APTA STANDARDS PROGRAM
RECOMMENDED PRACTICE

APTA PR-E-RP-014-99, Rev. 2
First Published: March 4, 1999
First Revision: February 13, 2004
Second Revision: May 13, 2026
Electrical Working Group

Diesel–Electric Passenger Locomotive Blended Brake Control

Abstract: This recommended practice provides a common design basis for the control and configuration of blended brake systems. It does not address the design and functionality of dynamic braking circuits as such, nor the protective features required by the dynamic braking function.

Keywords: blended brake

Summary: This recommended practice provides a common design basis for the control and configuration of blended brake systems.

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 Electrical Working Group as directed by the Passenger Rail Equipment Safety 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. The application of any recommended practices or guidelines contained herein is voluntary. 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 PR-E-RP-014-99, Rev. 1, which has been revised. Below is a summary of changes from the previous document version:

- Updated working group roster; format updated to latest APTA standards format.
- Addition of Summary section.
- Added new Section Foreword.
- Added applicability language in the Introduction.
- Merged former sections 1.1, Scope, and 1.2, Purpose, into Scope and Purpose.
- Moved former section 2, References, to the new sections Related APTA standards and References.
- Moved former section 3, Definitions, abbreviations and acronyms into new sections Definitions and Abbreviations and Acronyms.
- Renumbered former section 4, Blended brake system philosophies, to new section 1. Removed allowance for supplemental type philosophy.
- Renumbered former section 5, Blended brake setup, to new section 2. Dynamic brake interlock (DBI) reference has been eliminated. Added load preference when both dynamic braking and blended braking are requested simultaneously.

Table of Contents

List of Figures and Tables

Participants

The American Public Transportation Association greatly appreciates the contributions of the **PRESS Electrical Working Group**, which provided the primary effort in the drafting of this document. At the time this standard was completed, the working group included the following members:

Tammy Krause, *STV Inc.*, Chair
Andrew Jensen, *Amtrak*, Vice Chair
Piotr Jedraszczak, *Metra*, Secretary
Brandon Palko, *Amtrak,* Document Lead

Leith Al-Nazar, *Federal Railroad Administration*
Mark Anderson, *Huber+Suhner Inc.*
Carl Atencio, *American Rocky Mountaineer*
Andrew Aubert, *Transit Design Group Intl. Inc.*
James Brooks, *Utah Transit Authority*
Nicolas Bruque, *Siemens Mobility Inc.*
Dick Bruss, *Retired*
Josh Callen, *Hatch*
Andrew Clapham, *Network Rail Consulting Ltd.*
Benjamin Claus, *HDR*
Jacob Daly, *Amtrak*
Wulf Dicke, *Siemens Mobility Inc.*
Sebastian Durzynski, *Transit Design Group Intl. Ltd.*
Mo Ebrahimi, *Metrolinx (GO Transit)*
Alain Emery, *Saft*
Phillippe Etchessahar, *Alstom*
Gary Fairbanks, *Federal Railroad Administration*
Robert Fauvelle, *AtkinsRéalis*
Steve Finegan, *Finegan Rail Consulting Group LLC*
Adam Gagne, *Siemens Mobility Inc.*
Marc Gagne, *Transit Design Group Intl. Ltd.*
Yakov Goldin, *Retired*
Lowell Goudge, *Retired*
Patrick Groarke, *MTA Long Island Rail Road*
Klaus Gutzeit, *Hoppecke*
Jesse Halpern, *Amtrak*
Raul Heinrich, *Siemens Mobility Inc.*
Paul Jamieson, *Retired*
Paul Johnson, *WAGO Corp.*
Nigel Jones, *Jacobs*
Robert Jones, *Stadler*
Srinivas Kumar Katreddi, *WSP*
Victor Kelley, *AtkinsRéalis*
James Kendall, *Amtrak*
Clifford Kim, *SEPTA*
Christian Knapp, *Denver Transit Operators*
Joerg Kuehne, *Huber+Suhner Inc.*
Daniel Lanoix, *Self*
Brian Ley, *WSP*
John Listar, *Wabtec*
William Loria, *Siemens Mobility Inc.*
Francesco Maldari, *MTA Long Island Rail Road*
Ted Mavronicolas, *Saft*
John Moore, *Phoenix Contact*
Thomas Muehlbauer, *Stadler*
Chris Muhs, *TriMet*
Michael Nahom, *Eastern Connector Specialty Corp.*
Thomas Newey, *Network Rail Consulting Ltd.*
James Notarfrancesco, *Marmon IEI*
Alfonso Perez, *Huber+Suhner Inc.*
Joseph Reynolds, *MTA Metro-North Commuter RR*
Lars Ripley, *Stadler*
Harjot Singh Saini, *Hatch*
Bryan Sawyer, *Utah Transit Authority*
Gerhardt Schmidt, *Siemens Mobility Inc.*
Martin Schroeder, *Jacobs*
Richard Seaton, *Transit Design Group Intl. Inc.*
David Seenath, *Metrolinx (GO Transit)*
Sean Shim, *New Jersey Transit Corp.*
Gil Shoshani, *Marmon IEI*
Frank Sokolow, *MTA Long Island Rail Road*
Jeffrey St. Jean, *New Jersey Transit Corp.*
Daniel Swieca, *New Jersey Transit Corp.*
Adnan Syed, *Metrolinx (GO Transit)*
Jonathan Syfu, *STV Inc.*
Tamer Yassa, *Transport Canada*
Silvio Zahra, *Metrolinx (GO Transit)*
Steven Zuiderveen, *Federal Railroad Administration*

Project team
Nathan Leventon, *American Public Transportation Association*
Bryan Sooter, *American Public Transportation Association*

Introduction

This introduction is not part of APTA PR-E-RP-014-99, "Diesel–Electric Passenger Locomotive Blended Brake Control."

This recommended practice applies to all:

- railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
- railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This recommended practice does not apply to:

- rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
- tourist, scenic, historic, host railroads or excursion operations, whether on or off the general railroad system of transportation;
- operation of private cars, including business/office cars and circus trains unless otherwise required by other standards or regulations; or
- railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Scope and purpose

This recommended practice covers diesel–electric locomotives equipped with blended brakes. The blended brake system described herein coordinates the concurrent application of both dynamic brakes and friction brakes on a locomotive.

The purpose of this recommended practice is to provide a common design basis for the control and configuration of blended brake systems, as well as to promote standardization. This recommended practice does not address the design and functionality of dynamic braking circuits as such, nor the protective features required by the dynamic braking function.

Diesel–electric passenger locomotive units that include blended brake operation (whether single unit or multiple operation) should have electrical and friction braking controls that meet the provisions of this recommended practice.

Diesel–Electric Passenger Locomotive Blended Brake Control

1. Blended brake system philosophies

Blended brakes are commonly used to reduce thermal stress on locomotive wheels and/or braking disks, and extend locomotive brake shoe/pad life. For the purposes of this recommended practice, the friction braking system is designated as the primary brake, and the dynamic braking system as the secondary brake. These two systems operating together make up the blended brake systems described herein.

A blended brake system will need to be designed so the locomotive will arrive to a stop within the design limits of a friction-brake-only application.

Operation of the blended brake system is to remain local to each locomotive, not linked to any electrical trainline command.

Deceleration rates used in determination of stopping distance can be calculated one of two ways:

$$a = vf - vi/t \quad \text{or} \quad a = -0.733vi^2/d$$

where:
a = deceleration in mph/s,
vi = the initial velocity in mph,
vf = the final velocity in mph (0 mph),
d = stopping distance in feet
t = elapsed time in seconds from initiation of braking, until locomotive is completely stopped

For all deceleration rates used in this recommended practice, the $-0.733vi^2/d$ formula should be used, as this method properly accounts for the nonlinear nature of locomotive stopping action.

2. Blended brake setup

Blended brake operation is controlled by changes in brake pipe pressure, initiated by the movement of the automatic brake valve handle or lever (i.e., it is not MU trainline controlled). Provided that the throttle is in "idle" position and the dynamic brake handle (if so equipped) is in the off position, a nominal 10 lbf/in.^{2} (but at least 5 lbf/in.^{2}) of brake cylinder pressure should be applied when the brakes are applied. This 10 lbf/in.^{2} pressure (often referred to as "inshot" pressure) may be retained until brakes are released. This approach keeps the wheel treads clean and prevents snow or ice buildup on brake shoes/pads in inclement weather. It also makes for a smoother reapplication of friction retarding force when dynamic brake retarding force diminishes.

If both dynamic braking mode and blended braking mode are requested simultaneously, the highest electric brake demand will be in control of the electric brake command.

Upon entry to blended brake, dynamic brake mode of operation will be initiated, without the energization of MU trainlines #17, #21 and #24 (APTA PR-E-RP-017-99).

3. Blended brake control

3.1 Service braking

For service brake applications, blended brake is to operate in "dynamic priority," as described below.

The response of the blended brake system is to be such that the interpreted amount of requested braking effort (from the brake pipe pressure) minus the inshot pressure required for minimal friction braking (typically 10 lbf/in.^{2}) sets a reference value of dynamic brake retarding force required.

For a service braking request, the air portion of the blended braking effort is regulated as follows:

- Brake cylinder inshot pressure is initiated.
- Dynamic braking is used to satisfy the remainder of the braking request.
- If insufficient dynamic braking is available, devices that interpret the braking request will develop a brake cylinder pressure sufficient to satisfy the shortfall. The braking effort rate increase is to be limited by a maximum jerk rate established by agreement between the manufacturer and purchaser to reach full braking.

For full-service blended brake operation, dynamic brake should be used to the extent possible and be supplemented by friction brake as necessary to meet the required braking rate.

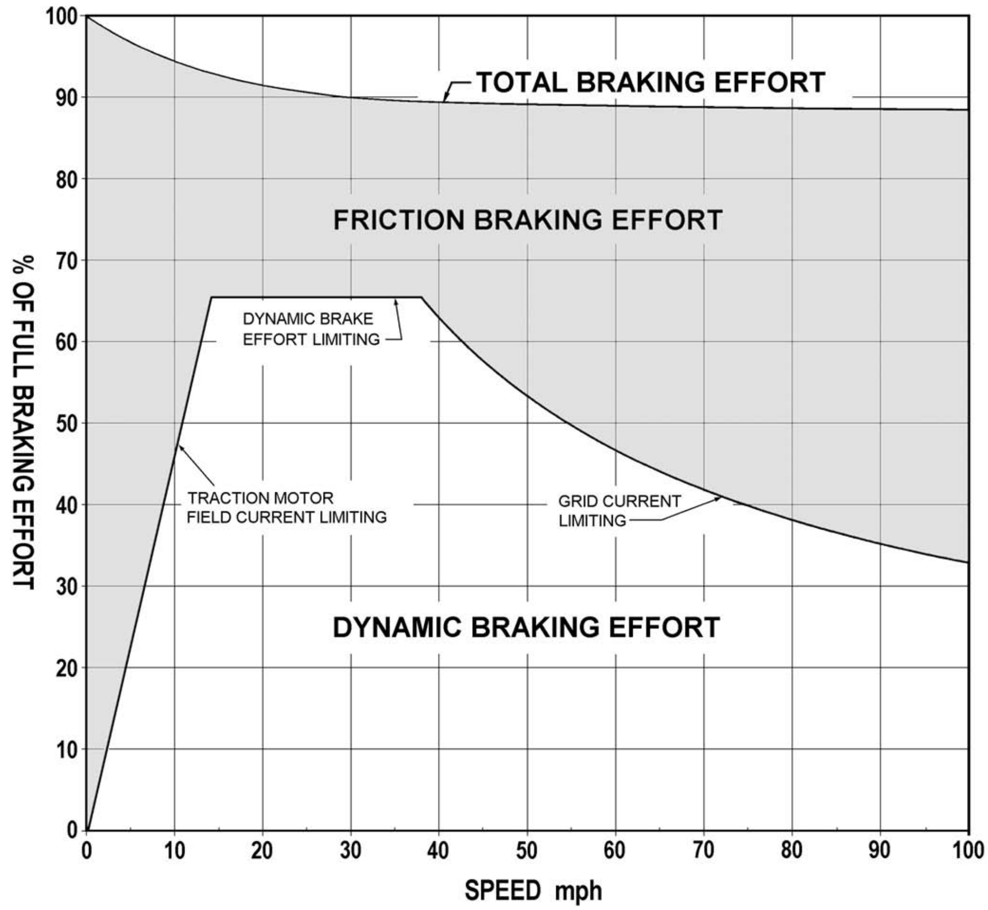
The response of the dynamic brake excitation and power circuits to the dynamic brake retarding force reference is to be such that grid current is held within the ampacity rating of the braking grids and the resultant dynamic brake retarding force does not exceed the reference, at any speed.

The relationship between the friction and dynamic brake systems are as follows:

- At high locomotive speeds, the dynamic brakes are limited by grid resistor capacity.
- In the middle speed range, dynamic brake effort is regulated to give the requested braking effort.
- At lower speeds, dc locomotives have traction motor field current as the sole constraint on dynamic brake effort generated (See **Figure 1**). Ac locomotives have no such constraint and have a controlled brake effort as in the middle speed range.

Wheel slide detection and management should be incorporated with the blended brake system.

FIGURE 1
Typical Speed-Braking Effort Curve for a dc Locomotive – Blended Brakes



3.2 Emergency braking

For emergency brake applications, blended brake is to operate in “friction priority,” as outlined below.

Upon initiation of an emergency braking request, full friction braking consistent with an emergency brake application is to be applied.

Dynamic braking may be added to the friction brakes if desired, to augment locomotive stopping performance within the maximum deceleration rate established by agreement between the manufacturer and purchaser. The dynamic braking must be designed so there is no negative safety consequence on the emergency brake application.

3.3 Blended brake lockout

A blended brake lockout (BBL) function provides for the automatic default to “friction only” braking mode upon detection of loss of proper control of the system.

An alarm is to signal a locked-out condition and continue until either the condition is reset or the blended brake is cut out. The alarm signal should further energize trainline wire #2 under failure modes that affect operational performance.

4. Qualification testing

Type tests are to be conducted on new/modified systems to confirm that braking performance meets the specified requirements. These tests should take place on dry, tangent track having minimal (ideally, no) grades. The track is to be suitably marked either physically, via a known wayside point, or inferred via onboard data captured during the test to provide a datum for braking initiation. Multiple tests are to be completed for each condition in both directions along the given section of track, to ensure repeatability of results and minimize environmental condition impacts.

> **NOTE:** In the case of modified systems, if software and/or hardware is changed, a safety analysis must be performed in order to assess to what extent the type tests must be performed.

> **NOTE:** These tests do not qualify the braking system for operation with low adhesion track conditions.

> **NOTE:** These tests do not qualify the operative thermal loading of the brake system (e.g., successive emergency brake applications).

4.1 Test procedure

Locomotive testing should be performed using a pair of locomotives, coupled back-to-back, in full MU. This method tends to mitigate the wind effects (for push–pull operation), allows for optimal movement of equipment used in the test, and provides a convenient location for test equipment and personnel.

With the locomotives at desired speed, the throttle is moved to "idle" just prior to the locomotive reaching the designated datum mark or point of intended brake application.

The automatic brake handle or lever is to be moved to the required braking position as the locomotive crosses the mark or point of intended brake application. The tests are to be timed, beginning when the handle is moved out of the "release" position.

The following data is to be recorded in continuous, real-time form:

- elapsed time from brake handle movement to stop
- speed
- brake cylinder pressures
- brake pipe pressure
- distance
- dynamic brake force

Tests are to be conducted for any speeds as may be required to show response for property-specific signal spacing/safety conditions and maximum operating speed.

Tests are to be conducted for each of the following conditions:

- full service, blended brakes
- full service, friction braking only
- emergency, blended brakes (if applicable)
- emergency, friction braking only

Related APTA standards

APTA PR-E-RP-006-99, "Diesel–Electric Passenger Locomotive Dynamic Brake Control"
APTA PR-E-RP-017-99, "27-Point Control and Communication Trainlines for Locomotives and Locomotive-Hauled Equipment"

Definitions

blended brake: The coordinated combination of two or more modes of braking (e.g., dynamic brake and friction brake) to produce the desired total retarding effort.

dynamic brake: A mode of operation of the propulsion system in which retardation is provided through the use of traction motors as generators, converting the kinetic energy of the vehicle or train into electrical energy.

primary brake: The mode of braking system chosen to provide sufficient braking to meet railroad operating requirements.

secondary brake: Any braking mode or combination of modes used to provide braking supplemental to the designated primary braking system; not needed in order to meet railroad stopping requirements.

Abbreviations and acronyms

ac alternating current
dc direct current
MU multiple unit

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	March 4, 1999	March 17, 1999
First revision	—	—	—	—	Feb. 13, 2004
Second revision	Nov. 16, 2025	Jan. 30, 2026	February 28, 2026	May 5, 2026	May 13, 2026

The passenger rail industry phased this recommended practice into practice over the six-month period from July 1 to December 31, 1999. The recommended practice took effect January 1, 2000.

