

Development of Recommended Practices for Audio Frequency Track Circuits

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Points of Discussion

- Getting Consensus
- Understanding the Challenges
- Defining an Approach to Incident Discovery
- A Complete Answer
- Questions

Getting Consensus

- The first meeting was initiated by recommendations from the National Transportation Safety Board (NTSB) and Federal Transit Administration (FTA)
 - Funded by grants from Transit Cooperative Research Program (TCRP)
 - Assisted by American Public Transportation Association (APTA), TCRP, and FTA.
- The meeting focused on getting consensus for NTSB/FTA recommendations from:
 - Signal Systems Managers and Operators.
 - Manufacturers.
- Their Defined Needs are Recommended Standards for:
 - Phase I Maintenance and Operation of Audio Frequency Track Circuits (AFTC).
 - Phase II Software Based Maintenance & Operations Tools for AFTC.
- Recommended Standards Program funded by APTA is currently in the first phase of the development process.

Understanding the Challenges of Audio Frequency Track Circuits

- Modern audio frequency train control systems have been in existence since the mid-1960's and manufactured by several vendors.
- The manufactured product includes a number of generations each with significant design changes & upgrades.
- Within the generational design changes there is also some number of variations in installation and design criteria.

Understanding the Challenges of Audio Frequency Track Circuits

- Major Variations in Audio Frequency Track Circuit Design
 - Analog Design
 - Secure Analog Transmissions.
 - Solid State Design.
 - Use of a 50% Duty Cycle.
 - Use of Dual Code Track and Train Transmission.
 - Use of Phase Synchronized Transmissions.
 - Next Generation Digital Design
 - Secure FSK Digital Transmissions.
 - Improvements in Quantity of Information Transmitted.
 - Microprocessor Based Design.
 - Enhanced Error Detection.

Understanding the Challenges of Audio Frequency Track Circuits

The design of a cost effective AFTC system includes tolerances under which the system can operate

- Out of tolerance issues that may affect the safe and reliable operation of track circuits:
 - Track systems design and maintenance.
 - Cable plant.
 - Rail vehicles design and maintenance.
 - Traction power systems design and maintenance.
 - System power supply irregularities.
 - Environmental electronic noise.

Understanding the Challenges of Audio Frequency Track Circuits

Manufacturers Failure Mode and Effects Analysis (FEMA) for AFTC Systems.

- Definition of Safety Failure.
 - Relay energized and track circuit shunted.
- Definition of Reliability Failure.
 - Any unintended safe state with the relay de-energized.
- **Detectable Failure**
 - **Any abnormal operation that would be recognizable to operations or maintenance personnel.**
- Undetectable Failure
 - Any failure having no effect on the observable operation of the item under test.

Understanding the Challenges of Audio Frequency Track Circuits

Definition of a Safety Failure During Failure Mode and Effects Analysis Process

- A failure that resulted in the track circuit energized while shunted with:
No other detectable abnormalities.
Designed to occur statistically once in
1,000,000,000 operations

Understanding the Challenges of Audio Frequency Track Circuits

For this discussion lets assume a detectable track circuit failure occurs twenty times per hour during AFTC system operation.

A detectable track circuit abnormality can potentially occur more than 20,000,000,000 during the safe design time frame.

Understanding the Challenges of Audio Frequency Track Circuits

The difference between a detectable abnormality caused by a reliability failure or a detectable abnormality caused by safety failure may not be easily defined. An example is a bobbing track circuits.

1. The great majority of these failures will be reliability problems. These types of failures will cause interruptions in operations but are a fail safe condition of the track circuit.
2. A much smaller number of failures will be intermittent loss of shunt safety problems. These failures, although detectable by an abnormality, will be unlikely to result in a safety related incident. However, these incidents should be responded to for maintenance action in a more timely manner than example one.
3. The least likely but still possible condition to occur may be a failure that could result in a safety related incident (a loss of shunt). Based on a FEMA analysis this type of incident is a detectable abnormality but needs to be properly diagnosed and flagged for immediate action.

Understanding the Challenges of Audio Frequency Track Circuits

- No matter the maintenance practice or aide the final determination of the issue and the response will always rely on the ability, empowerment, and training of the operations and maintenance staff.
- Issues of concern for a safe and reliable maintenance and operation of the transit system and associated recommended practices:
 - Understanding the criteria of a failure mode and affects analysis.
 - Accumulating of data.
 - Analyzing the data.
 - Prioritization of the failures.
 - Timely and effective response and repair.
 - Experience and training of responders.
 - Budget constraints.

Defining an Approach to Incident Discovery

- Determining Similarities With All Audio Frequency Track Circuits (AFTC)
 - First and foremost is the method of transmitting the intelligent **AUDIO FREQUENCY SIGNAL.**
 - All systems respond to the correct audio frequency carrier signal transmitted with a secure message.
 - All systems transmit a signal the length of the track circuit block where shunting identifies occupied track sections.
 - All systems work reliably within the systems and environmental standards defined in the original design.

Defining an Approach to Incident Discovery

- The current preferred common denominator for the transmission of unintended signals/conditions that will affect the safe and reliable operation of the track circuit is at the signal receive input to the track circuit module:
 - Known cases of unintended transmissions of sufficient amplitude to affect train operation have been detectable at the AFTC receiver input location.
 - Current Phase I review is initially focused on this location for development of techniques that investigate potential problems at regular intervals.

Defining an Approach to Incident Discovery

Concerns Phase I:

- Manufacturers definition and Authority understanding of AFTC detectable failure modes.
- Manpower availability and workload.
- Testing intervals.
- Training for operations and maintenance staff.
- Equipment needed for test procedure implementation.
- Elimination of outdated or ineffective maintenance Practices.

Future Phase II

- Authority, Railroad Infrastructure Capabilities (i.e. SCADA, Communications Backbone, Microprocessor Database).

Defining an Approach to Incident Discovery

- The approaches to discovery of AFTC incident discovery currently in review.
 - Initial macro review and analysis.
 - Investigate multiple train detection transmission characteristics of the AFTC system in the dynamic and static operating environment.

Defining an Approach to Incident Discovery

Methods in Review

- Current Phase I analysis of operating characteristics
 - Dynamic: With trains operation in track section under review.
 - Static: Without train in track section under review.
 - Methods and means to record and store data.
 - Documentation, data recording and analysis criteria.
- Future Phase II software based tool to assist in real time identification potential anomalies.

Defining an Approach to Incident Discovery

Goals Phase I

To detect during normal preventative maintenance programs abnormal conditions with the potential to affect the safe and reliable operation of Audio Frequency Track Circuits.

To review industry best practices and manufacturers recommendations to determine the methods and means to accumulate and record data with the purpose of proactive review and discovery by a central group of well trained and experienced employees.

Defining an Approach to Incident Discovery

Goals Phase II

To review industry practice to determine the needs and requirements to develop a recommended standard for a software based maintenance tool that can be used to assist operations and maintenance in the discovery and reaction to abnormal incidents that may affect the safe and reliable operation of track circuits.

A Complete Answer

Additional Concerns That No Track Circuit Maintenance Procedure Can Replace

- Is this an audio frequency track circuit problem?
- Signal systems are not just track circuits.
- Training of the operations and maintenance staff.
- Empowerment of the responding staff..
- Infrastructure and/or systems design and maintenance.
- Safety culture.



Questions