Prevention of Explosions During Battery Charging in Relation to Diving Systems

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IMCA D 055 Rev.1 – Version History

Date	Reason	Revision
January 2021	Revised to strengthen the battery box venting system alarm arrangements in hyperbaric rescue units	Rev. 1
July 2016	Minor updates made during review process; new publication number	Rev. 0
October 1989	Initial publication (AODC 054)	

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1 Introduction

Battery charging related explosions have caused fatal accidents in the offshore industry. There have also been a number of injuries and near misses. The two main causal factors appear to be:

- inadequate ventilation of flammable gas emitted during charging;
- faulty 'trickle charging' which generates explosive gases.

An incident, details of which are contained in IMCA Safety Flash 17/14, highlighted the dangers of battery explosion, although the root cause of this incident remains undetermined.

2 Application

This guidance is intended to apply internationally, but it is recognised that some countries will have legislation that requires different standards or practices to be followed. Where local or national laws are more stringent than the advice contained herein, they will always take precedence over this guidance.

3 Explosive Emissions from Batteries Under Charge

'Open cell' batteries freely emit flammable explosive gases when under charge. The designation 'closed cell' or 'sealed' battery implies that gas will not be given off; this only applies, however, if charging is carried out at exactly the recommended voltage and pressure relief valves are provided for that reason. Various factors can influence the charging process such as: a faulty charger which can result in higher current levels being generated; aging batteries which can partially short themselves out resulting in a higher charge going to the remaining cells; batteries reacting to higher temperature and pressure; a cracked battery case; the fact that different chargers of the same type can produce different charging rates; and the possibility of operator error.

It must be assumed that batteries can, and given the right set of circumstances will, give off gas during charging, regardless of their type or charging arrangements. This can result in an explosion caused either by the sheer pressure of gas accumulating in a sealed battery or sealed compartment, or ignition by an additional source outwith the battery.

4 Self-Propelled Hyperbaric Lifeboats (SPHL) – Design Considerations

An SPHL by virtue of its design can constitute a gas trap. The equipment it contains such as gas cylinders, diesel fuel, electric controls, etc. can give rise to the development of potentially dangerous situations. For example:

- leakage of oxygen and generation of diesel fumes which can greatly increase the risk of fire or explosion;
- leakage of inert gas(es);
- production of highly flammable hydrogen gas during the charging process;
- ignition of gas due to sparking from electrical controls.

For the above reasons, the atmosphere inside an enclosed lifeboat which has been 'closed' for some time must be considered as suspect until it has been well ventilated.

Consideration should be given to the installation of a gas analyser to permit continuous monitoring of explosive gas(es) in the atmosphere.

4.1 Ventilation of the Battery Compartment

When batteries are charged inside the non-pressurised section of an HRU, the battery compartment must be ventilated to the open atmosphere outside the HRU. A suitably sized safe fan (brushless type) or other appropriate means of venting the compartment should be used in such a way that the battery compartment atmosphere is expelled externally, while fresh air enters by another route. It may be possible to configure a system such that a negative pressure is maintained in the battery compartments. All ventilation systems should be active whenever the batteries are charging. (A battery compartment simply fitted with an opening may still be full of explosive gas(es), only the excess of which will drain through the opening due to the lack of positive venting.)

Commercial catalytic convertors are available which can be located in the battery compartment. These operate by combining any hydrogen generated by the charging process with oxygen from the atmosphere to produce steam.

4.2 Safety Trigger Mechanisms

There is a requirement to install robust safety mechanisms that will set off an alarm and stop battery charging if ventilation of the battery compartment fails (IMCA D024 section 15.3). There are various methods which can be used to ensure that the HRU has a safe system for ensuring battery compartments are kept free from hydrogen build up.

4.3 Positive Pressure or Fan-assisted Battery Compartment Ventilation

If the battery compartment venting system utilises induced flow as its means of ventilating the battery compartment(s), then there must be a flow switch at the outlet of the compartment(s), which will trigger when flow is lost. Once it is triggered, the flow switch should immediately set off an alarm and stop battery charging. If the battery compartment venting system utilises a brushless fan for inducing flow then a tacho may also be adopted as a part of the trigger mechanism in addition to the flow switch.

4.4 Vacuum System

Some systems may utilise a vacuum system to ensure the battery compartments are kept free of hydrogen. If this is so a flow switch approach will not be sufficient and thought must be given to the inclusion of a reactive pressure device within the vacuum system, such as a pressure switch or transducer. Such a reactive pressure device would then form the basis of the trigger mechanism used to set off an alarm and stop battery charging when the pressure differential is lost.

4.5 Proof Testing

All of the operational and safety equipment which make up the battery charging system must be subject to a regular functional test. This should be documented and captured in the dive system PMS.

5 Batteries Fitted to Diving Bells and Hyperbaric Rescue Chambers

Batteries located outside a diving bell or hyperbaric rescue chamber (HRC) must be contained in a pressure and waterproof container fitted with a pressure relief valve. Pressure relief valves repeatedly exposed to seawater can malfunction and either fail to operate or permit seawater to enter. Dry lithium batteries, often selected for their attractive power to weight ratio, can and do react to contact with seawater by releasing large volumes of gas. It should be noted that, as battery containers are built to resist seawater pressure, a considerable amount of energy can build up if the relief valve fails to operate. Accordingly, a great deal of energy would be released if the container fails or when it is opened for servicing and operators must take appropriate precautions.

Batteries and their containers located inside a diving bell would have to contend with heliox seepage into them and consequent pressure build up. It is advisable therefore that they be located outside.

6 Battery Charging Procedures

For the reasons previously stated, consideration may be given to removal of batteries from an SPHL for charging off site, but only if a second set, fully charged, is installed in the SPHL.

When batteries are charged on site the following procedures should be adopted:

- Batteries should be located outside the SPHL or physically isolated from the atmosphere inside the lifeboat by a water tight compartment;
- The charging policy to be adopted should be defined. Trickle charging should be employed only if the voltage is checked carefully and regularly to ensure that it complies with the manufacturer's specification. In the case of diving bells, trickle charging appears to be the only viable procedure;
- The lifeboat atmosphere should be ventilated;
- Appropriate ventilation arrangements for the battery compartment should be made as specified above;
- Consideration should be given to the installation of a gas analyser to monitor the lifeboat atmosphere.

Note: When batteries have been fully depleted the charging power source(s) may be prone to overheating.

7 Planned Maintenance

A maintenance policy should be adopted in line with the above. It should address the following main areas:

- condition of equipment, i.e. pressure relief valves, chargers, batteries and their maximum permissible age, etc.;
- ventilation of SPHL and monitoring of its atmosphere;
- ventilation of battery compartment(s);
- inclusion of a test protocol for functional testing of all safety trigger mechanisms intended to activate alarms and stop battery charging when flow, or pressure differential, is lost within the battery compartment venting system;
- induction of new crew members/technicians/personnel whether or not employed by the diving contractor, which should include: system description; dangers; and operating procedures;
- use of warning signs in accordance with national convention/standards drawing attention to the danger of explosion during battery charging from smoking, naked lights etc., for instance:

DANGER – EXPLOSION
BATTERIES UNDER CHARGE
NO ACCESS TO UNAUTHORISED PERSONS
NO SMOKING
NO NAKED LIGHTS

Note: The above is given as an example of what might be considered suitable wording.

8 Conclusion

Contractors should consult with their own safety and technical advisers to ensure that their charging procedures are suitable.

9 References

1. Battery packs in pressure housings (IMCA D 002)
2. IMCA international code of practice for offshore diving (IMCA D 014)
3. DESIGN for saturation (bell) diving systems (IMCA D 024)
4. Use of battery operated equipment in hyperbaric conditions (IMCA D 041)
5. IMCA Safety Flash 17/14 – October 2014 – *Lithium battery pack explosion*
6. IMCA Safety Flash 31/16 – November 2016 – *SPHL Battery Charging - Build-Up of Hydrogen*
7. IMCA Information Note 1354 *SPHL Battery Box*
8. HSE Publication: *Using electrical storage batteries safely* – INDG139
9. WorkSafe Australia – *Preventing battery explosions* – November 2012 – ALE0158/01/11.12