# Troubleshooting and Repair of Switches and Derails

## Course 302

PARTICIPANT GUIDE

SIGNALS TRAINING CONSORTIUM

# Troubleshooting and Repaid or Switches and Details

## Participant Guide

**Signals Maintenance Training Consortium**

**COURSE 302**

***September 2017 Draft***

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# How to Use the Participant Guide

## Purpose of the Course

The purpose of the *Switches and Derails Troubleshooting and Repair* course is to assist the participant in gaining knowledge in troubleshooting and repairing switches, derails 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.

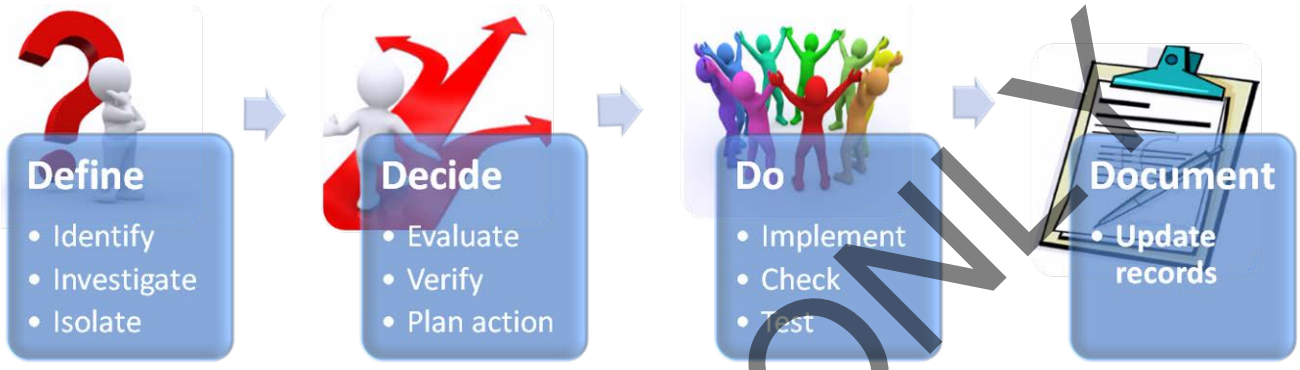


*Figure 1.1 The Four Ds: Steps in Troubleshooting Signals Systems*

## 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.
- Check log book for problems with the specific equipment – has the equipment displayed the same symptoms previously? Perhaps the symptoms have been treated but the problem not solved.
- What kinds of historical problems have there been with the generic equipment (routine breaks) – check for general problems with this

# Module 2

## *OVERVIEW TO TROUBLESHOOTING AND REPAIR OF SWITCHES AND DERAILS*

### Outline



### Purpose and Objectives

The purpose of this module is to provide the participant with an overview for troubleshooting and repair of switches and derails.

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

- Describe safety practices and processes as related to troubleshooting and repair of switches and derails
- Describe agency specific documentation procedures
- Describe types of malfunctions for switches and derails
- Explain process for when a switch or derail cannot be repaired promptly
- Describe specialized test equipment used for troubleshooting switches and derails

### Key Terms

- Delayed Repairs
- Documentation Procedures
- Hazards
- Job Site Analysis
- Malfunctions
- Repair
- Safety
- Scenario-Based Troubleshooting Problems
- Test Equipment
- Troubleshooting

# 2-1 OVERVIEW

While general troubleshooting is covered in the earlier module, troubleshooting switches and derails may present special circumstances and situations. Note that all material contained applies the same way to switches AND derails. In cases where the word "derail" is not included, it should be assumed that the information still applies.

# 2-2 TROUBLESHOOTING SAFETY AND PROCEDURES

### Analysis & Effective Response

From the first notice of a switch/derail problem, a signal maintainer should begin analysis. This should continue until the problem is corrected, and the switch/derail is tested and returned to service. Analysis can be defined as a "careful study of something to learn about its parts, what they do, and how they are related to each other." With this in mind, this section will look at the various facets of analysis for troubleshooting switches and derails.

**Initial Notice of Problem**

Often, a signal maintainer first learns of a switch/derail problem before they are ever on site. Consequently and to prepare for the work ahead, a signal maintainer must determine as much as possible about the nature of the problem and begin the critical process of communication prior to their arrival at the switch/derail location. This communication consists of alerting and asking questions to the appropriate personnel and departments. When there is a malfunction of a switch/derail, it is critical that the larger rail system be alerted and signal maintainer safety established by means of proper communication as determined by your agency. This important first step, and when done correctly, will help to begin restoration the switch/derail in the safest and fastest way possible.

Upon first learning of a switch/derail problem, a signal maintainer should complete the following:

1. Determine the nature of the problem
2. Predict hazard(s) related to the problem
3. Decide how to respond

**Determine the Nature of Problem**

In determining the nature of the problem, a signal maintainer should identify the location of the switch/derail and what affects the problem will have on traffic and the overall signal system. Properly determining the nature of the problem can make the troubleshooting process safer and more efficient.

**Predict Hazards Related to the Problem**

From the initial set of information, a signal maintainer must predict what potential hazards may exist. This initial set of problem data collection also begins a "Job Hazard Analysis."

**Decide How to Respond**

After determining as much information about the problem as possible and considering what potential hazards may exist, the signal maintainer must decide how to respond. In deciding how

to respond, the signal maintainer must consider proper communication, quickest route to location and items/people to gather beforehand.

Proper communication will depend on the nature of the problem and potential hazards. Proper communication may include informing a dispatcher. FRA 234.101 also provides guidelines for agency notification procedures.

Quickest route to location – A signal maintainer must know the rail system in conjunction with considering possible traffic difficulties that may result from rush hour or the switch/derail problem itself. Some signal maintainers may listen to radio communication while en-route to continue to learn about the problem and monitor the situation for better and faster response once on site.

Items and/or people to gather – After determining as much information about the problem as possible, a signal maintainer must consider what to gather and take to the location. Part of the planning and items to gather should include consideration and anticipation for what other problems may be encountered. Items to take may include any additional tools required, possible parts that will be needed, essential PPE, and any other items that may be necessary for restoration of the switch derail.

Some tools needed which are specific to switches and derails include:

- Spring gauge
- Lock rod wrench
- Switch crank
- Operating wrench
- Obstruction gauge
- Spanner wrench

In some cases of switch/derail troubleshooting, it may be determined early on that additional personnel may be required. These personnel may include other signal maintainers, track maintainers, police protection, etc. In the event that additional personnel may be needed, follow your agency's policy for obtaining that additional support.

**Classroom Activity**

With the assistance of your instructor, describe initial problem response procedures and directions at your agency

# Module 3

## *GENERIC TROUBLESHOOTING AND REPAIR OF SWITCHES AND DERAILS*

### Outline



### Purpose and Objectives

The purpose of this module is to provide an overview of troubleshooting procedures to be performed on all types of switches and derails.

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

- List common failures in all types of switches/derails
- Describe generic malfunctions common for switches/derails
- Identify generic symptoms for switch/derail malfunctions and possible causes
- Given a generic switch/derail problem and cause, describe possible solutions and/or necessary repair
- Test, troubleshoot, adjust or repair generic switch/derail components

### Key Terms

- Common Failures
- Corrective Actions
- Decide
- Electrical Readings
- Environment
- Evaluate
- Historical Problems
- Hypothesis
- Lock Rod
- Log Book
- Operating Rod
- Probable Cause
- Schematics
- Sensory Inspection
- Subsystems
- Symptom

# 3-1 OVERVIEW

This and all following modules in Course 302: Troubleshooting and Repair/Replacement of Switches and Derails will cover troubleshooting split into areas of common problems/probable causes, scenario based problems and component specific repair/replacement.

This module will cover all troubleshooting of switches and derails that is the same for all types of switches and derails:

- Manual
- Electrical
- Electro-Pneumatic
- Electro-Hydraulic

When troubleshooting differs from the generic content presented here, details will be covered in modules 4, 5, 6 and 7 respectively.

**Warning: Safety Precautions!**

Always take appropriate actions to secure the work area before performing any troubleshooting, repair or replacement. Always request time on the line. When performing troubleshooting, repair and/or replacement that does not require throwing the switch: secure points, disconnect electricity and shut off appropriate valves. More information on this in Course 202 Module 2: Overview and Safety.

## 3-2 GENERIC TROUBLESHOOTING OF SWITCHES AND DERAILS

To successfully troubleshoot it is important to know the system as well as common failures and problems with switches and derails.

The troubleshooting information found in the OEM manual that is specific to each piece of equipment can help speed the troubleshooting process. In addition, Table 3.1 Common Failures and Corrective Actions of All Switches/Derails provides a general list of common failures and problems often encountered with all types of switches and derails. While this table is helpful for initial troubleshooting, the list is not comprehensive and should only be used as a "place to start" in determining a solution to a specific problem. Note that because the electro-hydraulic switch/derail is drastically different than the others, there are a few items that apply to all switches/derails besides electro-hydraulic ones. These differences are noted in Table 3.1.

Also note that some common causes are shared by every type of switch/derail (manual, electric, electro-pneumatic, electro-hydraulic), while some may be specific to a certain type of switch/derail. For example, when an electric switch does not complete its throw, this may be caused by one of the probable causes listed in Table 3.1 such as an obstruction but it could also be caused by something unique to electric switches, such as an overload condition. These unique causes will be covered in modules 3, 4, 5 and 6 respectively.

***Figure 3.1 Switch Layout***

# Module 4

## *TROUBLESHOOTING AND REPAIR OF MANUAL SWITCHES AND DERAILS*

### Outline



### Purpose and Objectives

The purpose of this module is to provide an overview of troubleshooting procedures to be performed on manual switches and derails.

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

- Identify possible causes of manual switch/derail malfunctions
- Given a manual switch/derail problem and cause, describe possible solutions and/or necessary repair
- Demonstrate ability to troubleshoot and repair manual switches/derails using authority specifications and OEM manuals.
- Use a flowchart to troubleshoot and repair manual switches/derails
- Demonstrate ability to adjust/replace contacts
- Demonstrate ability to adjust/replace a clutch

### Key Terms

- Bus Voltage
- Clutch
- Contacts
- Decide
- Electric Lock
- Electrical Readings
- Environment
- Evaluate
- Handthrow Lever
- High Resistant Contacts
- Historical Problems
- Hypothesis
- Indication Contacts
- Lever Lock Bar
- Log Book
- Rectifier
- Schematics
- Sensory Inspection
- Subsystems

# 4-2 TROUBLESHOOTING OF MANUAL SWITCHES AND DERAILS

To successfully troubleshoot, it is important to know the system as well as common failures and problems with manual switches and derails.

The troubleshooting information found in the OEM manual that is specific to each piece of equipment can help speed the troubleshooting process. Module 3 also covered symptoms and probable causes in a generic way that applied to ALL switches and derails. While symptoms often have similar causes from one switch/derail type to the next, sometimes the same symptom may be caused by a different failure depending on the type of switch/derail.

Table 3.1 Common Failures and Corrective Actions of All Switches/Derails builds on the generic list presented in Module 1 by highlighting probable causes unique to manual switches. These differences are highlighted in the list below and in Table 3.1 by using bold text and an asterisk.

**Manual Switch Differences**:

- A switch that does not begin to throw may also be caused by problems with the **lever lock bar** or the **electric lock**
- A switch throwing but bouncing back may also be caused by damage to or obstruction of the **handthrow lever**
- Correct indication not displaying or flashing out of correspondence in CIL could also be caused by **high resistant contacts** (burnt, dirty, loose, etc.) or **indication contacts** which are not made up at the circuit controller. Note that these are possible causes for electric and electro-pneumatic switches/derails also.

***Figure 4.1 US&S T-21 Switch Machine***

***Table 4.1 Common Failures and Corrective Actions, Highlighting Causes Specific to Manual Switches/Derails***

| Symptom | Probable Causes |
|---|---|
| Switch does not begin throw | Switch not requested<br>Block or hold applied<br>Loose terminal<br>Faulty Wiring<br>Faulty relay<br>No Power<br>Switch in hand<br>Crank cut out contact is open<br>Track Circuit De-energized<br>Conflicting Route/Route Locks<br>**Lever Lock Bar***<br>**Electric Lock Problem*** |
| Switch does not complete throw | Switch out of adjustment |
| Switch throws but bounces back | Obstruction<br>Track conditions causing friction (loose braces/hardware, shifting in layout, etc.)<br>Misadjusted operating rod<br>**Handthrow lever damaged or obstructed*** |
| Correct indication is not displayed or is flashing out of correspondence in CIL | Switch in field is not mechanically locked<br>Point Detector Rod out of adjustment<br>Circuit controller correspondence issue<br>Faulty relays<br>No return energy<br>Wiring issue<br>Burnt out bulbs<br>Faulty component in control system (PLC, board, VIMS,VPI, VHLC, Microlok etc.)<br>Blown fuse<br>**High resistant contacts (burnt, dirty, loose, etc.)***<br>**indication contacts are not made up at circuit controller*** |

**** Probable causes for manual switches/derails that do not apply to all other types of switches/derails***

# Module 5

## *TROUBLESHOOTING AND REPAIR OF ELECTRIC SWITCHES AND DERAILS*

### Outline



### Purpose and Objectives

The purpose of this module is to provide an overview of troubleshooting procedures to be performed on electric switches and derails.

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

- Identify possible causes of electric switch/derail malfunctions
- Given a electric switch/derail problem and cause, describe possible solutions and/or necessary repair
- Demonstrate ability to troubleshoot and repair electric switches/derails using authority specifications and OEM electrics.
- Use a flowchart to troubleshoot and repair electric switches/derails
- Demonstrate ability to replace the motor in an electric switch

### Key Terms

- Clutch
- Conflicting Route
- Crank Cut Out
- Decide
- De-energized
- Electrical Readings
- Electro-hydraulic
- Electro-pneumatic
- Environment
- Evaluate
- Historical Problems
- Hypothesis
- Log Book
- Motor
- Overload
- Relay
- Schematics
- Sensory Inspection
- Subsystems
- Terminal
- Wiring

# 5-1 OVERVIEW

This module builds on previous modules and covers items specific to electric switches.

**Warning: Safety Precautions!**

Always take appropriate actions to secure the work area before performing any troubleshooting, repair or replacement. Always request time on the line. When performing troubleshooting, repair and/or replacement that does not require throwing the switch: secure points, disconnect electricity and shut off appropriate valves. More information on this in Course 202 Module 1: Overview and Safety.

# 5-2 TROUBLESHOOTING OF ELECTRIC SWITCHES AND DERAILS

To successfully troubleshoot it is important to know the system as well as common failures and problems with electric switches and derails. The troubleshooting information found in the OEM manual that is specific to each piece of equipment can help speed the troubleshooting process. Module 3 also covered symptoms and probable causes in a generic way that applied to ALL switches and derails. While symptoms often have similar causes from one switch/derail type to the next, sometimes the same symptom may be caused by a different failure depending on the type of switch/derail.

Some of the probable causes specific to electric switches are also relevant to the two other electric switch sub-types: electro-pneumatic and electro-hydraulic. In some cases, these causes are only common between electric and electro-hydraulic switches and derails.

Table 5.1 builds on the generic list presented in earlier by highlighting probable causes unique to electric switches (and in some cases electro-pneumatic and/or electro-hydraulic switches). These differences are highlighted in the list below and in Table 3.1 by using bold text and asterisks. The number of asterisks represents how many of the types of electric switches this information applies to:
1 Asterisk = Only applicable to electric switches
2 Asterisks = Applicable to electric and electro-hydraulic switches. This category exists because electric and electro-hydraulic switches have a motor, while electro-pneumatic switches do not
3 Asterisks = Applicable to all three types of electric switches (purely electric, electro-pneumatic and electro-hydraulic).

The information pertaining to electro-pneumatic and electro-hydraulic switches will be repeated in modules 6 and 7, respectively.

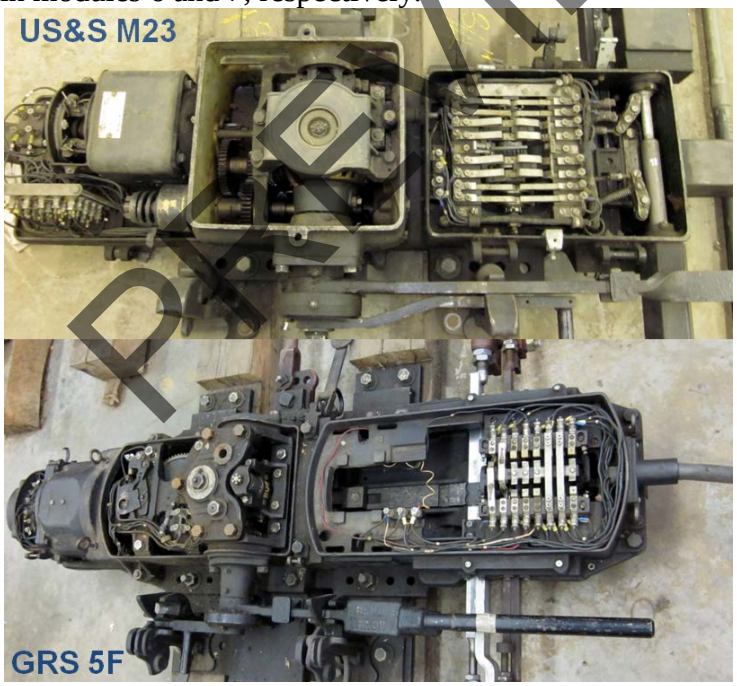

***Figure 5.1 M23 and 5F Comparison***

# Module 6

## *TROUBLESHOOTING AND REPAIR OF ELECTRO-PNEUMATIC SWITCHES AND DERAILS*

### Outline



### Purpose and Objectives

The purpose of this module is to provide an overview of troubleshooting procedures to be performed on electro-pneumatic switches and derails.

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

- Identify possible causes of electro-pneumatic switch/derail malfunctions
- Given an electro-pneumatic switch/derail problem and cause, describe possible solutions and/or necessary repair
- Demonstrate ability to troubleshoot and repair electro-pneumatic switches/derails using authority specifications and OEM electrics.
- Use a flowchart to troubleshoot and repair electro-pneumatic switches/derails
- Demonstrate ability to replace the switch air cylinder and CP valve assembly.

### Key Terms

- Air Cylinder
- Air Leakage
- Air Line
- Air Pressure
- Alignment Holes
- Cp Valve Assembly
- Decide
- Driving Nut
- Electrical Readings
- Electro-Pneumatic
- Environment
- Evaluate
- Historical Problems
- Hypothesis
- Log Book
- Point Detector
- Schematics
- Sensory Inspection
- Subsystems
- Valve Magnet
- Walking Beam

# 6-1 OVERVIEW

This module builds on previous modules and covers items specific to electro-pneumatic switches.

**Warning: Safety Precautions!**

Always take appropriate actions to secure the work area before performing any troubleshooting, repair or replacement. Always request time on the line. When performing troubleshooting, repair and/or replacement that does not require throwing the switch: secure points, disconnect air/electricity and shut off appropriate valves. More information on this in Course 202 Module 1: Overview and Safety.

## Troubleshooting Flow Chart

The following troubleshooting flow chart is also known as a decision tree. These types of diagrams are often included in the service electric to aid signal maintainers in determining the cause of a malfunction so that repair can be made as quickly as possible. CAUTION: The following are examples only. DO NOT use for actual troubleshooting. As always, follow your authority-specific procedures when troubleshooting.

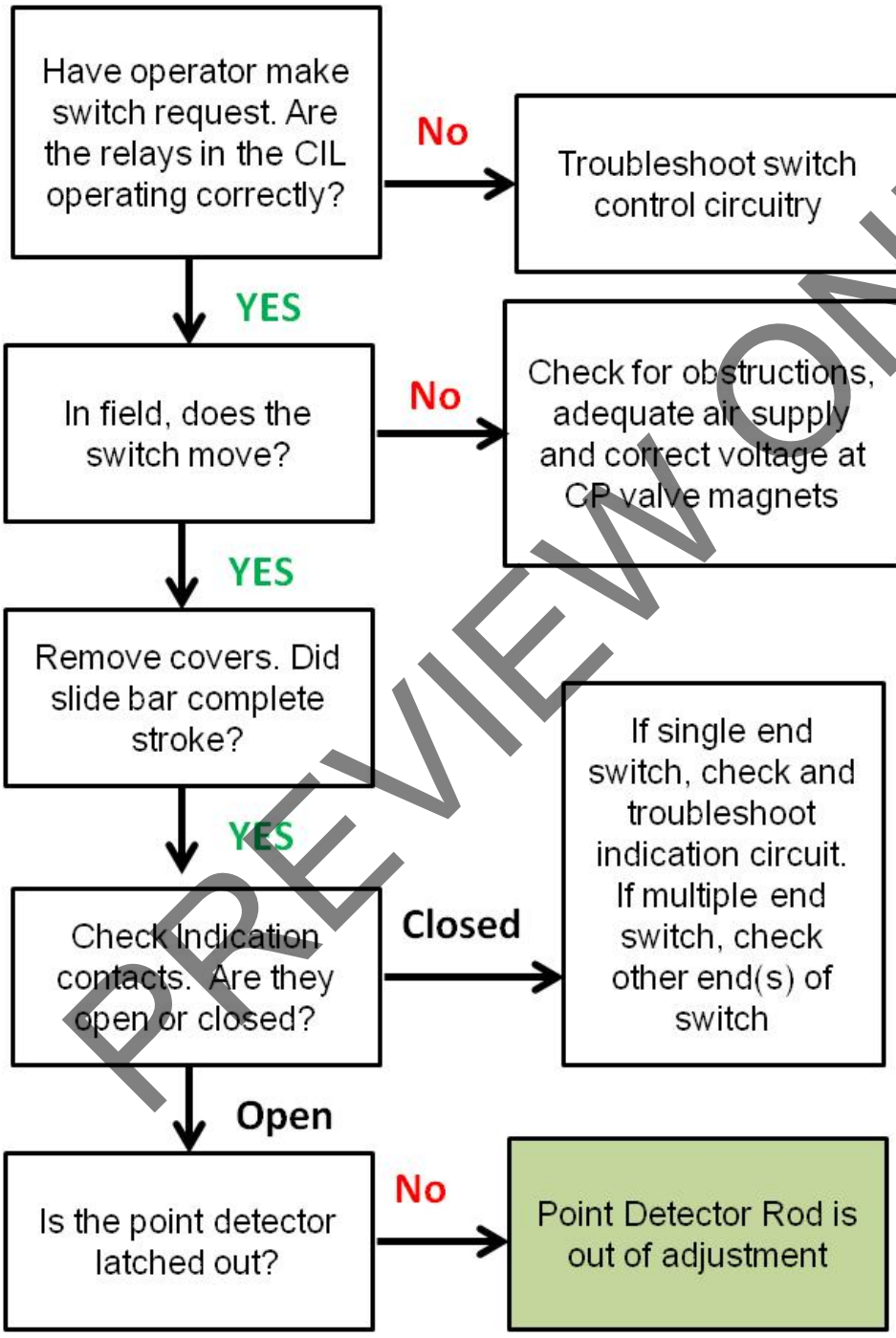


*Figure 6.4 Flowchart Related to Problem: Correct Indication is Not Displayed*

# Module 7

## *TROUBLESHOOTING AND REPAIR OF ELECTRO-HYDRAULIC SWITCHES AND DERAILS*

### Outline



### Purpose and Objectives

The purpose of this module is to provide an overview of troubleshooting procedures to be performed on electro-hydraulic switches and derails.

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

- Identify possible causes of electro-hydraulic switch/derail malfunctions
- Given a electro-hydraulic switch/derail problem and cause, describe possible solutions and/or necessary repair
- Demonstrate ability to troubleshoot and repair electro-hydraulic switches/derails using authority specifications and OEM electrics.
- Use a flowchart to troubleshoot and repair electro-hydraulic switches/derails
- Demonstrate ability to replace a proximity sensor on an electro-hydraulic switch/derail

### Key Terms

- Cable Connector
- Decide
- Directional Control Valve
- Electrical Readings
- Environment
- Evaluate
- Historical Problems
- Hydraulic Pressure
- Hydraulic Valve
- Hypothesis
- Lock Guide
- Log Book
- Pressure Relief Valve
- Proximity Sensor
- Schematics
- Sensory Inspection
- Setting Lever
- Setting Mechanism
- Subsystems
- Threaded Bores
- Union Nut

# 7-4 COMPONENT SPECIFIC CORRECTIVE MAINTENANCE

For illustrative purposes, an H&K hydro-electric switch is used for this procedure. You will need the following tools to complete this task: metric socket set, open end wrench set, screwdriver, two gauges and two screws. Note for the H&K electro-hydraulic, all tools will be in metric since it is a European switch. Exact measurements of tools, etc. will vary with the exact switch/derail. Always follow your OEM and authority specifications.

See Figure 7.5, Figure 7.6, Figure 7.7 and Figure 7.8 for further reference.

**Table 7.2 Procedures for Replacing a Proximity Sensor on an H&K Electro-Hydraulic Switch/Derail**

| Step | Procedure |
|---|---|
| 1 | Get time on switch. Set up appropriate protection |
| 2 | Bring the switch machine into one of the end positions with the **setting lever**. |
| 3 | Remove operating and indication power to the switch machine and follow all safe off procedures per standard operating procedures. |
| 4 | Loosen and remove the **screws** that attach the **lock guide** to the **setting mechanism**. |
| 5 | Screw one M6 x 60 screw respectively into the two **threaded bores**. This will allow you to detach the lock guide from the setting unit. |
| 6 | Raise the lock guide and fold it back. The proximity sensors can now be accessed. |
| 7 | Remove the M6 x M60 screws from the threaded bores. |
| 8 | Loosen the **union nut** of the cable connector and disconnect the connector. |
| 9 | Loosen the **locknut** of the defective proximity sensor. |
| 10 | Replace the defective proximity sensor. Using the correct gauge, set the clearance between the proximity sensor and operating plate at 0.157in (4mm) and tighten the locknuts. |
| 11 | Connect the **cable connector** and tighten the union nut. |
| 12 | Re-install the lock guide |
| 13 | Restore power to the indication circuit. |
| 14 | Place a **0.078in (2mm) gauge** between the lock guide and the locking support. |
| 15 | Bring the switch machine into the end position. The LED of the proximity sensor must light up when the lock guide is locked. |
| 16 | Replace the 0.078in (2mm) gauge with the **0.157in (4mm) gauge**. The LED of the proximity sensor must not light up when the lock guide is locked. |
| 17 | Restore operating power and perform all applicable tests as per OEM and/or Authority. |

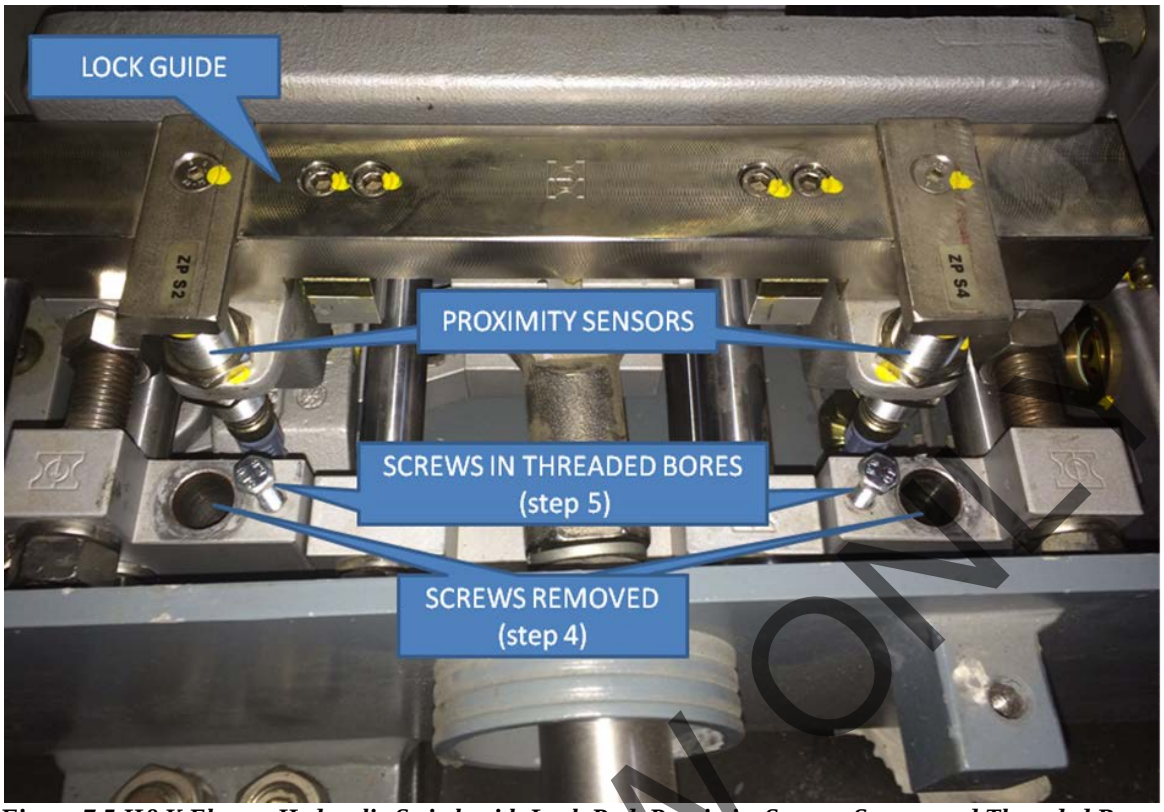


***Figure 7.5 H&K Electro-Hydraulic Switch with Lock Rod, Proximity Sensor, Screws and Threaded Bores Highlighted***

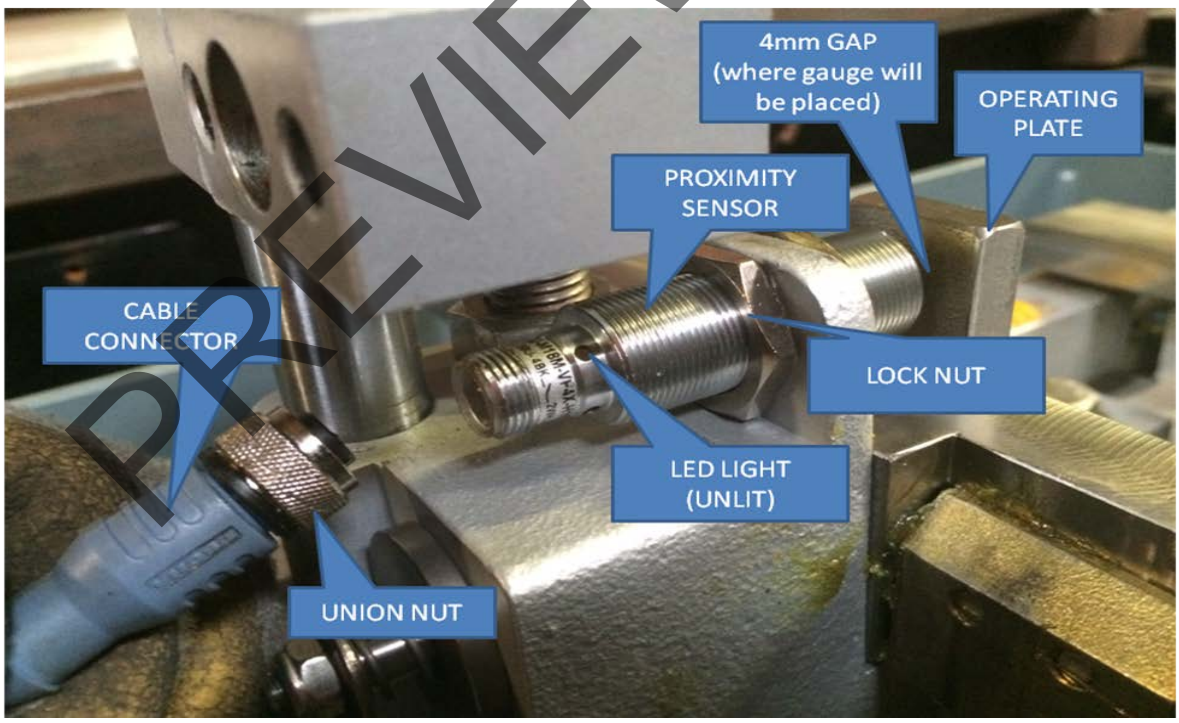


***Figure 7.6 Lock Guide Raised and Folded Back, Making Proximity Sensor Accessible (Step 6)***