Broken Rail Detection in Non-Signaled Territory

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Abstract

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BNSF has tested and installed three different systems for detection of broken rail in non-signaled territory. While the underlying coded track circuit methodology is the same as a conventional signal circuit, the application of circuit status by annunciation, or indication to the dispatch system and ETMS differs. Insulated joint placement, types of circuits, lengths of circuits, and potential migration to interoperable PTC are discussed for considerations in installing new broken rail detection systems.
Introduction

BNSF has tested and installed three related systems for detection of broken rail in non-signaled territory. Today I’ll talk about the previous paper on Broken Rail Detection Sleep Mode which was connected to our Electronic Train Management System (ETMS), a talker and voice reporting broken rail detection system, and a Track Integrity Warning System which is connected to our dispatch system and reports to ETMS equipped locomotives.

While the underlying coded track circuit methodology is the same as a conventional signal circuit, the application of circuit status by annunciation, or indication to the dispatch system and ETMS differs. I’ll talk about insulated joint placement, types of circuits, lengths of circuits, and potential migration to interoperable PTC for considerations in installing new broken rail detection systems.
ETMS and Broken Rail Detection

In 2004 Ray Franke with Ansaldo (US&S) and I presented a Broken Rail Detection Sleep Mode paper to this forum. This paper described how a Microlok II unit using Microtrax circuits were connected via data radio to ETMS in 2003 to provide broken rail detection in Track Warrant, non-signaled territory. As a locomotive approached the circuit, circuit statuses were sent to ETMS equipped locomotives. These statuses were treated as a hazard detector in the on-board system. If the circuit was down, the on-board computer enforced restricted speed over the circuit.

Since that time BNSF has implemented other broken rail detection systems. One system is a talker and voice radio based system, and another is a Track Integrity Warning System (TIWS) that reports to on-board ETMS and includes an updated Track Warrant dispatching interface.
Talker and Voice Reporting System

Later in 2004 BNSF started directional running using two subdivisions to improve capacity. One of the subdivisions, the Boise City Subdivision had 235 miles of non-signaled Track Warrant control. Due to concerns about increased traffic and the number of broken rails on this subdivision, track supervisors were hi-railing ahead of many trains on this subdivision.

This subdivision was not scheduled for a built out of data radio coverage for Hi-Rail Compliance System (HLCS), so it was decided to install long broken rail detection circuits and indicate the circuit status to the train crews using voice reporting. For this subdivision, the sole goal of this implementation was to report broken rail on the main track, and thus, switch and fouling status was not included in its implementation.
Transducers, Flashing Light

This implementation utilized a combination of dc track circuits and Microtrax circuits broken into Zones that varied in length from 4,500’ to nearly 27,000’. The variation in circuit length was caused by trying to match existing joints, avoid installing insulated joints in existing bidirectional crossing approaches, and trying to match certain end of a siding locations. The locations use solar or ac power to charge the battery for the Microlok ILoc unit, STC talker, and Kenwood voice radio units.
The broken rail detection systems check the rail for continuity and report track integrity status, on an **exception only** basis. The exception only basis was used to limit congestion on the voice radio system. The units report the Zone Down for a broken rail or main line track section occupied and Zone signs are located at the beginning of each Zone.
ILOK, STC Talker, Kenwood Radio

Individual subdivision instructions identify:

- Zone Locations
- Recall code for each end of the Zone
- Crew actions to be taken when a track integrity message is received
Track Panels and Solar Regulator

Track Integrity Radio Message

Since this system was set up as “Exception Reporting”, locations only transmit a Zone status message when a Zone is "Down". In the example below there will not be a radio transmission as the train enters Zone 5 because Zone 5 and Zone 6 circuits are up.
When approaching a track section ahead of a track section that has a broken rail or is occupied, the following message will be reported:

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BNSF Milepost xxxx.x.
Zone 6 integrity Down.
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When approaching the track section that has a broken rail or is occupied, an indicator on the equipment housing at the Zone sign will flash white as a train approaches and passes. The following message will also be reported as the train passes the equipment housing:

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BNSF Milepost xxxx.x
Zone 6 integrity down
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When entering the main track and integrity status is needed, a location can be called for current status using the recall code. The message will give the current status of track integrity on both sides of the location and report integrity Ok or Down. The call code for the location monitoring Zone 5 and Zone 6 would be entered in advance of occupying main track. The following message will be reported after entering the call code:
This talker and voice reporting system has detected and reported numerous broken rails since its installation.
Track Integrity Warning System

The third system installed is on BNSF’s Hettinger Subdivision. An ice storm severely damaged the existing poleline and an application was submitted to the FRA to remove ABS on this Subdivision. A waiver was granted to remove the ABS based on the number of trains running over the Subdivision at the time. Subsequently traffic changed and the FRA requested the ABS be reinstalled. BNSF asked if an alternate system could be installed that would build toward implementation of ETMS. An application was made and subsequently a waiver was granted for installation of a Track Integrity Warning System (TIWS) and Switch Position Monitoring System (SPMS), both of which have indications into the BNSF dispatch system and indicate to ETMS equipped locomotives.

Circuit Layout

In the diagram below the track is shown as a single line with vertical lines indicating the location of insulated joints defining the limits of broken rail detection circuits. The broken rail detection circuits are set up so meets can be made without fouling the circuit between ends of siding. These circuits were installed without an OS; but with separately indicated turnout track circuits. With this installation, the dispatcher is able to give a Track Warrant to a train heading eastbound in between the switches on the main track, while a westbound is heading into the siding.
The switch circuit controllers indicate to the dispatch system along with broken rail detection circuits. On the dispatcher screen the track circuit splits are shown with wider break points and labeled with the milepost when not at an end of siding.

Each broken rail detection circuit has the ability to report to the dispatch system from both ends and there are 38 broken rail detection circuits in this installation.

As the status of each broken rail detection circuit changes, there are two messages sent to the dispatcher, one from each end of the circuit.
The broken rail detection circuits are constantly active so detection and correction of the broken rail or circuit anomaly (broken bond, short, etc.) are indicated to the dispatcher and proactively corrected instead of waiting for a train to pass a signal as would happen in an ABS system.

The track occupancy or broken rail indications and switch indications to the dispatching system are checked by the track warrant system before issuing a track warrant. The dispatching system implements a restricted speed, speed restriction over the circuit for any non-indicating or down circuits. The track warrant system alarms if there is loss of communication or a circuit down ahead of the train within its track warrant. Once the track warrant has been issued, the track warrant system does not alarm on consecutive (normal train move) indications from the circuits.

This system is also being installed on BNSF’s Avard Subdivision.
Type of Circuits

There are several types of circuits that can be used for broken rail detection. The most common are:

- DC Track Circuits
- Coded Track Circuits
- Coded Audio Overlays

DC track circuits can be either end fed or center fed with end fed circuits up to about 9,000’ long and center fed circuits up to about 16,000’ long. To obtain this length, the specific source voltage, limiting resistors at each end, lead type and length, ballast resistance, and specific relays used in the circuit are important to reliable operation. Relays of the same resistance value do not necessarily give the same performance. High drop away current values on relays are critical for longer circuits, if you need long circuits. Relay manufacturers (Safetran, Alstom, and Ansaldo) can help with appropriate track circuit lengths for their various relays.

Coded track circuits such as Electro Code or Microtrax can be used. These circuits provide long distances, but like dc track circuits, the lead type and length, ballast resistance, and specific type of circuit are important to reliable operation. One
advantage of coded track circuits is they can be setup in a bidirectional fashion. This allows the same information for the circuit to be transmitted from either end and allows the transmitting radio to be closer to the locomotive potentially providing a more reliable communication path.

Another type of circuit is coded audio overlay. These overlays can be setup with or without insulated joints; but when installed without joints, finite circuit limits may be difficult to establish due to the frequency transmitting in both directions and not being cutoff by the insulated joints. These types of circuits are typically single ended and will require a greater coverage area by the data radio system.

Manufacturers are continuing to work on other types of circuits that will eliminate the need for insulated joints.
PTC and Broken Rail Detection

The new PTC rules have specific requirements for inclusion of broken rail detection.

Under § 236.0(c), by January 15, 2012, freight trains operating at or above 50 miles per hour, and passenger trains operating at or above 60 miles per hour, are required to have a block signal system unless a PTC system meeting the requirements is installed.

One of the rules covering this is the following:

§ 236.1007 Additional requirements for high-speed service.

(a) A PTC railroad that conducts a passenger operation at or greater than 60 miles per hour or a freight operation at or greater than 50 miles per hour shall have installed a PTC system including or working in concert with technology that includes all of the safety-critical functional attributes of a block signal system meeting the requirements of this part, including appropriate fouling circuits and broken rail detection (or equivalent safeguards).

(b) In addition to the…

Since current technology for block signal systems relies on track circuits—which also provide for broken rail detection—the final rule requires limiting speeds where broken rail detection is not available to the maximums allowed under the amended § 236.0 when a block signal system is not installed. The safety-critical functions of a block signal system include track circuits, which assist in broken
rail detection and unintended track occupancies (equipment rolling out), and fouling circuits, which can identify equipment that is intruding on the clearance envelope.

Another new rule is:

§ 236.1005 Requirements for Positive Train Control systems.
(a)(5) Limit the speed of passenger and freight trains to 59 miles per hour and 49 miles per hour, respectively, in areas without broken rail detection or equivalent safeguards.

This rule also addresses the issue of broken rails, which per the commentary in the Final Rule, is the leading cause of train derailments. FRA strictly limits the speed of passenger and freight operations in those areas where broken rail detection is not provided.

In addition to the new PTC rules, these circuits may also need to comply with rules such as §236.51 Track circuit requirements and §236.56 Shunting sensitivity.

While BNSF is not planning on running over 59/49 on the above subdivisions, the three broken rail detection equipped territories will be modified with appropriate processors and radios to make them interoperable PTC capable.
Closing

BNSF has been proactively working with the FRA and industry, installing and testing technology like ETMS and Broken Rail Detection, Switch Point Monitoring Systems, a Talker and Voice Reporting System, and Track Integrity Warning Systems that will move not only BNSF but the industry forward.

While the underlying coded track circuit methodology is the same as a conventional signal circuit, the application of circuit status by annunciation, or indication to the dispatch system and ETMS differed. Insulated joint placement, types of circuits, lengths of circuits, and implementation for interoperable PTC are all considerations in installing new broken rail detection systems.
References


