Inspection and Maintenance of Highway Grade Crossings

Course 204

PARTICIPANT GUIDE

SIGNALS TRAINING CONSORTIUM

Introduction and Overview to Inspection and Maintenance of Highway Grade Crossings

Participant Guide

Signals Maintenance Training Consortium

COURSE 204

September 2017 Draft

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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 *Inspection and Maintenance of Grade Crossings* course is to assist the participant in demonstrating proper and safe procedures for inspecting and maintaining highway grade crossings and their associated components.

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. *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 each course module. *Review exercises* conclude each module to assist the participants in reviewing key information.

Module 1

OVERVIEW AND SAFETY

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview for maintenance and inspection of highway grade crossings.

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 as related to grade crossing inspection & maintenance
- Identify tools and describe their required care necessary for highway grade crossing inspection and maintenance
- Identify agency specific schedules for grade crossing inspection and maintenance
- Describe inspection, maintenance & testing documentation for reporting as per agency regulations

Key Terms

- Catenary wire
- Communication
- Defective equipment
- Frequency selective voltmeter
- General public
- Hot gloves
- Insulated shepherds hook
- Insulated Shotgun
- Jumper wire
- On-track protection
- Personal fall arrest system
- Personal safety
- Potential hazards
- Rail system
- Reflective vest
- Secure the worksite
- Third rail
- Torque wrench
- Vehicle strobe light

1-1 OVERVIEW

In the previous course, *Course 101 Overview and Introduction to Signals*, the participant was introduced to highway grade crossings, their basic components and their basic operation. The approach to this next level of training, Course 204, is to help the participant hone necessary skills for inspecting and maintaining highway grade crossings and their systems. In doing so, this module supplements and enhances agency-specific on-the-job, classroom and other training required.

This course was developed by a consortium of signal specialists from several rail transit systems that, on the federal level, are governed by the Federal Railroad Administration (FRA) or the Federal Transit Administration (FTA). Each federal agency provides the baseline for compliance in areas of safety, testing, maintenance, and record keeping pertaining to track circuits. The approach of this module uses the guidelines outlined in FRA §234 for inspection, testing, maintenance and repair. Each signal maintainer should refer to the RTS SOP for applicable testing and maintenance. The FRA guidelines also prescribe standards to ensure that personnel working with, and affected by, safety-critical train control system related products receive appropriate training and testing.

One focus of this module is on the practice of safety for signal maintainers working around grade crossings. As such, this module supplements standard safety policies of the participant's rail transit system as well as the principles of safety covered in your orientation and in Course 100 of this series of courses, particularly the module on *Signal Maintainer Worker Safety*.

Safety extends to the proper use of tools when inspecting and maintaining highway grade crossings. This module discusses the safe use of standard tools the signal maintainer can expect to use when working on highway grade crossings.

Every rail transit system adheres to strict record-keeping and timetables for inspection and maintenance. These practices ensure the safety of rail passengers, workers, and properties. This module gives a thorough overview of maintenance record keeping.

This module forms the foundation of the specifics of preventive maintenance for the other modules which cover specific maintenance steps of highway grade crossing warning devices and systems. Within this module highway grade crossing worker safety, tools, and maintenance timetables are presented.

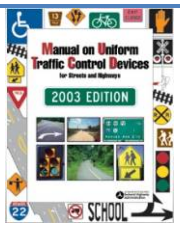
Some common acronyms are used throughout this course are:

- APTA The American Public Transportation Association
- AREMA American Railway Engineering and Maintenance-of-Way Association
- FRA Federal Railroad Administration
- FTA Federal Transit Administration.
- OEM Original Equipment Manufacturer
- PPE Personal Protective Equipment
- RTS Rail Transit System

1-2 SAFETY

Ensuring proper operation of highway grade crossings and their warning systems is mandatory and accomplished through effective maintenance & testing. Maintenance, inspection and testing of the highway grade crossing can create potentially dangerous situations to the employees responsible for completing these tasks. Strict adherence to sound safety practices and constant awareness are the requirements for avoiding accidents and fatalities.

The signal maintainer must have complete knowledge of all safety rules, policies, and guidelines of each RTS when inspecting and maintaining grade crossings. Roadway Worker Safety training along with any previous course work should be followed. Compliance with applicable federal, state and local requirements including OSHA, the CFR 49 Section 234 and the MUTCD is mandatory.



Regulations for the safety of highway grade crossing maintenance can be located in:

- **Code of Federal Regulations (CFR),** Part 49 Section 234
- **Manual on Uniform Traffic Control Devices (MUTCD)**
- **Roadway Worker Protection Training**
- **State safety oversight agency**

To prevent injuries, the signal maintainer must complete training & testing, follow supervisor and mentor lead, follow agency rules and procedures, maintain careful and accurate records, and use reference material when required.

Warning: Safety Precautions!

Your safety, your co-worker's safety and the safety of the public depend on you. Always follow your agency's specific requirements for safety as related to any highway grade crossing inspection and maintenance practices.

Safety and highway grade crossing maintenance can be considered in three categories: personal safety, the protection of train movement and equipment, and the safety of the general public.

Module 2

INSPECTION & MAINTENANCE HIGHWAY GRADE CROSSING THEORY OF OPERATION

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview for maintenance and inspection of highway grade crossings.

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

- Identify nomenclature, symbols and relays specific for highway grade crossings
- Describe highway grade crossing circuits for flashers, bells, crossing gates, detection circuits, island circuits and approach circuits
- Identify and explain a grade crossing advanced sequence of operation and related systems
- Identify the location of prints for highway grade crossing maintenance and inspection purposes

Key Terms

- Electrical symbols
- Layout symbols
- Nomenclature
- Series of circuits
- Subsystems

2-1 OVERVIEW

As we learned in Course 104, "Introduction and Overview of Highway Grade Crossings," the highway grade crossing includes circuits which detect the approaching or leaving train and consequently triggers the activation or deactivation of related active warning devices.

Detecting the presence of a train does not inherently tell anything about its movement or direction (or lack of movement, if that is the case). For this reason, the system based on detecting train presence is divided into zones to separate the detection information into three possible states: train approaching the crossing, train spanning the crossing, and train moving away from the crossing. From the very beginning of automatic crossing warning systems, this was done using track circuits to detect which of the zones the train was occupying. Logic was then used to determine movement and direction based on presence detected in one or more zones and the order in which the different zones were occupied.

For inspection and maintenance of highway grade crossings, a signal maintainer must have an understanding of how these circuits operate in conjunction with train movement and warning system operation. In this highway grade crossing inspection and maintenance module, we will further explore the theory of operation through a closer examination of related nomenclature, basic warning device circuits, and an advanced series of prints showing a highway grade crossing sequence of operation.

2-2 CIRCUIT SYMBOLS & NOMENCLATURE

The following table illustrates common symbols and nomenclature used in highway grade crossing electrical prints. Use the space, "Your Agency" to add any unique symbols or nomenclature used in prints in your transit agency.

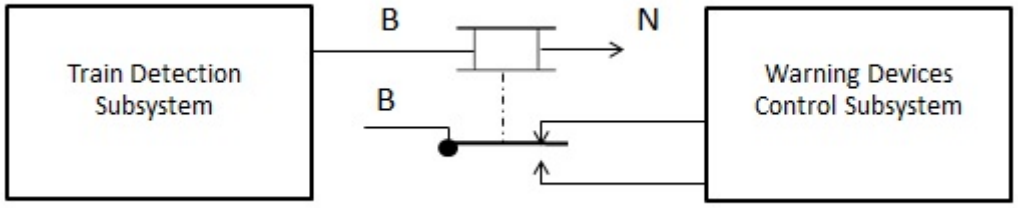


Figure 2.2 Primary Warning System Subsystems

The initial approach circuit, once crossed, must activate the warning systems and devices to provide ample warning time to motorists and pedestrians. Minimum warning times are established by the FRA, maintained by the transit properties and will be discussed in later modules of this course. Minimum warning time must not be less than 20 seconds.

You will also recall from Course 104, the direction of the train is determined by directional stick circuits and in some cases, more advanced train detection such as motion sensor detection and constant warning time circuits are utilized. To review these highway grade crossing related circuits or if your transit agency uses advanced train detection, then review Course 104 or see additional materials provided through your agency and instructor.

Basic Gate Operation

Prior to examining circuits, a basic understanding of gate operation is important and will be provided here with a more detailed explanation with specific and related maintenance requirements covered in later a module.

As covered in course 104, a crossing gate is made up of the gate arm, a gate mechanism, and other related parts. At highway grade crossings with crossing gates, the crossing gates are normally in the vertical position unless a train is present. When a train enters the approach and after flashers and bell has been operating for three to four seconds, the gate is lowered and remains in the horizontal position as it passes through the island circuit. Once the train has cleared the island circuit, the gate is raised back to vertical position. The trains location is determined through the detections circuits and the gates operate on the logic and information conveyed to the warning system.

The mechanism that typically maintains the gate in a vertical 90° position is a holding device or also known as the “hold-clear” mechanism. This device is located in the gate mechanism, can be either mechanical or electrical.

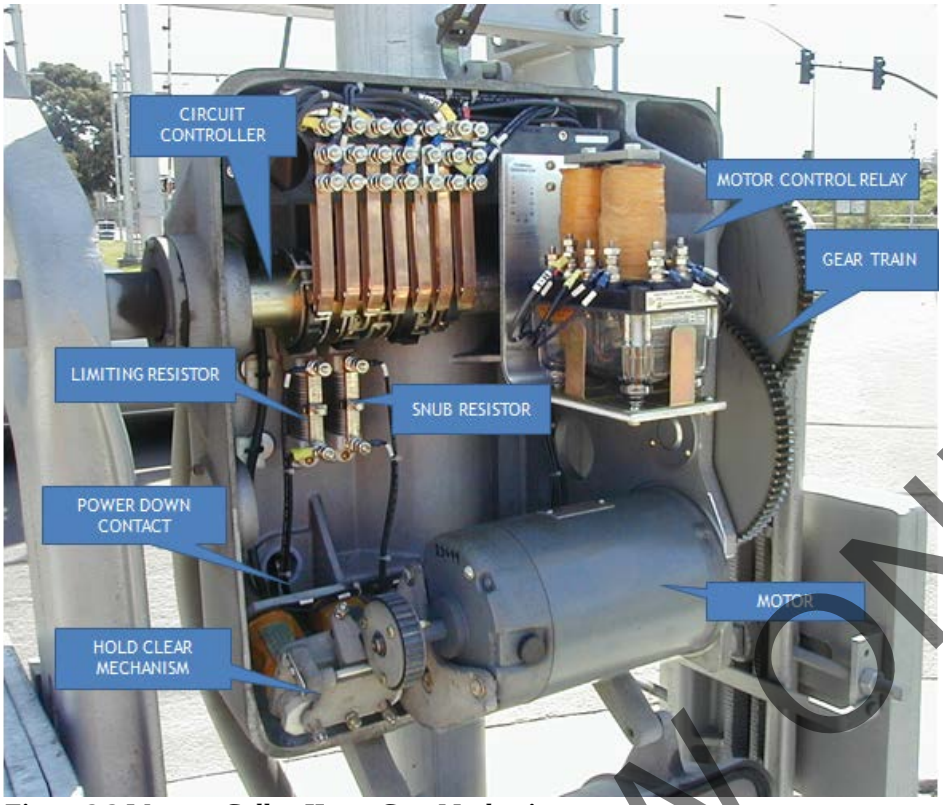


Figure 2.3 Western Cullen Hayes Gate Mechanism

Once the train has crossed the approach circuit, the energy is removed from this device and the "latch" that keeps the gate arm up is released. In most crossing gate systems, the gate mechanism has a power down feature that uses a motor to drive the gate arm to approximately 45° at which time the gate arm continues its descent with the assistance of gravity and dynamic snubbing to the horizontal position. The gate arm remains in this horizontal position until the train clears the island circuit at which time the train detection circuits send a signal to the gate mechanism to begin the process of raising the gate back to vertical position. A counterweight attached to the opposite side of the pivot offsets the gate arm weight to help the motor raise it from the down position. Power from the control circuit is controlled in the gate mechanism by individual contacts which control power flow by the physical position of the gate.

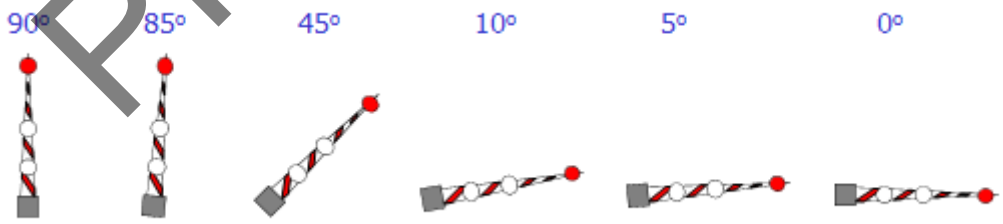


Figure 2.4 Gate Arm Descent from Vertical to Horizontal Position

Module 3

INSPECTION & MAINTENANCE WARNING DEVICES: SIGNS, LIGHTS & AUDIBLE DEVICES

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview for maintenance and inspection of highway grade crossings.

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

- Describe highway crossing warning devices: signs, lights and bells
- Identify regulatory requirements for inspection and maintenance of highway grade crossing warning devices: signs, lights and bells
- Describe and demonstrate inspection, maintenance & routine testing for highway warning devices: signs, lights and bells
- Identify a general and agency specific schedule for crossing component device inspection, maintenance & routine testing

Key Terms

- Alignment
- Electro-mechanical
- Electronic
- Flash rate
- Housing
- Illuminated
- Lamp brilliance
- Lamp condition
- Lamp voltage
- Light emitting diodes
- Rectifier
- Reflector
- Roundel
- Shield
- Skewed
- Stand-by battery power

3-1 OVERVIEW

Course 101 Module 4, Introduction to Highway Grade Crossings, introduced warning devices for highway grade crossings. Three of these devices include signage, flashers and audible devices. Along with understanding the electrical configuration of each device as explained previously in Module 2, knowledge of the warning device parts and components is also critical for inspection and maintenance of these devices and their operation. This section describes the regulatory references, inspection and maintenance methods, and recommended schedules in greater detail for these components.

Special tools and supplies required for the inspection, maintenance and testing of signs, lights and bells include:

- Multimeter
- Screwdrivers
- Wrench
- Pliers
- Cloth & soapy water (NO solvents)
- Replacement parts as needed: roundels, lenses and any other OEM specified parts

3-2 SIGNS

Signage at a highway-rail crossing typically involves at a minimum crossbucks and signs indicating the highway grade crossing identification number along with emergency phone contact information. A crossing with only signage and no active signal-based warning system would be considered a passive highway grade crossing. Sometimes, the highway grade crossing will also include additional signage to address needs of a more complex crossing. For example, a more complex or active highway grade crossing may include a number of tracks plaque, a train approaching sign, or a "No Right Turn"/"No Left Turn" sign.

Inspection and Maintenance

Regulations for signage include the following:

Signage Regulations

Component Characteristic	Regulatory Agency	Section
Signage	FRA AREMA	234.245 3.2

Usually, the only signs requiring maintenance and inspection from signal personnel are the signs directly part of the highway grade crossing. Most signage approaching the grade crossing along roadways or pedestrian walkways is the responsibility of local or state agencies.

A signal maintainer at a grade crossing must ensure all signs are **affixed** to appropriate structures (signal post or mast) and clearly **visible** to approaching motorists and pedestrians. Signs must be in good condition, missing or damaged signs should be replaced and the security of the mounting hardware should be checked.

Figure 3.1 Clearly Visible and Maintained Signage at a Highway Grade Crossing

Signs that are **illuminated** should be inspected for clear visibility. Lamp units within the signs will be maintained just as other lamps and flashers are maintained.

3-3 LIGHTS

Flashing light signals at highway grade crossings are available in various arrangements. Some warning devices include only a single mast-mounted flasher unit while other more complex arrangements may include cantilevers with mounted front and. General practices for most rail and transit agencies is to include two four-unit flashing signals per crossing with lights on each to flash in both directions at 35 to 65 flashes per minute. Other signal lighting may be added depending on the needs of the highway grade crossing such as gate arms with lights and adjunct devices such as active “No Left” turn signs.

There are two types of flashing lights currently in use: those using incandescent bulbs and those using **light emitting diodes** *(LED’s)*. Flashers using incandescent bulbs are typically 10 volt, 25 watt focus lamps mounted in front of curved mirrors to spread light beams for proper visibility. If LEDs (light emitting diodes) are used, a minimum of 200 LED’s are required to be used in place of one incandescent bulb. While these numbers comparatively seem high, LEDs require less power than a traditional incandescent bulbs, provide a faster on/off time with a more noticeable flash, require less maintenance and tend to last longer.

Module 4

INSPECTION & MAINTENANCE CROSSING GATES AND MECHANISMS

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview for maintenance and inspection of highway grade crossing gates and gate mechanisms.

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

- Describe highway grade crossing gates and gate mechanisms
- Identify regulatory requirements for highway grade crossing gates and gate mechanisms
- Describe and demonstrate inspection, maintenance & routine testing for highway grade crossing gates and gate mechanisms
- Identify agency specific schedules for gates and gate mechanism inspection, maintenance & routine testing

Key Terms

- Buffer
- Channel type breakaway adapter
- Excessive winds
- Fouling
- Gate arm adapter
- Gate arm condition
- Gate arm length
- Gate clear
- Gate contacts
- Gate delay
- Gate descent
- Gate keeper
- Gate mechanism
- Gate operation
- Gate speed
- Gear train
- Hold clear assembly
- Hold clear test
- Horizontal position
- Horizontal torque Labels
- Pivot breakaway type
- Retro-reflective tape
- Shear pin
- Spring scale
- Synchronized
- Terminal board
- Tip light
- Torque
- Torque adjustment
- Torque wrench
- Vertical position
- Vertical torque
- Wind bracket

Video:

Synchronized Flasher and Gate Lights
http://www.youtube.com/watch?v=taSbbfsLGzo&feature=youtu.be

The lights and wires should be secure to the gate arm. Inspection and maintenance for all highway grade crossing lighting is covered in Module 3: Inspection and Maintenance of Signs, Flashers and Audible Devices.

Gate arms are offset by the counterweight allowing for the gate arm to be raised without excessive motor current draw. The counterweight, as shown in Figure 4.4, is adjustable in two ways for an appropriate number of foot pounds of **torque** when the gate arm is in either vertical or horizontal position. The counterweight is attached to the gate via the stud plate assembly, gate arm support and gate arm adapter.

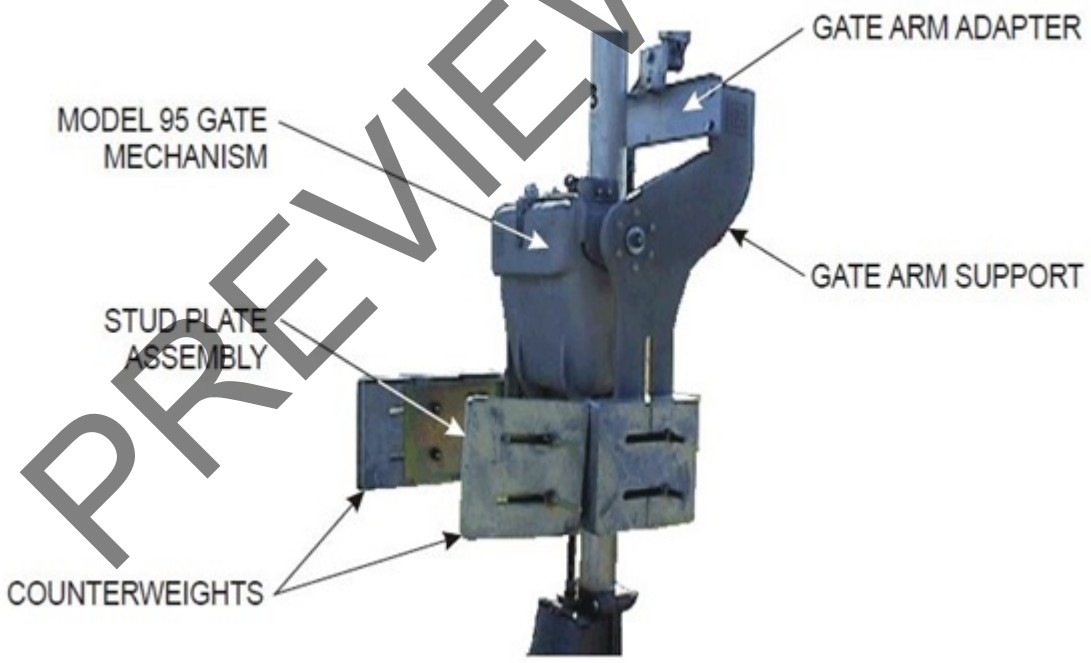


Figure 4.4 Exit Gate Mechanism showing a Counterweight and Gate Arm Adapter

A **gate arm adapter** is used to attach the gate arm to the gate. Adapters are used to protect the gate mechanism by allowing the gate arm to shear off at the attachment in the event a gate arm is stuck by a vehicle. A gate arm adapter is also shown in Figure 4.4

There are three main types of gate arm adapters: the pivot breakaway type, the gate keeper and the channel type breakaway adapter. The **pivot breakaway type** allows the vehicle-struck gate to break shear bolts and drop to the ground. As seen in Figure 4.5, the pivot breakaway gate arm adapter is comprised of four components: conversion bracket, casting adapter, pivot pin (sometimes called king pin), and shear pin bolts as seen in Figure 4.6 and Figure 4.7.

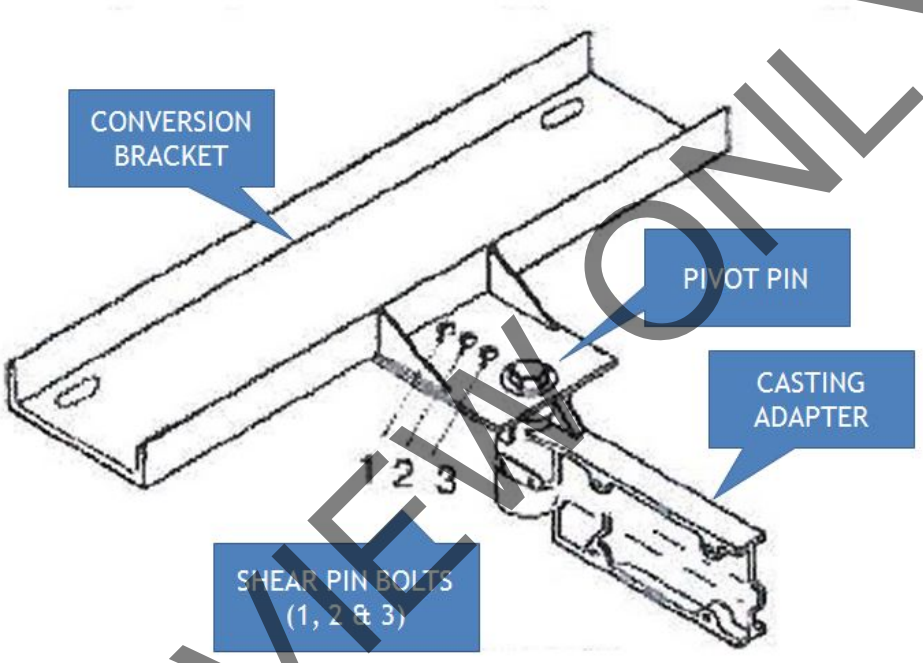


Figure 4.5 Safetran pivot breakaway, casting adapter and conversion bracket, and pivot pin

Figure 4.6 Shear Pin Bolt

Module 5

INSPECTION & MAINTENANCE OF WARNING SYSTEMS

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview for maintenance and inspection of highway grade crossings warning systems and circuits.

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

- Describe highway grade crossing warning systems: controls, power, track equipment and circuits
- Identify regulatory requirements for highway grade crossing warning systems
- Describe and demonstrate inspection, maintenance & routine testing practices for highway grade crossing controls
- Describe and demonstrate inspection, maintenance & routine testing practices for highway grade power
- Describe and demonstrate inspection, maintenance & routine testing practices for highway grade track equipment
- Describe and demonstrate inspection, maintenance & routine testing practices for highway grade circuits and wiring
- Identify agency specific schedules for inspection, maintenance & testing of highway grade warning systems

Key Terms

- .06 ohm shunt
- Activate crossing
- Battery charger
- Bi-directional
- Bonding
- Calibration
- Constant current
- Constant voltage
- Constant warning time equipment
- Control circuits
- Conventional
- Crossing control case
- Cutout
- Data port
- Directional stick circuit
- Distance voltage
- Event recorder device
- Fail-safe principle
- Final check
- Fouling
- Gate decent
- Grounds
- Grounds test
- Inputs
- Insulated joints
- Interconnection
- Joint coupler
- Level horizontal position
- Line circuit
- Load test
- Motion sensor
- Narrow band shunt
- Perpendicular
- Recovery
- Rectifier
- Reports
- Restart circuit
- Shunt the approach
- Solid state crossing controller
- Stand-by power
- Stand-by power test
- Station stop timer
- Surge protection
- Tagged
- Termination shunt
- Test links
- Test switch
- Track connection
- Traffic signal preemption
- Train detection
- Transmitter lead
- Variable impedance track circuit
- Vertical position
- Vital parameters
- Voltage
- Walked
- Warning system cutout
- Warning system operation
- Warning time

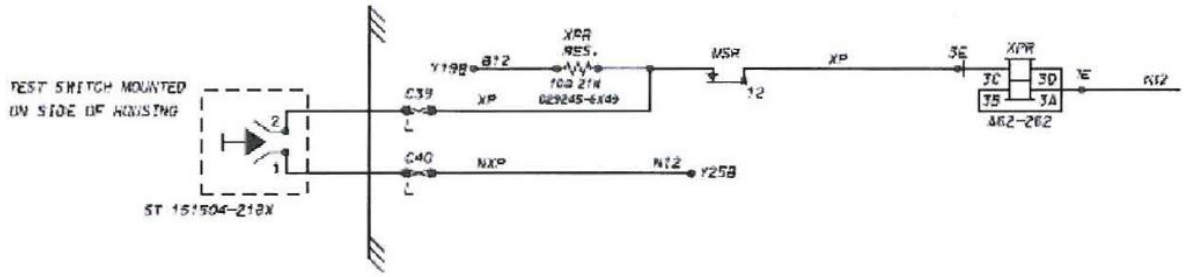


Figure 5.10 Test Switch Schematic

Inspection and Maintenance of the Test Switch

The test switch cover should be opened and inspected for signs of damage and for proper operation. After crossing maintenance and/or repairs are completed, a **final check** of the test button should be made before leaving the site.

Warning System Operation

Warning system operation refers to the actual proper operation of the crossing warning devices when circuits indicate the presence and movement of a train has been detected.

According to CFR Title 49 Part 234 Grade Crossing Signal Systems Safety § 234.257:
"Each highway-rail crossing warning system shall be tested to determine that it functions as intended when it is placed in service. Thereafter, it shall be tested at least once each month and whenever modified or disarranged."

Inspection and Maintenance of Warning System Operation

To begin maintenance and inspection, verify that the commercial power is on and the power off relay (if equipped) is energized. The "Power On" light, if equipped, should be illuminated. The "Power On" light should also be checked after all electric storms.

Observe and verify all track circuits are operating as intended. Visual inspections should always be completed when circuits are first placed in service, when modified, when or disarranged, or at least every 90 days. In some cases, circuits may need to be inspected more frequently depending on data results. Track circuits should be electrically tested with a **.06 Ω shunt** to verify intended operation whenever modified, disarranged or at least every 2 years. (Some agencies utilize a more stringent shunting level. For example, San Diego Trolley, Inc. maintains a .20 Ω shunt sensitivity.)

Next, activate the crossing by using a maintainer's test switch where provided as shown in Figure 5.11. Train movement may also be utilized to activate the crossing warning system. If a test switch is not provided, the warning system operation should be checked by de-energizing the XR directly. Again, some agencies may utilize test push button or **test links** on a crossing control relay to activate the crossing.

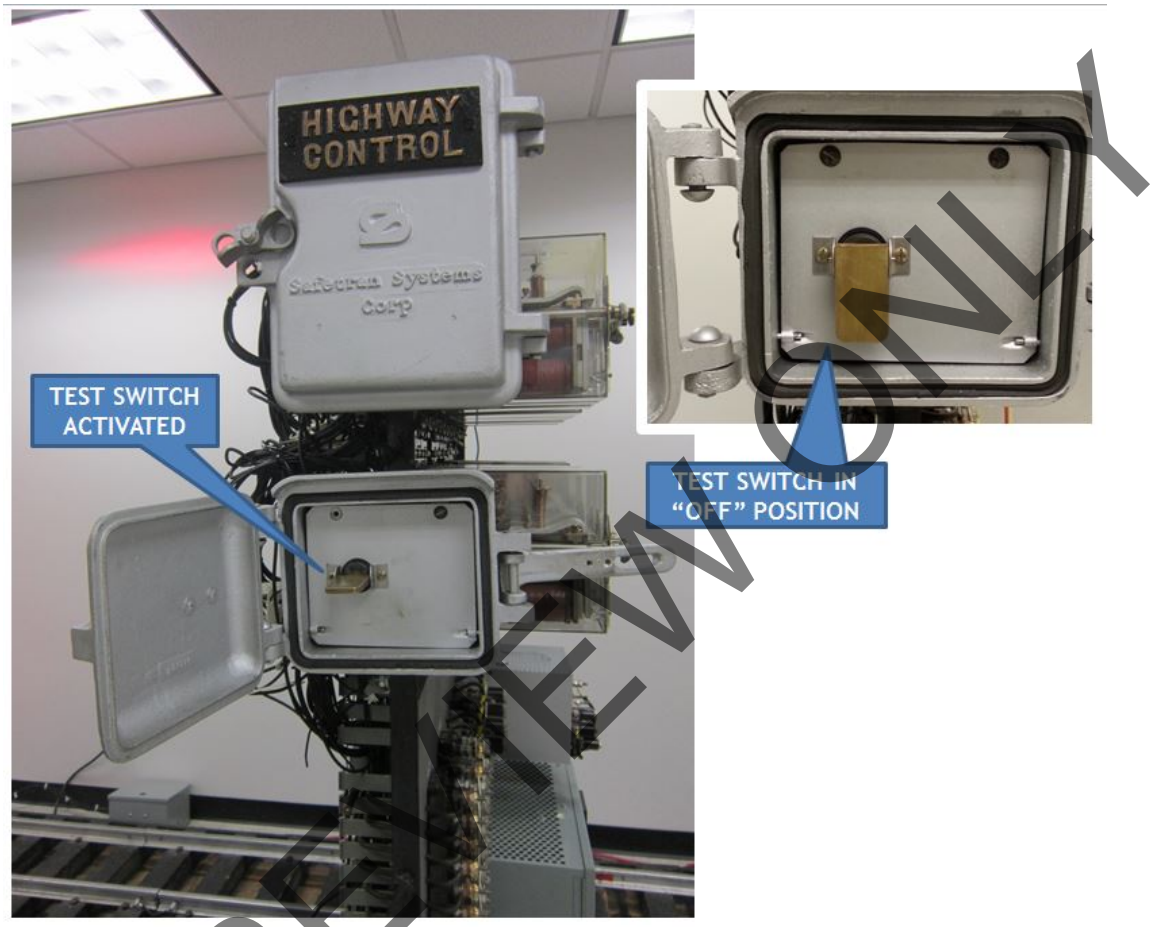


Figure 5.11 Test Switch for Warning System Operation Test

To verify proper **warning system operation**, observe and verify all gates, lights and bells operate as intended. You will recall from previous modules, these warning devices must operate within agency and regulatory guidelines.

Ensure the flasher and gate lights if present function as intended with the crossing activated. As soon as the crossing is activated, flashers and gate arm light should begin. As per FRA regulation, the number of flashes for each light unit is a minimum of 35 and maximum of 65 flashes per minute, and flashers should alternately light. If present, gate arm tip lights should remain on continuous, while middle and inside light flash in a synchronized manner with the flashers.

Module 6

HIGHWAY GRADE CROSSING GENERAL INSPECTION & MAINTENANCE PROCEDURES

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an overview for general and routine inspection, testing and maintenance of highway grade crossings.

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

- Describe general highway grade crossing instructions for inspection and maintenance practices
- Identify monthly highway grade crossing testing and inspection practices
- Identify quarterly highway grade crossing testing and inspection practices
- Identify annual highway grade crossing testing and inspection practices
- Describe agency specific procedures
- Describe cautions to take when inspecting and maintaining highway grade crossings

6-1 Overview

Course 204 Highway Grade Crossing Inspection and Maintenance Modules 1 – 5 focused on the a more detailed description of each component or section of the highway grade crossing along with related inspection and maintenance practices.

In Module 6, Highway Grade Crossing General Inspection and Maintenance Procedures, the participant is presented with a summarized version of the general routines for inspection, maintenance and testing for highway grade crossings at regularly scheduled intervals that include

general instructions, monthly inspection and testing, quarterly inspection and testing, and annually inspection and testing. Just as in all other modules, it is important to note that while this is a general guide and can be used to supplement a specific agency's procedures. Signal maintainers should always follow their agencies policy with regards to all inspection and maintenance practices.

Caution

- Always follow your agency's specific policy and procedure with regards to highway grade crossing inspection and maintenance routines, practices and schedules.

6-2 GENERAL INSTRUCTIONS

Proper precautions must be taken to protect highway traffic before any changes or test are started on highway-grade crossing warning systems which would adversely affect the public, operation of trains, or safety. Maintenance, testing, and repair work which may interfere with the safe operation of trains must not be started until train movements have been protected, and where applicable, proper authority attained.

Immediately after repairs, adjustments, or replacements have been completed, an appropriate test of the affected equipment must be made to verify that the system is operating as intended. This will also include a test of the activation equipment per manufacturer's instructions and your agency's procedures.

Rail Joints

Rail joints located within limits of a highway crossing detection circuit must be bonded. (FRA Standard 234.233) All crossing circuits located in non-signaled track or in turnouts of switches within the crossing approach must be double bonded. See bonding instructions in the track circuit course.

Fouling Wires

Fouling wires within a crossing approach must be two independent bond strands; wires should be placed as close as possible to the insulated joints in the turnout for maximum broken rail protection. (FRA Standard 234.231) Wires will be stapled to separate ties to minimize the possibility of both conductors being broken during tie replacement.

Housekeeping

All crossing signals, houses and other associated signal equipment must be maintained in good condition and kept clean. Relays must be properly seated. All doors must fit and work freely. Housings must be water tight and rodent free.

Grade Crossing System Placed in Service

Before placing grade crossing warning systems in service, all detection devices and must be tested and functioning properly. All lights must be properly aimed and focused and gate arms must be the correct length. Gate mechanisms should also be adjusted for proper torque settings. The use of a flagman during these procedures in appropriate high visibility clothing is recommended. (See your agency specifications regarding flagmen)

Activation of Warning System

Crossing warning system must be maintained to activate in accordance with the design of the system. In no event shall a crossing warning system provide less than twenty seconds of warning time before the grade crossing is occupied by rail traffic. (FRA Standard 234.225).

Train Detection Equipment

Train Detection

Train detection equipment must be maintained to detect a train or railcar in any part of a train detection circuit in accordance with the design of the specific warning system. (FRA Standard 234.227).

Shunt Sensitivity

Train detection circuit must detect the application of a 0.06 ohm shunt connected across the rails in any part or the circuit. (FRA Standard 234.229)*****.

***NOTE:** Check your agency's specifications as some agencies require the detection of a 0.20 ohm shunt for this application.

Alternate Warning

When automatic highway crossing warning fails to operate properly or is damaged, alternative means of warning highway users must be provided promptly and maintained until necessary repairs are made.