Introduction to Railway Signaling and Electromagnetic Interference

An Online Continuing Education Course for Engineers

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Introduction to Railway Signaling and Electromagnetic Interference

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INTRODUCTION

Purpose of this Course

A contractor or an engineer at a utility that might encroach on a railroad right-of-way or possibly affect sensitive signal equipment should spend a little time to become somewhat familiar with the many unique features of railroad operation. Knowledge of general rules for safety and conduct on railroad property, as well as a little familiarity with railroad jargon, saves a lot of explanation time by the railroad personnel and might avoid embarrassment or even endangerment of the visitor.

Railroad signal systems can be split into two major areas:

- The **wayside signal system** controls and protects trains and equipment moving upon the tracks. It will consist of colored light control signals along the track, control displays in the locomotive cab, or both. The signals and displays inform the train engineer of track conditions so he can safely stop his train before running into any hazards. Wayside signals must detect trains and equipment blocking the track, position of track switch points that might be open or thrown the wrong direction, broken rails, and many other hazards for which detectors might be devised, such as high water or rock slides. It can take up to four miles to stop a train, which is far beyond visibility in bad weather or curved track, so the engineer is totally dependent on the wayside signals to keep his train safe.
  Lesser-used tracks with lower speed limits often will not have wayside signals (**dark territory**). Rules and radio permits control trains in such areas. There is none of the complex electronic track and control equipment that is present on signaled territory, but crossing warning equipment can still be present.

- **Highway Crossing Warning signal systems** provide a warning of approaching trains to the public who might be crossing the tracks at roads or pedestrian walkways. They are installed on nearly all public crossings and most private and industrial crossings.

Highway crossing warning systems and wayside signal systems will often both exist on the same track. Both types of signal systems use some form of **track circuit** to detect the position of trains. Due to their longer length and ability to carry signal information between signal locations, DC or Coded DC track circuits are generally used for wayside signal train detection. Since track circuits for crossing train approach detection are comparatively shorter, audio frequency overlay (AFO) systems are used. Use of AFO for crossings also makes it easier to overlay the train detection track circuits for crossings on top of the DC track circuits used for wayside signals.

Signal equipment for both wayside and crossing signals is housed in the same kind of cases and bungalows. In fact, often, wayside and crossing warning equipment will be in the same housing. All signal equipment has power systems that are backed up by a rechargeable battery.

Generally, the track circuits used for wayside signals will be far less susceptible to electromagnetic interference (EMI) from nearby power transmission systems. They are basically "go- "no-go" systems that only have to detect the presence of a train. The more sophisticated highway approach track detection systems not only detect the presence of a train, but also its speed and distance from the crossing. This requires much analysis of the track circuit information and is very susceptible to outside voltages that might confuse the safety monitoring circuitry and cause false crossing activations.

Interruption of wayside signal operation will result in expensive maintainer calls regardless of time or weather. Worse, sudden red signals can cause emergency stops that can damage equipment or even derail trains. In high train density territories, since there is only one route for train traffic, even short train delays can result in several trains being "stacked" behind each other. Disruption of the normally smooth dispatcher operation can result in trains being delayed for hours.

Cooperation of railroad signal forces will be greater if they feel that utilities or contractors that could adversely affect their vital signal system appreciate the need to protect the systems as much as possible. Like knowing some of the language and rules of a foreign country, understanding some of the rules of operation, as well as the technical and political influences that railroads constantly deal with facilitate smooth relations with the railroad and assures mutual respect between the visitor and the railway personnel.

Learning Objectives in this Course

- Overview of railroad associations and regulating agencies
- Introduction to basic railroad terms and nomenclature.
- Introduction to the basics of railroad wayside and crossing signals
- Basics of signal equipment housings and bungalows
- Basics of electronically coded track circuits
- Fundamentals of railroad cab signals
- Problems with electromagnetic interference (EMI) from power lines
- Basics of railroad grade crossing signal systems
- Grade crossing signal operation failures and false activations
- A standard railroad crossing layout
- Train detection systems for crossing protection
- Calculating crossing warning times, including equipment activation and span times
- Determining the proper approach warning distance
- Operation of standard DC track circuits
- Design and operation of style C, ring 10, and AC/DC track circuits
- Susceptibility to EMI of style C track circuits

- Operation of three section crossing protection
- Audio frequency overlay (AFO) track circuits
- Use of joint couplers and tuned joint couplers
- Susceptibility of AFO to EMI
- Basic introduction to motion detectors (MDS), phase motion detectors (PMD's)
- Constant warning time detection (CWT) equipment
- Hazards of EMI to railroad personnel

RAILROAD ASSOCIATIONS AND REGULATING AGENCIES

Like most large companies, Railroads have Regulating Agencies and Associations. Since railroad signal engineers will often reference these, anyone working around railroads should know a little about them.

The Department of Transportation (DOT) was established in 1966 to regulate the movement of passengers and goods by air, sea, river, highway, and rail. More information may be obtained at their website at DOT.gov.

The DOT branch that regulates railroads is the Federal Railway Administration (FRA). It contains eight regions manned by dozens of signal inspectors who are responsible for assuring that the railroads maintain safe practices and adhere to the Code of Federal Regulations (CFR). Two CFR sections apply only to signal systems. **Section 233 contains rules for reports of required periodic testing of signal systems and reporting of failures. Section 234 contains regulations for the installation and testing of grade crossing signal systems to assure proper operation of warning systems** and the safety of the public where highways and railroads meet. For more information, check their site at FRA.DOT.gov.

The **Association of American Railroads (AAR)** focuses on safety, technology, and policy. It is the leading professional organization for the North American freight railroad industry and sets standards and collects data on major freight railroads to improve efficiency, security, and operations. The AAR represents the railroad industry in Washington, D.C., working with policymakers and regulators. The members of the AAR cover nearly 140,000 miles of freight rail lines.

The American Railway Engineering and Maintenance-of-Way Association (AREMA) is a professional organization for railway engineering personnel in North America. It has taken over from the AAR the development and publishing of recommended standards for railway infrastructure design, construction, and maintenance. AREMA fosters industry and technical knowledge for its nearly 6,000 members. AREMA produces the *Manual for Railway Engineering* and the *Portfolio of Trackwork Plans*, which serve as industry standards. AREMA has many technical committees that cover all areas of railroading, including signals. The committees are comprised of experts who focus on topics like track structures, signals, and communication to advance industry standards. The organization hosts an annual conference and expo, offering professional development, networking, and educational resources, as well as a format for the railroad industry to present its latest products. The AREMA Educational Foundation also provides scholarships and supports university student chapters to foster the next generation of railway engineers.

BASIC RAILROAD NOMENCLATURE

Some general terminology referring to direction, location, and operation should be understood:
Major railroads have 20,000 miles or more of track obtained through mergers with numerous different railroads. The many different routes, often paralleling each other, can be confusing. To help define different locations, railroads are broken up into **Divisions** that generally contain several **Subdivisions**. Sometimes, larger **Territories** or **Areas** will contain several Divisions. Most Divisions and Sub Divisions are named after prominent terminals or cities within them. Since one railroad can have several different routes between the same terminals, care must be taken to ensure the correct subdivision is being referenced when talking about a location. If possible, obtain a copy of the proper page of the railroad timetable that refers to the area where work is to be done.

All tracks are either **Eastbound/Westbound** or **Northbound/Southbound**. The directions refer to the terminal destinations at each end of the route or territory, not the compass direction of the track. Railroads wind through hilly country to find the most even grade. There might be places where the trains actually travel east on the westbound track before curving around and continuing west. This can be very confusing when discussing track location compared to powerline routes. Sometimes **Eastward** rather than Eastbound will be used, and the same with the other directions. Both “bound” and “ward” mean the same thing.

Railroads locate everything by **mileposts** similar to the interstate system. When providing information on work locations, be sure to determine the milepost locations on the railroad. Generally, if a highway crossing common to both the railroad and a paralleling powerline can be located and a powerline station measurement to the road is provided, the railroad can accurately determine the milepost of the crossing and determine the position of powerline towers and substations relative to their tracks. Due to the difficulty of converting stations on power lines or other facilities to mileposts on the railroad, maps showing locations of the facilities in relation to the railroad and other streets or landmarks are very useful.

Railroad Terms and Definitions

The railroad industry has been around for nearly two centuries. Naturally, a lot of jargon has evolved to provide nomenclature for the specialized equipment and operations involving railroads and signal systems. A little knowledge of railroad terminology will go a long way toward helping a utility engineer understand instructions or information being supplied by railroad signal personnel.

When words that are railroad terminology are introduced in the lessons, they will usually be in **boldface.** Most of the terms are explained in the listing of terms and definitions below.

Entire books have been filled with railroad jargon and definitions. Only the most basic terms that might be necessary to utility engineers are furnished below. It isn't necessary to try to understand those that seem confusing since they will be further explained later in this course. Most terms are fairly straightforward, however, and briefly becoming familiar with them will help you understand the course material.

ADVANCE PREEMPTION TIME (Aka Preempt): At highway crossings near a traffic intersection with traffic lights (separate from railroad crossing), notification of an approaching train is forwarded to the highway traffic signal control equipment by railroad equipment for a period of time prior to activating the railroad active warning devices. During the preemption time, the traffic signals controlling vehicle traffic moving toward the railroad crossing are turned red. They are held red long enough to allow vehicles to clear the area of the crossing before the warning lights flash, and gates are activated. Preemption time is the difference between the Maximum Preemption Time required for highway traffic signal operation to allow vehicles to clear the crossing and the Minimum Warning Time needed for the protection of vehicles.

APPROACH CIRCUIT (crossing signals): A train detection track circuit used to provide initial activation of a highway-rail grade crossing warning system.

BALLAST LEAKAGE CURRENT: The leakage current from one rail of a track circuit to the other through the ballast, ties, etc.

BALLAST RESISTANCE (See also: LEAKAGE CURRENT): The resistance offered by the ballast, ties, etc., to the flow of leakage current from one rail of a track circuit to the other. Generally, the ballast resistance is low when the ballast is wet or filled with dirt. Ballast resistance is high if the ties and ballast are new and have excellent drainage, or is very dry or frozen.

BLOCK: A length of track of defined limits, the use of which by trains and engines is governed by block signals, cab signals, or both. The term "block" might refer to the track between two signals or a longer track section between two sidings or control points that might contain several intermediate signals.

BUNGALOW (See SIGNAL ENCLOSURE)

CASE (See SIGNAL ENCLOSURE)

CHOKE COIL: An inductor used commonly in connection with signal lightning arresters. It is also used in series with track batteries to prevent shorting Audio Frequencies in areas where Audio Overlay track circuits and DC track circuits are overlapping.

CONDENSER: A common term for CAPACITOR, which is basically a very short-term storage device, like a very small battery.

CONSTANT WARNING TIME DEVICE or CWT (See also: MOTION SENSITIVE DEVICE): A device used as a part of a highway-rail grade crossing warning system to provide a relatively uniform warning time despite variations in train speed.

DARK TERRITORY: Areas of track that co[illegible] etection or control other than at highway crossings. (Colloquial)

FAIL-SAFE (Se[illegible] ay signaling design principle, the objective of w[illegible] a component or system.

FAILURE: A ter[illegible] nction.

FALSE ACTIVAT[illegible] ning system in response to a condition that re[illegible] in the control or track circuit. This is a safe failu[illegible] is required by failsafe design techniques. How[illegible] f the warning devices, which can result in the p[illegible]

FOREIGN CURREN[illegible] ect a signaling system, but which is not a par[illegible] l will generally use when referring to inductiv[illegible]

HIGHWAY-RAIL GRA[illegible] g of a highway with a railroad track at the same elevation.

HIGHWAY-RAIL GRADE CROSSING GATE: A device that forms part of a Highway-Rail Grade Crossing Warning System that provides a visual warning and blocks a portion of the highway approaching the railroad track.

HIGHWAY-RAIL GRADE CROSSING SIGN (CROSSBUCKS): A passive sign located at a railroad-highway crossing at grade to warn highway traffic to look for approaching trains.

HIGHWAY-RAIL GRADE CROSSING SIGNAL [See also: SIGNAL (Application, Flashing-Light)]: That part of a Highway-Rail Grade Crossing Warning System used at the crossing to provide visual warning to highway traffic.