APTA STANDARDS DEVELOPMENT PROGRAM

STANDARD

American Public Transportation Association
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Rail Transit Signal & Communications Working Group

Standard for Audio Frequency Track Circuit Inspection and Maintenance

Abstract: This Standard offers requirements necessary to assure the safety and reliability of audio frequency track circuit systems.

Keywords: AF track circuit, audio frequency track circuit, HF track circuit, bond, impedance bond, signal, shunt, shunting device, track circuit

Summary: This standard provides Audio Frequency Track Circuit tests that verify train detection (shunting), and continued proper operation. These tests include recording the measured values for comparison over time to predict possible equipment deterioration. This standard also provides track circuit inspection requirements.

Scope & purpose: This standard provides minimum requirements for inspection and maintenance of:

1. Analog audio frequency track circuits
2. Digital audio frequency track circuits.
3. Training criteria for maintenance and operation.
4. Evaluation of adequate maintenance staff requirements for corrective and preventative maintenance

APTA has developed this Standard for use by any entity, public, or private, that regulates, inspects, designs, specifies, builds, maintains, and/or operates public transportation facilities

The purpose of this standard is to provide a commonly accepted industry approach to test, inspect, maintain and manage audio frequency (AF) track circuits to a state of good repair.

Participants

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Introduction

This introduction is not part of APTA RT-SC-S-009-03 Rev 1 *Standard for Audio Frequency Track Circuit Inspection and Maintenance.*

This Rail Standard represents a common viewpoint of those parties concerned with its provisions, namely, transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a rail transit system's operations. In those cases, the government regulations take precedence over this standard. APTA recognizes that for certain applications, the standards or practices, as implemented by individual rail transit agencies, may be more robust than those given in this document.

This standard should be reviewed with the manufacturers for conformance with their recommended test practices:

- Prior to implementation in new systems for each unique installation of the AFTC systems.
- To assure conformance with existing AFTC System installations.
- Before implementation of a unique application in an existing AFTC system.

Alternate practices

Individual transit systems may deviate from this standard to accommodate their specific equipment and mode of operation. APTA recognizes that some transit systems may have unique operating environments that make strict compliance with every provision of this standard impossible. As a result, certain transit systems may need to implement the practices herein in ways that are different from those this document prescribes. Transit systems may develop alternate practices to the APTA standards so long as the alternates are based on a safe operating history and are described and documented in the System Safety Program Plan (SSPP), or another document that is referenced in the SSPP.

Documentation of alternate practices shall:

a) Identify the specific deviation from APTA standards;
b) State how each of these requirements will be met;
c) Describe the alternate methods used;
d) Describe and substantiate how the alternate methods do not compromise safety and provide a level of safety equivalent to the practices in the APTA safety standard (operating histories or hazard analysis findings may be used to substantiate this claim).

Audio Frequency Track Circuit Inspection and Maintenance

1. AF Track Circuits Tests

1.1 General

The following tests are required for all audio frequency (both analog and digital) track circuits. When track circuits are initially commissioned and whenever modified they must be adjusted and recorded in accordance with the manufacturer's recommendations. Whenever a track circuit is adjusted all data recommended to be recorded by the manufacturer must be evaluated. At a minimum the track circuit transmit signal level, and the track circuit receive signal level (shunted and un-shunted) must be checked to establish a base line for evaluation and comparison during any following tests. These tests are not recommended for use with audio frequency overlay train detection systems.

The RTS should develop an audio frequency track circuit maintenance and inspection procedure. As a minimum, each track circuit shall be inspected as follows:

- Inspect the track circuit for an accumulation of debris. Remove and bag debris.
- Inspect wayside drains for blockage or ineffective drainage.
- Inspect the track circuit for damage caused by standing water, water leaks, or retention.
- Inspect the track circuit for any condition that may interfere with the operation of the equipment.
- Inspect impedance bond and loop layout cables, wiring, bonding, and hardware for defective insulation, rust, corrosion, missing components, damage and loose or broken connections.
- Inspect track circuit insulated joints, gauge plates and switch rods for bridging, broken or deteriorated insulation, metal shavings, loose or missing hardware.
- Inspect the track circuit room and/or enclosure equipment for damage, cracks, breaks, defective latches, locks, hinges, covers, and loose, deteriorated, or damaged conduit connections, and hardware. Holes and unused entrances not used for ventilation shall be sealed.
- Inspect polyvinyl chloride (PVC), fiberglass, rubber and other cable conduit material for damage, cracks, breaks, loose conduit connections, missing or loose components, and hardware.
- Ensure covers, doors, and locks are in place and secured.

1.2 Shunt Sensitivity Verification

CAUTION: When a track circuit has to be taken out of service adequate measures must be taken to safeguard train operations.

Prior to conducting the following tests:

- Measure and verify that the power supplies and power sources are within specified tolerances
- Verify that the shunting device(s) and associated resistors are approved for this use
- Verify that shunt values are as specified by the manufacturer

Periodically every track circuit must be tested to verify it is functioning properly and that it detects a shunt at the design specified value. Typically the design specified shunting value is between 0.06 ohms and 0.5 ohms. The selected value will be application specific.
The track circuit to be tested is verified to be indicating clear or un-occupied when not shunted. To verify that the track circuit detects the shunt, a shunting device of specified value (soft shunt) is placed across the transmitter track connections and the track circuit is verified to be indicating occupied. The shunted receiver voltage should be recorded for trend analysis. The shunting device is then connected to the rails at the midpoint of the track circuit and again the track circuit is verified as indicating occupied. The shunted receiver voltage should be recorded for trend analysis. The shunting device is then connected across the rails at the receiver location and the track circuit is verified as indicating occupied. The shunted receiver voltage should be recorded for trend analysis.

If during any of these tests the track circuit fails to indicate occupied or intermittently indicates un-occupied – occupied (bobs) the track circuit is in a failure condition. The track circuit must be immediately removed from service, inspected and tested as recommended by the manufacturer. Under these conditions the track circuit is considered in a state of failure with manual modes of operation deployed until repaired and retested.

The levels recorded during the soft shunt tests should be compared against the previous readings for trend analysis based on test intervals. If the receiver signal level is at any time more than 10% different from the value recorded at the last track circuit adjustment further test and evaluation of the track circuit will be required.

If the double hard shunt test in section 1.4 is performed at the same time as the shunt sensitivity test (section 1.2) the midpoint soft shunt test can be omitted. If the mid-point soft shunt test is omitted then historical data will not be available for comparison

Agencies may elect to only verify that the shunt at the midpoint causes the track circuit to show occupied and then perform the double shunt test of section 1.4 in place of that described in the above paragraph.

Every track circuit shall have this test completed once every 12 months or at the frequency specified by the manufacturer. Specified test intervals should be provided in written documentation or included in the OEM manuals.

If a problem is found with track circuit shunting and corrected, the track circuit should be retested within 3 months.

1.3 Un-shunted Tests

Periodically each track circuit must be tested to determine if component deterioration or track condition changes (ballast, bonding, connections, IJ deterioration, etc.) have caused signal level changes. This is better done by measuring the track circuit's un-shunted signal levels. This provides a signal level that is not affected by shunt placement or impedance.

Periodically the un-shunted transmitter and receiver signal levels of the track circuit shall be measured, recorded, and compared to the baseline values established when the track circuit was last adjusted. At a minimum, measure the track circuit transmitter and receiver signal levels when the track circuit is not occupied and compare the readings with those previously recorded.

If the data is ten percent or more outside the established baseline value, immediate steps must be taken to determine cause and make the necessary repairs.

Each time this test is conducted the data shall be recorded. This data can then be analyzed for trends and be used to predict future problems.

Each track circuit shall have this test completed once every 12 months or at the frequency recommended by the manufacturer. Specified test intervals should be provided in written documentation or included in the OEM manuals.

If a problem is found with a track circuit during this test and corrected, the track circuit should be retested within 3 months.

1.4 Unintended or Spurious Signal Test

The purpose of these tests is to verify that there are no unintended or spurious signals entering the receiver after it has been shunted and isolated from the normal transmitter that could potentially result in a false un-occupancy indication. The test will be used to measure and analyze the signal on the receiver when the transmit signal is shunted. The recommended test is the double hard shunt test as described below. Alternate methods may be used as specified by the manufacturer.

The double shunt test requires that two hard shunts be placed centered on the midpoint of the track circuit approximately 75 feet apart. For track circuits 225 feet or less in length the hard shunts should be placed at approximately the 1/3 and 2/3 points. This configuration effectively eliminates signals in the rail from being the source of the receiver signals. If, with the double shunt, receiver levels are measured above the manufacturers recommend levels (specified levels should be provided in written documentation or included in the OEM manuals) operational protection must be immediately provided. The track circuit must be inspected and tested to determine the source or cause of the spurious signal. The operational protection must be maintained until the spurious signal is eliminated, reduced to an acceptable level, or verified to not affect the track circuit's ability to detect trains.

1.5 Cab Signal Levels

The cab signal transmit level and entering end rail currents or associated voltages shall be measured in accordance with the manufacturer's recommendations. The levels must be recorded when initially installed and whenever readjusted to provide baseline inputs. Signal levels measured at subsequent tests should be compared with the baseline inputs. If the change is outside the ranges specified by the manufacturer immediate steps shall be taken to investigate and repair. These levels shall be recorded at each subsequent test and be analyzed to determine trends and possibly predict future problems.

Each track circuit shall have this test completed once every 12 months or at the frequency recommended by the manufacturer. Specified test intervals should be provided in written documentation or included in the OEM manuals.

2. Training, Equipment & Safety

2.1 Training

The RTS and/or their maintenance contractors shall develop and execute training programs that provide employees with the knowledge and skills necessary to maintain the audio frequency track circuits that are operating on the Authority and to safely and effectively perform the tasks outlined in this recommend practice.

Training must be consistent with OEM's manuals and recommendations.

2.2 Test Equipment

The following tools are required for inspecting and maintaining audio frequency track circuits all test equipment should be procured in accordance with Manufacturers recommendations:

- Multi-meter*
- Oscilloscope*
- Frequency Counter*
- RTS- approved shunting devices
- RTS-approved portable radio
- Standard tools carried by maintenance personnel
- Additional tools as required by the test procedures, OEM, and/or RTS

* Calibrate in accordance with OEM and/or RTS requirements.

2.3 Materials

The materials required for inspecting, testing and maintaining audio frequency track circuits shall be as required by the OEM, test procedures, and/or RTS.

2.4 Personal Protective Equipment

Personal protective equipment, as required by the RTS, shall be worn at all times during inspection and maintenance.

2.5 Safety

It is recommended that the RTS have a System Safety Program Plan (SSPP). APTA will work with the RTS to develop an SSPP and will provide scheduled audit reviews at the request of the RTS as part of a Rail Safety Audit Program.

RTS safety rules, procedures, and practices shall be followed at all times.

Definitions

audio frequency track circuit: A device that may use audio frequency carrier(s) to transmit a vital signal to the train and uses audio frequency carrier (s) to detect the presence of a train within the limits of the track circuit.

automatic train control (ATC): The system for automatically controlling train movement, enforcing train safety, and directing train operations. ATC must include automatic train protection, and may include automatic train operation and/or automatic train supervision.

automatic train operation (ATO): The subsystem within the automatic train control system that performs any or all of the functions of speed regulation, programmed stopping, door control, performance level regulation, or other functions otherwise assigned to the train operator.

automatic train protection (ATP): The subsystem within the automatic train control system that maintains fail-safe protection against collisions, excessive speed, and other hazardous conditions through a combination of train detection, train separation, and interlocking.

automatic train supervision (ATS): The subsystem within the automatic train control system that monitors trains, adjusts the performance of individual trains to maintain schedules, and provides data to adjust service to minimize inconveniences otherwise caused by irregularities.

NOTE—The ATS subsystem also typically includes manual and automatic routing functions.

baseline measurements: Measurements which are taken when a track circuit is commissioned or readjusted after repair or modification.

fail-safe: A design philosophy applied to safety critical systems such that the result of hardware failure or the effect of software error shall either prohibit the system from assuming or maintaining an unsafe state, or shall cause the system to assume a state known to be safe

hazard: Any real or potential condition that can cause injury, death, or damage or loss of equipment or property.

impedance bond: A device of low resistance and low impedance to all frequencies to which it is not tuned, used with jointless audio frequency track circuits to couple inductively and confine the signaling energy to its own track circuit and equalize the return propulsion current between rails without impeding its flow.

interlocking: An arrangement of switch, lock, and signal devices that is located where rail tracks cross, join, separate, and so on. The devices are interconnected in such a way that their movements must succeed each other in a predefined order, thereby preventing opposing or conflicting train movements.

light rail transit: A mode of rail transit characterized by its ability to operate on exclusive rights-of-way, street running, and center reservation running, and to board and discharge passengers at track or vehicle floor level. It may or may not have grade crossings with rubber-tired vehicle roadways.

safety critical:
A term applied to a system or function, the correct performance of which is critical to safety of personnel and/or equipment. It is also a term applied to a system or function, the incorrect performance of which may result in a hazard.

NOTE: Vital functions are a subset of safety-critical functions.

self-revealing failure: Failures whose effects on system operation are immediately and clearly apparent.

service, revenue:
Transit service excluding deadheading or layovers.
Any service scheduled for passenger trips.

shunt: a device installed from one running rail to the other
Hard: Used to short circuit current between the transmitter and receiver of a track circuit.
Soft: Used to limit the current flow between transmitter and receiver by using a resister that represents the worst case shunting value of a train consist axel shunt

system safety: The application of engineering and management principles, criteria, and techniques to optimize all aspects of safety within the constraints of operational effectiveness, time, and cost throughout all phases of the system life cycle.

system safety program: The combined tasks and activities of system safety management and system safety engineering that enhance operational effectiveness by satisfying the system safety program plan and all safety requirements in a timely, cost effective manner throughout the system life cycle.

train: A consist of one or more basic operating units.

tuning unit: A device used to couple audio frequency transmission to the track.

vehicle: A land conveyance assembly for carrying or transporting people and objects capable of traversing a guideway, having structural integrity and general mechanical completeness, but not necessarily designed for independent operation.

vital function: A function in a safety critical system that is required to be implemented in a fail-safe manner.

Abbreviations and acronyms

APTA	American Public Transportation Association
ATC	automatic train control
ATO	automatic train operation
ATP	automatic train protection
ATS	automatic train supervision
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
NATSA	North American Transit Services Association
OEM	original equipment manufacturer

PPE personal protective equipment
RTS rail transit system
SSPP system safety program plan

Summary of Changes

1. Document formatted to the new APTA standard format.
2. Sections have been moved and renumbered.
3. Scope and summary moved to the front page.
4. Sections on definitions, abbreviations and acronyms moved to the rear of the document.
5. Two new sections added: 'Summary of document changes' and 'Document History'.
6. Some global changes were made to section headings and numberings and other cosmetic changes, such as capitalization, punctuation, spelling and grammar, and updating definitions.
7. The original document was written in 2003. Since then and with the experience of events, industry consensus deemed it necessary to develop a new standard by doing a major revamp of the old document. In doing so, it was found that there were too many changes to be documented, hence the reason why no specific point by point changes are shown.

Document History

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Rail Policy & Planning Approval	Publish Date
First published	Jun 10, 2003	-	-	Sept 28, 2003	Jan 28, 2004
First Revision	February 2014	April 2014	Sept 2014	December 11, 2014	December 31, 2014

Annex A (Informative)

Recommended additional support requirements

That manufacturers, designers and/or operators should meet regularly as necessary to define the rules, conditions, and constraints relevant to functional safety which need to be observed in the operation and maintenance of the track circuit equipment.

General topics which should be considered include:

- Identify maintenance and operation related assumptions used in Failure Mode and Effects Analysis
- Precautions in testing
- Rules and methods for maintenance and fault finding
- Periodic maintenance requirements and frequency
- Operational safety monitoring

It is recommended as part of contracts that manufacturers' be required to meet with operators and discuss issues of safety and reliability related to operation, test, and maintenance of AF track circuits. This should include documentation and estimated staffing requirements. This could be included in the training program.

It is recommended that manufacturers' issue Safety Notifications similar to the FRA requirements for any safety related issues with similar equipment operating at any Authority where that equipment may be installed.

It is recommended that manufacturers' review all generations of published material for audio frequency track circuit operation and identify test and adjustment differences between generations of equipment and where possible minimize differences, consolidate maintenance practices, and assure uniformity in maintenance procedures.

It is recommended that manufacturers' and operators discuss what test normally recommended by the manufacturers can be eliminated, added or reduced as a result of the tests in this document being performed.