APTA STANDARDS DEVELOPMENT PROGRAM

RAIL STANDARD

American Public Transportation Association
1666 K Street, NW, Washington, DC, 20006-1215

APTA RT-OP-S-006-03 Rev 2

First Revision: July 26, 2004

Second Revision: December 2012

Rail Transit Operating Practices Working Group

Rail Transit Signals Operating Rules

Abstract: This *Rail Standard* provides guidance for the development of rail transit system (RTS) operating rules pertaining to signals. It outlines the wide variety of signal systems and the requirements for rules pertaining to their operation.

Keywords: automatic block system, automatic train control, automatic train operation, automatic train protection, block, block signal, cab signal, call-on, fail safe, fail soft, signal indication, interlocking, permissive block, positive stop, restricted speed, signal, slow speed, timing signal, track car, vital function

Summary: This standard establishes requirements for rules governing rail transit signal systems. It was developed to help rail transit systems apply and utilize train control signal technology to enhance safe, efficient train operation through the application of rules and procedures. Development of clear, system-specific rules and procedures will enhance the safety of employees and the riding public while promoting the most effective use of RTS resources.

Scope and purpose: This standard addresses train control signals as they relate to rules for train operations and their applications in RTSs. This standard addresses operating rules related to fixed signals and signs that can be considered as part of the train control system. It also addresses operating rules related to traffic "bar" signals and other "informational" signals. This standard addresses practice for operating rules and procedures which relate to railway signals and signs associated with an operating rail transit system. As used in this standard, "signal" includes any device along the wayside that conveys operational information to the train operator and that originates in the system of train control utilized in the signal system, including on-board cab signal displays. Each RTS differs in operating characteristics, equipment design and environment; therefore, the RTS shall adapt this standard to its unique operating environment.

Participants

The American Public Transportation Association greatly appreciates the contributions of **William Bell**, **Amanda Nightingale**, **Gaynard Griffiths** and **Terry Mulcahy**, who provided the primary effort in the revising this *Rail Standard.*

At the time this standard was completed, the Rail Transit Standards Operating Practices Committee included the following members:

Charles Dziduch, *Chair*
Duane Sayers, *First Vice Chair*
David Murphy, *Second Vice Chair*

Tony Abdallah	Pat McBride
Ray Abraham	Harry McCall
Roy Aguilera	Pamela McCombe
Michael Avery	Pat McBride
William Bell	Harry McCall
Bill Capps	Bill McClellan
Brad Charkowske	Pat McWilliams
Jim Foley	Mark Miller
Gaynard Griffiths	Alan Miner
Larry Gaul	Terry Mulcahy
Scott Grott	Amanda Nightingale
Melvyn Henry	David Puglisi
Gary Howard	Greg Robinson
John Humphrey	Terry Spratt
Paul Jamieson	Russell Stone
Rich Krisak	John Squitieri
Jim Kelly	Debra Thacker
Lynetta Leeds	Tom Tupta
Stephen Lino	Denis Van Dyke
Reginald Mason	

Project consultants
Kenneth A. Korach,
Transportation Resource Associates, Inc.

Christopher Wallgren,
Transportation Resource Associates, Inc.

Project team
Charles Joseph,
American Public Transportation Authority

Contents

This introduction is not part of RT-S-OP-006-03 Second Revision January 2013 Rail Transit Signals Operating Rules

This standard represents a common viewpoint of those parties concerned with its provisions, namely transit operating/planning agencies, rail transit systems, manufacturers, consultants, engineers and general interest groups. The application of any standards or recommended practices 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 recommended practices, as implemented by individual rail transit systems, may be either more or less restrictive than those given in this document.

Note on alternate practices

Individual rail transit systems may modify the practices in this standard to accommodate their specific equipment and mode of operation. APTA recognizes that some rail transit systems may have unique operating environments that make strict compliance with every provision of this standard impractical. As a result, certain rail transit systems may need to implement alternatives to these standards and practices. A rail transit system may develop alternates to APTA standards so long as the alternates are based on a safe operating history and are described and documented in the system's safety program plan (or another document that is referenced in the system safety program plan).

Documentation of alternate practices shall:

- Identify the specific APTA rail transit safety standard requirements that cannot be met.
- State why each of these requirements cannot be met.
- Describe the alternate methods used.
- 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).

It must be noted that rail transit is not directly comparable to railroads (e.g. Amtrak, commuter, freight rail, etc). Rail transit systems differ greatly in the types of service, vehicles and technology employed, with some systems operating fully automated trains on exclusive rights-of-way and others operating on streets mixed with traffic. Rail transit demands a unique approach to solving its problems, and the APTA Rail Transit Standards Program was enacted to accomplish this complex task.

Rail Transit System (RTS) Signals Operating Rules

1. Objective

The objective of this standard is to attain a level of consistency between rail transit systems (RTS) and to achieve consistency in the concepts that support the operating rules.

This standard is not an attempt to establish uniformity among all RTSs in signal aspects, signal indications or related operating rules, nor is it intended to establish standards for the design of train control systems, or of elements of such systems, except where operating rules may be affected. Such a degree of standardization is neither desirable nor possible given the variations among rail transit systems in both train control technology and in operating philosophy.

2. Signal System

The primary purposes of a signal system on a rail system are:

- Train detection, to provide positive location of trains;
- Train separation, to protect a train from a collision with a train ahead operating on the same track;
- Train routing, to provide protection against conflicts and to verify safety of train movements at crossover locations or at interlockings; and
- Movement authority, to provide authority for the movement of trains on the right of way.

The secondary purposes of a signal system on a rail system may include:

- Positive stop enforcement;
- Broken rail detection; and
- Control of train speeds.

These are important concepts that have a strong impact on signal indications and on the implementation of associated rules.

2.1 Types of signals

Signals may be classified according to the source and nature of the information displayed. The RTS shall arrange portions of the operating rulebooks pertaining to signals according to the type and surety of information conveyed by the signal. This is particularly important when certain classes of signals are displayed by equipment designed according to fail-safe principles of design for train detection and location (e.g., train control system), and others are not (e.g., traffic bar signals). Thus, if a train or other rail vehicle cannot positively be detected and located by the train control system, it will require a separate category of rules to govern its movement. Such differentiation may be accomplished by numbering rules by series.

Types of signals include:

- Wayside signals;

- Cab signals;
- Traffic bar signals;
- Other fixed signals and signs governing speed, or that modify other signals

2.2 Train separation

The RTS shall develop and implement operating rules to work in conjunction with the signaling system to convey to the train operator the permission for movement and allowable maximum speed.

In locations with traffic bar signals, separation of trains along a route may be accomplished by one or more of the following methods; the one or more methods employed shall be reflected in the operating rules.

- Absolute block
- Manual block (Some RTS may refer to this as Permissive Block/Special Operations)
- Line of sight
- Timing devices or Control Center authorization

3. Train control

3.1 Types of train control systems

The RTS shall develop and implement rules that take into consideration the multiple types of control systems and their system application, including but not limited to the following:

- Automatic Block System (ABS)
- Automatic train operation (ATO), used on light rail and heavy rail. Multiple types and technologies of train control may be employed on a single RTS.
- Automatic train protection (ATP)
- Cab signal
- Communications based train control
- Line of sight

3.2 Interlocking and related systems

The RTS shall develop and implement rules that take into consideration interlocking and related systems.

Train control systems are also designed to manage train routing at junctions, crossings, movable bridges or other special locations. This may be accomplished through use of interlockings or by simple routing or switch position signals. The primary indication conveyed by interlocking signals is the safety of train movement. The signal system may also convey the following information:

- Normal route and condition of block ahead (for purposes of conveying train separation information);
- Diverging route, and condition of the block ahead;
- Third route, if such is available;
- Yard route, or other route into unsignaled territory; and
- Special cases/switch position indicator.

The route and aspect chart developed as part of the design of the train control system shall be the basis for development of operating rules and associated signals.

3.3 “Fail soft”

Within the fail-safe requirements associated with vital design principles, train control systems are generally configured to provide for limited movement of trains through fail-soft design. The RTS shall develop and implement operating rules that clearly delineate where such movement is at a level of safety that differs from that normally provided by the signal system. For example, if a wayside or cab signal system fails, the rules shall clearly define the remaining train movement capability and the level of protection that is provided by the train control under this alternate option. This shall also identify supplemental or alternate methods of protection, e.g., written train orders or verbal Control Center authorizations.

4. Rulebook content

RTS rulebooks shall contain an illustration representative of each aspect. See Section A.1 for an example of how to develop such illustrative charts. The RTS shall develop and implement rules associated with each aspect.

Examples of the following types of signals shall be identified and included in a rulebook, as appropriate to the individual RTS. They shall be identified and explained by category.

- End-of-track signals.
- Grade crossing signals. Special aspects may be displayed to the train operator to indicate status of crossing protection. In such cases, a rule shall govern train operation.
- Hand signals.
- Special fixed signs such as block limit signs and cab-signal cut-in signs.
- Special wayside signals and signs.
- Speed limit signals and signs.
- Traffic Bar Signals.
- Train Control, cab signals.
- Train Control, signs.
- Train Control, wayside signals.
- Work zone or slow zone signals.

4.1 Special rules

4.1.1 Non-Shunting Equipment

The RTS shall designate a special class of equipment in the rulebook for any equipment that operates on rail and is not positively detected by the train control system. Special rules that reflect the inability of the train control system to recognize the presence of and to regulate the movement of such equipment shall be included in the rulebook.

The RTS shall develop and implement special rules for the movement of equipment whenever any train detection fails. Such rules shall be consistent with the fail-safe principles incorporated in the train control design.

4.1.2 Movement past a stop signal

The RTS rules shall state a definitive procedure for movement past a stop signal. This procedure shall specify who is authorized to approve such movement and the method (written or verbal) by which such movement is accomplished. The RTS shall establish a protocol for documenting such approvals.

4.1.3 Timing signals

Certain types of signaling systems may be designed with timing circuits for speed control. The RTS may elect to develop a special aspect for the display of timing signals. When timing signals are used, the RTS shall develop and implement a rule regarding appropriate train operations for such signals.

4.1.4 Call-on signals

Special signals may be employed that require positive action by the train operator, train controller or both in order to display an aspect more favorable than stop under certain conditions. The RTS shall develop and implement a rule governing the usage of call-on signals.

4.1.5 Multiple aspects

On larger rail properties, cases may exist in which multiple aspects are utilized to convey an indication. While this is permissible, the RTS shall clearly delineate in the rulebook the aspects utilized for a particular indication. Under no circumstances shall a single aspect be used to convey more than one indication or rule.

4.1.6 Improperly displayed signals

Operating rules shall reflect the design philosophy associated with improperly displayed signals, specifically whether or not “light out” or “dark signal” protection is provided. Under no circumstances shall a rule be implemented or signals utilized that permit an improperly displayed signal to provide an indication that is more favorable than the actual condition.

4.2 Special issues for train control rules

When implementing portions of the operating rules pertaining to train control, the RTS shall address each of the following special conditions, as appropriate:

- Entry into street or other unsignaled territory and entry from unsignaled territory into signal controlled territory.
- Conflicting aspects between the cab signal and wayside signal, wayside signals and auto traffic signals, or the cab signal and the auto traffic signals.
- Movement of trains between ABS and cab signal territory.
- Freight operations, and other FRA interfaces (for non-FRA properties).
- Highway grade crossings.
- Movement of ATO equipment onto tracks where on-track protection is active

5. Definitions

absolute block: A block that no train is permitted to enter while it is occupied by another train.

automatic block system (ABS): A system of controlling train separation in which the signal aspects are activated by movement of trains into and out of blocks. The presence or absence of a train in a block is determined by a track circuit. If the circuitry fails, the signal shall display its most restrictive aspect.

automatic train control (ATC): A system that enforces speed restrictions and prevents exceeding speed restrictions by automatic brake applications; may additionally encompass automatic train operation, automatic train protection and automatic train supervision.

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

bar signal: An illuminated signal configured in the shape of a bar, normally positioned to appear in a vertical, angled or horizontal orientation. These are used as aspects to convey a signal indication. Bar signals are typically used on light rail transit systems.

block: A section of track of defined limits, the trains' entrance to which is governed by block signals and/or cab signals, or by verbal or written authority as prescribed by rule.

block signal: A fixed signal installed at the entrance to a block to govern trains entering and using that block.

cab signal: A signal in the train operator's cab that conveys either automatic block aspects or indicates the prevailing speed command, or both.

call-on: A signal aspect that requires the train operator to bring a train to a complete stop before proceeding into an occupied block at restricted speed.

fail safe: A design philosophy applied to safety-critical systems such that the result of a hardware failure or the effect of a 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.

fail soft: To fail in a manner that is consistent with fail-safe principles but that continues to provide some level of functionality. Under fail-soft conditions, vital functions are maintained, but at a lower or degraded level of functionality or operability. This includes a design using the concept of graceful degradation as part of the fail safe, in which the system is shut down through intermediate steps, all of which are fail safe.

interlocking: An arrangement of switches, locks and signal devices that is located where tracks cross, join or separate. 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.

maximum authorized speed: The maximum speed limit authorized over a defined track segment. Typically this is referred to as maximum permitted speed.

permissive block: A block that permits a train to enter while it is occupied by another train.

positive stop: The requirement that a train operator bring a train to a full and complete stop.

rail transit system (RTS): An organization that operates passenger train service and its supporting activities.

restricted speed: The allowable speed authorized, in conjunction with the line of sight rule in prescribed operating environments. This speed shall be defined in an RTS rulebook or standard operating procedure.

sign: A notice for giving directions or warning.

signal: A signal at a fixed location that indicates a condition that affects the movement of a train.

signal aspect: The appearance of a fixed signal conveying an indication as viewed from the direction of an approaching train. The appearance of a cab signal conveying an indication as viewed by the operator in the cab.

signal indication: The information conveyed by the aspect of a signal

slow speed: Speed developed by an individual RTS to temporarily reduce the speed of the train.

timing signal: A signal that controls train speed by requiring that a certain time elapse in an approach block.

track car: Any vehicle that operates on rail and that does not positively shunt track circuits.

train: A rail service vehicle such as any motorcar, locomotive, or other self-propelled on-track equipment, with or without cars coupled.

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

6. Abbreviations and acronyms

ABS	automatic block system
ATC	automatic train control
ATO	automatic train operation
ATP	automatic train protection
CBTC	communication-based train control
FRA	Federal Railroad Administration
RTS	rail transit system
SBD	safe braking distance

7. Summary of changes

a) Document formatted to a new APTA standard
b) Sections have been renumbered and moved around
c) Scope and summary moved to the front page
d) Updated Working Group membership list
e) Minor changes to spelling, capitalization and grammar
f) A note on alternate practices added
g) A new section *"Summary of Changes"* added
h) A new section *"Document History"* added
i) Definition section enlarged to incorporate new items and clarify some existing ones
j) Old Section 4 *"Types of Signals"* deleted and replaced with a new Section 2 *"Signal System"* which now explains the primary and secondary purposes of this system
k) Old Section 5 *"Train Control Systems and Related Signals"* deleted and replaced with a new Section 3 *"Train Control"* which includes among other items a new and more comprehensive sub-section on "Interlocking and Related Systems"
l) Annex A *"Information on Signal Systems for use in the Development of Signal Rules"* , major revisions made and in particular an expansion on Table 1 which separately discussed the three types of signals – wayside color light signals, wayside bar signals, and wayside interlocking signals

8. Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published	Dec 15, 2002	-	-	Jun 8, 2003	Jun 8, 2003
First revision	-	-	-	Jul 26, 2004	July 26, 2004
Second revision	Sept 11 & 12, 2012	4Q 2012	4Q 2012	4Q 2012	January 2013

Annex A (informative): Information on signal systems for use in the development of signal rules

A.1 Protocol for wayside signal aspects

Signal aspects used by RTS are varied and depend on the type of signaling system and their respective operating philosophies. While it is not possible to provide an exhaustive compendium of all types in current use, Tables 1, 2 and 3 attempt to describe some of the more typical aspects types, colors, and shapes of signals used in the transit industry. Therefore, this information is provided as a reference guide.

The RTS shall determine in its rulebook and other operating procedures the indication of each aspect and what specific actions should be taken by the train operator when encountering them.

Table 1
Wayside Color Signals for Train Separation

Signal Aspects	Indication	Actions by Train Operator
Red	Stop	Stop
Red with "Modifier" (Modifier may be an additional light or a flashing indication)	Stop & Proceed	Stop and proceed or proceed per rule when the condition of the block ahead is not certain. This could be an indication of a train ahead or a broken rail.
Green or Lunar	Proceed	Proceed at permitted speed
Yellow	Approach	Proceed at permitted speed prepared to stop at next signal

Note: Reference to color signals refers to circular or square wayside signal aspects for the purpose of distinguishing between these and bar signals.

Table 2
Wayside Bar Signals for Train Separation

Signal Aspect	Indication	Actions by Train Operator
Red Horizontal	Stop	Stop
Yellow or Amber Horizontal	Stop	Stop
Lunar Horizontal	Stop	Stop
Green Vertical	Proceed	Proceed at permitted speed
Lunar or White Vertical	Proceed	Proceed at permitted speed

Table 3
Wayside Interlocking Signals for Train Routing

Signal Aspects	Indication	Actions by Train Operator
Red / Red over Red	Stop	Stop
Red over Red with "Modifier" (Modifier may be an additional light or a flashing indication)	Stop Restricting or Call-On	Stop and call Control Center Proceed as prescribed by rule when condition of block ahead is not certain (generally proceed at restricted on-sight speed)
Lunar diagonal	Diverge	Proceed at speed prescribed by rule
Yellow	Diverge	Proceed at speed prescribed by rule
Yellow flashing	Diverge	Proceed at speed prescribed by rule
Red over Yellow	Diverge	Proceed at speed prescribed by rule
Red over Green	Diverge	Proceed at speed prescribed by rule

A.2 Signal Location Configuration

Train control signals convey information regarding conditions of one or more blocks ahead of a train. Such signals should be configured (such as with respect to signal location or indications) to keep trains at an interval no less than safe braking distance (SBD) at the following train's speed *unless* a special indication is provided. As an alternate, or as a supplement, this distance may also be enforced through engineered equipment, a combination of equipment and operator action, or solely through operator action as prescribed by the rules.

A.3 Advanced technology

As with all technology, train control systems have advanced and therefore require new operating rules to be implemented to incorporate these advances such as: Communication Based Train Control (CBTC) Systems or Positive Train Control (PTC).

The RTS should therefore consider developing operating rules for advanced technology train control such as:

- Train detection: The surety of train detection shall be reflected and rules shall be implemented for on-track equipment, "non-equipped" trains and other special vehicles.
- Commonality of indication and rules: Commonality and consistency of indications and rules with those based on conventional train control systems is desirable. This is particularly the case on rail transit systems that employ a mix of technologies.
- Fail soft design: Rules shall clearly delineate the modes of operation that are permissible under a partial or total failure of the train control system.

