DEPARTMENT OF THE AIR FORCE
Headquarters US Air Force
Washington DC 20330-1680

Air Force Job Qualification
Standard 3E0X2-214D
11 August 1994

# STATIONARY BATTERY BANKS
(Electrical Power Production Journeyman/Craftsman)

## SECTION A: GENERAL

1. This Air Force Job Qualification Standard (AFJQS) and attached Air Force Qualification Training Package (AFQTP) standardize on-the-job training (OJT) tasks and constitute an approved training program for the maintenance of Stationary Battery Banks. The AFJQS and AFQTP are used by unit training managers, supervisors, trainers, trainees, and other training functions to plan, conduct, and document OJT on this equipment.

2. Maintain the AFJQS IAW AFI 36-2233 and AFR 50-23. Routine changes will be accomplished via page changes and urgent changes will be disseminated via message. Enter additional local tasks in the blank areas on the AFJQS or add forms. Develop Task Training Guides for added tasks; they should be consistent in content and format with those in the AFQTP. Submit recommended AFJQS/AFQTP improvements/corrections to the 81 TRSS/TSQS, 601 D Street, Keesler AFB MS 39534-2229.

3. Review Air Force publishing bulletins and AFIND8 to identify available training materials. Use this AFJQS in conjunction with other applicable JQSs or the Specialty Training Standard (STS) and locally-assigned tasks to identify work center duty positions. Also, use this AFJQS along with other applicable JQSs and the STS to evaluate newly assigned personnel and identify individual training requirements.

4. Tasks listed on the AFJQS have been selected IAW the Instructional System Development (ISD) process and are the minimum, mandatory AF training requirements for this equipment. An asterisk (*) preceding a task statement indicates it may not be common to all equipment configurations and training may be deferred if not applicable. Rationale for this deferment should be documented in the work center training plan.

5. Trainees must accurately perform each assigned task unassisted IAW Technical References (TRs) prior to being certified. To qualify for skill-level upgrade, trainees must be certified on assigned tasks, satisfactorily complete career knowledge training, and meet mandatory specialty qualifications IAW AFRs 35-1 and 39-1. After upgrade, assign individuals to other work center duty positions and continue qualification training.

Supersedes QTP 542X2-214D, dated 25 July 1990
OPR: HQ USAF/LGMM
OCR: 81 TRSS/TSQO
DISTRIBUTION: F

**SECTION B: DOCUMENTATION**

1. AFJQS/STS tasks will be compiled in an automated training management system, such as the Core Automated Maintenance System (CAMS), if available. The system must contain each AFJQS/STS title line with appropriate AFJQS/STS numbers, titles, and dates. AFJQS/STS and automated documentation requirements are listed below.

a. Load applicable tasks in the automated training system or identify training requirements by circling the task numbers on each individual's AFJQS/STS.

b. If task statements contain more than one noun or action verb which precludes certification on the entire task, load/circle the noun or verb to indicate the individual is being trained only on that portion of the task.

c. When training is started on a task, enter the start date in the appropriate place. When training is complete, document training and task certification IAW local certification procedures.

2. The identification blocks listed below are to be used when the trainer is other than the trainee's immediate supervisor.

| TRAINEE'S NAME: | INITIALS: | SSN: |
|---|---|---|
| TRAINER'S NAME, INITIALS, DATE: | | |
| TRAINER'S NAME, INITIALS, DATE: | | |
| TRAINER'S NAME, INITIALS, DATE: | | |
| TRAINER'S NAME, INITIALS, DATE: | | |
| TRAINER'S NAME, INITIALS, DATE: | | |

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

MERRILL A. McPEAK, General, USAF
Chief of Staff

EDWARD A. PARDINI, Colonel, USAF
Director of Information Management

4 Atch
1. AF Form 797
2. Trainer's Guide
3. Skill Training Material
4. Knowledge Evaluation Pamphlet

1 Document Battery Bank Forms and Records
TR: Locally developed checklist/OI

2 Perform Monthly Preventive Maintenance Inspection (PMI)
TR: ANSI/IEEE Std 450-1987; Manufacturer's Manual

3 Perform Quarterly PMI
TR: ANSI/IEEE Std 450-1987; Manufacturer's Manual

4 Perform Annual PMI
TR: ANSI/IEEE Std 450-1987; Manufacturer's Manual

5 Troubleshoot Battery Bank
TR: Manufacturer's Manual

6 Replace Defective Battery/Cell
TR: Manufacturer's Manual; local operating procedures

7 Perform Proper Battery/Cell Disposal Procedures
TR: Locally Developed Checklist/OI

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**SUBJECT** **PAGE**



## LIST OF ATTACHMENTS

## INTRODUCTION

This Air Force Qualification Training Package (AFQTP) was developed to enhance on-the-job training for the maintenance of the stationary battery banks. It provides you, the trainer, the tools you need to rapidly train your people to a high degree of proficiency. It can also aid evaluators in performing well-rounded personnel evaluations. You'll find this AFQTP is a valuable tool that gives you and the people you train long-term dividends.

The goal of the 81st Training Support Squadron is to publish accurate training material beneficial to trainers and trainees. The value of your expertise in meeting this goal cannot be overstated. We ask you to assist us in meeting this goal. If you find discrepancies in this AFQTP or have suggestions for its improvement, we want to know about them. Use the Trainer Survey located at the back of this Trainer's Guide. Don't be shy in presenting your suggestions or telling us we made an error. In return, we pledge to provide you an answer and to devote our resources to providing you the best possible training material.

QUALIFICATION TRAINING FLIGHT
81st TRAINING SUPPORT SQUADRON
601 D STREET
KEESLER AIR FORCE BASE MS 39534-2229

## ABOUT THIS AFQTP

This AFQTP was developed using Instructional System Development (ISD) concepts by SSgt Troy A. Church. Mr. George McGrevey was the Training and Education Specialist. It was field tested and validated at SEADS/CEU, Tyndall AFB, FL, and NEADS/CEM, Griffiss AFB, NY.

**OBJECTIVES.** This AFQTP was developed with four objectives in mind.

1. To standardize on-the-job training.

2. To reduce training time while maintaining proficiency standards.

3. To provide trainers and trainees with a logically organized training plan which yields immediate and measurable feedback.

4. To provide a standard to measure task knowledge and performance during personnel evaluations.

**APPLICATION.** This AFQTP provides the trainee logical, step-by-step modules (lessons) covering task knowledge and the practical application of maintenance procedures. It permits the trainee to gain the required knowledge prior to demonstrating task proficiency. It also provides you a standardized training plan and a Knowledge Evaluation Pamphlet (KEP) for measuring the trainee's progress. Since the KEP provides excellent criteria for measuring task knowledge, it can also be used by task evaluators during personnel evaluations. This training material applies to personnel in upgrade and/or qualification training.

## TRAINING PACKAGE CONTENTS

This training package consists of an Air Force Job Qualification Standard with an attached Air Force Qualification Training Package which includes a Trainer's Guide, Skill Training Material, and Knowledge Evaluation Pamphlet. Carefully inventory the package to ensure all parts have been received. Please advise us immediately if portions of the package are missing. The purpose and content of each part of the training package are explained below.

### CAUTION

> This package is NOT intended to replace the applicable technical references. It is to be used in conjunction with these for training purposes only.

**AIR FORCE JOB QUALIFICATION STANDARD (AFJQS).** The AFJQS is a listing of all tasks performed on the stationary battery banks that require structured training and certification. Use and maintain the AFJQS IAW applicable Air Force directives.

**TRAINER'S GUIDE (TG).** The TG provides you, the trainer, the tools and information you need to effectively conduct on-the-job training using this AFQTP.

Task Training Guides (TTG). Attachment 2 contains a series of TTGs. Every task identified on the AFJQS is covered on a TTG. TTGs provide you a detailed sequence of actions which must be followed to conduct effective on-the-job training and meet minimum requirements for task certification. TTGs identify all the material required to train the task and any prerequisite training required before task training can begin. Each TTG also contains a Task Evaluation Checklist. These checklists aid you in measuring the trainee's ability to successfully perform the task. Task Evaluation Checklists reflect the major areas of a task which must be performed satisfactorily before certification.

**SKILL TRAINING MATERIAL (STM).** The STM contains instructions on what the trainee is responsible for during the course of completing this AFQTP. The STM also contains training modules, review questions, a review question confirmation key, and performance procedures.

AFQTP Module. Each AFQTP module provides information and guidance to the trainee concerning the task being trained. The module may present the required information or it may make specific reading assignments to the trainee. Each module contains review questions the trainee must answer.

Review Questions. Review questions measure the trainee's attainment of the knowledge associated with the training objective(s). Review questions are open-book.

Review Question Confirmation Key. A review question confirmation key is in the back of the STM. It is used by the trainee to verify the review question answers are correct. It provides immediate feedback to the trainee to reinforce learning.

Performance Procedures. Modules which contain criterion-based training objectives also include performance procedures the trainee must complete. These procedures specify, to the trainee, the conditions under which the task is performed, requirements of the procedure(s), and the standard of performance which must be met. They are performed in conjunction with the Task Evaluation Checklist.

**KNOWLEDGE EVALUATION PAMPHLET (KEP).** The KEP contains a test for each module. KEP questions are administered and checked by a trainer. Separate the KEP from the rest of the AFQTP and detach the KEP Key and Answer Sheet(s). Store the KEP and KEP Key in a secure place. Failure to do so compromises the KEP. The results of the KEP tests provide you immediate feedback as to how well the trainee understands the information.

## DEVELOPING INDIVIDUAL TRAINING PLANS

For training to be effective, carefully plan what you want the trainee to do. Use the following steps to plan training.

1. Determine your work center's needs to assure 100% task coverage. Develop a work center Master Task List (MTL) IAW applicable directives. AFQTP 750X0-215G, ISD for OJT, provides you detailed guidance on MTL and work center training program development.

2. Review the trainee's training record and determine the trainee's previous training and certification. AF Form 623, On-the-Job Training Record, provides this information for each military member. You must question or evaluate the trainee to determine current proficiency levels.

3. Assign the trainee to a duty position. The duty position is a series of work center tasks the trainee is responsible to perform after training is completed. When making this assignment, you must first consider the work center's needs and then the needs of the trainee. After the trainee completes the training requirements of the initial duty position, assign additional duty positions and conduct the necessary training for each. Keep in mind that the objective of training is to produce a 100% qualified technician.

4. Develop the trainee's training plan outlining which tasks are to be trained and when the training takes place. You can use a General Purpose form (such as the AF Form 3126) or create a computer generated Individual Training Plan for this purpose (see Attachment 1).

5. Interview the trainee. Discuss with the trainee the initial duty or expanded duty position and training program.

6. Should circumstances dictate a change in duty position, or in training schedule, discuss this with the trainee and annotate the trainee's training record, AF Form 623a. On the Individual Training Plan, annotate the remarks area.

## CONDUCTING OJT USING THIS TRAINING PACKAGE

1. Explain the AFJQS/AFQTP to the trainee and how they are used to conduct training. If the trainee is enrolled in upgrade training (UGT), explain any CDC requirements which may apply and the trainee's UGT responsibilities.

**NOTE**

Trainees in UGT must use this AFJQS/AFQTP to satisfy the performance criteria for each task selected for training.

2. Using the trainee's Individual Training Plan, select the first task for training and review the applicable TTG. Ensure all training material and references are available. Assure that the trainee is qualified on all prerequisites for this task.

3. Discuss with the trainee the task objective(s) and training steps listed on the appropriate TTG. Assign the corresponding STM module for the trainee to complete.

4. Verify the trainee completed the review questions. Answer any questions the trainee may have. The trainee may use the AFQTP modules and technical references (TRs) to answer the review questions.

5. When you and the trainee are satisfied with the trainee's knowledge of the material, administer the module KEP Questions. The trainee may NOT refer to the AFQTP modules

when answering the KEP questions. Normally, the trainee is not permitted to use TRs when taking a KEP test. If use of TRs is permitted, it will be stated in the STM and at the beginning of each KEP test. If TR use is permitted (open-book test), a score of 100% is required. If the use of TRs is not permitted, the trainee must score a minimum of 70% on the KEP tests. Check the trainee's KEP answers against the KEP Confirmation Key. Review missed KEP questions with the trainee to ensure understanding of the material. If the score is less than what is required, have the trainee restudy the module and retake the KEP.

6. Using the technical reference(s) and Task Evaluation Checklist as guidance, explain the task performance procedures to the trainee.

7. Demonstrate the task procedures to the trainee. Answer any questions the trainee has.

8. Have the trainee practice and explain the task procedures to you. Correct any errors the trainee may make.

9. Have the trainee perform the task procedures unassisted. Using the Task Evaluation Checklist, evaluate the trainee's performance. Should the trainee fail the evaluation, determine the cause of unsatisfactory performance. If the cause is a lack of knowledge, the trainee may have to retake the module. If the cause is a lack of trainee's skill, demonstrate the task again. Have the trainee practice the task under your supervision. When you and the trainee are satisfied that the task can be performed unassisted, reevaluate the trainee.

10. When the trainee performs the task at the desired level of proficiency without assistance, document training and task certification IAW local certification procedures.

11. Using the Individual Training Plan, assign additional tasks until the trainee completes the requirements for the duty position.

12. Expand the trainee's duty position, if possible, by adding more tasks to the Individual Training Plan. Training continues until the trainee is 100% work center task qualified or is reassigned.

**NOTE**

Should the trainee not complete the AFJQS/AFQTP before being reassigned to another location which has this equipment, we recommend you retrieve the training material from the trainee and forward it to the gaining work center.

13. Schedule periodic evaluations after the trainee is task certified. We recommend you use the performance procedures and Task Evaluation Checklists to conduct these evaluations. The KEP developed for this AFQTP may also be used to measure the trainee's knowledge of the tasks.

14. When training is complete, have the trainee complete the Trainee Survey located at the back of the Skill Training Material.

15. When you are satisfied that the trainee has completed all of the requirements for this AFJQS/AFQTP, remove Attachment 5, Training Certification document, from the back of this TG and process it as follows:

a. Have the work center supervisor or designated person certify AFJQS/AFQTP completion on the document.

b. Attach the Trainee and Trainer Surveys and KEP answer sheets to the document.

c. Forward the document to the commander or designated representative for concurrence/nonconcurrence.

d. Mail the completed document to the address specified.

e. Upon receipt of a properly completed certification document, the 81 TRSS/TSQS will forward a Certificate of Training through channels to the trainee.

# INDIVIDUAL TRAINING PLAN

TRAINEE: Amn Smith TRAINER: SSgt Jones

| QS NUMBER/ K NUMBER | | ESTIMATED TRAINING TIME | ESTIMATED START DATE | DATE TRAINING COMPLETED | REMARKS |
|---|---|---|---|---|---|
| XXXXX-XXXX | /1 | 2 days | 21 Jan 94 | 23 Jan 94 | |
| | /2 | 4 hours | 24 Jan 94 | 25 Jan 94 | |

EXAMPLE EXAMPLE

This Individual Training Plan is an example only. It does not reflect accurate training times.

# BATTERY BANK DOCUMENTATION
# TASK TRAINING GUIDE

TRAINEE'S NAME:_____

1. AFJQS TASK NUMBER: 1

2. ESTIMATED TASK TRAINING TIME:_____

3. TRAINING REFERENCES:

   a. Local operating instructions

   b. AFQTP Modules 1 and 2

4. REQUIREMENTS:

   a. Test equipment to be used: None

   b. Downtime/user release is/is not required.

5. TRAINING OBJECTIVE:

Given local operating instructions (LOIs), stationary battery bank log, and AF Form 719, document battery bank forms and records IAW prescribed procedures.

6. INITIAL TRAINING STEPS (Check when completed):

_ a. Discuss the objective for the task, including the work center speed and accuracy standards for performing the task. Also discuss the conditions under which it is normally performed.

_ b. Assign AFQTP Module 1.

_ c. Discuss the review questions and answers with the trainee.

_ d. Administer the KEP.

_ e. Check the KEP answers and review missed questions.

_ f. Assign AFQTP Module 2.

_ g. Discuss the review questions and answers with the trainee.

_ h. Administer the KEP.

__ i. Check the KEP answers and review missed questions.

7. OBJECTIVE TRAINING STEPS:

__ a. Using technical references and the checklist in para 8 as guidance, discuss the task steps for achieving the objective with trainee. Ensure all Notes, Cautions, and Warnings listed in the TR for each step are covered. Brief the trainee on all safety precautions and local procedures that apply.

__ b. Demonstrate correct task performance.

__ c. Review task steps with trainee and answer any questions.

__ d. Have trainee practice steps and assist as necessary.

8. TASK 1 EVALUATION:

a. Have trainee perform task steps unassisted and evaluate performance IAW the following checklist. (Return to step 7a if evaluation is unsatisfactory.)

__ (1) Documented monthly, quarterly, and annual inspection readings on stationary battery log.

__ (2) Documented battery bank historical information on AF Form 719.

__ b. Trainee is ready to be certified on AFJQS task 1. Follow local certification procedures.

__ c. Assign the next task for training.

# MONTHLY AND QUARTERLY PREVENTIVE MAINTENANCE INSPECTIONS (PMIs) TASK TRAINING GUIDE

TRAINEE'S NAME:_____

1. AFJQS TASK NUMBERS: 2 and 3

2. ESTIMATED TASK TRAINING TIME:_____

3. TRAINING REFERENCES:

   a. ANSI/IEEE Std 450-1987

   b. Manufacturer's manual

   c. AFQTP Module 3

4. REQUIREMENTS:

   a. Test equipment to be used

      (1) Digital Voltmeter
      (2) Battery Hydrometer
      (3) Battery Thermometer

   b. Downtime/user release is/is not required.

   c. Ensure trainee has completed AFQTP Modules 1 and 2.

5. TRAINING OBJECTIVES:

   a. Given ANSI/IEEE Std 450-1987, Section 4.3.1 General; manufacturer's manual; Digital Voltmeter; Battery Hydrometer; and proper cleaning equipment, perform a Monthly PMI IAW prescribed procedures.

   b. Given ANSI/IEEE Std 450-1987, Section 4.3.2 Quarterly; manufacturer's manual; Digital Voltmeter; Battery Hydrometer; Battery Thermometer; and proper cleaning equipment, perform a Quarterly PMI IAW prescribed procedures.

6. INITIAL TRAINING STEPS (Check when completed):

_ a. Discuss the objectives for the tasks, including the work center speed and accuracy standards for performing the tasks. Also discuss the conditions under which they are normally performed.

_ b. Assign AFQTP Module 3.

_ c. Discuss the review questions and answers with the trainee.

_ d. Administer the KEP.

_ e. Check the KEP answers and review missed questions.

7. OBJECTIVE 5a TRAINING STEPS:

_ a. Using technical references and the checklist in para 8 as guidance, discuss the task steps for achieving objective 5a with trainee. Ensure all Notes, Cautions, and Warnings listed in the TR for each step are covered. Brief the trainee on all safety precautions and local procedures that apply.

_ b. Demonstrate correct task performance.

_ c. Review task steps with trainee and answer any questions.

_ d. Restore system to normal operating configuration. Disconnect all test equipment used.

_ e. Have trainee practice steps and assist as necessary.

8. TASK 2 EVALUATION:

a. Have trainee perform task steps unassisted and evaluate performance IAW the following checklist. (Return to step 7a if evaluation is unsatisfactory.)

_ (1) Measured and recorded battery bank float voltage.

_ (2) Cleaned the battery bank and battery room.

_ (3) Measured and recorded battery charging current and voltage.

_ (4) Checked/corrected and recorded cell electrolyte.

_ (5) Checked cells for cracks and leaks.

_ (6) Checked for and corrected any evidence of corrosion on terminals, connectors, or racks.

_ (7) Measured and recorded battery room ambient temperature.

_ (8) Checked operation and condition of ventilation equipment.

_ (9) Measured and recorded pilot cell float voltage.

_ (10) Measured and recorded pilot cell specific gravity.

__ (11) Measured and recorded pilot cell temperature.

_ b. Trainee is ready to be certified on AFJQS task 2. Follow local certification procedures.

9. OBJECTIVE 5b TRAINING STEPS:

_ a. Using technical references and the checklist in para 10 as guidance, discuss the task steps for achieving objective 5b with trainee. Ensure all Notes, Cautions, and Warnings listed in the TR for each step are covered. Brief the trainee on all safety precautions and local procedures that apply.

_ b. Demonstrate correct task performance.

_ c. Review task steps with trainee and answer any questions.

_ d. Restore system to normal operating configuration. Disconnect all test equipment used.

_ e. Have trainee practice steps and assist as necessary.

8. TASK 3 EVALUATION:

a. Have trainee perform task steps unassisted and evaluate performance IAW the following checklist. (Return to step 9a if evaluation is unsatisfactory.)

_ (1) Completed Monthly Preventive Maintenance Inspection.

_ (2) Measured and recorded specific gravity of all cells.

_ (3) Measured and recorded float voltage of all cells.

_ (4) Determined the average cell temperature.

_ (5) Corrected any unbalanced cell temperatures.

_ (6) Determined when a Special Inspection is required.

__ b. Trainee is ready to be certified on AFJQS task 3. Follow local certification procedures.

__ c. Assign the next task for training.

ANNUAL PREVENTIVE MAINTENANCE INSPECTION (PMI)
TASK TRAINING GUIDE

TRAINEE'S NAME:_____

1. AFJQS TASK NUMBER: 4

2. ESTIMATED TASK TRAINING TIME:_____

3. TRAINING REFERENCES:

   a. ANSI/IEEE Std 450-1987

   b. Manufacturer's manual

   c. AFQTP Module 4

4. REQUIREMENT(S):

   a. Test equipment to be used:

      (1) Digital Voltmeter
      (2) Micro Ohmmeter
      (3) Battery Hydrometer
      (4) Battery Thermometer

   b. Downtime/user release is/is not required.

   c. Ensure trainee has completed AFQTP Modules 1 thru 3.

5. TRAINING OBJECTIVE:

Given ANSI/IEEE Std 450-1987, Section 4.3.3 Yearly; manufacturer's manual; Micro Ohmmeter; Digital Voltmeter; Battery Hydrometer; Battery Thermometer; and proper tools, perform an Annual PMI IAW prescribed procedures.

6. INITIAL TRAINING STEPS (Check when completed):

__ a. Discuss the objective for the task, including the work center speed and accuracy standards for performing the task. Also discuss the conditions under which it is normally performed.

__ b. Assign AFQTP Module 4.

__ c. Discuss the review questions and answers with the trainee.

__ d. Administer the KEP.

__ e. Check the KEP answers and review missed questions.

7. OBJECTIVE TRAINING STEPS:

__ a. Using technical references and the checklist in para 8 as guidance, discuss the task steps for achieving the objective with trainee. Ensure all Notes, Cautions, and Warnings listed in the TR for each step are covered. Brief the trainee on all safety precautions and local procedures that apply.

__ b. Demonstrate correct task performance.

__ c. Review task steps with trainee and answer any questions.

__ d. Restore system to normal operating configuration. Disconnect all test equipment used.

__ e. Have trainee practice steps and assist as necessary.

8. TASK 4 EVALUATION:

a. Have trainee perform task steps unassisted and evaluate performance IAW the following checklist. (Return to step 7a if evaluation is unsatisfactory.)

__ (1) Visually inspected all cells for sulfation, positive plate growth, sediment, and mossing.

__ (2) Measured and recorded intercell connector resistances.

__ (3) Corrected any out of tolerance intercell connector resistances.

__ (4) Inspected battery rack for integrity, level, corrosion, and security.

__ (5) Corrected and recorded all discrepancies.

__ b. Trainee is ready to be certified on AFJQS task 4. Follow local certification procedures.

__ c. Assign the next task for training.

# BATTERY BANK TROUBLESHOOTING
# TASK TRAINING GUIDE

TRAINEE'S NAME:_____

1. AFJQS TASK NUMBERS: 5, 6, and 7

2. ESTIMATED TASK TRAINING TIME:_____

3. TRAINING REFERENCES:

   a. Manufacturer's manual

   b. Local operating procedures

   c. AFQTP Module 5

4. REQUIREMENTS:

   a. Test equipment to be used:

      (1) Micro Ohmmeter
      (2) Digital Voltmeter
      (3) Battery Hydrometer
      (4) Battery Thermometer

   b. Downtime/user release is/is not required.

   c. Ensure trainee has completed AFQTP Modules 1 thru 4.

5. TRAINING OBJECTIVES:

   a. Given the manufacturer's manual, proper test equipment, and tools, perform battery bank troubleshooting IAW prescribed procedures.

   b. Given the manufacturer's manual, local operating procedures, a replacement battery/cell, and proper tools, replace a defective battery/cell IAW prescribed procedures.

   c. Given a defective battery/cell, local operating procedures, and proper equipment, dispose of a defective battery/cell IAW prescribed procedures.

6. INITIAL TRAINING STEPS (Check when completed):

_ a. Discuss the objectives for the tasks, including the work center speed and accuracy standards for performing the tasks. Also discuss the conditions under which they are normally performed.

_ b. Assign AFQTP Module 5.

_ c. Discuss the review questions and answers with the trainee.

_ d. Administer the KEP.

_ e. Check the KEP answers and review missed questions.

7. OBJECTIVE 5a TRAINING STEPS:

_ a. Using technical references and the checklist in para 8 as guidance, discuss the task steps for achieving objective 5a with trainee. Ensure all Notes, Cautions, and Warnings listed in the TR for each step are covered. Brief the trainee on all safety precautions and local procedures that apply.

_ b. Demonstrate correct task performance.

_ c. Review task steps with trainee and answer any questions.

_ d. Restore system to normal operating configuration. Disconnect all test equipment used.

_ e. Have trainee practice steps and assist as necessary.

8. TASK 5 EVALUATION:

a. Have trainee perform task steps unassisted and evaluate performance IAW the following checklist. (Return to step 7a if evaluation is unsatisfactory.)

_ (1) Identified battery bank malfunctions.

_ (2) Corrected battery bank malfunction.

_ (3) Documented malfunctions and corrective actions.

_ b. Trainee is ready to be certified on AFJQS task 5. Follow local certification procedures.

9. OBJECTIVE 5b TRAINING STEPS:

_ a. Using technical references and the checklist in para 10 as guidance, discuss the task steps for achieving objective 5b with trainee. Ensure all Notes, Cautions, and Warnings listed in the TR for each step are covered. Brief the trainee on all safety precautions and local procedures that apply.

_ b. Demonstrate correct task performance.

_ c. Review task steps with trainee and answer any questions.

_ d. Restore system to normal operating configuration. Disconnect all test equipment used.

_ e. Have trainee practice steps and assist as necessary.

10. TASK 6 EVALUATION:

a. Have trainee perform task steps unassisted and evaluate performance IAW the following checklist. (Return to step 9a if evaluation is unsatisfactory.)

_ (1) Determined when battery/cell replacement is necessary.

_ (2) Filled a dry charged battery/cell with electrolyte.

_ (3) Charged a new battery/cell.

_ (4) Replaced defective battery/cell.

_ b. Trainee is ready to be certified on AFJQS task 6. Follow local certification procedures.

11. OBJECTIVE 5c TRAINING STEPS:

_ a. Using technical references and the checklist in para 12 as guidance, discuss the task steps for achieving objective 5c with trainee. Ensure all Notes, Cautions, and Warnings listed in the TR for each step are covered. Brief the trainee on all safety precautions and local procedures that apply.

_ b. Demonstrate correct task performance.

_ c. Review task steps with trainee and answer any questions.

_ d. Restore system to normal operating configuration.

_ e. Have trainee practice steps and assist as necessary.

12. TASK 7 EVALUATION:

a. Have trainee perform task steps unassisted and evaluate performance IAW the following checklist. (Return to step 11a if evaluation is unsatisfactory.)

_ (1) Drained electrolyte from battery/cell (if applicable).

_ (2) Neutralized the electrolyte (if applicable).

_ (3) Neutralized and flushed the battery/cell (if applicable).

_ (4) Cleaned battery/cell case (if applicable).

_ (5) Sealed all battery/cell openings (if applicable).

_ (6) Secured the battery/cell to a pallet (if applicable).

_ (7) Turned in battery/cell for contract disposal (if applicable).

_ b. Trainee is ready to be certified on AFJQS task 7. Follow local certification procedures.

# TRAINER SURVEY

**NAME_____ RANK_____ DSN_____**

**UNIT ADDRESS_____ MAJCOM_____ DATE_____**

1. How long have you been a trainer on this equipment/ system/function?

   a. Less than 1 year
   b. 1 to 2 years
   c. 3 to 6 years
   d. 7 to 10 years
   e. 11 years or more

2. Which statement best describes the experience level of most technicians arriving at your duty location?

   a. No experience
   b. Limited experience (technical school or previous training)
   c. Experienced on related equipment/function
   d. Experienced on this equipment/function

3. What is the average training time required to fully qualify a trainee on this equipment/function?

   a. 30 days
   b. 60 days
   c. 90 days
   d. 120 days
   e. Other_____

4. The purpose of AFQTPs is to provide standardized training programs on specific equipment or functions. How well do you feel this AFQTP accomplished its purpose?

   a. Outstanding
   b. Excellent
   c. Satisfactory
   d. Marginal (Please explain; use extra paper if necessary)
   e. Unsatisfactory (Please explain)

5. Have you completed this AFQTP?

   a. Yes
   b. No (Please explain)

6. Were the technical references listed on the AFJQS correct?

a. Yes
b. No (Please explain)

7. The Trainer's Guide helped me to conduct an effective training program while using this AFQTP.

a. Yes
b. No (Please explain)

8. Was the information presented in the Skill Training Material (STM) technically correct?

a. Yes
b. No (Please explain)

9. Did the module arrangement follow a logical training sequence (easy to difficult, simple to complex)?

a. Yes
b. No (Please explain)

10. Would additional figures, illustrations, or examples help the trainee understand the material presented in the AFQTP?

a. Yes (Please explain)
b. No

11. Does the AFJQS contain all required tasks?

a. Yes
b. No (List tasks)

12. Do the review and KEP questions measure the knowledge required by the trainee to perform the task(s)?

a. Yes
b. No (Please explain)

13. While completing this package, the trainee

    a. had no major or unusual difficulties.
    b. had some minor problems.
    c. often required my assistance.
    d. could not have completed this AFQTP without assistance from an experienced trainer.

14. Approximately how many people have you trained using this AFQTP?_____

15. What improvements would you make to this AFQTP to help meet your training needs?

TRAINING CERTIFICATION FOR
AFJQS/AFQTP 3E0X2-214D
STATIONARY BATTERY BANKS

I certify the individual listed below has completed all of the requirements for the above AFJQS/AFQTP. Date completed _____.

_____
**(Please Print)** TRAINEE'S RANK, FIRST, MI, LAST NAME SSN

_____
**(Please Print)** UNIT MAILING ADDRESS, INCLUDING ZIP CODE

_____
SUPERVISOR'S RANK/NAME

_____
DUTY TITLE DSN

CONCUR/NONCONCUR

_____
Commander or Designated Representative

Please attach the completed and graded KEP answer sheet(s) and Trainer/Trainee Surveys and mail to the address listed below. A certificate of training will be issued upon receipt of these documents.

81 TRSS/TSQS
601 D STREET
KEESLER AFB MS 39534-2229

**NOTE**

Do NOT submit trainees for training certificates more than once per AFJQS/AFQTP. Some AFJQSs/ AFQTPs are used for recurring training, but only ONE certificate will be issued for a trainee per AFJQS/AFQTP.

PERSONAL DATA
PRIVACY ACT OF 1974
(5 U.S.C. 552)

# TABLE OF CONTENTS

## PREFACE

This Air Force Qualification Training Package (AFQTP) was developed to standardize the OJT program for Stationary Battery Banks. It explains the functional operation, PMI and service routines, and adjustments for Stationary Battery Banks.

Put this package to use. We hope you'll find it to be a valuable tool which aids you in becoming proficient in the shortest possible time.

This AFQTP was developed by SSgt Troy A. Church, 81st Training Support Squadron, Keesler AFB, MS. The Training and Education Specialist was Mr. George McGrevey. It was validated by SEADS/CEU, Tyndall AFB, FL, and NEADS/CEM, Griffiss AFB, NY.

## CAUTION

This package is NOT intended to replace the applicable technical references. It is to be used for training purposes only.

## INSTRUCTIONS TO THE TRAINEE

1. Be sure your trainer explains the qualification training process (task assignment, proficiency attainment, task certification), your responsibilities, and how to use this AFQTP.

2. Review the Air Force Job Qualification Standard (AFJQS) and this Skill Training Material (STM) to get an idea of their content.

3. Your trainer uses the AFJQS to assign your initial tasks and the corresponding AFQTP modules. You and your trainer jointly plan your anticipated progress.

4. Make sure you understand the prerequisites before attempting each module (ask your trainer). If you are not familiar with the prerequisites, training is necessary.

5. Within normal workload constraints, set aside sufficient time to work on the package. Studies into effective training programs indicate that the best trainees reserve the same time each day to complete their study. Pace yourself; establish a schedule and stick to it. Give yourself top priority in becoming qualified.

6. After you read the information in the module, answer the review questions and immediately check your responses. You may use the AFQTP modules and technical references to answer the questions. Ask your trainer to explain the questions you don't understand or answer incorrectly. Refer to applicable technical references for more detailed information.

7. After you answer the review questions, your trainer will administer the Knowledge Evaluation Pamphlet (KEP). Answer all KEP questions and give the answer sheet to your trainer for grading. Your trainer will discuss any incorrect answers with you. You are normally NOT allowed to use the AFQTP modules to answer the KEP questions. If you are not permitted to use technical references, you must score 70% or more on each test. In some cases, technical references may be used to answer the KEP questions. This is identified at the beginning of the particular module test. If you are permitted to use the references (open-book test), you must score 100%.

8. You are required to demonstrate your task proficiency by completing the performance procedures identified at the end of each module. When both you and your trainer are satisfied that you have attained the required proficiency level, you may be certified on the AFJQS following local certification procedures. If you are not completely satisfied that you have obtained the required proficiency level, further study and practice are needed before you initial the AFJQS.

**CAUTION**

You are not to perform on the equipment without your trainer being present.

9. Your trainer assigns additional tasks (modules) until you have completed the entire package and have become position qualified.

10. We need your help in revising this AFQTP and in developing future AFQTPs. Make note of any problem areas you find as you encounter them. If you have recommendations, suggestions, corrections, or comments, please jot them down on the Trainee Survey located at the back of this book. When you complete the AFQTP, give the survey to your trainer to attach to the Training Certification document located at the back of the Trainer's Guide. When we receive the Training Certification document and all attachments, we will forward

your Certificate of Training. We pledge to devote all our resources to providing you with the best possible training materials.

# MODULE 1
# INTRODUCTION TO STATIONARY BATTERY BANKS

## OBJECTIVES

a. Identify major components of a stationary battery bank.

b. Describe the function and theory of operation of a stationary battery bank.

c. State specific safety precautions to follow when performing maintenance on batteries.

## TRAINING REFERENCES

1. ANSI/IEEE Standard 450-1987

2. Manufacturer's manual

## INTRODUCTION

This AFQTP was developed to assist in your training to perform maintenance on stationary battery banks. This module begins with a brief overview of battery bank components and theory of operation. Then, it moves on to the specific safety precautions to follow when performing maintenance on batteries.

## INFORMATION

MAJOR COMPONENTS. Stationary battery banks consist of primarily batteries, but there are several other components that complete the whole system. Let's take a look at these various components.

Batteries. A lead-acid storage battery is an electrochemical device that produces Direct Current (DC). The battery is actually a group of identically sized cells of the same construction. The number of cells connected in series determines the voltage rating of a battery bank. A basic lead-acid cell has a working voltage of 2.00 volts. Cells connected in series form a battery and their voltages are additive. Six cells connected in series will, therefore, provide a battery voltage of 12.00 volts.

The discharge capacity of a battery is its ability to deliver a certain number of amperes of current for a specific number of hours before the cell voltage drops to a given voltage (usually called dead). The capacity of a cell is determined by the size and number of positive and negative plates in the cell. The standard most commonly used to rate a battery is the 8-hour rating. This refers to how many amperes the battery can produce per hour for 8 hours. An example is a 100 amp-hour battery which provides 12.5 amps per hour for 8 consecutive hours (12.5 times 8 = 100).

## BASIC LEAD-ACID BATTERY THEORY

Basic Cell Construction. A lead-acid battery is a very simple device consisting of two metallically dissimilar electrode "plates," a dilute sulfuric acid solution "electrolyte," and a chemically inert container. In a fully charged cell, the active material of the positive plate is lead peroxide ($PbO_2$) and the active material of the negative plate is sponge lead (Pb). The chemical composition of the electrolyte is $H_2SO_4$.

Discharging Cell. As a lead-acid cell discharges, the electrolyte ($H_2SO_4$) divides into $H_2$ and $SO_4$. The $H_2$ combines with some of the oxygen produced at the positive plates to form water ($H_2O$). The $SO_4$ combines with the lead (Pb) of both plates to form lead sulfate ($PbSO_4$). Since the amount of sulfuric acid in the electrolyte is reduced by this electrochemical action, the specific gravity of the electrolyte decreases.

Charging Cell. During charging, the electrochemical process that occurred during discharge is reversed. The lead sulfate ($PbSO_4$) on the positive and negative plates is converted back to lead peroxide ($PbO_2$) and sponge lead (Pb), respectively. The specific gravity of the electrolyte increases as the $SO_4$ from the plates combines with hydrogen from the water to form sulfuric acid ($H_2SO_4$). As a cell approaches full charge, the electrochemical action of charging slows down; thus, the cell cannot absorb all the energy of the charging current. This "additional" energy separates the water in the electrolyte into its basic components: hydrogen and oxygen. Hydrogen is liberated at the negative plate, and

oxygen is liberated at the positive plate. These gases are then normally vented to the atmosphere through a flame arrestor.

Intercell Connectors. The intercell connectors connect all the cells together electrically. These connectors provide the path for current flow between each cell. They are usually thin, lead-coated copper strips that are bolted to the cell terminals.

Vent Caps. Vent caps allow the cell to breathe. The cells release gases while charging, and if these gases are not allowed to escape, the cells may explode. Many of the vent caps are designed to prevent external sparks or flames from igniting and exploding internal cell gases.

Battery Rack. The battery rack supports the batteries in staggered rows to allow for ease of maintenance. Battery racks must be secured to the floor to ensure integrity. Battery banks in earthquake zones must have racks with added support on the front, back, and sides of the batteries.

Battery Charger. The battery charger provides a charging current to the batteries. It provides a "float charge" to maintain the batteries at a constant fully charged condition. It also provides an "equalizing charge" which recharges the batteries at a high rate after a large discharge and to compensate for charge irregularities. Most chargers have a charging ammeter and voltmeter mounted on the front.

Battery banks that support Uninterruptible Power Supplies (UPS) have battery chargers included in the UPS control modules. Batteries used for power plant controls have a separate battery charger, usually located near the battery bank. You should refer to the manufacturer's manual for your particular battery charger for specific information. This completes our discussion on the battery bank components. We will now discuss the function of the battery bank.

FUNCTION. The function of the battery bank is to supply DC electricity to an intended source. Solid State Uninterruptible Power Supply (SSUPS) battery banks provide DC electricity to the SSUPS during power fluctuations and power failures. Battery banks used for power plants supply power for switchgear controls: electrical and engine safety circuits: and in some cases, DC emergency lighting. As you can see, battery banks supply power for various reasons. We will now briefly discuss the operation of a battery bank.

OPERATION. The battery bank is made up of many individual cells connected together. These cells are connected in series to provide a working voltage. For example, 60 cells x 2 volts = 120 volts DC. This voltage is supplied to the support equipment when required and takes on an amperage draw. The cells carry this load until the power is not required any longer or the batteries discharge. In a previous reading assignment, you read how the individual cell discharges under load. After the load is removed from the batteries, the battery charger must charge the batteries. An equalizing charge restores the batteries to a full charge in a minimum amount of time. The battery charger accomplishes this by reversing the flow of current through the cells.

During normal day-to-day operation, the batteries receive a "float charge" to maintain the batteries at the fully charged condition. As you can see, the battery bank plays an important part in maintaining power. It is very important that the batteries are maintained properly, so they are ready at all times. We will now discuss the safety precautions required when working around batteries.

SAFETY PRECAUTIONS. As you know, safety is the responsibility of everyone. Getting the job done is important, but getting it done safely is, by far, the most important aspect of the job. In this section, we will discuss safety hazards and the personal and shop safety equipment associated with maintaining stationary battery banks.

During the operation of a battery, water breaks down to its basic elements of hydrogen gas and oxygen. Hydrogen gas is explosive, if ignited. Therefore, it is important to have sufficient ventilation in the battery bank room/area. The chemicals in batteries, and electrical shocks are other hazards that must be considered. Proper lifting and handling procedures are also a "must."

Hydrogen Gas. Hydrogen gas is lighter than air and is colorless, odorless, and tasteless. The amount of hydrogen generated during charging is governed by the amount of charging current (amperes) supplied to the battery. Hydrogen concentrates under the cell cover of each cell in the battery bank.

Flame arrestor vent plugs are used to prevent the possibility of an internal explosion in the cell. Once they are installed, water can be added through the top. For the flame arrestor to work properly, the electrolyte level must be above the stem of the flame arrestor. Flame arrestors are rated to protect the cell up to a 50-ampere charging current. Do not exceed this charging amount.

Never bring burning materials, such as matches, cigarettes, or any type of open flame, into or near the battery area. Electrical sparking can also ignite the hydrogen gas and must be avoided. All battery connections must be torqued to their proper values (the battery bank must be disconnected during this procedure). Loose connections can cause sparking, arcing, and excessive heat, and cause an explosion if sufficient hydrogen gas is present. When using tools for maintenance, NEVER lay them on top of a battery. An accidental short will cause arcing and could cause the battery to explode right in your face. Therefore, always insulate the handles of your tools to prevent accidental shorting.

Static Electricity. Did you know the human body can build up a static charge well over 1000 volts? All of us, at one time or another, have touched something and felt a jolt and heard a loud snap. This condition is caused by static electricity build-up. If you should touch a cell terminal post and this reaction should happen, the spark could cause an explosion. Before working on a battery bank, discharge the static electricity by first touching a grounded surface, such as a grounded metal work bench. Additionally, if more than one person is working on the battery bank, they should work apart from each other. This will eliminate the possibility of creating a shock between them.

Electrolyte. The electrolyte in a cell consists of a mixture of sulfuric acid and water. If sulfuric acid should contact the skin, severe burns could result. As a power production technician, you have handled batteries at one time or another and probably have holes in your fatigues. They are more than likely the result of spilled sulfuric acid. When acid comes in contact with your clothing or other material, it needs to be neutralized immediately by applying a solution of bicarbonate of soda and water (one pound of soda to one gallon of water). Apply the solution until it stops bubbling, then rinse the material with clean water. If acid comes in contact with your skin, you should immediately rinse the affected area with clean water. If acid comes in contact with your eyes, IMMEDIATELY flush them with clean water and report to the base hospital or clinic.

When mixing electrolyte, ALWAYS pour acid into water. Never pour water into acid because this will cause a violent chemical reaction that will splatter the solution over the surrounding area. Pour the acid very slowly into the water while slowly stirring the solution. Do not handle acid with a specific gravity of 1.400 or more. Acid with specific gravity of this amount will cause severe burns.

Electrical Shock. Stationary battery banks produce DC voltages which power UPSs, power plant systems, and emergency lighting systems. The cells are connected in series to increase the bank's output voltage from 2.0 volts DC to a voltage of 2.0 volts DC times the number of cells that are connected. High voltages are produced by this adding action which increases the possibility of electrical shock. Keep the aforementioned hazards in mind and exercise extreme care when working around batteries and battery charging equipment. Again, remember, if two people are working on the bank, remain apart to avoid a possible shock.

Handling. Care must be taken when handling individual cells to protect yourself, as well as the cell. Batteries are heavy and can cause painful strains and injury to your back, hands, or feet. Some of the larger cells must be lifted with a lifting belt and spreader in conjunction with a crane or hoist. Smaller cells may be lifted by placing the hands underneath the cell. Never lift a cell by the terminal posts because damage can occur to the cell.

Personal Protective Equipment. It is important to have the proper personal protective equipment on hand when working with batteries. When using sulfuric acid, the wearing of goggles or face shields must be of the type that will protect the eyes from the front as well as the sides. The apron and gloves must be of acid resistant materials. When lifting cells, safety shoes and hard hats (plastic type) are recommended. Metallic safety hats must be avoided because of possible shorting of the cells if the hat is dropped.

Shop Safety Equipment. There are many items of safety equipment and instructions which need to be available and maintained in the shop. As a minimum, the following must be available:

1. Eyewash--must be located in the battery area and readily accessible for use in the event that electrolyte comes in contact with the eyes.

2. Emergency shower--must be located in the battery area for the use of personnel in the event of accidental electrolyte splashing on a person's body.

3. Ventilation system--normally an exhaust fan or door louvers, or a combination of the two, is satisfactory. If an air conditioning system is needed to maintain temperature, it must be vented to the atmosphere and should be separate from other systems.

4. Fire extinguishers--hand-held $CO_2$ type extinguishers are recommended. Check the manufacturer's manual for the type of fire extinguisher approved for batteries.

5. Technical publications--it is essential that specific manuals for your equipment are available. There are many different types and makes of batteries and they must be maintained properly; therefore, either applicable technical orders or commercial manufacturer's manuals must be readily accessible to personnel performing maintenance on batteries.

6. AFOSH standards--these standards prescribe the proper safety practices needed to maintain a safe environment and ensure proper operations. AFOSH Standards 127-31, 127-32, 127-50, and 127-66, detail safety practices applicable to batteries and battery banks. It is imperative that you be familiar with these standards, or at least know how to locate needed information in them.

**SUMMARY**

The objective of this module was to introduce you to stationary battery banks. Included was a description of major components, function and theory of operation, and specific safety precautions to follow when performing maintenance.

Stationary battery banks consist primarily of batteries, but there are several other components that add to the system. These components include intercell connectors, vent caps, battery racks, and battery chargers.

The function of the battery bank is to supply DC electricity to an intended source. The source could be a SSUPS, power plant switchgear, safety circuits, or emergency lighting. During operation, the battery bank supplies voltage to the support equipment and takes on an amperage draw. The cells carry this load until the power is not required any longer or the batteries fully discharge.

Proper safety precautions must be followed when performing maintenance on batteries. The safety precautions you must follow include ensure proper ventilation, know proper electrolyte handling procedures, know how to protect against electrical shock, know proper battery handling procedures, wear personal protective equipment, and ensure shop safety equipment is available and functioning properly.

This concludes our discussion of battery bank components, theory of operation, and safety precautions. Keep these items in mind as we discuss the specific maintenance

procedures throughout this AFQTP. Proper maintenance and safety precautions ensure your battery bank is always in a ready status.

**REVIEW QUESTIONS**

Answer the following questions and then compare your responses with the confirmation key in the back of this book. Your responses do not have to match word-for-word but should convey the same basic meaning. Review the applicable portions of this module for all missed questions.

1. What determines the voltage rating of a battery?

2. What is the purpose of intercell connectors?

3. List the two types of charges a battery charger can provide.

4. List three pieces of power plant equipment that require a battery bank.

5. What is the purpose of an equalizing charge?

6. How are cells usually connected?

7. What can result from loose connections of cell connectors?

8. What is used to neutralize sulfuric acid?

9. Why should a cell never be lifted by the terminal posts?

10. Which personal protective equipment must you use when working with batteries?

**ADDITIONAL INSTRUCTIONS**

When ready, ask your trainer to administer the KEP questions for this module. This is a closed-book test and you must score 70% or more. Your trainer will check your answers and review any incorrectly answered questions with you. When you have achieved the KEP standard, your trainer will assign the next module.

# MODULE 2
# BATTERY BANK DOCUMENTATION

## OBJECTIVES

Given local operating instructions (LOIs), stationary battery bank log, and AF Form 719, document battery bank forms and records IAW prescribed procedures.

a. State the proper procedures for completing a stationary battery log.

b. State the proper procedures for completing an AF Form 719.

## PREREQUISITE

Must have completed AFQTP Module 1.

## TRAINING REFERENCE

Local operating instructions

## INFORMATION

In this module, we discuss the two forms used when performing maintenance on stationary battery banks. The stationary battery log and AF Form 719, Historical Record Diesel Electric Generator and System, are used to document specific battery readings and maintenance data. These forms provide useful information to determine performance trends and to identify any battery inconsistencies.

STATIONARY BATTERY LOG. The stationary battery log is used to record the individual cell readings taken during monthly, quarterly, and annual inspections. These readings are compared with other previous readings to identify any major changes in cell status. Areas, such as significant changes in electrolyte level or hydrometer readings, may

indicate a bad cell or overcharging. When filling out the stationary battery log, you need to write legibly and accurately so the readings are interpreted properly.

There are many different forms on which to record battery bank readings. But, in general, each contains the information covered in the following paragraphs. Refer to your stationary battery log during this discussion.

Top Section. This area contains the specific battery bank information. This information can be acquired from the historical record or the previous battery bank log.

Pilot Cell Readings. This section has several different blocks, so we will look at each separately.

Cell Number. This block is used to identify the pilot cells in the battery bank. The pilot cells are identified to represent a sampling of the entire battery bank. Normally, one cell per row is identified. Cells with high or low readings can also be identified to ensure they remain within tolerance.

Charger. During the monthly inspection, the battery bank voltage and charging current are measured and recorded in this block.

Temperature. Ambient (room) and cell temperature are recorded in this block. These temperatures are measured during monthly inspections. Cell temperature is measured with a battery thermometer or a hydrometer with a built-in thermometer. The cell temperature is used to correct specific gravity readings.

Acid Level. In this area, you must record the distance the electrolyte level is from the high-level mark on the cell. This measurement is expressed in fractions of an inch.

Cell Volts. Float and open circuit voltages of the cell are recorded in this block. The procedures for obtaining these readings will be identified in a forthcoming module.

Hydrometer. This block is used to record specific gravity readings of the electrolyte. The indicated hydrometer reading and the corrected reading are documented in this area. The corrected reading is calculated by adding 1 (.001) point for every 3 degrees the cell temperature is above $77^{o}$ Fahrenheit. The same formula is used when the cell temperature is below $77^{o}$ Fahrenheit.

Quarterly/Annual battery bank readings. This section is very similar to the previous section. During monthly inspections, the acid level block is filled out for all the cells in the battery bank. This block is expressed by the distance the electrolyte level is below the high mark on the battery. For example, if the electrolyte is one half of an inch below the high mark, 1/2 is recorded on the form for that particular cell.

During quarterly and annual inspections, the other areas in this section are filled out. Again, the discussion on the quarterly and annual inspections will indicate the procedures for obtaining these readings.

Water Added. This section is filled out whenever water is added. You indicate the date and amount of water that was added.

Discharge Test. This section is filled out when a discharge test is performed. Normally, you will not be required to perform a discharge test.

Connector Retorque. When the intercell connectors are retorqued, enter the date and torque setting in this section.

Remarks. Any additional pertinent data should be identified in this section. Items, such as condition of battery rack, ventilation system, battery room, or other equipment, should be noted here. As you can see, the battery bank log is simple to use. This form is completed monthly and filed in the battery bank historical file. When performing a quarterly or annual inspection, the monthly readings are recorded on the same form. We will now move on to documenting the AF Form 719.

AF FORM 719, HISTORICAL RECORD DIESEL ELECTRIC GENERATOR AND SYSTEM. The AF Form 719 is used to record pertinent historical data, such as performance of maintenance inspections and any special repair or maintenance actions. An AF Form 719 is required for each battery bank maintained.

This form is maintained in the historical folder for each individual battery bank. The form provides a quick reference of man-hours, costs, and specific maintenance performed on the battery bank. Refer to an AF Form 719 during our discussion of the specific sections of the form.

Top Section. This section is used to record specific information on a particular battery bank. This information can be obtained from the previous AF Form 719 or directly from the battery bank.

Maintenance Section. In this area, you indicate specific maintenance performed. Include all monthly, quarterly, and annual inspections and the dates performed. Other repair actions and maintenance, such as replacing a cell or cleaning of intercell connectors, are recorded here. The engine hours block is marked N/A as indicated. Man-hours used to perform the job are identified in the man-hour block. The labor cost, parts cost, and cumulative cost are filled out in accordance with local operating procedures.

**SUMMARY**

The stationary battery log and AF Form 719, Historical Record-Diesel Electric Generator and System, are used to document specific battery readings and maintenance data. These forms provide useful information to determine performance trends and to identify any battery inconsistencies.

The stationary battery log is used to record the individual cell readings taken during monthly, quarterly, and annual inspections. These readings are compared with other previous readings to identify any major changes in cell status.

The AF Form 719 is used to record pertinent historical data, such as performance of maintenance inspections and any special repair or maintenance actions. The form provides a quick reference of man-hours, costs, and specific maintenance performed on the battery bank.

Completing these forms is not difficult; however, it is very important to include clear and accurate information on them. Proper documentation will provide you information concerning immediate and future battery bank maintenance.

**REVIEW QUESTIONS**

Answer the following questions and then compare your responses with the confirmation key in the back of this book. Your responses do not have to match word-for-word but should convey the same basic meaning. Review the applicable portions of this module for all missed questions.

1. Which form is used to record monthly inspection readings?

2. How is the acid level section of the stationary battery log completed?

3. Where on the stationary battery log would you record the retorque value of the intercell connectors?

4. What information is documented in the top section of the stationary battery log?

5. Where are the monthly, quarterly, and annual inspections recorded on the AF Form 719?

6. Where is AF Form 719 on the battery bank normally found?

7. AF Form 719 is used to record which type of items?

**ADDITIONAL INSTRUCTIONS**

When ready, ask your trainer to administer the KEP questions for this module. This is a closed-book test and you must score 70% or more. Your trainer will check your answers and review any incorrectly answered questions with you. When you have achieved the KEP standard, proceed to the performance procedures.

**PERFORMANCE PROCEDURES**

Your trainer will demonstrate procedures for documenting battery bank forms and records. Following the demonstration, you will be given an opportunity to practice the procedure. When you feel comfortable with the procedure, you will be evaluated on the following:

1. Document monthly, quarterly, and annual inspection readings on stationary battery log.
2. Document battery bank historical information on AF Form 719.

After you complete these procedures, your trainer will review your work. When you are proficient in performing the procedures, you may be certified on the AFJQS. Your trainer will assign the next task.

# MODULE 3
# MONTHLY AND QUARTERLY PREVENTIVE MAINTENANCE INSPECTIONS (PMIs)

## OBJECTIVES

1. Given ANSI/IEEE Std 450-1987, Section 4.3.1 General; manufacturer's manual; Digital Voltmeter; Battery Hydrometer; and proper cleaning equipment, perform a Monthly PMI IAW prescribed procedures.

a. State the procedures for measuring and recording float voltage at battery terminals.

b. Identify general appearance and cleaning requirements for batteries, battery racks, and battery rooms.

c. State the procedures for measuring and recording battery charger current and voltage.

d. State the procedures for measuring and recording electrolyte levels.

e. State the procedures for inspecting cell containers.

f. Identify evidence of corrosion at terminals, connectors, or racks.

g. Explain the procedures used to check battery room ambient temperature and ventilation system.

h. List the steps to measure and record pilot cell float voltage, specific gravity, and temperature.

2. Given ANSI/IEEE Std 450-1987, Section 4.3.2 Quarterly; manufacturer's manual; Digital Voltmeter; Battery Hydrometer; Battery Thermometer; and proper cleaning equipment, perform a Quarterly PMI IAW prescribed procedures.

a. State the procedures for measuring the temperature of electrolyte in representative cells.

b. State the procedures for determining when a Special Inspection is required.

**PREREQUISITES**

1. Must have completed AFQTP Modules 1 and 2.

2. Must be able to operate a Digital Voltmeter, a Battery Hydrometer, and a Battery Thermometer.

**TRAINING REFERENCE**

1. ANSI/IEEE Std 450-1987

2. Manufacturer's manual

**INTRODUCTION**

In this module, we cover the Monthly and Quarterly Preventive Maintenance Inspection (PMI) procedures for stationary battery banks. Performing these inspections properly ensures long life and dependability from your battery bank. We'll start with the Monthly Inspection, and then move on to the Quarterly Inspection. Let's get started.

**INFORMATION**

MONTHLY INSPECTION

The Monthly Inspection is also accomplished as part of the Quarterly and Annual Inspections. The Monthly Inspection is a general look at the condition of the battery bank. Let's take a look at what ANSI/IEEE Std 450-1987 states.

**STOP**

> Read Section 4.3.1 General, in ANSI/IEEE Std 450-1987, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations. When you are finished, return to this module.

As you can tell, the Monthly Inspection is not difficult; however, it is important to accomplish it correctly. Let's look at each of the inspection steps.

Float Voltage Measured at Battery Terminals. This step simply measures the voltage of the battery bank. Using a Digital Voltmeter, set the voltage setting to the approximate float voltage of the battery bank. Determine the approximate float voltage by multiplying 2.25 volts times the number of cells (2.25 x # cells = approx float voltage). Set the voltmeter to the proper voltage setting on the DC scale, and then measure the voltage at the terminal ends of the battery bank. Record this voltage reading in the appropriate block of the stationary battery log.

General Appearance. Inspect the appearance and cleanliness of the battery, battery rack, and battery area. Look for leaks, cracks, corrosion, and any other abnormalities. These types of problems are usually quite obvious during this inspection.

It is important to keep the batteries and battery room clean and free of obstructions. By doing this, you will reduce many possible hazards and increase your ability to identify malfunctions.

When necessary, wipe off the accumulation of any dust from the cell covers and containers with a cloth dampened in clean water. If the cell covers or containers are damp with spilled electrolyte, wipe them with a cloth dampened with a solution of bicarbonate of soda and water.

Additionally, you should check the personal safety gear, the eyewash, and emergency shower for proper operation and serviceability during the Monthly Inspection.

Charger Output Current and Voltage. This step identifies the amount of charge being placed on the battery bank. Measure the charging current and voltage by using the ammeter and voltmeter located on the battery charger. Record this reading on the stationary battery log. Charging current and voltage will vary from bank-to-bank, so check with your trainer or the Local Operating Instructions to obtain the acceptable charger readings for your location.

Electrolyte Level. Measure the distance between the electrolyte high- and low-level line on all the cells. Record this measurement on Quarterly/Annual battery bank readings section of the battery bank log.

The electrolyte in all the cells must be maintained between the high- and low-level lines marked on the cell case. Electrolyte levels beyond these parameters will cause changes in cell specific gravity, temperature, and load carrying capacity. Never allow the electrolyte level to fall below the top of the cell plates, this can cause serious damage to the cell.

All the cells must be refilled when the electrolyte level of any one cell reaches the low-level line. Take specific gravity readings prior to adding distilled water or no sooner than 48 hours after refilling to ensure accurate readings. Adding distilled water to the electrolyte changes the specific gravity. The electrolyte must have sufficient time to mix with the water to obtain an accurate reading.

Refilling. Distilled water is used in most batteries to refill the electrolyte to the proper level. Check the manufacturer's manual for your specific battery requirements. Prior to refilling the batteries, you must don the proper safety gear. This includes the rubber apron, face shield, goggles, and acid resistant gloves.

**CAUTION**

Whenever working with batteries, be sure to follow proper safety precautions discussed in Module 1. As always, no smoking or open flames are permitted in the battery area.

To refill the cell, remove the vent cap cover and add distilled water using a battery filler or non-sparking funnel. Add distilled water until the electrolyte level is even with the high-level line. When you are finished, replace the vent cap cover and wipe up any spills.

Continue this procedure for all the cells. Be sure to record the amount of distilled water used on the battery bank log.

Cracks or Leakage. In this step, you must look closely at the cell containers for cracks or leaks. If the cell containers are kept clean, leaks and cracks are easily identified. In most cases, a leak or crack in the container requires cell replacement. This procedure is discussed in a forthcoming module.

Corrosion. In this step, you must identify any corrosion of the terminals, connectors, or battery racks. Routine corrosion control of the battery connections and battery racks ensures the system performs as designed.

Corrosion of the terminals and connectors is identified by greenish deposits of copper salts. This may be caused by spilled electrolyte or seepage through the terminal posts. Remove corrosion by wiping terminals and connectors with a cloth dampened with a solution of bicarbonate of soda and water. Follow with a cloth dampened with clear water and dry with a clean cloth. The entire connection should then be recoated with a thin application of NO-OX-ID grease.

Corrosion of the battery rack can be identified by the formation of rust. Or, in serious cases, by pitting or the formation of cavities that develop under tubercles. Corrosion of the battery rack needs to be dealt with as soon as possible. If left unattended, the corrosion would soon become cancerous and destroy the integrity of the rack.

Temperature and Ventilation. This step requires you to measure and record the battery room temperature and inspect the condition of the ventilation system.

The battery room temperature is monitored to ensure the batteries are not subjected to large temperature variations. Large temperature changes affect battery longevity and load carrying capability. Check the battery manufacturer's manual for maximum allowable temperature variations. Measure and record the ambient temperature on the stationary battery log.

Check the operation and condition of the battery room ventilation system. Simply ensure that all fans and louvers do what they are supposed to do. Fans should run smooth and quiet and louvers should move freely. All vents must be clean and clear of obstructions. Proper ventilation ensures the gasses released from the batteries vent out of the battery room.

If these gasses are not vented, they could ignite and cause an explosion. Contact the Environmental Health office if you feel the battery room is not ventilated correctly.

Pilot Cell Checks. This step checks the individual voltage, specific gravity, and temperature of each of the pilot cells. Pilot cells are specific cells identified to provide a sampling of the entire battery bank. The amount of pilot cells to use is up to each work center. When selecting pilot cells, choose the cells that represent average and extreme conditions (i.e., hot and cold temperatures, high- and low-specific gravity readings, high- and low-float voltage readings, etc.). The cells selected need to represent the overall condition of the battery bank. Let's move on and look at each of the specific checks to accomplish on each pilot cell.

**CAUTION**

Be sure to follow proper safety practices when performing checks on the batteries. Safety procedures and personal protective equipment were identified in Module 1 of this AFQTP.

Float Voltage. Checking the cell float voltage is a relatively simple procedure using a Digital Voltmeter. Each cell is approximately 2-3VDC, so set your voltmeter accordingly. Place the positive lead on the positive terminal of the cell and the negative lead on the negative terminal. The meter will indicate the float voltage of the cell. Record this reading on the stationary battery log and continue this procedure until all pilot cells have been checked. Check the manufacturer's manual for the specific voltage for your batteries.

Specific Gravity. The specific gravity of a cell identifies the condition and state of charge. One of the most important points to keep in mind when taking hydrometer readings is that the readings must be taken from the proper location and depth indicated by the battery manufacturer. On several types of large cells, there are reading tubes built into the diagonal corners of the cover. The purpose of these tubes is to enable taking the specific gravity readings at a point one-third down from the top of the plates. A hydrometer with a long nozzle is used for this purpose. When taking the reading, the hydrometer must be held in a vertical position with just enough electrolyte drawn in to allow the float to move freely. To avoid incorrect readings, the float should not touch the sides, top, or bottom of the barrel. Position the holder so the surface of the liquid is at eye level and read the mark on the hydrometer scale. Read only where the electrolyte level is straight across and not at an angle. Disregard the curvature of the liquid where it contacts the hydrometer body. When

removing the hydrometer from the cell, place your finger at the bottom of the syringe to prevent electrolyte from being spilled. Record the reading obtained in the appropriate block of the pilot cell reading section of the stationary battery log.

Temperature. Cell temperature is measured in degrees fahrenheit using a thermometer. Many hydrometers have a thermometer built in. If this is the case, you can read the temperature at the same time you measure the specific gravity. Some batteries have thermometers installed in the cell and can be read by looking through the cell case. In some cases, you will have to use a battery thermometer. To use the battery thermometer, place it carefully in the cell, half way down in the electrolyte. Wait until the thermometer reading stabilizes, and then read the temperature. Record the cell temperature in the correct block of the stationary battery log.

The specific gravity reading obtained from the previously described procedure may or may not indicate the actual state of charge of a cell. Both temperature and level of electrolyte affect specific gravity readings. As the temperature of the electrolyte increases, it expands and becomes less dense; therefore, the specific gravity is lowered. When the temperature decreases, the electrolyte contracts and becomes more dense. This results in a higher specific gravity reading. In either case, the specific gravity reading is not a true indication of the state of charge of the cell. True readings are based on a temperature of $77^{o}$F ($25^{o}$C). To obtain a true reading when the temperature is above $77^{o}$, one point (.001) is added to the reading for each three degrees above $77^{o}$. If the temperature is below $77^{o}$, one point (.001) is subtracted for each three degrees below $77^{o}$. For example: a cell's temperature is $80^{o}$F, and the measured specific gravity is 1.225, the corrected specific gravity is 1.226.

Another condition to consider is the level of electrolyte in the cell. The specific gravity reading is based on the electrolyte at the high-level line. Evaporation causes a loss of water in the cells. When this loss of water occurs, the battery acid-water mixture then has a greater concentration of acid which results in a higher specific gravity reading. Certain manufacturers recommend adjusting the specific gravity readings for this condition, 15 points (.015) is subtracted from the reading for every half-inch of liquid loss or 30 points (.030) for every inch of loss. For example: the electrolyte level is 1/2 inch below the high-level line and the measured specific gravity is 1.225, the corrected reading would be 1.210. Be sure to check the manufacturer's manual to determine if electrolyte level adjustments are required.

Water should only be added after taking the reading. If water is added before the reading is taken, the reading will be false because the water will not have had time to mix with the acid sufficiently. The result of this condition will be a low reading. The mixing time is usually several days for antimony cells and several weeks for calcium cells on float charge. Record the corrected specific gravity reading in the appropriate block in the pilot cell reading section of the stationary battery log.

This concludes our discussion of the Monthly Preventive Maintenance Inspection. As you can see, this inspection identifies the general condition of the battery bank. During the troubleshooting module in this AFQTP, specific procedures are identified to correct out-of-tolerance readings identified during the inspections. We will now move on and discuss the Quarterly Inspection.

QUARTERLY INSPECTION

At least once per quarter, the Monthly Inspection should be augmented with measuring and recording the specific gravity and voltage of each cell. The procedures for obtaining these readings are the same as the Monthly Inspection. Additionally, part of the Quarterly Inspection entails measuring the temperature of electrolyte in representative cells. The procedures for obtaining these readings are covered in the following paragraphs. These measurements identify the condition of each cell. Out-of-tolerance cells are identified and corrected to ensure the entire battery bank is at a high state of readiness.

**STOP**

> Read Section 4.3.2 Quarterly, in ANSI/IEEE Std 450-1987, IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations. When you are finished, return to this module.

Temperature. This step requires measuring and recording the temperature of 10% of the number of cells in the battery bank. Earlier in this module we discussed how to measure cell temperature. If you have questions on this procedure, review that section of this module. You may use the pilot cell temperatures measured during the previous step. Take additional cell temperatures until you have the required 10%. Calculate the average temperature by dividing the number of cells measured into the total sum of the temperatures measured. For

example: 12 cells were measured and the sum of the temperatures from these cells is 936. Divide 12 into 936 and the average temperature is 78 degrees. Individual cell temperatures cannot exceed the average by more than five degrees. If any cells exceed this amount, corrective action must be taken. Temperature correction procedures are discussed in Module 5 of this AFQTP.

Special Inspection. The Special Inspection is actually a Quarterly Inspection performed at a different time. Periodically, batteries experience abnormal conditions, such as severe discharge or overcharge. When this occurs, you must perform the Special Inspection. Follow the steps for the Quarterly Inspection but document the inspection as a Special Inspection in the historical record.

**SUMMARY**

Covered in this module were the procedures for completing the Monthly and Quarterly Preventive Maintenance Inspections (PMI). The Monthly PMI is a general inspection of the battery bank. The Quarterly PMI involves a more detailed inspection of each cell.

The Monthly Inspection should include a check and record of the following: battery terminal float voltage; general appearance of battery bank and associated equipment; charger current and voltage; electrolyte levels; battery room ambient temperature and ventilation inspection; and pilot cell specific gravity, voltage, and temperature. Any abnormalities identified during this inspection must be corrected.

The Quarterly Inspection also includes the Monthly Inspection. This inspection involves measuring and recording the specific gravity and voltage of each cell. Also recorded, is the temperature of electrolyte in representative cells.

Many premature battery failures can be traced to the lack of proper preventive maintenance. To get good performance from a battery, you must keep it in good working order. Ensuring that the Monthly and Quarterly Inspections are carried out in accordance with prescribed procedures will ensure that the battery bank is capable of performing its intended purpose.

**REVIEW QUESTIONS**

Answer the following questions and then compare your responses with the confirmation key in the back of this book. Your responses do not have to match word-for-word but should convey the same basic meaning. Review the applicable portions of this module for all missed questions.

1. What is the approximate float voltage of a battery bank that has 60 cells?

2. Where is the float voltage measurement taken?

3. What should you look for when checking the appearance of the individual cell?

4. In addition to inspecting the appearance and cleanliness of the battery, battery rack, and battery area, which other equipment should also be inspected during the Monthly Inspection?

5. What is used to measure the battery charger voltage?

6. What is used to measure the battery charging current?

7. What is the correct level of electrolyte that must be maintained in a cell?

8. Why should you never allow the electrolyte to fall below the level of the plates?

9. How should corrosion of the terminals and connectors be removed?

10. Why should corrosion of the battery rack be dealt with as soon as possible?

11. Why is it important to have proper ventilation in the battery room?

12. What does the specific gravity reading indicate?

13. How must a Hydrometer be read to obtain an accurate reading?

14. Which other readings are used to calculate the corrected specific gravity?

15. What is the specific gravity measurement corrected to if the cell temperature is 71$^{o}$ F?

16. What is the purpose of measuring the electrolyte temperatures of 10% of the cells in the battery bank?

17. Which steps of the Quarterly Inspection are required during a Special Inspection?

**ADDITIONAL INSTRUCTIONS**

When ready, ask your trainer to administer the KEP questions for this module. This is a closed-book test and you must score 70% or more. Your trainer will check your answers and review any incorrectly answered questions with you. When you have achieved the KEP standard, proceed to the performance procedures.

**PERFORMANCE PROCEDURES**

Your trainer will demonstrate Monthly and Quarterly PMI procedures. Following the demonstration, you will be given an opportunity to practice the procedure. When you feel comfortable with the procedure, you will be evaluated on the following:

1. Measure and record battery bank float voltage.
2. Clean the battery bank and battery room.
3. Measure and record battery charging current and voltage.
4. Check/correct and record cell electrolyte.
5. Check cells for cracks and leaks.
6. Check for and correct any evidence of corrosion on terminals, connectors, or racks.
7. Measure and record battery room ambient temperature.
8. Check operation and condition of ventilation equipment.
9. Measure and record pilot cell float voltage.
10. Measure and record pilot cell specific gravity.
11. Measure and record pilot cell temperature.
12. Measure and record specific gravity of all cells.
13. Measure and record float voltage of all cells.
14. Determine the average cell temperature.
15. Correct any unbalanced cell temperatures.
16. Determine when a Special Inspection is required.

After you complete these procedures, your trainer will review your work. When you are proficient in performing the procedures, you may be certified on the AFJQS. Your trainer will assign the next task.

# MODULE 4
# ANNUAL PREVENTIVE MAINTENANCE INSPECTION (PMI)

## OBJECTIVES

Given ANSI/IEEE Std 450-1987, Section 4.3.3 Yearly; manufacturer's manual; Micro Ohmmeter; Digital Voltmeter; Battery Hydrometer; Battery Thermometer; and proper tools, perform an Annual PMI IAW prescribed procedures.

a. Explain the procedures for visually inspecting the cells.

b. Explain the procedures for checking/correcting intercell connector resistances.

c. Explain the procedures for inspecting the battery rack.

## PREREQUISITES

1. Must have completed AFQTP Modules 1 thru 3.

2. Must be able to operate a Digital Voltmeter, a Micro Ohmmeter, a Battery Hydrometer, and a Battery Thermometer.

## TRAINING REFERENCES

1. ANSI/IEEE Std 450-1987

2. Manufacturer's manual

## INFORMATION

This module discusses the procedures for completing an Annual Preventive Maintenance Inspection of a stationary battery bank. This inspection is much more involved

than the Monthly or Quarterly Inspections. During this inspection, you will complete a very detailed check of the individual cells, intercell connectors, and the condition of the battery rack.

The first step of the Annual Inspection is to complete a Quarterly Inspection. As you know, part of the Quarterly Inspection is to complete a Monthly Inspection. After you complete these inspections, be sure to document all your findings on the stationary battery log. If you have any questions about the Quarterly Inspection, refer to Module 3 of this AFQTP or ask your trainer.

**STOP**

Read ANSI/IEEE Std 450-1987, Section 4.3.3 Yearly. When you are finished, return to this module.

**NOTE**

Be sure to follow all the proper safety procedures when performing maintenance on the battery bank. Wear proper personal protective equipment when performing battery bank maintenance.

Cell Condition. Conduct a detailed inspection of each cell and record any positive findings in the historical records. Inspect the cells for evidence of sulfation, positive plate growth, excessive sediment, and mossing.

Evidence of Sulfation. Sulfation will show up as a white crystalline powder-like ring around the center of the cell. Sulfation is caused by long periods of low-float voltage and/or frequent discharges with insufficient recharges.

Evidence of Positive Plate Growth. Positive plate growth is caused by excessive discharging and charging cycles and is most common in lead calcium cells. The growth tends to break down the plate grid and ruptures the battery. If positive plate growth is noticed, replace the cell.

Excessive Sediment. Sediment is plate material that has fallen to the bottom of the cell jar. Normally, sediment is not a problem; however, when there is excessive charging and

discharging, sediment will build up rapidly and, in severe cases, can cause the cell to short-circuit. Cells should be replaced before the sediment reaches the bottom of the plates.

Evidence of Mossing. Mossing is deposits of sponge-like layers of lead on the negative plates. This is caused primarily by excessive charging and is prevalent in lead calcium batteries. In severe cases, mossing can cause a cell to short-circuit.

Intercell Connector Resistance Checks. Checking the resistance of intercell connectors provides an indication of whether there is any corrosion or loose connections. Using a Micro Ohmmeter, measure the resistance of each intercell connector. Place the Ohmmeter leads on the terminal posts and read the resistance. Be sure not to touch the connector while taking the reading. Continue this procedure until all of the connectors have been measured. Record the readings from each connector on a sheet of paper or a locally developed form. It is a good idea to maintain these readings in the battery bank historical file to identify any trends.

Once you have measured and recorded all the connector resistances, compare the readings against the original installation readings. If the original readings are not available, determine the average of the current readings. The current resistance can not be more than 20% above the original or average resistance. If any of the connectors have a resistance 20% above the average, they must be retorqued.

**NOTE**

Prior to retorquing/disconnecting the intercell connectors, be sure to disconnect the battery bank from the load. Check local operating instructions for the correct procedures. Be sure to get proper authorization prior to performing this procedure.

Retorque. Retorque the intercell connections to the torque value identified in the manufacturer's manual. Use a torque wrench which permits the torque value to fall in the mid-range of the wrench. Also, be sure to insulate the wrenches used or cover other terminals to reduce the chance of any shorting. Recheck the resistance of the connectors and identify any that do not fall into the allowable value. If the resistance is still above 20%, the connector must be disassembled and cleaned.

Cleaning. To disassemble the connector, you simply loosen and remove the bolts. Again, be sure any tools used are insulated properly.

Using a stiff bristle non-metallic brush, thoroughly clean the bolts, connectors, and the cell terminals. Do not use a wire brush. Care must be taken not to remove the lead plating and expose the copper on the connectors, terminal plates, or terminal posts. When all corrosion has been removed, apply a thin coat of NO-OX-ID grease to all contact areas. When applying the grease, heat it to a cream-like consistency and apply with a paint brush. The melting temperature is approximately 135 , this should be identified on the label. Do not overheat the grease. If the grease is overheated it will turn into an insulating shellac and, as it ages, will increase the resistance of the connection.

When remaking the connections, install the stamped-flat washer with the sharp edge away from the lead plated copper intercell connector to avoid damaging the lead plating. When using lockwashers, install the lockwasher between the nut and the flat washer. Then, torque the connector bolts to the torque value recommended by the manufacturer. Torque all bolts several times to ensure that the proper torque value has been applied. After all bolts are torqued properly, reapply a thin coat of corrosive resistance grease to them. When tightening the bolts to the proper torque value, use a torque wrench that allows the torque value to be indicated near the center of the range to ensure an accurate reading. Using a wrench that is too large will result in an inaccurate amount of torque applied.

Measure the resistance again to ensure it is within tolerance. If there is no Micro Ohmmeter available for checking the resistance, you must retorque all the intercell connectors to the original specifications.

Battery Rack. The last step of the Annual Inspection is to inspect the battery rack. The battery rack supports all the cells, so it is important that it is in good repair. Check the rack for integrity, level, corrosion, and that it is securely anchored to the floor. Do not accomplish any adjustments to the battery rack while it is loaded. Be sure to record any discrepancies on the stationary battery log and AF Form 719.

## SUMMARY

This module discussed the procedures for completing an Annual Inspection of a stationary battery bank. Included in the Annual Inspection are all the requirements for

completion of both the Monthly and Quarterly Inspections. After both inspections have been completed, you will conduct a very detailed check of the individual cells, the intercell connector resistances, and the condition of the battery rack.

The next step of the Annual Inspection is to conduct a detailed visual inspection of each cell and record any positive findings in the historical records. Inspect the cells for evidence of sulfation, positive plate growth, excessive sediment, and mossing.

Upon completion of the cell inspections, you must inspect the intercell connectors. Checking the resistance of intercell connectors provides an indication of whether there is any corrosion or loose connections. Increased resistance is a cause for concern and may require corrective action.

The last step of the Annual Inspection is to inspect the condition of the battery rack. Inspect the rack for integrity, level, corrosion, and that it is securely anchored to the floor. Correct any discrepancies found during the battery rack inspection. However, do not accomplish any adjustments while it is loaded.

Completing the Annual Inspection without cutting corners is very important and will eliminate minor problems and lengthen the serviceable life of your battery bank. Maintaining accurate battery bank records provides an indication of the condition of the system and assists in predicting possible future problems.

**REVIEW QUESTIONS**

Answer the following questions and then compare your responses with the confirmation key in the back of this book. Your responses do not have to match word-for-word but should convey the same basic meaning. Review the applicable portions of this module for all missed questions.

1. What causes excessive positive plate growth?

2. What is the indication of sulfation build-up in a cell?

3. Why is the resistance measured on the intercell connectors?

4. What do you use for resistance comparisons if the original readings are not available?

5. How do you accomplish resistance readings if a Micro Ohmmeter is not available?

6. What is used to clean battery bank bolts, connectors, and terminals?

7. Where are battery rack discrepancies recorded?

**ADDITIONAL INSTRUCTIONS**

When ready, ask your trainer to administer the KEP questions for this module. This is a closed-book test and you must score 70% or more. Your trainer will check your answers and review any incorrectly answered questions with you. When you have achieved the KEP standard, proceed to the performance procedures.

**PERFORMANCE PROCEDURES**

Your trainer will demonstrate Annual PMI procedures. Following the demonstration, you will be given an opportunity to practice the procedure. When you feel comfortable with the procedure, you will be evaluated on the following:

1. Visually inspect all cells for sulfation, positive plate growth, sediment, and mossing.
2. Measure and record intercell connector resistances.
3. Correct any out of tolerance intercell connector resistances.
4. Inspect battery rack for integrity, level, corrosion, and security.
5. Correct and record all discrepancies.

After you complete these procedures, your trainer will review your work. When you are proficient in performing the procedures, you may be certified on the AFJQS. Your trainer will assign the next task.

# MODULE 5
# BATTERY BANK TROUBLESHOOTING

## OBJECTIVES

1. Given the manufacturer's manual, proper test equipment, and tools, perform battery bank troubleshooting IAW prescribed procedures.

    a. Explain the procedures for identifying problems with the battery bank.

    b. Explain the procedures for correcting battery bank malfunctions.

2. Given the manufacturer's manual, local operating procedures, a replacement battery/cell, and proper tools, replace a defective battery/cell IAW prescribed procedures.

    a. Explain the procedures for determining when battery/cell replacement is necessary.

    b. Explain the steps for activating a new battery/cell.

    c. Explain the procedures for replacing a defective battery/cell.

3. Given a defective battery/cell, local operating procedures, and proper equipment, dispose of a defective battery/cell IAW prescribed procedures.

    a. Explain the procedures for disposing of a defective battery/cell.

    b. Explain the procedures for neutralizing a defective battery/cell.

## PREREQUISITES

1. Must have completed AFQTP Modules 1 thru 4.

2. Must be able to operate a Micro Ohmmeter, a Digital Voltmeter, a Battery Hydrometer, and a Battery Thermometer.

## TRAINING REFERENCES

1. Manufacturer's manual

2. Local operating procedures

## INTRODUCTION

In the previous modules, we discussed how to complete the Preventive Maintenance Inspections. In this module, our discussion includes procedures to isolate and correct specific discrepancies identified during the Preventive Maintenance Inspections. In many cases, replacing a bad cell is the only way to correct a problem. This being the case, we have also included a discussion on activating a new cell and correctly disposing of a defective cell. Here again, proper maintenance and repair of your battery bank will ensure long, dependable service.

## INFORMATION

### TROUBLESHOOTING

Corrosion. The most common problem found on battery banks is corrosion. The presence of corrosion can cause a voltage drop which prevents the proper charging voltage from reaching all the cells. Such a condition can cause overcharging in some cells and undercharging in other cells. The overcharged cells may be damaged while the undercharged cells will not be able to supply the proper voltage and current needed during an emergency.

Remove all corrosion from the battery bank before performing any other corrective actions. As stated above, corrosion affects charging of the cells. You cannot accurately determine a malfunction if corrosion is causing a problem. Remove corrosion first, and then determine if there is a problem.

Corrosion Removal. When removing corrosion, be sure to wear the proper protective clothing identified in Module 2.

Removing corrosion from battery connections may require a complete disassembly of the battery bank. If such is the case and continued use of the circuit is a necessity, arrangements should be made to ensure that the circuit is usable. Once the equipment is released for the corrosion removal process, the first step is to apply a mixture of bicarbonate of soda and water to neutralize the corrosion. Next, clean the contact surfaces of the post and lead-plated surfaces with a stiff bristle non-metallic brush. Do not use a wire brush. Be careful not to remove the lead plating and expose the copper on the connectors and terminal posts.

When all corrosion is removed, apply a thin coat of NO- OX-ID grease to all contact areas. When applying the grease, heat it to a cream-like consistency and apply with a paint brush. Do not overheat the grease. If the grease is overheated, it will turn into an insulating shellac. Then, as it ages, the resistance of the connection will increase.

Cracks and Leaks. Cracks in the cell case are not usually repairable. Normally a cell that is cracked or leaking must be replaced. The procedures for cell replacement are discussed later in this module.

Cell Readings. Readings taken during the PMIs provide a telltale sign of the condition of the individual cells. The temperature, specific gravity, and voltage of a cell identifies if it is being charged correctly or if it requires an adjustment to the rate of charge. The manufacturer's manual should provide the specific tolerances for voltage, specific gravity, and temperature. Let's look at some of the causes and corrective actions for improper charging.

Overcharging. There are several symptoms which indicate that overcharging is occurring, or has occurred. The following points out the most common symptoms:

1. Melted grease on terminals.

2. Abnormal loss of water. (You must determine abnormal water loss by checking your battery records and through experience of working with your battery bank.)

3. Positive post dark gray or shiny black. (The positive post should be a charcoal gray.)

4. Evidence of positive plate growth.

5. Excessive sediment.

6. Evidence of mossing.

If one or more of these symptoms of overcharging are recognized, you should determine the cause. Listed next are a few common causes of overcharging and the recommended corrective action for each.

| | CAUSE | | CORRECTIVE ACTION |
|---|---|---|---|
| 1. | Battery Charger improperly adjusted | - | Readjust charger |
| 2. | Charger DC Voltmeter out of adjustment | - | Calibrate DC Voltmeter |

**NOTE**

Do not rely on the charger voltmeter--the float and equalize voltages must be checked at the battery terminals with a Digital Voltmeter.

| | | | |
|---|---|---|---|
| 3. | Corrosion on terminal connections | - | Disconnect/clean connections |
| 4. | Too many equalizing charges | - | Reduce the amount of charges |

Undercharging. Undercharging cells in a battery bank can also result in various problems. Just as overcharging results in certain symptoms, so does undercharging. The following are some of the symptoms which might indicate undercharging conditions:

1. The specific gravity readings are low.

2. The floating voltage readings are low.

3. There is a low open-circuit voltage reading.

4. Evidence of sulfation.

The common causes of undercharging and the recommended corrective action for each are listed below:

| | CAUSE | | CORRECTIVE ACTION |
|---|---|---|---|
| 1. | Floating voltage set too low | - | Adjust floating voltage |
| 2. | Charger Voltmeter out of calibration | - | Calibrate Voltmeter and adjust floating voltage |

**NOTE**

Do not rely on the charger voltmeter--the float and equalize voltages must be checked at the battery terminals with a Digital Voltmeter.

| | | | |
|---|---|---|---|
| 3. | Corrosion on terminal connections | - | Disconnect/clean connections |

Over or under compensation of specific gravity readings. Either over or under compensating when taking specific gravity readings results in erroneous readings. This provides false indications of the state of the cells. The two most common causes of over and under compensation of specific gravity readings are (1) not reading the hydrometer properly (the proper method for reading hydrometers is discussed in a previous module) and (2) not taking the electrolyte sample from the proper place or depth. You should refer to the manufacturer's manual to determine the proper location and depth for taking these readings.

Cell Temperature. Large cell-temperature deviations are usually caused by shorting conditions, which are also evident by the cell voltage. This is cause for immediate cell replacement. Other small temperature deviations are usually caused by outside conditions that are part of the installation ambient temperature. While operation at elevated temperatures will reduce life expectancy, it will not adversely affect capacity.

Equalizing Charge. Equalize charging is the charging of a battery by a higher voltage than the floating charge for a specific number of hours. The amount of time a charge is

applied depends on the charge voltage that is used. The normal equalizing charge is 2.33 volts per cell.

The purpose of the equalizing charge is to compensate for any irregularities that may have occurred during the floating charge. Normally, a deviation in the specific gravity of more than 10 points (0.010) is reason to provide an equalizing charge. The equalizing charge is also used to restore a battery to full charge in a minimum amount of time after a discharge, such as a power failure.

The equalizing charge is a voltage that is higher than the floating voltage, it is determined by using the maximum total voltage that the connected equipment will tolerate. The charge is applied until the specific gravity and voltage readings show no increase. It is very important to check the manufacturer's manual for the amount of voltage and for the length of time that the charge should be applied. The normal equalizing charge for a 60-cell battery is 140 volts (2.33 volts per cell times 60 cells).

Most deviations in the battery readings are corrected by removing corrosion and providing an equalizing charge. Cracks, excessive mossing, sediment, and positive plate growth normally require cell replacement. Let's move on and discuss the procedures to replace a defective cell.

## CELL REPLACEMENT

Replacing battery bank cells. The replacement of battery bank cells is included in this module because the result of troubleshooting often requires such replacement. Replacing cells is basically the same for all stationary battery banks. Let's first discuss the procedures for activating a new cell, and then the replacement procedures.

Prior to replacing a defective cell, you must activate a new cell and have it ready. As always, when working with batteries, you must follow the proper safety precautions and wear your personal protective clothing.

Cell activation. New cells are generally shipped in two forms, dry-charged or wet-charged. The wet charged cell has electrolyte already installed. This type cell normally requires an initial charge prior to installation. Follow the manufacturer's manual for specific charging rates and times.

A dry charged cell requires electrolyte to be added to the cell. Normally, the electrolyte for the cell is shipped with the cell. The electrolyte is premixed to the proper specific gravity for the cell.

**CAUTION**

Never use electrolyte that has a specific gravity above 1.400. This electrolyte is extremely dangerous and should not be handled.

The best place to fill the cell with electrolyte is at the base battery shop. Battery shops are designed and equipped with all the proper safety equipment. If there is no available battery shop at your location, use a well ventilated area with an eyewash and shower available. Be sure to have on hand a good supply of bicarbonate of soda to use as a neutralizing agent.

Fill the cell with the electrolyte using a nonmetallic funnel or filling tube (attached to the electrolyte container). Pour slowly and carefully to avoid any spills. Refer to the manufacturer's manual for the proper initial fill level. Install the flame arrestor on the cell as soon as you fill the cell. This will help to prevent any internal explosions. Allow the cell to stand for four hours to allow the plates to absorb the acid. Refill the cell up to the low-level line. The cell should be charged within 12 hours of filling to avoid any degradation of the cell capacity. Now, the cell is ready to be placed on the battery rack and be charged. Let's look at the replacement procedures, and then we'll charge the battery.

Cell replacement. The first thing to do in cell replacement is to disconnect/isolate the battery bank from the load. Follow the local procedures to isolate the battery bank. Also, be sure to get the proper authorization.

**NOTE**

Never use jumper cables when removing battery cells. The cables may cause a higher resistance in the circuit which could result in a voltage drop and excessive heat.

With these precautions observed, you are now ready to disconnect and remove the cell. The following are cell removal and replacement steps which apply to both the power plant and SSUPS battery banks:

1. Disconnect the connectors on the cell to be removed.

2. Remove the cell from the rack. Do not lift the cell by the terminals, lift from the bottom or use a lifting strap.

3. Place a new cell on the rack.

Make sure the positive and negative posts are in proper position to be connected. (The cells are connected in series, positive to negative.) It is important that the condition of the new cell be checked before installing it.

4. Check the electrolyte level. If the new cell is a wet-charged cell, the level should be between the high and low marks on the side of the cell. If, however, the cell is a dry-charged cell, it should be filled to the level recommended by the manufacturer's manual.

5. Apply a thin coat of NO-OX-ID grease to the connectors and connect them to the new cell.
6. Torque the bolts to the torque value specified by the manufacturer.

7. Apply NO-OX-ID grease to the bolts.

The next procedure includes the steps for charging. They are not the same for both wet and dry cells. For a wet-charged cell, the following steps apply:

1. Set the battery charger to the equalize charge rate, normally 2.33 volts per cell.

2. Refer to the manufacturer's manual for the amount of charge time.

3. After the voltage and current meter readings have stabilized, take the specific gravity reading.

4. Set the battery charger to the normal float voltage.

As previously stated, the procedure for charging dry- charged cells is different from that of wet-charged cells. The dry-charged cell must be activated. To activate a dry- charged cell, you must apply a constant voltage of 2.50 volts per cell for lead-antimony cells and 2.70 volts per cell for lead-calcium cells. When activating the new lead- antimony or lead-calcium cells, the higher charging voltage is also applied to all the other cells. Therefore, a sufficient amount of distilled water must be available during activation to replenish the water loss caused by evaporation due to these higher voltages. Refer to the manufacturer's manual for more detailed information on this procedure and for the amount of charge time.

**CAUTION**

During charging, the cells must not exceed 3VDC per cell and 110 degrees. Charging must be stopped to allow the cells to stabilize.

At the completion of the charge, take a specific gravity reading of the new cell. If the specific gravity reading is within the range indicated on the nameplate, set the charge to the normal floating voltage. If the specific gravity reading is higher than that listed, remove some of the electrolyte and replace it with additional water. If, however, the specific gravity reading is lower than that listed, remove some of the electrolyte and replace it with electrolyte originally used for filling the cell. It is important to wait a minimum of three days before any further adjustments are made to the electrolyte. This provides time for the electrolyte mixture in the cell to become fully stabilized.

In the event a cell is removed and you do not have a replacement cell, the following steps should be taken:

1. Follow the same procedure as previously outlined for removing a bad cell.

2. After the cell has been removed, physically arrange the remaining cells so they can be connected together electrically. The battery bank is capable of operating with one or two cells missing.

3. Lower the floating voltage by the amount of float voltage per cell for each missing cell. This will eliminate the possibility of overcharging the battery bank.

4. Lower the equalizing charge.

5. Lower the low voltage alarm and shutdown voltages, if so equipped.

Be sure to follow the specific instructions of the manufacturer for initializing, charging, and replacing any cells. Once the defective cell is replaced, you must properly dispose of it. Let's move on and look at these procedures.

CELL DISPOSAL

Once a cell is not needed any longer, it must be disposed of. A battery/cell cannot just be thrown in the dumpster. The electrolyte and lead plates in the cell are corrosive and can cause severe injury.

There are many different ways to properly dispose of a cell. Each base/area has different procedures for cell disposal. Your local supply or DRMO (Defense Reutilization Management Office) should provide you with the correct procedures for disposal. In most cases, DRMO will be handling the shipment of the cells. They may ship the cell wet (with electrolyte), dry (without electrolyte), or may have a contract for shipment. It is also a good idea to contact the Environmental Health office, they may provide information on any state or local requirements. Let's look at some of the more common disposal procedures.

Wet shipment. When cells are shipped wet, the electrolyte remains in the cell. Clean the outside of the cell thoroughly using a mixture of water and bicarbonate of soda. Ensure all openings are sealed. Use the original caps if possible. Place the cell(s) on a wooden pallet and cover with cardboard or plywood. Do not stack the cells on top of each other. Strap the cover and the cells to the pallet. The cells are now ready to be delivered to DRMO.

Dry Shipment. When a cell is shipped dry, the electrolyte is removed and must be neutralized. Perform this procedure at a battery shop when possible. First, you must drain the electrolyte from the cell. This can be accomplished by pouring the electrolyte from the cell into a nonmetallic tub/sink. Use extreme safety precautions when performing this procedure. Neutralize the electrolyte by mixing bicarbonate of soda with the electrolyte. Normally, once the electrolyte is neutralized it can be poured into a commercial drain. Check local policies for specific requirements.

Neutralize the cell by flushing a mixture of bicarbonate of soda and water through the cell. This should be accomplished a minimum of two times to ensure the cell is neutralized. Place the cell upside-down to allow it to drain thoroughly. Clean the outside of the cell and strap the cell to a wooden pallet.

Contract Shipment. DRMO may have a specific contract with a local agency to dispose of batteries. In most cases, the contractor will only require the cells to be clean on the outside. DRMO will provide you with any specific requirements for contract shipment.

As you can see, there are many different requirements and procedures for battery disposal. Be sure to always check local policies for all the specific requirements for proper cell disposal.

**SUMMARY**

This module discussed the procedures for troubleshooting a battery bank. In many cases, replacing a bad cell is the only way to correct a problem. Also included was a discussion on activating a new cell and correctly disposing of a defective cell.

The most common problem found on battery banks is corrosion. The presence of corrosion can cause a voltage drop which prevents the proper charging voltage from reaching all the cells. Such a condition can cause overcharging in some cells and undercharging in other cells. Remove all corrosion from the battery bank before performing any other corrective actions.

Readings taken during the PMIs provide a telltale sign of the condition of the individual cells. The temperature, specific gravity, and voltage of a cell identifies if it is being charged correctly or if it requires an adjustment to the rate of charge. Most deviations in the battery readings are corrected by removing corrosion and providing an equalizing charge. Cracks, excessive mossing, sediment, and positive plate growth normally require cell replacement.

Prior to replacing a defective cell, you must activate a new cell and have it ready. New cells are generally shipped in two forms, dry-charged or wet-charged. Wet-charged cells are given an equalizing charge, while dry-charged cells must be activated with the

proper voltage. When replacing a cell, follow the manufacturer's instructions and local procedures to isolate the battery bank.

Once a cell is no longer needed, it must be disposed of. Each base/area has different procedures for cell disposal. Your local supply or DRMO should provide you with the correct procedures for disposal. In most cases, the DRMO will be handling the shipment of the cells. They may ship the cell wet, dry, or may have a contract for shipment.

It is important to know how to accurately identify and correct possible problems of your battery bank. Thorough inspections and common sense will identify many of them. In the event the only solution to the problem is cell replacement, be sure to follow the procedures of the manufacturer's manual and local operating instructions. Always check local policies for all the specific requirements for proper cell disposal.

**REVIEW QUESTIONS**

Answer the following questions and then compare your responses with the confirmation key in the back of this book. Your responses do not have to match word-for-word but should convey the same basic meaning. Review the applicable portions of this module for all missed questions.

1. List three indications of a cell being overcharged.

2. List the three most common causes of cells overcharging and the corrective actions needed.

3. List three indications of cells being undercharged.

4. List the three most common causes of undercharged cells and the corrective actions needed.

5. What are two common causes of over or under compensation of specific gravity readings?

6. Why shouldn't jumper cables be used on a battery bank?

7. When replacing a cell on a SSUPS battery bank, you should _____ the bank from the system.

8. How is the new cell connected electrically on the rack?

9. Which procedure is used to replace a cell when there is no replacement cell?

10. Will high cell temperature affect cell load capacity?

11. Why must lifting straps and spacers be used when lifting the cell?

12. Which safety precautions must be used when disposing of a battery/cell?

**ADDITIONAL INSTRUCTIONS**

When ready, ask your trainer to administer the KEP questions for this module. This is a closed-book test and you must score 70% or more. Your trainer will check your answers and review any incorrectly answered questions with you. When you have achieved the KEP standard, proceed to the performance procedures.

**PERFORMANCE PROCEDURES**

Your trainer will demonstrate how to troubleshoot a battery bank, replace a defective battery/cell, and perform a proper battery/cell disposal procedure. Following the demonstration, you will be given an opportunity to practice the procedure. When you feel comfortable with the procedure, you will be evaluated on the following:

1. Identify battery bank malfunctions.
2. Correct battery bank malfunction.
3. Document malfunctions and corrective actions.
4. Determine when battery/cell replacement is necessary.
5. Fill a dry-charged battery/cell with electrolyte.
6. Charge a new battery/cell.
7. Replace defective battery/cell.
8. Drain electrolyte from battery/cell (if applicable).
9. Neutralize the electrolyte (if applicable).
10. Neutralize and flush battery/cell (if applicable).
11. Clean battery/cell case (if applicable).
12. Seal all battery/cell openings (if applicable).
13. Secure the battery/cell to a pallet (if applicable).
14. Turn in battery/cell for contract disposal (if applicable).

After you complete these procedures, your trainer will review your work. When you are proficient in performing the procedures, you may be certified on the AFJQS.

REVIEW QUESTIONS CONFIRMATION KEY

MODULE 1

1. The number of cells connected in series
2. They connect the cells electrically
3. Float charge and Equalize charge
4. Switchgear, Safety circuits, Emergency lights, or Uninterruptible Power Supply (UPS)
5. To restore batteries to full charge in a minimum amount of time
6. In series
7. Sparking, arcing, excessive heat, and possible explosion
8. A mixture of bicarbonate of soda and water
9. Damage may occur to the terminal and the cell
10. Goggles/face shield, acid resistant gloves, and apron

MODULE 2

1. Stationary Battery Log
2. Document the level of the electrolyte level using fractions of an inch
3. Connector retorque section
4. Specific battery bank information
5. In the maintenance section
6. Battery bank historical folder
7. Man-hours, costs, and specific maintenance performed

MODULE 3

1. 135 volts
2. At the terminal ends of the battery bank
3. Leaks, cracks, and corrosion
4. Personal safety gear, the eyewash, and emergency shower
5. Battery Charger Voltmeter
6. Battery Charger Ammeter
7. Between the high- and low-level lines
8. This can cause severe damage to the cell
9. Remove corrosion by wiping terminals and connectors with a cloth dampened with a solution of bicarbonate of soda and water. Follow with a cloth dampened with clear water and dry with a clean cloth
10. If left unattended, the corrosion would soon become cancerous and destroy the integrity of the rack
11. If gasses are allowed to build up, it may cause an explosion
12. The condition and state of charge of the cell
13. At eye level, straight, and level
14. Electrolyte level and temperature
15. Subtract 2 points (.002) from the actual reading
16. To determine the average temperature for all the cells

17. All steps required for the Quarterly Inspection are required for the Special Inspection

MODULE 4

1. Excessive discharging and charging cycles
2. A white crystalline or powder-like ring around the center of the cell
3. The resistance provides an indication of whether there is any corrosion or a loose connection
4. The average of the current resistance readings
5. All connections must be retorqued to the original specifications
6. Stiff bristle non-metallic brush
7. Stationary battery log and AF Form 719

MODULE 5

1. Melted grease, abnormal loss of water, positive post dark gray or shiny black
2. CAUSE — CORRECTIVE ACTION
   a. Battery charger improperly adjusted - Readjust charger
   b. DC Voltmeter out of calibration - Calibrate Voltmeter
   c. Corrosion on connections - Clean connections
3. Low specific gravity readings, Low floating voltage reading, Low open-circuit voltage
4. CAUSE — CORRECTIVE ACTION
   a. Floating Voltage too low - Adjust Floating Voltage
   b. Charging Voltmeter out of calibration - Calibrate Voltmeter
   c. Corrosion on connections - Clean connections
5. Not reading the hydrometer properly and not taking the specific gravity reading from the proper location
6. The cables may cause a resistance which could result in a voltage drop and excessive heat
7. Disconnect
8. In series, positive to negative
9. Remove the cell, arrange the remaining cells so they can be connected together, and reduce the charging voltage by 2.0 volts for every cell removed
10. No. It will reduce life expectancy
11. To reduce the chance of causing damage to the cell case and terminals
12. Wear proper protective clothing, proper ventilation, and no open flames

**TRAINEE SURVEY**

**NAME_____ RANK_____ DSN_____**

**UNIT ADDRESS_____ MAJCOM_____ DATE_____**

1. What is your time in service (TIS)?
   a. 0-3 yrs
   b. 4-8 yrs
   c. 9-16 yrs
   d. 17 yrs or more

2. Have you had previous training on this equipment/function?

   a. Yes (Please explain; use extra paper if necessary)
   b. No

3. The purpose of AFQTPs is to provide standardized training programs for specific equipment or functions. How well do you feel this AFQTP accomplished its purpose?

   a. Outstanding
   b. Excellent
   c. Satisfactory
   d. Marginal
   e. Unsatisfactory (Please explain)

4. The material presented in the Skill Training Material (STM) was

   a. easy for me to understand.
   b. unclear in some areas. (Please identify)
   c. difficult for me to understand. (Please explain)

5. Were the modules arranged in a logical learning format (easy to difficult or simple to complex)?

   a. Yes
   b. No (Please explain)

6. Was information presented in the AFQTP (including reading assignments) sufficient for you to answer both the Review and KEP questions?

   a. Yes
   b. No (Please explain)

7. Did you find any technical errors in the material?

   a. Yes (List errors)
   b. No

8. The illustrations (diagrams, figures, and examples) in the AFQTP were

   a. high quality and aided learning.
   b. poor quality, but still helpful.
   c. limited; additional illustrations are needed.
   d. non-existent in this AFQTP.

9. Would additional figures, illustrations, or examples help you better understand the material presented in the AFQTP?

   a. Yes (Please explain)
   b. No

10. Did the tasks listed on the AFJQS cover the major requirements for this equipment/function?

   a. Yes
   b. No (Please explain)

11. The reading grade level for this package was

   a. much too high.
   b. slightly high.
   c. about right.
   d. too low.

12. What improvements would you make to this AFQTP to help meet your training needs?

# KNOWLEDGE EVALUATION PAMPHLET (KEP)

This pamphlet should be separated from the package immediately and stored to prevent compromise of the questions. The KEP confirmation key located at the back of this pamphlet should be detached and stored.

After the trainee completes each module, the supervisor/trainer administers the corresponding KEP test. Using the KEP confirmation key, the supervisor/trainer checks the trainee's answers and reviews the incorrect responses. If the trainee does not achieve the minimum required score on each module test, he/she must reaccomplish the entire module.

The answer sheet for the KEP is located at the back of this pamphlet. This answer sheet may be detached to make it easier to enter the answers.

The trainee's responses to the KEP questions will aid us in evaluating the effectiveness of this training package. After the questions have been answered for all the module tests, please attach the completed and graded answer sheets and trainee/trainer surveys to the Training Certification document located in the back of the Trainer's Guide and send the package to us at this address:

81 TRSS/TSQS
601 D STREET
KEESLER AFB MS 39534-2229

**KEP QUESTIONS - MODULE 1**

1. Which best describes a lead-acid battery?

   a. An electromechanical device that produces voltage
   b. A group of different sized cells connected in series
   c. A group of identically sized cells connected in parallel
   d. An electrochemical device that produces direct current (DC)

2. What is the chemical symbol for sulfuric acid?

   a. Pb
   b. $H_2O$
   c. $PbO_2$
   d. $H_2SO_4$

3. Which best describes the charge required to maintain batteries at the fully charged state on a day-to-day basis?

   a. Float
   b. Constant
   c. Equalize
   d. Variable

4. Which type charge is used to restore batteries to full charge after a load has been applied to the battery bank?

   a. Float
   b. Constant
   c. Equalize
   d. Variable

5. What is installed on most batteries to reduce the chance of a possible internal explosion?

a. Vent caps
b. Arc shields
c. Flame arrestors
d. Explosion proof vents

6. Which best describes the mixture used to neutralize a sulfuric acid spill?

a. 1/2 lb of baking soda and 1 gallon of water
b. 2 lbs of baking soda and 5 gallons of water
c. 1 lb of bicarbonate of soda and 1 gallon of water
d. 1 lb of bicarbonate of soda and 5 gallons of water

7. When moving a large battery cell, which of the following is the proper lifting technique?

a. Place your hands underneath the cell and lift
b. Use a lifting belt and spreader in conjunction with a crane or hoist
c. Connect the cables to the terminal posts and lift with a crane or hoist
d. Have two people place their hands underneath the cell and lift together

**KEP QUESTIONS - MODULE 2**

1. When are charging voltage and current readings taken?

    a. Weekly
    b. Monthly
    c. Quarterly
    d. Annually

2. Which cells are used to represent a sampling of the entire battery bank?

    a. Test
    b. Pilot
    c. Varies
    d. Every tenth cell

3. Which block in the Quarterly/Annual Battery Bank Readings section is filled out during the monthly inspection?

    a. Acid level
    b. Float voltage
    c. Hydrometer reading
    d. Open circuit voltage

4. How many points would be added to the hydrometer reading if the cell temperature is 83 degrees Fahrenheit?

    a. 1
    b. 2
    c. 3
    d. 4

5. Which information must be documented on the stationary battery log after adding water to the battery bank?

a. Date and type
b. Date and amount
c. Type and amount
d. Amount and level

6. In which section of the stationary battery log is the condition of the battery rack and ventilation system documented?

a. Top
b. Remarks
c. Pilot cell readings
d. Quarterly/Annual battery bank readings

7. All significant maintenance and repair performed on the battery bank is documented on

a. AF Form 1841, Maintenance Action Sheet.
b. AF Form 1167, Daily Power Plant Operation Log.
c. AF Form 487, Emergency Generator Operating Log.
d. AF Form 719, Historical Record Diesel Electric Generator and System.

8. Which item would be documented on AF Form 719?

a. Cell temperature
b. Cell replacement
c. Hydrometer readings
d. Cell float voltage readings

**KEP QUESTIONS - MODULE 3**

1. Which instrument is used to measure the battery bank float voltage?

   a. Ohmmeter
   b. Analog Ammeter
   c. Digital Voltmeter
   d. Battery Hydrometer

2. On which form is the float voltage recorded?

   a. Stationary battery log
   b. AF Form 1167, Daily Power Plant Operation Log
   c. AF Form 487, Emergency Generator Operating Log
   d. AF Form 719, Historical Record Diesel Electric Generator and System

3. Which problems can be identified when checking the appearance of the battery bank?

   a. Leaks, cracks, and corrosion
   b. Leaks, cracks, and float voltage
   c. Corrosion, high temperature, and leaking
   d. Specific gravity, temperature, and voltage

4. What is used to clean acid spills?

   a. Plain water
   b. Battery water
   c. Approved solvent
   d. Mixture of water and bicarbonate of soda

5. What is used to measure battery charging current?

    a. Ohmmeter
    b. Digital Voltmeter
    c. Battery Hydrometer
    d. Battery Charger Ammeter

6. Measuring the battery charger voltage is conducted during which inspection?

    a. Weekly
    b. Monthly
    c. Quarterly
    d. Annually

7. The electrolyte in all cells must be maintained at which level?

    a. Below the low-level line
    b. Above the high-level line
    c. Three-eighths of an inch above the cell plates
    d. Between the high- and low-level lines

8. What action should be taken if the electrolyte level of one cell is below the low-level line?

    a. Refill the cell
    b. No action is required
    c. Refill other cells at low-level line
    d. Refill all cells to the high-level line

9. Which problem(s) can be identified when inspecting cell containers?

a. Frothing
b. Cracks and leaks
c. Improperly floated cell
d. Excessive self-discharge

10. In most cases, a leak or crack in a cell container would require battery bank replacement.

a. True
b. False

11. Corrosion of the battery bank terminals and connections is identified by greenish deposits of which substance?

a. Sulfur
b. Zinc oxide
c. Iron sulfide
d. Copper salts

12. After removing corrosion from battery terminals and connections, what must be applied to them?

a. Teflon tape
b. 90-weight oil
c. NO-OX-ID grease
d. Wheel bearing grease

13. Normally, what is used to vent battery gasses out of the battery room?

a. Fans and vents
b. Normal air flow
c. Windows and fans
d. Air handling units

14. Where would you find information concerning the maximum allowable temperature variations for your battery bank?

a. Tables of allowance
b. Environmental health
c. Manufacturer's manual
d. Base Civil Engineer (BCE)

15. How many points must be added to the specific gravity reading of a cell with a temperature of 80 degrees?

a. 1
b. 2
c. 3
d. 4

16. The primary purpose of the battery hydrometer is to measure electrolyte

a. level.
b. temperature.
c. conductivity.
d. specific gravity.

17. Which percent of battery bank cells are used to determine the average cell temperature?

a. 5
b. 10
c. 15
d. 20

18. What is the maximum allowable temperature in degrees Fahrenheit a cell may be above the average before corrective action is required?

a. 5
b. 10
c. 15
d. 20

19. When is a Special Inspection required?

a. Quarterly
b. Annually
c. After a power outage
d. After a severe discharge

20. The Special Inspection is actually a Monthly Inspection performed at another time.

a. True
b. False

**KEP QUESTIONS - MODULE 4**

1. A sponge-like layer of lead deposited on the negative plate of a cell is an indication of

a. mossing.
b. sediment.
c. sulfation.
d. positive plate growth.

2. Plate material that has fallen to the bottom of the cell jar is an indication of

a. mossing.
b. sediment.
c. sulfation.
d. positive plate growth.

3. What is the first step to take with an intercell connector when its resistance reading is above the allowable value?

a. Clean
b. Replace
c. Retorque
b. Disassemble and clean

4. Which percent above the installation value is the maximum allowable resistance of the intercell connectors?

a. 10
b. 15
c. 20
d. 25

5. A wire brush should be used to clean battery terminals and intercell connectors.

   a. True
   b. False

6. The battery rack is inspected for

   a. security, corrosion, level, and rigidity.
   b. integrity, level, corrosion, and security.
   c. integrity, corrosion, rigidity, and level.
   d. corrosion, security, cleanliness, and level.

7. Adjustments to the battery rack are allowed when it is loaded.

   a. True
   b. False

**KEP QUESTIONS - MODULE 5**

1. What is the most common problem found on stationary battery banks?

   a. Mossing
   b. Leaking
   c. Corrosion
   d. Undercharging

2. Which of the following is an indication of overcharging?

   a. Evidence of sulfation
   b. Abnormal loss of water
   c. Low open-circuit voltage
   d. Low specific gravity readings

3. Large cell-temperature deviations are usually an indication of

   a. mossing.
   b. sediment.
   c. overcharging.
   d. internal shorting.

4. Reducing the number of equalize charges is a corrective action for

   a. corrosion.
   b. overcharging.
   c. undercharging.
   d. low specific gravity readings.

5. An equalizing charge is required when specific gravity readings deviate more than

a. 5 points (0.005).
b. 10 points (0.010).
c. 15 points (0.015).
d. 20 points (0.020).

6. What is the normal charging voltage for a 60 cell battery bank during an equalizing charge?

a. 120
b. 125
c. 135
d. 140

7. Normally, a cell with a low specific gravity reading should be replaced.

a. True
b. False

8. Which action is required when a cell has excessive positive plate growth?

a. Equalize charge
b. Replace the cell
c. Remove the growth
d. Reduce charging voltage

9. What is the correct electrolyte level when initially filling a new cell?

a. Low-level line
b. High-level line
c. One-fourth inch below the low-level line
d. Between the high- and low-level line

10. To avoid possible damage to the cell, it should be charged within how many hours?

a. 6
b. 12
c. 24
d. 48

11. When activating a new cell, charging voltage must not exceed _____VDC.

a. 2.25
b. 2.50
c. 2.75
d. 3.00

12. It is discovered that a cell needs to be replaced but you do not have a replacement cell. Which procedures should you follow?

a. Shut the battery bank down until the new cell arrives
b. Leave the cell in the battery bank until you receive the new cell
c. Remove the cell and use jumper cables to connect the remaining cells together
d. Remove the cell and arrange the remaining cells so they can be connected together

13. Normally, after a new cell is charged, how long should you wait before making adjustments to the electrolyte specific gravity?

a. 1 week
b. 3 days
c. 24 hours
d. 12 hours

14. Which agency can provide you with the correct procedures for cell disposal?

a. AGE
b. BCE
c. CSU
d. DRMO

15. How high can cells be stacked when preparing for disposal?

a. 1
b. 2
c. 3
d. 4

16. What is used to neutralize the inside of the cell?

a. Water
b. Battery water
c. Acid neutralizer
d. Bicarbonate of soda

17. What is the minimum number of times a cell should be flushed to ensure it is neutralized?

a. 1
b. 2
c. 3
d. 4

# KEP CONFIRMATION KEY

| MODULE 1 | MODULE 2 | MODULE 3 | MODULE 4 | MODULE 5 |
|---|---|---|---|---|
| 1. d | 1. b | 1. c | 1. a | 1. c |
| 2. d | 2. b | 2. a | 2. b | 2. b |
| 3. a | 3. a | 3. a | 3. c | 3. d |
| 4. c | 4. b | 4. d | 4. c | 4. b |
| 5. c | 5. b | 5. d | 5. b | 5. b |
| 6. c | 6. b | 6. b | 6. b | 6. d |
| 7. b | 7. d | 7. d | 7. b | 7. b |
| | 8. b | 8. d | | 8. b |
| | | 9. b | | 9. a |
| | | 10. b | | 10. b |
| | | 11. d | | 11. d |
| | | 12. c | | 12. d |
| | | 13. a | | 13. b |
| | | 14. c | | 14. d |
| | | 15. a | | 15. a |
| | | 16. d | | 16. d |
| | | 17. b | | 17. b |
| | | 18. a | | |
| | | 19. d | | |
| | | 20. b | | |

KEP QUESTIONS ANSWER SHEET

NAME_____ RANK_____ DAFSC_____ DSN_____

ORGANIZATION_____MAJCOM_____ DATE COMPLETED_____

| MODULE 1 | MODULE 2 | MODULE 3 | MODULE 4 | MODULE 5 |
|---|---|---|---|---|
| 1. ____ | 1. ____ | 1. ____ | 1. ____ | 1. ____ |
| 2. ____ | 2. ____ | 2. ____ | 2. ____ | 2. ____ |
| 3. ____ | 3. ____ | 3. ____ | 3. ____ | 3. ____ |
| 4. ____ | 4. ____ | 4. ____ | 4. ____ | 4. ____ |
| 5. ____ | 5. ____ | 5. ____ | 5. ____ | 5. ____ |
| 6. ____ | 6. ____ | 6. ____ | 6. ____ | 6. ____ |
| 7. ____ | 7. ____ | 7. ____ | 7. ____ | 7. ____ |
| | 8. ____ | 8. ____ | | 8. ____ |
| | | 9. ____ | | 9. ____ |
| | | 10. ____ | | 10. ____ |
| | | 11. ____ | | 11. ____ |
| | | 12. ____ | | 12. ____ |
| | | 13. ____ | | 13. ____ |
| | | 14. ____ | | 14. ____ |
| | | 15. ____ | | 15. ____ |
| | | 16. ____ | | 16. ____ |
| | | 17. ____ | | 17. ____ |
| | | 18. ____ | | |
| | | 19. ____ | | |
| | | 20. ____ | | |

NOTE: After completing and grading all tests, attach this answer sheet, along with the Trainee and Trainer Surveys, to the Training Certification document located in the back of the Trainer's Guide. Send the package to the following address:

81 TRSS/TSQS
601 D STREET
KEESLER AFB, MS 39534-2229