Signal Power Distribution Troubleshooting and Repair

Course 307

PARTICIPANT GUIDE

SIGNALS TRAINING CONSORTIUM

TROUBLESHOOTING AND REPAIR OF SIGNALS POWER DISTRIBUTION

Participant Guide

Signals Maintenance Training Consortium

COURSE 307

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NOTE: All images contained within this document were contributed by Signals Training Consortium members unless otherwise noted.

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How to Use the Participant Guide

Purpose of the Course

The purpose of the *Power Distribution Troubleshooting and Repair* course is to assist the participant in gaining knowledge in troubleshooting and repairing signals power distribution systems and their associated components.

Approach of the Book

Each course module begins with an outline, a statement of purpose and objectives, a list of key terms, and review exercises. The *outline* will discuss the main topics to be addressed in the module. *Learning objectives* define the basic skills, knowledge, and abilities course participants should be able to demonstrate to show that they have learned the material presented in the module. A list of *key terms* identifies important terminology that will be introduced in this module. *Review exercises* conclude each module to assist the participants in reviewing key information.

Module 1

PRINCIPLES OF TROUBLESHOOTING

Outline

Purpose and Objectives

The purpose of this module is to provide an overview to troubleshooting signal systems equipment and machinery within the context of general troubleshooting and best practices.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- Examine the importance of troubleshooting
- Restate the troubleshooting process
- Identify troubleshooting steps
- Identify troubleshooting best practices
- Apply troubleshooting principles to some common signal systems problems and causes.

Key Terms

- Four Ds
- Root Cause
- Root Cause Analysis (RCA)

1-1 OVERVIEW

Troubleshooting is an integral part of signal systems maintenance. The signal maintainer is guided through a process of troubleshooting in order to get to the heart of the reported signals problem so that solutions can be applied quickly and equipment can be safely returned to service in the most efficient way possible.

As part of the Signals Training Consortium series of courses, this course guides the participant through the troubleshooting process by identifying some general strategies, tips, pitfalls, and application procedures. In later courses, the participant will apply this general approach while troubleshooting specific areas of the signals system such as track circuits, switches, interlockings, grade crossings, and power distribution by examining common failures and discussion examples.

1-2 THE PROCESS OF TROUBLESHOOTING

Troubleshooting may be defined as a systematic approach to finding the source of a problem in an effort to restore an operation. Troubleshooting is problem-solving in a methodical and organized manner. Sometimes troubleshooting a problem is simple. At other times it may be complex, and problems may be difficult to diagnose. Whatever the level of complexity of a signals system, the approach to troubleshooting should be orderly and logical.

The focus of troubleshooting is to find the **root cause** of a problem: that which is initiating a problem. In order to get at the root cause, the troubleshooter would apply **Root Cause Analysis** (**RCA**) which is the collective term that describes the processes or procedures that help guide signal maintainers not only to discover and understand the initiating causes of a problem, but to determine what is needed to prevent recurrence.

In general, there is a series of steps in troubleshooting. There are many descriptions of these steps in the signals industry, but a simple approach involves four steps which we can refer to as the **Four Ds**. They are:

1. **Define**
2. **Decide**
3. **Do**
4. **Document**

1-3 FOUR STEPS IN TROUBLESHOOTING

Figure 1.1 illustrates the four-step method for troubleshooting. Some rail transit authorities may have additional or different steps in approaching troubleshooting but, in general, all the principles are captured in these four steps which can be followed when beginning to troubleshoot a problem within transit signal systems. This list is a basic approach or model that the participant can follow.

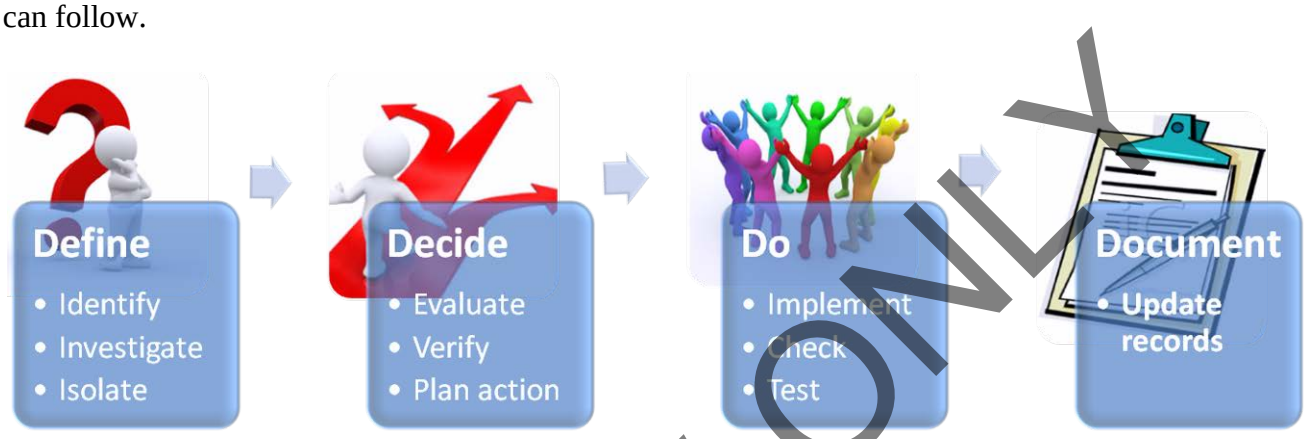

Figure 1.1 The Four Ds: Steps in Troubleshooting Signals Systems

Step 1 - Define

Identify Symptoms, Investigate Situation, Isolate Problem

In order to define the problem, the signal maintainer needs to identify the symptoms of the trouble call by collecting as much information as possible on the reported problem. Some questions the signal maintainer may ask are:

- Who may have relevant knowledge about the problem?
- What other local equipment is having trouble? Look at broader, larger picture.
- Investigate initial complaints or situation, employ sensory inspection – check the problem out for yourself. Is there an environmental condition that is affecting the equipment performance? Have temperatures dropped too low? Is something overheated? Do you notice any unusual smells or sounds? Do any parts of the system seem unusual to the touch?
- Use your eyes, ears, nose, when possible to get a feel for the problem.

Module 2

OVERVIEW TO TROUBLESHOOTING AND REPAIR OF SIGNAL POWER DISTRIBUTION

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview for troubleshooting and repair of signal power distribution.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- Describe FRA and other regulatory or agency specific guidelines for documentation procedures
- Describe safety practices and processes as related to power distribution troubleshooting & repair
- Describe specialized test equipment used for troubleshooting power distribution
- Describe how to verify operation of power supply
- Describe how to identify and recognize when power is not functioning as normal
- Explain processes for delayed repairs

Key Terms

- Additional personnel
- Best practices
- Cable finder
- Confirm
- Delayed Repairs
- Documentation Procedures
- Effectively protected
- Follow-up tasks
- Half-split methods
- Initial notification of problem
- Job hazard analysis
- Job Site Analysis
- Potential hazard
- Preliminary observation
- Proper communication
- Quickest route to site
- Record
- Safety hazards
- Sensory inspection
- Short finder
- Task analysis
- Verify power operation

2-1 OVERVIEW

While general troubleshooting is covered in the earlier module, troubleshooting a power distribution for signal systems may present special circumstances and situations that are unique when compared to the rest of the signal and rail system. With signal power distribution, not only will signal maintainers need to accurately diagnose the problem and effectively make the repair, they may also need to contend with other conditions such as other signal and rail departments and environmental concerns.

Consideration for these extenuating circumstances in addition to general troubleshooting skills is the basis and foundation for troubleshooting signal power distribution. Module 2 will explore the general processes and safety considerations related to troubleshooting as well as basic definitions and specialized tools sometimes required.

Working on signal power distribution is dangerous work.

Warning: Safety Precautions!

As with all work on train tracks, the signal maintainer must strictly adhere to the worker safety policies of the transportation agency.

Signal maintainers must adhere City Safety Oversight (local), Department of Transportation (state), FRA, OSHA, NFPA, FTA, and agency specific safety department's govern safety regarding working with power and power distribution.

Your Agency's Safety Policy Power and Governing Regulations

Ultimately, a signal maintainer's job is to restore power to signal service when a problem arises. However, troubleshooting power distribution not only presents the challenges of general troubleshooting for a signal maintainer, but also presents situations that can prove to be stressful

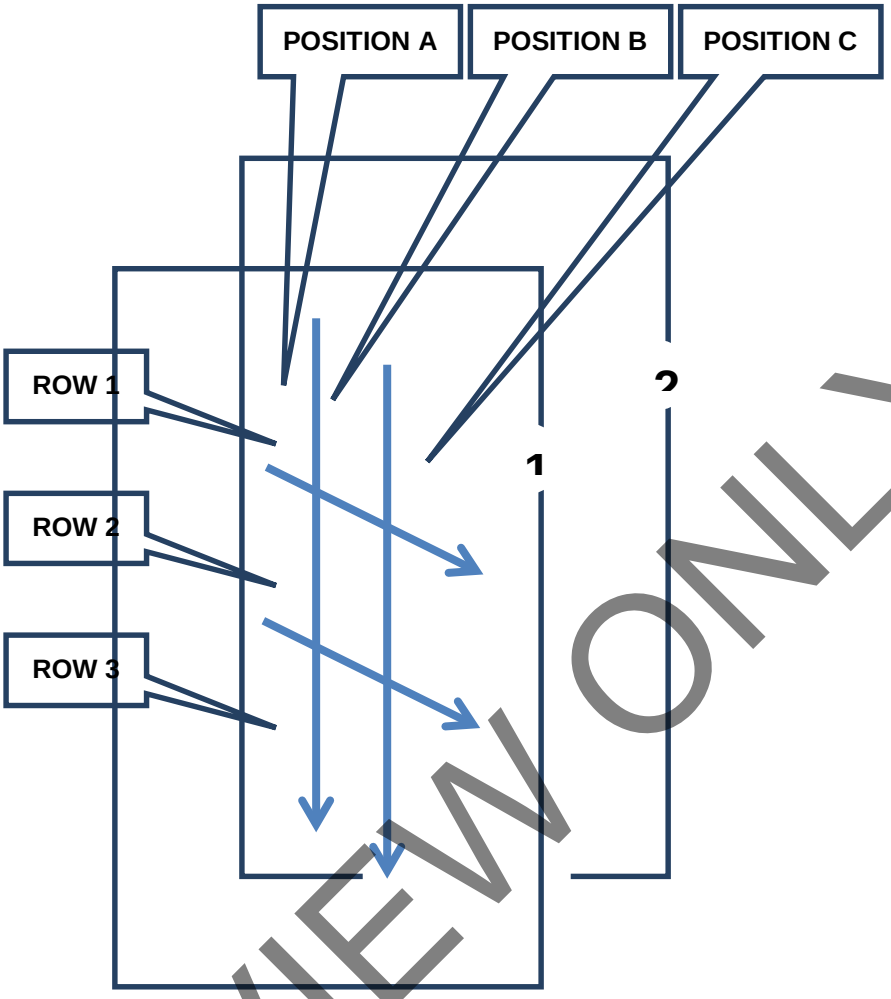

Figure 2.3 Alpha-numeric order of racks in CIL

When troubleshooting signal power distribution, the signal maintainer many times may reference the circuit diagrams located in the CIL for two reasons:

1. To trace circuit connections with other components to see where a problem may lie and therefore may be resolved.
2. A signal maintainer will also seek to determine if power is on normal or standby.
3. To identify OEM part numbers in case they need to be replaced.

Typically, these rack locations correspond to the components represented in the circuit diagrams supplied by the OEM.

In addition to this location system of racks, rows, and positions, each transit agency may have a unique method of identifying locations. In some cases, this system may be computerized making

Module 3

TROUBLESHOOTING AND REPAIR OF SIGNAL POWER DISTRIBTUTION USING ELECTRICAL PRINTS

Outline

Purpose and Objectives

The purpose of this module is to provide an overview of the use of prints for troubleshooting procedures in signal power distribution systems.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- Identify basic nomenclature and symbols for power distribution equipment
- Identify the layout of power distribution and circuits using prints
- Measure input and output of power using prints
- Identify various prints representing various power distribution systems
- Explain how to use prints for troubleshooting signal power distribution systems
- Explain how to sectionalize power sources for testing and troubleshooting

Key Terms

- Nomenclature
- Path of power
- Reference sheet
- Symbols

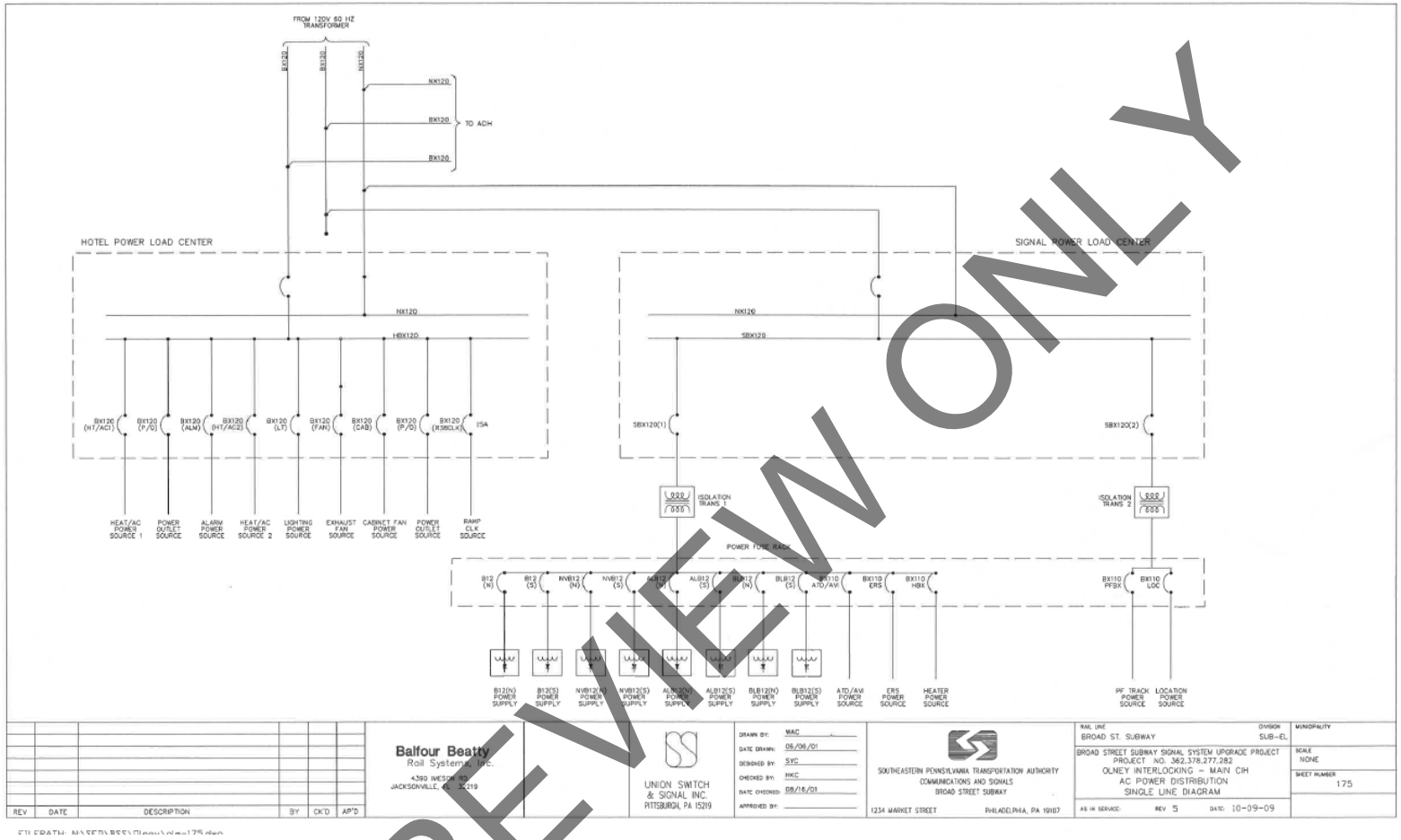

Figure 3.2 Sheet 175 AC Power into the CIL

Sheet 176 shows AC power distributed from the 120V/208V 30 60HZ transformer and on to the load center for both signal and CIL ("Hotel") power. Signal load power continues to the right and on to sheet 177 and 178.

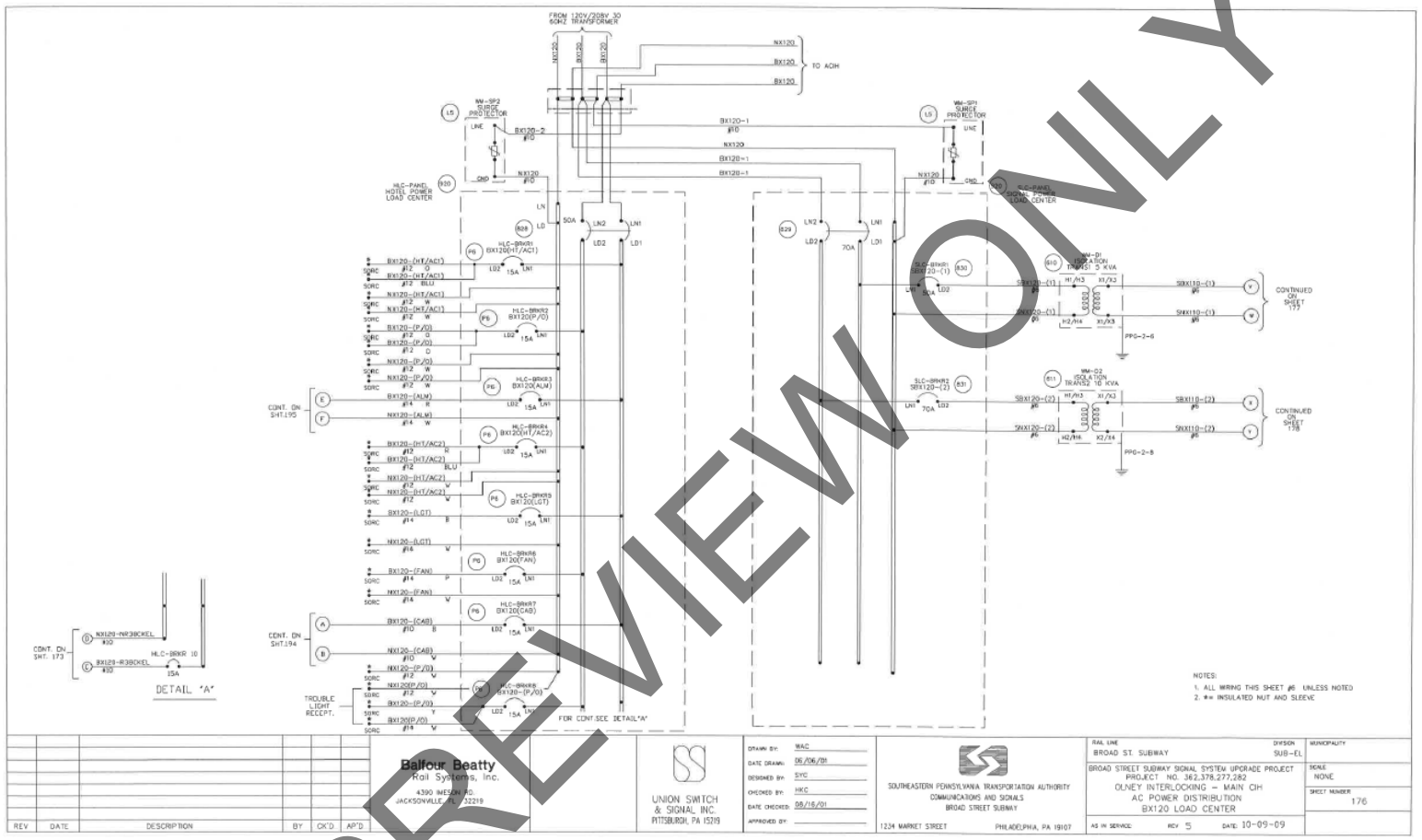

Figure 3.3 Sheet 176 AC Power into the CIL and Signal Load Center

Module 4

TROUBLESHOOTING AND REPAIR OF SIGNAL POWER DISTRIBUTION SYSTEMS AND COMPONENTS

Outline

Purpose and Objectives

The purpose of this module is to provide direction for troubleshooting and repair of signal power distribution components.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- List steps in testing, troubleshooting, and repairing/replacing primary power source and its components
- List steps in testing, troubleshooting, and repairing/replacing secondary power source and its components
- Troubleshoot and replace batteries
- Troubleshoot and replace frequency converters
- Troubleshoot and replace inverters
- Troubleshoot, adjust or repair rectifiers
- Troubleshoot, adjust or repair transfer switches
- Troubleshoot, adjust or repair transformers, circuit breakers, and cables
- Troubleshoot, adjust or repair UPS (emergency or standby power)
- List guidelines for generator hookup, use and removal

Key Terms

- Age
- Continuity test
- Hydrometer
- Mother board
- Pilot check
- Polarity
- Root cause
- Single cell
- Transient spikes

Battery Troubleshooting and Repair

In addition to standard PPE for signal maintainers, it is recommended that chemical resistant and all voltage resistant gloves and face shields be used during any battery repair and/or replacement work is conducted.

The NFPA70E offers directives and guidelines by OSHA for working on live equipment in 1910.33(a)(2) and should be followed for any battery-related troubleshooting and repair tasks.

Batteries typically are not typically a problem if routine inspection and maintenance is consistently performed. Proper maintenance usually prevents most battery repairs and replacements. However, a battery problem may be indicated when during a check, current or voltage isn't functioning, or putting out proper voltage, as intended.

Figure 4.1 Battery Bank, courtesy of TriMet

Warning: Safety Precautions!

- Follow OEM recommendations for battery repair and/or replacement
- Be aware of chemicals and temperatures within batteries
- Check OEM warranty
- Follow proper procedures for disposing of bad batteries, shipping papers may be needed, OEM may recommend, agency will have own in-house procedures
- Spill Kit may be in larger power room, located in a drum in case of battery overflow or acid has boiled over
- Wear proper PPE: chemical and voltage resistant gloves, goggles, protective clothing
- Be aware of amp hours that vary between batteries and locations – higher amp hour requirements for areas with more equipment.

The table below provides steps and guidelines for troubleshooting and replacing a battery cell.

Table 4.1 Battery Troubleshooting Steps

Step	Procedure
1	Review OEM literature for the battery.
2	Check battery temperature. Temperature variations exist among different types of batteries and charge is based on temperature.
3	Individual cell check: obtain voltage for each cell
4	Inspect for cleanliness, high resistance and loose connections (Acid eats wire away from connection reducing surface area and connection gets worse over time due to corrosion and / or oxidation) a. Oxide inhibitor that coats and seals of the air, decreases conductivity b. Vaseline or gel to keep resistance down c. Anti-corrosion grease, di-electric grease
5	Verify charger is functioning properly and any present problem is not a battery problem.
6	Complete a **pilot check**, or randomly selected one cell, to test. Complete a load test o check for voltage, gravity level and temperature. Document all test and results. a. Primary cells are not rechargeable and repair is by replacement. b. Reminder: All cells should be checked quarterly or monthly depending on agency policy.

Module 5

RESOLVING PROBLEMS WITH SIGNAL POWER DISTRIBUTION

Outline

Purpose and Objectives

The purpose of this module is to provide an overview of possible problems and troubleshooting procedures to be performed on signal power distribution systems.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- Identify common problems and possible solutions for signal system power distribution
- Apply knowledge of troubleshooting and repair to signal power distribution problems.
- Use a flowchart to troubleshoot and repair signal power distribution.

Key Terms

- Analyze
- Cause
- Comprehensive
- Consulted
- Corrective action
- Scenarios
- Sub-system
- System

Table 5.3 Common Failures and Corrective Actions for Track Circuit Problems Related to Signal Power Distribution

Track Circuit Problem Due to Possible Power Distribution Failure	
Symptom **Erratic track circuit operation - relays not picking all the way, chattering or circuit failures**	**Possible Causes** - Interference from foreign AC - High resistance conductors - Low voltage - Loose connections - Open test link - Brown out - Low voltage - Overcurrent - Ground in circuit - Power source failing - Loss of primary and/or secondary power - Phase select unit
Possible Solutions - Bad return and/or impedance bond - Locate and repair shunt / short in system - Tighten all connections - High resistant connections - Fuse are loose, replace as needed - Troubleshoot ground/shunt/short – repair and test - Replace phase unit	
Symptom **Track circuit indication /Track Relays not picking**	**Possible Causes** - Circuit failures - Short - Power supply failure - Bad A/C vane - Loss of local power - Dead battery/Battery not charging or low voltage - Loss of utility power - Open test link - Bad cell - Bad rectifier / battery charger - Charger failure or battery failure - Loose connections - Problem with ground / shunt / short - Possible tripped breaker or blown fuse
Possible Solutions	

Troubleshooting Note Record Form

Use the troubleshooting note record on the following page to complete the activity.

Classroom Activity

Using what you already know about signals power distribution and the **Troubleshooting Note Record Form** (Figure 5) to assist in organizing your thoughts and for taking notes to come up with solutions for the following problems. Consider each problem and determine:

- What **systems** or **subsystems** are involved?
- What are all possible **causes** and which is the most likely cause?
- What are possible **corrective actions**?

Your instructor will have the findings and solutions to these problems (**Troubleshooting Scenario Discussion Problem** - Appendix A) to verify your ideas when you are finished.