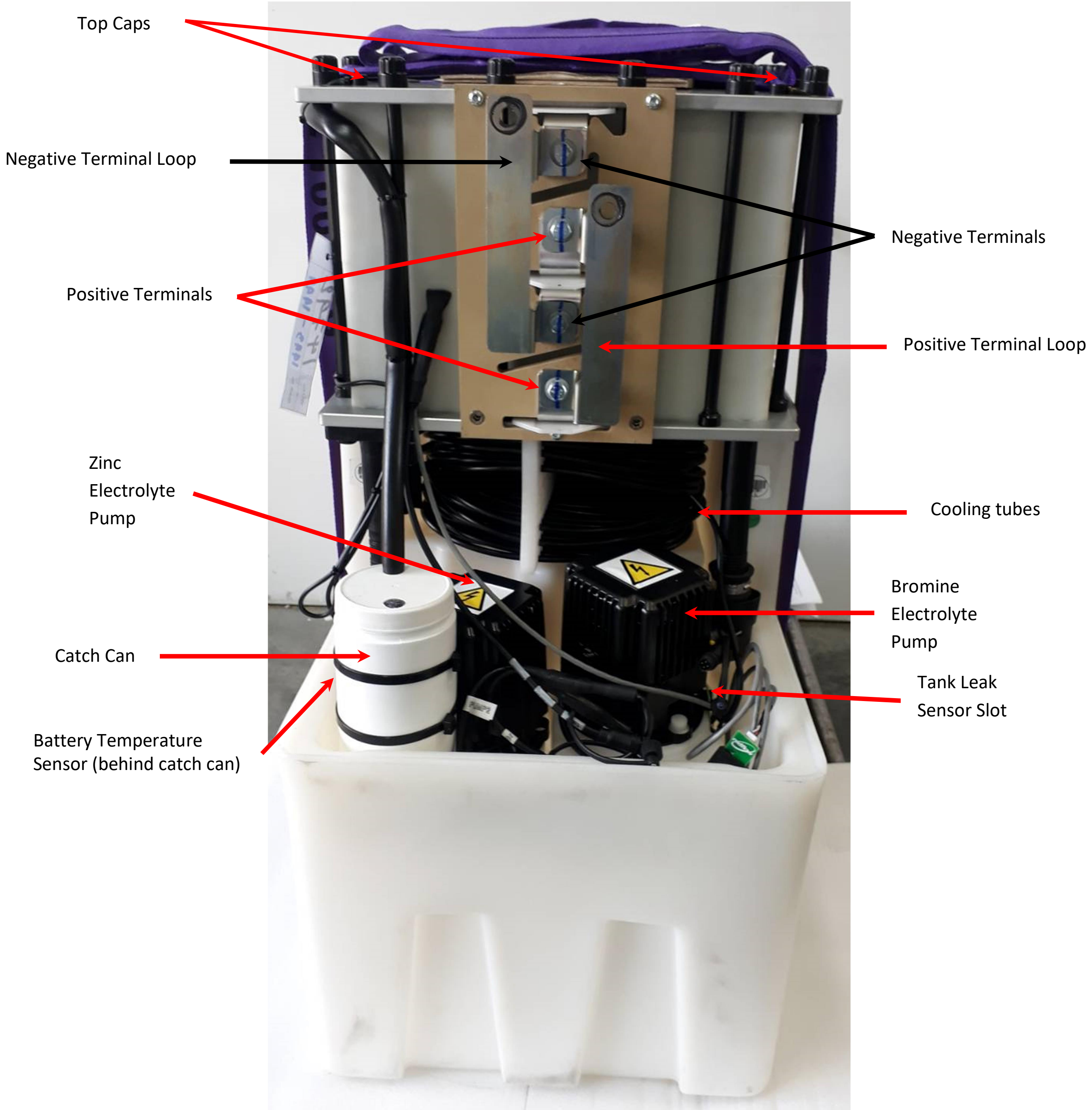

Figure 11: ZBM2 terminal plates and pumps (front side view)

4.1. Electrode Stack

The ZBM2 has 2 electrode stacks connected in parallel, with each stack made up of 30 cells in series. The top terminal on each stack is the negative terminal and the bottom is the positive terminal. The socket head cap screws that hold the terminal loops to the stack electrical connections are torqued to 12Nm (8.9 ft-lb) and are marked to indicate the position of the screw relative to the terminal loop for correct torque. No electrical connections are to be added to the socket head cap screw connections, see Figure 11.

4.2. Electrolyte Tanks

The ZBM2 has 2 tanks; the inner tank is referred to as the Bromine tank and the outer tank is referred to as the Zinc tank. The tank name relates to which half of the electrode the electrolyte is pumped into i.e. the Zinc tank electrolyte is pumped into the negative electrode side of each cell and the Bromine tank electrolyte is pumped into the positive electrode side of each cell. The stored electrolyte enables electrolyte to be pumped into the stack to continue the chemical reactions required during charging and discharging. The amount of electrolyte is sized to allow the delivery of 10kWh of energy when fully charged.

4.3. Pumps

The ZBM2 has 2 pumps (one in each tank) and are used to pump the electrolyte into the stack. The Bromine pump pumps electrolyte from the Bromine tank into the positive electrode side of each cell. The Zinc pump pumps electrolyte from the Zinc tank into the negative electrode side of each cell. The pumps are powered from the MMS via cables connected to the base of the MMS. The cables and MMS are labelled to enable correct connection. The pumps' speed and operation are controlled by the MMS. The pumps are shown in Figure 12.

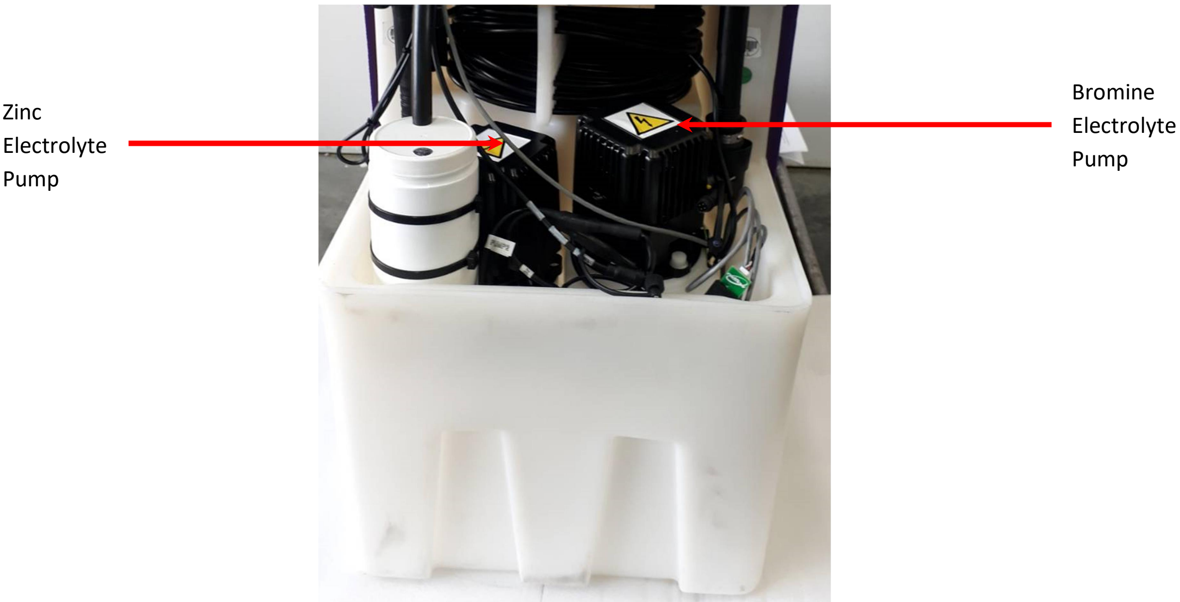

Figure 12: ZBM2 pumps

4.4. Catch Can

The catch can is connected to the low pressure relief valve via a catch can tube. Any gas released from the low pressure relief valve will flow into the Catch Can, which traps gases using activated carbon, reducing the concentration of any emissions that exit the ZBM2. See Figure 13.

Figure 13: Catch can

4.5. Cooling Tubes

The cooling tubes are used to cool the ZBM2 by pumping electrolyte through the tubes while the fan is blowing cooler air over them.

4.6. Fan

The fan blows air over the cooling tubes to lower the ZBM2 temperature. The operation of the fan is controlled by the MMS which turns on and controls fan speed based on the battery and air temperature measured by the Battery and Air Temperature Sensors.

4.7. Gas Handling Units

The ZBM2 has 2 gas handling units (see Figure 14) that relieve pressure inside the tanks in the event of an operational issue. The Zinc tank gas handling unit houses the low pressure relief valve, any gas released from this valve is diverted to the catch can via the catch can tube (see Section 4.4). The Bromine tank gas handling unit houses the high pressure relief valve, which provides redundancy in the event of an issue with the low pressure relief valve.

Figure 14: Gas handling units

4.8. Lifting Straps

The ZBM2's lifting straps are provided with the ZBM to enable movement of the ZBM with appropriate lifting devices, see Section 3.2 for more detail. They should not be removed.

4.9. Sensor Analog Loom

The Analog Loom has 4 sensors: Tank Leak Sensor, Floor Leak Sensor, Air Temperature Sensor and Battery Temperature Sensor (see Figure 15). The Analog Loom 12-pin UT Connector connects to the Loom terminal on the base of MMS.

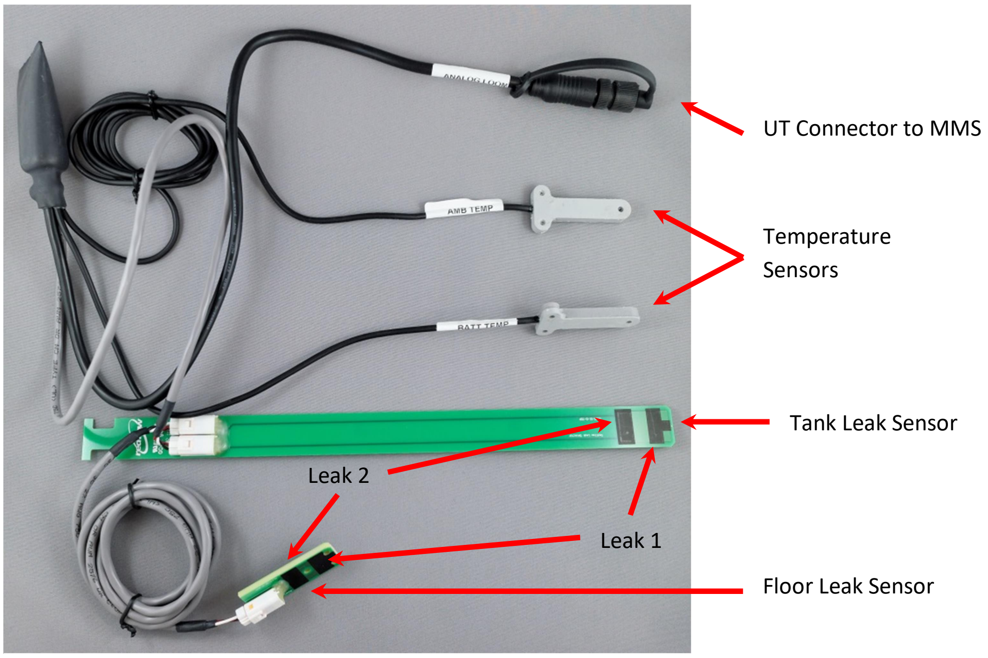

Figure 15: Sensor analog loom

All 4 sensors provide information to the MMS which are used to make decisions on the operation of the ZBM2. The status of each sensor can be accessed using the BMS online interface (see Section 8.1). The locations of the sensors of the Sensor Analog Loom are described in Section 5.

4.9.1. Tank Leak Sensor

The tank leak sensor is used to determine if an electrolyte leak has occurred from the ZBM2 and has flowed internally between the ZBM2 tanks. The location of the tank leak sensor is shown in Figure 11. The following should be noted about the tank leak sensor:

- The leak sensor utilises two level sensors: Leak 1 and Leak 2 (shown in Figure 15). Leak 1 signifies a lower level of electrolyte, and therefore a less significant leak than Leak 2. Leak 1 and Leak 2 are each electrically connected in parallel to the Leak 1 and Leak 2 readings of the floor leak sensor. Therefore, if a Leak 1 is detected, both the tank and floor leak sensors should be checked to determine where Leak 1 has been sensed.
- The MMS reads the status of each sensor and if a leak has occurred, operation of the ZBM2 will be shut down.

4.9.2. Floor Leak Sensor

The floor leak sensor is used to determine if an electrolyte leak has occurred from the ZBM2 and has flowed externally from the ZBM2. It should be installed under the ZBM2 tank during initial setup of the ZBM2.

- The leak sensor utilises two level sensors: Leak 1 and Leak 2 (shown in Figure 15). Leak 1 and Leak 2 are each electrically connected in parallel to the Leak 1 and Leak 2 readings of the tank leak sensor. Therefore, if a Leak 1 is detected, both the tank and floor leak sensors should be checked to determine where Leak 1 has been sensed.
- The MMS reads the status of each sensor and if a leak has occurred, operation of the ZBM2 will be shut down.
- To prevent false leak trips, the floor leak sensor should not be mounted on any conductive surface. To assist with this, the floor leak sensor is supplied with a cover.
- It should be noted that if the floor leak sensor is mounted horizontally, Leak 2 will trip at approximately the same time as Leak 1.

4.10. Power Cables

The ZBM2 includes three Power Cables with waterproof connectors that provide DC power to the ZBM2's pumps and cooling fan from the MMS. These connections are internal to the ZBM2. The three power cables are:

- Cooling Fan (4-pin connector)
- Zinc Pump (5-pin connector)
- Bromine Pump (5-pin connector)

4.11. MMS

DANGER

The MMS has a pump power supply that outputs 141VDC. The two pump connectors on the bottom of the MMS have 141VDC on them.

The ZBM2 is a "smart" battery that comes with in-built intelligence to protect the ZBM2 battery and allows the user to gain more information about operation and any issues that arise. Communication with the MMS is most effectively done using the BMS (see Section 4.12).

The MMS is mounted on to the ZBM2 battery's terminals and is also where connections are made to the ZBM2 from any external system or communications device. The required connections are shown below in Figure 16 and Figure 17.

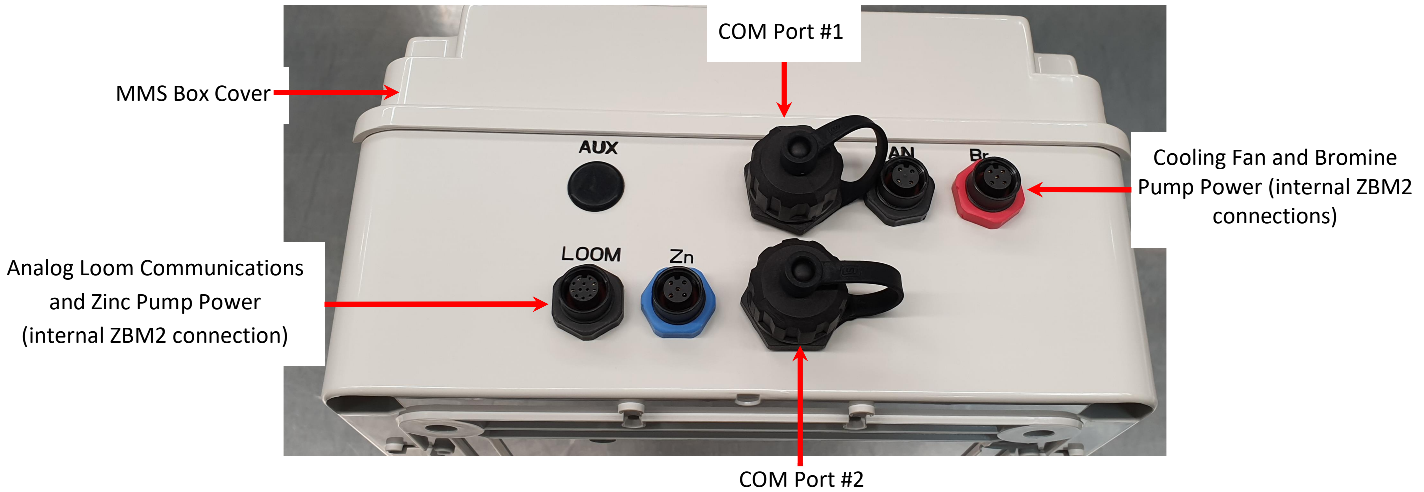

Figure 16: MMS connections

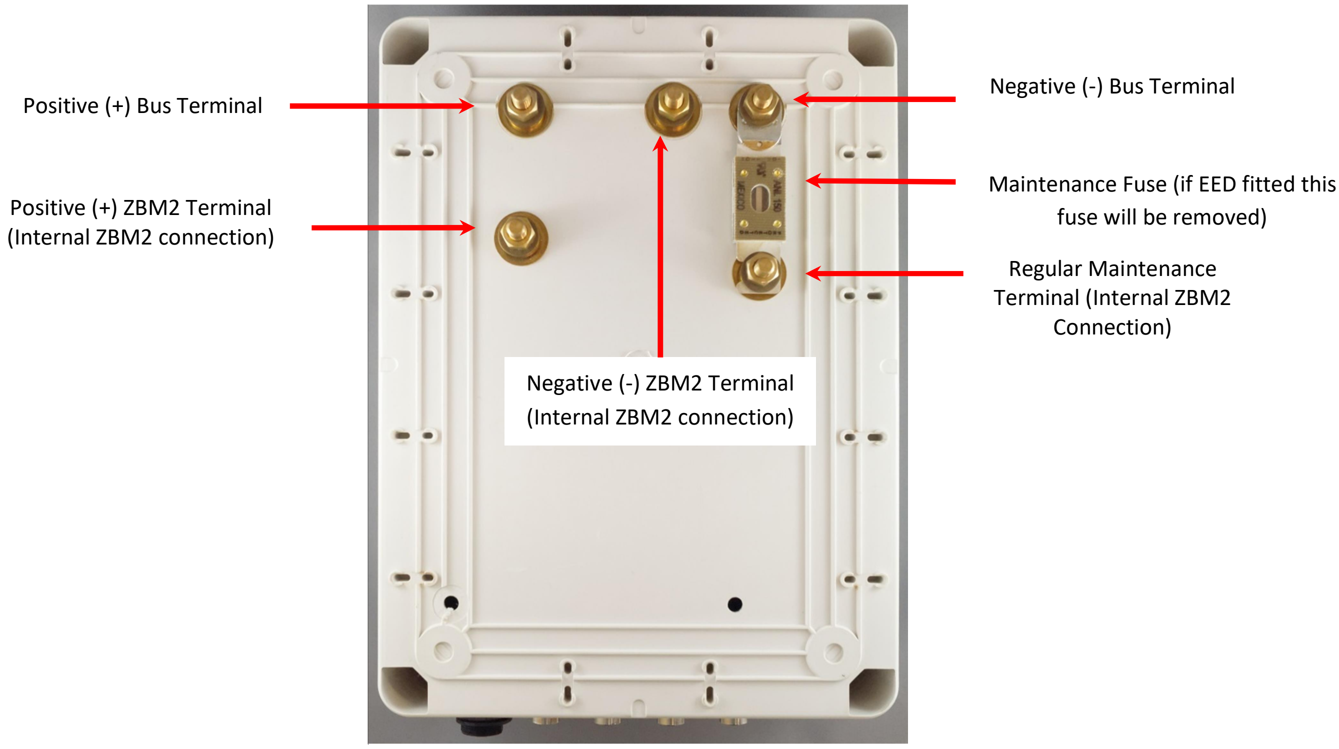

Figure 17: MMS terminal connections

4.12. BMS

Redflow offers an additional accessory for use with the ZBM2 called the Battery Management System (BMS) (see Figure 18). When powered and provided with an internet connection, a single BMS allows the user to monitor, log and control operation of up to 12 ZBM2s via an online interface. A minimum of 1 BMS is required for every site installation.

Figure 18: Redflow BMS

See Section 5 for connection information, and Sections 6.4, 6.5 and 8.1 for operational information.

4.13. Energy Extraction Device (EED)

The EED is designed for the purpose of optimising the process of discharging the ZBM2 undergoing a maintenance cycle, see section 9.4.7 for an explanation of the maintenance cycle and stripping. The EED allows ZBM batteries to discharge into the DC bus (either to loads, into other ZBM batteries, or via an inverter to the grid). Connection between the EED and the ZBM is controlled by the MMS internal contactors.

Table 3: Technical specifications of the EED

Input voltage range	5-55Vdc
Output voltage range	55-62Vdc
Default output voltage	57V
Maximum input current	20Adc

Figure 19: Energy Extraction Device

When the EED is turned on, the ZBM2 stack discharges all the way down to 5V. When the ZBM2's voltage falls below 5V, the EED enters a semi-shorting mode, where the EED internally uses the remaining energy within the ZBM by switching on its semi-shorting circuit.

The ZBM2s are supplied with an EED fitted to the Stack plate. If there is not room in the enclosure to mount the EED it can be installed external to the ZBM. Install double sided temperature conductive tape to the base of the EED and mount it on a metal part. The metal part acts as a heatsink to prevent the EED from overheating. If you have any questions on the heatsink size contact Redflow.

Figure 20 EED not fitted to ZBM

4.14. Safety Guards and Covers

Interference with any of the following by anyone other than a Redflow trained installer will void the warranty. For avoidance of doubt contact Redflow first.

STOP

All low voltage (LV) work must be performed by licensed electrical personnel who are responsible for ensuring that all local and government regulations and applicable standards are complied with. This is a warranty condition.

The ZBM2 includes the following guards and covers to protect any personnel in the vicinity of the ZBM2.

4.14.1. Terminal Collar

The terminal collar may only be removed by a ZBM2 trained installer.

The IP2X-rated terminal collar prevents direct contact or accidental contact by other objects (e.g. tools) with the ZBM2's terminals when they are live (and potentially carrying hazardous currents and voltages). The terminal collar can be removed from de-energised batteries for maintenance (see Section 8) using a flat-head screwdriver.

The terminal collar is shown in Figure 21.

Figure 21: Terminal collar

DANGER

The terminal collar must only be removed once the ZBM2 has been de-energised as described in Section 6.5. The terminal collar must always be replaced and correctly secured before re-energising the ZBM2.

4.14.2. MMS Box Cover

The MMS Box Cover protects the user from hazardous voltages inside the MMS. The cover must only be removed once the ZBM2 has been de-energised as described in Section 6.5, and must always be replaced and correctly secured before re-energising the ZBM2.

The MMS box cover is shown in Figure 9 and Figure 16.

DANGER

The MMS Box cover must never be removed if the ZBM2 is energised as it contains hazardous voltages and current. If removed, the MMS box cover must always be replaced and correctly secured before re-energising the ZBM2.

4.14.3. Pump Cover

The IP2X-rated pump cover prevents direct contact with the ZBM2's pump casings, which may become live with a hazardous voltage of 141V (with respect to electrical ground) in a fault situation. The pump cover cannot be removed without destruction.

The black plastic pump covers over the zinc and bromine pumps are shown in Figure 11.

DANGER

The pump cover must never be removed, apart from the rare case when a pump needs to be replaced. In this case, it must only be removed once the ZBM2 has been de-energised as described in Section 6.4. A new pump cover must always be used and correctly secured before re-energising the ZBM2.

4.14.4. Fan Cover

This IP2X-rated cover prevents direct contact with the ZBM2's fan blades, which can present a cutting hazard. The fan cover should never need to be removed from the fan.

The fan cover is shown in Figure 22.

Figure 22: Fan cover

DANGER

The fan cover shall only be removed when a fan needs to be replaced. In this case, the whole fan assembly must only be removed once the ZBM2 has been de-energised as described in Section 6.5. A new fan with fan cover must always be correctly secured before re-energising the ZBM2.

5. ZBM2 Installation and Connection

This section lists the steps to perform in installing and connecting a ZBM2 into an energy storage system. Installation in compliance with these instructions by suitably qualified and Redflow trained personnel is a condition for a valid warranty.

DANGER

DC cabling must conform to local standards and regulations, for a maximum battery current of 125A or lower.

Ensure all connecting systems are completely de-energised during this process – do not start power until all steps in this section have been completed.

This process must only be performed by personnel with the appropriate qualification as per local regulations and who have also received ZBM2 training. This is a warranty condition.

Prior to this process, ensure the battery is taken out of the crate following the procedure in Section 3.3.

Step 1 Check for any electrolyte leaks both visually and by the presence of a chlorine-like smell. If a leak is present, do not operate the ZBM2 and contact Redflow. Contact details are provided inside the front cover of this manual. Leaks must be cleaned up in accordance with Appendix C. Appendix F contains the SDS for the electrolyte as well as global emergency contact details.

Step 2 Check all hoses (see Figure 23) are securely fitted with hose clamps and have not disconnected or kinked during transport.

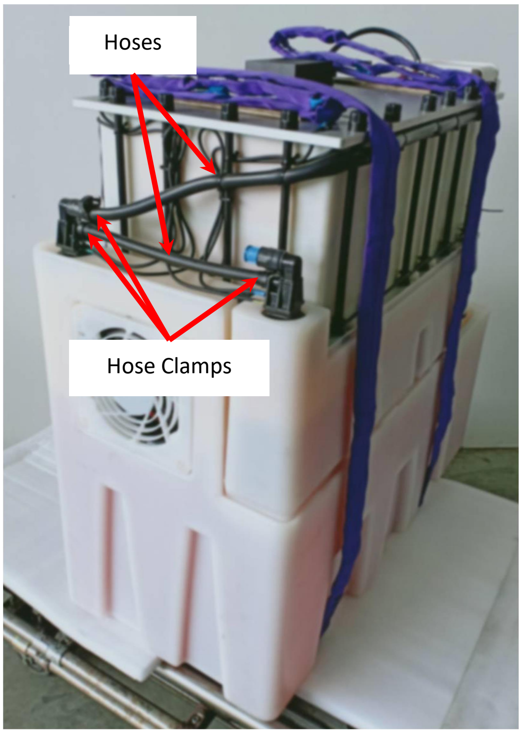

Figure 23: Hoses and hose clamps on the ZBM2

Step 3 Using a multimeter, check that the ZBM2 is fully discharged by ensuring the voltage across the positive and negative ZBM2 terminals shown in Figure 24 (not the bus terminals) is 0V when disconnected from any bus.

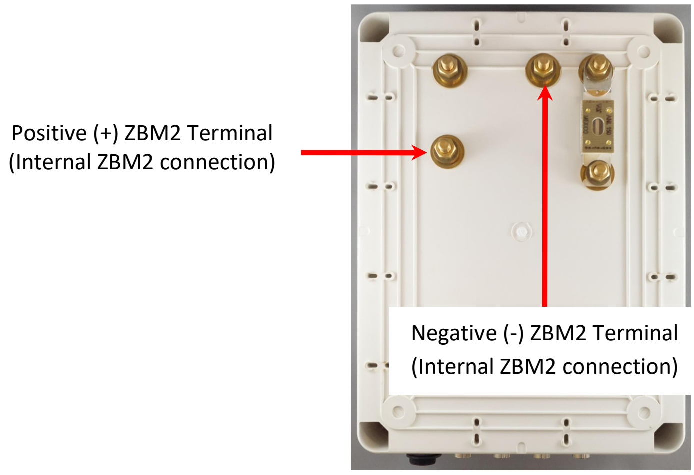

Figure 24: Positive and negative ZBM2 terminals

Step 4 Check that the torque marks on the 4 ZBM2 terminal socket head cap screws line up correctly. If the torque marks on the ZBM2 terminal connections do not line up correctly remove the MMS, torque to 12Nm (8.9 lb-ft) and re-mark (see Figure 25).

Figure 25: ZBM2 terminal connections

Correctly torqueing the battery terminal connections is critical and is a condition of warranty. If they are not sufficiently tight, then heat can be generated during high current operation leading to ZBM2 failure.

It is recommended that a thermal imaging camera be used to monitor ZBM2 performance to ensure there are no such heat spots. ZBM2 failure arising from incorrectly torqued battery terminal connections is not covered by warranty.

Step 5 Inspect to make sure that the ZBM2 Viton capillary tubes (see Figure 26) have not been damaged during transportation or installation. Also check to make sure each end of the tubes are securely connected and are not hanging free.

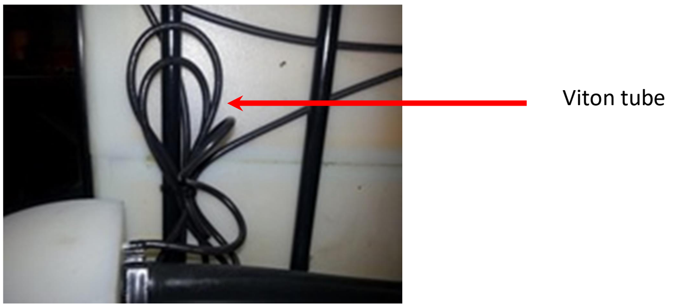

Figure 26: Viton tube

Step 6 Using a forklift, crane or other suitable lifting device (as shown in Figure 27), place the ZBM2 into the prepared location with the recommended secondary spill containment. The final location needs to have a flat, stable and fully-supported base surface for the ZBM to be installed on. Check the two lifting straps are connected correctly to the lifting device. The lifting mechanism must lift both straps at the same time securely, and in such a way as to keep the ZBM2 level with a minimum amount of swaying. Ensure care is taken to avoid excessive force and damage to the ZBM2 during movement and when placing the ZBM2 on to the prepared location.

It is recommended that Steps 1-5 be repeated once the ZBM2 is in its required location.

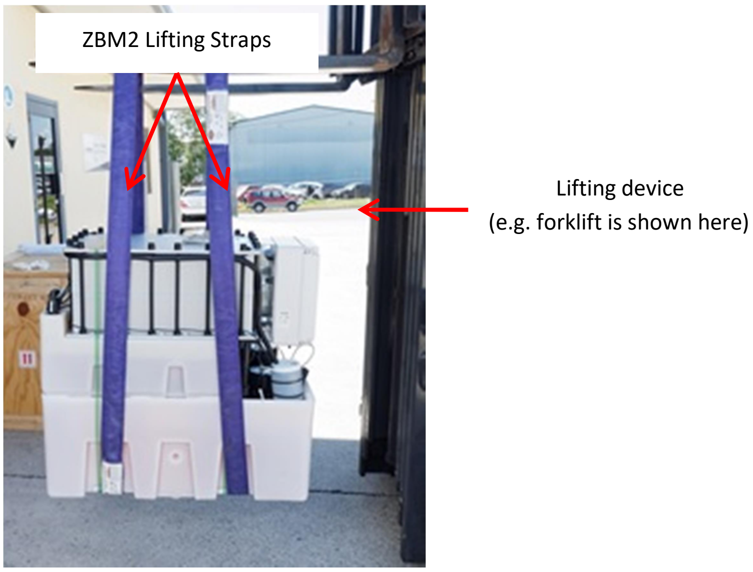

Figure 27: Lifting the ZBM2

Step 7 Ensure all elements of the sensor analog loom are located in the correct positions. The floor leak sensor should be placed in the recommended secondary spill containment at the base of the ZBM2 (and should not rest on a conductive surface). The tank leak sensor (see Figure 28) must be installed on the Bromine pump. The temperature sensors should already be installed in their correct locations (see Figure 29 and Figure

30). Ensure the analog loom is connected to its terminal on the base of the MMS (see Figure 31) via the UT connector.

Figure 28: Tank Leak Sensor location

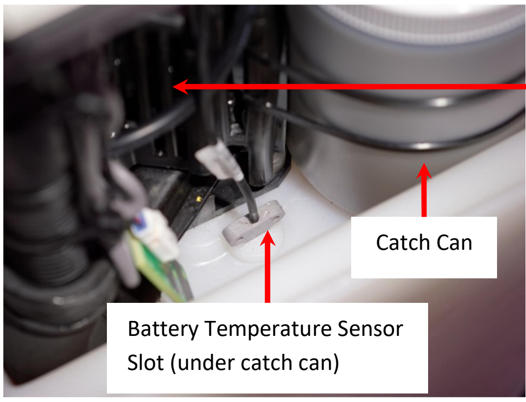

Figure 29: Battery Temperature Sensor location

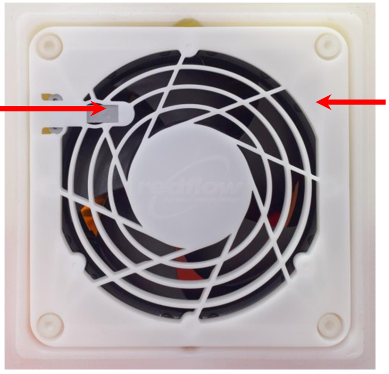

Figure 30: Air Temperature Sensor location

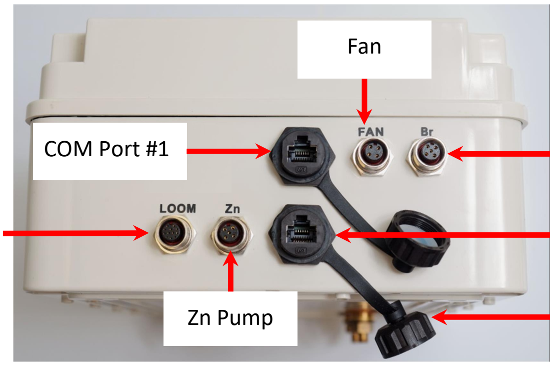

Figure 31: MMS connections

Step 8 Ensure the power cables are connected to their corresponding MMS connections (see Figure 31):

- The 5-pin connector on the cable labelled ZN PUMP to the Zn connector on the MMS.
- The 5-pin connector on the cable labelled BR PUMP to the Br connector on the MMS.
- The 4-pin connector on the cable labelled FAN to the FAN connector on the MMS.

Step 9 Connect the BMS to the ZBM2 via the Communications ports on the MMS (see Figure 31). The Communications ports enable connection of Modbus RTU over RS-485.

This is done by using a Cat6 cable and cutting the RJ45 connector off one end. Using the standard colour coding in the cable, strip the blue/white, solid blue and solid orange (568A cables) or green (568B cables) wires. Connect these wires to the B, A and SH ports respectively of the 485 section on the BMS as shown in Figure 32.

The BMS also requires a 9-65VDC power supply connected to the 9-65V + and – ports of the BMS and an open internet connection to the RJ45 port as shown in Figure 32.

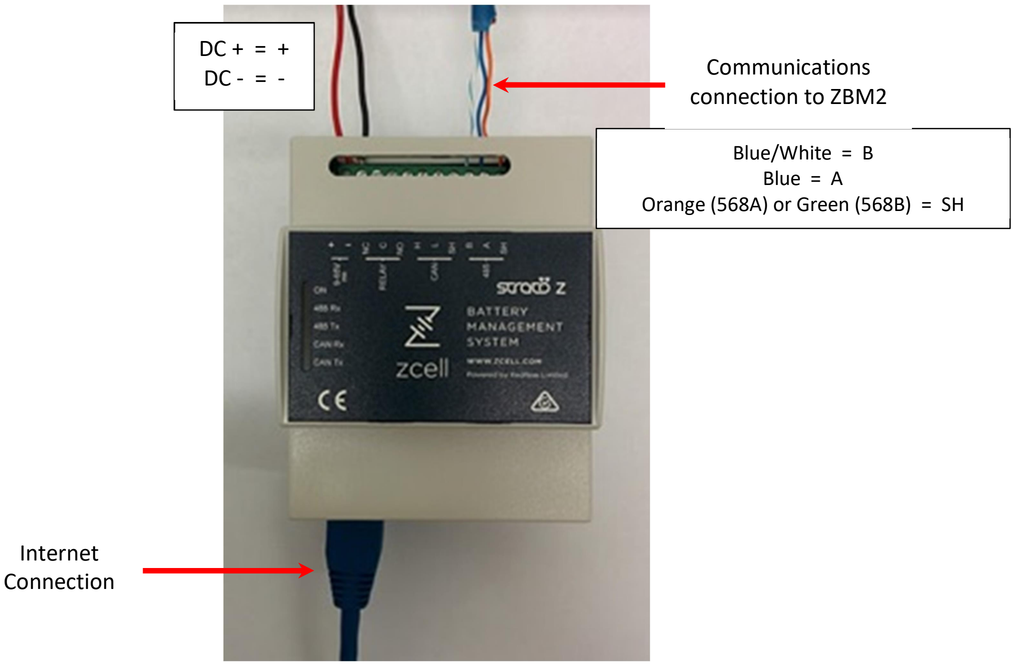

Figure 32: BMS connections

To connect to the MMS, connect the Cat6 cable from the BMS through the RJ45 boot in the following sequence shown below in Figure 33. Firstly, feed the Cat6 cable through the waterproof cap (a), followed by the rubber grommet (b) and the cable mount (c).

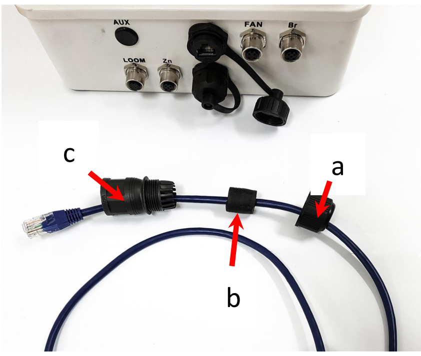

Figure 33: Cat6 cable assembly

Finally, plug the Cat6 cable into the MMS via the data plug inside the rubber boot, on the end of the cord. Tighten all parts of the RJ45 Boot to ensure the cable is secure and waterproof as shown. Cover the second Communications port on the MMS with an RJ45 cap if utilising a single MMS.

For connection of multiple ZBM2s, a daisy chain can be established by plugging the first end of the Cat6 cable into Communication Port #2 of the first MMS and the second end into the Communication Port #1 of the second MMS (see Figure 31). Cover the unused Communication Port with an RJ45 cap.

Figure 34: MMS communication cable connected

Step 10 Connect positive and negative cables to the input bus terminals on the back of the MMS (see Figure 35 and Figure 36) then to an appropriately sized circuit breaker (maximum rating 125A). The 125A DC circuit breaker is not provided with the ZBM2, and the cabling must be appropriately sized. Both the positive and negative terminal cables are terminated with 8mm eyelets at the MMS.

This is done by first removing the terminal cover, then removing the washers and nuts from the two studs of positive and negative bus terminals, as shown in Figure 36. Apply conductive carbon grease to the positive and negative bus studs.

Slide the positive (+ve) cable eyelet end over the Bus (+ve) terminal on the back of the MMS. Place the Belleville washer onto the stud, ensuring that the Belleville washer is curved towards the MMS Box so that the cone is pointing towards the electrode stack (see Figure 37). Screw the nut over the Belleville washer, and **tighten to 10Nm** using a torque wrench with a 13mm open head attachment. Repeat this process for the negative (-ve) cable eyelet end over the Bus (-ve) terminal on the MMS.

Figure 35: MMS Connections

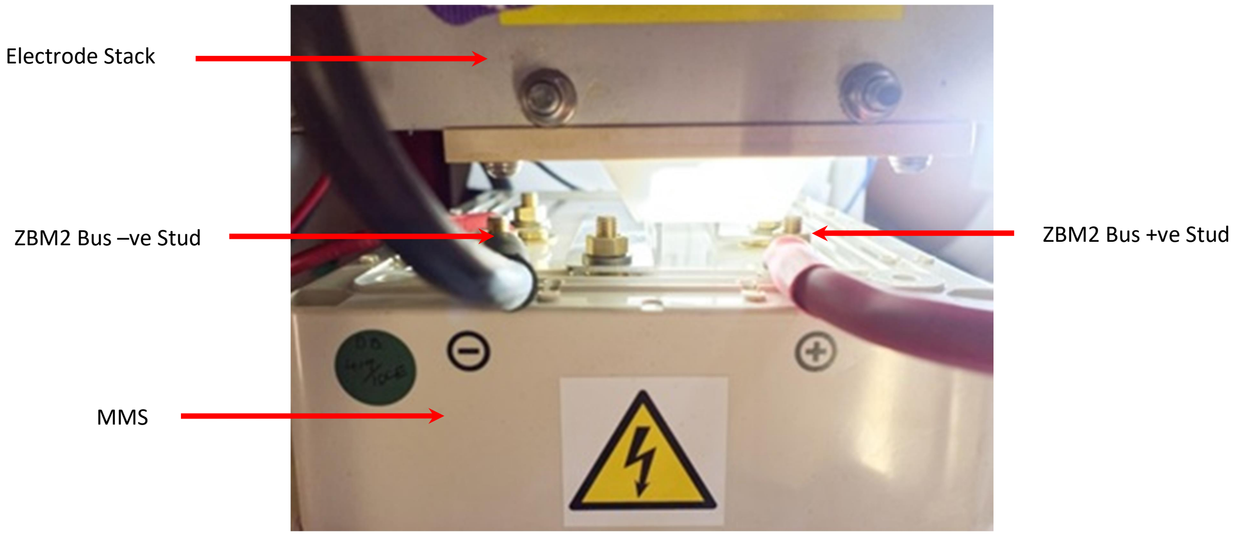

Figure 36: Bus cable connections

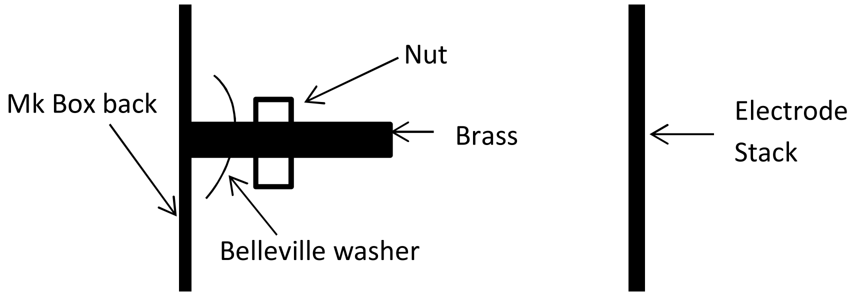

Figure 37: Belleville washer orientation (side view)

Mark the nut and MMS box on the positive and negative terminals with a permanent marker to indicate that the connection has been correctly torqued to 10Nm (7.4ft-lb) as shown in Figure 38.

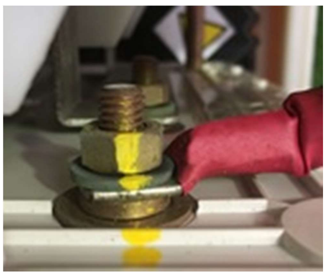

Figure 38: Torque marking

Step 11 Tidy the ZBM2's lifting straps away neatly as shown in Figure 39. They remain on the ZBM2.

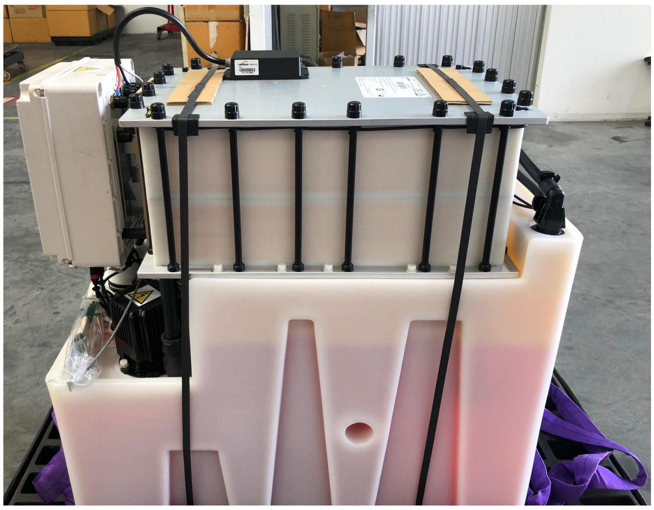

Figure 39: Lifting straps

Step 12 Ensure all safety covers and guards are secured in place (refer to Section 4.12 4.13 for a list of covers). Refit the terminal collar, using the fasteners provided with it.

Step 13 Connect the de-energised energy storage system to the ZBM2 circuit breaker and energise the system.

5.1. ZBM2 Set-Up Example: Inverter and Load

The diagram below presents an example circuit that can be used to operate a ZBM2 (see Figure 40).

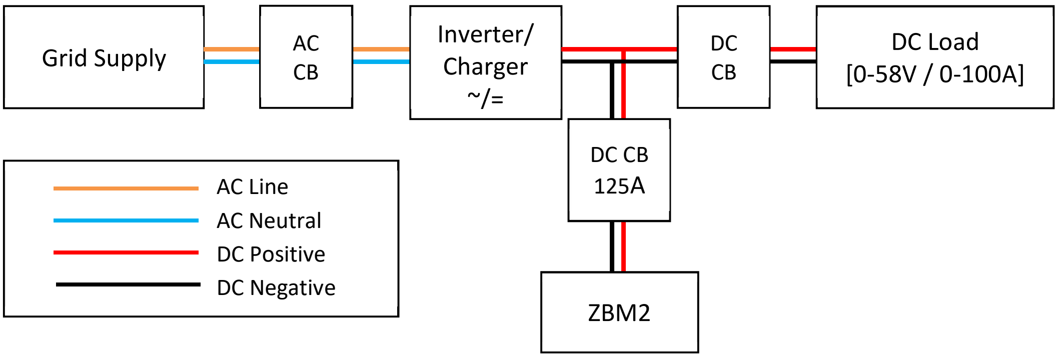

Figure 40: Example connections ZBM2

An explanation of each of the elements in Figure 40 is given below.

- **Grid supply:** provides the power needed to support the load and charge the ZBM2.
- **Circuit Breaker (CB):** circuit protection for AC/DC. These should be sized appropriately for the inverter and load.
- **Inverter/Charger:** converts the AC grid supply to DC for the ZBM2.
- **ZBM2:** charges when power is applied to terminals and discharges when a load is connected and no other adequate source of power is available. Multiple ZBM2s could be connected in parallel.
- **DC Load:** the load that the battery and inverter needs to supply.

It is also important to note the following operational guidelines:

- In order for the ZBM2 to undergo its Self-Maintenance Cycle (see Section 9.4.7 for more information), it must first be completely discharged. This will occur automatically either through an external load connected (faster and more efficient solution) or through its own pumps and fan load (when no load is available). A fully charged battery will take approximately 7 days to fully discharge using its own pumps and fan as load.
- In order for the ZBM2 to complete its Self-Maintenance Cycle (see Section 9.4.7 for more information), it must have external power from the inverter. This is to enable the ZBM2's pumps and MMS to operate even though the terminal voltage is ~0V.
- The ZBM2 can be continuously powered without damage as it will automatically disconnect the battery terminals from the bus when fully charged but will still source auxiliary power from the bus.
- Control and monitoring of the performance of the ZBM2 is done using Redflow's BMS product.

6. ZBM2 Operation

This section provides information about the operation of the ZBM2. At all times, the ZBM2 must remain intact, with all fittings and components connected as new.

6.1. Operating “From Empty”

The ZBM2’s default state of charge is fully discharged, and it can remain in this state indefinitely. ZBM2s are charged from 0% state of charge up to the desired capacity at or below 100%, and then discharged from there. Typically, constant power charge and discharge modes are used, but the variable supply from a PV array on a cloudy day is equally effective.

6.2. ZBM2 Operating Modes

The ZBM2 operates in one of two modes: Run Mode and Offline Mode.

- **Run Mode** is the standard mode in which the ZBM2 is available to be charged and discharged, and self-manages its regular maintenance cycle requirements and any operational issues. The ZBM2 will automatically disconnect from the bus in a number of operational events, such as overcurrent and overcharge.
- **Offline Mode** can be set by the user to make the ZBM2 unavailable for use (will not respond to requests until it is placed back into Run Mode) but will still be self-managed to ensure the ZBM2 is in a safe state.

6.3. Discharge Curves

The graph in Figure 41 below shows the performance of the ZBM2 at different C rates.

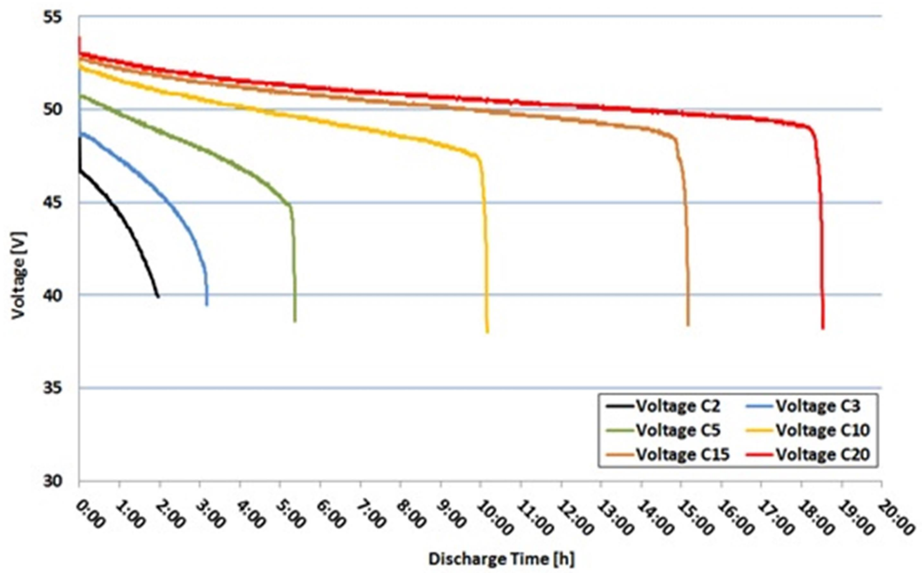

Figure 41: ZBM2 performance at different C rates

6.4. Start Up Procedure

Once all steps in Section 5 have been completed, the ZBM2 can be put into operation. This is done by using the BMS online interface, as shown in the steps below. For multiple ZBM systems connect the communication cable one ZBM at a time and repeat the following steps.

Step 1 Locate the ZBM2 connected to the BMS so that it can be controlled. This is done by selecting Battery Setup from the Configuration drop-down list in the top menu (see Figure 42) in the BMS online interface.

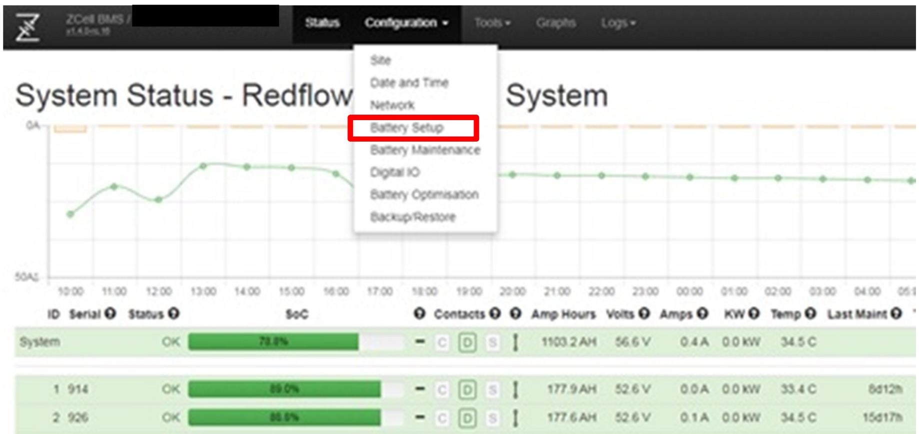

Figure 42: BMS interface showing Battery Setup selection

Select the appropriate Modbus Address for the required ZBM2 (default factory settings set the Modbus Address to 99) and click + Add Battery (see Figure 43).

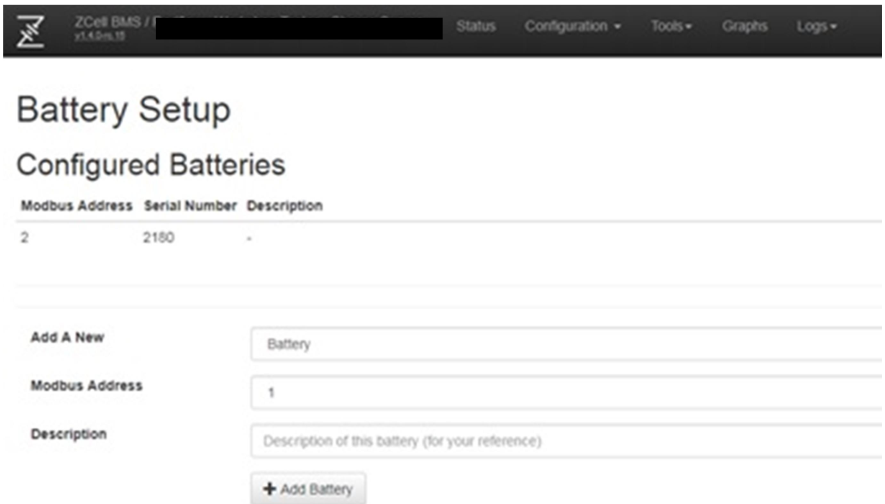

Figure 43: BMS interface showing Battery Setup screen

Step 2 Look for any ZBM2 firmware updates prior to operation. This is done by selecting Upgrade Battery from the Tools drop-down list in the top menu (see Figure 44).

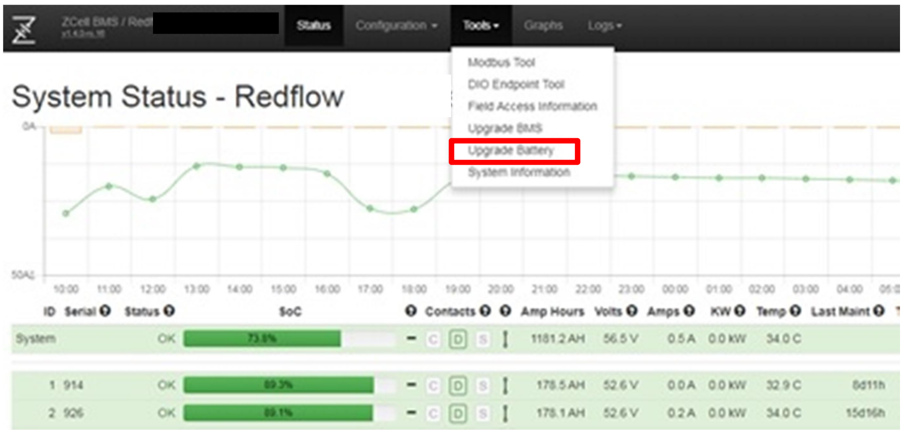

Figure 44: BMS interface showing Upgrade Battery selection

Select the ZBM2 or ZBM2s that require firmware updates by using the check boxes in the Unit # section. Select the Bundled Firmware File, and click Upgrade. This is shown in Figure 45.

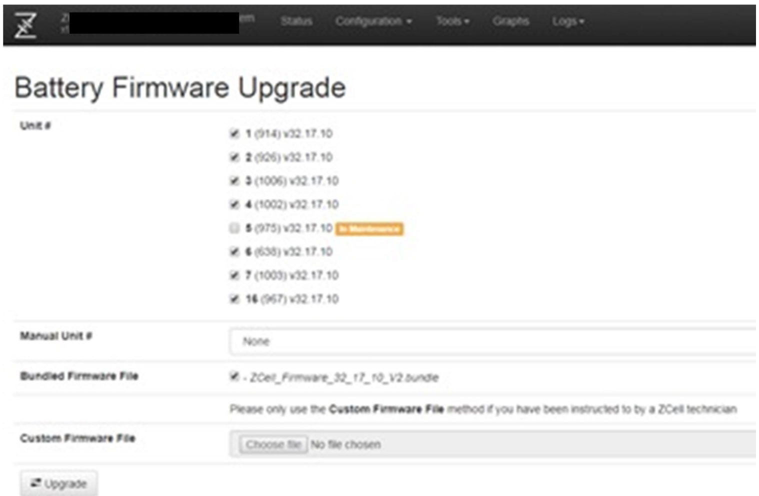

Figure 45: BMS interface showing Battery Firmware Upgrade screen

Step 3 Put the ZBM2 into Run mode by going to the system Status page (see Figure 44) and clicking the ZBM2 that should be started. On the ZBM2's Battery Status page, click the "bring battery online" link (see Figure 46). The Operational Mode will change from "offline" to "run" after the user confirms this operation.

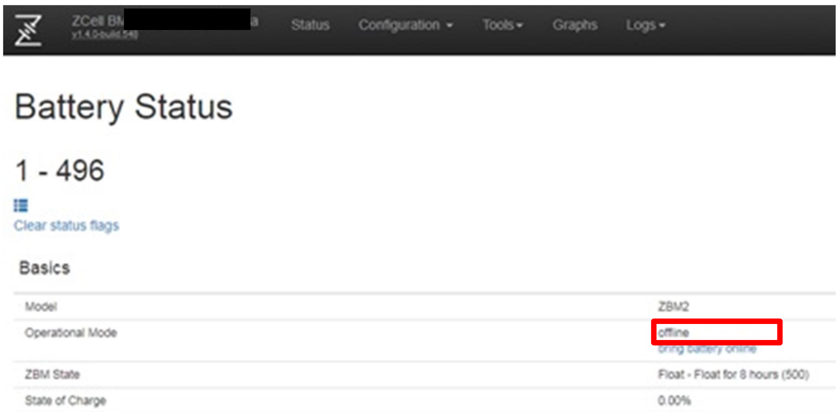

Figure 46: BMS interface showing how to bring a ZBM2 online

It is a warranty requirement that if a charged ZBM has been offline for more than one month then the ZBM will need to discharge and strip. This is done to ensure the state of charge calculation is correct. This is done by opening the MODBUS Tool page (see Figure 47) located in the Tool drop down list then entering the following:

- Select the Write tab
- In the section Unit# enter the address of the ZBM
- In the section Register Address enter 0x9034
- In the section New Value enter 1

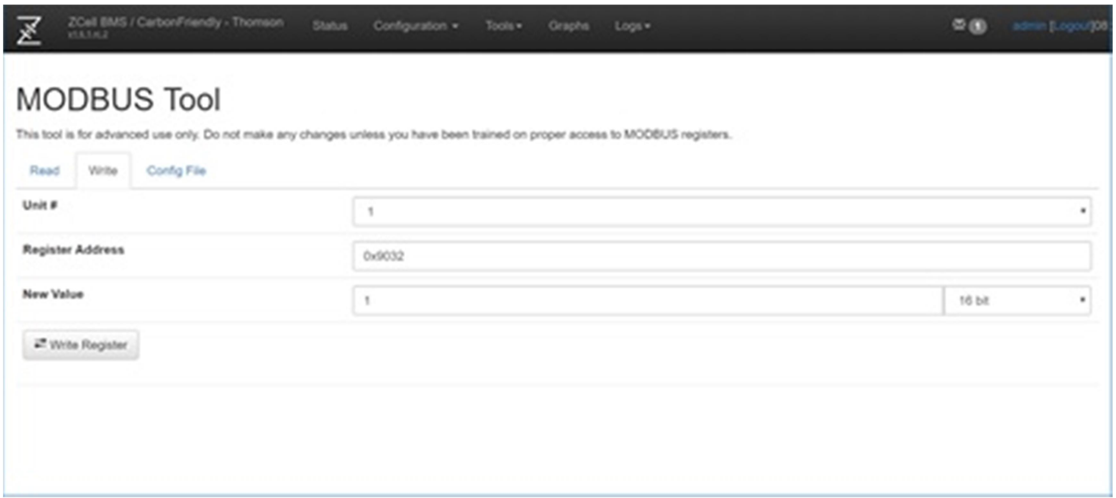

Figure 47 BMS interface showing manual command to discharge and strip

6.5. Shutdown Procedure

The complete shutdown procedure below must be used when shutting down the system for storage, shipping, de-energised maintenance or ZBM2 replacement.

Step 1 Where possible, discharge the ZBM2 and perform a self-maintenance cycle. Note that if a load is connected to the bus and the ZBM2 is fully or partially charged, the ZBM2 will discharge faster than if left to self-discharge only. During periods of self-maintenance, the ZBM2 will electrically isolate itself from the MMS (and external DC bus). As a result of there being no battery power available, it’s MMS requires external power at all times while undergoing self-maintenance.

Step 2 Using the BMS online interface, put the ZBM2 into Offline mode. This is done by going to the system Status page and clicking the ZBM2 that should be shut down. On the ZBM2’s Battery Status Page, click the “take battery offline” link (see Figure 48). The Operational Mode will change from “run” to “offline” after the user confirms this operation.

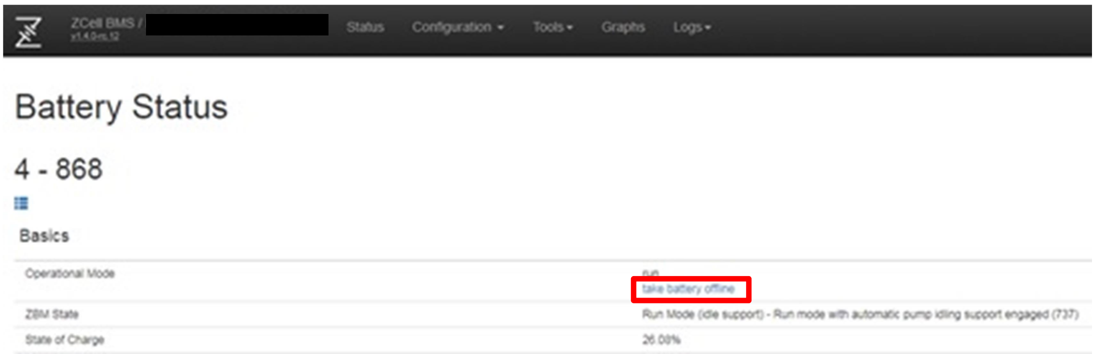

Figure 48: BMS interface showing how to take a ZBM2 offline

Step 3 Disconnect the ZBM2 from any bus, load or charger connections by switching off any connected circuit breakers.

Step 4 Using a multimeter, measure the voltage across the battery terminals to confirm that the ZBM2's terminal voltage is approximately 0V.

7. ZBM2 Wear and Failure Processes

7.1. Leaks

The ZBM2 tanks have been designed so as to include a small containment area for minor leaks. However, it should be noted that electrolyte could overflow so secondary containment should be used, and this should be taken into account in system design (see Section 9.1.2).

Redflow has implemented leak detection in its ZBM2 to prevent damage to ZBM2s if leaks occur. This functionality detects the presence of a leak in or near a ZBM2 via the use of the leak detectors on the Analog Loom. In the event that a leak is detected, the MMS internals will disconnect the charge/discharge contactor and stop both pumps.

7.2. Stack Degradation

Gradual reduction in electrode conductivity occurs as the ZBM2 is used. This is the normal life limiting process in the ZBM2. Eventually, the electrode resistance increases to the point where the electrode stack needs to be replaced. If this occurs, contact Redflow for an approved part replacement and procedure.

7.3. Incorrect Operation

The battery can be damaged due to incorrect handling and operation. These are addressed throughout this Manual and must be adhered to during design, transport, installation, commissioning and operation of all Energy Storage Systems using ZBM2s. Incorrect handling and operation will void the warranty.

7.4. Electrolyte Contamination

Electrolyte contamination can occur when the tank is not properly sealed, or from copper exposure during some stack short circuits. Redflow has implemented internal functionality to halt operation of a ZBM2 before a stack short circuit occurs.

Minimise the risk of electrolyte contamination by avoiding the disconnection of any parts involved in the hydraulic circuit (pumps, tubes and Gas Handling Units). Unless contamination of the electrolyte has occurred as a direct result of a defect that originated during manufacturing or workmanship by a Redflow authorised representatives, the electrolyte contamination will void the warranty.

7.5. Pump Failures

Redflow has implemented pump failure detection internally to prevent damage to ZBM2s when pumps operate incorrectly. This functionality will detect if pumps have seized or if they are running when they are not supposed to be doing so. In the event that abnormal pump operation is detected, the charge/discharge contactors will be disconnected and the Zinc pump will run (if that pump is still operational). If this occurs, contact Redflow for an approved part replacement and procedure.

7.6. Electronics and Electrical

These components have been designed to ensure sources of failure are minimised. It is important to follow the instructions in this manual to ensure that the ZBM2 is not subjected to potentially damaging electrical connections. During operation, the ZBM2 continually monitors hardware status and operational parameters for unexpected issues. This information can be monitored with the BMS online interface (see Section 8.1 for more information). The ZBM2 will attempt self-protection from specific failures, but may require manual intervention in some cases.

7.7. Over Temperature

Over temperature inside the ZBM2 can damage the battery. The in-built cooling fan will automatically begin operation when the battery temperature exceeds 30 °C (86 °F), with control also dependent on ambient air temperature. Operation will then be automatically suspended if the battery temperature exceeds 50°C (122 °F). It should be noted that if the temperature of the electrolyte continues to significantly increase, this may result in high pressures inside the ZBM2 as gases are evolved (see Section 9.3 for related design considerations).

8. ZBM2 Maintenance

A systematic approach to preventative maintenance of the ZBM2 is required for warranty validity. Maintenance procedures are separated into condition monitoring and periodical procedures. A checklist is provided in Appendix D that must be used to record maintenance activities.

STOP

A fully completed and up-to-date checklist (provided in Appendix D), along with any supporting documentation for any abnormalities, is required in order to qualify for any ZBM2 warranty claim.

If a part replacement is required, only Redflow-approved parts may be used; this is a requirement for any warranty claims. If replacements are necessary, contact the supplier of the ZBM2.

It is recommended that adequate space to at least access the MMS side of the ZBM2 for electrical connections be provided in all installations. **There should also be adequate space provided to allow individual ZBM2s to be removed and/or replaced at end of life, or for servicing of individual components.**

8.1. Ongoing Maintenance

Ongoing condition monitoring maintenance involves remote monitoring of ZBM2 performance. If an operational or hardware issue occurs with the ZBM2, a warning or failure alarm will be shown in the BMS online interface. The Status page shows these alarms at a high level, as shown in Figure 49. The individual Battery Pages show more detail about these alarms, as shown in Figure 50. These alarms must be responded to in a timely manner and any external issues addressed. If left unattended, these could cause damage to the ZBM2 and void any warranty claims.

Figure 49: BMS interface showing warning and failure alarms on the Status page

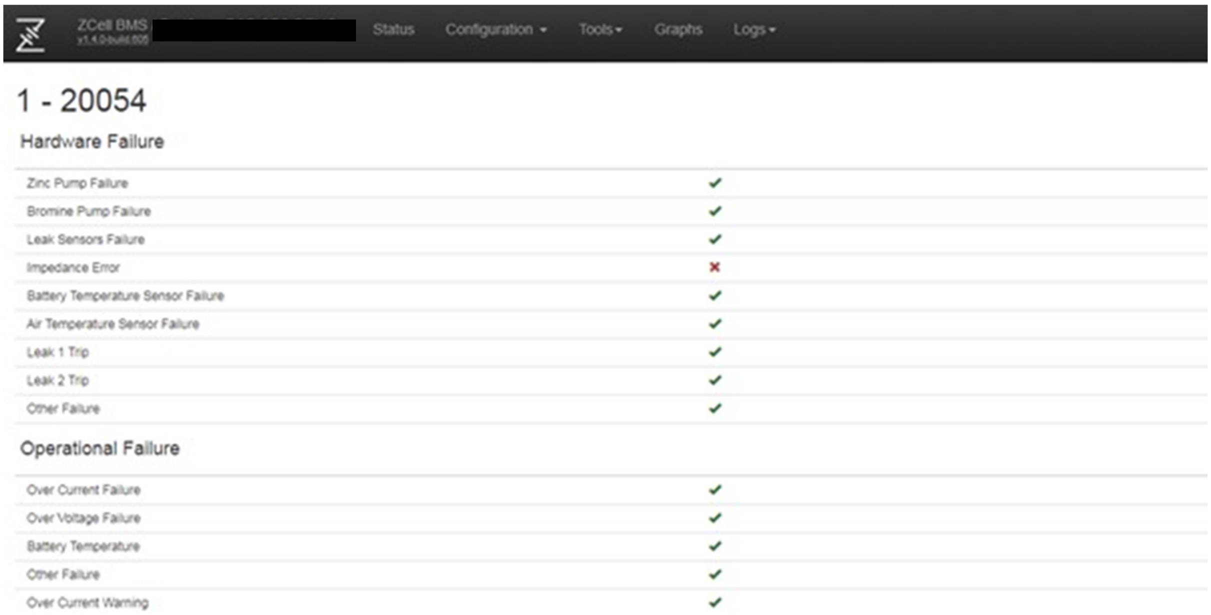

Figure 50: BMS interface showing details warnings and failures on the Battery Status page

8.2. Periodic Maintenance

At least at annual intervals, the following maintenance tasks should be undertaken. Periodic maintenance must be recorded in the checklist provided in Appendix D. If the ZBM2 is operating in areas of high concentration of dust and dirt, it is recommended that on-site maintenance be performed at shorter intervals.

STOP

DO NOT SHORT CIRCUIT BATTERY TERMINALS.

Any tools used MUST BE insulated and suitably rated and eye protection MUST BE worn. Remove all jewellery before performing any maintenance.

- Check the battery temperature reading is correct.
- Check the air temperature reading is correct.
- Check the cooling fan (part of the ZBM2) operates correctly.
- Check the zinc electrolyte pump operates correctly.
- Check the bromine electrolyte pump operates correctly.
- Check the BMS interface to ensure the ZBM2 is running with no faults.

If any of the above checks identify defects, contact the supplier of the ZBM2 for Redflow-approved part replacement and procedures. Untrained maintenance on any of these parts is not allowed and voids the ZBM2 warranty.

STOP

Ensure that the ZBM2 has been fully discharged, a regular maintenance cycle has been run, and shutdown has occurred as specified in Section 6.5 before the following maintenance tasks are undertaken.

- Check the ZBM2 for any electrolyte leaks visually and by the presence of a chlorine-like smell. If a leak is present, Appendix C provides more information on how to clean up electrolyte spills. Appendix F contains the SDS for electrolyte and uncharged electrolyte.
- Check all components of the ZBM2, including the pumps and analog loom, for signs of corrosion.
- Ensure there are no kinks in the Catch Can hoses.

If any of the above checks identify defects, contact the supplier of the ZBM2 for Redflow-approved part replacement and procedures. Untrained maintenance on any of these parts is discouraged and voids the ZBM2 warranty. If the battery continues to operate for 30 or more days without the defects (if any) identified during an inspection being rectified, the ZBM2 warranty will be deemed void.

Then, continue with the checks:

- Check all ZBM2 hose clamps are securely fitted.
- Check the ZBM2 connections are securely fitted.
- Check that the ZBM2 battery terminals are correctly torqued at 10Nm (7.4 ft-lb). A thermal imaging camera can be used to monitor ZBM2 performance (energised) to ensure there are no hot spots, especially arising from incorrectly torqued battery terminals.
- Clean the ZBM2 of any dust or dirt that has built up.
- Check and remove any animal ingress.

STOP

Ensure that any and all safety guards or covers (see Section 4.14) that may have been removed from the ZBM2 during maintenance are replaced and secured before re-energising the ZBM2.

8.3. Cleaning

No cleaning of the externals of the ZBM2 should be required. However, it is especially important that users *DO NOT USE* the following liquids to clean a ZBM2:

- Soapy water
- Alcohol
- Any other detergents

Use of the above listed parts voids the warranty.

Tap water may be used to clean the ZBM2 if required. The ZBM2 must be dried before packing.

9. ZBM2 System Integration

This section outlines some general guidelines for system integrators when using the ZBM2 in energy storage systems (ESS).

9.1. System Design Guidelines – Safety

There are several potential safety issues to consider when using the ZBM2 in an energy storage system (ESS):

- ZBM2 terminal voltage up to 58V DC during charge
- Short circuit current of up to approximately 600A DC – conductors and protective devices need to be designed accordingly
- ZBM2 electrolyte is conductive and corrosive (1-3 pH) – avoid wetting electrical components
- Secondary containment for electrolyte (max 100L per ZBM2) is recommended (see Section 9.1.2)
- Charged electrolyte contains bromine complex – manage fume risks (see Section 9.1.3)
- ZBM2 operation may evolve hydrogen – manage explosive atmospheres (see Section 9.1.3)

The following safety systems should be designed into ZBM2-based ESS.

9.1.1. Shutdown Systems

Automatic, manual and remote shutdown capabilities should be implemented in any ESS. Lethal voltages exist inside these battery systems. Guidance on the ZBM2 shutdown procedure can be found in Section 6.5.

9.1.2. Spillage Management System

The presence of liquid electrolyte in the ZBM2 means that there is potential for a spill to occur. While the ZBM2's own tanks can hold small amounts of electrolyte from minor leaks, external spill management equipment should be considered for the full electrolyte volume of 100L (26gal). The ESS should include secondary spill containment to prevent any environmental contamination in the case of spillage from the ZBM2 batteries. The electrolyte itself is water-based and can be diluted with water. Any polyethylene container, bunding or bag can be used to contain the electrolyte. Other plastics compatible with ZBM2 electrolyte include polypropylene, PVC and more expensive materials including PVDF, Teflon and Viton. Note that many plastics including nylon, acetal and neoprene are not compatible with the bromine-rich electrolyte. More detail on spills and managing them can be found in Appendix C.

9.1.3. Hydrogen & Bromine Gas Management/Detection System

Low levels of gas may be emitted during operation of the ZBM2. As with all batteries that use water-based electrolyte, some hydrogen can be generated inside the ZBM2 during operation. Although

Redflow's ZBM2s are sealed systems, they have pressure relief valves to manage internal pressures, which can result in hydrogen and bromine gas escaping into the battery enclosure during operational issues that result in high pressures inside the ZBM2. Further, any spills or leaks of electrolyte will result in some bromine gas in the ESS. The levels of these gases are safe during normal operation with no requirements for personal protective equipment (PPE) unless there is an operational issue (see Section 2.1.4). If this occurs, the risks associated with hydrogen gas include a potentially explosive environment in high concentrations, and the risks associated with bromine gases can be found in the SDS in Appendix F. As such, ESS should include adequate ventilation (see Section 9.2.3) and be monitored to ensure these gases remain at safe levels.

Further, each ZBM2 is equipped with a Catch Can (see Figure 11) to capture gases generated during operation. The hole in the Catch Can should be used to insert a non-kinkable PVC tube to connect the Catch Can to an area safe to vent gases to (e.g. outside in open air). This tube must be made from non-kinkable PVC (e.g. FlexPVC or Spaflex) and is not supplied by Redflow with the ZBM2.

Refer to Section 9.2.3 for more information about Ventilation Requirements.

9.1.4. Fire Control System

An automatic fire control system may be required according to local regulations. However, the likelihood of a fire generated inside the ZBM2 is quite low. As a precaution, naked flames or any glowing heaters and other devices must not be used in the vicinity of ZBM2 enclosures or battery rooms. Fire extinguishers should also be installed in any ESS as a precaution, and be chosen for the materials in the ESS.

9.1.5. Noise

Noise associated with the ZBM2's operation is minimal, and has been measured to be maximum 77.0dB at one metre with background noise of 54.8dB. If noise is a concern, this should be accounted for in the system design.

9.2. System Design Guidelines – Mechanical

Locating the ZBM2 inside an enclosure or a dedicated battery room needs to take into consideration a range of issues.

- ZBM2 weight
- ZBM2 physical size
- The ZBM2 is only designed for stationary applications. It contains different fluids that need to separate and blend during different stages of ZBM2 operation. There are no baffles installed in the electrolyte tanks to control the electrolyte in non-stationary applications.
- The ZBM2 must be upright for operation, transportation and storage and be situated on a flat, level surface. While it is a sealed system and will not leak if it is on its side, the ZBM2 is not specifically designed to operate or remain for any length of time in these conditions.
- The ZBM2 is not intended to withstand large forces and weights. Standing or leaning on the ZBM2 must not occur.

- The ZBM2 should be installed in an area that has sufficient ambient light and/or a similar level of sufficient artificial light in order to allow for safe installation, operation and maintenance.
- The ZBM2 must be installed in clean and dry conditions, and protected from the natural elements and falling items.
- Adequate insulation for the operating voltages and currents must be used on all materials in the ESS.
- Secondary containment: required in case of electrolyte spills or leaks.
- Enclosures must meet relevant standards and local environmental conditions.
- Adequate airflow is provided to the ZBM2s and electronics (see Sections 9.2.1 and 9.2.3).
- Correct ZBM2 orientation and adequate physical clearance should be provided around ZBM2s to allow for easy maintenance and visual access (see Section 8 for maintenance requirements).
- System design must not restrict the flow of electrolyte in any piping or tubing included with the ZBM2, this is a warranty condition.

9.2.1. Separation of ZBM2s and ESS Electronics

The ZBM2 must be installed in a section of the ESS separate from the other electronics (with no common flow of air), and with its own ventilation (see Section 9.2.3). However, in the case where power electronics must be situated in very close proximity to ZBM2s, airtight enclosures for the power electronics must be used. This is to prevent exposing the power electronics to hydrogen or bromine gas.

9.2.2. Corrosion Protection

Due to the corrosive nature of the ZBM2's electrolyte, any metals or similar materials that may corrode should be corrosion-protected.

- Copper bus bars should be Zinc plated and/or coated with polyethylene.
- Do not use uncoated steel including stainless steel. Coating options are: PVC, powder coating, zinc plating, hot dipped galvanised.
- Do not use stainless steel fasteners use zinc plated or galvanised fasteners.
- Aluminium should be anodised (>20 micron).
- Cables ties must be polypropylene not nylon.

If building an enclosure contact Redflow for further support.

9.2.3. Ventilation Requirements

The ZBM2 is not intended for use in explosive environments. ZBM2s must never be installed in airtight enclosures. Ventilation of any enclosures or battery rooms containing ZBM2s is required both for thermal management (see Section 9.3) and management of hydrogen and bromine gases that can be emitted during some operational issues. As a guide for gas management, the IEC Standard, IEC 62485-2, should be followed as ZBM2 gas emissions are similar to those for lead-acid batteries. Issues to be considered include adequate free space between ZBM2s and other components, adequate airflow (e.g. via the use of fans), and adequate placement of vents, windows and other openings.

The recommended airflow rates outlined in Table 2 (50l/s/ZBM2) for thermal management far exceed the airflow requirements to address any gas emissions. Airflow must be directed in such a way so as not to oppose the ZBM2's cooling fan path as shown in Figure 9.

Due to the risks posed by inadequate airflow leading to a build-up of gases during an operational issue, it is highly recommended that any ESS including ZBM2s be fitted with an airflow sensor at least for those ESS relying on artificial (not natural) airflow, to alert users if the ZBM2 installation is not receiving adequate airflow.

9.2.4. Securing ZBM2s

The ZBM2 is not supplied with any specific lock-down mechanisms as it is designed for stationary applications. If the system is required to be rated for high vibration or earthquake zones, then additional mechanical methods of securing the ZBM2 will need to be implemented. Personnel should not approach or be in the vicinity of the ZBM2 when it is experiencing high vibrations.

9.3. System Design Guidelines – Thermal Management

Management of the thermal load generated as the battery discharges and charges is normally achieved through fan-forced ventilation and by allowing the battery electrolyte temperature to rise during operation.

The most important criterion is to design for a sufficient flow of air through the ZBM2's fan cooling system. The ZBM2 is not a battery that can be installed in a sealed container since a significant amount of heat needs to be dissipated. The discharge of a single ZBM2 can generate as much as 2kWh of heat. If this discharge occurs over 2 hours, then heat is being generated at 1kW per hour.

Thermal design considerations include:

- Redflow recommends that enclosures and battery rooms are designed for at least the airflow rate stated in Table 2 for adequate thermal management.
- The presence of fans can have implications on the noise level generated by the ESS, and this needs to be taken into consideration during enclosure design, especially if the ESS is to be installed in close proximity to work or sleeping areas.
- An air-conditioned enclosure can be utilized; however, the same ventilation requirements are required as for sealed lead-acid batteries.
- The thermal mass of the ZBM2 will absorb some of the heat generated during operation.
- ZBM2 operating temperature range (see Table 1).
- Cables and their insulation connecting to the ZBM2 should be capable of withstanding temperatures of 70-110°C as cables may reach these temperatures at high currents.

It should be noted that significantly high ZBM2 temperatures can lead to gas evolution, high internal ZBM2 pressures and in extreme cases, a rupture to relieve pressure should both the pressure relief valves fail.

9.3.1. Temperature Considerations

ZBM2 operation will automatically be suspended when the battery temperature reaches 50°C (122°F) to prevent the ZBM2 operating in extreme ambient temperatures. It should be noted that depending on a range of operating parameters, including enclosure design, ventilation and charge/discharge rates, the battery temperature is in most cases higher than the ambient temperature.

The most effective way to maintain the ZBM2 within its acceptable temperature range is for the ESS to use fan ventilation when ambient temperature conditions are hot. Well-ventilated enclosures or battery rooms and slower charge/discharge rates will also result in lower battery temperatures. Active cooling with chillers or air conditioners is generally not required. When the ambient temperature is cold, it is advised that heaters should be used to raise the ambient temperature around the ZBM2. Further, operating the ZBM2, especially at full power, will raise its internal temperature compared to when it is not operational.

9.4. System Design Guidelines – Electrical

A typical ZBM2-based ESS, which is developed by System Integrator partners, consists of:

- Batteries, either single or multiple ZBM2s, or a combination of ZBM2s and other types of batteries.
- BMS for communication with the ZBM2s (see Sections 4.12 and 9.5 for more information).
- A bi-directional Power Conversion System (PCS) which may be DC-AC for typical grid-connected applications or it may be DC-DC for some off-grid applications, e.g. Telecom applications.
- A Unit Master controller with an appropriate communications link and user interface to allow the end customer to operate the ESS.
- Grid-interconnection components as required by the application (e.g. transformers).
- It is recommended that the top stack plate be grounded using the grounding hole provided to avoid any possible static charge build up.

It is warranty requirement that operational electrical parameters found in Table 1 must be adhered to (see the Redflow website for warranty terms).

9.4.1. Voltages

A critical element when designing for the use of ZBM2s is to understand the charge and discharge voltages of the ZBM2. While the ZBM2 has been designed to operate with nominal 48V devices (such as inverters), the voltages produced can be outside the voltage ranges of some systems that have been designed specifically for 48V lead-acid batteries. Figure 51 shows the typical voltages produced by the ZBM2 during charging and discharging. The ZBM2 can be discharged down to a voltage of 40V at which the battery automatically disconnects from the DC bus.

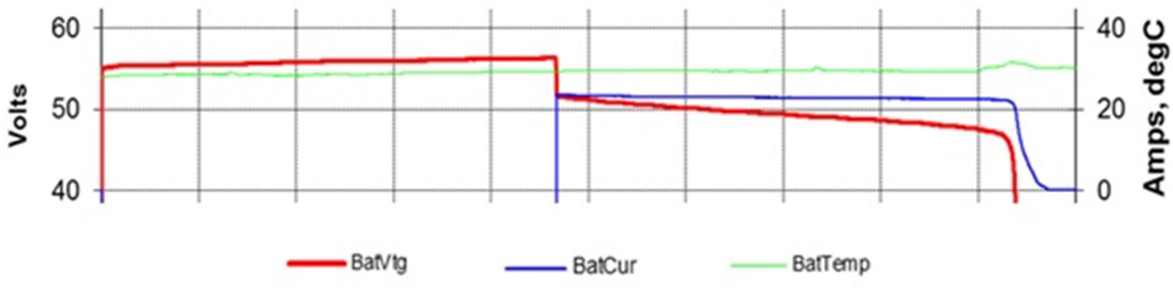

Figure 51: Excerpt from Figure 52 showing ZBM2 voltage profile

While the battery voltages are classified as extra low voltage (ELV) in Australia, care should be taken in design to ensure systems are safe according to local regulations.

9.4.2. Currents

The charge current needs to be limited to conform to the maximum charging power limit per ZBM2 specified in Table 1. The MMS will disconnect from the bus if a charge current above 50A or a voltage above 60V is measured, so the maximum charging current should be set to a value below 50A.

The discharging current at which the MMS will disconnect from the bus is 125A. The disconnection will occur after detecting a current of:

- 125A for 13 minutes, or
- 126A for 60 seconds, or
- 128A for 5 seconds, or
- instantaneously for 130A or above

Operating the ZBM2 at higher currents than those listed above will void the ZBM2 warranty.

All fault protection equipment (such as fuses and circuit breakers) should be chosen and designed for fault currents of 125A and above, while taking into account the level of normal operating currents stated in this section.

It should be noted that when multiple ZBM2s are operated in parallel, the maximum charge and discharge currents are cumulative, e.g. two ZBM2s can be charged with a maximum of 100A (50A each). If one of the multiple ZBM2s disconnects from the bus (e.g. because it has reached 100% SOC or it requires self-maintenance soon (see Section 9.4.7)), then the maximum charging current will reduce by 50A. As such, any chargers connected to the bus should be able to prevent a higher power still being pushed into the bus, e.g. by voltage control or by limiting the charger current based on the number of ZBM2s connected to the bus).

9.4.3. Power Output

The ZBM2's power ratings are stated in Table 1. The duration of the ZBM2's peak discharge power depends on various parameters including the battery's current state of charge, age and temperature.

9.4.4. Energy Output

The ZBM2 energy capacity is stated in Table 1. Unlike lead-acid batteries, the ZBM2 is designed to provide 100% of the available energy.

9.4.5. Response Time

The full load response time of a ZBM2 is fast when the pumps are running, but requires a short start-up period when operating from standby. The ZBM2 operates in the same manner as any other battery, and can swap from full power charging to full power discharging almost instantaneously.

9.4.6. Efficiency

Stack DC-DC energy efficiency of the ZBM2 is up to 80% without ancillary components. However, the cumulative effect of inverters, cooling systems, and additional power electronics will reduce overall round-trip efficiency to lower levels.

9.4.7. Self-Maintenance

Self-maintenance is the process of stripping all zinc from the electrodes of the ZBM2. The ZBM2 needs to be used in such a way that it can undergo self-maintenance regularly. It is a condition of any warranty claim (see Redflow website for warranty terms) that the ZBM2 has undergone self-maintenance at the frequency specified in Table 1. The self-maintenance process in a standard ZBM2 cycle is shown in Appendix E. Normally the maintenance cycles are scheduled by the site BMS which is highly configurable to match the site's requirements.

Key aspects of the self-maintenance process include:

- The ZBM2 will automatically enter, run and exit self-maintenance mode using its MMS. The user has control over the timing of the self-maintenance cycle by utilising the BMS interface. This is accessed by navigating to the Battery Maintenance page in the Configuration drop down menu.
- In the event that the communication link between the BMS and ZBM2 is lost, the MMS has an inbuilt safety measure to ensure self-maintenance is performed at sufficient intervals to prevent damage to the ZBM2.
- To minimise time to complete the maintenance cycle the ZBM2 must be fully discharged before entering self-maintenance mode.
- When required, the ZBM2 will flag that it needs to start the self-maintenance process in the next 24 hours. It will automatically prevent further charging and only allow discharge to occur. The ZBM2 will then continue to discharge until it is sufficiently discharged to automatically enter the Self-Maintenance state, or the 24 hours has expired.
- When it is not connected to a BMS, if the ZBM2 is not fully discharged when the 24 hours has expired, the ZBM2 will disconnect from the bus and utilise its own pumps and fan as loads into which to self-discharge to enable it to fully discharge. Note that this can take several days if the ZBM2 is fully charged.
- When connected to a BMS, the ZBM2 will continue to remain in the discharge-only phase past the 24 hour time period until such time that the ZBM2 has been fully discharged.
- After discharge is completed, excess zinc is automatically stripped from the ZBM2's electrodes. The user should allow two-three hours for a full self-maintenance cycle to be performed by a ZBM2 after it has discharged.

- During the self-maintenance cycle the stack will discharge down to 0V so the 40V required to run the pumps will need to be provided externally. This could be other ZBM2s on the same DC bus.
- If there is no external power available to the ZBM2 when it begins the self-maintenance cycle or external power is lost during self-maintenance, the ZBM2 will power down. When external power is returned, the ZBM2 will continue where it stopped in the self-maintenance cycle.

If the application requires a continuous source of battery power to be available, the system should be designed with at least 2 ZBM2s or as a hybrid with a different form of power back-up.

- Single ZBM2 ESS – means that periodically there will be no voltage from the ZBM2 terminals during the self-maintenance cycle.
- Multi-ZBM2 ESS – the BMS can arrange the stripping program such that only one ZBM2 is undergoing self-maintenance at a time and the remaining ZBM2s are available.

Self-maintenance can be optimised by the BMS noting the following:

- Discharge all stored energy into the load prior to running the self-maintenance cycle. This means that the stored energy can be used in a "useful" way (i.e. it is not wasted) and the ZBM2 will not be out of service for any additional period of time to self-discharge.
- Strip cycles can be run during times when the battery does not need to operate but a power source is still available. In a grid-connected solar shifting application, the self-maintenance cycle can be done in the early hours of the morning when the battery has been completely discharged, there is no solar power available to charge the batteries and grid power can be less expensive.

9.4.8. Parallel Arrangements of ZBM2s

Multiple ZBM2s can be connected in parallel arrangements. The optimal arrangement often depends on the voltage, current and other power electronics requirements of the ESS. By default, the ZBM2 comes with the standard MMS for parallel connection. ZBM2s must not be connected in series.

9.5. System Design Guidelines – Communications

Communication with each ZBM2 is done using a BMS with an internet connection. This provides an online interface to one or multiple ZBM2s in a system and can communicate with each ZBM2 individually using unique MODBUS addresses.

It is important to note that 1 BMS can be used to communicate with up to 12 ZBM2s in one system. If the system designed has more than 12 ZBM2s contact Redflow for the best recommended solution.

The BMS can also connect to other components in the larger energy system, including energy management systems and inverters, to enable control of the ZBM2s from those components.

The full ZBM2 warranty is dependent upon the ZBM2 BMS remaining connected to the internet for the duration of the warranty. A shorter warranty will apply for ZBM2s without a BMS or whose BMS does not remain connected, as specified in the Redflow Battery Warranty document.

Appendix A Abbreviations and Definitions

The following acronyms, abbreviations and terms are defined here within the context of this manual.

Term	Definition
°C	Degrees Celsius
°F	Degrees Fahrenheit
A	Amp
AC	Alternating Current
Ah	Amp Hour
BMS	Battery Management System
DC	Direct Current
EED	Energy Extraction Device
ELV	Extra-Low Voltage
ESS	Energy Storage System
GHU	Gas Handling Unit
I	Current
in	Inch
IBC	Intermediate Bulk Container
IPxx	International Protection Rating
kg	Kilogram
kW	Kilowatt
kWh	Kilowatt hour
lb	Pound
ft-lb	Foot pound
LV	Low Voltage
mm	millimetre
MMS	Module Management System
must	Indicates a mandatory requirement
Nm	Newton metre
PPE	Personal Protective Equipment
SDS	Safety Datasheet
SOC	State of Charge
V	Volt
W	Watt
ZBM2	Zinc-Bromine Module 2

Appendix B EC Declaration of Conformity

CERTIFICATE

EC DECLARATION OF CONFORMITY

redflow
advanced energy storage

In accordance with:- **EC Machinery Directive 2006/42/EC (Annex IIA) / EC Electromagnetic Compatibility Directive 2014/30/EU (Annex IV)**

We herewith declare that the:-

Product description:	**Zinc-bromide flow battery module 3kW/10kWh**
Model Number:	ZBM2
Serial Number:	All serial numbers containing "S222A000"
Manufacturer:	RedFlow Limited. 27 Counihan Rd, Seventeen Mile Rocks, QLD, 4073, Australia

When used in accordance with the manufacturer's instructions, conforms with the essential health and safety requirements of the Machinery Directive and conforms with the protection requirements of the EMC Directive by virtue of its design, construction and assessment.

In support of this declaration the subject machine has been evaluated as complying with the following:-

a) The Machinery Directive (Annex I), by compliance with the applicable clauses of the following harmonised standards including:-
EN ISO 12100-1:2010 / EN 60204-1:2006/AC:2010 and associated standards
(RedFlow Limited Technical File for Compliance with 2006/42/EC (Document Number: RFCE010) dated December 2017, Revision 4.0 is held by the manufacturer. Certificate of Conformity (150117GRa dated 17th January, 2015) issued by SRCS (Projects etc Pty) Accredited Inspection Body for the EU Machinery Directive refers.

b) The EMC Directive (Annex II), by application of **EMC Assessment Procedure ref RedFlow Limited, Electromagnetic Assessment (Document Number: RCE020) dated December 2017.**
Redflow Limited Technical Documentation for Compliance with 2014/30/EU (Document Number: RFCE015) dated December 2017, Revision 4.0 is held by the manufacturer. Certificate of Conformity (150117GRb dated 17th January, 2015) issued by SRCS (Projects etc Pty) Accredited Inspection Body for the EU EMC Directive refers.

The Person Authorised to Compile the Technical File" (TF) under the EU Machinery Directive (2006/42/EC) and "Authorised Representative" under the EU EMC Directive (2014/30/EU) under Contract No. 141120CEI/PROJ/REDFLOW1 dated January 2015 is:- Mr. John McAuley, Compliance Engineering Ireland Ltd., Raystown, Ratoath Road, Ashbourne, Co. Meath, IRELAND.

If the equipment is modified without the agreement of the undersigned, this declaration becomes invalid.

Tim Harris

CEO

Signed on behalf of RedFlow Limited

11 May 2018 / Brisbane, Australia

Date/Place of Signing

www.redflow.com

Appendix C Addressing ZBM2 Electrolyte Spills/Leaks

This section provides guidance on how to assess the severity of an electrolyte spill or leak, and how to manage the clean-up.

1. Electrolyte Spill or Leak Classification

It is necessary to assess and classify the severity of an electrolyte spill in order to be able to address it effectively. The table below provides guidelines for determining if the spill or leak is minor or major.

Characteristic	**Minor Spill/Leak**	**Major Spill/Leak**
Volume	Less than 1 (one) litre	More than 1 (one) litre
Flow Rate	Slow drip or no visible flow	High flow rate
Smell	No strong smell	Strong chlorine-like smell
Colour	Clear or light yellow	Deep red
Location	No liquid is near electrical connections	Liquid is near electrical connections

2. Electrolyte Spill or Leak Clean Up

This section provides guidelines for cleaning up a ZBM2 electrolyte spill or leak. All personnel involved in clean-up activities must be aware of the content of the Redflow Battery Electrolyte SDS in Appendix E.

Step 1 **Assess the Severity of the Spill/Leak**

Using the information in the table above, assess the severity of the spill or leak as minor or major.
If the spill/leak is minor, proceed to Step 2.
If the spill/leak is major, proceed to Step 3.

Step 2 **Minor Electrolyte Spill/Leak Clean Up**

Step 2.1 Apply personal protection equipment.

Step 2.2 If the spill/leak is associated with a ZBM2, pause the operation of the ZBM2 (if the MMS has not already done this).
Inspect the ZBM2 for the cause or source of the leak.
Using rags or disposable wipes, clean up the visible electrolyte.
Discharge the ZBM2 safely.
Manage all clean up materials as hazardous waste by placing them in an acid debris waste accumulation container.
Contact Redflow support for advice on how to proceed.

Step 2.3 If the spill is not associated with a ZBM2, for example, electrolyte is spilt from its container, use rags or disposable wipes to clean up the electrolyte.
Apply absorbent (as specified in Section 3 of Appendix C below) to neutralise remaining electrolyte.
Manage all clean up materials as hazardous waste by placing them in an acid debris waste accumulation container.

Step 3 Major Electrolyte Spill/Leak Clean Up

Step 3.1 Alert colleagues that the electrolyte spill/leak has occurred and if a strong chlorine-like odour is evident, evacuate the hazardous area.

Step 3.2 Apply personal protection equipment.

Step 3.3 If the spill/leak is associated with a ZBM2, stop the operation of the ZBM2.
Isolate electrical connections.
Inspect the ZBM2 for the cause or source of the leak and if possible prevent further leakage from occurring.
Using rags or disposable wipes, clean up the visible electrolyte.
Apply absorbent (as specified in Section 3 of Appendix C below) to neutralise remaining electrolyte.
Manage all clean up materials as hazardous waste by placing them in an acid debris waste accumulation container.
If possible, discharge the ZBM2 safely.
Actively ventilate the affected area.
Contact Redflow support for advice on how to proceed.

Step 3.4 If the spill/leak is not associated with a ZBM2, inspect for the cause or source of the spill and if possible prevent further spillage from occurring. This may require the use of other appropriate containers (e.g. polyethylene) to contain the spill.
Using rags or disposable wipes, clean up the visible electrolyte.
Apply absorbent (as specified in Section 3 of Appendix C below) to neutralise remaining electrolyte.
Manage all clean up materials as hazardous waste by placing them in an acid debris waste accumulation container.

3. Clean Up Materials

Rags and disposable wipes are suitable for cleaning up electrolyte.

Neutralising Electrolyte - uncharged

Commercial absorbents or acid neutraliser absorbents (that have a significant colour change to signify complete neutralisation of acids) can be used for electrolyte clean-up.
Lime or baking soda can also be used to neutralise acid and therefore an electrolyte spill.

Neutralising Electrolyte – charged

Household grade ammonia (~10%) solution can be used to neutralise bromine complex, or charged electrolyte spills. Caution must be exercised, to prevent a violent exothermic reaction. Add ammonia solution slowly to the spilt electrolyte.

NOTE: All materials to be used in contact with electrolyte in future need to be rinsed of any acid, ammonia or other neutralising agents prior to re-use to avoid chemical imbalance in the electrolyte.

NOTE: Any disposal of materials that have come into contact with electrolyte must be disposed of in accordance with local laws and regulations.

Appendix D Maintenance Checklist

Warranty is voided if annual maintenance checks are not done.

ZBM2 Annual Checks												
Maintenance Technician:	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
Date	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /
Check the BMS interface for any warning or failure alarms	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check the battery temperature reading is correct	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check the air temperature reading is correct	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check the cooling fan operates correctly	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check the zinc electrolyte pump runs	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check the bromine electrolyte pump runs	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check the ZBM2 for any electrolyte leaks visually and by the presence of a chlorine-like smell.	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check the ZBM2 for signs of corrosion	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check hoses connected to the catch can are not kinked.	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check ZBM2 hose clamps are securely fitted	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check the ZBM2 circuit protection is maximum of 125A	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Check that the ZBM2 five MMS terminals are correctly torqued at 10Nm (7.4 ft-lb).	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass	☐ Pass
Clean the ZBM2 of any dust or dirt	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done
Check and remove any animal ingress	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done	☐ Done

Appendix E Standard Test Cycle

Figure 52 shows Redflow's Standard ZBM2 test cycle which is run in the case of a warranty claim. The standard test cycle starts with a fully discharged ZBM2.

There are two operating modes that the ZBM2 goes through during this standard cycle at 25 °C:

1. Charging (9.2 hour period from 0 to 9.2 hours):
    - Current (blue trace, using right axis) at -25A DC (negative = charging) for 9.2 hours.
2. Discharging (10 hour period from 9.2 to 19.2 hours):
    - Current ranges from 25A DC to 0A DC as the voltage (red trace, using left axis) falls from 52V DC to 0V DC.
    - The ZBM2 continues to discharge until the battery current is very close to 0A, and the ZBM2 is empty.

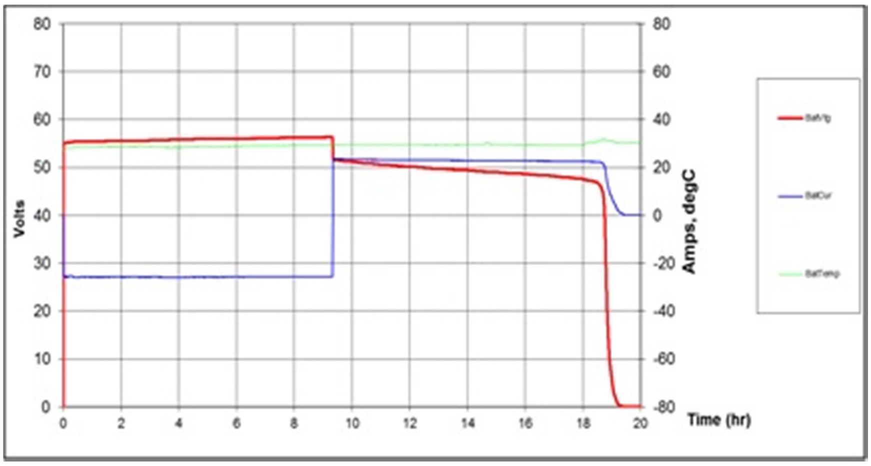

Figure 52: ZBM2 Standard Test Cycle

Appendix F Redflow ZBM2 Safety Data Sheet

This section contains the safety datasheet for the ZBM2.

1. PRODUCT IDENTIFICATION

TRADE NAME AS LABELLED:	ZBM2
PRODUCT NUMBER:	ZBM2
CHEMICAL NAME:	Mixture
INTENDED USE:	Energy storage
U.N. NUMBER:	2794
U.N. DANGEROUS GOODS CLASS:	8 BATTERIES, WET, FILLED WITH ACID (contains Zinc Bromide, polybromide oil)
SUBSIDIARY RISK:	None
MANUFACTURER'S NAME:	RedFlow International Pty Ltd
ADDRESS:	27 Counihan Road, Seventeen Mile Rocks, Brisbane, QLD, Australia, 4073
BUSINESS PHONE:	+61 (0) 7 3376 0008
24 HR EMERGENCY CONTACT:	3E Company
Contract No.:	334179
EMERGENCY PHONE:	Refer to Section 17, Global Emergency Contact.
DATE OF PREPARATION:	15 January 2014
DATE OF LAST REVISION:	21 February 2019

2. HAZARDS IDENTIFICATION

Health Hazard

Skull and Crossbones

Corrosion

Aquatic pollutant

Signal word: Danger

H302	Harmful if swallowed
H314	Causes severe skin burns and eye damage
H317	May cause an allergic skin reaction
H341	Suspected of causing genetic defects
H400	Very toxic to aquatic life
H410	Toxic to aquatic life with long lasting consequences

P201	Obtain special instructions before use
P202	Do not handle until all safety precautions have been read and understood.
P260	Do not breathe dusts or mists
P261	Avoid breathing dust / fume / gas / mist / vapours / spray
P264	Wash hands thoroughly after handling
P270	Do not eat, drink or smoke when using this product
P272	Contaminated clothing should not be allowed out of the work place
P280	Wear protective gloves / protective clothing
P281	Use personal protective equipment as required
P301+P312	If SWALLOWED: Call a POISON CENTER or doctor / physician if you feel unwell.
P301+P330+P331	If SWALLOWED: Rinse mouth. DO NOT induce vomiting.
P302+P352	If ON SKIN: Wash with soap and water.
P303+P361+P353	If on skin or hair: Remove / Take off immediately all contaminated clothing. Rinse skin (hair) with water shower.
P308+313	If exposed or concerned: Get medical advice / attention.
P321	In the case of accident or if you feel unwell seek medical advice immediately (show this SDS where possible)
P330	Rinse mouth.
P333+313	If skin irritation or a rash occurs: Get medical advice / attention.
P363	Wash contaminated clothing before re-use.
P405	Store locked up.

P501	Dispose of contents / container in accordance with the local regulations in force.

This product is classified as Dangerous Goods according to the ADG code 7th Edition of Australia, and Regulation (EC) no. 1272/2008 of the European Union, and contains corrosive, toxic (Cat. 4), and possible mutagenic (Cat. 2) components.

3. COMPOSITION AND INFORMATION ON INGREDIENTS

Ingredient	CAS	WT %	Hazard Statement Code(s)	Hazard Class and category Codes
N Ethyl N Methyl Pyrollidinium Bromide (MEP)	69227-51-6	< 8%	H341	Muta. 2
Zinc Bromide	7699-45-8	17-21%	H302, H314, H317, H400, H410	Acute Tox. 4 Skin Corr. 1B Skin Sens. 1 Aquatic Acute 1 Aquatic Chronic 1
Zinc Chloride	7646-85-7	< 3%	H302, H314, H400, H410	Acute Tox. 4 Skin Corr. 1B Aquatic Acute 1 Aquatic Chronic 1
Potassium Chloride	7447-40-7	< 3%	No information	
Water	7732-18-5	> 20%	No information	
Polybromide oil	N/A	< 1%	No information	
Aluminium	7429-90-5	4%	No information	
Carbon plastic electrode (25% carbon, 75% polyethylene)	N/A	3%	No information	
Polyethylene	9002-88-4	30%	No information	
Polyolefin	N/A	1%	No information	
Electrical and steel parts	N/A	7%	No information	
Copper parts (bus bars)	7440-50-8	>1%	No information	

Precautionary Statements

H302	P264, P270, P301+312, P330, P501
H314	P260, P264, P280, P301+330+331, P303+361+353, P363, P304+340, P310, P321, P305+351+338

H317	P261, P272, P280, P302+352, P333+313, P321, P363, P501
H341	P201, P202, P281, P308+313, P405, P501
H400	P501
H410	P501

4. FIRST AID MEASURES

Eye

If electrolyte from this product is in eyes, hold eyelids apart and flush continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre, or a doctor, or for at least 15 minutes.

Inhalation

If electrolyte from this product is inhaled, remove affected person(s) from contaminated area. To protect rescuer use a Type B (Inorganic and acid gas) respirator where an inhalation risk exists. Apply artificial respiration if not breathing. Contact emergency personnel.

Skin

If skin or hair contact with electrolyte from this product occurs, remove contaminated clothing and flush skin and / or hair with running water. Continue flushing with water until advised to stop by a Poisons Information Centre or a doctor.

Ingestion

For advice if electrolyte from this product is ingested, contact a Poison Information Centre on 13 11 26 (Australia Wide) or a doctor (at once).

The decision to induce or not to induce emesis in ingestion is often controversial, is not automatic, and must be carefully considered. Emesis may be indicated in substantial recent ingestions. Contraindications to emesis induction include: signs of oral, pharyngeal, or oesophageal irritation; a depressed gag reflex; or central nervous system excitation or depression. If these are present or likely, EMESIS SHOULD NOT BE INDUCED.

Special treatment

Treat symptomatically.

First aid facilities

Eye wash facilities and safety shower should be available if electrolyte from this product is being handled.

Symptoms of Exposure

Electrolyte from this product is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes and skin. Symptoms include spasm, inflammation and oedema of the larynx, spasm, inflammation and oedema of the bronchi, pneumonitis, pulmonary oedema, burning sensation, cough, wheezing, shortness of breath, headache and nausea.

Potential health effects

Inhalation	May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract.
Skin	May be harmful if absorbed through the skin. Causes skin burns. May cause bromide rash and / or skin blackening in the longer term.
Ingestion	Harmful if swallowed, causes burns.
Eyes	Causes eye burns.

5. FIRE FIGHTING MEASURES

Suitable extinguishing equipment

In a fire situation select extinguishing media based on the cause of the surrounding fire. Product will not react adversely with water, foam or dry agent based extinguishers. Prevent contamination of drains or waterways. Wear full protective equipment including Self Contained Breathing Apparatus (SCBA) when combating fire. Use water-fog to cool intact containers and nearby storage areas.

Special hazards

This product is considered to be non-flammable; however, if heated to decomposition this product may evolve fumes of bromine, hydrogen bromide and carbon monoxide. Many organic compounds and some reactive metals may burn in a bromine atmosphere.

Advice for fire fighters

Remain upwind and notify those downwind of hazard. Wear full protective equipment including Self Contained Breathing Apparatus (SCBA) when combating fire. Use water-fog to cool intact containers and nearby storage areas.

6. ACCIDENTAL RELEASE MEASURES

Spillage of electrolyte from this product

Contact emergency services where appropriate. Use personal protective equipment to prevent skin / eye contact. Clear area of all unprotected personnel. Ventilate area where possible. Contain spillage, then cover / absorb spill with non-combustible absorbent material (vermiculite, sand, or similar), collect and place in suitable containers for disposal. Wash spill site with water.

7. STORAGE AND HANDLING

Store in secured, cool, dry, well-ventilated area in a tightly closed container. Store removed from combustible materials, heat or ignition sources, alkalis, acids, metals and foodstuffs. Ensure containers are adequately labelled and protected from physical damage. Containers that are opened must be carefully re-sealed and kept upright to prevent leakage. When not stored in original battery packaging, electrolyte must be stored in a thick walled polyethylene container. Handle and open container with care.

Before use carefully read the product label. Use of safe work practices are recommended to avoid eye or skin contact and inhalation. Observe good personal hygiene, including washing hands before eating. Wash hands thoroughly after use.

Prohibit eating, drinking and smoking in contaminated areas.

Prevent release into the environment.

PPE

Eye / Face	Wear goggles / full face mask where there is a risk of splashing.
Hands	Wear PVC or rubber gloves.
Body	Not required if suitable engineering controls are in place however chemical resistant suit should be considered if a risk assessment deems it necessary.
Respiratory	Type B respirator where risk of inhalation occurs.

8. EXPOSURE CONTROLS

Ingredient	Reference	TWA	STEL
Zinc Chloride(fume)	SWA(AUS)	1 mg / m3	2 mg / m3
Zinc Bromide (fume)	Data not available		
N Ethyl N Methyl Pyrollidinium Bromide (MEP)	Data not available		

This product should be handled in well-ventilated conditions. Do not create mists / sprays. As far as possible use appropriate engineering controls to reduce exposure to splashes / mists / sprays.

9. PHYSICAL AND CHEMICAL PROPERTIES

	Electrolyte	Plastics
Appearance	YELLOW LIQUID (with possible dark brown oily component)	Translucent white or black
Solubility (water)	SOLUBLE	NOT RELEVANT
Odour	Bromine odour	NOT RELEVANT
Specific Gravity	1.5	NOT RELEVANT
pH	1 to 2	NOT RELEVANT
% Volatiles	N/A	NOT RELEVANT
Vapour Pressure	7 mBar	NOT RELEVANT
Flammability	NON FLAMMABLE	NOT RELEVANT
Vapour Density	5.2 (Air = 1)	NOT RELEVANT
Flash Point	NOT RELEVANT	341°C
Boiling Point	128°C	NOT RELEVANT
Upper Explosion Limit	NOT RELEVANT	NOT RELEVANT
Melting Point	NOT AVAILABLE	129°C - 133°C
Lower Explosion Limit	NOT RELEVANT	NOT RELEVANT
Evaporation Rate	0.1 (Butyl acetate = 1)	NOT RELEVANT
Auto ignition Temperature	NOT RELEVANT	330°C - 410°C
Decomposition Temperature	NOT AVAILABLE	290°C
Partition Coefficient	NOT AVAILABLE	NOT RELEVANT
Viscosity	0.7 cSt	NOT RELEVANT

10. STABILITY AND REACTIVITY

Chemical stability

Stable under recommended conditions of storage.

Conditions to avoid

Avoid heat (> 60°C), sparks, open flames and other ignition sources.

Material to avoid

The electrolyte contained in this product will corrode most metals.

Hazardous

May evolve toxic gases (metal oxides, nitrogen oxides, carbon oxides) when heated to decomposition.

11. TOXICOLOGICAL INFORMATION

Health hazard

Corrosive. The electrolyte contained in this product has the potential to cause adverse health effects. Use safe work practices to avoid eye or skin contact and inhalation. Engineered solutions such as using suitable pumps to transfer material rather than attempting to manually pour should be considered.

Summary

Product contains bromide. Some individuals may experience an allergic reaction with "bromide rash" and possible acne-like eruptions or boils. N-ethyl-N-methylpyrrolidinium bromide (MEP) is classified as a human mutagen (Cat. 2). MEP has been documented to produce a positive mutagenic result in the in-vivo somatic cell mutagenicity assay, the bone marrow micronucleus test.

Eye

Corrosive - irritant. Contact with the electrolyte contained in this product may result in irritation, lacrimation, pain, redness, corneal burns and possible permanent damage.

Inhalation

Corrosive - irritant. Over exposure to the electrolyte contained in this product may result in irritation of the nose and throat, coughing, nausea, dizziness and headache. Aspiration into lungs may cause chemical pneumonitis and pulmonary oedema

Skin

Corrosive. Contact with the electrolyte contained in this product may result in irritation, redness, pain, rash, dermatitis and possible burns. May cause possible allergic reaction with bromodera (bromide rashes) and possible acne-like eruptions or boils.

Ingestion

Corrosive. Ingestion of the electrolyte contained in this product may result in burns to the mouth and throat, nausea, vomiting, abdominal pain and ulceration.

Toxicity Data

ZINC CHLORIDE (7646-85-7)

LCLo (Inhalation):	1960 mg/m^3/10 minutes (rat)
LD50 (Ingestion):	200 mg/kg (guinea pig)
LDLo (Intraperitoneal):	30 g/kg (7-8 day pregnant rat)
TCLo (Inhalation):	4800 mg/m^3/30 minutes (man)
TDLo (Ingestion):	15 mg/kg (chicken - tumours)

POTASSIUM CHLORIDE (7447-40-7)

LD50 (Ingestion):	1500 mg/kg (mouse)
LD50 (Intraperitoneal):	620 mg/kg (mouse)
LD50 (Intravenous):	117 mg/kg (mouse)
LDLo (Ingestion):	20 mg/kg (man)
LDLo (Intraperitoneal):	900 mg/kg (guinea pig)
LDLo (Intravenous):	77 mg/kg (guinea pig)
LDLo (Subcutaneous):	2120 mg/kg (frog)
TDLo (Ingestion):	60 mg/kg/days (woman)

12. ECOLOGICAL INFORMATION

The major constituents of this material are considered to be very harmful to aquatic life. No environmental toxicity data is available for N-Ethyl-N-Methyl Pyrollidinium Bromide.

13. DISPOSAL CONSIDERATIONS

Waste disposal

Wearing protective equipment, absorb spills with non-organic absorbent (i.e. vermiculite or clay) and collect and place in suitable containers for disposal. For large quantities, contact the manufacturer for additional information. Prevent dispersal of product and product residues to waterways and the environment.

Legislation

Dispose of in accordance with relevant local legislation.

14. TRANSPORT INFORMATION

CLASSIFIED AS DANGEROUS GOODS BY THE AUSTRALIAN DANGEROUS GOODS CODE - Edition 7, and Regulation (EC) no. 1272/2008 of the European Union.

UN No. 2794
Shipping Name: BATTERIES, WET, FILLED WITH ACID (contains Zinc Bromide, polybromide oil)
Class 8 DG
Packaging Group NIL
Hazchem Code 2R

IATA

UN No. 2794
Shipping Name: BATTERIES, WET, FILLED WITH ACID (contains Zinc Bromide, polybromide oil)
Class 8 DG
Packaging Group NIL
Hazchem Code 2R

IMDG

UN No. 2794
Shipping Name: BATTERIES, WET, FILLED WITH ACID (contains Zinc Bromide, polybromide oil)
Class 8 DG
Packaging Group NIL
Hazchem code 2R
Mark: MARINE POLLUTANT

ADR/RID

UN No. 2794
Shipping Name: BATTERIES, WET, FILLED WITH ACID (contains Zinc Bromide, polybromide oil)
Class 8 DG
Packaging Group NIL
Hazchem code 2R
Marking: Environmentally hazardous substance

15. REGULATORY INFORMATION

AICS

All chemicals listed on the Australian Inventory of Chemical Substances (AICS) with the exception of polybromide oil.

ESIS

All chemicals listed via the European chemical substances information system with the exception of polybromide oil.

16. OTHER INFORMATION

EXPOSURE STANDARDS - TIME WEIGHTED AVERAGES

Exposure standards are established on the premise of an 8 hour work period of normal intensity, under normal climatic conditions and where a 16 hour break between shifts exists to enable the body to eliminate absorbed contaminants. In the following circumstances, exposure standards must be reduced: strenuous work conditions; hot, humid climates; high altitude conditions; extended shifts (which increase the exposure period and shorten the period of recuperation).

ABBREVIATIONS:

ADG	Australian Dangerous Goods.
BEI	Biological Exposure Indice(s).
CAS#	Chemical Abstract Service number - used to uniquely identify chemical compounds.
mg/m³	Milligrams per Cubic Metre.
N.O.S.	Not Otherwise Specified.
pH	Relates to hydrogen ion concentration using a scale of 0 (high acidic) to 14 (highly alkaline).
ppm	Parts Per Million.

STEL	Short Term Exposure Limit.
SWA	Safe Work Australia.
TWA	Time Weighted Average.

This SDS has been prepared according to the guidelines published by Safe Work Australia. The information presented is believed to be correct to the best of our knowledge, but does not claim to be all inclusive. The information in this document is based on our present knowledge and should be only considered as a guide. As with any chemical substance an in house risk assessment should always be carried out.

17. GLOBAL EMERGENCY CONTACT

PHONE NUMBERS FOR GLOBAL SERVICES WITH CLIENT ACCESS CODE							
Customer Support							
Americas		**Europe**		**Asia Pacific**		**Middle East/Africa**	
1.866.519.4752 (US, Canada, Mexico)		No Toll Free Access		No Toll Free Access		No Toll Free Access	
(+)1 760 476 3962		(+)1 760 476 3961		(+)1 760 476 3960		(+)1 760 476 3959	
Countries*	**Languages**	**Countries***	**Languages**	**Countries***	**Languages**	**Countries***	**Languages**
Argentina	English	Belgium	English	Australia	English	Algeria	English
Brazil	Spanish	Denmark	Spanish	Hong Kong	Japanese	Egypt	Arabic
Canada	French CA	Finland	German	India	Korean	Israel	Persian
Costa Rica	Portuguese	France	French	Japan(KDD)	Chinese	Kuwait	Turkish
Mexico	Other	Germany	Italian	Malaysia	Thai	Morocco	French
Peru		Italy	Russian	New Zealand	Other	Oman	Other
USA		Netherlands	Other	S. Korea		Saudi Arabia	
		Poland		Singapore		South Africa	
		Portugal		Taiwan		Turkey	
		Russia		Thailand		United Arab Emirates	
		Spain					
		Switzerland					
		UK					

	Regulation	Country	Number	Languages
Country Specific * *	**Required**			
		Australia	(+)61 1 800 686 951	English
		China	(+)86 4001 2001 74	Chinese
	Recommended			
		New Zealand	(+)64 800 451719	English
	Optional			
		United Kingdom	(+)44 8 08 189 0979	English

End of Safety Data Sheet

Appendix G Document Revision History

Version	Date	Details of Change	Author
1.0	Original	Original release for ZBM Gen2.9	MNM
2.0	20 Nov 2015	Updates for ZBM2	MNM
2.1	10 Jun 2016	Updates – new SDS, Section 6 – Communications Protocol, 5kW power.	MD
2.2	23 June 2016	Complete review by BOC New pictures Addition of Ethernet connection info	MD
2.3	20 July 2016	Review by MG Change of temperature range	MD
2.4	21 July 2016	Further review by BO	MD
2.5			MD
2.6	31 August 2016		MD
2.7	10 Nov 2016	Change in language around gas generation	MD
2.8		Grammatical and layout corrections. Improved detail and explanation.	BOC
2.9	21 Apr 2017	Introduction of BMS Changes to MMS information Grammatical changes	MD
	18 Oct 2017	Addition of BMS information Changes to self-maintenance behaviour New Changes to Maintenance Requirements SDS	MD
	15 Nov 2017	Updates with new BMS pictures and connections	MD
3.0	11 May 2018	Updates the ZBM label Updates the EC Declaration of Conformity	PW
4.0	26 June 2019	Added updated safety datasheet Section 6.4 and 6.5 added instruction to discharge and strip ZBM if ZBM has been offline for more than 1 month. Added EED Grammatical changes Table 1 and 2 updated Warranty references added	BOC

This page has intentionally been left blank.

redflow
advanced energy storage

Telecommunication Application

Renewables Integration

On and Off Grid Remote Power

Micro Grid and Smart Grid

Transmission and Distribution Deferral