THE IEEE 1491 BATTERY MONITORING STANDARD AND REVISION ACTIVITIES

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(IEEE Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications)

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ABSTRACT

IEEE Std1491™-2005, "Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications" was released at the end of 2005 after several years of development. IEEE Std. 1491™-2005 is sponsored by the Institute of Electrical and Electronics Engineers (IEEE) Power Engineering Society's Stationary Battery Committee.

This paper presents some pertinent information regarding this relatively new Guide and what it means to the audience in a simple and informative fashion. It also discusses the work that is currently under way to update and revise the standard.

The paper examines the scope and purpose of the Guide and presents the seventeen defined monitoring parameters. These monitoring parameters are looked at from a data collection, user and manufacturer's perspective to see if all are really needed and should any be removed or redefined. It also asks the question; is there anything missing?

The paper concludes by looking at where battery monitoring is going and what the future may have in store.

INTRODUCTION

Discussions and development of this Guide commenced in 1995, with IEEE Project Authorization Request (PAR) formally approved in December 1996. The need for this standard was established as several battery monitoring systems had been developed and were coming into the marketplace. As a result, a guide to battery monitoring was considered to be of use to battery users, maintainers and integrators. The initial work on this Guide, and its initial drafting was developed by the Battery Monitoring working group under the IEEE Standards Coordination Committee 29 (SCC29). In 2002, SCC 29 became a part of the IEEE PES Power Engineering Society (PES), and was renamed the Stationary Battery Committee. It is responsible for all stationary standby battery standards for the IEEE Standards Association. SCC21 sponsors stationary battery standards in alternative energy applications.

IEEE 1491-2005 moved from PAR status to a formal released standard in late 2005, and went through 3 formal approval ballots. Many contributions, changes, and additions were made by members of the Working Group and other interested parties during the period from 1996 to 2005. At the time this Guide was completed the Battery Monitoring Working Group was composed of 44 members, who are named in the standard. When the standard was formally balloted and approved, there were 45 individuals who balloted the standard, who are also identified in the guide standard.

During the 10 years of development there were 3 different chairmen of the working group. The technology in the standard was drawn from all parts of the battery industry. This included manufacturers of batteries, battery monitoring and battery measurement equipment, Uninterruptible Power Supplies (UPS), rectifier/chargers, and many other manufacturers and users of battery connected equipment. Other contributions came from installation, maintenance, and consulting firms, computer and software technology organizations, and from many others in varied engineering disciplines.

Presently, IEEE 1491-2005 has been formally opened up for revision under a new PAR. A new working group has been formed to complete this activity and to align this Guide with current technology, and other applicable standards under the control of the Stationary Battery Committee.

CONTENT

The present Guide is divided into 11 clauses as listed and described in Table 1 below:

1.	Provides the scope and purpose.
2.	References other related standards.
3.	Contains terms and definitions.
4.	Refers to safety items.
5.	Contains battery types referred to by this standard.
6.	Discusses battery monitoring techniques, benefits, and limitations.
7.	Lists all monitoring parameters with their description, purpose, plus indications and interpretations.
8.	Describes communications and interfaces.
9.	Discusses operating environments.
10.	Contains installation considerations.
11.	Discusses monitoring considerations for different battery applications.

Table 1.

The Guide contains five annexes. Two are "normative" (a part of the Guide), and three are "informative" which contain supplemental information not considered an integral part of the Guide

These annexes are:

A (normative) - Communication Options
B (informative) - AC Ripple Voltage and Current
C (normative) - Environment
D (informative) - Sensors
E (informative) - Software

IEEE 1491 MEASUREMENT PARAMETERS

Clause 7 contains battery measurement parameters subject to continuous monitoring. At present there are 17 defined parameters. Each parameter has a description, purpose of monitoring, and an indications and interpretation analysis. A list of the present measurement parameters is shown below:

1. Float Voltage
2. Equalizing Voltage
3. Recharge Voltage
4. Open Circuit Voltage
5. Discharge Voltage
6. Midpoint or Partial String Voltage
7. Cell/Battery DC Current
8. Ripple Voltage
9. Ripple Current
10. Cell/Unit Temperatures
11. Ambient Temperature
12. Cycles
13. Cell/Battery Ohmic Values
14. Specific Gravity
15. Electrolyte Level
16. Connection Resistance
17. Ground Fault Detection

Below are samples including a brief summary of some selected measurement parameters contained within the present Guide.

1- Float Voltage

- Description
  The voltage applied to a cell/battery to maintain it in a fully charged condition during normal operation.
- Purpose of monitoring
  Identify and report out-of-range values.
- Indications and interpretations
  Loss of capacity, sulfation, grid corrosion end of life issues, gassing, water loss, (dry-out in VRLA), and thermal runaway.

5 – Discharge Voltage

- Description
  Discharge voltage is the voltage measured across battery and cell terminals at any point in time during discharge.
- Purpose of monitoring
  Collection of information concerning battery terminal and individual cell voltages during discharge is fundamental in determining the capacity of the battery, analysis of individual cell performance, and inter-cell connection integrity.
- Indications and interpretations
  Indication of low battery/cell capacity, battery deterioration, low state of charge, and/or high connection resistance.

8 – Ripple Voltage

- Description
  Ripple voltage is the AC voltage component on the DC bus. Applications such as telecommunications, switchgear, and engine starting, will typically have lower ripple components than UPS
- Purpose of monitoring
  To identify and report out of range values that could impact the performance of the battery and/or charging system.
- Indications and interpretations
  The normal level of ripple voltage for each system must be individually determined by initial and ongoing measured values. Monitoring the exact value of this parameter is not as important as trending the value as the system ages.

10 - Cell/Unit Temperatures

- Description
  Cell/ Unit temperature is the actual temperature of the cell as measured by a contact or non-contact temperature-measuring device.
- Purpose of monitoring
  Temperature measurements are used to identify potential battery problems and can be used to control rectifier/charger output.
- Indications and interpretations
  Abnormal temperatures affect the operation of the battery.
  Changing temperature trends indicate other changing conditions.

13 – Cell/Battery Ohmic Values

- Description
  The internal ohmic value of a cell/unit consists of any value of resistance, conductance, or impedance derived from the relationships between changes in voltages and currents in a stationary battery under various conditions and used as an indicator of a battery's state of health.
- Purpose of monitoring
  These measurements provide information about battery internal state of health.
- Indications and interpretations
  Changes and differences are subject to careful interpretation, and can be considered significant.

WHY THE REVISION?

Present revision activity objectives, are to further and more correctly define the measurement parameters, based on changes in technology and collective monitoring experience gained. Additional information and new parameters will be added as deemed appropriate. Examples include a more comprehensive definition of the term "ohmic value" or a possible change of that term. In addition, "ripple voltage and current" is being redefined with its resultant indications and interpretations.

EXAMPLE

An example of initial changes (under process) for Section 7. 13 – "Cell/Battery Ohmic Values." This includes the following revised description of this parameter:

<u>"The internal ohmic value of a cell/unit consists of a value, commonly expressed as resistance, conductance, or impedance, derived from the response to changes in voltage or current stimulus."</u>

Items including coup de fouet, sulfation, noise, and other measurable parameters may be added.
There are now many manufacturers of battery monitoring equipment and systems that didn't exist when the original battery monitoring Guide was first developed over 10 years ago. These newer, and redesigned, monitors include advancements in technology and techniques, which may result in the need for updating monitoring descriptions and parameters.

PRESENT REVISION ACTIVITY

Draft changes are presently in process, with the next draft change session in June 2007 at The Stationary Battery Committee Columbus, Ohio meetings.

Some of the actual assignments for the working group are as follows:

Section 7.3 – Recharge Voltage re-write.

An informative annex will be written defining all voltages (float, equalize, discharge, recharge, etc.,) present during all distinct operational modes. This annex will refer to all presently defined voltage parameters in Section 7 – Measurement Parameters.

Several individuals are assigned to write changes to ripple parameters: "Ripple Voltage and Ripple Current." These individual committee members will coordinate their changes and new material with each other. The assignments regarding this are as follows:

1. Re-write Annex B (AC ripple voltage and current).
2. Words will be included regarding crest factor as it relates to ripple.
3. This activity will be applied and coordinated with Annex B (AC ripple voltage and current), and inputted to section 7.8 (Ripple Voltage), and 7.9 (Ripple Current).

A re-write of Annex C.1 (Ambient Temperature) will be applied and appropriate portions of this annex will be included into Sections 7.10 (Cell/Unit Temperatures), and 7.11 (Ambient Temperature).

A small task force group within the working group has been assigned to submit recommendations for coordination of IEEE 1491 and IEEE 1660 (Battery Cycling). This would also be applied to section 7.12 (Cycles).

Individuals within the working group will re-write section 7.13 (Ohmic Measurements). This will also generate a new Annex on this subject. These items will be coordinated with the output of the Ohmic Value Task Force assigned in the last General Meeting of the Stationary Battery Committee.

The objective of the this Task Force, and the Battery Monitoring Working Group, is to provide a uniform "Ohmic Value" definition across other battery standards, i.e.: IEEE 450 – IEEE Recommended Practice For Maintenance, Testing and Replacement of Vented Lead-Acid Batteries in stationary Applications, IEEE 1188 – IEEE Recommended Practice for Maintenance, Testing and Replacement of Valve-Regulated Lead-Acid Batteries for Stationary Applications, and IEEE 1106- IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications .

CONCLUSION

Battery Monitoring can be carried out manually, automatically, or using a combination of both. Some users are trending toward smaller, more distributed battery installations, and more installations in remote locations. These factors, coupled with the lack of battery knowledge and maintenance skills of the end user's personnel, lead the authors to believe that automatic remote monitoring and analysis will rapidly become more significant. This monitoring will also include certain automatic control features imposed on the battery and associated charging equipment.

As new battery chemistries and technologies move into the stationary battery arena, monitoring and management are, and will increasingly become, an integral part of the battery system. This integration is offered in some of the commercially available energy storage systems that utilize chemistries other than Lead-Acid or Nickel-Cadmium.

Monitoring techniques will become more refined, the components will become more economical, and economy-of-scale will drive down the cost of monitoring. Indeed, monitoring may well be built into the battery. Technologies that allow the provided monitoring data to be fed to a computer system and then automatically acted on are available now. A variety of methods to accomplish this are also now available in web-based applications.

As the technology advances, the ability of the monitoring equipment becomes more sophisticated, and the algorithms for automated management are becoming more refined. These enhancements will allow for a much better stream of meaningful data to be presented to the end user, and allow the automated management of most battery systems.

Automated battery management will be capable of handling the normal day-to-day monitoring of the batteries, act to enhance the condition of the battery, and in the event of an issue that it cannot deal with, notify the responsible parties that they need to intervene.

Specifiers and users now have a recognized Standard/Guide to refer to in Request for Proposal (RFP), Request for Quotation (RFQ) and other bid documents and specifications. These will require that battery systems and monitoring equipment meet certain aspects and guidelines of IEEE 1491. This is also an American National Standards Institute (ANSI) approved standard.

Other standards, codes, methods and guides will refer to IEEE 1491 in their documents. In certain cases, public safety, insurance and permitting entities will establish substantial monitoring requirements.

REFERENCES

IEEE Std 450™, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.

IEEE Std 484™, IEEE Recommended Practice for Installation Design and Implementation of Vented Lead-Acid Batteries for Stationary Applications.

IEEE Std 946™, IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations.

IEEE Std 1106™, IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.

IEEE Std 1184™, IEEE Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems.

IEEE Std 1187™, IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Storage Batteries for Stationary Applications.

IEEE Std 1188™, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.

IEEE Std 1189™, IEEE Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.

IEEE Std 1491™, IEEE Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications.

NFPA 1, Uniform Fire Code™.

NFPA 70, National Electric Code® (NEC®)

Federal Communications Commission, Part 15 FCC Rules, Subpart J, Class B.