APTA STANDARDS PROGRAM

RECOMMENDED PRACTICE

APTA PR-E-RP-017-99, Rev. 2
First Published: October 28, 1999
First Revision: March 22, 2004
Second Revision: May 13, 2026
Electrical Working Group

27-Point Control and Communication Trainlines for Locomotives, Locomotive-Hauled Equipment and DMUs

Abstract: This document defines recommended practices for 27-point MU control and communication trainlines, including functional hardware and interfaces on the vehicles with circuit functions, for use on new/rebuilt locomotives, locomotive-hauled vehicles and DMUs.

Keywords: 27-point, communication trainline, control command, digital trainline, MU trainline, trainline

Summary: This recommended practice defines the functionality of 27-point MU and communication trainline systems, as well as their application to passenger cars, locomotives and DMUs.

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-017-99, Rev. 1, which has been revised. Below is a summary of changes from the previous document version:

- Retitled document from "27-Point Control and Communication Trainlines for Locomotives and Locomotive-Hauled Equipment" to "27-Point Control and Communication Trainlines for Locomotives, Locomotive-Hauled Equipment and DMUs."
- Updated working group roster; format updated to latest APTA standards format.
- Addition of Summary section.
- Addition of Foreword section.
- Added applicability language in the Introduction.
- Added power car as a vehicle type throughout document.
- Merged former sections 1.1, Scope, and 1.2, Purpose, into Scope and Purpose.
- Revised figures and tables in former sections 8, Illustrations, 8.1, Tables, and 8.2 Figures. Redistributed revised tables and figures in appropriate places within document.
- 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, General, to new section 1.
    - Added new section 1.2.1, Grounded and ungrounded trainline systems. Added separation requirement between MU trainline and Communication trainline.
    - Added new section 1.2.4, Digital trainline (DTL) (reference only). Added functional description of digital trainline.

- Added new section 1.3.1, Crossing wires. Added reversing of certain trainline functions base on orientation.
- Added new section 1.3.2.5, DMUs. Added recommendations for DMU 27-point configuration.
- Added new section 1.3.3.5, Establishing end-of train. Added process for establishing end-of-train for intercity communication trainline.
- Added new section 1.3.3.6, Loop relays. Added recommendations for loop relays.
- Added new Figure 3, Typical Loop Relay Schematic.
- Added new section 1.3.3.7, Locomotive communication trainline Push/Pull mode switch. Added functional description of locomotive communication trainline Push/Pull mode switch.
- Added new Figure 4, Typical Locomotive Push/Pull Mode Switch Schematic.
- Added new section 1.3.3.8, Cab car communication cable setup switch. Added functional description of cab car communication cable setup switch.
- Added new section 1.3.3.9, Door summary circuit #18/23 Trainline. Added functional description of door summary circuit #18/23 trainline.
- Added new Figure 5, Typical Simplified Door Summary Circuit and Local Door Status Lights Schematic.
- Added new Figure 6, Typical Door Summary – Traction Interlock Schematic.
- Added new section 1.3.3.10, Brake status lights circuits #19/#20 trainline. Added functional description of brake status lights circuits #19/#20 trainline.
- Added new Figure 7, Typical Brake Status Lights Schematic.
- Added new section 1.3.3.11, Preventing ground loops. Added recommendations for preventing ground loops.
- Added new section 1.4, Environment. Added functional environment conditions.

- Renumbered former section 5, Application to vehicles, to new section 2.
  - Renumbered former section 5.1, End location (left/right/both), to new section 2.1. Added new end of vehicle recommendations.
  - Added new section 2.1.3.1, Intercity/long distance. Added operational description for intercity/long distance cars and DMUs.
  - Added new section 2.1.3.2, Commuter. Added operational description for commuter cars and DMUs.
- Renumbered former section 6, Testing, to new section 3.
  - Renumbered former section 6.1.3, Functional tests, to new section 3.1.3. Added recommendations to demonstrate operation of any device that interrupts a trainline circuit, operation of end-of-train relays, and Push/Pull mode switches.
  - Renumbered former section 3.2.2, Functional tests, to new section 3.2.2. Added new recommendations for functional tests of new vehicles.
  - Renumbered former section 6.2.3, Cable swing and interference, to new section 3.2.3. Revised recommendations for cable swing and interference tests.
- Renumbered former section 7. Wire function tables, to new section 4.
  - Renumbered former table 3 to new table 2.
  - Added new table 3, MU System for Diesel-Electric Locomotives: PRIIA-305-005.
  - Added new table 4, MU System for Dual Mode Diesel-Electric Locomotives: PRIIA-305-011.
  - Added new table 5, MU System for DMUs, PRIIA-305-009.
  - Renumbered former table 2 to new table 6.
  - Renumbered former table 5 to new table 7.

  - Renumbered former table 6 to new table 8.
  - Added new table 9, MU System Jumper Cable (Black Heads).
  - Renumbered former table 8, to new table 10.
  - Renumbered former table 9, to new table 11.
  - Added new table 12, 27-Point Communication Jumper Cable (Blue Heads).
  - Added new table 13, Alternate 27-Point Communication Jumper Cable (Red Heads).
- Added APTA PR-CS-RP-019-12, "Pushback Couplers in Passenger Rail Equipment," APTA PR-M-RP-001-97, "End of Car Connections with Tightlock and Interlocking Knuckle-Type Couplers," APTA PR-M-S-016-06, "Safety Appliances for Rail Passenger Cars," and APTA PR-M-S-018-10, "Powered Exterior Side Door System Design for New Passenger Cars," to Related APTA documents.
- Added 49 CFR, §231: Railroad Safety Appliances, 49 CFR, §238.131: Exterior side door safety systems-new passenger cars and locomotives used in passenger service, 49 CFR, §238.133: Exterior side door safety systems-all passenger cars and locomotives used in passenger service, and PRIIA Specifications to References.
- Added DMU (diesel multiple unit) and Door summary circuit to Definitions.
- Added Appendix A, Figure for reference.
  - Renumbered former Figures 3A, 3B, 4A, and 4B to new Figures 9-12.

Table of Contents

Foreword ii
Participants vii
Introduction viii
Scope and purpose viii

1. General 1
1.1 Purpose of 27-point trainlines 1
1.2 Types of trainlines 1
1.3 Configurations 2
1.4 Environment 10

2. Application to vehicles 11
2.1 End location (left/right/both) 11
2.2 Provisions for future installation 11
2.3 Mounting 12
2.4 Keying and identification 12
2.5 Junction boxes 12
2.6 Car wire routing 12
2.7 Wiring 13

3. Testing 13
3.1 Production tests 13
3.2 Vehicle proof-of-design test 14

4. Wire function tables 15
4.1 Categories of function 15

Related APTA standards 29
References 29
Definitions 29
Abbreviations and acronyms 30
Document history 31

Appendix A: Figure for reference 32

List of Figures and Tables

Figure 1 Typical Consist 27-Point Jumper Cable Arrangement 2
Figure 2 27-Point Receptacle Positions 4
Figure 3 Typical Loop Relay Schematic 6
Figure 4 Typical Locomotive Push/Pull Mode Switch Schematic 7
Figure 5 Typical Simplified Door Summary Circuit and Local Door Status Lights Schematic 8
Figure 6 Typical Door Summary – Traction Interlock Schematic 9
Figure 7 Typical Brake Status Lights Schematic 10
Table 1 MU System for Diesel-Electric Locomotives (1) 16
Table 2 MU System for Electric Locomotives (1) 17
Table 3 MU System for Diesel-Electric Locomotives: PRIIA-305-005 (1) 18
Table 4 MU System for Dual Mode Diesel-Electric Locomotives: PRIIA-305-011 (1) 19
Table 5 MU System for DMUs, PRIIA-305-009 (1)(2) 20
Table 6 MU System for Cab Car Compatible with Diesel-Electric Locomotives (1) 21
Table 7 MU System for Cab Car, Compatible with Electric and Diesel-Electric Locomotives (1) 22
Table 8 MU System for Pass-Through (Black Receptacle) 23
Table 9 MU System Jumper Cable (Black Heads) 24
Table 10 Communication System for Passenger Equipment (Blue Receptacle) 25
Table 11 27-Point Alternative Communication System for Passenger Equipment (Red Receptacle) 26
Table 12 27-Point Communication Jumper Cable (Blue Heads) 27
Table 13 Alternate 27-Point Communication Jumper Cable (Red Heads) 28

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Introduction

This introduction is not part of APTA PR-E-RP-017-99, "27-Point Control and Communication Trainlines for Locomotives Locomotive-Hauled Equipment and DMUs."

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 or excursion operations, 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;
- railroads that operate only on track inside an installation that is not part of the general railroad system of transportation; or
- vehicle-to-vehicle interfaces that are permanently or semi-permanently coupled within trainsets; however, the exposed ends are still subject to this recommended practice.

Scope and purpose

The purpose of this document is to define 27-point MU control and communication trainline, jumper cable, and associated receptacle contact functions and installation requirements on vehicles so as to allow intermixing of cars, locomotives and DMUs of varying designs while maintaining mechanical and electrical compatibility of the trainline systems. This applies to new/rebuilt locomotives, locomotive-hauled vehicles and DMUs.

For the mechanical intercar and inter-locomotive jumper/receptacle interfaces for mounting receptacles on the end of the vehicles, see APTA PR-M-RP-001-97, "End-of-Car Connections with Tightlock and Interlocking Knuckle-Type Couplers."

For 27-point jumper and receptacle hardware, see APTA PR-E-RP-019-99, "27-Point Jumper and Receptacle Hardware for Locomotives and Locomotive-Hauled Equipment."

27-Point Control and Communication Trainlines for Locomotives, Locomotive-Hauled Equipment and DMUs

1. General

1.1 Purpose of 27-point trainlines

An electrical trainline allows a single point in the train to issue commands to all or some of the vehicles simultaneously. Likewise, indications are provided from one or more points in the consist to a central monitoring point.

1.2 Types of trainlines

1.2.1 Grounded and ungrounded trainline systems

MU and communication trainline systems employ two distinct and mutually exclusive philosophies regarding grounding of the vehicle dc/battery system:

- MU trainline system (locomotive or DMU battery) is ungrounded (floating).
- Communication trainline system employs a grounded system (car battery), with the battery negative grounded to the car body on each car.

It is essential to maintain electrical separation between (i.e., not to cross-connect) these two systems, as it affects the fault tolerance to the systems to prevent false control system actions from undesired circuit grounds.

> **NOTE:** Some door control trainline systems on some cars require the grounded system to detect accidental grounds, which are not uncommon due to the exposure to weather of many door components. Thus if there is a ground in the car door control wiring, it will trip the local circuit breaker, rather than allow an unintended feed, which might otherwise cause a dangerous condition, such as a false door open command.

1.2.2 MU (multiple unit) trainline

This trainline is used to convey signals relating to traction, dynamic brake and traction/locomotive status indications among locomotives or DMUs of a consist. In push-pull consists, it is used to convey these signals between cab car operator console and the locomotive, or between locomotives located at both ends of the train. In DMUs, it conveys these signals among the consist.

Vehicles conforming to this recommended practice are generally compatible with most freight locomotive MU trainlines (as defined in AAR S-512-1994). Individual railroad rules and operating practices govern intermixing of this equipment.

Electric locomotives use a very similar pin assignment as diesel locomotives, but it does differ, as indicated in **Table 2**.

1.2.3 Communication trainline

This trainline is used to convey control and indication signals, as well as audio (for public address, intercom, etc.) throughout the consist. Most of the functions reside only within the passenger cars; however, several signals are conveyed to the locomotive and cab car to indicate train status for such items as brakes applied/released and door closed summary.

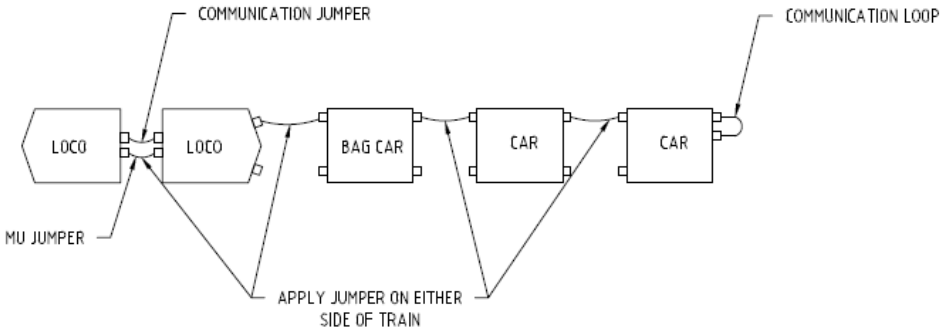
1.2.4 Digital trainline (DTL) (reference only)

This trainline, used only on some equipment, provides a high-speed Ethernet data link throughout the consist. It is used primarily for functions such as destination signs, passenger information system, entertainment, health monitoring, etc. However, it may provide car trainline control as well. Receptacles are mounted on the car ends on both sides, with a portable jumper interconnecting vehicles. Refer to PRIIA Specification 305-919, "DTL Hardware Requirements," for details on the mounting and equipment requirements.

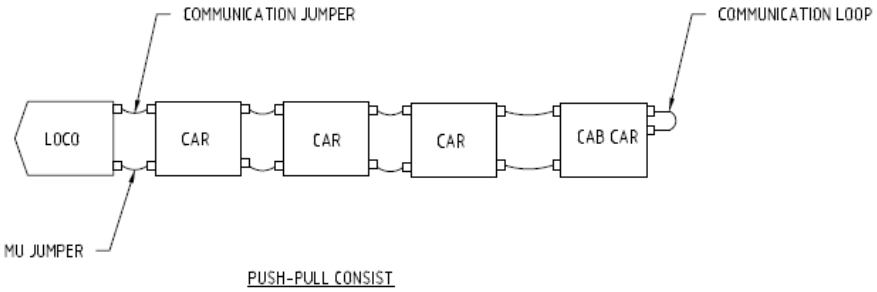
1.3 Configurations

A single jumper cable for a given type of trainline is required at vehicle-to-vehicle coupling. Refer to **Figure 1**.

FIGURE 1
Typical Consist 27-Point Jumper Cable Arrangement



INTERCITY CONSIST - LOCO-HAULED



PUSH-PULL CONSIST

NOTE: If car is equipped with communication and MU receptacles on both sides, jumpers can be applied on either side.

1.3.1 Crossing wires

When a car or locomotive is turned end-for-end in a consist, some trainline functions are reversed, which must be addressed for these systems to work properly: e.g., forward/reverse and left side/right side doors. This is achieved by crossing the respective wires at the B-end of the vehicle and also crossing the same wires in the jumper cables. Refer to **Table 1** through **Table 13**. This allows the locomotive or car to be turned end-for-end and still maintain the trainline integrity. Note also that the loco-loco-car jumper is electrically different from the car-car communication cable.

1.3.2 MU trainline system configurations

1.3.2.1 General

- 27 conductor trainline
- 74 Vdc nominal voltage, ungrounded
- Voltage source from locomotive
- On/off commands/indications except for two analog

1.3.2.2 Locomotives

- Four MU receptacles, two on each end of locomotive
- One MU jumper coupled between units when two or more locomotives are coupled
- Receptacle arrangement shown in **Figure 2**
- Receptacle location shown for reference in Appendix A (Figure 9 and Figure 10, APTA PR-M-RP-001)
- Conductor function assignment per **Table 1** or **Table 2** (Section 4)

1.3.2.3 Power cars

- Two MU receptacles on the end connected to the rest of the consist
- Receptacle arrangement shown in **Figure 2**
- Receptacle location shown for reference in Appendix A (Figure 9, Figure 10 and Figure 11, APTA PR-M-RP-001)
- Conductor function assignment per **Table 1** or **Table 2** (Section 4)

1.3.2.4 Cars equipped for push/pull operation

- Four MU receptacles, two per end (one receptacle per end is permissible but not recommended because cars cannot be turned end-for-end)
- One MU jumper coupled between adjacent vehicles
- Receptacle arrangement shown in **Figure 2**
- Receptacle location shown for reference in Appendix A (Figure 11 and Figure 12, APTA PR-M-RP-001)
- Conductor function assignment per **Table 3**, **Table 4** or **Table 5** (Section 4)

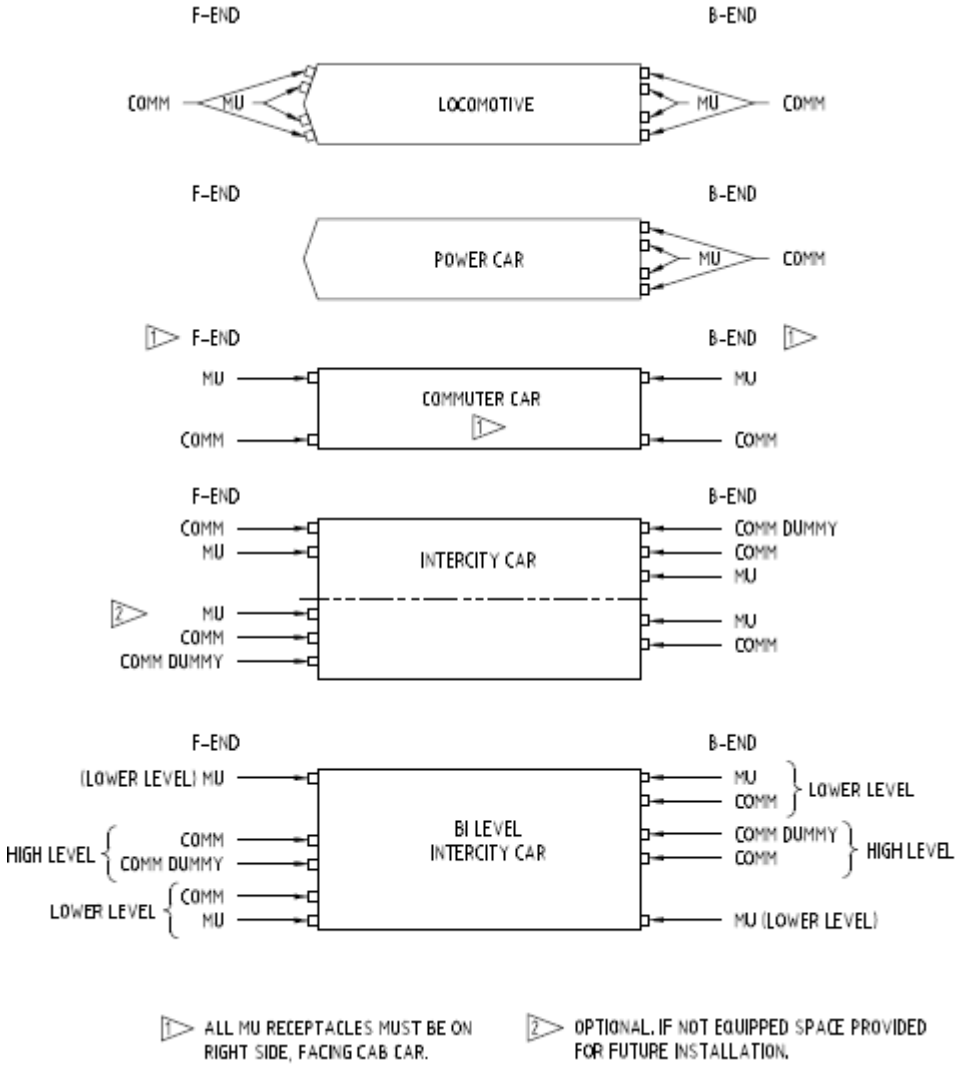
NOTE: The MU trainline connects to equipment only on locomotives, power cars and cab cars, and merely passes through other intermediate vehicles.

1.3.2.5 DMUs

- Four MU receptacles, two on each end of MU
- One MU jumper coupled between units when two or more DMUs are coupled
- Receptacle arrangement is shown in **Figure 2** as “car”

- Receptacle location is shown for reference in Appendix A (Figure 11 and Figure 12, APTA PR-M-RP-001)
- Conductor function assignment per **Table 5** (Section 4)

FIGURE 2
27-Point Receptacle Positions



NOTE: Power car may be double-ended. DMU may be any of the car types.

1.3.3 Communication trainline system configurations

1.3.3.1 General

- 27 conductor trainline
- 74 Vdc nominal voltage, grounded negative
- Shields for audio wiring grounded at one point only per vehicle
- On/off commands/indications
- Audio analog signals on balanced lines

1.3.3.2 Locomotives

- Four communication receptacles, two on each end of locomotive
- One communication jumper coupled between units when two or more locomotives are coupled
- Receptacle arrangement shown in **Figure 2**
- Receptacle location shown for reference in Appendix A (Figure 9 and Figure 10, APTA PR-M-RP-001)
- Conductor function assignment per **Table 6** or **Table 7** (Section 4)

1.3.3.3 Power cars

- Two communication receptacles
- Receptacle arrangement shown in **Figure 2**
- Receptacle location shown for reference in Appendix A (Figure 9, Figure 10 or Figure 11, APTA PR-M-RP-001)
- Conductor function assignment per **Table 6** or **Table 7** (Section 4)

1.3.3.4 Cars and DMUs

- Four communication receptacles, two per end (one receptacle per end is permissible but not recommended because cars cannot be turned end-for-end)
- One communication jumper coupled between adjacent vehicles
- Receptacle arrangement shown in **Figure 2**
- Receptacle location shown for reference in Appendix A (Figure 11 and Figure 12, APTA PR-M-RP-001)
- Conductor function assignment per **Table 6** or **Table 7** (Section 4)

NOTE: Generally, the communication trainline connects to functions on all passenger-carrying cars and passes through non-passenger cars, such as express equipment. Some but not all functions connect to equipment in the locomotive; this typically includes indications of train status, such as all brakes applied/released, door closed summary, etc.

1.3.3.5 Establishing end-of-train

The intercity communication trainline system (refer to **Table 6**) requires that the rear end of the train (relative to the cab controlling the train) be identified in order for the brake applied/released and door closed summary circuits to function properly. These trainlines function with a car battery positive feed being applied to each of the three trainlines at the rear of the last car. The indications are then fed via a series-circuit to the controlling cab where they light indicators and, in the case of the door summary function, also enable traction. Each of the three circuits provide indication only when all cars in the train meet their respective criteria: all brakes applied, all brakes released and all doors closed. To ensure that these circuits function as intended, it is essential that both car and locomotive circuitry are reviewed together.

1.3.3.6 Loop relays

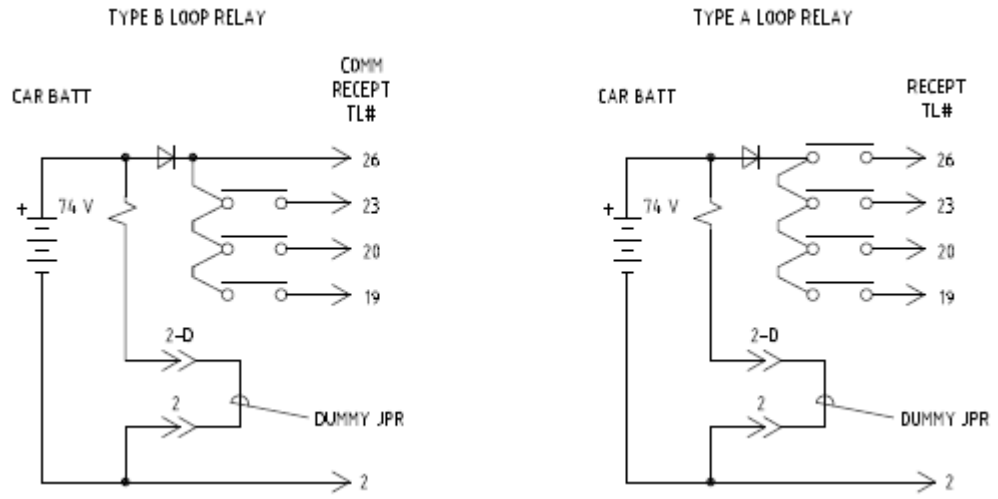
A-end and B-end loop relays are often employed in cars to establish end-of-train, with the respective relay energized at the rearmost end of the consist. Looping a jumper cable between the communication trainline receptacle and the adjacent dummy receptacle at the rear of the train is one method for activating these circuits via the loop relays, though other methods are used. Refer to **Figure 3** for a schematic of the typical arrangements. It is recommended going forward that for new equipment, only Type B be employed, as it is universal, unlike Type A, which is not.

When the consist is first made up, changed, or direction of travel reversed on a push-pull consist, a new end-of-train must be established. There are three scenarios:

1. **Locomotive-hauled consist:**
   - End-of-train must be established on the rearmost car.
   - Type A or B loop relay circuit will work.
2. **Push-pull consist with locomotive on one end and cab car on the other:**
   - End-of-train must be established on the rearmost vehicle.
   - Type A or B loop relay circuit will work.
3. **Push-pull consist with locomotive on both ends:**
   - End-of-train must be established on the rearmost vehicle.
   - Requires a Type B loop relay circuit on at least one car in the consist; the others may be either Type A or Type B.

If a type of digital bus via DTL is used in parallel, automatic detection of train end is also a possible fourth scenario and could switch the loop relay without crew interaction.

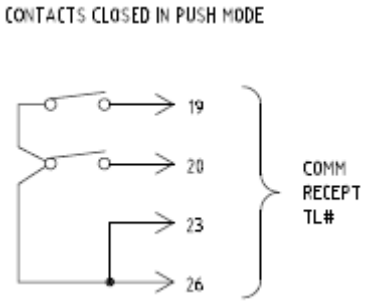
FIGURE 3
Typical Loop Relay Schematic



1.3.3.7 Locomotive communication trainline Push/Pull mode switch

Some locomotives are equipped with a Push/Pull mode switch, which establishes whether the locomotive is in Push or Pull mode in the consist. In the “Pull” position, the locomotive expects to see brake applied/released and door closed summary signals coming from the train behind it. In the “Push” position, this switch takes the place of the loop relay at the rear of the last car, establishing “end-of-train” there. Through the use of this switch, there is no need to mate and unmate the communication jumpers on opposite ends of the consist when changing ends. This concept will work with consists of locomotive/cab car, as well as with a locomotive on both ends of the consist. Refer to **Figure 4** for a typical schematic of this switch.

FIGURE 4
Typical Locomotive Push/Pull Mode Switch Schematic



1.3.3.8 Cab car communication cable setup switch

As explained above for locomotives, a cab car must also incorporate a method to identify when it is in control of the train or not so that the brake status as well as the door closed summary indicators are activated appropriately. This also applies to DMU operator cabs; one end of the consist is the controlling cab, while the cab at the rear is the "end-of-train."

1.3.3.9 Door summary circuit #18/#23 Trainline

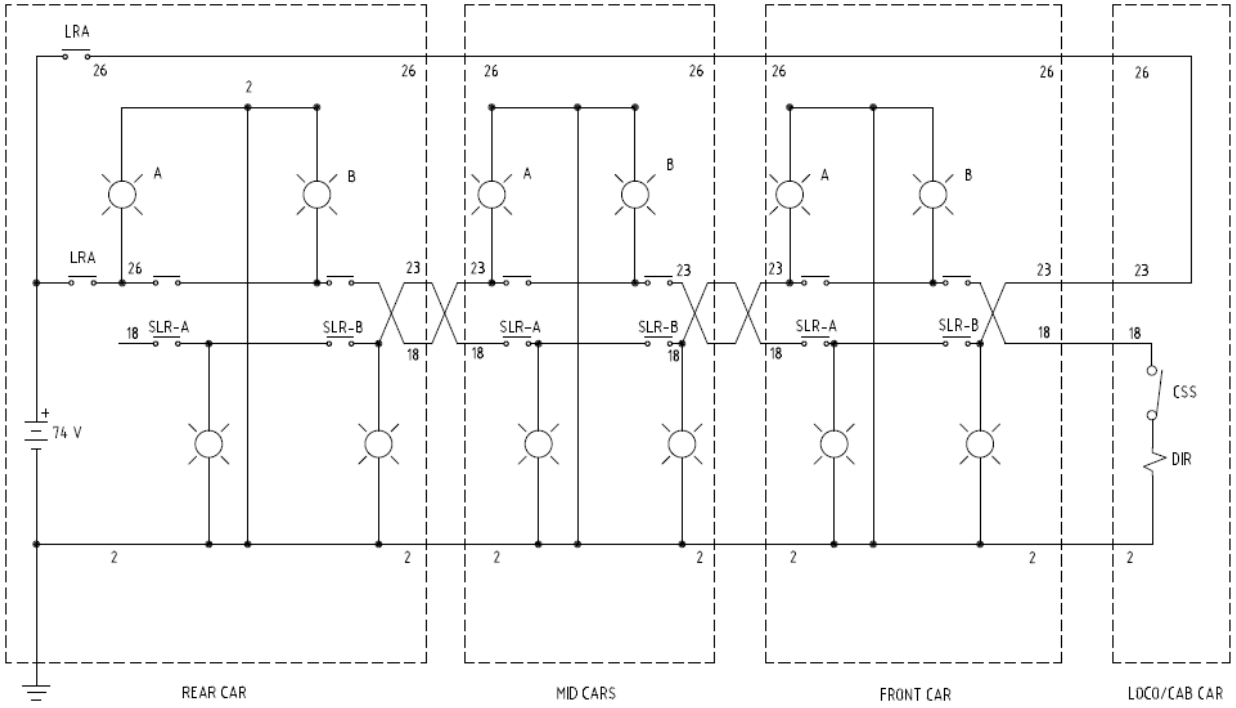
The door summary circuit is used to give an indication in the controlling cab of the train that all exterior side doors throughout the train consist are closed and latched, and/or locked out with a door isolation lock. It is a series circuit, with the feed on #23 originating at the rear of the rearmost car via the loop relay, and feeding an indicator light in the cab: "All Doors Closed".

It also includes a traction inhibit feature in the controlling cab that prevents the train from taking traction power when the train is stopped and until all doors are closed and latched, and removes traction power from the train should any door open while the train is in motion. Operating cabs are also equipped with a door summary circuit bypass switch that, when activated, overrides the door summary circuit. Details of the requirements for this circuit are provided in APTA PR-M-S-018-10, "Powered Exterior Side Door System Design for New Passenger Cars." Refer to **Figure 5** for a simplified typical schematic of this circuit.

The #18 and #23 trainlines together provide this door closed summary, in conjunction with the local door closed status. When the conductor activates a door control station, this interrupts the #18 and #23 trainlines. This allows the status of the train door rearward and forward of the location to be indicated on the local door control panel. The rearward indication is fed from the rear of the train, while the forward indication comes from the front of the train via the #26 to #23 loop at the front of the train.

FIGURE 5

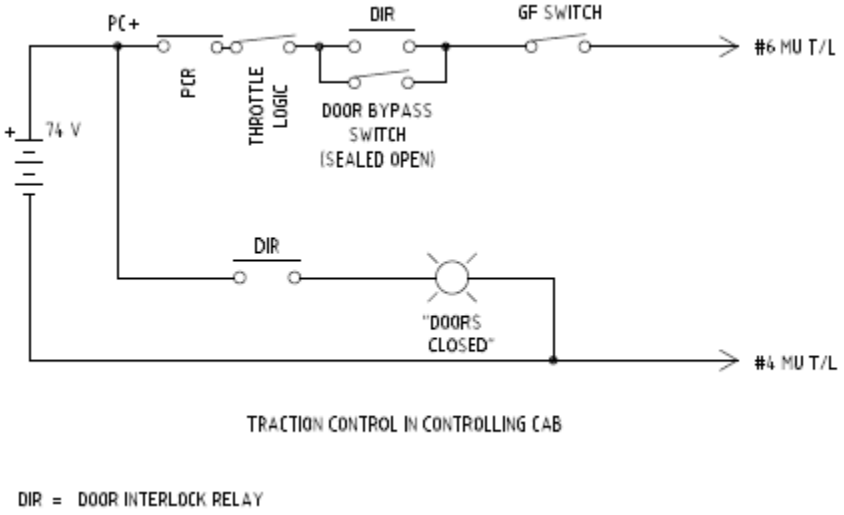
Typical Simplified Door Summary Circuit and Local Door Status Lights Schematic



DOOR CLOSED INDICATOR LT. (LOCAL)
LR = LOOP RELAY
CCS = CAB SETUP SWITCH CLOSED WHEN CAB ACTIVE.
DIR = DOOR INTERLOCK RELAY WHEN ENERGIZED, ALLOWS TRACTION
SLR = SIGNAL LIGHT RELAY CONTACTS CLOSED WHEN DOORS CLOSED LOCALLY

As a companion to **Figure 5**, **Figure 6** shows typical logic to interface the door summary circuit with the traction control circuit, employing the #6 Generator Field trainline. This also illustrates the engineer's "Door Closed Indicator" light. The "Door Bypass" switch is also indicated, which is required to be a sealed switch. This circuit applies to both locomotives and cab cars.

FIGURE 6
Typical Door Summary – Traction Interlock Schematic

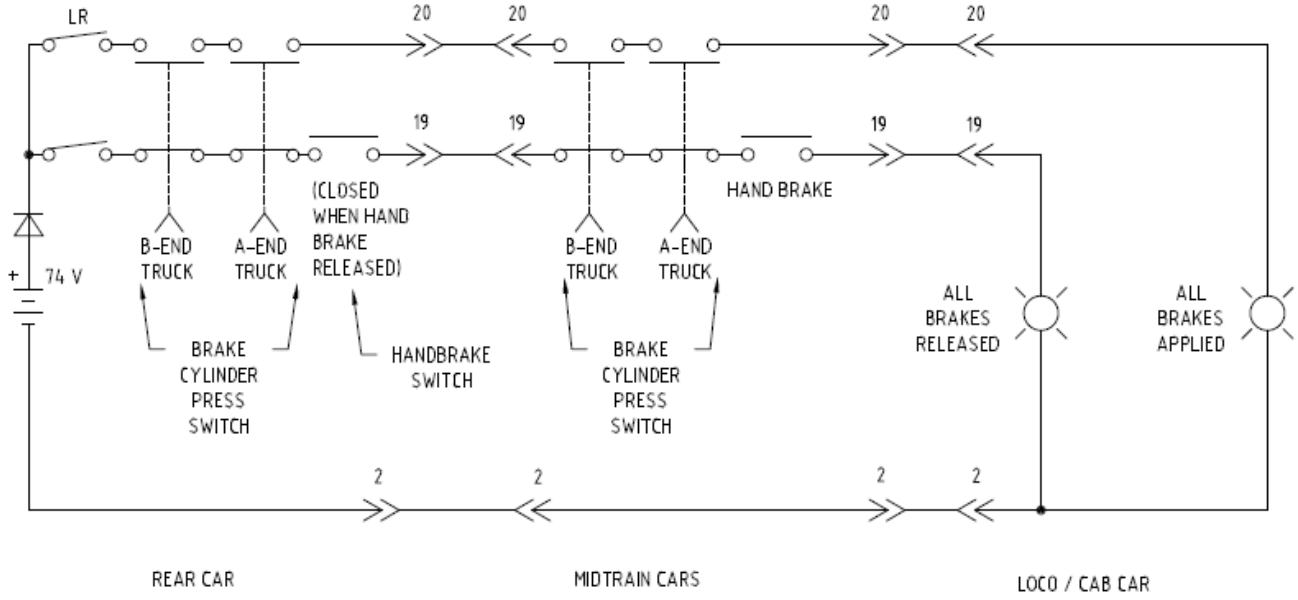


1.3.3.10 Brake status lights circuits #19/#20 trainline

The two brake status light circuits provide an indication to the controlling cab of the status of the brakes throughout the train consist, exclusive of the locomotive(s). They are series circuits, with the feed originating at the rear of the rearmost car via the loop relay, each feeding an indicator light in the cab: “All Brakes Released” and “All Brakes Applied”.

In both cases, a pressure switch piped downstream of the respective truck cutout cock monitors brake cylinder pressure on that truck. Thus, when there is brake cylinder pressure on both trucks, the applied status is established. Likewise, when there is no brake cylinder pressure on either truck, the released status is established. The brake released trainline also incorporates a switch that closes when the handbrake is released. Accordingly, the “All Brakes Released” status indicates that both pneumatic brakes and handbrakes are released throughout the train. Refer to **Figure 7** for a simplified typical schematic of this circuit.

FIGURE 7
Typical Brake Status Lights Schematic



1.3.3.11 Preventing ground loops

To prevent ground loops in the communication trainline system, the following practices are used:

- Within a car or locomotive, the shield of a cable is grounded at only one point.
- The trainline cable shields are grounded at only one point.
- In jumper cables, the shields on the communication wires are connected only on one end of the cable to the #1 contact.

1.4 Environment

The equipment should be designed and manufactured to operate reliably and without degradation under the following environmental conditions or with any additional requirements as specified by the authority. Of particular concern are shock, vibration and ambient temperature.

- heavy rain, driven by wind or water from a hose
- hail, ice and powdered snow
- blown sand, dust, ballast and rocks
- vehicle speeds to 125 mph (200 km/h)
- wind gusts to 90 mph (145 km/h)
- salt (sea spray or from roads during winter months)
- impact from airborne road debris
- car washing chemicals and wash rack operations

2. Application to vehicles

2.1 End location (left/right/both)

The design of the ends of the vehicles shall be integrated early on in the design to comprehensively and holistically meet the following requirements for the 27-point as well as HEP and DTL (if equipped) trainlines:

- Location and clearance requirements of APTA PR-M-RP-001-97, "End-of-Car Connections with Tightlock and Interlocking Knuckle-Type Couplers." This companion document defines receptacle mounting locations and clearance criteria to prevent mechanical interference between different cable systems, couplers, etc., as well as identifying issues that affect the inter-vehicle end-to-end relationships dynamically.
- This must take into account all practical combinations of vehicles that may be intercoupled: car-to-car, car-to-locomotive (both locomotive ends) and locomotive-to-locomotive (on both ends).
- Moreover, this must take into account not only the new vehicles, but also how the new vehicles will interface with existing rolling stock with which they may operate.

The location of the receptacles on the end of the vehicle is shown for reference in Figure 10, Figure 11, Figure 12 and Figure 13 in Appendix A.

2.1.1 Locomotives

Receptacles for a given function (MU, car control, etc.) should be provided on all four corners of the locomotive.

2.1.2 Power cars

Receptacles for a given function (MU, car control, etc.) should be provided on both sides of the train end of the power car (or both ends, as applicable), to allow it to be used on either end of the consist.

2.1.3 Cars and DMUs

2.1.3.1 Intercity/long distance

Operation of intercity/long distance cars is such that any car can be rotated end-to-end—e.g., A-end to A-end or A-end to B-end. Accordingly, this requires MU and communication trainline receptacles on both sides of all cars.

2.1.3.2 Commuter

Operation of some commuter authorities is such that all cars always face the same orientation within the consist, e.g., A-end to B-end. Accordingly, this allows the possibility of installation of MU and communication jumper cables to be on only one side of the cars (e.g., MU on the right and communication on the left). This option prevents inter-fleet operation of the cars outside the original railroad fleet. All cars having only one sided trainlines should be built to allow for future installation of the 27-point receptacles on both sides on both ends.

2.2 Provisions for future installation

If the trainline is installed on only one side of the car, provisions should be provided for future installation on the second side, which include receptacle mounting hole covered with a blanking plate, conduit for wiring, and sufficient room in the junction boxes to add the additional receptacle wiring.

2.3 Mounting

The plate to which the receptacles (and jumper flanges, if used) are mounted should be reinforced to resist, without bending, forces produced from pulling the locked jumper out of the receptacle, such as by an unauthorized uncoupling. The jumper cable should be sacrificial relative to the car body components under these conditions, to avoid damage to the internal wiring of the vehicle.

Receptacle mounting should be such that there is adequate clearance between jumpers, receptacles and uncoupling rods, diaphragm/buffer, couplers, air hoses, etc.

For details of these requirements, refer to APTA PR-M-RP-001-97, “End-of-Car Connections with Tightlock and Interlocking Knuckle-Type Couplers.”

There should be no interference that restricts the receptacle cover from being fully opened to allow insertion or withdrawal of jumpers.

2.4 Keying and identification

Receptacles and jumper cables should be keyed, color-coded and labeled per Section 1 of APTA PR-E-RP-019-99, “27-Point Jumper and Receptacle Hardware for Locomotives and Locomotive-Hauled Equipment,” to prevent cables having different functions from being cross-connected. Labeling should be provided on the receptacle cover and/or adjacently on the car body.

2.5 Junction boxes

An external stainless-steel junction box, equipped with railroad-designated terminal blocks, should be provided near the end of each vehicle to provide for the connection of the receptacle pigtails with the vehicle car body wiring. The terminal blocks for different functions—MU, communication, etc.—should be physically separate. Individual terminals should be permanently labeled for each specific wire name.

> **NOTE:** If an internal junction box is utilized, other materials may be used; however the requirements for terminals and their labeling remains the same for internal or external junction boxes".

2.6 Car wire routing

2.6.1 End to end

Wiring practice should generally conform to APTA PR-E-RP-002-98, “Installation of Wire and Cable on Passenger Rolling Stock,” with the following additional requirements:

- Wiring connecting the 27-point receptacles from one end of the vehicle to the other should be run in conduit or equivalent.
- Where trainline wires are required to cross, (such as forward/reverse and door control wires), this should occur at the B-end (rear) of the vehicle.
- The wiring for the different types of trainline systems (MU and communication) should be mechanically separated, including separate conduits, so as to minimize the risk of electromagnetic interference and to prevent accidental cross-connection, either from installation or from mechanical injury sustained in service.
- The routing of the trainline cables, particularly under-car, should be selected so as to ensure that it is well protected from mechanical damage, especially from wayside debris.

2.7 Wiring

2.7.1 Standards

Wire should conform to APTA PR-E-RP-009-98, "Ampacities for Wire and Cable Used on Passenger Rolling Stock with Flame, Smoke and Toxicity Considerations."

2.7.2 Terminations

The preferred method of termination should be with vibration-resistant, ring-tongue and crimp-type lugs.

NOTE: In internal areas, spring clamp terminals are also acceptable.

2.7.3 Continuity

All like pins of the trainline cable systems should have continuity between all like receptacles, whether the function is currently in use or not.

2.7.4 Spare circuit availability

In addition, all 27 wires of each of the trainline systems should be brought within the vehicle to suitable terminal blocks so current spares are easily available for future assignment.

2.7.5 End to end spare wires

All undesignated function pins and conductors should be marked as spare wires and should be installed between end-of-car junction boxes for each trainline cable system. Spare or unused wires should not be grounded.

3. Testing

3.1 Production tests

Each vehicle should undergo a complete set of tests on the entire system, demonstrating the qualities described in this section.

3.1.1 Insulation

Insulation resistance and dielectric tests should be conducted in accordance with the requirements of APTA PR-E-S-001-98, "Electrical Insulation Integrity."

3.1.2 Continuity

Continuity tests should be conducted in accordance with the requirements of APTA PR-E-S-001-98 to ensure the following:

1. Continuity exists between all intended contacts of all receptacles.
2. Continuity exists between trainlines and each vehicle connection to the trainline circuits.
3. No wires are unintentionally grounded.
4. No wires are shorted or cross-connected to unintended circuits.

3.1.3 Functional tests

Each conductor of each trainline should be exercised to ensure that the equipment to which it is connected transmits/receives the trainline signal correctly. Proper operation of any device that interrupts a trainline circuit, such as pressure switches or relays, should be demonstrated. Operation of end-of-train relays (or equivalent) should be verified; likewise, Push/Pull mode switches on locomotives and cab cars (so equipped).

3.2 Vehicle proof-of-design test

A proof-of-design type/qualification test should be conducted on the new vehicles.

3.2.1 New vehicle tests

At a minimum, a pair of vehicles should be tested, but should there be more than one vehicle type, all types should be included in the test. In addition, all new vehicle types should be tested with all types of existing vehicles with which the new equipment is to be operated.

3.2.2 Functional tests

These tests should include operating each conductor of each trainline in all possible modes of operation (including new car to existing car and existing car to new car) to demonstrate proper functioning of all controls and indications. This should include turning vehicles end-for-end to verify that systems such as doors and/or forward/reverse function correctly. Tests should also verify proper operation between cars and locomotives, especially brake applied/released and door closed summary, in both locomotive leading and trailing situations. In the case of cab cars, the test should include full operation of all MU wires with one or more locomotives. Proper functioning of end-of-train relays (or equivalent) should be verified; likewise, Push/Pull mode switches on locomotives and cars (so equipped). This should be done in both Push and Pull modes. For diesel locomotives, this should also verify that energizing solely #3 MU wire results in the locomotive diesel engine shutting down.

3.2.3 Cable swing and interference

Tests should be conducted with the new and all existing rolling stock with which it might operate, coupled to verify successful interfaces and freedom from interferences in actual track conditions. This must take into account all practical combinations of vehicles that may be intercoupled: car-to-car, car-to-locomotive (both locomotive ends) and locomotive-to-locomotive (on both ends). Tests include the following criteria:

1. Inspect to verify that the location and clearance requirements of the following are met:
    a. 49 CFR Part 231, “Railroad Safety Appliances”
    b. APTA PR-CS-RP-019-12, “Pushback Couplers in Passenger Rail Equipment”
    c. APTA PR-M-S-016-06, “Safety Appliances for Rail Passenger Cars”
2. Verify that receptacle mounting provides sufficient clearance among receptacles and jumper cables of HEP, 27-point communication, MU, ECP brakes and Digital Trainline (DTL, if applicable) so they do not rub or foul one another, nor the uncoupling mechanism, buffer/diaphragm, air hoses or coupler. Jumpers must not interfere with normal use of safety appliances (including uncoupling mechanism) or required clearances. Variables include the worst-case combination of the following:
    a. Relative motion to adjacent vehicle: resulting from operation on worst-case track conditions (i.e., FRA Class 1), in curving, lateral displacement passing through two facing point turnouts or crossovers (reverse curves), in buff and draft, vertical track curves (rises and dips) etc. This should be conducted at locations where the most demanding track geometry occurs.
    b. Coupler motion laterally and vertically.
    c. Diaphragm movement (both adjacent to another car and when unrestrained).
    d. Conditions of when jumpers are inserted into the receptacles, as well as when receptacles are empty or looped.
    e. There should be no interference that restricts the receptacle cover from fully opening to allow insertion or withdrawal of jumpers.
3. On the outside side of the coupling, verify that the jumpers are sufficiently long to reach without strain/pullout.
4. On the inside of the coupling, verify that the jumper low points do not violate the 2 in. above top-of-rail minimum, nor do they collide with each other.

NOTE: Depending on car design, the handbrake mechanism will need to be included in this review if it is located within the respective areas.

4. Wire function tables

4.1 Categories of function

The following tables identify wire functions in two categories:

- preassigned
- suggested use

4.1.1 Preassigned wire functions

Preassigned functions are those for which a wire is exclusively assigned for all vehicles, regardless of whether the function itself exists on the vehicle. For example, dynamic brake functions may not be installed on a specific locomotive, but the wires in the trainline will be assigned exclusively for that function and cannot be used for other purposes.

4.1.2 Suggested use wire functions

Suggested use is a function that is currently in use on some vehicles, and if those vehicles are to be intermixed with other model vehicles, the same function must be assigned. These wire functions are herein designated as "spare," with suggested function, if any, in parentheses.

4.1.3 Diesel MU AAR trainline standard

The diesel locomotive MU configuration is based on the AAR Standard S-512-1994 and will allow inter-mating of APTA standard locomotives with most freight locomotive types.

4.1.4 Communication trainline conventions

Two alternate communication trainline functionality conventions have been provided. The intercity version (**Table 6**) provides a convention suited for long-haul or commuter equipment. The commuter version (**Table 7**) provides an alternative that is already in use in a number of commuter-type operations.

TABLE 1

MU System for Diesel-Electric Locomotives (1)

Pin #	Wire Name	Gauge AWG	Function Name	Voltage Range (2)	Function (3)	Current
1	SL	14	Spare (reserved for Cruise Control)	—	n/a	
2	SG	14	Alarm Bell	74	C/I	
3	DV	14	D Throttle	74	C	
4	N	10	Control Negative (4)	0	—	
5	ES	14	Emergency Sand	74	C	
6	GF	12	Generator Field	74	C	
7	CV	14	C Throttle	74	C	
8	FO	12	Forward (#8 & #9 cross on B-end) (5)	74	C	
9	RE	12	Reverse (5)	74	C	
10	WS	14	Wheel Slip	74	I	
11	SP	14	Spare	—	n/a	
12	BV	14	B Throttle	74	C	
13	PC	12	Control Positive (6)	74	—	
14	SN	14	Spare (Parking Brake)	—	n/a	
15	AV	14	A Throttle	74	C	
16	ER	14	Engine Run	74	C	
17	B	14	Dynamic Brake Set Up	74	C	
18	RLC	12	Spare (Remote Loadmeter Positive)	(8)	I	0-100 mA
19	RLD	12	Spare (Remote Loadmeter Negative)	—	I	0-100 mA
20	BW	14	Dynamic Brake Warning	74	I	
21	BG	14	Dynamic Brake Start	74	C	
22	CC	14	Air Compressor Control	74	C	
23	SA	14	Manual Sand	74	C/I	
24	BC	14	Dynamic Brake Excitation	0-74 (8)	C	
25	HLS	12	MU Headlight	74	C	
26	SV	14	Remote Reset (7)	74	C	
27	SP	14	Spare	—	n/a	

1. All MU power is provided from the locomotive, *not* the cab car. This is done to keep the locomotive and car battery systems galvanically isolated.
2. Unless noted, all signals are Off-On maintained at 0 or 74 Vdc.
3. C = Command, I = Indication
4. The negative side of each locomotive and cab car is common to all of them via this wire.
5. #8 and #9 cross both within the locomotive and also within the MU jumper.
6. The lead locomotive feed +74 Vdc to trailing units as well as cab car via this wire.
7. Momentary actuation.
8. Analog signal.

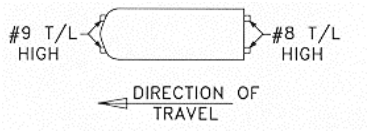


TABLE 2

MU System for Electric Locomotives (1)

Pin #	Wire Name	Gauge AWG	Function Name	Voltage Range (2)	Function (3)	Current
1	SL	14	Pantograph Raise	74	C	
2	SG	14	Alarm Bell	74	C/I	
3	DV	14	D Throttle	74	C	
4	N	10	Control Negative (4)	0	—	
5	ES	14	Emergency Sand	74	C	
6	GF	12	Generator Field	74	C	
7	CV	14	C Throttle	74	C	
8	FO	12	Forward (#8 & #9 cross on B-end) (5)	74	C	
9	RE	12	Reverse (5)	74	C	
10	WS	14	Wheel Slip	74	I	
11	GC	14	Parking Brake Applied	74	I	
12	BV	14	B Throttle	74	C	
13	PC	12	Control Positive (6)	74	—	
14	SN	14	Pantograph Lower	74	C	
15	AV	14	A Throttle	74	C	
16	ER	14	Spare	—	—	
17	B	14	Dynamic Brake Set Up	74	C	
18	RLC	12	Remote Loadmeter Positive	(8)	I	0-100 mA
19	RLD	12	Remote Loadmeter Negative	—	I	0-100 mA
20	BW	14	Spare	—	—	
21	BG	14	Dynamic Brake Start	74	C	
22	CC	14	Spare	—	—	
23	SA	14	Manual Sand	74	C/I	
24	BC	14	Dynamic Brake Excitation	0-74 (8)	C	
25	HLS	12	No Power Brake	74	I	
26	SV	14	Remote Reset (7)	74	C	
27	SP	14	Main Circuit Breaker Control	74	C	

1. All MU power is provided from the locomotive, *not* the cab car. This is done to keep the locomotive and car battery systems galvanically isolated.
2. Unless noted, all signals are Off-On maintained at 0 or 74 Vdc.
3. C = Command, I = Indication
4. The negative side of each locomotive and cab car is common to all of them via this wire.
5. #8 and #9 cross both within the locomotive and also within the MU jumper.
6. The lead locomotive feed +74 Vdc to trailing units as well as cab car via this wire.
7. Momentary actuation.
8. Analog signal.

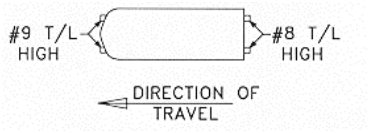


TABLE 3

MU System for Diesel-Electric Locomotives: PRIIA-305-005 (1)

Pin #	Wire Name	Gauge AWG	Function Name	Voltage Range (2)	Function (3)	Current
1	SL	14	Spare (reserved for Cruise Control)	—	n/a	
2	SG	14	Alarm Bell	74	C/I	
3	DV	14	D Throttle	74	C	
4	N	10	Control Negative (4)	0	—	
5	ES	14	Emergency Sand	74	C	
6	GF	12	Generator Field	74	C	
7	CV	14	C Throttle	74	C	
8	FO	12	Forward (#8 & #9 cross on B-end) (5)	74	C	
9	RE	12	Reverse (5)	74	C	
10	WS	14	Wheel Slip	74	I	
11	SP	14	Spare	—	n/a	
12	BV	14	B Throttle	74	C	
13	PC	12	Control Positive (6)	74	—	
14	SP	14	Parking Brake Applied	74	I	
15	AV	14	A Throttle	74	C	
16	ER	14	Engine Run	74	C	
17	B	14	Dynamic Brake Set Up	74	C	
18	RLC	12	Remote Loadmeter Positive	(8)	I	0-100 ma
19	RLD	12	Remote Loadmeter Negative	—	I	0-100 ma
20	BW	14	Dynamic Brake Warning	74	I	
21	BG	14	Dynamic Brake Start	74	C	
22	CC	14	Spare (Air Compressor Control)	—	n/a	
23	SA	14	Manual Sand	74	C/I	
24	BC	14	Dynamic Brake Excitation	0-74 (8)	C	
25	HLS	12	Spare	—	n/a	
26	SV	14	Remote Reset (7)	74	C	
27	SP	14	Spare	—	n/a	

1. All MU power is provided from the locomotive, *not* the cab car. This is done to keep the locomotive and car battery systems galvanically isolated.
2. Unless noted, all signals are Off-On maintained at 0 or 74 Vdc.
3. C = Command, I = Indication
4. The negative side of each locomotive and cab car is common to all of them via this wire.
5. #8 and #9 cross both within the locomotive and also within the MU jumper.
6. The lead locomotive feed +74 Vdc to trailing units as well as cab car via this wire.
7. Momentary actuation.
8. Analog signal.

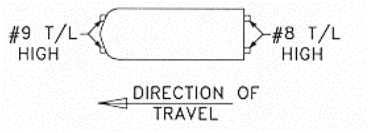


TABLE 4

MU System for Dual Mode Diesel-Electric Locomotives: PRIIA-305-011 (1)

Pin #	Wire Name	Gauge AWG	Function Name	Voltage Range (2)	Function (3)	Current
1	SL	14	Spare (reserved for Cruise Control)	—	n/a	
2	SG	14	Alarm Bell	74	C/I	
3	DV	14	D Throttle	74	C	
4	N	10	Control Negative (4)	0	—	
5	ES	14	Emergency Sand	74	C	
6	GF	12	Generator Field	74	C	
7	CV	14	C Throttle	74	C	
8	FO	12	Forward (#8 & #9 cross on B-end) (5)	74	C	
9	RE	12	Reverse (5)	74	C	
10	WS	14	Wheel Slip	74	I	
11	BA	14	Initiate 3rd Rail Traction; Diesel Off (6)(7)(8)	74	M	
12	BV	14	B Throttle	74	C	
13	PC	12	Control Positive (2)	74	—	
14	SN	14	Initiate Diesel traction w/3rd Rail Shoes Deployed (6)(7)(8)	74	M	
15	AV	14	A Throttle	74	C	
16	ER	14	Engine Run	74	C	
17	B	14	Dynamic Brake Set Up	74	C	
18	RLC	12	Remote Loadmeter Positive	(9)	I	0-100 mA
19	RLD	12	Remote Loadmeter Negative	—	I	0-100 mA
20	BW	14	Dynamic Brake Warning	74	I	
21	BG	14	Dynamic Brake Start	74	C	
22	CC	14	Spare (Air Compressor Control)	—	n/a	
23	SA	14	Manual Sand	74	C/I	
24	BC	14	Dynamic Brake Excitation	0-74 (9)	C	
25	HLS	12	Spare	—	n/a	
26	SV	14	Remote Reset (4)	74	C	
27	SP	14	Initiate Diesel Traction with Shoes Retracted (6)(7)(8)	74	M	

1. All MU power is provided from the locomotive, *not* the cab car. This is done to keep the locomotive and car battery systems galvanically isolated.
2. Unless noted, all signals are Off-On maintained at 0 or 74 Vdc.
3. C = Command, I = Indication, M = Momentary
4. The negative side of each locomotive and cab car is common to all of them via this wire.
5. #8 and #9 cross both within the locomotive and also within the MU jumper.
6. The lead locomotive feed +74 Vdc to trailing units as well as cab car via this wire.
7. Momentary actuation.
8. Circuits #11, #14 and #27 together determine the mode. There are four modes of operation: diesel traction, shoes retracted; diesel traction, shoes deployed; third rail traction, diesel on; third rail traction, diesel off.
9. Analog signal.

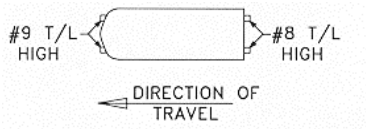


TABLE 5

MU System for DMUs, PRIIA-305-009 (1)(2)

Pin #	Wire Name	Gauge AWG	Function Name	Voltage Range (3)	Function (4)	Current
1	SL	14	Spare (reserved for Cruise Control)	—	n/a	
2	SG	14	Alarm Bell	74	C/I	
3	DV	14	D Throttle	74	C	
4	N	10	Control Negative (5)	0	—	
5	ES	14	Emergency Sand	74	C	
6	GF	12	Generator Field	74	C	
7	CV	14	C Throttle	74	C	
8	FO	12	Forward (#8 & #9 cross on B-end) (6)	74	C	
9	RE	12	Reverse (6)	74	C	
10	WS	14	Wheel Slip	74	I	
11	SP	14	Spare	—	n/a	
12	BV	14	B Throttle	74	C	
13	PC	12	Control Positive (7)	74	—	
14	SP	14	Spare	—	n/a	
15	AV	14	A Throttle	74	C	
16	ER	14	Engine Run	74	C	
17	B	14	Dynamic Brake Set Up	74	C	
18	RLC	12	Remote Loadmeter Positive	(9)	I	0-100 mA
19	RLD	12	Remote Loadmeter Negative	—	I	0-100 mA
20	BW	14	Dynamic Brake Warning	74	I	
21	BG	14	Dynamic Brake Start	74	C	
22	CC	14	Spare (Air Compressor Control)	—	n/a	
23	SA	14	Manual Sand	74	C/I	
24	BC	14	Dynamic Brake Excitation	0-74 (9)	C	
25	HLS	12	Spare	—	n/a	
26	SV	14	Remote Reset (8)	74	C	
27	SP	14	Spare	—	n/a	

1. This MU trainline system is interoperable with diesel-electric locomotives and cab cars.
2. If operated with a locomotive, All MU power is provided from the locomotive, *not* the DMU car. If operated with a cab car, all MU power for the cab car is provided by the DMU car. This is done to keep the various battery systems galvanically isolated.
3. Unless noted, all signals are Off-On maintained at 0 or 74 Vdc.
4. C = Command, I = Indication
5. The negative side of each locomotive and cab car is common to all of them via this wire.
6. #8 and #9 cross both within the locomotive and also within the MU jumper.
7. The lead locomotive feed +74 Vdc to trailing units as well as cab car via this wire.
8. Momentary actuation.
9. Analog signal.

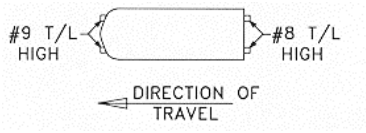


TABLE 6

MU System for Cab Car Compatible with Diesel-Electric Locomotives (1)

Pin #	Wire Name	Gauge AWG	Function Name	Voltage Range (2)	Function (3)	Current
1	SL	14	Spare	—	n/a	
2	SG	14	Alarm Bell	74	C/I	
3	DV	14	D Throttle	74	C	
4	N	10	Control Negative (4)	0	—	
5	ES	14	Emergency Sand	74	C	
6	GF	12	Generator Field	74	C	
7	CV	14	C Throttle	74	C	
8	FO	12	Forward (#8 & #9 cross on B-end) (5)	74	C	
9	RE	12	Reverse (5)	74	C	
10	WS	14	Wheel Slip	74	I	
11	SP	14	Spare	—	n/a	
12	BV	14	B Throttle	74	C	
13	PC	10	Control Positive (6)	74	—	
14	SP	14	Spare	—	n/a	
15	AV	14	A Throttle	74	C	
16	ER	14	Engine Run	74	C	
17	B	14	Dynamic Brake Set Up	74	C	
18	RLC	12	Remote Loadmeter Positive	(8)	I	0-100 mA
19	RLD	12	Remote Loadmeter Negative	—	I	0-100 mA
20	BW	14	Dynamic Brake Warning	74	I	
21	BG	14	Dynamic Brake Start	74	C	
22	CC	14	Spare	—	n/a	
23	SA	14	Manual Sand	74	C/I	
24	BC	14	Dynamic Brake Excitation	0-74 (8)	C	
25	HLS	12	Spare	—	n/a	
26	SV	14	Remote Reset (7)	74	C	
27	SP	14	Spare	—	n/a	

1. All MU power is provided from the locomotive, *not* the cab car. This is done to keep the locomotive and car battery systems galvanically isolated.
2. Unless noted, all signals are Off-On maintained at 0 or 74 Vdc.
3. C = Command, I = Indication
4. The negative side of each locomotive and cab car is common to all of them via this wire.
5. #8 and #9 cross both within the locomotive and also within the MU jumper.
6. The lead locomotive feed +74 Vdc to trailing units as well as cab car via this wire.
7. Momentary actuation.
8. Analog signal.

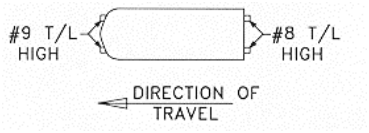


TABLE 7

MU System for Cab Car, Compatible with Electric and Diesel-Electric Locomotives (1)

Pin #	Wire Name	Gauge AWG	Function Name (2)		Voltage Range (3)	Function (4)	Current
			Diesel Mode	Electric Mode			
1	SL	14	Spare	Pantograph Raise	74	C	
2	SG	14	Alarm Bell		74	C/I	
3	DV	14	D Throttle		74	C	
4	N	10	Control Negative (5)		0	—	
5	ES	14	Emergency Sand		74	C	
6	GF	12	Generator Field		74	C	
7	CV	14	C Throttle		74	C	
8	FO	12	Forward (#8 & #9 cross on B-end) (6)		74	C	
9	RE	12	Reverse (6)		74	C	
10	WS	14	Wheel Slip		74	I	
11	SP	14	Spare	Parking Brake Applied	74	I	
12	BV	14	B Throttle		74	C	
13	PC	10	Control Positive (7)		74	—	
14	SN	14	Spare (Parking Brake Applied)	Pantograph Lower	74	C	
15	AV	14	A Throttle		74	C	
16	ER	14	Engine Run	Spare	74	C	
17	B	14	Dynamic Brake Set Up		74	C	
18	RLC	12	Remote Loadmeter Positive		(9)	I	0-100 mA
19	RLD	12	Remote Loadmeter Negative		—	I	0-100 mA
20	BW	14	Dynamic Brake Warning	Spare	74	I	
21	BG	14	Dynamic Brake Start		74	C	
22	CC	14	Spare		—	n/a	
23	SA	14	Manual Sand		74	C/I	
24	BC	14	Dynamic Brake Excitation		0-74 (9)	C	
25	HLS	12	Spare		—	n/a	
26	SV	14	Remote Reset (8)		74	C	
27	SP	14	Spare	Main Circuit Breaker Control	74	C	

1. All MU power is provided from the locomotive, *not* the cab car. This is done to keep the locomotive and car battery systems galvanically isolated.
2. Mode selector switch configures various trainline wires to operate appropriately for either diesel or electric locomotive operation.
3. Unless noted, all signals are Off-On maintained at 0 or 74 Vdc.
4. C = Command, I = Indication
5. The negative side of each locomotive and cab car is common to all of them via this wire.
6. #8 and #9 cross both within the locomotive and also within the MU jumper.
7. The lead locomotive feed +74 Vdc to trailing units as well as cab car via this wire.
8. Momentary actuation.
9. Analog signal.

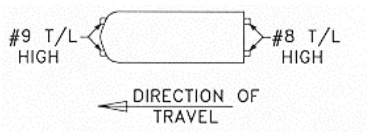


TABLE 8

MU System for Pass-Through (Black Receptacle)

Pin #	Wire Name	Gauge AWG	Notes
1	SL	14	
2	SG	14	
3	DV	14	
4	N	10	
5	ES	14	
6	GF	12	
7	CV	14	
8	FO	12	(#8 & #9 cross on B-end)
9	RE	12	
10	WS	14	
11	SP	14	
12	BV	14	
13	PC	10	
14	SP	14	
15	AV	14	
16	ER	14	
17	B	14	
18	RLC	12	
19	RLD	12	
20	BW	14	
21	BG	14	
22	CC	14	
23	SA	14	
24	BC	14	
25	HLS	12	
26	SV	14	
27	SP	14	

TABLE 9

MU System Jumper Cable (Black Heads)

Pin #	Wire Name	Gauge AWG	Jumper Wire Crossing
1	SL	14	
2	SG	14	
3	DV	14	
4	N	10	
5	ES	14	
6	GF	12	
7	CV	14	
8	FO	12	These two cross
9	RE	12	
10	WS	14	
11	SP	14	
12	BV	14	
13	PC	10	
14	SP	14	
15	AV	14	
16	ER	14	
17	B	14	
18	RLC	12	
19	RLD	12	
20	BW	14	
21	BG	14	
22	CC	14	
23	SA	14	
24	BC	14	
25	HLS	12	
26	SV	14	
27	SP	14	

TABLE 10

Communication System for Passenger Equipment (Blue Receptacle)

Pin #	Wire Name	Gauge AWG	Function Name	Voltage Range (Vdc) (1)	Function (2)	Notes on Crossing
1	Shield	— (3)	Shield (common over all five twisted pairs)	n/a	n/a	
2	TB-	10	Battery Negative (4)	0	Common	
3	PA1	14/2 Shielded	PA (BLK) (3)	0 dB (8)	A	
4	PA2		PA (WHT)			
5	PA3	14/2 Shielded	Intercom (BLK) (5)	0 dB (8)	A	
6	PA4		Intercom (WHT)			
7	PA5	14/2 Shielded	PA Control (BLK) (6)	±13	C	
8	PA6		PA Control (WHT)			
9	RA1	14/2 Shielded	Music -3 (BLK) (5)	0 dB (8)	A	
10	RA2		Music -3 (WHT)			
11	EP1	12	Brake Application (Reserved) (7)	74	C	
12	EP2	12	Brake Release (Reserved) (7)	74	C	
13	EP3	12	Brake Negative (Reserved) (7)	0	Common	
14	D1	12	Open Doors RH	74 (9)	C	X to 15
15	D2	12	Open Doors LH	74 (9)	C	X to 16
16	D3	12	Close Doors RH	74 (9)	C	X to 17
17	D4	12	Close Doors LH	74 (9)	C	X to 16
18	DC1	12	Door Closed Summary Light	74	I	X to 23
19	BR	12	All Brakes Released	74	C	
20	BA	12	All Brakes Applied	74	C	
21	HJ	12	Hot Journal	74	C	
22	CS	12	Conductor Signal	74 (9)	C	
23	DC2	12	Door Close Light	74	I	X to 18
24	PA7	14/2 Shielded	Passenger Information (BLK) (5)		Analog or Digital	
25	PA8		Passenger Information (WHT)			
26	BLS	12	Conductor Door Closed Light Feed	74	I	
27	AN	12	Attendant Call	74	C	

1. Unless noted, all signals are Off-On maintained at 0 or 74 Vdc derived from the car battery system.
2. C = Command, I = Indication, A = Audio
3. Shield common for all five shielded pairs, with one-point ground to carbody. Shield is continuous over length of locomotive/car.
4. Negative side of each car 74 Vdc system is common to all cars via this wire. The negative is grounded to the carbody in each car at the battery.
5. Transformer coupled with 600 Ω balanced line (four places).
6. Derived from PA unit.
7. These three are powered from the locomotive battery system.
8. Communication line measured in dB.
9. Momentary +74 Vdc signal
10. Shields connected only on one end of jumper to avoid ground loops.

TABLE 11

27-Point Alternative Communication System for Passenger Equipment (Red Receptacle)

Pin #	Wire Name	Gauge AWG	Function Name (1)	Voltage Range (Vdc) (2)	Function (3)	Current	Notes on Crossing
1		12	Zero Speed	36	C		
2		12	Enable Door LH	36 (8)	C		X to 11
3		12	Door Interlock (4)	74	C		
4		10	Car Battery Negative (5)	Common	Common		
5		12	Spare	NA	F		
6		12	Buzzer Power	36	C		
7		16	Intercom (BLK) (6)	X dB (9)	A		
8		12	Spare	n/a	F		
9		16	PA/Intercom Control (BLK)		C		
10		16	PA/Intercom Control (WHT)		C		
11		12	Enable Doors RH	36 (8)	C		X to 2
12		NA	Intercom (Shield)	n/a	n/a		
13		16	Intercom (WHT)	X dB (9)	A		
14		12	Door Closed Light (4)	74	C/I		
15		16	PA (BLK) (7)	X dB (9)	A		
16		16	PA (Shield)	n/a	n/a		
17		12	Open Doors LH	36 (8)	C		X to 27
18		12	Close Doors LH	36 (8)	C		X to 26
19		10	Cab MU Supply Positive (4)	74	C		
20		16	PA (WHT)	X dB (9)	A		
21		12	Cab Buzzer	36 (8)	C		
22		12	Door Override (4)	74	C/I		
23		12	Spare	n/a	F		
24		10	Car Battery Positive	36	C		
25		12	Spare (Door Station Activated)	36	C		
26		12	Close Doors RH	36 (8)	C		X to 18
27		12	Open Doors RH	36 (8)	C		X to 17

1. The applications within this table represents an alternative arrangement used by some railroads and are not interoperable.
2. Unless noted, all signals are Off-On maintained at 0 or 36 Vdc derived from the car battery system.
3. C = Command, I = Indication, A = Audio, F = Future
4. These four are powered from the locomotive battery system.
5. Negative side of each car 36 Vdc system is common to all cars via this wire.
6. #7 and #13 with #12 as shield, transformer coupled on 150 Ω balanced line.
7. #15 and #20 with #16 as shield, transformer coupled on 150 Ω balanced line.
8. Momentary +36 Vdc signal.
9. Communication line measured in dB.
10. Shields connected on only one end of jumper to avoid ground loops.

TABLE 12

27-Point Communication Jumper Cable (Blue Heads)

Pin #	Wire Name	Gauge AWG	Jumper Wire Crossings	
			Car-Car Only	Loco-Loco-Car Only (Blue Band)
1	1	(shield)		
2	2	10		
3	3	14 shielded		
4	4	14 shielded		
5	5	14 shielded		
6	6	14 shielded		
7	7	14 shielded		
8	8	14 shielded		
9	9	14 shielded		
10	10	14 shielded		
11	11	12		
12	12	12		
13	13	12		
14	14	12	X to 15	X to 15
15	15	12	X to 14	X to 14
16	16	12	X to 17	X to 17
17	17	12	X to 16	X to 16
18	18	12	X to 23	
19	19	12		
20	20	12		
21	21	12		
22	22	12		
23	23	12	X to 18	
24	24	14 shielded		
25	25	14 shielded		
26	26	12		
27	27	12		

1. Shields connected on only one end of jumper to avoid ground loops.

TABLE 13

Alternate 27-Point Communication Jumper Cable (Red Heads)

Pin #	Wire Name	Gauge AWG	Wire Crossings
1	1	14	
2	2	14	X to 11
3	3	14	
4	4	10	
5	5	14	
6	6	14	
7	8	14	
8	9 BLK	16/2 shielded	
9	10 WHT		
10	7 BLK	16/2 shielded	
11	13 WHT		
12	shield	Shield for 7 & 13	
13	15 BLK	16/2 shielded	
14	20 WHT		
15	shield	Shield for 15 & 20	
16	11	14	X to 2
17	14	14	
18	17	14	X to 27
19	18	14	X to 26
20	19	10	
21	21	14	
22	22	14	
23	23	14	
24	24	10	
25	25	14	
26	26	14	X to 18
27	27	14	X to 17

Related APTA standards

APTA PR-CS-RP-019-12, "Pushback Couplers in Passenger Rail Equipment"
APTA PR-E-S-001-99, "Electrical Insulation Integrity"
APTA PR-E-RP-002-98, "Installation of Wire and Cable on Passenger Rolling Stock"
APTA PR-E-RP-009-98, "Ampacities for Wire and Cable Used on Passenger Rolling Stock with Flame, Smoke, and Toxicity Considerations"
APTA PR-E-RP-019-99, Rev. 2, "27-point Jumper and Receptacle Hardware"
APTA PR-M-RP-001-97, "End of Car Connections with Tightlock and Interlocking Knuckle-Type Couplers"
APTA PR-M-S-016-06, "Safety Appliances for Rail Passenger Cars"
APTA PR-M-S-018-10, "Powered Exterior Side Door System Design for New Passenger Cars"

References

Code of Federal Regulations:
- 49 CFR, §231: Railroad Safety Appliances
- 49 CFR, §238.131: Exterior side door safety systems-new passenger cars and locomotives used in passenger service
- 49 CFR, §238.133: Exterior side door safety systems-all passenger cars and locomotives used in passenger service

American Association of Railroads, Standard S-512-1994, 27-Point Control Plug and Receptacle Standard

PRIIA Specifications:
- 305-001: Specification for PRIIA Bi-Level Passenger Rail Car
- 305-003: Specification for PRIIA Single Level Passenger Rail Car
- 305-005: Specification for Diesel-Electric Passenger Locomotives
- 305-007: Specification for Trainset
- 305-009: Specification for Diesel Multiple Units (DMUs)
- 305-011: Specification for Dual Mode (DC 3rd Rail) Passenger Locomotives
- 305-919: "Digital Trainline Hardware

Definitions

27-point jumper cable: A cable assembly having a 27-conductor plug on one or both ends, which is used to provide a flexible electrical connection between two cars and/or locomotives.

27-point receptacle: The receptacle mounted on the ends of rail vehicles into which the 27-point jumper cables mate.

DMU (diesel multiple unit): A self-propelled passenger vehicle utilizing diesel traction. Some or all of the consist may have traction power. Likewise, one or more cars is equipped with an operator's cab from which the train is controlled.

door summary circuit: A trainline door circuit that provides an indication in the controlling cab of the train that all exterior doors are closed and latched, and/or locked out with a door isolation lock.

jumper, fixed: A cable assembly having a 27-conductor plug on one end and the other end permanently fixed to the vehicle, which is used to provide a flexible electrical connection between two cars and/or locomotives.

looping: The process of connecting a jumper cable between two adjacent receptacles on the same vehicle. This is normally done on the exposed end of the last car of a train and establishes circuits identifying that point as the end of the train for various trainline circuits.

power car: For purposes of this document, a power car is a rail vehicle other than a locomotive containing a HEP source and control system. This generally takes the form of a baggage car or a car converted from a locomotive that has had the traction power system removed. It may also be part of a semi-permanently coupled trainset, in which case only one end of a power car may be suitable to be attached to the train.

receptacle, dummy: A receptacle that is used to hold the free end of an unconnected jumper cable. The dummy may include one or more contacts to establish end-of-train circuit functions for the trainline, or it may be a purely passive device with no contacts.

trainline: For the purposes of this recommended practice, an electrical cable system that allows electrical signals to be sent over the entire length of the train. Types include power, control, communication and data, often with more than one function contained within the same cable. The trainline may connect to equipment in each vehicle, or may simply pass through, providing a signal path between vehicles on opposite ends of that vehicle.

trainline, car control/communication: A trainline (referred to within this document as "communication") whose function is primarily to convey car control and communication signals throughout the train. Typical signals include: door controls and indications, public address, brake applied/ released indications, door closed summary, etc.

trainline, multiple unit (MU): A trainline whose primary function is to convey traction and dynamic brake commands and indications. This trainline is used to provide those signals between:

- locomotives coupled together;
- cab car and locomotive; and
- locomotives or power cars placed at opposite ends of the train.

Abbreviations and acronyms

Ω	ohms
COMM	27-point communication trainline
dc	direct current
dB	decibels
DMU	diesel multiple unit
DTL	digital trainline
ECP	electrically controlled pneumatic
FRA	Federal Railroad Administration
HEP	head end power
mA	milliampere
MU	multiple unit
PA	public address
PRIIA	Passenger Rail Investment and Improvement Act of 2008
Vdc	volts direct current

Document history

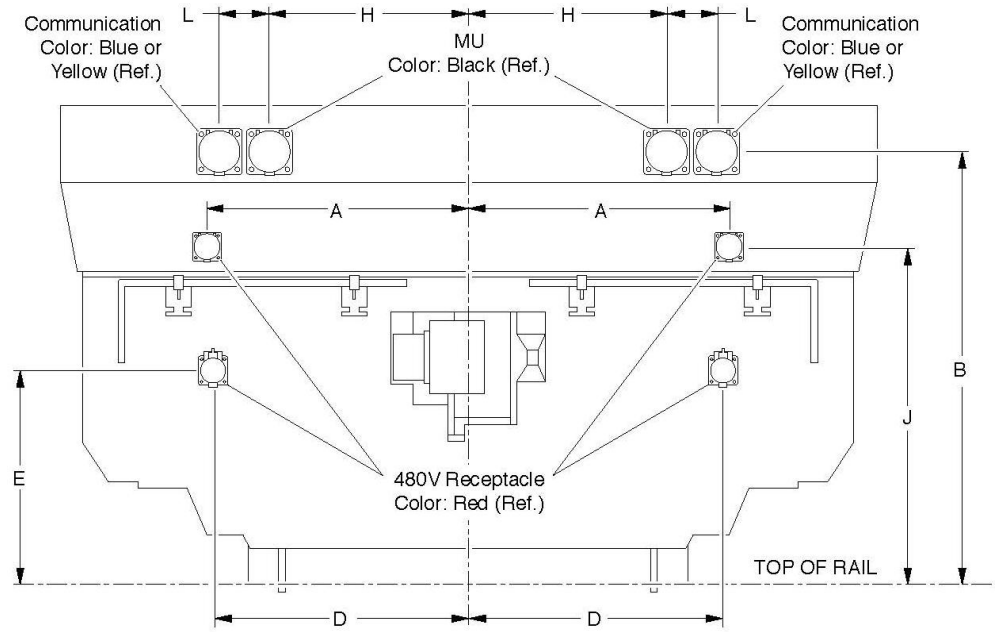
Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	Oct. 28, 1999	Jan. 11, 2000	Oct. 28, 1999
First revision	—	—	—	March 22, 2004	—
Second revision	Nov. 16, 2025	Jan. 30, 2026	April 19, 2026	May 5, 2026	May 13, 2026

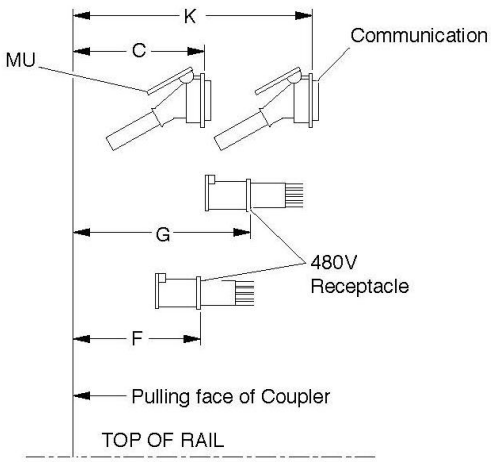
The passenger rail industry phased this recommended practice into practice over the six-month period from July 1 to December 31, 1999. The recommended practice took effect January 1, 2000.

Appendix A: Figure for reference

The figures in this appendix are part of APTA PR-M-RP-001, "End-of-Car Connections with Tightlock and Interlocking Knuckle-Type Couplers" and are provided here as reference-only materials to assist in the understanding of the locations of receptacles and jumper cables located on the ends of cars and locomotives. For details affecting the mounting, refer to that document.

Figure 9, APTA PR-M-RP-001: End-of-Vehicle Trainline Connector Typical Location, Locomotive F-End

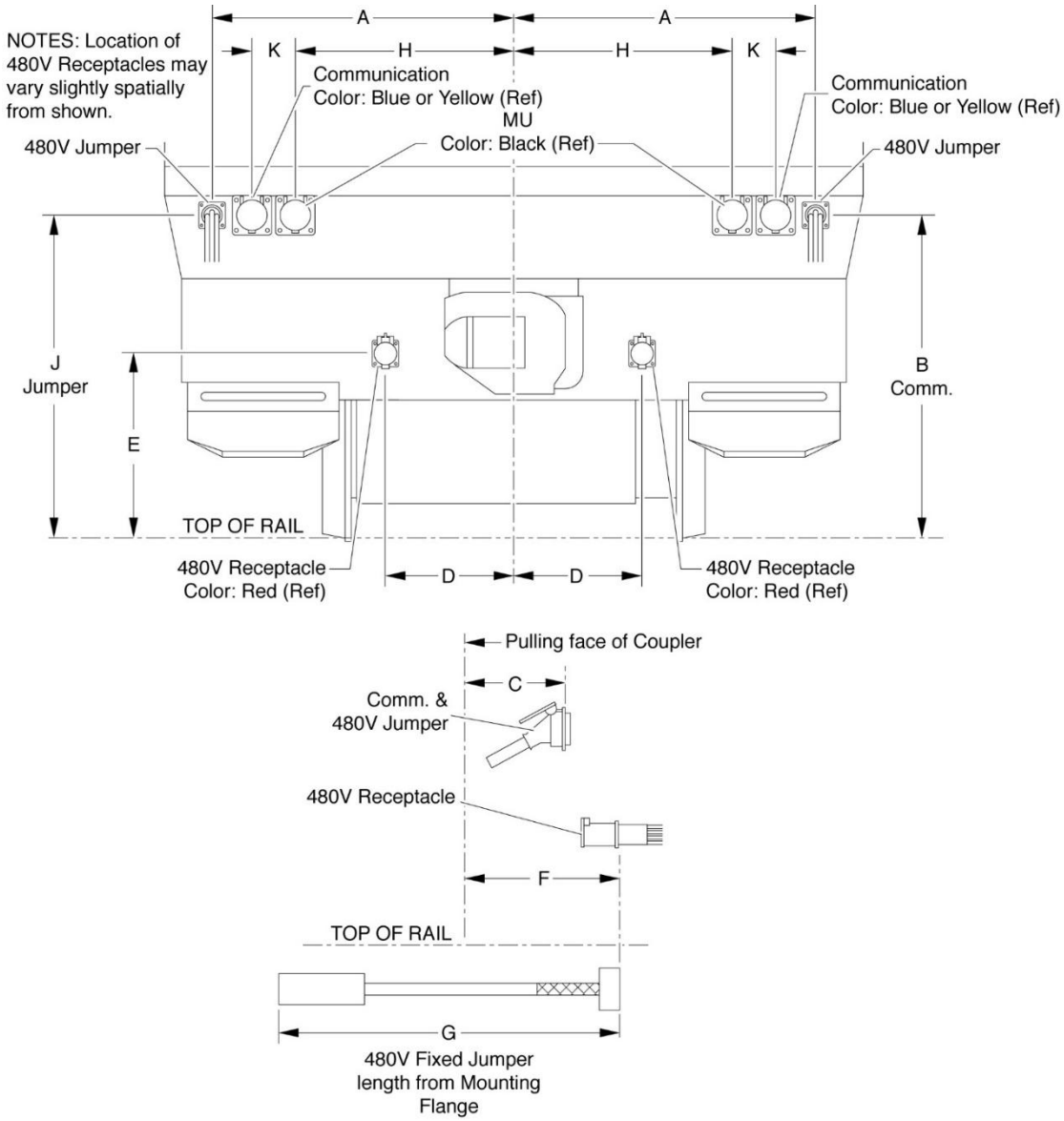




	A	B	C	D	E	F	G	H	J	K	L
Option 1	29.25	64.46	19.19	37.50	32.01	18.75	26.54	29.25	50.28	21.56	7.50
Option 2	39.00	53.00	25.50	38.63	33.25	33.25	21.75	19.12	40.75	25.50	7.12

NOTE: This can also represent the B-end of a dual cab locomotive. Dimensions are in inches.

Figure 10, APTA PR-M-RP-001: End-of-Vehicle Trainline Connector Standard Location, Locomotive B-End

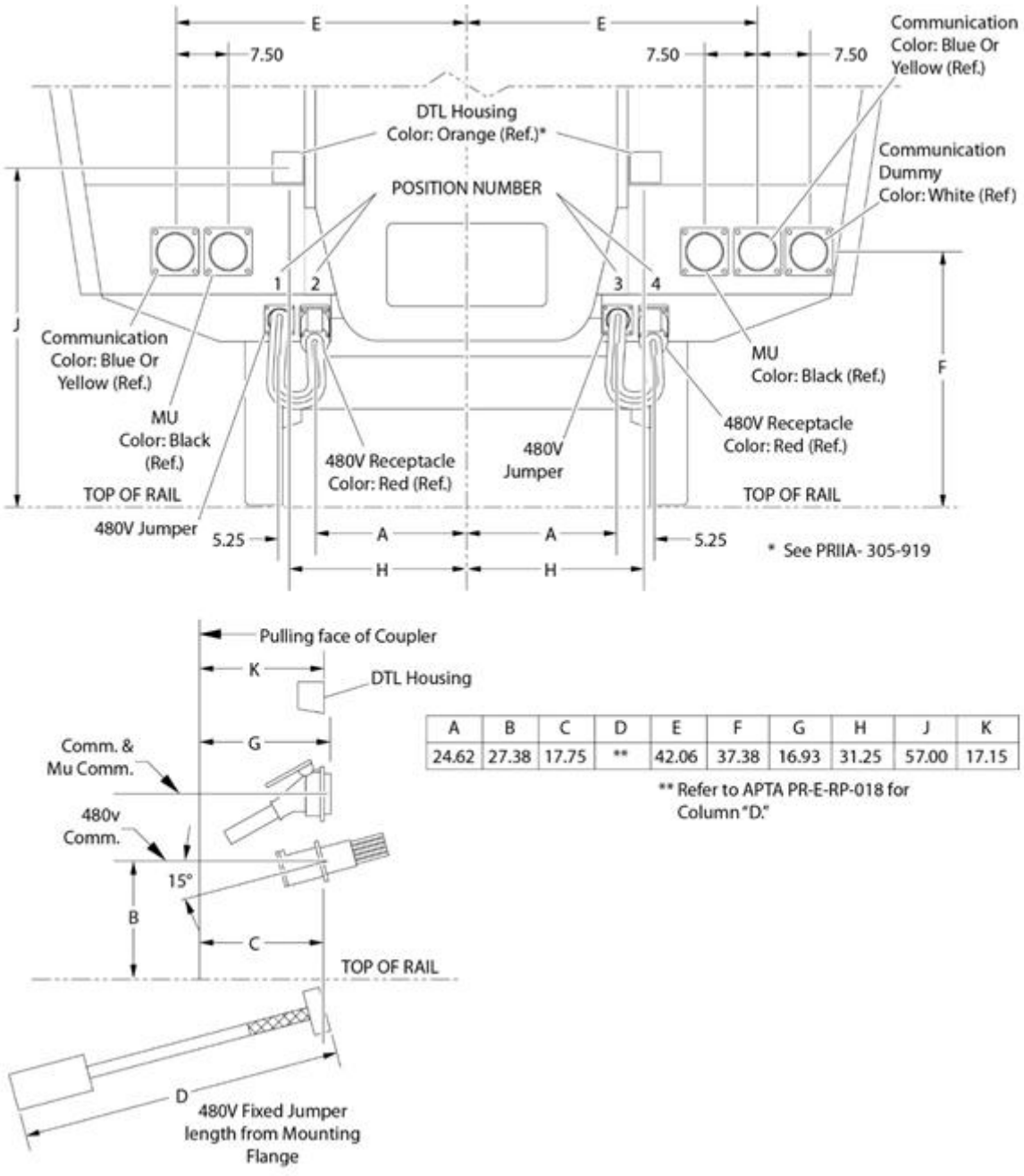


	A	B	C	D	E	F	G	H	J	K
Option 1	43.00	53.83	35.13	35.08	33.04	31.63	*	29.25	50.50	7.50
Option 2	45.82	57.18	18.15	23.00	27.88	25.50	*	39.50	50.06	8.00

* Refer to APTA PR-E-RP-018 for Column "G."

NOTE: Dimensions are in inches.

Figure 11, APTA PR-M-RP-001: End-of-Vehicle Trainline Connector Standard Location, Low-Level Car End

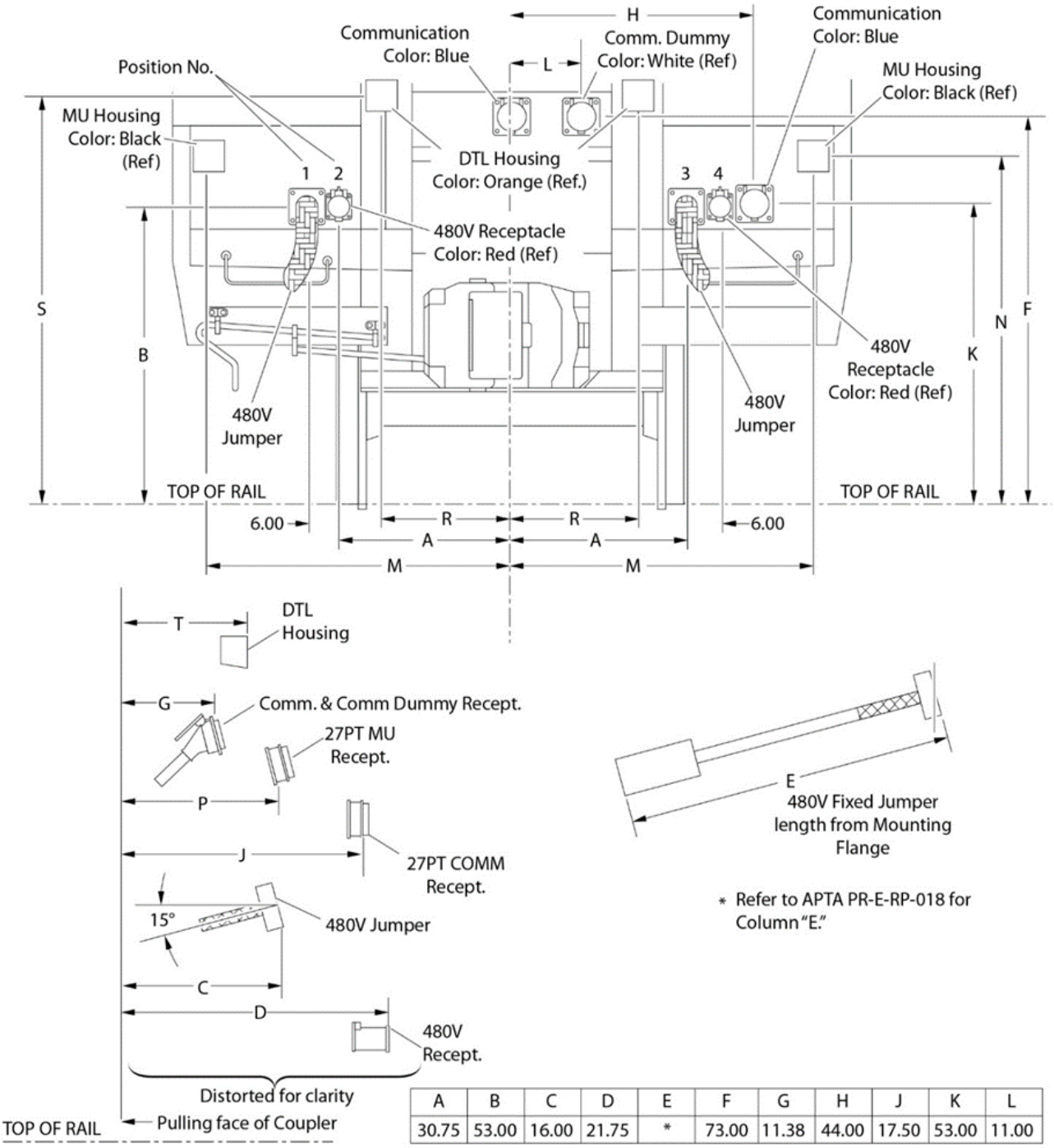


A	B	C	D	E	F	G	H	J	K
24.62	27.38	17.75	**	42.06	37.38	16.93	31.25	57.00	17.15

** Refer to APTA PR-E-RP-018 for Column "D."

NOTE: Dimensions are in inches.

Figure 12, APTA PR-M-RP-001: End of Vehicle Trainline Connector Standard Location, High-Level Car End



A	B	C	D	E	F	G	H	J	K	L
30.75	53.00	16.00	21.75	*	73.00	11.38	44.00	17.50	53.00	11.00

M	N	P	R	S	T
51.50	60.50	15.00	31.25	57.00	13.00

NOTE: Dimensions are in inches.