

IEEE Standard for the Functioning of and Interfaces Among Propulsion, Friction Brake, and Train-borne Master Control on Rail Rapid Transit Vehicles

Sponsor

Rail Transit Vehicle Interface Standards Committee
of the
IEEE Vehicular Technology Society

Reaffirmed 9 June 2005

Approved 18 March 1999

IEEE-SA Standards Board

Abstract: The interfaces between and among functional systems on rail rapid transit vehicles is prescribed. The systems themselves are treated as “black boxes;” requirements for the input signals and the output response are given. For each category of interface, three type are listed in increasing technical sophistication.

Keywords: friction brake, interfaces, master control, propulsion, rail vehicles, rapid transit

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 1999 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 30 June 2005. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

Print: ISBN 0-7381-1650-5 SH94736
PDF: ISBN 0-7381-1651-3 SS94736

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

Note: Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; (978) 750-8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

(This introduction is not part of IEEE Std 1475-1999, IEEE Standard for the Functioning of and Interfaces Among Propulsion, Friction Brake, and Train-borne Master Control on Rail Rapid Transit Vehicles.)

This introduction provides background on the rationale used to develop this standard, which may aid in the understanding, usage, and applicability of this standard.

Rail transit vehicles have been notable for their lack of standardization. Some real-life factors have contributed to this, primarily because of historic differences in the civil infrastructure and electrical power supply. This standard sets forth a framework for the interfaces among the propulsion system, friction brake system, and master control, but does not attempt to standardize the individual systems themselves and does not dictate that all vehicles must use the most advanced technology available.

This standard applies to rail transit vehicles, which are usually, but not exclusively, electrically powered. These vehicles include railway electric multiple unit (EMU) cars, Heavy rail vehicles (HRVs) (subway or elevated cars), Light rail vehicles (LRVs) (streetcars), including units that combine powered and unpowered trucks or axles. All of these vehicles can be operated under the control of a driver or varying levels of complexity of train control computer, which are lumped together for this purpose as vehicle on-board (master) control (VOBC). In general, the type of train operation does not normally affect the propulsion/brake interface, and this standard can be applied irrespective of the presence or absence of a human driver. Fully automated, driverless implementations of the above vehicle types are sometimes included in the mode of transit referred to as automated guideway transit (AGT) and, to the extent that the vehicle does not have other unique requirements, this standard can be applied. It is not intended that this standard be universally required for all AGT systems, and neither is it intended that this standard apply to locomotives hauling trains nor to locomotive-hauled (including “push-pull”) cars.

The classes of railway vehicles (such as those termed diesel multiple unit [DMU]), which use a diesel engine or other nonelectric prime mover, have features of the propulsion and braking systems used in these vehicles that are similar to those used in conventional electrically powered vehicles. To the extent that these systems are similar to those used in electrically powered vehicles, this standard can be applied.

NOTES:

1—Self-propelled railway vehicles operating on common carrier railroad trackage are subject to regulations issued by governmental bodies (e.g., federal, state, and local bodies). In selected jurisdictions, this is also true for rail transit vehicles. The user should recognize that such regulations always take precedence over a consensus standard.

2—Master control, as defined in 3.2 and utilized herein, is a term selected to apply broadly to any VOBC from manual control, as historically understood, to all forms of automatic train control (including, but not limited to, automatic train protection, automatic train stop, automatic train operation, and cab signals and all combinations thereof).

At the time this standard was completed, the VOBC/Propulsion/Brake Working Group had the following membership:

David R. Phelps, *Chair*

Nicholas J. Brearey
James H. Dietz
David Dimmer
Harold C. Gillen
George Heisey

Harold B. Henderson
Paul E. Jamieson
Kevin D. Johnson
Richard J. Mazur

Rob E. McHugh
Fred M. Perilstein
Radovan Sarunac
Matthieu Vanasse
Henry J. Wesling

The following members of the balloting committee voted on this standard:

Robert Anderson
Linda Sue Boehmer
Lance G. Cooper
Brad Craig
Jim Dietz
Robert J. DiSilvestro
Charles P. Elms
John Ewing
Claude Gabriel
Harold C. Gillen
Robert L. Gottschalk
Yehuda Gross
Robert Heggstad

James R. Hoelscher
Paul E. Jamieson
Kevin D. Johnson
Donald A. Johnston
Don Kane
Ronald Kangas
Abe Kanner
James W. Kemp
William J. Kleppinger
Ron Lawrence
David A. Male
Thomas J. McGean
Robert E. McHugh
Kamel Mokhtech

Howard Moody
Ed Mortlock
Robert Pascoe
Fred M. Perilstein
William Petit
David R. Phelps
Alan F. Rumsey
Louis Sanders
Gene Sansone
Tom Sullivan
Arun Virginkar
Norman Vutz
David Yager

When the IEEE-SA Standards Board approved this standard on 18 March 1999, it had the following membership:

Richard J. Holleman, *Chair*

Donald N. Heirman, *Vice Chair*

Judith Gorman, *Secretary*

Satish K. Aggarwal
Dennis Bodson
Mark D. Bowman
James T. Carlo
Gary R. Engmann
Harold E. Epstein
Jay Forster*
Ruben D. Garzon

James H. Gurney
Lowell G. Johnson
Robert J. Kennelly
E. G. "Al" Kiener
Joseph L. Koepfinger*
L. Bruce McClung
Daleep C. Mohla
Robert F. Munzner

Louis-François Pau
Ronald C. Petersen
Gerald H. Peterson
John B. Posey
Gary S. Robinson
Akio Tojo
Hans E. Weinrich
Donald W. Zipse

*Member Emeritus

Also included is the following nonvoting IEEE-SA Standards Board liaison:

Robert E. Hebner

Kim Breitfelder
IEEE Standards Project Editor

Contents

1. Overview.....	1
1.1 Scope.....	1
1.2 Purpose.....	1
2. References.....	2
3. Definitions, abbreviations, and acronyms.....	2
3.1 Definitions.....	2
3.2 Abbreviations and acronyms.....	8
4. Complexity of interfaces.....	9
4.1 Type I interfaces	9
4.2 Type II interfaces	9
4.3 Type III interfaces.....	9
5. Functional interfaces.....	10
5.1 Emergency brake	10
5.2 Direction	11
5.3 Traction/brake mode selection.....	13
5.4 Modulation interfaces	17
5.5 Blending.....	25
5.6 Load weigh.....	27
5.7 Speed.....	28
5.8 Penalty brake.....	30
5.9 Spin/slide.....	31
5.10 No-motion detection	33
5.11 Alertness monitoring.....	34
5.12 Specialized brake functions	35
5.13 Specialized propulsion functions	36
5.14 Door status	38
5.15 Data and fault annunciation	39
Annex A (informative) Bibliography.....	41
Annex B (informative) Example block diagrams for the three interface types	42
Annex C (informative) Alternative forms of propulsion system response to power modulation interface signals	44

IEEE Standard for the Functioning of and Interfaces Among Propulsion, Friction Brake, and Train-borne Master Control on Rail Rapid Transit Vehicles

1. Overview

This standard applies to new procurements or major rehabilitation of rail transit vehicles occurring on or after the effective date of this standard (18 March 1999). Existing rail transit vehicles and those vehicles that are currently being procured need not comply except where specifically required by the authority having jurisdiction. Where a need exists to maintain compatibility with existing rail transit vehicles, those portions of this standard in conflict with the compatibility requirement need not apply.

1.1 Scope

This standard prescribes the interface functionality among propulsion, friction brake, and train-borne master control. It encompasses performance parameters, communication methods, and the means for measurement and verification of performance. “Third party” systems performing functions traditionally carried out in one of the above systems are also covered.

1.2 Purpose

Numerous functional protocols presently exist for interfaces among train-borne master control, propulsion, friction brake, spin-slide control, etc. This has led to a lack of standardization, compatibility, and interchangeability, with attendant higher first cost and recurrent integration problems. Standards, when used by vehicle purchasers, carbuilders, and system suppliers, are expected to lower costs, reduce vehicle introduction problems, improve reliability, and facilitate upgrades. Standards will ensure prioritization of safety functionality.

2. References

This standard shall be used in conjunction with the following publications. If the following publications are superseded by an approved revision, the revision shall apply. In case of a conflict between this standard and the referenced document, this standard shall take precedence. Those provisions of the referenced documents that are not in conflict with this standard shall apply as referenced.

IEEE Std 100-1996, The IEEE Standard Dictionary of Electrical and Electronics Terms, Sixth Edition.¹

IEEE Std 1473-1999, IEEE Standard for Communication Protocol Aboard Trains.

IEEE P1476/D4.0, 16 April 1999, Interfaces for Passenger Train Auxiliary Power Systems.²

IEEE P1478/D4.0, 7 April 1999, Environmental Standards for Rail Rapid Transit Electronic Equipment.

IEEE P1482/D699, June 1999, Rail Vehicle Monitoring and Diagnostics Systems.

3. Definitions, abbreviations, and acronyms

3.1 Definitions

For the purposes of this standard, the following terms and definitions apply. IEEE Std 100-1996, The IEEE Standard Dictionary of Electrical and Electronics Terms, should be referenced for terms not defined in this clause. Because the rail transit industry possesses a significant amount of unique terminology, the *Urban Public Transportation Glossary* [B2]³ has been utilized as a source for many of the following definitions. *Webster's New Collegiate Dictionary* [B3] has been utilized as a general reference.

3.1.1 actual weight: The measured weight of a finished, ready-to-run vehicle; the tare weight. *Synonym:* **empty weight.**

3.1.2 adhesion (coefficient of): During rolling contact, the ratio between the longitudinal tangential force at the wheel-rail/running surface interface and the normal force.

3.1.3 alertness function: A device or system that monitors the operator for signs of incapacitation, usually by requiring movement or response to take place within a prescribed period of time.

3.1.4 authority: A geographical or political division created specifically for the single purpose of providing transportation service.

3.1.5 authority having jurisdiction: The entity that defines the contractual (including specification) requirements for the procurement.

3.1.6 automated guideway transit: Any guided transit mode with fully automated operation (i.e. no crew on the train). The term usually refers, however, only to guided modes with small and medium-sized vehicles that operate on exclusive right-of-way.

¹IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://www.standards.ieee.org/>).

²Numbers preceded by P are IEEE authorized standards projects that were not approved by the IEEE-SA Standards Board at the time this publication went to press. For information about obtaining drafts, contact the IEEE.

³The numbers in brackets correspond to those in the bibliography in Annex A.

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

3.1.8 automatic train operation (ATO): The subsystem within the automatic train control (ATC) 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.

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

3.1.10 automatic train stop: A wayside system that works in conjunction with equipment installed on the vehicle to apply the brakes at designated restrictions or on a dispatcher's signal, should the operator not respond properly.

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

3.1.12 basic operating unit: (A) A single vehicle designed for independent operation. **(B)** A permanent or semipermanent combination, designed for independent operation, consisting of two or more vehicles of one or more types.

3.1.13 battery voltage: Voltage that is provided within specified limits by the low voltage power supply (or, in its absence, the control voltage on-board battery).

NOTE—Battery voltage limits are specified in IEEE P1476/D4.0.

3.1.14 blending: The combination of two or more modes of braking (e.g., rheostatic electric brake, regenerative electric brake, and friction brake) to produce the desired total retarding effort.

3.1.15 brakes applied: An indication that all friction brakes are applied to some agreed-upon preset level.

3.1.16 braking effort: Longitudinal retarding force generated by the friction brake system or the propulsion system (in electric brake).

3.1.17 builder: The entity manufacturing the product.

3.1.18 cab signal (system): A signal located in the cab, indicating a condition affecting the movement of a train and used in conjunction with interlocking signals and in conjunction with or in lieu of block signals.

3.1.19 car: See: **vehicle**.

3.1.20 car builder: The entity assembling or manufacturing the vehicle.

3.1.21 coast: The mode of operation of a vehicle or train in which both tractive effort from the propulsion system and braking effort from the propulsion and friction brake systems are zero.

NOTE—The inherent design characteristics of some propulsion systems require that a negligible level of electric brake be present in the coast mode.

3.1.22 cock: A pneumatic device having two positions, closed/shut and open/through.

3.1.23 consist: The makeup or composition (number and specific identity) of individual units of a train.

3.1.24 control voltage: Voltage that is provided for operating the controlled elements of the vehicle. *See also: battery voltage.*

NOTE—Control voltage may or may not be the same nominal potential as the battery voltage.

3.1.25 crush loaded weight: The weight of a vehicle when loaded with crew, all seats occupied, and standees to a specified maximum number.

3.1.26 cut out: The state of being disabled by the conscious use of a cutout device or function.

3.1.27 cutout: A device or function whose purpose is deliberately to disable a specified device or function, e.g., “dynamic brake cutout.”

3.1.28 data recorder: The device used to record any type of data.

3.1.29 data recording: The act of recording any type of data.

3.1.30 deadman: A pressure- or activity-actuated alertness device to detect inattention or disability of a train operator.

NOTE—A deadman can be contained within the master controller main handle grip, obtained by a separate foot switch, or obtained through an alertness type function. The device, when not properly maintained in an operational condition, will result in an emergency or full service brake application.

3.1.31 derail detector: A device so arranged as to detect a derailment condition.

3.1.32 doors closed: A state, as given by trainline signal indication, in which doors are fully closed and locked.

3.1.33 doors locked: The condition reached in the door-closing cycle when the drive has achieved a latching condition that will hold doors closed mechanically until a door-opening cycle is initiated.

3.1.34 doors open: A state, as given by trainline signal indication, in which doors are not fully closed and locked.

3.1.35 electric brake: A mode of operation of the propulsion system in which retardation is provided.

NOTE—Although generally considered synonymous with dynamic brake, electric brake is a more global term, in that it includes the possibility of providing retardation by drawing power from the line or by other means not dependent on conversion of kinetic energy into retarding power, which is the key element of dynamic braking.

3.1.36 electric coupler: A device used to allow trainline signals to be transmitted from vehicle to vehicle or unit to unit in a train, with the connection of trainlines performed automatically when vehicles are coupled.

3.1.37 emergency brake: Fail-safe, open-loop braking to a complete stop with an assured maximum stopping distance, considering all relevant factors. Once the brake application is initiated, it is irretrievable, i.e., it cannot be released until the train has stopped or a predetermined time has passed.

3.1.38 empty weight: *See: actual weight.*

3.1.39 event recorder: An on-board device/system with crashworthy memory that records data to support accident/incident analysis.

3.1.40 fade: (A) The condition occurring during a braking cycle at low speed wherein the fundamental characteristics of the propulsion system utilized do not support the power requirement of the level of dynamic electric brake called for. Consequently, the level of dynamic electric brake actually generated decreases as a function of speed along an inherent characteristic. **(B)** In electric braking systems capable of supporting the level called for to zero speed, a deliberately created characteristic wherein the level of electric brake decreases as a function of speed to allow a smooth transition to friction brake for the purpose of the final stop.

3.1.41 fail-safe: A design philosophy applied to safety-critical systems such that the result of a 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.

3.1.42 forward: The direction of motion of the train corresponding to the direction of vision of an operator or attendant when occupying his or her normal position in a normal orientation.

NOTE—For an unattended vehicle, forward may be defined by the prevailing direction of operation on the guideway segment being utilized.

3.1.43 friction brake: The system of pneumatic, electropneumatic, hydraulic, electrohydraulic, or electric valves, controls, actuators and associated components which, in combination, provide the capability of braking the vehicle to a stop purely by the action of friction devices upon the wheel tread, disc rotors, or other surfaces.

3.1.44 full field: In a propulsion system, the motor connection in which, for series motors, the exciting field current is the same as the armature current, or, for separately excited motors, the exciting field current is at its maximum value relative to the armature current.

3.1.45 heavy rail transit: A mode of rail rapid transit generally characterized by fully grade-separated construction, operation on exclusive rights-of-way, and station platforms at the floor level of the vehicles.

3.1.46 heavy rail vehicle: A vehicle operating on a heavy rail transit system. Typically, electrically propelled, bidirectional, capable of operating in multiple unit, and designed for rapid, high-level boarding and discharging of passengers.

3.1.47 light rail transit: A mode of rail transit characterized by its ability to operate on exclusive rights-of-way, street running, center reservation running, and grade crossings, and its ability to board and discharge passengers at track or vehicle floor level.

3.1.48 light rail vehicle: A vehicle that operates on a light rail transit system, capable of boarding and discharging passengers at track or vehicle floor level.

3.1.49 load weighing: A function incorporated in the propulsion or friction brake system that measures changes in sprung vehicle weight. Its purpose is to permit control of tractive effort in order to achieve a constant effort-to-weight ratio for a given master control command.

3.1.50 master control: The train-borne device or system directly providing the control signals to the train.

3.1.51 master controller: A physical device utilized by a human operator to provide the master control of a train.

3.1.52 multiple unit: A system of simultaneous control of all vehicles in a consist from one master control through the means of trainlines.

3.1.53 no motion: A safety-critical function utilized to indicate that the train is at zero speed or sufficiently close to zero speed. Used to inhibit the ability of the doors to open when the train is moving and can be used for functions, such as emergency brake reset, that may require an indication of the no motion condition.

3.1.54 parallel: In a propulsion system, the motor circuit in which the final parallel or series-parallel motor connection is achieved and the maximum available per-motor voltage is applied.

3.1.55 panic brake: Using any available form of braking, whether or not fail-safe, to obtain the shortest possible stopping distance.

3.1.56 parking brake: A means that supplies static braking forces to maintain a vehicle or train in a no motion state.

3.1.57 penalty brake: A function of the automatic train protection portion of the master control system, accomplished by a safety critical, full-service, or emergency brake application.

NOTE—Although most commonly associated with an overspeed operating condition, penalty braking may be initiated for a variety of reasons, depending on the vehicle design and the requirements of the authority having jurisdiction.

3.1.58 pneumatic brake pipe: A pressurized air line, continuous over the length of the train, used variously to indicate train integrity, provide indication of an emergency condition, equalize reservoir pressures, or propagate a brake application signal.

3.1.59 power knock out: A function, derived from friction brakes being applied above a low preset level on any truck, that removes propulsion power on every vehicle in the train.

3.1.60 propulsion system: The system of motors, drive mechanisms, controls, and other devices that propels or retards a vehicle.

3.1.61 purchaser: An entity that contractually acts as the customer.

3.1.62 redundancy: The existence in a system of more than one means of accomplishing a given function.

3.1.63 regenerative brake: A form of dynamic brake in which the electrical energy generated by braking is returned to the power supply line, provided to on-board loads, or a combination thereof during the braking cycle instead of being dissipated in resistors.

3.1.64 reliability: The probability that a system will perform its intended functions without failure, within design parameters, under specific operating conditions, and for a specific period of time.

NOTE—The ambient environmental conditions for operation are specified by the authority having jurisdiction, or, in the absence of such specifications, are specified by IEEE P1478/D4.0.

3.1.65 reverse: The direction of operation that is opposite to forward.

3.1.66 reverser: (A) The portion of the master controller used to change the commanded direction of train movement. (B) A circuit device used to change motor connections in order to change the direction of motor rotation and thus train movement.

3.1.67 rheostatic brake: A form of dynamic brake in which the electrical energy generated by braking is dissipated as heat in on-board resistors during the braking cycle.

3.1.68 safety critical: A term applied to a system or function, the correct performance of which is critical to safety or personnel and/or equipment; also a term applied to a system or function, the incorrect performance of which may result in an unacceptable risk of a hazard. *See also:* **fail-safe**.

NOTE—A safety critical designation may require the incorporation of additional special safety design features.

3.1.69 sanding: Dropping or blowing of sand or similar material on the top of the rail head to increase the coefficient of friction to obtain better adhesion.

3.1.70 series: In a propulsion system, the motor connection in which all motors are connected in a series circuit for the purpose of applying to them some fraction (usually one half) of the maximum available per-motor voltage.

3.1.71 service: The operation of the vehicles under normal conditions with or without revenue passengers.

3.1.72 service brake (maximum): A nonemergency brake application that obtains the (maximum) brake rate that is consistent with the design of the brake system, retrievable under the control of master control.

3.1.73 service braking: *See:* **service brake (maximum)**.

3.1.74 snow brake: A constant application of light friction brake intended to create enough heat to mitigate the buildup of snow and ice, which would interfere with the brake actuators.

3.1.75 straight air brake: An arrangement of brakes whereby air is admitted from the main reservoir through a brake valve to the straight air pipe to the brake cylinders in the operating unit.

NOTE—In most rail transit vehicle applications, an electropneumatic overlay is utilized to assist in the straight air brake command transmission.

3.1.76 straight air pipe: A method of transmitting a pneumatic command from the active cab to the straight air brake equipment on each vehicle in the operating unit.

3.1.77 supplier: The entity that contractually acts as the source of a product.

NOTE—The supplier may or may not be the actual builder.

3.1.78 switch (position): In a propulsion system, the historic name for the lowest level of positive tractive effort and power; so called because it is typically utilized for slow-speed switching movements, such as yard moves, train makeup, etc.

3.1.79 track brake: A magnetic friction brake that compresses against the running rail and is activated by an electrical signal.

3.1.80 traction system: *See:* **propulsion system**.

3.1.81 tractive effort: The force generated at the wheel-rail interface as a result of the action of the propulsion system. It may be either positive, indicating motoring/powering, or negative, indicating brake.

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

3.1.83 trainline(s): Wires routed through and/or between vehicles or units by means of couplers, jumpers, or other means so that power or signals may be transmitted to all vehicles of the train.

3.1.84 trip switch/cock: A device mounted on the truck of a vehicle, responding to a raised arm on the way-side, used to cause an emergency brake application if a train attempts to pass a mandatory stop signal.

3.1.85 truck: A rail vehicle component that consists of a frame—normally two axles, brakes, suspension, and other parts—and supports the vehicle body and can swivel under it on curves. If powered, it may also contain traction motors and associated drive mechanisms.

3.1.86 unit: See: **basic operating unit**.

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

3.1.88 weak field: In a propulsion system, a motor connection or operating mode in which the exciting field current is less than the full field value.

3.1.89 wheel diameter compensation: A function that corrects for either the wear of the wheel(s) or the difference(s) in rolling diameter between different wheels on the vehicle or both.

3.1.90 wheel slide: During braking, the condition existing when the rotational speed of the wheel is slower than that for pure rolling contact between tread and rail/running surface.⁴

3.1.91 wheel slip: The condition existing when the rotational speed of the wheel does not correspond with pure rolling contact between tread and rail/running surface.⁵

3.1.92 wheel spin: During acceleration, the condition existing when the rotational speed of the wheel is faster than that for pure rolling contact between tread and rail/running surface.⁶

3.2 Abbreviations and acronyms

AGT	automated guideway transit
ATC	automatic train control
ATO	automatic train operation
ATP	automatic train protection
ATS	automatic train stop; automatic train supervision
DMU	diesel multiple unit
EMU	electric multiple unit
HRV	heavy rail vehicle
LCD	liquid crystal display
LED	light emitting diode
LRV	light rail vehicle
PWM	pulse width modulation
TRB	Transportation Research Board
VOBC	vehicle on-board (master) control

⁴For convenience and simplicity, the definitions of wheel slide, wheel slip, and wheel spin ignore the presence of the microslip phenomenon generally called “creep,” physically necessary to generate longitudinal force at the wheel-rail interface.

⁵See footnote 4.

⁶See footnote 4.

4. Complexity of interfaces

For each of the interfaces specified in Clause 5, standards are established for up to three levels of complexity. In using this standard, the authority having jurisdiction shall specify a level of complexity for each interface, consistent with the design requirements of the vehicle.

NOTE—The requirements for some interfaces, as defined in this standard, may preclude the use of some interface types. In those instances, this standard will specify the type of interface to be used (e.g., “Same as Type I interface”).

4.1 Type I interfaces

A Type I interface, in the context of this standard, has the following characteristics:

- a) Interface signals are primarily of the “off-on” form.
- b) Except where the nature of the interface requires otherwise, the signals are transmitted at the voltage level of the control battery system.
- c) Signal flow across a given interface is one-way.
- d) Fault annunciation is limited to simple indicating lights or similar means.
- e) No data recording or fault logging is provided, except as may be required by regulation.

4.2 Type II interfaces

A Type II interface, in the context of this standard, has the following characteristics:

- a) Interface signals are a mix of digital and analog/proportional signals, usually at the vehicle battery voltage or from a power supply derived therefrom.
- b) Signal flow across a given interface remains one way.
- c) Fault annunciation is still limited to indicating lights or similar means, but more indications, both local and trainlined, may be provided.
- d) Data recording or fault logging, if provided, is done at one system level, either at the vehicle level or at the functional system level. Both levels may be provided, but there is no exchange of information between the levels.

4.3 Type III interfaces

A Type III interface, in the context of this standard, has the following characteristics:

- a) Most interface functions extensively use serial communication links or data buses.
- b) Signal flow and communication across interfaces are two-way.
- c) Comprehensive system, vehicle, and train information displays are available to the operator.
- d) Integrated data recording and fault logging is provided, in which information is shared among system levels, including train level, vehicle level, and functional system level.

An example of a simplified block diagram for a consist of vehicles comprising Type I, Type II, and Type III interfaces is given in Annex B, Figure B.1, Figure B.2 and Figure B.3, respectively.

5. Functional interfaces

5.1 Emergency brake

5.1.1 Interfaces

To meet the safety critical requirements, the interfaces for the emergency brake shall be Type I. The emergency brake interface shall be one chosen from the following:

- a) Trainlined pneumatic brake pipe
- b) Trainlined pneumatic brake pipe with one digital battery trainline overlay (one or two wire, single or double break)
- c) Four digital battery voltage trainlines; loop configuration with origin and destination being the same device:
 - 2 wires—battery positive
 - 2 wires—battery negative

NOTE—If the four-wire method is used, the voltage drop over wire length must be considered. The purchaser may select combinations of these methods.

5.1.2 Signal origin(s)

Any of the following systems or components, as utilized, shall be capable of initiating an emergency brake application as specified by the authority having jurisdiction:

- Master control
- Brake pipe and brake pipe control details
- Coupler equipment
- Derail detector
- Main reservoir pressure
- Passenger/crew emergency function
- Trip cock/trip switch
- Truck excess swivel
- Logic functions within the propulsion or friction braking systems

5.1.3 Signal destination(s)

The following systems shall receive an emergency brake signal:

- Master control
- Friction brake system
- Propulsion system
- Spin-slide system (if a separate functional system)

5.1.4 Signal characterization

For pneumatic or electric emergency brake system, signal condition shall be as follows:

- Presence of control signal = “1” = no emergency
- Absence of control signal = “0” = emergency

The emergency brake control must be treated as a safety critical interface function.