Introduction and Overview to Highway Grade Crossings

Course 104

PARTICIPANT GUIDE

SIGNALS TRAINING CONSORTIUM

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Participant Guide

Signals Maintenance Training Consortium

COURSE 104

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Purpose of the Course

The purpose of the *Introduction and Overview to Highway Grade Crossings* course is to provide the participant with an introduction to highway grade crossings. This introduction will include basic terminology, regulations and oversight specific to highway grade crossings, general highway grade crossing components, control circuits and warning systems.

Approach of the Book

This course 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 course. A list of *key terms* identifies important terminology that will be introduced in this course. *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 course. A list of *key terms* identifies important terminology that is introduced in this course. *Review exercises* conclude this course to assist the participants in reviewing key information.

INTRODUCTION AND OVERVIEW TO HIGHWAY GRADE CROSSINGS

Outline

Purpose and Objectives

The purpose of this module is to provide the participant with an introduction to highway grade crossings. This introduction will include basic terminology, regulations and oversight specific to highway grade crossings, general highway grade crossing components, control circuits and warning systems.

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

- Identify key highway grade crossing terminology & nomenclature
- Describe regulations pertaining to highway grade crossings
- Describe the principles of highway grade crossing operation
- Identify and describe highway grade crossing warning equipment
- Identify and describe highway grade crossing control circuits
- Describe highway grade crossing warning systems
- Identify three types of warning system malfunctions

Key Terms

- Activation Failure
- Active “No Left” Turn
- Active “No Right” Turn
- Advanced warning sign
- Approach circuit
- Backlights
- Battery
- Cantilever
- Circuit controller
- Constant warning time
- Conventional circuit
- Crossbuck
- Crossing controller
- Crossing gates
- Directional stick
- Emergency signage
- Entrance gate
- Exit gate
- False activation
- Flashing light unit
- Four quadrant gate
- Gate arm
- Gate arm adapter
- Gate arm counterweight
- Gate mechanism
- Gear train
- Gate heater element
- Hold Clear Device
- Island circuit
- Motion sensor
- Motor
- Number of Tracks plaque
- Overlay detection circuit
- Partial activation
- Traffic signal preemption
- Warning bell
- Warning systems
- Warning system cut-out
- Warning time
- Wind bracket

Figure 1 A Wigwag Signal in Southern Oregon 2007 - Courtesy Wikipedia.org

As road systems and their use continued to grow, the need to standardize signage and warning systems became increasingly important. In 1923, the first standardization of highway grade crossing signals in the United States occurred during the annual meeting of the American Railway Association (now the Association of American Railroads). While highway grade crossing systems have been improved over the years, the basic idea of providing a train-based warning system to allow for an effective amount of warning time and minimal inconvenience to the motorist have remained the same.

This module is intended to explore the modern grade crossing in terms of regulations, warning devices, basic operation, and warning system logic circuits.

Warning: Safety Precautions!

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

1-2 HIGHWAY GRADE CROSSING REGULATION

There are well over 200,000 highway grade crossings in the United States. Railroad and transit agencies work in conjunction with local, state and federal agencies to ensure the safety of these highway grade crossings. It is important to note that highway authorities are normally responsible for installing and maintaining all advanced warning signals, advanced warning signs and other supplemental signs on roads approaching a grade crossing. On the other hand, railroad and transit agencies are responsible for installing and maintaining signage, flashing light signals, warning bells, gate arms and gate mechanisms.

Several federal organizations and associations set the standards by which highway grade crossings are established and maintained by rail agencies. Under the U.S. Department of Transportation, two of the ten agencies who primarily govern highway grade crossings are the Federal Railroad Administration (FRA) and the Federal Highway Administration (FHWA). Railroad agencies must follow the FRA guidelines. Transit agencies are not mandated to follow FRA guidelines, however many follow them as a matter of practice all-the-same. Grade Crossing Signal System Safety is covered in The Code of Federal Regulations Title 49 Part 234. Two publications issued by the FHWA related to highway grade crossings include the Railroad-Highway Grade Crossing Handbook and the earlier mentioned Manual on Uniform Traffic Control Devices (MUTCD). The Railroad-Highway Grade Crossing Handbook provides detailed guidance regarding warning devices, locations of warning devices, train detection, preemption, warning times, and pre-signals. The MUTCD offers guidance and a minimum national level of standard for grade crossing signage and signals related to preemption; pavement markings; flashing light signals; gate systems; and, train detection.

While these federal agencies provide standards, state and local agencies also govern highway grade crossings for both railroad and transit. As always, refer to your specific transit organization for these guidelines.

Lastly, AREMA, or American Railway Engineering and Maintenance-of-Way Association, provides railway design and maintenance standards. AREMA is not a governing agency, but most transit agencies have adopted the AREMA standards as industry standard. The AREMA manual section 3.3 includes instruction for the maintenance of highway grade crossings and associated equipment.

Warning: Safety Precautions!

Always refer to your transit organization for specific guidelines and regulations.

Figure 4 Highway Grade Crossing Sign Indication Crossing Identification Number and Phone Number for Emergencies – MDysart 2013

Sometimes when needed, a highway grade crossing may include optional signs depending on the grade crossing design and/or state traffic laws. A "Do Not Stop on Tracks" sign or traffic signs such as a "Stop" or "Yield" as seen in Figure 5 are examples of optional signs sometimes found at a highway grade crossing.

Figure 5 Passive highway grade crossing with a crossbuck mounted on an mast and with optional yield sign, Courtesy Oregon.gov

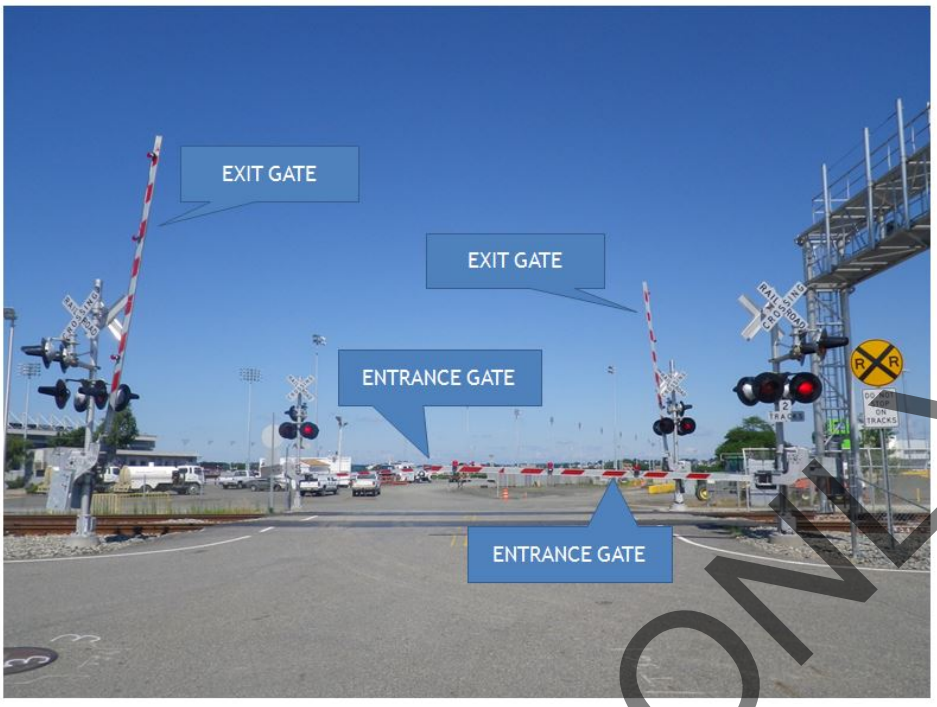

Figure 15 Four Quadrant Gate System with Entrance Gates Lowered and Exit Gates Raised

Figure 16 Four Quadrant Gate System with Both Entrance Gates Lowered and Exit Gates Lowered Creating a Sealed Corridor

Some agencies use vehicle detection loops (inductive) in the highway grade crossing. If vehicle detection loops are used, then detection loops will restrict the lowering of the exit gates once all vehicles have cleared the crossing.

Regardless of detection loops, train detection circuits beyond the crossing will detect that the train has cleared the crossing and allow the gates to rise to their normal vertical position so the highway grade crossing can be accessed by motorists and pedestrians once again.

The Gate Mechanism

As stated earlier, crossing gates are comprised of gate arms which are lowered to prevent a motorist access to the railroad crossing in front of an oncoming train. The gate mechanism, as seen in Figure 17, is responsible for lowering and raising the gate arm.

A gate mechanism has a DC motor, a gear train to transfer power from motor to gate arm, a buffer to prevent the gate from slamming into the housing at its end of rotational operation, a snubbing circuit to slow the gate down during descent/ascent before it hits bottom or top, an over-speed circuit to prevent the gate from moving too fast, and an electric or mechanical brake to lock the gate's drive train at the vertical position. The gate is counter weighted so that the gate arm side is heavy, as seen in Figure 18.

Figure 17 Gate Mechanism at a Highway Grade Crossing

Figure 18 Gate Arm Counterweight

When the gate is to be brought down, the brake is de-energized and the motor is powered down from a vertical 90° to about 45°. At 45°, the motor power is cut and the moving mass will coast to the horizontal position or 0°. At all times when the brake is de-energized and there is

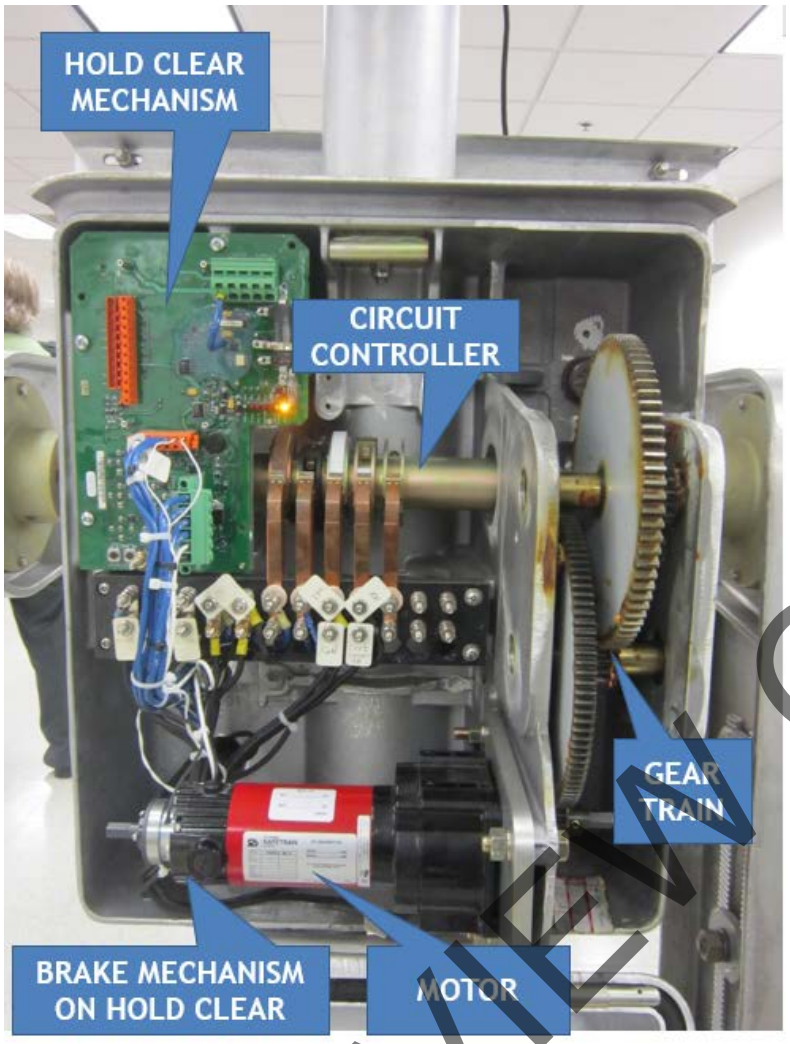

Figure 20 Safetran S60 Gate Mechanism Circa Approximately 2005

Sometimes a **wind bracket,** or *wind guard,* is incorporated to limit the lateral movement of the gate arm's upright position in the event of high winds when the crossing is clear. The bracket or guard will help prevent the arm or shear pin from breaking and from hanging up in branches or overhead wires . Wind brackets are attached to the mast and are typically used with longer gate arms.

Adjunct Warning Devices and Equipment

Other devices that can sometimes be part of a highway grade crossing system include data recording devices, active "No Left" or "No Right" turn signals, advanced warning signs, and pavement markings. **Data recording devices** record the crossing signal events at the highway grade crossing and can be useful in the event of an accident. **Active "No Left"** or **"No Right" turn signals**, as seen in Figure 21, warn motorists not to make turns and are intended to keep vehicles from turning into an activated crossing. A "Second Train" approaching signal can be used at a highway crossing next to a railroad station, to provide a specific warning that a second train is coming.

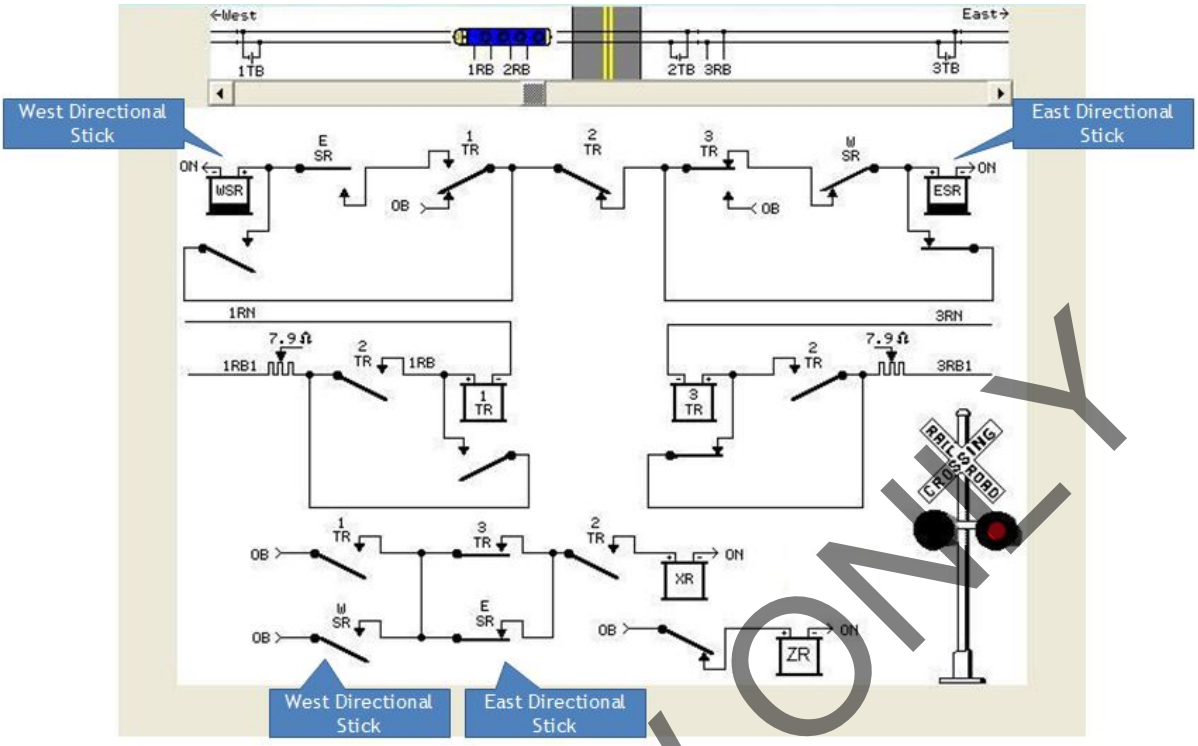

Figure 24 Highway Grade Crossing Electrical Diagram Showing Directional Stick Circuits

Understanding the Highway Grade Crossing Sequence of Operation and a Directional Stick Circuit

Given the earlier mentioned crossing train detection circuits and directional stick circuits, let's explore an example sequence of operation of a highway grade crossing with the passage of a train.

Table 1 Sequence of Operation Nomenclature

Sequence of Operation Nomenclature	
TB	Transmit Battery Wires
RB	Relay Receive Wires
TR	Track Relay
ESR	East Stick Relay
WSR	West Stick Relay
XR	Crossing Relay
ZR	Flasher Relay

Figure 25 is a highway grade crossing electrical diagram showing a track with a train nearing but has not entered the crossing and is not quite to the first approach circuit indicated by 1TB on the track layout. The track relays (1TR, 2TR, 3TR) are up, and the directional stick relays (west stick relay or WSR and east stick relay or ESR) are down.

1-7 SUMMARY

Highway grade crossings are a critical part of signaling in rail operations. Because highway grade crossings involve not only rail operations but also highway and/or pedestrian crossings, other regulatory agencies are involved in this area of signaling. Warning system devices are provided at highway grade crossings to alert motorist and pedestrians of oncoming train. Some of these devices are passive meaning they are fixed and not train activated. Other warning system devices are active with their operation dependent on signals from train detection circuits. A warning system malfunction occurs in the event the highway grade crossing circuits are not activated as intended. In some cases, highway grade crossings exist in close proximity to highway traffic-controlled intersections in which case traffic signal preemption is required.

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