# 18. APTA PR-E-RP-019-99 Recommended Practice for 27-Point Jumper and Receptacle Hardware for Locomotives and Locomotive-Hauled Equipment

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**APTA Commuter Rail Executive Committee**

**Abstract:** This document defines the recommended practices for 27-point MU Control and Communication, jumper and receptacle hardware for use on new and rebuilt locomotives and locomotive-hauled vehicles.

**Keywords:** hardware, trainline, 27-point,

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# APTA PR-E-RP-019-99
# Recommended Practice for 27-Point Jumper and Receptacle Hardware for Locomotives and Locomotive-Hauled Equipment

## 1. Overview

### 1.1 Scope

This document defines the recommended practices for 27-point jumper cables and receptacle hardware for new and rebuilt equipment. *APTA PR-E-RP-017-99* covers associated vehicle and system recommended practices.

### 1.2 Purpose

The purpose is to define recommended practices for 27-point jumper cables and associated receptacles, both for construction standards and to ensure mutual mechanical compatibility among products manufactured by different vendors.

## 2. References

AAR S-512-1994, 27-Point Control Plug and Receptacle Standard

APTA PR-E-S-001-98, Standard for Insulation Integrity

APTA PR-E-RP-002-98, Recommended Practice for Wiring of Passenger Equipment

APTA PR-E-RP-009-98, Recommended Practice for Wire Used on Passenger Rolling Stock

APTA PR-E-RP-017-99, Recommended Practice for 27-point Control and Communications Trainlines

## 3. Definitions abbreviations and acronyms

### 3.1 Definitions

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

**3.1.1 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.

**3.1.2 27-Point receptacle:** The receptacle(s) mounted on the ends of rail vehicles into which the 27-point jumper cables mate.

**3.1.3 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.

**3.1.4 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.

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

**3.1.6 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.

**3.1.7 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, etc.

**3.1.8 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
- Locomotives or power cars placed at opposite ends of the train

# 4. General

## 4.1 Identification by mechanical interlocking

Receptacle housings and mating jumper cable plugs for different services (MU, car communication, etc) should be mechanically interlocked to prevent a jumper being inserted into a different service receptacle. This should be achieved by a combination of two techniques:

### 4.1.1 Keyways

A master key on the metal jumper head and corresponding keyway in the metal receptacle housing to provide plug orientation in the receptacle.

### 4.1.2 Rotate contact block

Rotating the contact block into one of three positions, relative to the housing, to provide unique keying of the mating. (The contact block itself is the same for all applications.)

## 4.2 Identification by color code

As an identification aid (Refer to Figures 2 through 4 of *APTA PR-E-RP-017-99*[1]), receptacles and associated jumpers should be color-coded and receptacle covers labeled as given in Table 1 (unless otherwise required by the railroad):

**Table 1 Color Code**

| Function | Color* | Label |
|---|---|---|
| MU control | Black | "MU" |
| Communication[2] | Blue | "Comm" |
| Communication[3] | Yellow | "Comm" |
| Communication Dummy | White | "Dummy" |
| MU Dummy (if required) | Yellow | "Dummy" |

*Colors in accordance with OHSA regulations.

## 4.3 Current rating

Contact rating of the mated jumper and receptacle contacts should be 30 amps continuous over the entire operating range of the assemblies.

## 4.4 Contact mating force

Plug/receptacle contact mating force should be 54 +/- 10 lbs.(240 +/- 45 newtons). Individual contacts should fall between eight (8) and 52 ounces. (2.2 and 14.5 newtons).

## 4.5 Jumper head retention in the receptacle

The head of the jumper cable should be retained in the receptacle by the engagement of a boss on the inside surface of the cover into a corresponding cavity in the jumper head. The jumper cable should be sacrificial relative to the receptacle. Design of this interface should be such that neither the receptacle nor the jumper cable is damaged by pulling the locked jumper out of the receptacle, such as by an unauthorized uncoupling.

## 4.6 Environment

The receptacles and jumper cables should be suitably rated for the mechanical conditions experienced on the vehicle, especially shock, vibration and ambient temperatures. As these conditions are site- and vehicle-specific, they should be specified by the authority in the contract specification documents.

[1] For references in Italics, see Section 2
[2] "Intercity" protocol (see APTA RP-E-017-99, Section 7 and Table 8)
[3] Commuter" protocol (see APTA RP-E-017-99, Section 7 and Table 9)

The following are examples of conditions that may occur and should be the subject of such detailed specifications:

- Exposure to weather typically experienced throughout the United States.
- Temperature range -40°F to +140°F (-40°C to +60°C).
- 5% to 100% relative humidity, including condensing
- Blown and flying sand, dust, ballast, water, ice and other debris at up to 125 mph. (200 km/hr).
- Combined vertical and horizontal movement incidental to motion between vehicles.
- Diesel fuel, car washing solvents and other fluids commonly experienced in the railroad environment.
- Being dropped onto the ground or other parts of the vehicle occasionally, as might occur when applying or removing jumpers from a vehicle.

# 5. Receptacle considerations

## 5.1 Overall assembly

The flange-mounted receptacle assembly should consist of a metallic housing equipped with a contact block having 27 contacts, conforming to Figures 1 through 3. The spring-loaded hinged cover should provide a retention force to maintain the mated jumper cable in position in the receptacle.

Receptacles for different purposes should be mechanically interlocked to prevent cross-connecting jumper cables as per Section 4.1.

Pigtail wiring may be provided by the receptacle manufacturer or may be installed by the car/locomotive builder.

## 5.2 Housing

### 5.2.1 Housing and cover

The receptacle housing and its cover should be of an aluminum alloy or an equivalent corrosion-resistant material. The cover should open a minimum of 90 degrees to allow easy insertion of the jumper plug.

### 5.2.2 Cover spring and hinge

The cover spring and hinge pin should be stainless steel or an equivalent corrosion resistant material.

### 5.2.3 Cover gasket

A durable, long-life gasket, secured with compatible adhesive, should be provided on the inside face of the cover to provide a weatherproof seal when the cover is closed.

### 5.2.4 Flange seal

A durable, long-life seal, secured with compatible adhesive, should be provided on the mounting flange to provide a waterproof seal between the receptacle and the surface to which it is mounted.

### 5.2.5 Replacement considerations

A slot should be provided in the housing to make it possible to pass the rear insulator disk of the contact block, in a fully wired condition, through the housing without disconnecting any wiring. This is to allow a damaged housing to be replaced on a vehicle without having to disconnect any wiring.

### 5.2.6 Assembly color

The assembly should be painted and labeled in accordance with Section 4.2.

## 5.3 Contact block

The contact block consists of a pair of insulator disks carrying the 27 contact pins, located in accordance with Figure 1. Each pin is crimped onto its respective wire and protected with a one-piece molded grommet. This should provide:

- A resilient mount for the contact,
- Electrical insulation at the crimp,
- Mechanical support of the wire as it emerges from the contact.

Each contact cavity should be numbered per Figure 1 with raised characters a minimum of 3/32" (2.4 mm) high on the exposed face of the front and the wire side of the back insulation disk.

The contact block assembly should be secured to the housing with screws and suitable locking hardware of stainless steel or approve equal corrosion-resistant material.

## 5.4 Contact pins

Pin contacts should be fabricated from materials that meet or exceed the performance of copper alloy and should be silver-plated. The crimp barrel end of the contact should accept either # 10, 12 or 14 AWG wire. Crimping should be done consistent with *APTA PR-E-RP-002-98 Recommended Practice for Wiring of Passenger Equipment*,[4]. Proper crimp tooling should be used to ensure low contact resistance and satisfactory resistance to wire pullout. All crimps should show the capability to withstand a minimum of 50-pound (180 newtons) tensile pull. The male contact should be the flexible side of the male-female joint and should have adequate

[4] For references in Italics, see Section 2.

spring loading in a 0.3125 in. +0.002/-0.000 (7.934 +.051/-.000 mm) socket to meet the contact rating. To ensure low contact resistance, the use of a multi-contact band or equivalent is recommended. This contact shroud should be of a spring type material that does not take a set or deform due to shock encountered in normal service, including occasional dropping.

### 5.5 Wire for receptacles

The wiring should consist of the number count and size specified by the appropriate wiring schematic, Figure 3. Each wire should be identified by a permanent marker located approximately 6" (150 mm) from the free end.

The wire should be 600 volt, 110 degree C, with tinned conductor, with cross-linked polyolefin insulation, per *APTA PR-E-RP-009-98, Recommended Practice for Wire Used on Passenger Rolling Stock*[5], and as identified below:

**Table 2. Wire for Receptacles**

| Wire Gauge (AWG) | Stranding | Wire OD (inches |
|---|---|---|
| #10 | 27/24 | 0.183 |
| #12 | 19/25 | 0.146 |
| #14 | 19/27 | 0.127 |
| #14/2 shielded >85% coverage, with drain | 19/27 | 0.378 |

## 6. Jumper cables

### 6.1 Jumper assemblies

The portable jumper cable assembly should consist of two 27-conductor plugs connected with a flexible rubber conduit, conforming to Figures 1,4 & 5. The jumper plug should accept the positive retention force of the spring-loaded hinged receptacle cover to maintain the mated jumper cable in position in the receptacle.

Jumper cables for different purposes should be mechanically interlocked to prevent cross-connecting jumper cables, as described in Section 4.1. During an unauthorized uncoupling of vehicles, the jumper cable should be sacrificial so preventing damage to the, receptacle or its mounting, as described in Section 4.5.

The jumper cable assembly should be capable of being stretched as described in Section 6.5 without damage.

### 6.2 Head

The heads should be of an aluminum alloy or approved equal corrosion resistant material. They

[5] For references in Italics, see Section 2.

should be securely attached to the rubber conduit (hose) mechanically, without adhesive, and ensure that the plugs cannot rotate on the conduit. The connection or joint at each end between plug head and rubber conduit should be watertight. The head assembly should be painted in OSHA colors in accordance with Section 4.2.

## 6.3 Contact block

The contact block consists of a pair of insulator disks carrying the 27 contact sockets, located in accordance with Figure 1. Each contact should be crimped onto its respective wire and protected with a one-piece molded grommet. This should provide:

a) a resilient mount for the contact,

b) electrical insulation at the crimp,

c) mechanical support of the wire as it emerges from the contact.

The terminated contacts should be secured resiliently in the contact block to permit slight radial movement to allow for minor misalignment between plug and receptacle contacts. The front insulation disk should be molded from a durable, long-life, molded electrical grade elastomer suitable for the specified environment. It should have a high durometer rating which will prevent the contacts from being pulled out of the assembly when plugs are withdrawn from the receptacle under adverse conditions. The rear insulation disk should be molded from a shock-resistant electrical grade plastic material and should have a low moisture absorption property. The contact block is keyed to the head so it can only be installed in the correct orientation. The same contact block is used regardless of the head keying. Each contact cavity should be numbered per Figure 4 with raised characters a minimum of 3/32” (2.4 mm) high on the exposed face of the front and the wire side of the back insulation disk. The joints between the contact block and the head and contacts to contact block should be waterproof. The contact block assembly should be secured to the head with corrosion-resistant screws and suitable locking hardware.

## 6.4 Contact sockets

Socket contacts should be fabricated from materials that meet or exceed the performance of copper alloy and be silver-plated. The crimp barrel end of the contact should accept either # 10, 12 or 14 AWG wire. Crimping should be done consistent with *APTA PR-E-RP-002-98, Recommended Practice for Wiring of Passenger Equipment*. Proper crimp tooling should be used to ensure low contact resistance and satisfactory resistance to wire pullout. All crimps must show the capability to withstand a minimum of 50 pound (180 newtons) tensile pull.

## 6.5 Wire for jumpers

The wiring should consist of the number count and size specified by the appropriate wiring schematic, Figure 5. Each wire should be identified by a permanent marker located approximately 6" (150 mm) from the one end. There should be a minimum of six (6) in. (150 mm) slack in the cut length of the wire bundle for removal of the insulation stack from the head and the replacement of a contact, if needed.

The slack should be evenly distributed throughout the length of the jumper to prevent excess

strain and flexing on the contact termination, as well as allow for hose stretch during adverse conditions. The wire should be 600 volt, with tinned conductor, with highly flexible thermosetting insulation, and as identified below:

**Table 3 Wire for Jumpers**

| Wire gauge (AWG) | Stranding | Wire OD (inch) |
|---|---|---|
| #10 | 105/30 | 0.180 |
| #12 | 65/30 | 0.158 |
| #14 | 41/30 | 0.146 |
| #14 shielded; >85% coverage, with drain | 105/34 | 0.175 |

## 6.6 Hose

The rubber conduit hose should be of braid reinforced construction, having a nominal inside diameter of 1-1/4 inch. The braid lay should be such that stretching of up to six inches is possible, but that it should return to its nominal length within 30 minutes at 60 degrees F. (15 degrees C). The hose and its attachment to the heads should be capable of withstanding a minimum tensile pull of 600 pounds (2.16 kilonewtons) without damage. The hose should resist damage from sunlight, weather, oil and fluid common to the railroad environment. The inner diameter of the conduit hose, when stretched 10% of the overall jumper length should not be sufficiently reduced in size to cause the wires to be gripped. This is to prevent the wires from being pulled from the crimped contacts or being broken.

## 6.7 Hanger

Jumper cables of 90-inch (2.3 meters) length or more should have a hanger arrangement to allow it to be supported mid-span. The hanger should be electrically non-conductive and include a metal insert for the attachment of the supporting hook or clevis.

# 7. Tests

## 7.1 Acceptance tests

Acceptance tests should be conducted by the manufacturer on all receptacles and jumper cables. The requirements for tests are contained in *APTA PR-E-S-001-98, Standard for Insulation Integrity*, as well as the following, and should be performed on each jumper and receptacle:

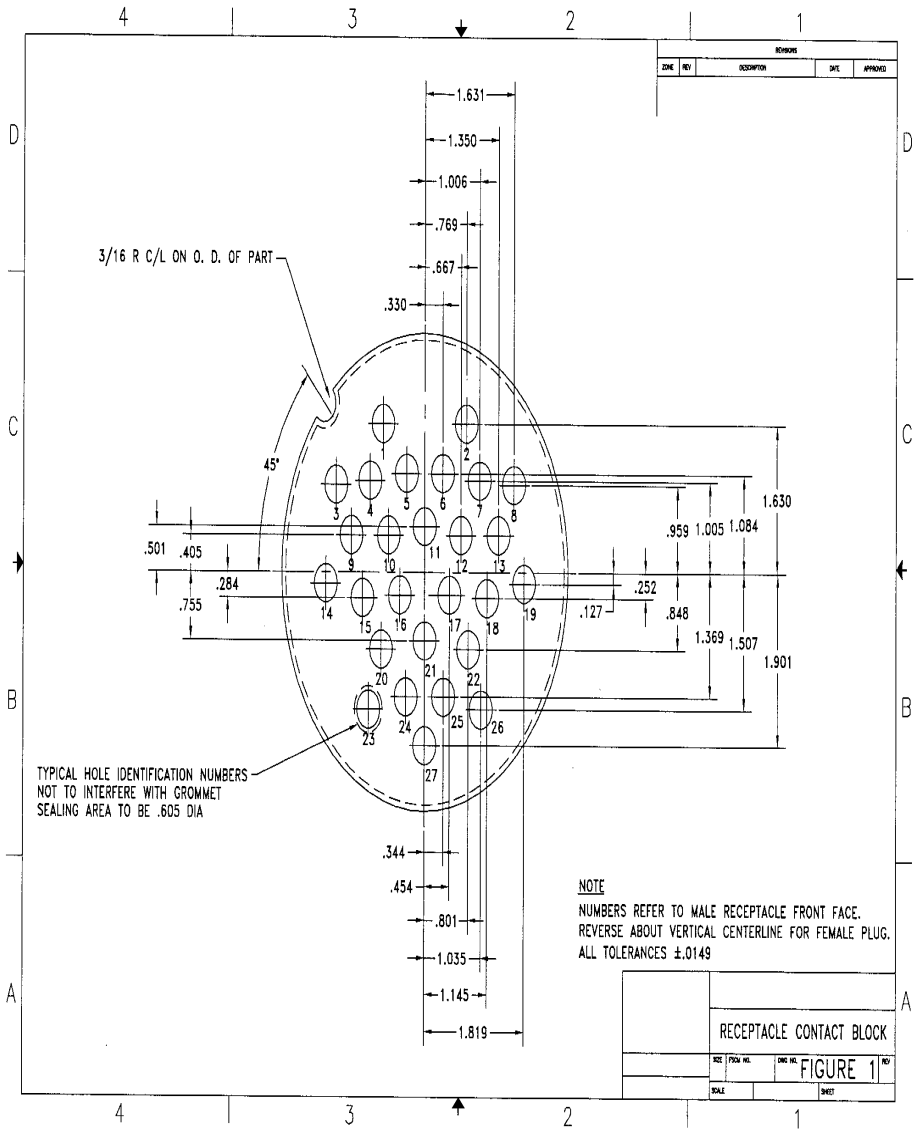
- Continuity
- Freedom from unintended cross connections
- HiPot at 1500 VAC
    - To housing

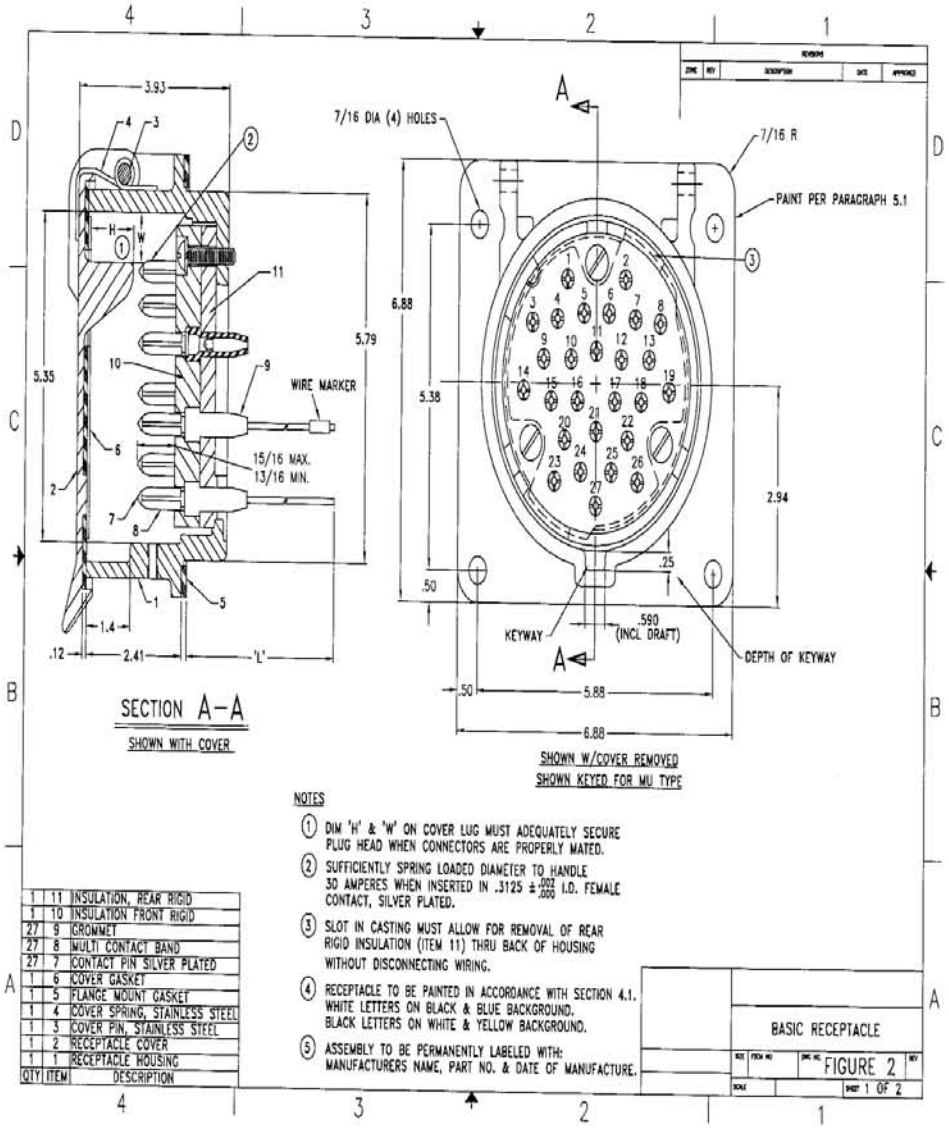
  - Among conductors
  - Between shields and the conductor within
- Mating (to ensure proper alignment and operation of each contact, as well as proper retention of the multi-contact band, etc)
- Mating force measurement (periodic sample only)

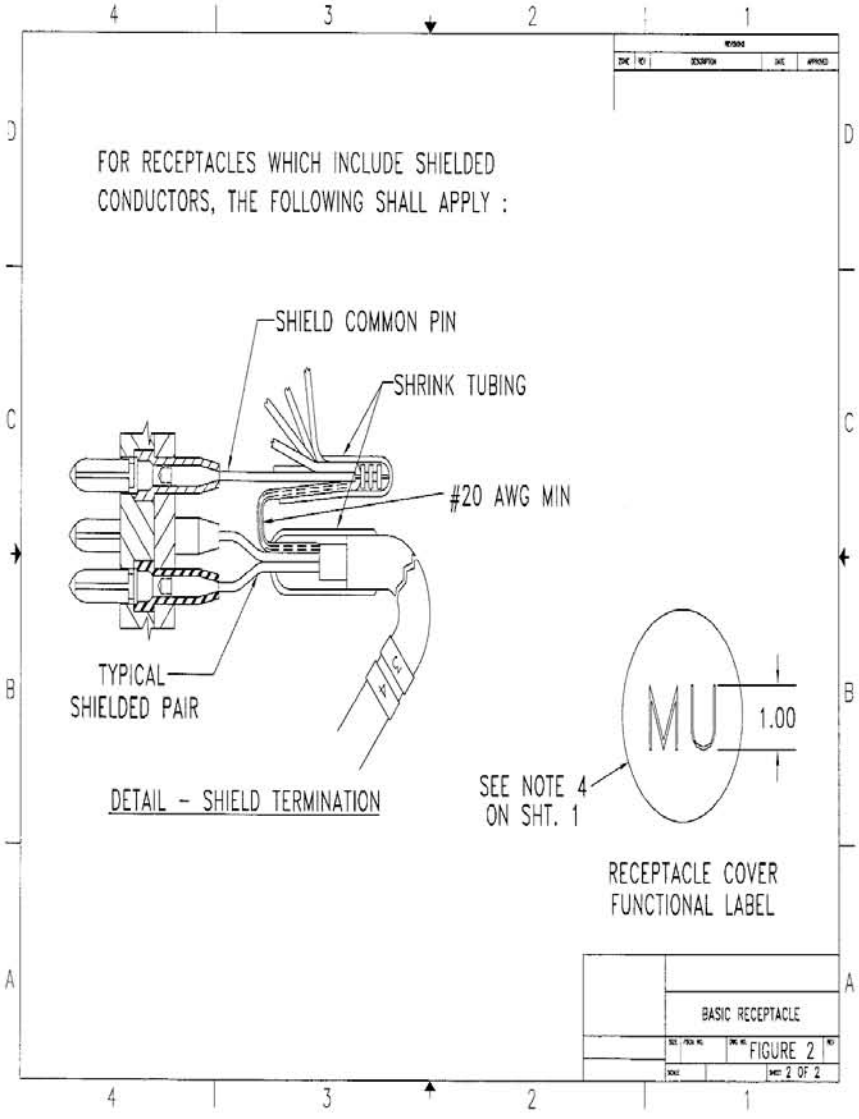
## 8. Illustrations

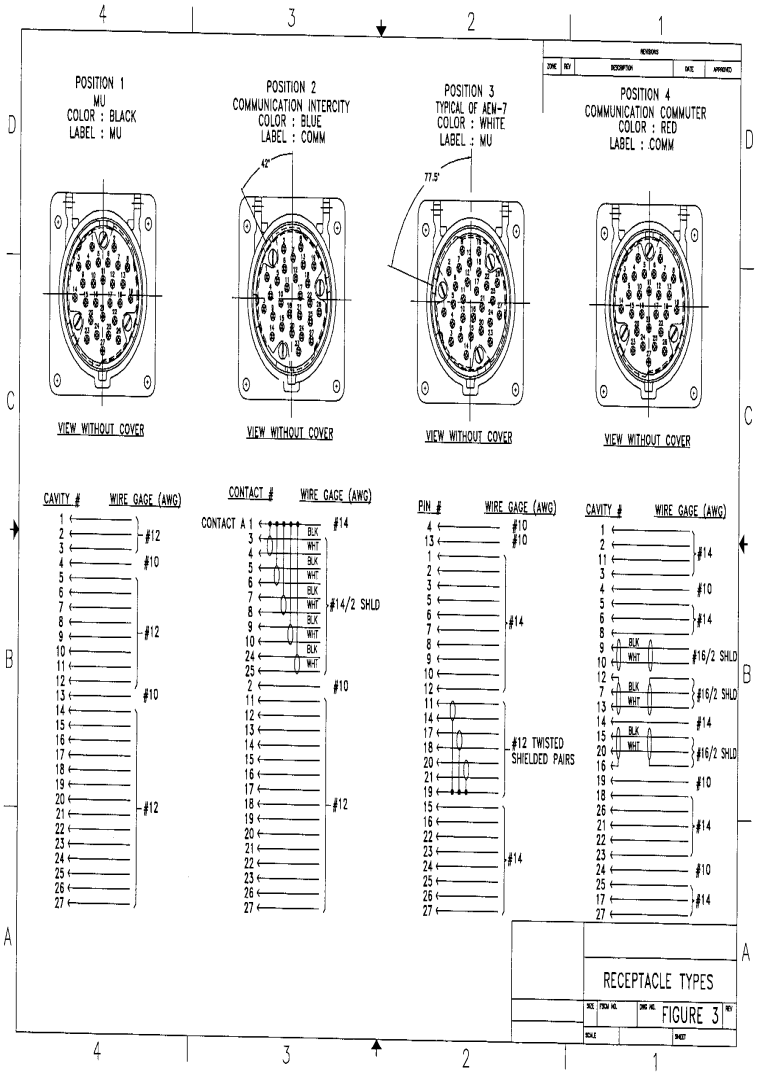
Figures:

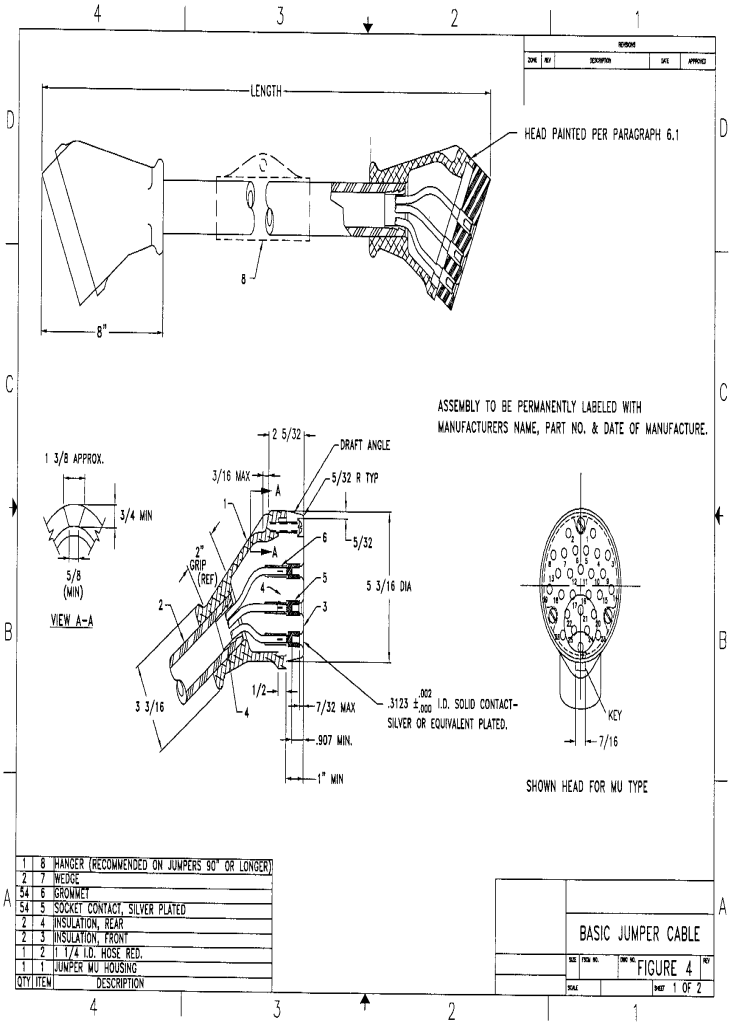
1. Receptacle Contact Block
2. Basic Receptacle
3. Receptacle Types
4. Basic Jumper Cable
5. Jumper Cable Types

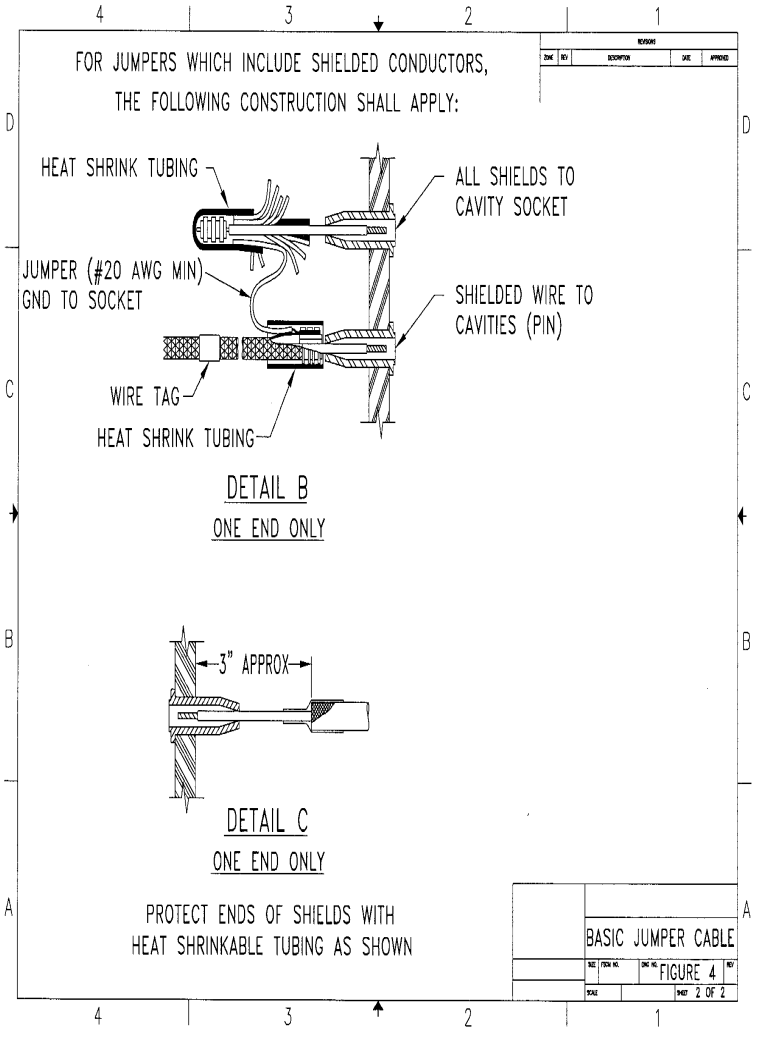

3/16 R C/L ON O. D. OF PART
45°
TYPICAL HOLE IDENTIFICATION NUMBERS
NOT TO INTERFERE WITH GROMMET
SEALING AREA TO BE .605 DIA
1.631
1.350
1.006
.769
.667
.330
.344
.454
.801
1.035
1.145
1.819
.501
.405
.284
.755
.959
1.005
1.084
1.630
.252
.127
.848
1.369
1.507
1.901
NOTE
NUMBERS REFER TO MALE RECEPTACLE FRONT FACE.
REVERSE ABOUT VERTICAL CENTERLINE FOR FEMALE PLUG.
ALL TOLERANCES ±.0149
RECEPTACLE CONTACT BLOCK
FIGURE 1

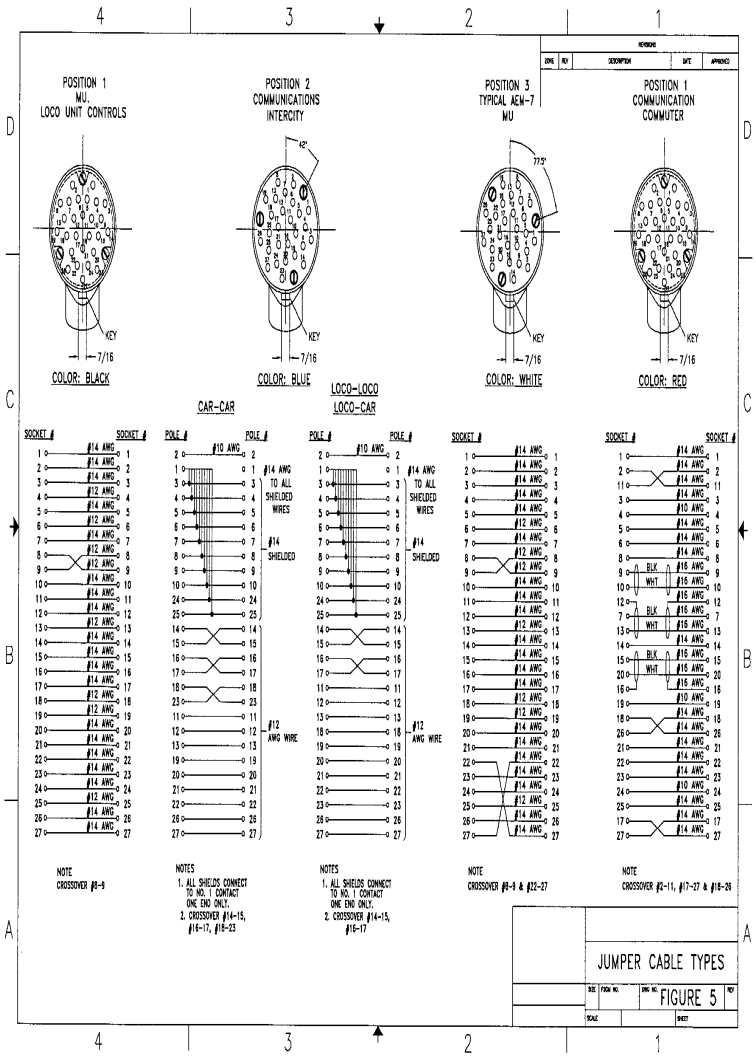

3.93
7/16 DIA (4) HOLES
7/16 R
PAINT PER PARAGRAPH 5.1
6.88
5.79
5.35
WIRE MARKER
15/16 MAX.
13/16 MIN.
5.38
2.94
.25
.50
KEYWAY
.590
(INCL DRAFT)
DEPTH OF KEYWAY
1.4
.12
2.41
'L'
5.88
6.88
SECTION A-A
SHOWN WITH COVER
SHOWN W/COVER REMOVED
SHOWN KEYED FOR MU TYPE
NOTES
1 DIM 'H' & 'W' ON COVER LUG MUST ADEQUATELY SECURE PLUG HEAD WHEN CONNECTORS ARE PROPERLY MATED.
2 SUFFICIENTLY SPRING LOADED DIAMETER TO HANDLE 30 AMPERES WHEN INSERTED IN .3125 ± .002/.000 I.D. FEMALE CONTACT, SILVER PLATED.
3 SLOT IN CASTING MUST ALLOW FOR REMOVAL OF REAR RIGID INSULATION (ITEM 11) THRU BACK OF HOUSING WITHOUT DISCONNECTING WIRING.
4 RECEPTACLE TO BE PAINTED IN ACCORDANCE WITH SECTION 4.1. WHITE LETTERS ON BLACK & BLUE BACKGROUND. BLACK LETTERS ON WHITE & YELLOW BACKGROUND.
5 ASSEMBLY TO BE PERMANENTLY LABELED WITH: MANUFACTURERS NAME, PART NO. & DATE OF MANUFACTURE.
QTY ITEM DESCRIPTION
1 11 INSULATION, REAR RIGID
1 10 INSULATION FRONT RIGID
27 9 GROMMET
27 8 MULTI CONTACT BAND
27 7 CONTACT PIN SILVER PLATED
1 6 COVER GASKET
1 5 FLANGE MOUNT GASKET
1 4 COVER SPRING, STAINLESS STEEL
1 3 COVER PIN, STAINLESS STEEL
1 2 RECEPTACLE COVER
1 1 RECEPTACLE HOUSING
BASIC RECEPTACLE
FIGURE 2
SHEET 1 OF 2


FOR RECEPTACLES WHICH INCLUDE SHIELDED CONDUCTORS, THE FOLLOWING SHALL APPLY :
SHIELD COMMON PIN
SHRINK TUBING
#20 AWG MIN
TYPICAL SHIELDED PAIR
DETAIL - SHIELD TERMINATION
MU
1.00
SEE NOTE 4 ON SHT. 1
RECEPTACLE COVER FUNCTIONAL LABEL
BASIC RECEPTACLE
FIGURE 2
SHT 2 OF 2


POSITION 1
MU
COLOR : BLACK
LABEL : MU
POSITION 2
COMMUNICATION INTERCITY
COLOR : BLUE
LABEL : COMM
42°
POSITION 3
TYPICAL OF AEM-7
COLOR : WHITE
LABEL : MU
77.5°
POSITION 4
COMMUNICATION COMMUTER
COLOR : RED
LABEL : COMM
VIEW WITHOUT COVER
VIEW WITHOUT COVER
VIEW WITHOUT COVER
VIEW WITHOUT COVER
CAVITY # WIRE GAGE (AWG)
#12
#10
#12
#10
#12
CONTACT # WIRE GAGE (AWG)
CONTACT A 1
#14
BLK
WHT
#14/2 SHLD
#10
#12
PIN # WIRE GAGE (AWG)
#10
#10
#14
#12 TWISTED SHIELDED PAIRS
#14
CAVITY # WIRE GAGE (AWG)
#14
#10
#14
#16/2 SHLD
#16/2 SHLD
#14
#16/2 SHLD
#10
#14
#10
#14
RECEPTACLE TYPES
FIGURE 3


LENGTH
HEAD PAINTED PER PARAGRAPH 6.1
8"
ASSEMBLY TO BE PERMANENTLY LABELED WITH MANUFACTURERS NAME, PART NO. & DATE OF MANUFACTURE.
1 3/8 APPROX.
3/4 MIN
5/8 (MIN)
VIEW A-A
2 5/32
DRAFT ANGLE
3/16 MAX
5/32 R TYP
5/32
2" GRIP (REF)
5 3/16 DIA
3 3/16
1/2
7/32 MAX
.907 MIN.
1" MIN
.3123 +.002 -.000 I.D. SOLID CONTACT-SILVER OR EQUIVALENT PLATED.
KEY
7/16
SHOWN HEAD FOR MU TYPE
1 8 HANGER (RECOMMENDED ON JUMPERS 50" OR LONGER)
2 7 WEDGE
54 6 GROMMET
54 5 SOCKET CONTACT, SILVER PLATED
2 4 INSULATION, REAR
2 3 INSULATION, FRONT
1 2 1 1/4 I.D. HOSE RED.
1 1 JUMPER MU HOUSING
QTY ITEM DESCRIPTION
BASIC JUMPER CABLE
FIGURE 4
1 OF 2


FOR JUMPERS WHICH INCLUDE SHIELDED CONDUCTORS,
THE FOLLOWING CONSTRUCTION SHALL APPLY:
HEAT SHRINK TUBING
ALL SHIELDS TO CAVITY SOCKET
JUMPER (#20 AWG MIN) GND TO SOCKET
SHIELDED WIRE TO CAVITIES (PIN)
WIRE TAG
HEAT SHRINK TUBING
DETAIL B
ONE END ONLY
3" APPROX
DETAIL C
ONE END ONLY
PROTECT ENDS OF SHIELDS WITH HEAT SHRINKABLE TUBING AS SHOWN
BASIC JUMPER CABLE
FIGURE 4
2 OF 2


POSITION 1
MU.
LOCO UNIT CONTROLS
POSITION 2
COMMUNICATIONS
INTERCITY
POSITION 3
TYPICAL AEM-7
MU
POSITION 1
COMMUNICATION
COMMUTER
KEY
7/16
COLOR: BLACK
COLOR: BLUE
COLOR: WHITE
COLOR: RED
CAR-CAR
LOCO-LOCO
LOCO-CAR
SOCKET #
POLE #
#14 AWG
#10 AWG
#12 AWG
#14 AWG TO ALL SHIELDED WIRES
#14 SHIELDED
#12 AWG WIRE
BLK
WHT
NOTE
CROSSOVER #8-9
NOTES
1. ALL SHIELDS CONNECT TO NO. 1 CONTACT ONE END ONLY.
2. CROSSOVER #14-15, #16-17, #18-23
CROSSOVER #8-9 & #22-27
CROSSOVER #2-11, #17-27 & #18-26
JUMPER CABLE TYPES
FIGURE 5