Orientation

Course 100

PARTICIPANT GUIDE

SIGNALS TRAINING CONSORTIUM

Orientation

Participant Guide

Signals Maintenance Training Consortium

COURSE 100

September 2019 Version

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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 *Orientation* course is to assist the participant in being oriented to signaling and train control.

Approach of the Book

Each course module begins with an outline, a statement of purpose and objectives, and a list of key terms. The *outline* will discuss the main topics to be addressed in the module. A list of *key terms* identifies important terminology that will be introduced in this 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.. *Review exercises* conclude each module to assist the participants in reviewing key information.

Module 1

INTRODUCTION TO SIGNALING AND TRAIN CONTROL

Outline

Purpose and Objectives

The purpose of this course is to provide the participant with an overview to signaling and train control and to introduce the participant to the foundation of their work as a signal maintainer.

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

- Explain the purpose of a signaling system
- Explain the evolution of railroad signaling
- Specify how signal maintainers are responsible for the safety of the general public
- Identify the importance of governing agency and location operating rules/policies
- Define “fail-safe”
- Explain why systems have to fail in a safe manner
- Differentiate between vital and non-vital
- Discuss future technologies, such as PTC

Key Terms

- Aspect
- Automatic Train Control
- Block
- Block System
- Closed Circuit principle
- Communication Based Train Control (CBTC)
- Disc And Cross Bar Signal
- Fail Safe
- Fixed Signal
- Indication
- Interlocking
- Non-Vital
- Positive Train Control (PTC)
- Rail Safety Improvement Act (RSIA)
- Segments
- Semaphore
- Time Table System
- Track Circuit
- Train Order System
- Vital

1-1 OVERVIEW

Signal maintainers install, repair and maintain the signal systems that are used to direct train movements in railroad system. The new signal maintainer will soon learn that there are two words that will be repeated throughout their career. The words are **safety** and **efficiency.** The Institute of Railway Signal Engineers (IRSE) describes the twin purposes of signaling systems as:

> The purpose of a signaling system is to facilitate the safe and efficient movement of trains on the railroad. Safety and efficiency do not always sit easily with each other. The fundamental safety requirements of a signaling system include keeping trains adequately separated from each and stopping (or slowing) trains where necessary to avoid potentially unsafe situations. Efficient operation of the railroad, on the other hand, is mainly about sending as many trains as possible along a given portion of track, as quickly as possible, using the minimum of infrastructure.
>
> The main function of a signal system is therefore to set up a route for the passage of each train over the track that it is to traverse, authorize the train operator to make the movement, maintain the route while making its movement, and finally release the route (for use by other trains) after the passage of the train.

Signal maintainers develop their craft through learning on the job as well as through training programs sponsored through their employer and union. They are schooled in the stringent federal, state, and local regulations which govern railroad signal systems and, in railroad operations, including topics on electricity, electronics, and mechanics.

The participant will also see some common acronyms are used throughout this course. They are:

- APTA The American Public Transportation Association
- AREMA American Railway Engineering and Maintenance-of-Way Association
- FHWA Federal Highway Administration
- FRA Federal Railroad Administration
- FTA Federal Transit Administration
- IRSE Institution of Railway Signaling Engineers
- MUTCD Manual on Uniform Traffic Control Devices
- OEM Original Equipment Manufacturer
- PPE Personal Protective Equipment
- RTS Rail Transit System

1-2 EVOLUTION OF RAILROAD SIGNALING

The purpose of a railroad signaling system is to move trains efficiently and safely. Early railroads had short lines and few trains so the need to oversee traffic of these trains was minimal. As time progressed and train traffic increased, the need for traffic control was becoming paramount. Sidings, or pull off tracks were developed to divert slower trains and allowed trains to pass each other on single track operation. The **time table system** was implemented to coordinate and safely control the growing number of trains in service. The time table consisted of information on the times of each of the regular trains, the days they ran, and the stations at which opposing trains would meet or pass by each other.

As the demand for railroad travel grew and the speed of locomotives increased so did the urgency for tighter controls. The **train order system** was put in place which offered more flexibility, cut down on costly delays and enabled trains to be added to run more often. It was the telegraph patented by Samuel Morse in 1837 that enabled the more flexible train order operation that was issued on the Erie Railroad in 1851. Train orders replaced timetables and kept to a specific format so the information conveyed would be clear and concise. Train orders made it possible to add, delete and reschedule trains. However, time was a factor to allow all parties to receive the new information.


TRAIN No. 3.

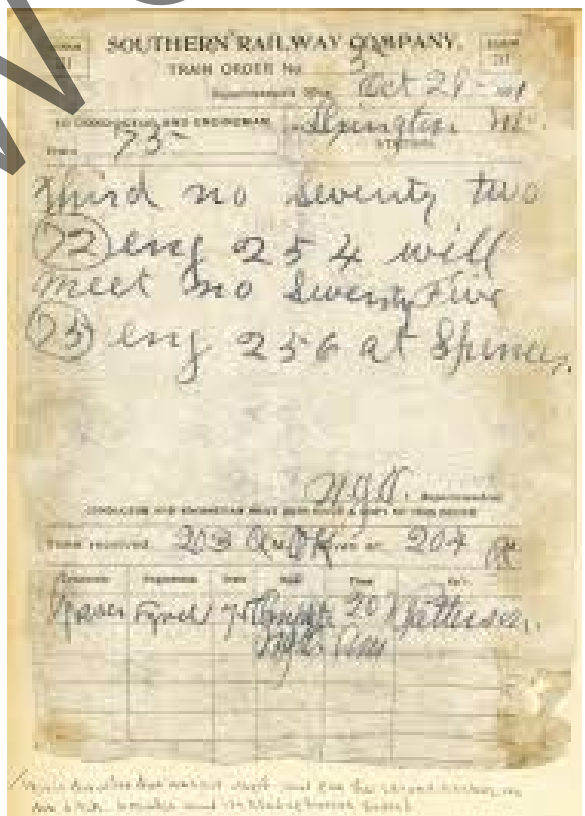
Chicago to Los Angeles

AND SAN DIEGO.

Via Chicago, Santa Fé & California Ry., Chicago to Kansas City.
Via Atchison, Topeka & Santa Fé R. R., Kansas City to Albuquerque.
Via Atlantic & Pacific R. R., Albuquerque to Barstow.
Via California Southern R. R., Barstow to Los Angeles or San Diego.

PRINCIPAL POINTS. | DAYS.

Figure 1.1 Santa Fe timetable from 1889 (Wikipedia)


SOUTHERN RAILWAY COMPANY.

TRAIN ORDER No. 3

Oct 21 - 01

Springfield Ill.

73

Third no Seventy two

(22) eng 254 will

meet 3rd no Seventy Five

(23) eng 256 at Springfield

Time received 203 QuK 204

Figure 1.2 Train Order Document from Southern Railway Company (http://williamfcody.bbhc.org/)

Module 2

ROADWAY WORKER PROTECTION AND ON-TRACK SAFETY

Outline

Purpose and Objectives

The purpose of this course is to provide the participant with an introduction to the Right-of-Way (ROW) and on-track safety topics. This module should not be substituted for standard ROW safety training and policies.

At the completion of this course, the participant should be able to complete the exercises with an accuracy of 70% or greater related to these objectives:

- Identify purpose and various forms of roadway worker protection
- Define rail roadway worker protection
- Recognize the importance of maintaining situational awareness in the field
- Examine vital communications between dispatch/central control, other departments, and roadway workers
- Identify physical characteristics/rules in effect of your rail transportation system to reduce your personal risk and injury

Key Terms

- CFR 214
- Fall Protection
- Foul of Track
- Job Briefing Forms
- Job Safety Briefing
- Lookout
- On-track safety
- On-track Safety Program
- Pinch Points
- Roadway Worker in Charge (RWIC)
- Trip, Slip and Fall Hazards

2-1 OVERVIEW

In the rail industry, the term "roadway workers" refers to any person whose work involves being on or has the potential to foul the track. Railroad policy and rules define **foul of track** as the area within four feet of the nearest rail of a railroad track, and a location on or near a railroad track where a person or equipment is close enough to be struck by passing railway equipment or items protruding from the railway equipment. Roadway workers are employees or contractors of a railroad system whose duties include inspection, construction, maintenance or repair of railroad track, bridges, roadway signal and communication systems, electrical traction systems, roadway facilities or roadway maintenance machinery on or near the track or with the potential of fouling a track. Working on or with potential to foul a rail right-of-way is dangerous work and being aware of personal safety is the best way signal maintainers can protect themselves from injuries. A worker should not foul the track unless required in the performance of their duties. Also, the roadway worker must be constantly aware of hazards on the job.

See **A Knock at your Door** video series for illustration of safety risks on the railroad:

Pt 1: https://www.youtube.com/watch?v=31XyWpQCWRc

Pt 2: https://www.youtube.com/watch?v=QMpkRt9SZio

Pt 3: https://www.youtube.com/watch?v=gx9VVAfHefg

Warning: Safety Precautions!

- You are primarily responsible for your own safety.
- Expect the movement of train or equipment on any track, in any direction, and at any time.

The federal government has set into law specific guidelines to protect roadway workers while they are on the job. The regulations are widely known as **CFR 214**[1] and are generally adapted by many railroad agencies whether or not they are under the jurisdiction of the Federal Railroad Administration (FRA) or the Federal Transit Administration (FTA). Both FRA and the FTA are agencies within the U.S. Department of Transportation. If your agency is subject to CFR 214 Railroad Workplace Safety there is potential for fines for the roadway worker as well as the agency if those rules are violated. Under federal railroad safety laws the FRA has jurisdiction over all railroads except "rapid transit operations in an urban area that are not connected to the general railroad system of transportation". FRA exercises jurisdiction over all railroad passenger operations, regardless of the equipment they use.

2-2 RAIL ROADWAY WORKER PROTECTION

Safety is at the core of the career of a signal maintainer and it should always be a priority on every project or work order. Since 2011, accidents attributed to human factors accounted for almost 40 percent of all reported train accidents, resulting in millions of dollars in damages to the United States' railroad industry. Accidents attributed to human factors, unlike any other causes except "miscellaneous", have also increased since 2010 as shown in Table 2.1 Percentage Frequency of All Train Accidents by Cause.

Table 2.1 Percentage Frequency of All Train Accidents by Cause

Cause	2009	2010	2011	2012	*2013
Human factors	34	34	37	38	37
Track & Signal defects	38	39	36	36	35
Equipment defects	14	13	12	12	11
Miscellaneous causes	14	14	16	15	16
TOTAL	100	100	100	100	100

*January to August data
Source: FRA Safety Data http://safetydata.fra.dot.gov

From the FRA's *Compliance with Railroad Operating Rules and Corporate Culture Influences*

> Employees who perform their jobs in an unsafe manner usually violate operating and safety rules. Human-factors related incidents are caused, or influenced by, unsafe work behavior and attitudes, as opposed to non-behavior related factors like inclement weather or undetected faulty track. Therefore, *nearly all human-factor incidents and injuries can be associated with one or more operating or safety rule violations*.

While there are federal, local and other laws that govern the safety of railroad roadway workers, it is ultimately up to the individual worker to always be vigilant in safety.

[1] CFR is the abbreviation for **Code of Federal Regulations** and the 214 number refers to the part of the federal law where **railroad workplace safety** is addressed.

Module 3

SIGNAL SYSTEM COMPONENTS

Outline

Purpose and Objectives

The purpose of this course is to provide the participant with an orientation to the basic components of railroad signaling systems and to provide a foundation for more in-depth exploration of signal systems in this series of courses.

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

- Identify Track Circuits
- Identify Switches and Derails
- Identify Train Stops
- Identify Grade Crossings
- Identify Signaling
- Identify Interlockings

Key Terms

- Active Highway Grade Crossing System
- Alternating Current Track Circuit
- Audio Frequency Track Circuit
- Coded Track Circuit
- Derail
- Direct Current Track Circuit
- Dragging Equipment Detector (DED)
- Electronic Track Circuit
- Highway-rail Grade Crossing
- Interlocking
- Passive Highway Grade Crossing System
- Power Frequency Track Circuit
- Railroad Signal System
- Signal
- Switch Machine
- Switch
- Track (Rail)
- Track Circuit
- Train Stop

3-2 TRACK CIRCUITS

The track circuit is the essential component of signaling. The track circuit is the means of detecting whether or not a section of track has any rail cars standing on it. Therefore, the track circuit is the basis of train detection.

A **track circuit** is an electrical series circuit comprised of a section of rail, a transmit feed or battery end, and a receiver or relay end. The rails provide a path for current to flow from an energy-producing device (transmit end) to an energy-receiving device (receiver end). In general, most track circuits operate by sensing the loss of transmitted energy at the receiver end of the track circuit.

The purpose of a track circuit is to detect the presence of a train. Track circuits can also detect broken rails which are essentially an opening in the electrical circuit; to detect the condition of rails, such as broken rails or wires; as well as to maintain the integrity of the signal system. There are, of course, other conditions that affect the track circuit such as poor ballast conditions, loss of power supply, or any failed component within the track circuit.

The fail-safe principle as discussed in Module 1 is best illustrated in the design of a track circuit. In use in North America since the 1870s, the purpose of a track circuit is to detect the presence of trains; to detect broken rails or wires; as well as to maintain the integrity of rail devices. The theory is as follows: electrical energy is transmitted along a section of the track from the feed end to the relay end that receives this particular form of electrical energy. The feed end and relay end are electrically defined by insulated rail joints, or their equivalent, at either end.

If nothing is blocking the flow of electrical energy between the feed and relay ends, then a "non-occupancy" or "unoccupied" condition results in a clear track circuit: it is safe to set a route and permit a train to proceed.

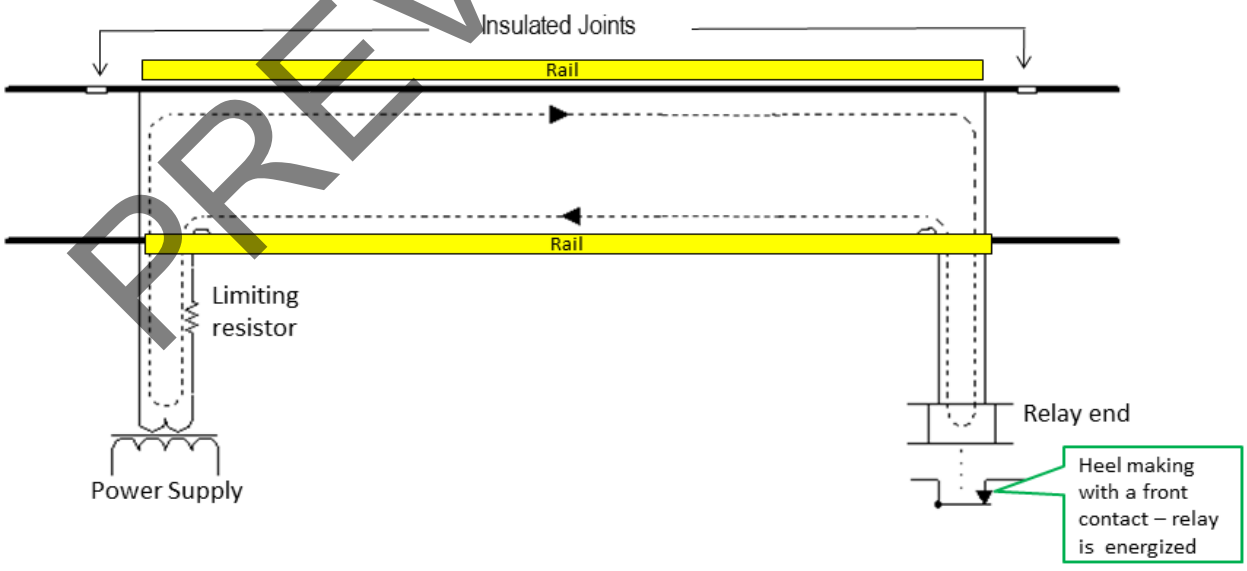


Figure 3.1 Unoccupied Track Circuit

When, as Figure 3.2 illustrates, one of the defined conditions is present on the rails in the track circuit, the flow of electricity is removed from the relay, thus the relay is de-energized, and the contact is open. In this illustration, the train's axles provide a short circuit, a process known as shunting current away from the relay. An "occupied" condition is relayed to the wayside signal and the signal shows a stop indication for that block.

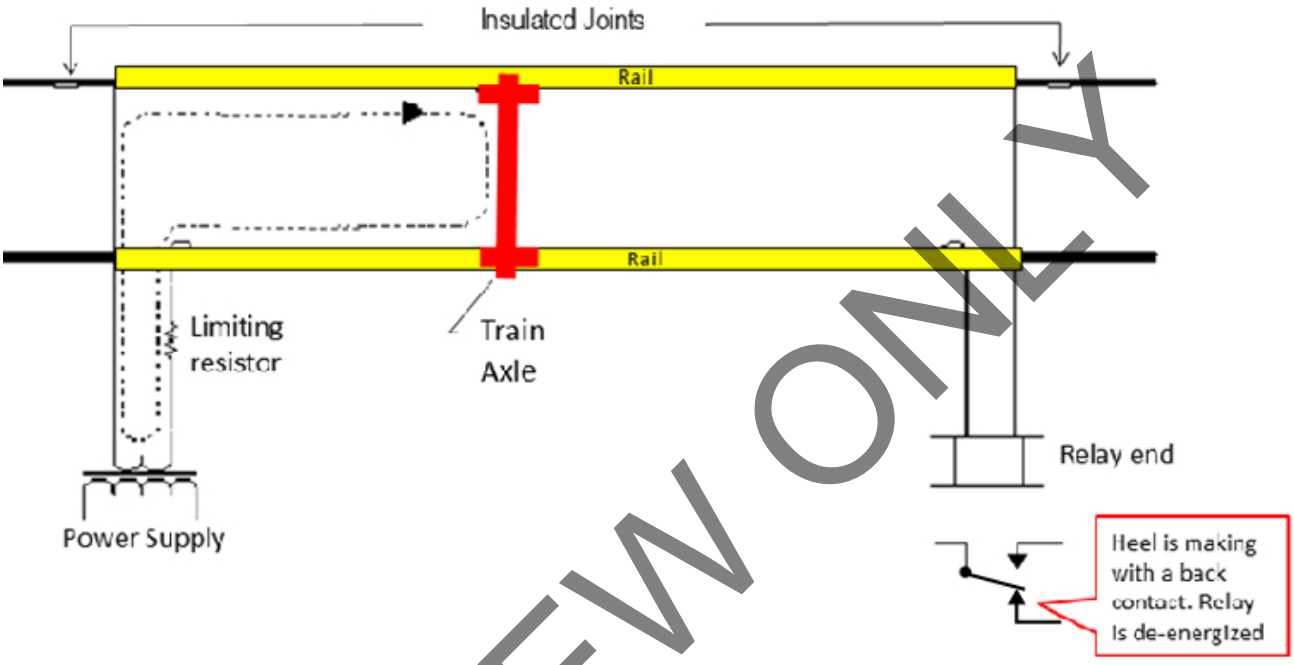


Figure 3.2 Track Circuit Occupied by Train

There are several types of track circuits and some railroads operate on different types of track circuits. The type of track circuit is designated by its source of electrical energy. In later courses, the participant will identify other types of track circuits and how to maintain and troubleshoot them. For now, there are generally five types of track circuits:

1. **Direct current (DC)** is the flow of electric current that goes in a constant direction. Direct current is typically produced by batteries and rectifiers.
2. **Alternating current** or **Power Frequency (AC/PF)** is an electric current that reverses its direction many times a second at regular intervals.
3. **Audio Frequency** (**AF**). The AF track circuit uses a **transmitter** and a receiver. The transmitter introduces an audio signal of a specific assigned carrier frequency and modulation rate into the track through wires connected directly to the rails.
4. **Coded track circuit** can be AC or DC circuit where the energy source is transmitted as pulses through the circuit and the receiver is designed to respond to the pulses.
5. **Electronic circuit** can be AC or DC circuit that is based on microprocessor modules which are programmed for train detection and signaling.

Module 4

RELAYS AND RELAY LOGIC

Outline

Purpose and Objective

The purpose of this module is to provide the participant with the basic understanding of relays and relay logic.

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

- Define the fundamentals of relays with respect to railroad signaling
- List commonly used relay terminology
- List different types of relays used in railroad signaling
- Illustrate simple relay circuits

Key Terms

- Armature
- Back Contact
- Coil
- De-Energized
- Dependent Contact
- Distant Relay
- Drop Line
- Energized
- Engineering Data Sheet (ED Sheet)
- Front Contact
- Heel
- Home Relay
- Independent Contact
- Nomenclature
- Original Equipment Manufacturer (OEM)
- Plug Board (Mounting Base)
- Rail Transit System (RTS)
- Registration Plate (Indexing Plate)
- Specification Sheets (Spec Sheets)
- Straight Line
- Symbols

4-1 OVERVIEW

Throughout railroad and transit history signaling functions have been carried out by relay circuitry. The signal maintainer should know the basics of relays, nomenclature and relay logic because they are the foundation to understanding how signal systems work and how to make informed decisions in order to install, replace, repair, test and troubleshoot signal circuits and components.

The track circuit is one of the most essential circuits in all signaling systems. The track relay is the primary component used in the track circuit and is designed for train detection and broken rail protection.

As defined by the Association of American Railroads (AAR) a relay is a device that is operated by changes in the condition of an electrical circuit that in turn affects the operation of other devices in the same or other electrical circuits. A relay is comprised of a number of contacts similar to banks of switches and one or more coils. Some other functions of relays are:

- Operations may be controlled remotely
- Lower powered circuits may control higher powered circuits and vice versa
- Multiple circuits may be controlled by one circuit
- Enables multiple operations in a specified order

Although many railroad properties are now using microprocessor based vital systems, relay circuits are still being installed. Therefore, an understanding of relay logic is essential in maintaining and troubleshooting signal and communication circuits.

This module introduces the new signal maintainer to relay components, relay circuit nomenclature and symbols, as well as basic applications of relay logic and circuit diagrams. In the discussion on relays, this module focuses on vital relays.

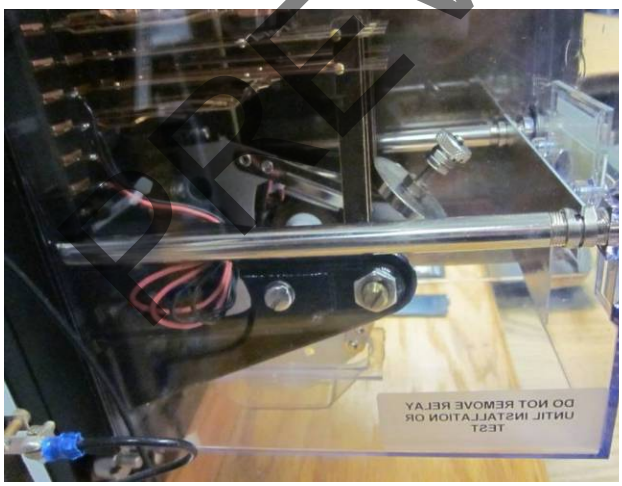


Figure 4.1 Vane Relay for AC Track Circuit - Courtesy MBTA

Figure 4.2 A Group of Alstom B1 Relays - Courtesy MBTA

4-2 RELAY TERMINOLOGY

Relays are categorized as vital or non-vital. Vital relays control or operate critical and safety-sensitive actions and functions. Recall from Module 1, that APTA's definition of a vital relay is one that meets "certain stringent specifications, [and is] so designed that the probability of its failing to return to the prescribed state upon de-energization is so low as to be considered practically nonexistent".

Some examples of vital relays are track relays, switch control and correspondence relays, and home relays. Non-vital relays usually initiate or indicate an action once the vital relay logic allows and completes the action. (See Figure 4.3)

Figure 4.3 Examples of Non-vital Relays ©Alstom ©GTE

Vital relays and circuit designs apply a failsafe principle: a characteristic which ensures that a fault or malfunction of the vital relay will cause the system to revert to a state that is known to be safe. Through the function of vital relay logic and circuit design, faults should bring the system to a "stop and stay" or to the most "restrictive" state possible. Vital relays are the major topic of this module.

The basic components of a relay are the contacts, heel, coil, and armature and these are illustrated in Figure 4.4. When there is no current to the coils of a relay the heels are making with back ***contacts*** and the relay is *de-energized*. The *heel* is the moveable part of the relay operated by the electromagnetic characteristics of the *coil*.

Module 5

INTRODUCTION TO PRINTREADING

Outline

Purpose and Objectives

The purpose of this course is to provide the participant with an introduction to reading and interpreting circuit plans.

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

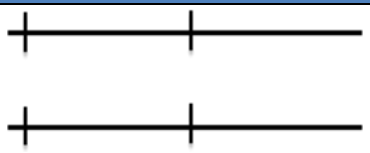
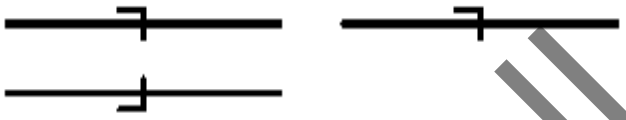
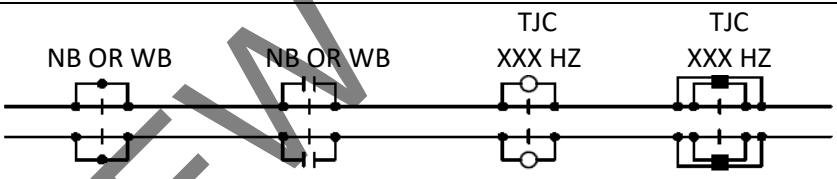
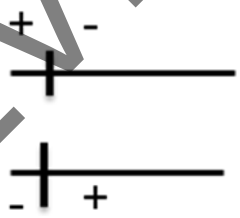
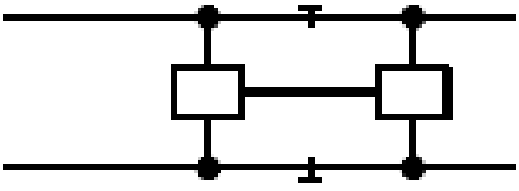
- Identify components, symbols, and nomenclatures of circuit plans
- Identify indexes, revisions and track layouts
- Identify FRA or other regulations for up-to-date circuit plans in specified locations including CILs

Key Terms

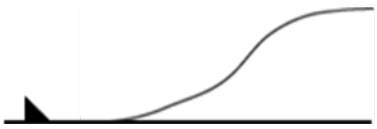
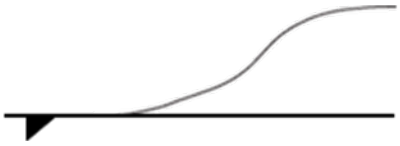
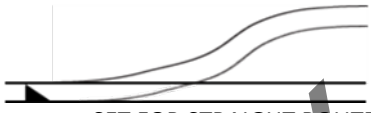
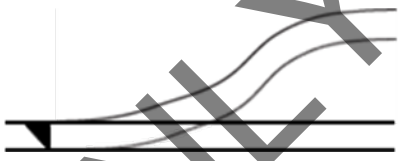
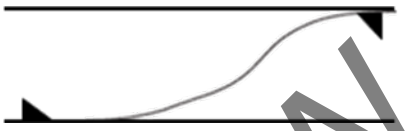
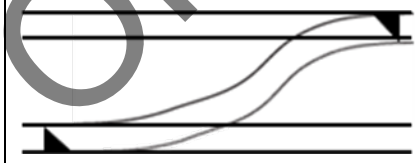
- Aspect
- Cantilever Flashing Light Signal
- Circuit Components
- Computer-Aided Design (CAD) Software
- Electrical Symbols
- Flashing Light Signal
- Flashing Light Signal And Gate Arm Mechanisms
- Grid System
- Highway-Rail Grade Crossing
- Layout Symbols
- Nomenclature
- Prints
- Revision Block
- Signal Indication
- Signal
- Symbols
- Title Block

Layout Symbols

Layout symbols can be categorized as those for track, switches, signals, crossings, and housings. Some typical symbols are shown in the following tables.

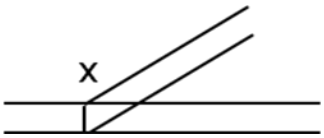
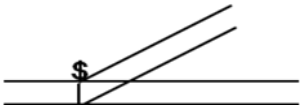
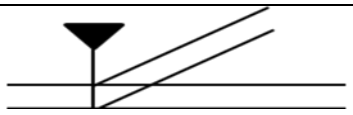
Track Symbols	
Insulated Rail Joints Track Circuits in Both Directions	
Insulated Rail Joints Track Circuit on Left None on Right	
Insulated Rail Joints Track Circuit on Right None on Left	
Insulated Rail Joints With Bypass Device	 NB= NARROW BAND WB=WIDE BAND TJC=TUNABLE JOINT COUPLES
Track Polarity and Insulated Joints	
Impedance Bonds	

Single and double tracks and switches allow trains to enter and cross over between tracks. The symbols for single switch and crossover switch types are shown in the following table.

Switch Symbols By Type		
	Single Line Plan	Double Line Plan
Single Switch	 SET FOR STRAIGHT ROUTE  SET FOR DIVERGING ROUTE	 SET FOR STRAIGHT ROUTE  SET FOR DIVERGING ROUTE
Crossover	 Set for straight route	 Set for straight route

Source: 2011 AREMA® C&S Manual, Part 16.2.6

Switch fixtures are also assigned symbols and some are shown in the following table.

Symbols for Switch Fixtures	
Switch Equipped with Switch Circuit Controller	
Switch Equipped with Spring Mechanism	
Switch Equipped with Electric Lock	

Module 6

PREPARATION FOR INSPECTION AND MAINTENANCE

Outline

Purpose and Objectives

The purpose of this course is to provide the participant with an overview for work in inspecting and maintaining signal systems.

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

- Identify procedures for testing and reporting per Government, Agency and OEM
- Restate the purpose of preventive maintenance at your agency
- Describe record keeping procedures, generally and specific to your Agency
- Identify and explain purpose and use of common tools and equipment
- Demonstrate ability to maintain and care for tools and equipment
- Identify common tools used for mechanical and electrical maintenance tests
- Identify other tools and equipment required by your Agency

Key Terms

- Designated Signal Personnel
- Maintenance Schedule
- Preventative Maintenance Plan

Abbreviations Used in this Module

OEM	Original Equipment Manufacturer
AC	Alternating Current
DC	Direct Current
PTE	Portable Test Equipment
PM	Preventative Maintenance

NIRC SIGNAL DEPARTMENT RS&D FORM
Maintenance Form 5
Monthly Battery Cell Voltage Record
Semi-Annual Load Maintenance Record

Remarks Attached
Yes ☐ NO ☐

Print Name: _____ ID: _____ District: _____ Subdistrict _____
Signature: _____ Initials: _____ Location Name: _____ MP _____
DOT ID: _____ Page ___ of _____

Monthly Cell Voltage Readings

Line	Date of Test	Battery	Total Volts	Individual Cell Voltage Readings 1	2	3	4	5	6	7	8	9	10	11	12	Water Added (Y/N)	Initials
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Semi-Annual Operational Load Record

Line	Date	Battery	Charging Current	Individual Cell Voltage Readings	Water Added (Y/N)	Initials
11						
Line	Date	Battery	Charging Current	Individual Cell Voltage Readings	Water Added (Y/N)	Initials
12						

Monthly Cell Voltage Readings

Line	Date of Test	Battery	Total Volts	Individual Cell Voltage Readings 1	2	3	4	5	6	7	8	9	10	11	12	Water Added (Y/N)	Initials
1																	

NOTE: Record battery bank charging current when "Constant Current Rectifier" is in use.

Figure 6.1 Courtesy of the Metropolitan Rail Corporation (METRA, Northeast Illinois Commuter Rail System)

6-3 TOOLS AND EQUIPMENT FOR MAINTENANCE

The signal maintainer is required to have a set of agency-approved tools, both common and specialized, in order to inspect and maintain signal systems. A standard tool bag for a signal maintainer may be comprised of the following tools:

- Adjustable wrench
- Assorted Allen wrench
- Chisels, punches
- Combination wrench set
- Crimpers
- Lineman's pliers
- Fuse pullers
- Grease gun, oil can
- Grinders / bonding equipment
- Hammer
- Lockout/Tagout materials
- Multimeter
- Needle nose pliers
- Penetrating oil
- Pocket knife
- Ruler – tape measure (must be non-conductive material)
- Screwdrivers, assorted including Phillips, straight-end
- Shunts
- Slip joint pliers (Channel Locks – brand)
- Switch gauge, filing gauge, obstruction gauge
- Terminal wrench
- Wire strippers

Often during inspection and maintenance, the signal maintainer performs mechanical and electrical tests. Each test requires a particular tool or set of tools. There are many specialized tools that will become part of a signal maintainer's regular duties. Some are shown in the next section.

Module 7

GUIDELINES AND RECOMMENDED PRACTICES

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with a list of best practices and recommendations regarding characteristics for jumpers, removing equipment from service, returning equipment to service.

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

- Discuss recommended characteristics for devices used in the removal of equipment from service
- Identify recommended procedures for removing equipment from service
- Identify recommended procedures for placing equipment back into service

Key Terms

- Alligator Clips
- Dispatcher
- Eyelet
- Flag Person
- Hours Of Service
- Jumpers
- Jumper Bag
- Jumper Tags
- On Track Protection

7-1 OVERVIEW

Most railway systems have structured procedures in place for signal equipment to be taken out of service as well as for the equipment to be returned to service. These procedures may include informing the **dispatcher** (RTS authorized personnel) of information involving the equipment being removed from service up to and including critical information and details regarding malfunctioning signal equipment, especially at highway grade crossings. Other procedures may include the assignment of flag persons or police officers near highway grade crossings as well as attaining any on track safety protections necessary for the signal maintainer's work.

Note: Signal maintainers must be aware of and follow all procedures set by their railroad transportation agency.

This module, developed with a consortium of rail signal specialists with nearly 700 combined years of experience identifies some of the best practices the signal maintainer should take to remove equipment from service as well as to return equipment to service.

7-2 RECOMMENDED CHARACTERISTICS FOR JUMPERS

The use of jumpers is a common method of disabling signal equipment used in the signal industry. **Jumper wires** also known as ***jumpers***, in the application of disabling signal equipment, are lengths of wire of a certain gauge used to connect points in a circuit which are separated or open due to a signal malfunction or for work which affects the proper operation of the signal system. For example, track equipment which intermittently shunts a track while working can cause a highway grade crossing warning system to activate when a train is not approaching. Jumpers are used to deactivate that portion of the warning system.

Warning: Safety Precautions!

Any protection temporarily defeated by the use of a jumper must be provided by other means.

Warning: Safety Procedures!

- The use of jumpers in signal circuits to disable the normal engineered operation of the signal system **is an extremely dangerous practice and should be avoided except in the most necessary of circumstances**.
- Jumpers may also be used to enable/activate equipment
- The signal maintainer must have a complete understanding of the consequences of disabling circuits.
- When jumpers are in use, an engineered system that ensures the safety of the public, agency employees, and equipment is bypassed.
- Signal maintainers who do not treat jumpers with the utmost care risk injury and death to all who are dependent on these signal safety systems to operate correctly and as designed.
- All Agency policies, procedures, protocols, and accounting for deactivated circuits MUST be strictly followed.
- Signal maintainers risk employer discipline, personal liability, and criminal prosecution for the misuse of jumpers.
- No unauthorized jumper shall be used.

Consequences of Improper Use of Jumpers

The unauthorized use of jumpers can have dire consequences on the safety of rail passengers and workers. In October 2012 an Amtrak train entered the Niles, Michigan yard from the main track traveling at 61 mph. The train derailed about 291 feet after diverging from the main track and traveled 1,148 additional feet before coming to a stop on a yard track. See *Figure 7.1*.

GLOSSARY

Active Highway Grade Crossing System : A highway grade crossing system that includes visible, audible, and physical barriers, which are activated on the approach of a train.

Alligator Clips: A type of fixed termination for jumpers.

Alternating Current Track Circuit: A type of track circuit where an electric current that reverses its direction many times a second at regular intervals, also known as Power Frequency.

Automatic Train Control: a system that initiates a penalty brake application if the engineer fails to reduce speed in compliance with cab signal indications.

Armature: Related to relays, pivotal metal fixture that is linked to the heel contacts.

Aspect: the nature or appearance of a signal.

Audio Frequency Track Circuit: The AF track circuit uses a **transmitter** and a receiver. The transmitter introduces an audio signal of a specific assigned carrier frequency and modulation rate into the track either through wires connected directly to the rails. Block: area of track between two towers.

Block system: system of rules made for travel within and between blocks and communication between adjacent towers. The main rule was that only one train could be moving within a given block.

Cantilever Flashing Light Signal: Common apparatus used at a highway-rail grade crossing

CFR 214: Specific guidelines set into law by the federal government to protect roadway workers while they are on the job. Many railroad systems use CFR 214 as the foundation for developing their own recommendations and guidelines for roadway worker protection.

Circuit Components: Fuses, transformer, relays, and contacts

Closed Circuit principle: The principle of circuit design where a normally energized electric circuit which, on being interrupted or de-energized, will cause the controlled function to assume the most restrictive condition.

Coded Track Circuit: A type of track circuit which can be AC or DC circuit where the energy source is transmitted as pulses through the circuit and the receiver is designed to respond to the pulses.

Coil: A relay component which possesses electromagnetic characteristics which impact the operation of other relay components, such as the heel.