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Rail Transit Signals Operating Rules and Procedures

Abstract: This standard provides guidance for the development of rail transit agency operating rules and procedures pertaining to signals and train control. 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, timing signal, non-shunting equipment, vital function.

Summary: This standard establishes requirements for operating rules and procedures governing rail transit signal systems. It was developed to help rail transit agencies apply and utilize train control signal technology to enhance safe, efficient train operation through the application of operating 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 rail transit agency resources.

Foreword

The American Public Transportation Association is a standards development organization in North America. The process of developing standards is managed by the APTA Standards Program's Standards Development Oversight Council (SDOC). These activities are carried out through several standards policy and planning committees that have been established to address specific transportation modes, safety and security requirements, interoperability, and other topics.

APTA used a consensus-based process to develop this document and its continued maintenance, which is detailed in the manual for the APTA Standards Program. This document was drafted in accordance with the approval criteria and editorial policy as described. Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

This document was prepared by the Operating Practices Working Group as directed by the Rail Standards Policy and Planning Committee.

This document represents a common viewpoint of those parties concerned with its provisions, namely transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. APTA standards are mandatory to the extent incorporated by an applicable statute or regulation. In some cases, federal and/or state regulations govern portions of a transit agency's operations. In cases where there is a conflict or contradiction between an applicable law or regulation and this document, consult with a legal adviser to determine which document takes precedence.

This document supersedes APTA RT-OP-SP-006-03, Rev. 3, which has been revised. Below is a summary of changes from the previous document version:

- Some global changes to section headings and numbering resulted when sections dealing with references and acronyms were moved to the end of the document.
- Changed references from "rail transit system (RTS)" to "rail transit agency."
- Global edits for grammar, syntax, clarity and consistency throughout the document.
- Expanded Section 2, "Signal system."
- Renamed Section 3.3 to "Fail-safe and fail-soft."
- Expanded Section 4, "Operating rulebook."
- Added Section 4.1.5, "Reverse-operation signals."
- Added Section 4.1.8, "Out-of-service signals."
- Added Section 4.1.10, "Temporary permission and authority methods for train movement."
- Added Section 4.1.11, "Train operations management during signal or train control failure mode."
- Added Section 4.1.12, "Rail operating employee responsibilities for reporting signal conditions."
- Added Section 4.1.13, "Hand signals."
- Added Section 4.1.14, "Wayside signage."
- Added Section 4.1.15, "Trip stops and penalty brake applications."
- Added Section 4.1.16, "Signal violation reporting."
- Added Section 4.1.17, "Station clearance indicators."
- Added Section 4.1.18, "Consideration for broken rail impacts on rail operations.
- Added Section 5, "Coordination with outside stakeholders."
- Added a diagonal signal aspect in Table 1.
- Edited A.3 for clarity.

Table of Contents

Foreword ii
Participants iv
Introduction v
Scope and purpose v
Note on alternate practices v

1. Objective 1

2. Signal system 1
2.1 Types of signals 1
2.2 Safe spacing of trains 2

3. Train control 2
3.1 Types of train control systems 2
3.2 Interlocking and related systems 3
3.3 Fail-safe and fail-soft 3

4. Operating rulebook 3
4.1 Additional rules and procedures 4
4.2 Requirements for other operating conditions 6

5. Coordination with outside stakeholders 6

6. Management of change 6

Related APTA standards 8
Definitions 8
Abbreviations and acronyms 10
Document history 10

Appendix A (informative): Information on signal systems for use in developing signal rules 11

List of Figures and Tables

TABLE 1 Wayside Color Signals[1] for Train Separation 11
TABLE 2 Wayside Bar Signals for Train Separation 12

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Introduction

This introduction is not part of APTA RT-OP-S-006-03, "Rail Transit Signals Operating Rules and Procedures."

APTA recommends the use of this document by:

- individuals or organizations that operate rail transit systems;
- individuals or organizations that contract with others for the operation of rail transit systems; and
- individuals or organizations that influence how rail transit systems are operated (including but not limited to consultants, designers and contractors).

Scope and purpose

This standard addresses train control signals as they relate to rules and procedures for train operations and their applications in rail transit agencies. Specifically, it addresses operating rules related to fixed signals and signs that can be considered as part of the train control system; operating rules related to traffic "bar" signals and other "informational" signals; and practice for operating rules and procedures that relate to railway signals and signs associated with an operating rail transit agency.

As used in this standard, "signal" includes but is not limited to any device along the wayside that conveys operational information to the train operator, including those that originate in the system of train control utilized in the signal system, including on-board cab signal displays; fixed and temporary wayside signage; and manually given signals from roadway workers. Each rail transit agency differs in operating characteristics, equipment design and environment; therefore, the rail transit agency shall adapt this standard to its unique operating environment.

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 impossible. As a result, certain rail transit systems may need to implement the standards and practices herein in ways that are more or less restrictive than this document prescribes. 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; and
- 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).

Rail Transit Signals Operating Rules and Procedures

1. Objective

The objective of this standard is to achieve consistency in the concepts that support signals operating rules and procedures.

This standard is not an attempt to establish uniformity among all rail transit agencies 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.

2. Signal system

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

- train detection, to provide positive location of trains
- train separation or safe train spacing, to protect a train from a collision with a train ahead operating on the same track
- headway management and train routing, to provide protection against conflicting train movements or indication of possible conflicting train movement and also to verify safety of train movements at crossover locations and at interlockings
- movement authority, to provide authority for the movement of trains on the right-of-way
- centralized traffic control/managing train movement from a central location

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

- positive stop enforcement
- speed enforcement and control of train speeds
- broken rail detection
- signal indication
- switch alignment indication
- indication of oncoming trains for roadway workers or other trains
- control of crossing warning systems
- signal violation detection
- interfacing with all non–rail transit agency traffic, such as motor vehicles, cyclists and pedestrians

2.1 Types of signals

The rail transit agency shall classify signals according to the source and nature of the information displayed. The rail transit agency 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 and procedures to govern its movement. Such differentiation may be accomplished by numbering rules by series.

Types of signals may include, but are not limited to the following:

- wayside signals
- interlocking signals
- station signals
- berthing signals/markers
- automatic block signals
- cab signals
- traffic bar signals
- motor vehicle traffic signals
- indicators, including, but not limited to
    - grade crossings
    - switch points
    - derail positions
- fixed signals and signs governing speed and/or operating conditions, including but not limited to interlocking signals that modify other signals
- flagging or hand signals

2.2 Safe spacing of trains

The rail transit agency 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 to provide for safe spacing of trains.

When safe spacing of trains is not accomplished by the train control system, safe spacing of trains along a route may be accomplished by one or more of the following methods and shall be reflected in the operating rules:

- absolute block
- manual block (some rail transit agencies may refer to this as permissive block/special operations)
- line of sight
- timing devices
- operations control center (OCC) authorization

3. Train control

3.1 Types of train control systems

The rail transit agency shall develop and implement rules and procedures that take into consideration the relevant types of train control systems and their system application, including but not limited to the following:

- automatic block system (ABS)
- automatic train control (ATC)
- automatic train operation (ATO)
- automatic train protection (ATP)
- cab signaling
- communications-based train control (CBTC)

3.2 Interlocking and related systems

The rail transit agency shall develop and implement rules and procedures 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, dedicated approach signals, or 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:

- route
- status of block ahead (to prevent trains from colliding)
- speed restriction
- yard route or other route into unsignaled territory
- indicators
- operations over unique track configuration or equipment
- special operations
- automatic train supervision

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 at interlockings.

3.3 Fail-safe and 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 rail transit agency shall develop and implement operating rules and procedures 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 and procedures 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 OCC authorizations.

4. Operating rulebook

Rail transit agency operating rulebooks shall contain an illustration representative of each aspect. See Appendix A for an example of how to develop such illustrative charts. The rail transit agency shall develop and implement operating rules and procedures associated with each aspect.

The rail transit agency operating rulebooks shall indicate purposes of all signal aspects, including but not limited to main line track and yard track.

Examples of the following types of signals shall be identified and included in an operating rulebook, as appropriate to the individual rail transit agency. They shall be identified and explained by category. Examples may include the following:

- wayside signals:
    - end-of-track signals
    - grade crossing signals (special aspects may be displayed to the train operator to indicate status of crossing protection)

- wayside signage (may include block limit signs and cab-signal cut-in signs slow zones, no whistle, power off, dark territory, no clearance, sectionalizer, etc.)
    - speed limit signals
    - traffic bar signals
    - train control, cab signals
    - train control, wayside signals
    - work zone or slow zone signals
    - reverse-operation signals
- cab signal indications
- hand signals and/or flagging

4.1 Additional rules and procedures

The rail transit agency shall establish rules and procedures for the following situations. The rail transit agency may also develop a corresponding procedure related to the following rules.

4.1.1 Non-shunting equipment

Where applicable, the rail transit agency shall designate a class of equipment in the appropriate rulebook(s) for any equipment that operates on rail and is not positively detected by the train control system. Rules and procedures 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. See APTA RT-OP-S-021-15, “On-Track Equipment Safety Requirements,” for further information concerning use of OTE and its relationship to train control and signal systems.

4.1.2 Movement to pass a stop signal

The rail transit agency shall establish rules and procedures for movement to pass a stop signal. The rule(s) shall specify who is authorized to approve such movement and the method (written or verbal) by which such movement is accomplished. The rail transit agency 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 rail transit agency may elect to develop a special aspect for the display of timing signals. When timing signals are used, the rail transit agency shall develop and implement a rule regarding appropriate train operations for such signals.

4.1.4 Call-on signals

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 rail transit agency shall develop and implement a rule governing the usage of call-on signals.

4.1.5 Reverse-operation signals

Some rail transit agencies have reverse operation signals, which are sometimes differentiated from other signals by size or location. The rail transit agency shall determine if additional rules are required regarding operation through reverse-operation signals.

4.1.6 Multiple aspects

At some rail properties, cases may exist in which multiple aspects are utilized to convey an indication. While this is permissible, the rail transit agency 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.

4.1.7 Improperly displayed or dark signals

Operating rules and procedures shall reflect the design philosophy associated with improperly displayed or dark 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 or dark signal to provide an indication that is more favorable than the actual condition.

4.1.8 Out-of-service signals

The rail transit agency shall establish operating rules and procedures governing train movement past signals that have intentionally been taken out of service. The rail transit agency shall identify how it will notify train operating personnel of the requirements for such operation, if temporary conditions exist.

4.1.9 Movement through obstructed, malfunctioning or out-of-service grade crossings

The rail transit agency shall develop rules and procedures for movements through grade crossings with faulty automatic warning devices or whose AWDs indicate faults with grade crossing equipment. In street-running systems, the rail transit agency shall do the same for grade crossings where there are rail/bar or traffic signal malfunctions impacting safe train, vehicular and/or pedestrian movement.

4.1.10 Temporary permission and authority methods for train movement

If the rail transit agency establishes a process whereby train operators passing through a single track area must obtain a physical item (e.g., token), an employee must board the train, or there is some other physical means of granting the right to proceed on a restricted section of track, then the rail transit agency shall establish procedures governing the process.

4.1.11 Train operations management during signal or train control failure mode

The rail transit agency shall establish rules and procedures governing train operations during any failure of a signal or of any aspect of the train control system. Considerations may include the following:

- authority for directing movement
- communications protocols
- securement of switches and interlockings
- train management, spacing and operation

4.1.12 Rail operating employee responsibilities for reporting signal conditions

The rail transit agency shall require rail operating employees to report any deficient/defective signal condition or missing signal device to the OCC.

4.1.13 Hand signals

The rail transit agency shall develop rules and procedures concerning the use of hand signals that govern train movement.

4.1.14 Wayside signage

The rail transit agency shall develop rules and procedures concerning fixed or temporary wayside signage and the instruction it provides governing train movement.

4.1.15 Trip stops and penalty brake applications

Where applicable, the rail transit agency shall develop procedures for reporting situations when a train passes a trip stop that applies braking on a train.

Where applicable, rail transit agencies with other methods of penalty brake applications, such as via an automatic train control system, shall develop procedures for reporting situations and responding to situations when a penalty brake application occurs.

4.1.16 Signal violation reporting

The rail transit agency shall require train operators to report any signal violation to the OCC and await further instruction.

4.1.17 Station clearance indicators

Where applicable, rail transit agencies with station clearance indicators shall develop rules governing their use.

4.1.18 Consideration for broken rail impacts on rail operations

The rail transit agency shall develop protocols for train operations when broken rail indications may be present.

4.2 Requirements for other operating conditions

As applicable, the rail transit agency shall develop operating rules and procedures for conditions such as the following:

- Entry into street or other unsignaled territory and entry from unsignaled territory into signal-controlled territory.
- Conflicting signal indication between the cab signal and wayside signal, wayside signals and auto traffic signals, or the cab signal and the auto traffic signals.
- Transition of operation between different levels or types of signaling or train control.
- Freight operations and other FRA interfaces (for non-FRA properties).
- Grade crossings.
- Loss of SCADA coupled with a failed signal system.
- Movement into and through established work zones or areas where equipment or personnel are fouling or have the potential to foul the right-of-way. See APTA RT-OP-S-004-03, “Work Zone Safety Practices,” and APTA RT-OP-S-016-11, “Roadway Worker Protection Program Requirements.”
- Signal bypass or application of automatic train protection bypass.

5. Coordination with outside stakeholders

Rail transit agencies whose signals are maintained by outside stakeholders, such as those whose trains operate using traffic signals maintained by a city or department of transportation, shall establish formal processes, such as memoranda of understanding, for ensuring that traffic signals are functional and status is communicated with the rail transit agency for proper train operation management.

6. Management of change

The rail transit agency shall establish a process for reviewing and modifying, as applicable, any signals operating rules and procedures as a result of any changes to the configuration of the operating signals or train

control system. The rail transit agency shall maintain a process for tracking any changes made to the signals operating rules and procedures, which may be temporary or permanent.

The rail transit agency shall establish a process for reviewing and modifying, as applicable, any employee training programs, as they relate to signals operating rules and procedures. See APTA RT-OP-S-013-03, "Training of Rail Operating Employees," for further information concerning operations training.

Prior to any rules being put into effect, the rail transit agency shall train employees on signals operating rules and procedures that have changed.

See APTA RT-OP-RP-028-21, "Managing Short- and Long-Term Changes Affecting Rail Operations," for more information.

Related APTA standards

APTA RT-OP-S-001-02, "Rulebook Development and Review"
APTA RT-OP-S-004-03, "Work Zone Safety Practices"
APTA RT-OP-S-011-10, "Rule Compliance Program Requirements"
APTA RT-OP-S-013-03, "Training of Rail Operating Employees"
APTA RT-OP-S-016-11, "Roadway Worker Protection Program Requirements"
APTA RT-OP-S-021-15, "On-Track Equipment Safety Requirements"
APTA RT-OP-RP-028-21, "Managing Short- and Long Term Changes Affecting Rail Operations"

Definitions

For the purposes of this standard, the following terms and definitions apply. The job titles listed below are used in this standard for informational purposes only. It is up to the individual rail transit agency to determine and utilize titles as it finds appropriate.

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, then 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 a 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 in light rail transit agencies.

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, 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 one another 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*.

non-shunting equipment: Any vehicle that operates on rail and that does not positively shunt track circuits.

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

positive stop: The requirement that a train be brought to a full and complete stop, either by the actions of a train operator or the train control system.

rail transit agency: 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 a rail transit agency rulebook or standard operating procedure.

right-of-way: The area at track level or above track level within a distance designated by the rail transit agency of the centerline of the closest tracks.

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.

timing device: An advance warning device designed to permit safe and efficient operation of rail and/or highway traffic over crossings.

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

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.

Abbreviations and acronyms

AWD automatic warning device
ABS automatic block system
APTA American Public Transportation Association
ATC automatic train control
ATO automatic train operation
ATP automatic train protection
CBTC communication-based train control
FRA Federal Railroad Administration
OCC operations control center
OTE on-track equipment
PTC positive train control
SCADA Supervisory Control and Data Acquisition
SBD safe braking distance

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	Dec. 15, 2002	-	-	June 8, 2003	June 8, 2003
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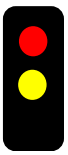
Appendix A (informative): Information on signal systems for use in developing signal rules

A.1 Protocol for wayside signal aspects

Signal aspects used by rail transit agencies 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, **Table 1** and **Table 2** attempt to describe some of the more typical types, colors and shapes of signals used in the transit industry. Therefore, this information is provided as a reference guide and is not intended to require agencies to change their aspects to match those in the tables.

The rail transit agency 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[1] for Train Separation

Signal Aspects	Indication	Aspect	Actions by Train Operator
Red	Stop		Stop.
Dark signal (no illumination)	Stop		Stop.
Red with “modifier” (modifier may be an additional steady light or a flashing indication)	Stop and 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	Proceed		Proceed at permitted speed.
Lunar	Proceed		Proceed at permitted speed.
Yellow	Approach		Proceed at permitted speed and be prepared to stop at next signal.

1. 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	Aspect	Actions by Train Operator
Red horizontal	Stop		Stop.
Yellow horizontal	Stop		Stop.
Amber horizontal	Stop		Stop.
White horizontal	Stop		Stop.
Lunar Horizontal	Stop		Stop.
White Vertical	Proceed		Proceed at permitted speed.
Lunar Vertical	Proceed		Proceed at permitted speed.
Green Vertical	Proceed		Proceed at permitted speed.
Diagonal	Diverging move		Indicates alignment established for diverging movement.

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 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 communications-based train control systems or positive train control.

