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PRESS Mechanical Working Group

ECP Passenger Cable-Based Braking System—Interoperability Procedure

Abstract: This safety standard contains the test procedure that SUPPLIER-A and SUPPLIER-B intend to complete to establish the interoperability baseline among ECP systems that comply with the APTA family of standards for electronically controlled pneumatic (ECP) brake systems operating on passenger cars that are part of the general railroad system.

Keywords: brake, ECP, railcar, train, interoperability, test

Summary: This standard identifies the minimum tests for the demonstration of interoperability between suppliers at a vehicle level for ECP brake systems in service on passenger train equipment. It is not the intent of this test procedure to verify that a supplier complies with all the requirements of APTA. This test procedure will validate only that the SUPPLIER-A and SUPPLIER-B systems are functionally interoperable between locomotives and cars equipped with SUPPLIER-A or SUPPLIER-B ECP equipment. The scope of the tests will include ECP mode. Any new supplier will need to qualify with all previously approved (conditionally approved) suppliers' equipment.

Scope and purpose: The objectives of this standard are to define the minimum required interoperability tests, to define the acceptance criteria for such tests, and to ensure that trains in ECP passenger operation with cars and locomotives equipped with two different suppliers' systems can safely interoperate.

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Introduction

This introduction is not part of APTA PR-M-S-026-19, "ECP Passenger Cable-Based Braking System—Interoperability Procedure."

This standard applies to all:

1. Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. 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 standard does not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. Tourist, scenic, historic, or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

ECP Passenger Cable-Based Braking System—Interoperability Procedure

1. Description of ECP braking system

An ECP braking system is a train-powered braking system actuated by compressed air and controlled by electronic signals originating from a lead locomotive or cab car. The electronic signals are used to communicate service and emergency brake applications, as well as to control power and receive feedback from other devices in the train. Since brake commands are derived from electronic signals, the brake pipe will typically remain charged and provide backup brake commands.

The “cable-based” ECP brake system provides communications and a potential source of power to all the ECP brake devices in the train via a two-conductor electric trainline that spans the entire length of the train.

The system provides shorter response times to braking commands and includes support for graduated releases and reapplications. The system responds appropriately to undesired separation or malfunction of hoses, cabling or brake pipe.

2. Test configuration

2.1 Test location

This test procedure is intended to be run only at the host supplier’s site. By using a variety of equipment configurations from both suppliers, it will not be necessary to repeat this test at the visiting supplier’s facility.

2.2 Test rack configuration

Tests shall be performed using various train configurations as defined in the test procedures that will include both SUPPLIER-A and SUPPLIER-B supplied equipment to validate interoperability requirements. Supplier A will be the visiting supplier, and Supplier B will be the host supplier.

> **NOTE:** Tests can be run with a separate EOT device, instead of using the last ECP vehicle set as an EOT.
> **NOTE:** Throughout this standard, the term ”locomotive” means either a locomotive or cab car performing the functions of a locomotive.

The systems to be tested include the following components:

- Locomotive and cab car HEU, PSC and IDM equipment:
  - SUPPLIER-A
  - SUPPLIER-B
- Coach car CCD and IDM equipment:
  - SUPPLIER-A
  - SUPPLIER-B

2.3 Equipment configuration

For each vehicle used in the test, ensure that the locomotive and car ID parameters are set per **Table 1** and **Table 2**:

TABLE 1
Locomotive Configuration Parameters

Parameter	Value
Vehicle road number	n/a for test
Vehicle type	n/a for test
Stretched length	n/a for test
Nominal weight	216,100 lbs
Number of axles	4
Wheel diameter	n/a for test
Train net braking ratio	n/a for test
BP set point default	110 psi
Suppression brake application	n/a for test
Low-input voltage detect limit	n/a for test
Low-input voltage clear limit	n/a for test
Vehicle orientation reference	0

TABLE 2
CCD Configuration Parameters

Parameter	Value
Reporting mark	Per test rack car position (car 1, car 2, car 75, etc.)
Car type	n/a for test
Car length	n/a for test
Brakes controlled	1.0
Number axles	4
Empty weight	n/a for test
Loaded weight	n/a for test
Brake constant	n/a for test
Reservoir constant	n/a for test
Net braking ratio	n/a for test
Minimum service pressure	10 psi
Empty/load device type	n/a for test
Sequencing orientation	Per supplier requirements.
Loaded FS pressure	41 psi
Emergency ratio	120%

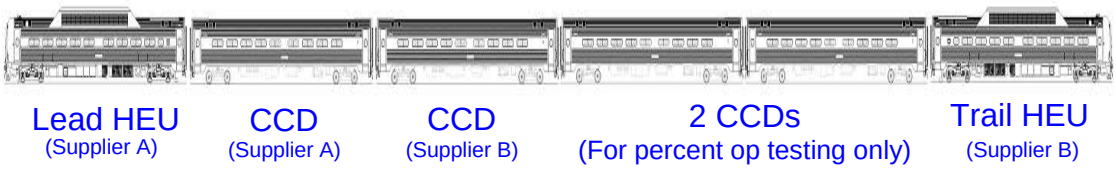
3. ECP test procedures

As identified herein, the ECP operational tests include, but are not limited to, the following:

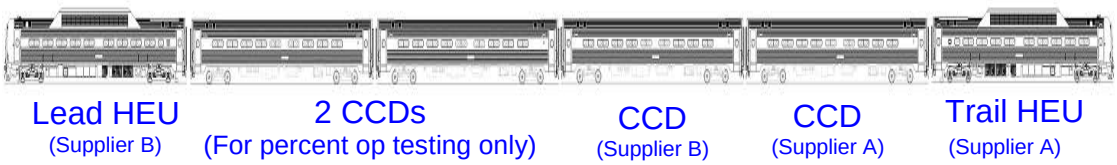
- system initialization
- sequencing
- system mode control
- train brake control
- trainline power supply control
- fault response and recovery

Unless otherwise stated, all tests are to be performed twice, once with Supplier A's HEU equipment in lead and once with Supplier B's HEU equipment in lead. The test configuration shall include at a minimum the following devices: a SUPPLIER-A HEU and PSC, a SUPPLIER-A CCD, a SUPPLIER-B CCD, and a SUPPLIER-B HEU and PSC.

- Supplier A lead



- Supplier B lead



3.1 ECP mode entry and exit

3.1.1 ECP Trail

NOTE: This test is required to be run only once.

A. Start this test with all HEUs set to ECP trail.
B. Using trainline protocol analyzer, verify that none of the HEUs are broadcasting any HEU beacons or system commands on the trainline.

Test passed if all identified verification items are correct.

TEST PASSED? ☐**Yes** ☐**No**

3.1.2 ECP Operating Mode Selection—ECP Trail to RUN

A. Start this test with the HEU in the lead vehicle position in TRAIL state, the brake pipe charged to 110 psi (±2 psi) and car reservoirs charged to main reservoir equalizing pipe, the AUTO handle in Release, and the last vehicle set up as an EOT.
B. From the HEU in the lead vehicle position, set the ECP mode to RUN (respond to any operator prompts as required).

C. Using the display of the HEU in the lead vehicle position, verify that the ECP system has entered INIT mode and that a brake interlock is commanded with TBC = 100 percent (full service).
D. Allow the ECP system to complete a train makeup. From the HEU in the lead vehicle position, follow the operator prompts and crew messages and enter RUN mode.
E. Using the display of the HEU in the lead vehicle position, verify that the system enters RUN mode with trainline power turned ON.
F. If not already prompted to do so, move the AUTO handle to FS and ensure that the full-service brake interlock clears.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.1.3 ECP Operating Mode Selection—RUN to END ECP

A. Start this test with the HEU in the lead vehicle position in LEAD state, the ECP system mode set to RUN, the brake pipe and car reservoirs charged, the ECP TBC = 0 percent (Release), trainline power set to AUTO, and the trailing HEU set up as an ECP EOT.
B. From the HEU in the lead vehicle position, reduce brake pipe to below 25 psi and set ECP system mode to CUTOUT/END ECP.
C. Using the display of the HEU in the lead vehicle position, verify that trainline power turns OFF and that ECP display information is no longer displayed.
D. Verify that the CCDs transition into emulation mode with the brakes set to an emergency level.
E. Verify that within 10 s after step B that the last vehicle stops sending EOT beacons.
F. Recharge brake pipe and ensure that all CCDs release.
G. Make a minimum service application and ensure that all vehicles apply a minimum service brake.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2 RUN Mode operation

These tests verify ECP RUN Mode functions, including initial restart of CCDs via trainline power application; HEU automatic detection of EOT and head-end termination; initialization mode; that a full-service brake interlock is maintained; that the correct number of vehicles is found; that the percent operable is correct; and that the train's consist is correct.

3.2.1 ECP Initialization

A. Start with the Car Onboard power set to OFF, the CCDs shut down, brake pipe pressure at 0 psi and the AUTO handle in emergency.
B. Verify that all intercar connectors are connected, including the termination cables at both the lead and trail vehicles and that the cars are shut down.
C. At the trail vehicle position leave the HEU in trail state and enable the vehicle as EOT function per the supplier's specific requirements.
D. At the HEU in the lead vehicle position, follow the supplier's procedure to initialize the ECP system, and request system RUN mode with trainline power set to AUTO.
E. Using the display of the HEU in the lead vehicle position, verify that the system enters INIT mode and that a 120 percent brake application is commanded.
F. Using the display of the HEU in the lead vehicle position, verify that trainline power turns ON and remains ON.

G. Using the display of the HEU in the lead vehicle position, verify that the correct number of vehicles is found.
H. Using the display of the HEU in the lead vehicle position, verify that the correct number of potentially operative brakes is found and that the operator is prompted to confirm the total number of operative brakes and is provided the ability to increase the total number of operative brakes.
I. Accept the number of operative brakes found.
J. At the HEU in the lead vehicle position, charge brake pipe and initiate train SEQUENCING in accordance with the supplier's procedure.
K. After sequencing completes, use the display of the HEU in the lead vehicle position to verify that the percent operable increases to 100 percent.
L. Using the display of the HEU in the lead vehicle position, verify that the brake pipe pressure received from the EOT is continuously displayed by the HEU, and verify that it is charged or charging.
M. At the HEU in the lead vehicle position, clear the brake interlock per supplier instructions.
N. Verify that the system is in ECP RUN mode.
O. At the HEU in the lead vehicle position, command a TBC of 0 percent (Release) and verify that the cars release the brakes.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.1.1 ECP Initialization—Train with Identical CCD Addresses

This test verifies that, if all CCDs were to have the same subnet/node address, then a train makeup is successfully completed and that all CCDs are assigned a unique subnet/node address.

A. Use an ECP portable test unit (PTU) tool and assign all CCDs the same subnet/node address.
B. At the HEU in the lead vehicle position with trainline termination connected, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
C. Verify that the correct number of vehicles is found. Verify that the correct number of potentially operative brakes is found.
D. Verify that all CCDs have been assigned a unique subnet/node address and that they are in the range specified in APTA PR-M-S-023-19, latest revision **"**ECP Passenger Cable-Based Brake DC Power Supply – Performance Requirements."

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.1.2 ECP Initialization—Operation at Various BP Set Points

This test verifies that if a supplier's ECP vehicle allows ECP operation with feed valve settings of other than 110 psi, that the HEU changes the train dynamic configuration message and that the system correctly responds to these changes.

A. At the HEU in the lead vehicle position with trainline termination connected, follow the supplier-specific procedure to change the feed valve setting to the supplier's lowest allowed value, initialize the ECP system, and enter system RUN mode with trainline power set to AUTO and brake pipe charged.
B. At the HEU in the lead vehicle position, command a brake release (TBC = 0 percent).

C. At the HEU in the lead vehicle position, command a full-service brake application (TBC = 100 percent).
D. Verify that the SUPPLIER-B and the SUPPLIER-A CCDs provide brake cylinder pressure of approximately 38 to 41 psi.
E. Slowly drop BP down to 55 psi and verify that the CCDs remain at full service and do not indicate a critical loss of BP.
F. Slowly drop BP down to half of the current feed valve setting and verify that the CCDs go to an emergency brake cylinder level and that an operator warning for loss of brake pipe is displayed.
G. At the HEU in the lead vehicle position, set the ECP system mode to CUTOUT/END ECP.
H. Follow the supplier-specific procedure to restore the feed valve setting to 110 psi.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.1.3 CCD Status Response

This test verifies that the CCD status message from either a SUPPLIER-B or a SUPPLIER-A CCD is correctly received from either a SUPPLIER-B or a SUPPLIER-A HEU.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode.
B. Using the display of the HEU in the lead vehicle position, show the CCD status information of the other suppliers CCD. Verify that the information (cut-in/cut-out status, BP pressure, reservoir pressure, BC pressure, etc.) is displayed properly.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.1.4 PSC Status Response

This test verifies that the Trainline Power Supply PSC status message from either a SUPPLIER-B or a SUPPLIER-A PSC is correctly received by either a SUPPLIER-B or a SUPPLIER-A HEU.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO.
B. Using the display of the HEU in the lead vehicle position, if PSC information is provided by the supplier, verify that the PSC status information is shown properly.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.1.5 EOT Status

This test verifies that the ECP EOT status message from either a SUPPLIER-B or a SUPPLIER-A EOT is correctly received from either a SUPPLIER-B or a SUPPLIER-A HEU.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO.
B. Using the display of the HEU in the lead vehicle position, verify that the EOT status information is shown properly.

Test passed if all identified verification items are correct.

TEST PASSED? ☐Yes ☐No

3.2.2 Train Sequencing

The purpose of this test is to verify that the HEU correctly performs train sequencing. Sequencing shall be tested with the locomotives connected to the first car in the train and then repeated with the locomotives connected to the last car in the train. The ability to handle sequencing pulses in both polarities is verified.

A. Connect the F end end of the lead position vehicle to its termination. Connect the B end end of the lead position vehicle to the rest of the train and B end of the last vehicle to the rest of the train.
B. Set up the last vehicle as EOT or, if using a standalone EOT, connect the EOT to the A end of the last vehicle.
C. With the lead position HEU set to ECP trail state, charge the brake pipe and car reservoirs to 110 psi.
D. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with train sequencing completed and trainline power set to AUTO.
E. Using the display of the HEU in the lead vehicle position, verify that the HEU determines the correct order of the vehicles in the train. When run with Supplier A in lead, the correct order is lead HEU, then car 1, then car 2 and then the last vehicle. When run with Supplier B in lead, the correct order is lead HEU, then car 2, then car 1 and then the last vehicle.
F. Using the display of the HEU in the lead vehicle position, verify that the HEU determines the correct orientation of each vehicle in the train. For the lead locomotive, the F end is forward. For the last vehicle, the B end is forward.
G. At the HEU in the lead vehicle position, set the ECP system mode to CUTOUT/END ECP.
H. Connect the B end of the lead position vehicle to its termination. Connect the F end of the lead position HEU to the rest of the train. Leave the B end of the last vehicle connected to the rest of the train and set up the last vehicle as EOT or, if using a standalone EOT, connect the EOT to the short hood end of the last vehicle.
I. Repeat steps C through E.
J. Using the display of the HEU in the lead vehicle position, verify that the HEU determines the correct orientation of each vehicle in the train. For the lead HEU, the B end is forward. For the last vehicle, the B end is forward.
K. At the HEU in the lead vehicle position, set the ECP system mode to CUTOUT/END ECP.
L. Reverse the polarity of the trainline between the lead position HEU and the last vehicle (either by inserting a crossover cable or by rewiring an end-of-vehicle junction box).
M. Repeat steps C through E.
N. Using the display of the HEU in the lead vehicle position, verify that the HEU determines the correct orientation of each vehicle in the train. For the lead HEU, the B end is forward. For the last vehicle, the B end is forward.

O. At the HEU in the lead vehicle position, set the ECP system mode to CUTOUT/END ECP.
P. Remove the trainline crossover that was installed in step L.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.3 Brake control

3.2.3.1 Brake Control—Normal Mode

The purpose of this test is to verify that the cars respond to apply and release the brake as TBC is changed in various steps. This test also demonstrates that the SUPPLIER-A and SUPPLIER-B CCDs achieve the same target BC pressure during the various brake applications and releases made in this procedure.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, independent/park brake set to Release and a TBC of 0 percent.
B. At the HEU in the lead vehicle position, make a minimum service application and verify that the TBC is displayed as 10 percent. Verify that the BC pressure on both a SUPPLIER-B and a SUPPLIER-A car is 10 psi ±3 psi.
C. At the HEU in the lead vehicle position, increase the TBC to 100 percent in steps of approximately 10 percent (wait approximately 10 s at each step). Verify that the CCDs increase brake cylinder pressure according to the change in TBC. Verify that each of the supplier's cars and locomotives achieve within ±3 psi of the BC pressures shown in **Table 3**.

TABLE 3
Brake Cylinder Pressures

TBC	Approximate Loco BCP	Approximate Car BCP
10	11	10
20	16	13
30	22	17
40	28	20
50	34	24
60	40	27
70	46	31
80	52	34
90	58	38
100	64	41

D. At the HEU in the lead vehicle position, generate an ECP-only emergency and verify that the TBC shown on the lead HEU increases to 120 percent. Verify that the BC pressure on both a SUPPLIER-B and a SUPPLIER-A car is emergency brake cylinder pressure± 3 psi and on a SUPPLIER-B locomotive is emergency brake cylinder pressure ±3 psi.
E. Move the AUTO handle to EMERGENCY.
F. Using the display of the HEU in the lead vehicle position, verify that the TBC remains 120 percent and that brake pipe pressure rapidly decreases to zero. Verify that the lead and trailing HEU's and all cars' brake cylinder pressures are at emergency pressure.

G. Move the AUTO handle to Release.
H. Using the display of the HEU in the lead vehicle position, verify that the TBC remains at 120 percent. Verify that the TBC cannot be reduced to less than 120 percent until 120 s after the handle was moved to 120 percent in step D.
I. After 120 s (from step E), recover the emergency brake application and recharge the brake pipe.
J. At the HEU in the lead vehicle position, and the TBC at 100 percent, decrease the TBC to 10 percent in steps of approximately 10 percent (wait approximately 10 s at each step). Verify that the CCDs decrease brake cylinder pressure according to the change in TBC. Verify that each of the supplier's cars and locomotives achieve within ±3 psi of the BC pressures shown in **Table 4**.

TABLE 4
Brake Cylinder Pressures

TBC	Approximate Loco BCP	Approximate Car BCP
10	11	10
20	16	13
30	22	17
40	28	20
50	34	24
60	40	27
70	46	31
80	52	34
90	58	38
100	64	41

K. At the HEU in the lead vehicle position, release the brakes (TBC = 0 percent) and verify that the CCDs release the brakes. Verify that the BC pressure on both a SUPPLIER-B and a SUPPLIER-A car and the locomotive is zero.
L. Verify that an undesired emergency brake pipe reduction has not occurred during the above tests.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.3.2 Brake Control—Pneumatic Backup

The purpose of this test is to verify that when the brake pipe is vented to zero when there are CCDs that are not capable of operating in ECP, that their pneumatic backup function applies emergency brake cylinder pressure. It also verifies that when the brake pipe is then recharged, the pneumatic backup releases the brake cylinder pressure.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO and a TBC of 0 percent.
B. Using the lead HEU operator display, cut out a car from Supplier A and a car from Supplier B per the supplier's instruction so that they are incapable of responding electrically to a pneumatic emergency.
C. Move the AUTO handle to EMERGENCY and verify that the brake pipe rapidly decreases to zero.
D. Verify that the CCDs that were not disabled in step B apply emergency brake cylinder pressure. Verify on both the disabled SUPPLIER-B and SUPPLIER-A cars that the BC pressure has increased

to 46 to 49 psi and does not increase to equalization pressure. Depending on how the car was disabled, this may need to be measured using a gauge or equivalent test instrument.

E. At the HEU in the lead vehicle position, set the ECP system mode to CUTOUT/END ECP.
F. Verify that trainline power is OFF and that the CCDs enter emulation but do not release their brakes.
G. Move the AUTO handle to Release and recharge brake pipe pressure.
H. Verify that all CCDs release brake cylinder pressure.
I. Make a minimum service application and ensure that all vehicles apply a minimum service brake.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.4 Snow Brake Control

NOTE: Required only if supported by supplier.

The purpose of this test is to verify that the Snow Brake Control functions correctly.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO and a TBC of 0 percent.
B. Activate the Snow Brake Control with the HEU in the lead vehicle position via the supplier's instruction.
C. Using the display of the HEU in the lead vehicle position, verify that the Snow Brake Control is ON.
D. Verify that the Snow Brake Control is active on each car.
E. Turn off the Snow Brake Control with the HEU in the lead vehicle position via the supplier's instruction.
F. Using the display of the HEU in the lead vehicle position, verify that the Snow Brake Control is OFF.
G. Verify that the Snow Brake Control is no longer active on each car.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.5 Trainline Power Control

The purpose of this test is to verify that the Trainline Power Control functions correctly, including control of multiple power supplies.

3.2.5.1 Power OFF Mode

A. With the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO and a TBC of 0 percent.
B. Verify that all available trainline power supplies are ON.
C. Using the display of the HEU in the lead vehicle position, verify that trainline power is ON.
D. With the HEU in the lead vehicle position, set trainline power OFF.

E. Using the display of the HEU in the lead vehicle position, verify that the trainline power turns OFF and remains OFF at all power supplies.
F. Using the display of the HEU in the lead vehicle position, verify that the HEU display for trainline power is OFF.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.5.2 AUTOMATIC Power Mode—EOT Detected

A. With the HEU in the lead vehicle position with trainline termination connected, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO and a TBC of 0 percent.
B. Disconnect trainline at the last vehicle and verify that trainline power turns OFF. Note that the brakes apply due to loss of EOT beacon in RUN mode.
C. Reconnect the EOT and verify that trainline power can transition to ON.

NOTE: This may or may not require an operator action at the HEU.

D. With the HEU in the lead vehicle position, set the ECP system mode to CUTOUT/END ECP.
E. With the HEU in the lead vehicle position and with trainline termination connected, follow manufacturer procedure to initialize the ECP system with the last vehicle disconnected.
F. Verify that 230 V turns ON and then OFF in 8 s or less.

NOTE: This is due to the lack of an EOT.

G. Reconnect the last vehicle and verify that trainline power can transition to ON.

NOTE: This may or may not require an operator action at the HEU.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.5.3 HEU Multiple PSC Management

The purpose of this test is to verify the interoperability requirements, enabling a non-lead PSC (trainline power supply) as a primary when the lead PSC cannot be enabled as a primary.

A. Create a condition that will cause the lead locomotive's PSC (trainline power supply) to *not* be enabled as a primary PSC (such as it not being able to receive HEU beacons).
B. With the HEU in the lead locomotive position with trainline termination connected, follow manufacturer procedure to attempt to initialize the ECP system for entering RUN mode with trainline power set to AUTO and a TBC of 0 percent.
C. Verify that trainline power does NOT turn on and that RUN mode is NOT entered.
D. Verify that the display of the lead HEU provides the operator with the trail vehicle's reporting mark and that it provides a prompt requesting the operator to confirm that the trail vehicle/PSC is in the train.
E. Follow the lead HEU's prompt to confirm that the trail vehicle/PSC is in the train.
F. Verify that the trail locomotive's trainline power supply turns on.

G. Using the display of the HEU in the lead locomotive position, verify that trainline power is ON.
H. Verify that RUN mode can be entered and that trainline power remains on.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.6 Individual CCD CUT-OUT and CUT-IN Commands

The purpose of this test is to verify that the CCDs cut out and release brake cylinder pressure in response to an individual Cut-Out/Cut-In command when the operating mode is RUN.

A. From the HEU in the lead vehicle position with trainline termination connected, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO and a TBC of 100 percent.
B. From the HEU in the lead vehicle position, send an individual CUT-OUT command to a CCD (when using a SUPPLIER-B HEU select a SUPPLIER-A CCD, and when using a SUPPLIER-A HEU select a SUPPLIER-B CCD).
C. Verify that the CCD selected in step B goes to CUT-OUT and that its brake cylinder pressure releases to zero.
D. Using the display of the HEU in the lead vehicle position, verify that the percent operable decreases.
E. From the HEU in the lead vehicle position, send an individual command of CUT-IN to the CCD selected in step B.
F. Verify that the CCD selected in step B goes to CUT-IN and that its brake cylinder increases to full service.
G. Using the display of the HEU in the lead vehicle position, verify that the percent operable changes to 100 percent.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.7 CCD Isolated Critical Loss CUT-OUT

The purpose of this test is to verify that, if a CCD with an isolated critical fault detects that the fault condition is cleared, then the HEU still considers such a CCD as cut out and inoperative until the HEU determines that the CCD is cut in.

A. At the HEU in the lead vehicle position with trainline termination connected, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO and a TBC of 100 percent.
B. On one car only, close the two end-of-car cut-out cocks and vent brake pipe to zero (when using a SUPPLIER-B HEU select a SUPPLIER-A CCD, and when using a SUPPLIER-A HEU select a SUPPLIER-B CCD).
C. Using the display of the HEU in the lead vehicle position, verify that the CCD on this car cuts out due to an isolated critical condition.
D. Using the display of the HEU in the lead vehicle position, verify that the percent operable decreases.
E. Open the cut-out cocks on the isolated car and allow the brake pipe in this car to recharge.

F. At the HEU in the lead vehicle position, verify that the CCD can be cut in (either automatically by the HEU or when necessary by operator action).
G. Using the display of the HEU in the lead vehicle position, verify that the percent operable changes to 100 percent. Note that this may take more time to complete than one polling cycle.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8 Fault response and recovery

3.2.8.1 Loss of EOT Beacon

The purpose of this test is to verify that if the HEU fails to receive the EOT beacon for 6 s, then the HEU commands an emergency brake and it remains in effect for a minimum of 120 s. The test verifies that recovery from this fault condition can be made if the HEU subsequently receives the EOT beacon.

A. With the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO and a TBC of 0 percent.
B. Disconnect the EOT from the trainline and verify that within 6 to 8 s the cars apply brakes. Verify that BC pressure increases to emergency.
C. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 120 percent
    - Trainline power = OFF
D. Using the brake control handle in the lead locomotive, attempt to go to full service (TBC = 100 percent) and verify the following:
    - TBC remains at 120 percent
    - Trainline power = OFF
E. Reconnect the EOT to the trainline.
F. After at least 120 s has passed from the completion of step B, proceed to step G.
G. Recover the penalty and verify that the car's brake application can be released and that the trainline power can be restored.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.2 EOT Detects Low BPP

The purpose of this test is to verify that when the EOT detects low brake pipe pressure (BPP), the HEU provides a warning to the operator.

A. With the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Reduce brake pipe on only the ECP EOT to 70 psi.

C. Using the display of the HEU in the lead vehicle position, verify the following:
   - TBC = 0 percent
   - a warning is provided to the operator

D. Recharge brake pipe on the ECP EOT to 82 psi.

Test passed if all identified verification items are correct.

TEST PASSED? ☐Yes ☐No

3.2.8.3 System Loss of HEU Beacon

The purpose of this test is to verify that when the system-critical loss fault occurs on all network devices as a result of a loss of HEU beacon, the HEU commands an emergency brake application and the CCDs and trailing vehicle self-initiate an emergency brake application.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Disconnect the ECP trainline intercar connector between the lead vehicle and the first car and verify that within 6 to 8 s the CCDs make a brake application and that BCP increases to emergency.
C. Using the display of the HEU in the lead vehicle position, verify that TBC is at 120 percent and that Trainline Power is OFF.
D. Using the brake control handle in the lead vehicle position, attempt to go to full service (TBC = 100 percent) and verify that it is not possible to go to TBC = 100 percent at this time.
E. Using the display of the HEU in the lead vehicle position, verify that TBC = 120 percent and Trainline Power is OFF.
F. Reconnect the inter-car connector and after at least 120 s has passed from the completion of step B, proceed to G.
G. At the HEU in the lead vehicle position, verify that the ECP system can be recovered from emergency and the trainline power can be restored.

Test passed if all identified verification items are correct.

TEST PASSED? ☐Yes ☐No

3.2.8.4 Loss of HEU Beacon on Last Vehicle

The purpose of this test is to verify that when the last vehicle loses the HEU beacon, an emergency brake application is provided by the vehicle. It also verifies that recovery from this fault condition can be made by the HEU commanding a critical fault logic reset.

A. Connect the lead position vehicle to the last vehicle and configure the last vehicle as an EOT.
B. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
C. Disconnect the trainline ECP intercar connector between the 2 vehicles and verify that the brakes start to apply on the last vehicle within 6 to 8 s.
D. After a minimum of 120 s from step C, reconnect the trainline ECP intercar connector.

E. At the HEU in the lead vehicle position, set the train back up in ECP RUN Mode and set the TBC to 0 percent.
F. Verify that the last vehicle's brakes release.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.5 Loss of HEU Beacon on Two Devices Only (One Supplier B CCD, One Supplier A CCD)

The purpose of this test is to verify that when the system-critical loss fault occurs on only two network devices as a result of a loss of HEU beacon, an emergency brake application is provided by the car(s). It verifies that recovery from this fault condition can be made by the HEU commanding a critical fault logic reset.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN Mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. At the same time, disconnect the ITC trainline in front of the first car and behind the second car and verify that the brakes start to apply on both cars within 6 to 8 s.
C. After a minimum of 120 s, reconnect the CCD cables.
D. At the HEU in the lead vehicle position, set the train back up in ECP RUN Mode and set the TBC to 0 percent.
E. Verify that the brakes release on both cars.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.6 EOT Detects Loss of BPP

NOTE: For standalone EOT configurations only.

The purpose of this test is to verify that when the EOT detects a loss of BP pressure, the HEU commands a full-service brake. It verifies that recovery from this fault condition can be made once the EOT clears this condition.

A. Disconnect the termination at the last vehicle and connect a standalone ECP EOT device.
B. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
C. Reduce brake pipe on only the EOT to less than 61 psi.
D. Using the display of the HEU in the lead vehicle position, verify that TBC is 100 percent as a result of a loss of BPP at the EOT.
E. Using the display of the HEU in the lead vehicle position, verify the following:
    - the penalty cannot be recovered at the HEU
    - TBC remains at 100 percent
F. Recharge brake pipe on the EOT to greater than 82 psi.
G. With the HEU in the lead vehicle position, verify that the penalty can be recovered, and recover from penalty.

H. With the HEU in the lead vehicle position, set TBC to 0 percent.
I. Verify that the brakes release.
J. Disconnect the standalone EOT and reconfigure the last vehicle as EOT.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.7 System Loss of BPP

The purpose of this test is to verify that when the system-critical loss fault occurs on all network devices as a result of a loss of BP pressure, the HEU commands an emergency brake application. The test also verifies recovery from this fault condition.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Manually open the brake pipe, creating a trainline brake pipe emergency reduction to zero.
C. Verify that within 1 to 3 s the CCDs make a brake application.
D. Verify that BC pressure increases to emergency.
E. Using the display of the HEU in the lead vehicle position, verify the following:
    - BP = 0
    - TBC = 120 percent
F. Manually close the brake pipe.
G. Move the AUTO handle to emergency and verify the following:
    - BP = 0
    - TBC = 120 percent
H. After approximately 60 s (EAB reset timer), move the AUTO handle directly to Release and verify that the TBC remains at 120 percent.
I. Recover from the penalty and charge BP to the set point and release the brakes.
J. Verify that the brakes release.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.8 Loss of BPP on the Last Vehicle

The purpose of this test is to verify that when the system-critical loss fault occurs on the last vehicle as a result of a loss of BP pressure, the HEU commands an emergency brake application. The test also verifies that recovery from this fault condition can be made when the condition has cleared.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Close the brake pipe angle cock before the last vehicle.
C. Vent brake pipe to zero at an emergency rate on only the last vehicle.
D. Using the display of the HEU in the lead vehicle position, verify that TBC is at 120 percent.
E. Verify that the brakes on all cars on the train charge to the emergency level.
F. With the HEU in the lead vehicle position, verify that the penalty cannot be recovered until the condition at the end of the train is cleared.
G. Slowly open the angle cock and recharge the brake pipe on the last vehicle.

H. Wait until BP has charged to at least 82 psi on the EOT.
I. With the HEU in the lead vehicle position, verify that the penalty can be recovered and recover from penalty.
J. With the HEU in the lead vehicle position, set the TBC to 0 percent.
K. Verify that the brakes release.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.9 Loss of BPP on Two Devices Only (One Supplier A CCD, One Supplier B CCD)

The purpose of this test is to verify that when the system-critical loss fault occurs on a minimum of two vehicles as a result of a loss of BP pressure, the HEU commands an emergency brake application. The test also verifies that recovery from this fault condition can be made when the condition has cleared.

A. This test can be performed on any two adjacent cars outfitted with a SUPPLIER-A CCD and a SUPPLIER-B CCD.
B. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
C. Close the brake pipe angle cocks between the cars adjacent to the two cars chosen for this test, isolating BP on these two cars from the rest of the train.
D. Vent brake pipe to zero at an emergency rate on only the two cars chosen for this test.
E. Verify that the brakes apply on all cars.
F. With the HEU in the lead vehicle position, verify that the penalty cannot be recovered (until the condition is cleared).
G. Slowly open the angle cocks closed in step C, and recharge the brake pipe on these two cars.
H. Wait until BP has charged to at least 82 psi on the two chosen cars.
I. With the HEU in the lead vehicle position, verify that the penalty can be recovered at the HEU and recover from penalty.
J. With the HEU in the lead vehicle position, set the TBC to 0 percent.
K. Verify that the brakes release.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.10 System Loss of HEU Beacon and BPP

The purpose of this test is to verify that when the system-critical loss occurs on all network devices as a result of a simultaneous loss of HEU beacon and brake pipe pressure, the HEU and cars command an emergency brake application.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Manually open the brake pipe, creating a trainline brake pipe emergency reduction to zero, and at the same time disconnect the ECP intercar connector between cars 1 and 2.
C. Using the display of the HEU in the lead vehicle position, verify that the TBC on the HEU changes to 120 percent.
D. Verify that the BC on all cars applies to an emergency level.

E. Manually close the brake pipe and reconnect the ECP intercar connector.
F. With the HEU in the lead vehicle position, recover from the emergency.
G. Allow the brake pipe to recharge.
H. With the HEU in the lead vehicle position, set TBC to 0 percent.
I. Verify that all cars release brakes.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.11 Critical Loss Relay Message—CCDs and Trailing HEU Generated

The purpose of this test is to verify that CCDs and trailing HEUs that have self-initiated an emergency generate the critical loss relay message if the TBC is not 120 percent within 5 s of self-initiating the emergency. This test uses an ECP message simulator to simulate the lead HEU. This is required to keep the TBC less than 120 percent. It verifies that the critical-loss message is sent until the TBC changes to 120 percent or a 50 to 70 s monitoring period ends. A trainline-protocol analyzer is needed to verify that the "critical loss relay" message has occurred.

A. Charge BP to feed valve, and then set the HEU in the lead vehicle position to trail state.
B. Use an ECP message simulator to send HEU beacons with INIT mode, a TBC of 100 percent and trainline power ON. Manually turn on trainline power within 3 s of starting the HEU beacons.
C. After 10 s, change the HEU beacon mode to RUN and the TBC to 0 percent, and ensure that all cars release their brakes.
D. Close off the BP between cars 1 and 2.
E. Create a pneumatic emergency brake pipe reduction on the front half of the train.
F. Verify that all cars in the train (both front half and back half) increase their BC to an emergency level.
G. Use a message protocol analyzer and verify that within 5 ± 1 s from the time the CCDs and HEUs in trail state self-initiated an emergency, the CCDs and trail state HEUs generate the critical loss relay message. (Due to the limited bandwidth of the network, not all of these messages are expected to make it through.) Verify that critical loss relay messages are received from CCDs in both the front half and the rear half of the train.
H. With the message protocol analyzer, verify that this message is repeated approximately every 5 s for the next 50 to 70s and then stops.
I. Use the ECP message simulator to command the TBC to 120 percent.
J. Recharge the brake pipe and reopen BP between the cars selected in step C. Once BP is charged, close off the BP between the same two cars.
K. Use the ECP message simulator to command the TBC to 0 percent, and verify that all CCDs release BC.
L. Create a pneumatic emergency brake pipe reduction on the front half of the train.
M. Use the message protocol analyzer and verify that the CCDs and trailing HEU generate the critical loss relay message and that the message is repeated every 5 s.
N. After approximately 20 s, use the ECP message simulator to command the TBC to 100 percent.
O. Use the message protocol analyzer to verify that the critical loss relay messages do not stop.
P. After a maximum of 30 s from the second pneumatic emergency, use the ECP message simulator to command the TBC to 120 percent.

Q. Use the message protocol analyzer to verify that the critical loss relay messages stop.
R. Open brake pipe blockage between the cars selected in step C.
S. Recharge the brake pipe, and use the ECP message simulator to cut out the train.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.12 Reduced Percentage of Operative Brakes

The purpose of this test is to verify that when the percent operable decreases below 95 percent, an operator warning is provided, and then again when the percent operable falls below 90 percent, and then again when the percent operable falls below 85 percent, and then again when the percent operable falls below 75 percent. It verifies that a penalty brake is applied when the percent operable decreases below 50 percent. It also verifies that the HEU correctly determines the percent operable, including CCDs that are inoperable because of communication loss with the HEU, low reservoir or cut-out by the operator. Recovery is verified by the percent operable increasing appropriately.

For this section of the test, two additional ECP cars are required to obtain the desired percent operable levels. These cars may be either freight- or passenger-equipped cars.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Simulate the closing of one of the truck cut-out switches on one of the passenger CCDs.
C. Wait a complete polling cycle of the CCDs.
D. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 0 percent
    - % Operable = reduces to 92 percent
    - A Below 95% Operable Brakes warning is provided
E. Disconnect the CCD trainline connector on the CCD that has a simulated truck cut-out.
F. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 0 percent
    - % Operable = reduces to 85 percent
    - A Below 90% Operable Brakes warning is provided
G. Simulate the closing of one of the truck cut-out switches on one of the remaining passenger CCDs.
H. Wait a complete polling cycle of the CCDs.
I. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 0 percent
    - % Operable = reduces to 78 percent
    - A Below 85% Operable Brakes warning is provided
J. At the HEU in the lead vehicle position, command the last CCD to CUT-OUT.
K. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 0 percent
    - % Operable = reduces to 64 percent
    - A Below 75% Operable Brakes warning is provided
L. Pneumatically cut out one of the remaining two cars, open their reservoirs to atmosphere and vent the reservoir pressure.
M. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 0 percent
    - % Operable = reduces to 50 percent

N. Simulate the closing of one of the truck cut-out switches on the HEU in the lead vehicle position.
O. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 100 percent
    - % Operable = reduces to either 42 percent if the lead vehicle was a coach car or 35 percent if the lead vehicle was a locomotive
P. With the HEU in the lead vehicle position, attempt to recover from the penalty. Verify that the HEU cannot recover from this condition in RUN mode.
Q. Remove the simulation of a closed truck cut-out switch on the HEU in the lead vehicle position.
R. Using the display of the HEU in the lead vehicle position, verify that % Operable increases to 50 percent and that the penalty may be cleared.
S. On the car from step L, open the branch pipe cock and allow the reservoirs to recharge.
T. Using the display of the HEU in the lead vehicle position, verify that % Operable increases to 57 percent.
U. With the HEU in the lead vehicle position, recover from the penalty and release the brakes.
V. Verify that the cut-in car's BC releases.
W. Cut in the truck cut-out switches closed in steps B and G. Then reconnect the CCD trainline connector on the CCD from step E.
X. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 0 percent
    - % Operable = increases to 85 percent
Y. With the HEU in the lead vehicle position, command the CCD that was cut out in step J to CUT-IN.
Z. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 0 percent
    - % Operable = increases to 100 percent

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.13 Reduced Percentage of Operative Brakes—CCDs with Low Battery

The purpose of this test is to verify that the HEU correctly determines and responds correctly to a reduced percent operable when CCDs have a low battery. This test shows that CCDs with a low or missing battery are counted as inoperable but may not be displayed as inoperable until the total inoperable reaches less than 90 percent with trainline power OFF or less than 85 percent with trainline power ON. A penalty should occur when the percent operable drops below 50 percent. Recovery from the penalty with trainline power OFF is verified by turning trainline power ON. Recovery from the penalty with trainline power ON is verified by the CCDs clearing their low-battery condition.

For this section of the test, two additional ECP cars are required to obtain the desired percent operable levels. These cars may be either freight- or passenger-equipped cars.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Create a low-battery condition on one CCD. (This can be done by disconnecting the battery from the CCD.) Allow adequate time for the low-battery condition to be detected.
C. With the HEU in the lead vehicle position, set the TBC to 100 percent.
D. Verify that the CCD with low battery in step B makes a full-service brake application.
E. At the HEU in the lead vehicle position, set the TBC to 0 percent.
F. Verify that the CCDs with low battery in step B release brake application.

G. Using the display of the HEU in the lead vehicle position, verify that the percent operable on the driver screen remains at 100 percent.
H. From the HEU in the lead vehicle position, command two of the remaining CCDs to CUT-OUT.
I. Verify the following:
    - TBC = 0 percent
    - % Operable = reduces to 57 percent
J. From the HEU in the lead vehicle position, command one of the remaining CCDs to CUT-OUT.
K. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 100 percent
    - % Operable = 42 percent
    - The operator is prompted that there is a penalty resulting from there being less than 50 percent operable brakes
L. With the HEU in the lead vehicle position, leave the ECP system mode in RUN and attempt to recover from the penalty. Verify that the HEU cannot recover from this condition in RUN mode.
M. Reconnect the battery on the CCD from step B and allow adequate time for them to recover.
N. Using the display of the HEU in the lead vehicle position, verify that the % Operable increases from 42 to 57 percent.
O. With the HEU in the lead vehicle position, recover from the penalty and release the brakes.
P. Simulate the closing of the truck cut-out switches on the last vehicle; 2 if it's a cab car or 1 if it's a locomotive.
Q. Using the display of the HEU in the lead vehicle position, verify the following:
    - TBC = 100 percent
    - % Operable = reduces to 43 percent
    - The operator is prompted that there is a penalty resulting from there being less than 50 percent operable brakes
R. With the HEU in the lead vehicle position, attempt to recover from the penalty. Verify that the HEU cannot recover from this condition in RUN mode.
S. Remove the simulation of a truck cut-out on the last vehicle.
T. Using the display of the HEU in the lead vehicle position, verify that the % Operable increases to 57 percent.
U. With the HEU in the lead vehicle position, recover from the penalty and release the brakes.
V. With the HEU in the lead vehicle position, command the three CCDs that were cut out in step H to CUT-IN.
W. Using the display of the HEU in the lead vehicle position, verify that the % Operable increases to 100 percent.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.14 High Trainline Voltage

The purpose of this test is to verify that when the HEU receives a high trainline voltage exception from an EOT or PSC, the HEU provides a warning and a visual indication that trainline power is applied.

A. With the HEU in the lead vehicle position with trainline termination connected, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Manually turn trainline power ON using a special procedure provided by the PSC supplier. (This is done to generate the high trainline voltage exception from the PSCs and the EOT).
C. With the HEU in the lead vehicle position, command trainline power OFF.

D. Using the display of the HEU in the lead vehicle position, verify that trainline power stays ON and an alarm for Trainline Voltage Applied is provided.
E. Using the display of the HEU in the lead vehicle position, verify that the trainline power indication displays ON and that the EOT and PSCs indicate a high trainline condition.
F. Manually turn trainline power OFF and verify that the trainline power is OFF.
G. Using the display of the HEU in the lead vehicle position, verify that the EOT and PSCs Trainline Voltage Applied status is cleared and that the trainline power indication displays OFF.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.8.15 HEU Receives CCD Incorrect BCP Exception

The purpose of this test is to verify that when the HEU receives an incorrect BC pressure exception from a CCD, it provides a warning to the operator.

A. With the HEU in the lead vehicle position with trainline termination connected, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 100 percent and brake pipe charged to 110 psi.
B. On any car, vent BC to atmosphere through an external means (by opening a test cut-out cock, etc.).
C. Using the display of the HEU in the lead vehicle position, verify that an Incorrect BCP alarm occurs.
D. With the HEU in the lead vehicle position, command the car from step B to cut out. (This cut-out may be performed automatically by the HEU or may require a manual action by the operator.)
E. Verify that the CCD cuts out.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.2.9 ECP System Diagnostic Tests

The purpose of this test is to verify that a supplier's diagnostics (optional) are compatible with other suppliers' equipment. If a supplier's HEU does not provide a diagnostic test, then that diagnostic test is not required to be done with this supplier's HEU.

A. With the HEU in the lead vehicle position with trainline termination connected, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Follow the supplier's instructions to run any provided embedded train-wide diagnostics and verify that they pass correctly.

NOTE: This procedure does not isolate whether a diagnostic failing is caused by a failure in the tested equipment or is caused by the diagnostic using nonstandard features that may not be supported by other suppliers. This test is provided to highlight potential incompatibilities between suppliers.

C. If a supplier provides the Train Snapshot Test, perform the test with both suppliers' HEUs, PSCs, CCDs and the other supplier's EOT function. Create a low-battery or a missing-battery condition on one CCD from both suppliers. Create an isolated low-brake-pipe-pressure condition while keeping reservoir charged on one CCD from both suppliers (do this such that it does not cause a system-critical loss of brake pipe pressure). Create a low reservoir condition on one CCD from both suppliers. Follow the supplier's instructions to perform the test from this supplier's lead HEU.

D. Verify that all steps of the Train Snapshot Test can be completed, and verify at the conclusion of the test that the following information is correct and is available on the display of the lead HEU:
   - number of locomotives
   - number of trainline power supplies
   - number of CCDs reporting
   - number of CCDs reporting trainline power ON
   - number of inoperative CCDs
   - number of CCDs reporting brake pipe pressure low
   - number of CCDs reporting reservoir pressure low
   - number of CCDs reporting battery low
   - EOT device
   - EOT status

E. If a supplier provides the Communication Network Test, perform the test with both suppliers' CCDs and the other supplier's EOT function. Follow the supplier's instructions to perform the test from this supplier's lead HEU. Perform the test in RUN mode.

F. Verify that all steps of the Communication Network Test can be completed, and verify at the conclusion of the test that the supplier's test result information is complete and is available on the display of the lead HEU.

Test passed if all identified verification items are correct.

TEST PASSED? ☐Yes ☐No

3.2.10 Coach Car ECP Equipment as the EOT

NOTE: This test is only for configurations that support a coach car as an EOT.

The purpose of this test is to verify that coach car equipment correctly operates as an EOT and correctly transmits EOT beacons.

A. Begin this test with a lead vehicle position connected to the rest of the train with its trainline terminated. Charge the brake pipe and car reservoirs to 110 psi.

B. Set up one of the other supplier's coach cars to function as an EOT. Note that the EOT setup process may differ between suppliers.

C. At the HEU in the lead vehicle position, set the ECP system mode to RUN.

D. Using the display of the HEU in the lead vehicle position, verify the following:
   - RUN mode is entered.
   - The BP pressure at the rear vehicle is shown as the EOT pressure.
   - The train sequences properly, with the coach car configured as EOT vehicle shown as the last vehicle in the train.

Test passed if all identified verification items are correct.

TEST PASSED? ☐Yes ☐No

3.2.10.1 EOT Low-Battery Charge

NOTE: This test is for standalone and coach car configurations only.

The purpose of this test is to verify that an EOT correctly reports a low-battery condition, and that when this condition exists, the HEU commands a penalty full-service brake application and a warning to the operator. Recovery is verified by the EOT clearing its low-battery condition.

A. At the HEU in the lead vehicle position, follow manufacturer procedure to initialize the ECP system and enter system RUN mode with trainline power set to AUTO, a TBC of 0 percent and brake pipe charged to 110 psi.
B. Follow the supplier's special procedure to create a low-battery condition on the EOT. Allow adequate time for the condition to be generated.
C. Using the display of the HEU in the lead vehicle position, verify the following:
    - A TBC = 100 percent penalty is enforced
    - The operator is prompted that the EOT has a low-battery condition
D. With the HEU in the lead vehicle position, attempt to recover from the penalty.
E. Verify that the brakes cannot be recovered in RUN mode (because of the low EOT battery condition).
F. Reset the low-battery condition on the EOT. Allow adequate time for the condition to be cleared.
G. With the HEU in the lead vehicle position, attempt to recover from the penalty.
H. Verify that the ECP system recovers from the penalty.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

3.3 Transition from One Lead HEU to Another While in ECP

The purpose of this test is to verify that the ECP system allows a transition from one ECP lead unit to another without requiring that ECP mode be exited. During this transition, the train brakes must remain applied until the new lead has control.

A. Begin this test with one supplier's equipment conditioned as a lead HEU in ECP system RUN mode with the train brakes released.
B. Follow the supplier's recommended procedure to set the current lead HEU to ECP trail.
C. Ensure that on completion of step B, all train vehicles remain in ECP mode with an ECP emergency BCP, that a pneumatic emergency does not occur, and that trainline power is OFF.
D. From the other supplier's HEU at the other end of the train, follow the supplier's recommended procedure to set it up as the new lead HEU.
E. Using the display of the HEU in the lead vehicle position, verify the following:
    - RUN mode is entered.
    - The BP pressure at the rear vehicle is shown as the EOT pressure.
    - The train sequences properly, with the previous lead vehicle shown as the last vehicle in the train.
F. Release the train brakes and ensure that all vehicles fully release their brakes.

Test passed if all identified verification items are correct.
TEST PASSED? ☐Yes ☐No

Related APTA standards

The following standards are the complete set of Passenger ECP standards:

APTA PR-M-S-020-17, "Passenger Electronic 26C Emulation Braking System—Performance Requirements"
APTA PR-M-S-021-17, "ECP Passenger Cable-Based Braking System—Performance Requirements"
APTA PR-M-S-022-19, "ECP Passenger Cable-Based Brake System Cable, Connectors and Junction Boxes—Performance Requirements"
APTA PR-M-S-023-19, "ECP Passenger Cable-Based Brake DC Power Supply—Performance Requirements"
APTA PR-M-S-024-19, "Intratrain Communication Requirements for ECP Cable-Based Passenger Train Control Systems"
APTA PR-M-S-025-19, "ECP Passenger Cable-Based and Passenger Emulation Braking System—Approval Procedure"
APTA PR-M-S-026-19, "ECP Passenger Cable-Based Braking System—Interoperability Procedure"
APTA PR-M-S-027-19, "ECP Passenger Cable-Based Braking System—Configuration Management"

Definitions

backup battery: The battery source that is part of the CCD and is used to power the system when trainline power and local car battery power are not present.

cab car: The car that provides controlling functions to remotely operate a trail locomotive and to provide braking and traction commands. The ECP components of a cab car include elements of both HEU and CCD functionality.

car control device (CCD): An electronic control device that replaces the function of the conventional pneumatic service and emergency portions during electronic braking and provides for electronically controlled service and emergency brake applications. A CCD is activated by presence of trainline power and contains a battery that is charged from trainline power.

Car ID Module: A module on the car that stores car-specific data and provides it to the CCD in such a way that the CCD always contains the correct characteristics, parameters (constants), and other information for the car or brake set on which it is placed. The car-specific data is mechanically tied to the car in such a way that it cannot be changed inadvertently in the field, even if CCDs are swapped.

ECP brake (trainline) DC power supply: A DC supply operating at nominally 230 VDC to provide electrical power, via the trainline, to all connected ECP devices. The power supply is mounted within a locomotive and is controlled by a power supply controller (PSC).

Emulation mode: Non-ECP mode of operation in which the electronic pneumatic components emulate the performance of the 26C control valve and follow the brake pipe for determining brake cylinder pressure.

end-of-train (EOT) device: Physically the last network node in the train, which transmits a status message (EOT beacon) once per second. The EOT must be connected to the network and transmitting status messages to the HEU before the trainline power can be energized continuously. The EOT continually reports brake pipe pressure and trainline voltage to the HEU. An EOT is activated by the presence of trainline power. ECP equipment on a locomotive or car at the end of the train may perform the ECP EOT function.

head end trainline terminator: A terminator is attached to the front of the trainline that provides an electrical termination of the trainline at the lead locomotive to minimize impedance-related communications faults. The HEU automatically confirms the presence of the head end trainline termination before the trainline power can be energized continuously.

head end unit (HEU): A brake system control device mounted within the locomotive and used to control the ECP brake system.

Locomotive ID Module: A module on the locomotive that stores locomotive-specific data. The Locomotive ID Module provides data for the HEU and PSC in such a way that the HEU and PSC always contain the correct characteristics, parameters (constants) and other information for the locomotive on which they are placed. The locomotive-specific data is mechanically tied to the locomotive such that it cannot be changed inadvertently in the field, even if the HEU or PSC is replaced.

operative brake: An individual brake set that is fully functional. One brake set is two braked trucks.

pneumatic backup (PB): A system provided on each car to apply emergency brake cylinder pressure in the event of a vented brake pipe. The PB system is also capable of assisting in propagating pneumatic pressure signals through the brake pipe.

power supply controller (PSC): A controller that interfaces with the trainline communication network and controls a trainline power supply as commanded by the HEU.

snow brake: Means of applying a light brake cylinder pressure on a vehicle to prevent the accumulation of ice and snow between the friction material and the braking surface.

trainline: A two-conductor electric wire spanning the train that carries both trainline power (to operate all CCDs and EOT devices) and communications network signals (superimposed on the power voltage).

Abbreviations and acronyms

AAR	Association of American Railroads
BCP	brake cylinder pressure
BP	brake pipe
BPP	brake pipe pressure
CCD	car control device
DC	direct current
EAB	electronic air brake
ECP	electronically controlled pneumatic
EOT	end of train
HEU	head end unit
IDM	identification module
NATSA	North American Transportation Services Association
NYAB	New York Air Brake
PB	pneumatic backup
psi	pounds per square inch
PSC	power supply controller
PTU	portable test unit
s	seconds
TBC	train brake command
VDC	voltage direct current

Summary of document changes

- This is the first publication of this document.

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