FIA Guidance
Testing of lead acid batteries used in Fire Detection & Alarm System Power Supplies

FIA Guidance for the Fire Protection Industry

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1. Executive Summary / Abstract

1.1. This document examines the methods for test, measurement and validation of the capacity of batteries used in secondary or backup supplies to support fire alarm systems in a primary supply failure condition. It describes the need for battery testing and verification, the implications for getting it wrong, the pros and cons of the various methods available today and the recommendations for the most appropriate methods to be used.

1.2. The document concludes that:
- accurate testing of battery capacity is essential
- all test methods have some form of limitation
- the most accurate tests are problematic to implement on site
- Inadequate and / or inconsistent test methods are likely to result in variable results
- given the limitations of available technology, momentary or pulse load testing is currently ‘the best compromise’ for field use

2. Scope

2.1. This document is specifically directed at rechargeable batteries associated with power supplies covered by EN 54 Part 4 and therefore does not include batteries appropriate to other fire protection devices.

2.2. This document assumes that the power supply and battery are appropriately sized for the system capacity required.

3. Introduction / Background

3.1. Fire alarm systems use various types of industrial batteries as a secondary power supply for situations where the local primary supply is interrupted or fails. BS 5839 Part 1 sets out the design calculations and standby periods required that are used to size the battery capacity to support the system including a de-rating factor which caters for the inherent loss of capacity through the battery ageing process.

3.2. Design calculations are based on the performance norms and typical operating environments. These may not be appropriate for the entire operational life of a battery and do not cater for the possibility of a fault developing. High operational temperatures, intermittent partial short circuits and physical damage are examples of factors that can have an adverse effect on the realisable capacity of a battery. There is a real need to test and verify the effective battery capacity at each periodic maintenance visit.

3.3. The testing method used must not materially affect the charge state of the battery; to ignore this necessity would compromise the backup period for which the battery will support the fire alarm in a primary supply failure condition. It is also important to recognise that a testing regime is only a part of the assessment of the operational life of the battery. Age is also a significant factor as is storage or operational temperature(s) (for example).

The time taken to carry out the testing must also be considered; during testing the fire alarm system will not have its battery connected and any prolonged test should be avoided.
3.4. There are a number of methods used to test batteries; acceptable methods vary by battery type, chemistry and application but for each method there are specific pros and cons. Techniques include simple voltage measurement, coulomb counting, impedance / conductance measurement, load testing and electrolyte analysis.

3.5. Use of inappropriate testing technology for a given battery type can result in both false positive and false negative results leading to adverse implications:

Reporting a failing battery as satisfactory

- Fire Alarm System secondary or backup supplies will not support the system as intended, leading to the potential failure of detection and / or evacuation strategies.
- The root cause of premature battery failure is unlikely to be investigated.

Reporting a good battery as failing

- Inappropriate costs to end users of new batteries.
- Unnecessary disposal and other environmental costs.
- If occurring repeatedly should raise unnecessary investigations into root cause of premature failures.

4. Available methodologies

The following assume(s) that batteries under test are in a fully charged state

4.1. Full load test

4.1.1. General principles

a. For this test a constant current is drawn from the battery for an extended period of time (typically 20 hours), measurements of current and voltage are taken periodically from which the capacity of the battery can be calculated. Calibrated current, voltmeter and temperature measurement equipment of appropriate accuracy are required.

4.1.2. Advantages

a. Widely accepted as the most accurate method of testing.
b. Same test can be applied to various battery technologies.
c. Battery capacity in % terms can be calculated.

4.1.3. Disadvantages

a. Environment, Health & Safety issues due to potentially large current flows and heat dissipation.
b. Limited commercial availability of integrated test equipment.
c. Manual calculation required to find % capacity.
d. Leaves battery under test requiring a full recharge after test.
e. Safe space required for test equipment.
f. Battery discharge characteristics (specific to manufacturer and type) may not be available
g. Expensive test process
h. Full load test period 8+ hours.
i. Relies on specific test method implementation to be consistent

4.2. Reduced load or Maintenance load test
4.2.1. General principles
Similar to the full load test except that the period is reduced (usually performed by operating the system on battery for a shorter period of time than for a full load test). Calibrated current, voltmeter and temperature measurement equipment of appropriate accuracy is required.

4.2.2. Advantages
a. Sufficiently accurate and consistent results (only) if test properly designed and executed (rarely the case) but, if so, could be close to full load test.
b. Battery capacity in % can be calculated.

4.2.3. Disadvantages
a. Very difficult to define an appropriate test.
b. Environment, Health & Safety issues with potentially large current flows and heat dissipation.
c. Battery discharge characteristics (specific to manufacturer and type) may not be available.
d. Manual calculation required to find % capacity.
e. Leaves battery under test requiring a partial recharge.
f. Relies on specific test method implementation to be consistent.

4.3. Electrical electrolyte analysis

4.3.1. General principles
Test meter electrically analyses the electrolyte of the battery and from this the capacity of battery is estimated. Note: this is not a measurement of the specific gravity of the electrolyte.

4.3.2. Advantages
a. Lightweight portable equipment.
b. State of charge of battery under test not affected.
c. Capacity of battery displayed as Ah.
d. Minimal test time.

4.3.3. Disadvantages
a. Algorithms and adjustment tables used: results tend to be best match and unreliable.
b. Not easily calibrated.
c. Results intolerant of battery and environmental temperature changes.
d. Some models provide inconsistent results.
e. Limited to use on wet cells.

4.4. Momentary load or Pulse load

4.4.1. General principles
Test meter loads the battery with a pulsed or momentary series of loads. The duration and repetition of the load test cycle varies depending on the battery type and size.

4.4.2. Advantages
a. Accurate and consistent results.
b. Lightweight portable equipment.
c. Applicable to most fire alarm batteries.
d. Battery under test capacity unaffected.
e. Capacity of battery displayed as % or Ah.
f. Minimal test time; only a few seconds required.
4.4.3. Disadvantages
   a. Not as comprehensive as a full load or proper reduced load test

   Note: Care must be taken that the pulse or momentary load test equipment is correctly connected to the batteries. Poor connection can increase the apparent impedance of the battery and show as a fault

4.5. Battery voltage reading

4.5.1. General principles
   Typically the voltage of the battery is measured and compared to the optimal value expected; a small variation to this test is to allow a current to be drawn from the battery for a period of time to eliminate the surface charge.

   Note: A voltage test alone is insufficient to determine capacity

4.5.2. Advantages
   a. Simple calibrated voltmeter measurement
   b. Minimal test time

4.5.3. Disadvantages
   a. Does not give a true indication of health and condition of the battery; surface charge, temperature and age of battery affect results.
   b. Only applicable to Lead Acid type batteries.
   c. Prone to misinterpretation.
   d. Capacity % of battery under test undetermined.

5. Recommendations of Standards

   The following paragraphs detail the relevant clauses from standards relevant to fire alarm systems including the quality standard ISO 9001 all of which are referred to by third party certification schemes such as BAFE SP203 and LPS 1014.

5.1. BS 5839 Part 1 2013

   5.1.1. Clause 45.3 Recommendation for periodic inspections and test of the system
   45.3(e) "Batteries and their connections should be examined and momentarily load tested with the mains disconnected... to ensure that they are in good serviceable condition and not likely to fail before the next service visit..."

   5.1.2. Clause 25.3 Recommendations for fire alarm system power supply units
   “The following recommendations apply to every power supply unit that forms part of the fire alarm system.
   a) Transition between the normal supply and the standby supply, and vice versa, should not cause any interruption to the operation of the system or result in a false alarm.
   b) A fault in the normal supply should not adversely affect the standby supply or vice versa. The operation of a single protective device should not result in failure of both the normal and the standby supply.
   c) The presence of the normal or the standby supply should be indicated by a green indicator, located in a position that makes it readily obvious to any person responsible for monitoring faults on the fire alarm system (e.g. at the location of the main indicating equipment).
d) Normal and standby supplies should each be independently capable of supplying the maximum alarm load of the system (see 3.35), irrespective of the condition of the other supply.

Clause 25.4 Recommendations for standby supplies

The following recommendations are applicable.

The standby supply should comprise a secondary (rechargeable) battery with an automatic charger.

The battery should be of a type having a life of at least four years under the conditions of use likely to be experienced in the fire alarm system. Automotive batteries (of the type used for starting car engines) should not be used.

Labels should be fixed to all batteries indicating their date of installation. The labels should be so sited that they can be read without disturbing the batteries.

The charging rate of the battery should be such that, having been discharged to its final voltage, the battery can be charged sufficiently to conform to 25.4e) after a charging period of 24 h.

NOTE 1
This is the requirement within BS EN 54-4, but it is included here as a reminder that connecting larger batteries than originally designed, for example due to an unforeseen extra load, can result in unacceptably long recharge times.

The capacity of all standby batteries that serve any part of the system which has to operate correctly in order to satisfy the recommendations of this part of BS 5839 should be such as to satisfy the following recommendations. The capacity required to satisfy these recommendations should be calculated in accordance with Annex D.

1) For a Category M or Category L system, the capacity should be sufficient to maintain the system in operation for at least 24 h, after which sufficient capacity should remain to provide an “Evacuate” signal in all alarm zones for at least 30 min, unless the building is provided with an automatically started standby generator [see 25.4e)2]].

NOTE 2
If the premises are likely to be unoccupied for longer than the duration of the standby battery capacity at any time, and there is a facility for transmission of fire signals to an alarm receiving centre, it would be of benefit to transmit power supply fault signals to the alarm receiving centre, for notification of the user.

2) For a Category M or Category L system in a building with an automatically started standby generator that serves the fire alarm system, the capacity should be sufficient to maintain the system in operation for at least six hours, after which sufficient capacity should remain to provide an “Evacuate” signal in all alarm zones for at least 30 min.

NOTE 3
If a circuit serving part of the fire alarm system (e.g. distributed power supply unit) is not served by the standby generator, the capacity of the standby battery ought to conform to 25.4e)1).

3) For a Category P system in which either of the following apply, the capacity should be sufficient to maintain the system in operation for at least 24 h, after which sufficient capacity should remain to operate all fire alarm devices for at least 30 min:
i) where the building is continuously manned, or inspected outside normal working hours, such that staff in the building would be aware of a power supply fault indication on the system within no more than six hours of its occurrence; or

ii) where power supply fault signals are transmitted automatically to an alarm receiving centre, instructed to notify a keyholder and, if required, the previously agreed service provider immediately on receipt of a fault indication from the premises.

4) For all other Category P systems, the capacity should be sufficient to maintain the system in operation for at least 24 h longer than the maximum period for which the premises are likely to be unoccupied or for 72 h in total, whichever is less, after which sufficient capacity should remain to operate all fire alarm devices for at least 30 min. If the building is likely to be unoccupied for more than the duration of the standby battery capacity at any time, and there is a facility for transmission of fire signals to an alarm receiving centre, power supply fault signals should also be automatically transmitted to the alarm receiving centre, for immediate notification of a keyholder.

If, in addition to the equipment recommended in Clause 23, additional CIE, over and above that necessary for compliance with this part of BS 5839, is provided, it might not be necessary for any standby battery capacity supplying the additional equipment to conform to 25.4e). However, if the equipment is used as the normal method of indication of fire to persons responsible for monitoring the system, a standby supply should still be provided for this additional equipment. If the equipment recommended in Clause 23 is suitably sited for use as a “default” in the event of failure of the additional equipment, the capacity of the standby batteries serving the additional equipment should be sufficient to operate the system in the quiescent mode for at least four hours. If the equipment recommended in Clause 23 is not suitably sited to enable effective control and monitoring of a fire incident, the standby power supplies for the additional equipment should satisfy the recommendations of 25.4e).

5.2. Extract from ISO 9001 section 7.6

“Where necessary to ensure valid results, measuring equipment shall
a. be calibrated or verified at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded;”

6. Calibration

Any test and inspection regime should ensure that the condition report is reliable and consistent. The condition of the secondary power supply is a significant issue and any doubt in the reported state should be avoided where ever possible.

Any validation method which uses measurement equipment that cannot be calibrated in some form is likely to be unreliable over time and variable between test devices.

The consistency of the test method used across the industry is also an important factor; use of calibrated equipment loses its value if the test methods implemented are not consistent.

7. Conclusions
While testing the battery the engineer should also consider the charging rate of the battery such that, having been discharged to its final voltage, the battery can be charged sufficiently to conform to 25.4e) of BS 5839-1 after a charging period of 24 hours

Accurate testing of battery capacity is essential to avoid both premature replacement of batteries and misreporting systems as satisfactory. It is also essential to identify those systems where premature battery failure would warrant further investigation.

All test methods have some form of limitation.

The most accurate tests are problematic to implement on site, commercially expensive and leave a battery with less than full charge thus compromising the available capacity until a recharge is achieved leaving the premises management with a fire safety risk.

Manual test methods that need to be replicated accurately by different engineers across the industry over time even using calibrated test equipment are likely to result in inconsistency.

Field experience has shown that the electrolyte analysis type battery testing is currently not sufficiently accurate, consistent or reliable to be satisfactory for Fire Alarm battery capacity verification.

Inadequate and / or inconsistent test methods are likely to result in variable results.

Given the limitations of available technology, momentary or pulse load testing is currently ‘the best compromise’ for field use

8. References & Bibliography

BS 5839, Fire detection and fire alarm systems for buildings – Part 1: Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises