PERFORMING STATIONARY BATTERY SYSTEM CONDITION ASSESSMENTS AT GENERATING STATIONS

E. Scott Slickers, PE
Electrical Systems Engineer
PSEG Power
Newark, New Jersey 07102

ABSTRACT

This paper describes reasons for and the resulting benefits derived from performing a systematic assessment of stationary battery systems. I describe the processes used for assessment plan development, the methodology for implementation and writing a report of findings. I also discuss examples of findings, lessons learned and resulting action items.

INTRODUCTION

Why spend the time, money and effort to perform a detailed assessment of your battery systems? There are many good reasons; some which are obvious but many others may not be. The company I work for has aggressive goals related to station and system performance. Recently, critical reviews the health and performance of all systems identified opportunities for improvement. Stationary batteries and DC systems were areas identified for potential improvements. To accomplish these improvements, a battery system condition assessment was performed.

Our company is typical to many other companies utilizing stationary battery systems in UPS and emergency power. We have a wide variety of battery sizes and types; including flooded and valve regulated lead acid batteries. Not only is station equipment availability and performance critical; but more important is safety, reliability and compliance with all applicable regulatory standards. By their very nature, battery systems are critical but sit “silent” and not utilized a majority of the time. The proper operation, maintenance, testing and compliance documentation are critical to supporting system operational requirements. In performing evaluations of battery system conditions some gaps were identified that further reinforced the need to perform periodic routine assessments in the future. When was the last time you performed a thorough physical condition and maintenance practices assessment of all your facilities DC systems? Do you have an up to date centralized data base with details of all the components and reference documents? Taking the time to collect, analyze and act on physical inspection findings and data yielded an enormous amount of useful information. Some of the reasons the system conditions assessment project was initiated included:

- Recent events of poor battery system performance that led to equipment damage or extended equipment outage time.
- Review of insurance inspection report comments.
- The need to evaluate impacts of proposed regulatory changes. Specifically, the pending revisions to NERC system protection maintenance reliability standard PRC-005 and potential impact on existing practices of maintenance and the appropriate documentation for compliance evidence.
- Recognizing that we have a continually changing work force (aging). New and replacement employees that may or may not have the technical skill sets to perform inspections, test and evaluate data for negative trends. Organizational changes that created the opportunity for gaps in established maintenance programs to develop.
- Need to have an updated centralized data base with details of battery system components and inspection data. We have added many battery systems to the fleet in recent years, and not all of the relevant OEM data was available for reference as needed.
- The need to perform audits for compliance with existing process and procedures. Also, to reevaluate the accuracy of existing procedures and processes. Are they in alignment with equipment that has been recently installed? How do they compare to the latest industry best practices and recommendations?
- Recognizing that future needs for replacement equipment needed to be determined in order to plan for future resource requirements.
- Assessing the results of any training and how it impacted inspection and maintenance practices. Does the training reflect what is needed and is it being applied in practice?

ASSESSMENT PLAN DEVELOPMENT
(DETAILED PREPARATION IS THE KEY TO SUCCESS!)

After the need for an assessment plan was justified and approval received, I recognized that planning of the assessment implementation was just as critical as actually performing it. Looking back, one key element to my success was the preparation and planning; it cannot be overstated how critical that was! With limited resources and inability to visit facilities multiple times, a good assessment plan dictates that a formal – measurable process be in place. In my case, there were 154 battery systems at 15 sites located in 5 different states targeted in the assessment scope. Taking the time up front to develop a process with a schedule and distinct set of goals has to be done.

I wrote a formal plan that was tailored to the organization's needs. In the plan, you should define the purpose, scope, methodology and planned deliverables of the report. Have a draft of the plan reviewed and approved so there is no misunderstanding about expectations of scope and deliverables when the final report is issued. Depending on your technical skill set, some additional preparation prior to the plan development may be in order. In my case, I have many technical responsibilities within the organization that include various areas of responsibility beyond battery systems. I recognized the need to increase my basic knowledge and get some refresher training. Being self critical and recognizing gaps in knowledge was important. Industry events that include seminars with training events are great opportunities to gather knowledge and resources. These events also allow you to meet people within the industry who can provide support for your technical questions.

I elected to solicit some specialized technical expertise to provide independent analysis and help with the physical cell inspections. That turned out to be one of my best decisions. Besides the expert opinions received, a big benefit to me was that my understanding and knowledge of battery types, capabilities and systems increased significantly. That knowledge in turn has provided great value dealing with issues long after the assessment was completed.

I also began to assemble all the relevant reference documents that would be needed to support the basis for my inspections, findings and recommendations. I highly encourage you to collect, *read* and utilize all the relevant IEEE recommended practices and guides for all the battery types. I found that, in addition to my own development, these data collection tasks are ideal for a new cadet engineer as a development tool. Collecting related information, reviewing drawings, determining where to get reference data, and then assembling into a central database will start to get them familiar with the details of your facilities. Additional resources I gathered in the plan development prior to performing the assessment are listed below.

- **Existing databases**: Do you have a list of battery system components? If so collect them and use them to compile a master data base that will be expanded and updated with all the information collected.
- **Online drawings**: Assemble and print a set of drawings for reference during field walk down.
- **Access to work management process, procedures and data**: If you have an existing work management system review the process and procedures, collect the reports and any associated data. This can be used for trend analysis and comparison to compliance with recommended practices. Sometimes data is retained at the facility itself or a centralized location. Review the data and look for gaps that may be filled when performing inspections.
- **OEM (original equipment manufacturer) data sheets**: Begin to collect all the relevant OEM operations and maintenance manuals; these can then be easily referenced for technical issues. You will find this information useful when looking at field conditions and inspections data. For example, recommended float/equalize voltages, verifying ratings, specific gravity information, and comparison of load test data to published ratings. Many times with older batteries that information is not on the jar or has become illegible.
- **IEEE recommended practices**: Collecting all the recommended practices for each type of battery you have.
- **Electrical installation and safety codes**: Become familiar with the installation requirements.
- **Insurance provider or underwriter information requirements**: They can be a valuable source of information regarding trends within the industry and providing lessons learned from other's experiences. Also review any findings and recommendations from previous inspections.
- **Training lesson plans**: Obtain instructor outlines and any literature from recent training modules. If possible, sit in on a training session to determine what is and what is not being covered.

- **Relevant regulatory standards**: Having the standards will allow you to verify compliance with existing requirements. Also of equal importance is researching any recent or pending changes that may impact your maintenance practices and data retention requirements for compliance.

Once the plan is approved, prioritize the goals and determine what resources and time are needed. Some facilities may be new and not require much in the way of detailed inspections as compared to older facilities. Some facilities may be slated for retirement, so they may move to a lower priority in the event the allotted time runs short. Preparing a schedule with all the activities is helpful to coordinate the sequence and make best use of time when performing assessments. If you have many facilities and they are in a diverse geographic area the preparation is even more important. In many instances you can take advantage of being at a facility for another purpose and perform the assessment as a second activity. Advanced planning also allows responsible personnel at facilities to be contacted so they can be prepare requested information and participate in the physical inspections.

Allow time in the scheduled visit to discuss any items that may need immediate action. It is also good time to discuss why the assessment is being performed and how it supports corporate goals and what the potential impacts are of pending regulatory changes. A word of caution when developing the plan; don't bite off more that you can chew. Depending on availability of your (and other's) time, the number of facilities you want to include and their physical locations, there may be a need to do things in phases. Also as said before, tailor the plan with the goals prioritized, recognize what has to be done in the field versus what can be done in the office. Performing physical inspections and collecting data will provide you the ability to perform more detailed analysis later as your time allow or specific needs arise.

The primary focus of my assessment was the physical condition of batteries, racks, chargers and enclosures. I also evaluated maintenance work practices, reviewed test data, required data retention practices, regulatory requirements and industry and OEM experiences. I did a basic overview of system configuration design review, but left a detailed analysis of capacity or protection for future recommendations based on inspection observations. Recognize that some of the items you set out to do may not be completed due to time and resource availability.

FIELD INSPECTIONS AND DATA COLLECTION

Once you start the physical inspections and data collections it may be easy to get side tracked. I found having a data collection sheet to be a valuable resource as a tracking tool. When going to multiple locations within a facility having one data sheet for each system allowed me to keep track of what information I needed and to make sure all assessment tasks were complete before leaving. I kept all my rough notes with inspection observations, findings and potential recommendations on these sheets. Also on this sheet I listed things that had potential for being generic issues and action items. These sheets provided the details and basis I needed to address prior to starting a detailed report, and it assured I approached each battery assessment consistently.

Figure 1 is an example of a data sheet I used. If you plan ahead, the data sheet can easily be configured so that as raw data and information is entered there are links to populate a master index with desired information (another good job for the cadet engineer!). In addition, a digital camera proved to be another valuable tool. Taking high definition pictures of all the components and having them available was useful for jogging my memory when writing the report. The pictures were also stored by system ID in a central data base. Pictures of items that needed immediate attention were included in the final report summary. When at the facility I reviewed the maintenance procedures, test data and archive methods.

FIGURE 1. Typical data collection and assessment sheet

INDIVIDUAL SYSTEM DATA COLLECTION SHEET EXAMPLE

Battery Assessment Data Sheet and Checklist

Station	Battery Equip Tag Name:	
Unit /System	DC 1 Line Dwg No.	

Battery Information

Manufacturer:	*Typ Cell S/N & Date Code*	
Model /Type:	*8 Hr Rating:*	Voltage
Date of Mfg.	*# of Cells*	In Service Date
Specific Gravity	*Pilot Cell ID*	Cell Temperature

Charger Information

Charger Equip Tag Name	Mfg/Model	
Redundant Chargers?	Alarm to control room?	Capacity

Misc. Station Information

Other	
Battery Functional Location Info:	(Work Management Program ID For Battery)
Charger Functional Location Info:	(Work Management Program ID For Charger)

Condition Assessment Walkdown Data, Observations and Associated items Checklist

In this section general notes are listed about the battery, chargers, racks, enclosures, HVAC, safety equipment, etc. while collecting the detailed data llisted on checklist.

Copy OEM Data on file with maintenance Instructions and capacity information?			
OEM Contacted for information bulletins?		Any Known issues? (describe below)	
Room/Enclosure Inspections	HVAC :	Eyewash:	Lighting/Fixtures:
	Racks:		
Last Battery Acceptance / Load Test date:		*Last Annual Inspection performed*	
Battery Inspections	Cells:	Connections:	Plates/Sediment:
	Cell Temp:	Charge Current:	Electrolyte Level:
	Pilot Cell identified?		
Charger Inspections	Indications/Alarms:		
	Output Volts	Output Amps	
Maint. Records	Maintenance Records Collected:		
	Maintenance Procedures Collected:		
	Work mangement Plans / Notifications Printed:		
Oper Round Sheets	Exist:	Cover Batteries:	
	Get Copy:	Archives:	

Battery/Charger/Enclosure Inspection Notes

In this section, notes are taken for reference when preparing assessment report. Note condition of cells (plates/post/jars). Note condition of chargers (any alarms/grounds?)

Auxiliary Equipment Notes

In this section list notes associated with the auxiliary equipment (lighting, racks, HVAC, safety equipment, etc.)

Post walkdown assessment checklist

Review System components/loads as compared to basic design basis:
Maintenance Plan Vs, Recommended PM/PdM review. Proper items and criteria:
Do the current Maintenance Practices meet regulatory criteria?:
Inspection and test data reviewed:
Operator Rounds review:
Maint Plan in work management system?:
Update Master Database:
Review last load test data:

Remaining Life assessment:

Date of Assessment:	Completed By:

PREPARING THE REPORT OF ASSESSMENT FINDINGS

Typically nobody will read a huge assessment report from front to back, especially if it discusses many systems in multiple facilities, therefore consideration for specific goals of multiple end users of the report will enhance its effectiveness. Each section was targeted to a specific perspective audience to allow for efficient use. Having the report details segregated by topic and location allows the desired information to be quickly accessed, understood and utilized efficiently. With the exception of the executive summary, each major section provided a detailed analysis with reference to standards and what gaps exist. Each section has specific information that is useful depending on the reader's perspective. Consider the wide variety of audiences prior to writing each section. The report format I used was as follows:

- Introduction: A brief section on what was done, why it was done and how it was done.
- Executive summary: A very condensed version of report with brief summary of findings and recommendations. Remember that everybody will read this section, so any items that need immediate attention should be described up front.
- Assessment methodology and references used.
- Generic assessment findings. This section includes a detailed overall assessment from a fleet perspective.
- Maintenance and inspection plans review.
- Training program review
- Detailed physical inspection findings, do this on a facility and system basis. This section will be utilized by a station manager or maintenance manager to review the specific observations, details of gaps with maintenance, inspections, data retention, negative trends and recommendations.
- Recommendations: This section refers the reader to their specific sections of the report that details the gaps, what remediation is required and who owns the action item.

FINDINGS, BENEFITS AND LESSONS LEARNED

There were many gaps identified as a result of the assessment, many of which may have gone unaddressed if a report with recommendations (corrective actions) was not issued. Examples of the things that could be found include:

- Wrong float and equalize voltages for the style battery
- Alarms on battery chargers
- High ambient room or enclosure temperatures
- Frequency of inspections and testing was not in accordance with published practices.
- Misapplication of testing protocol with regards to the battery design.
- Test data record retention issues - ability to quickly access the data from central location.
- Overdue or no scheduled load test.
- Need to update some maintenance procedures and work management system entries to align with the current equipment installations and pending regulatory changes.
- Improper maintenance/test practices and housekeeping issues.
- Not being able to recognizing issues with plates / separators / jars / connections and noting such on inspection sheets for corrective actions.
- Some banks approaching end of life based on age and/or test data analysis with no replacement strategy in place.

Many benefits and lessons were learned as a result of the assessment:

- Identification of types of issues listed above.
- The collection of information and loading it into a master data base provides an excellent resource when battery issues arise. Having an up to date listing with the types of battery, age, information regarding recent test, etc is an excellent resource. The updated data is now managed in a centralized location that all have access to.

- Needs for equipment replacement in the short term and longer term were identified that will be used in the planning and budgeting process. Doing this will avoid emergent work and reduce unplanned equipment outages.
- I established contacts and relationship with equipment suppliers that can assist with technical questions. They also provided suggestions and recommendations of alternative solutions when technical questions arise or replacement equipment is under consideration.
- The benefit to having a cadet engineer associate involved with the assessment process provided him with a great learning opportunity and helped with his development.
- Training modules are being revised to emphasize the requirements of a proper maintenance program to address the gaps uncovered.
- A few safety issues were discovered and quickly rectified.

CONCLUSIONS

If no battery assessment has been performed recently at your facility, then one is probably needed. The results of performing a systematic assessment will yield many benefits that will justify the time and resources required.

ACKNOWLEDGEMENTS

I want to thank Marco Migliaro of ESA Consulting Engineers. His technical knowledge and valuable input with developing and implementing the assessment were of great help. His encouragement, willingness to teach and share information was invaluable. I would also like to thank Clint Bogan of PSEG Power for his technical reviews and support in performing the assessment.