13. APTA PR-E-RP-014-99
Recommended Practice for Diesel Electric Passenger Locomotive Blended Brake Control

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Abstract: This Recommended Practice provides a common design basis for the control and configuration of blended brake systems. 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.

Keywords: blended brake

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The American Public Transportation Association greatly appreciates the contributions of the following individual(s), who provided the primary effort in the drafting of the *Recommended Practice for Diesel Electric Locomotive Blended Brake Control*.

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1. Overview

1.1 Scope

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 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.

1.2 Purpose

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.

2. References

APTA PR-E-RP-006-99, Recommended Practice for Diesel-Electric Passenger Locomotive Dynamic Braking Control

3. Definitions, abbreviations and acronyms

3.1 Definitions

For the purpose of this recommended practice, the following definitions apply.

3.1.1 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.

3.1.2 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.

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

3.1.4 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.

4. 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.

The maximum amount of blended brake retarding force required for a passenger locomotive falls into one of two categories:

- "substitutional" type system, where the maximum blended brake retarding force equals that of a friction only system or,
- "supplemental" type system, where the maximum blended brake retarding force exceeds that of a friction only system. This arrangement provides shorter stopping distances than possible with a friction brake system only.

APTA recommends that a substitutional type system be used (dynamic brake retarding force is used only to substitute for an equivalent friction brake retarding force). A supplemental type system should be used only to meet unusual railroad physical characteristics.

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:

$a = v / t$ or $a = 0.733\, v^2 / d$, where:

a is deceleration in mph/sec,

v is the initial velocity in mph,

d is stopping distance in feet, and

t is the elapsed time in seconds from initiation of braking, until the locomotive is completely stopped.

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

5. Blended brake set-up

Blended brake operation is initiated by the movement of the automatic brake valve handle or lever. Provided the throttle is in "idle" position and dynamic brake handle (if so equipped) is in the off position, a nominal 10-psi (but at least 5-psi) of brake cylinder pressure should be applied. This 10-psi pressure (often referred to as "inshot") is retained until brakes are released. This approach keeps the wheel treads clean and prevents snow or ice build-up on brake shoes/pads in inclement weather. It also makes for a smoother reapplication of friction retarding force when dynamic brake retarding force diminishes.

Upon entry to blended brake, dynamic brake mode of operation will be initiated, without the energization of MU trainlines Nos. 17, 21 and 24.

A dynamic brake interlock is to be provided to override dynamic portion of blended braking whenever the dynamic brake handle is moved to an active position. Returning the dynamic brake handle to zero will resume normal blended braking, dictated by the automatic brake valve handle position.

6. Blended brake control

6.1 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 automatic brake valve handle) minus the 10 psi inshot pressure 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 of 10 psi 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 to a minimum of ten seconds to reach full braking.

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 shown in Figure 1.

– 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. AC locomotives have no such constraint, and have a controlled brake effort as in the middle speed range.

In the event that rail conditions do not support adhesion and it has been detected that the wheels are sliding, both dynamic brake and friction retarding forces are to be reduced to aid recovery from the slide condition.

6.2 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.

A small amount of dynamic braking may be added to the friction brakes if desired, to augment locomotive stopping performance. This is recommended only if the locomotive can benefit from the added retarding effort generated.

6.3 Blended brake lockout (BBL)

A blended brake lockout function provides for the automatic lockout of the dynamic brakes, upon detection of loss of proper control of the system. Lockout of blended brakes will cause the locomotive to operate in "friction only" braking mode.

The blended brake function is to be locked out upon detection of either of the following conditions:

– An abnormally high locomotive braking effort continuously for fifteen (15) seconds. This could be due to a malfunction of either the dynamic brake system, the friction brake system, or both,

– A wheel slide condition lasting continuously for a defined period of time, which should be a maximum of fifteen (15) seconds.

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 No. 2.

7. Qualification testing

Type tests are to be conducted on new 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 to provide a datum for braking initiation. Multiple stops are to be made for each condition, to ensure repeatability of results. Each stop is to be made in the same direction.

7.1 Test procedure

Locomotive testing should be performed using a pair of locomotives, coupled back-to-back, in full M.U. 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.

The brake handle or lever is to be moved to the required braking position as the locomotive crosses the mark. The tests are to be timed, beginning when the handle is moved out of the “release” position.

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

– elapsed time from brake handle movement

– speed

– brake cylinder pressure

– distance

Tests to be conducted for a family of speeds, based on specific property characteristics. Recommended values:

– Any speeds as may be required to show response for Property-specific signal spacing.

– Maximum track speed,

– 70 mph, 112 kph

– 50 mph, 80 kph

– 30 mph, 48 kph

– 20 mph, 32 kph

Tests to be conducted for each of the following conditions:

– full service, blended brakes,

– full service, friction braking only,

– emergency, friction and dynamic,

– emergency, friction braking only.

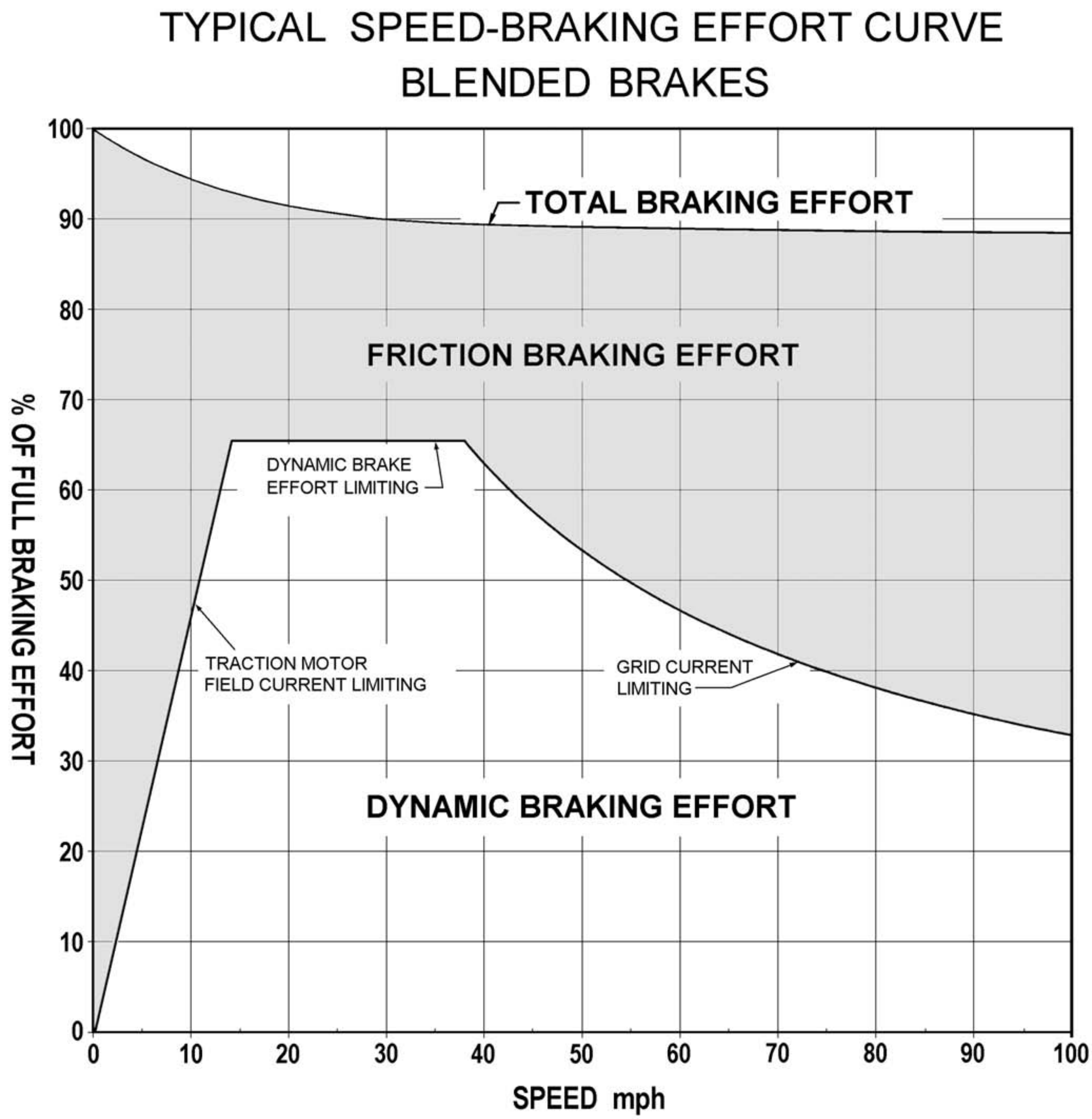
TYPICAL SPEED-BRAKING EFFORT CURVE
BLENDED BRAKES
TOTAL BRAKING EFFORT
FRICTION BRAKING EFFORT
DYNAMIC BRAKE
EFFORT LIMITING
TRACTION MOTOR
FIELD CURRENT LIMITING
GRID CURRENT
LIMITING
DYNAMIC BRAKING EFFORT
% OF FULL BRAKING EFFORT
SPEED mph
0
10
20
30
40
50
60
70
80
90
100

Figure 1.