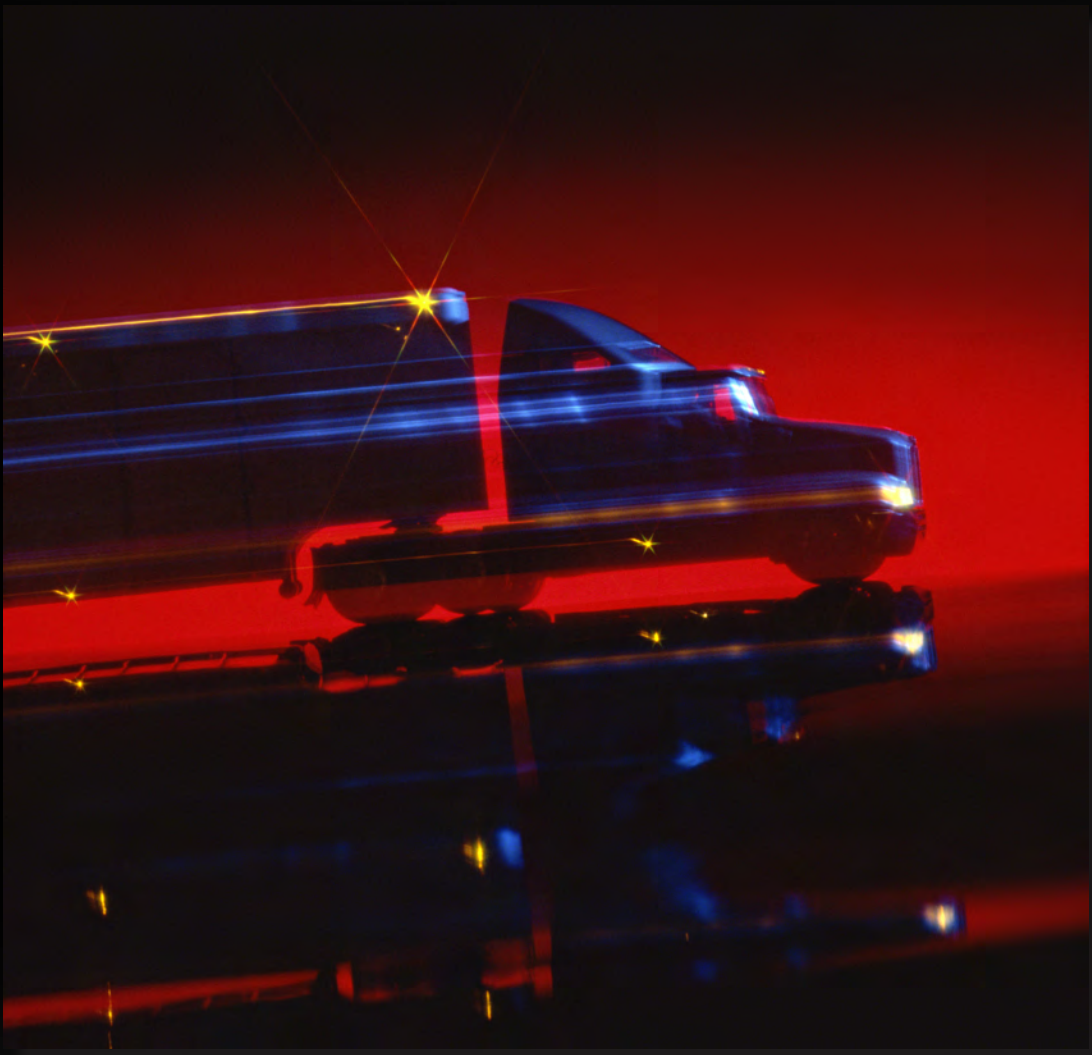
Peterson Trailer Lighting Troubleshooting and Repair Guide



PETERSON

Vehicle Lighting & Harness Systems

Glossary

Introduction

Safety is our common goal. Proper understanding of vehicle safety lighting systems is critical to achieving that standard.

This Guidebook is intended to provide basic troubleshooting and repair recommendations to help technicians better understand harness and lighting failures. TMC Recommended Prac-tices will be referenced, and copies of these practices are included in the appendix. Follow all OEM/TMC recommended practices.

At Peterson our job is to provide our customers with maximum value in vehicle safety lighting, mirrors and other safety related products and accessories through a commitment of continu-ous improvement in quality, cost, and service.

We partner with you to make operating safely our number one goal.

ATA's TECHNOLOGY & MAINTENANCE COUNCIL

For more than 60 years, TMC's member-driven Recommended Maintenance and Engineering Practices have been setting the standards that help trucking companies specify and maintain their fleets more effectively. TMC's industry best practices also provide guidance to manufacturers in the design of their equipment.

TMC has grown into an organization of more than 2,300 members with representatives from virtually every sector of the industry, including fleets, owner/operators, manufacturers, suppliers, service providers, educators, press, association representatives and technicians.

Disclaimer: The materials and information in this book have been prepared or assembled by Peterson Manufacturing and are intended for informational purposes only. Some of the information may be dated and may not reflect the most current developments.

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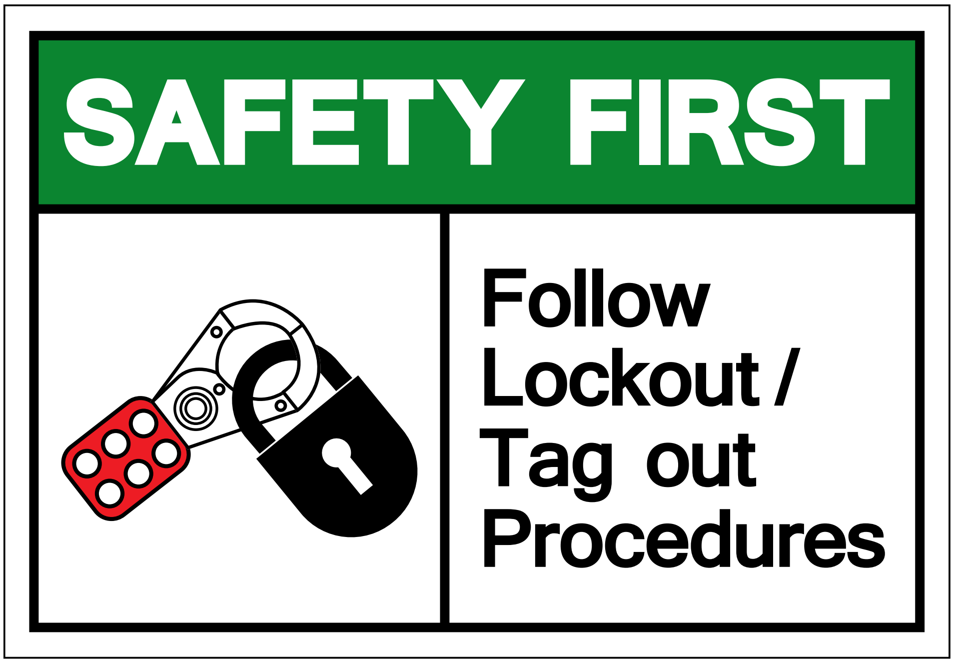
or go to *pmlights.com*

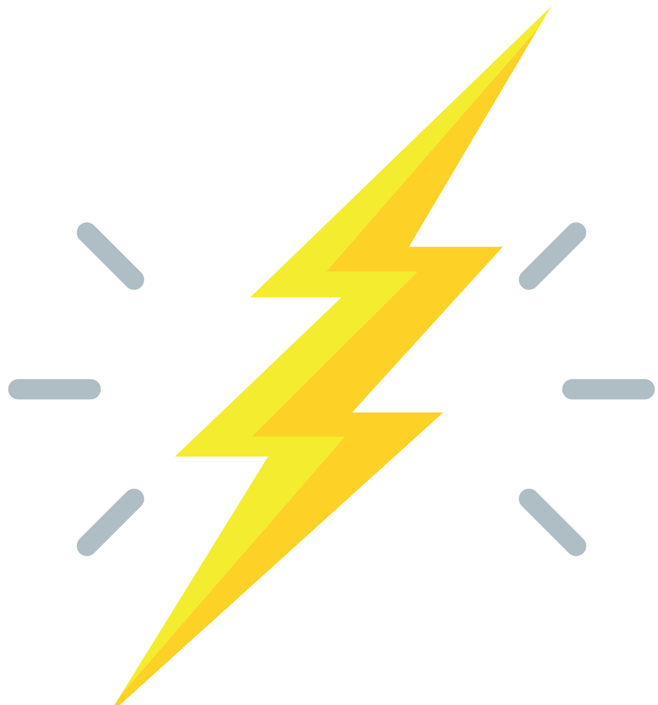
Safety

Safety

Always wear eye protection when working underneath equipment. Debris can easily fall or be blown into your eyes when working under equipment. Ensure a lock out tag out process is in place so that the equipment you are working on will not be moved without your knowledge and consent.

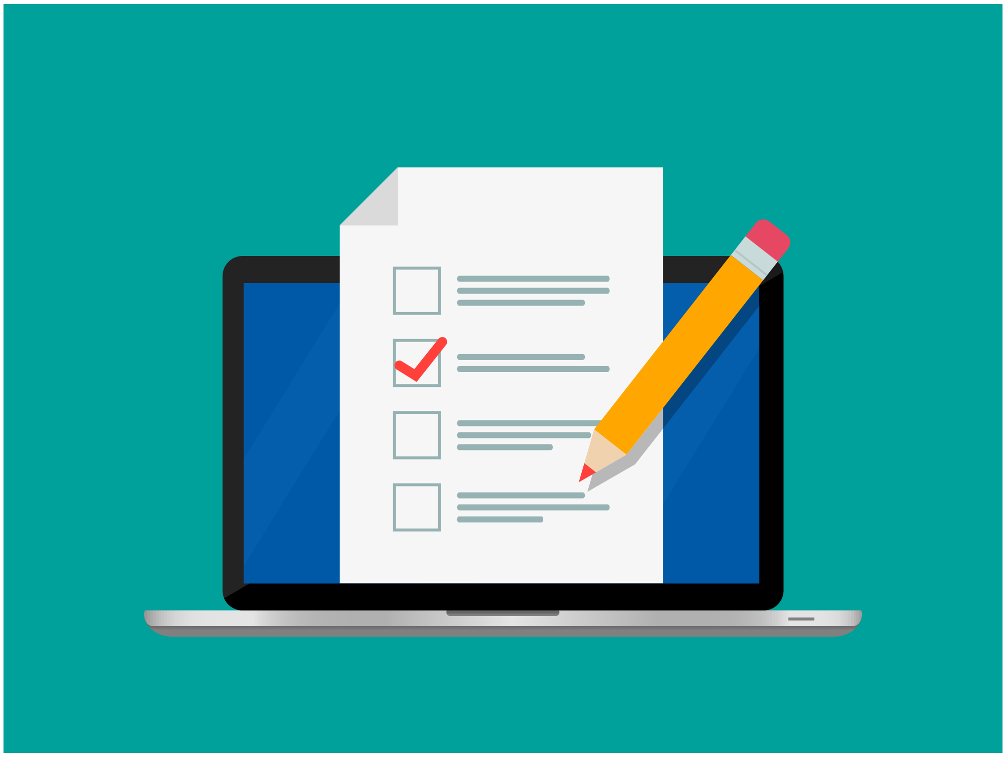


Electrical Terms



Electrical Terms

Definitions of electrical terms. TMC Recommended Practices RP 1406, Basic Electrical/Electronic Diagnostic Procedures, is included in this guidebook for this purpose. Review and become familiar with these terms. It will aid your understanding of the electrical system and troubleshooting. In addition, you can evaluate your electrical knowledge, see TMC RP 1204A.



ABS	Anti-lock braking system. Used to prevent wheel lock-up on a motor vehicle braking system.
Alternator	A AC generator that produces alternating current which is internally rectified to DC current before being used.
Alternator Maximum Amperage Output	The amount of current, measured in amps, that an alternator will produce while running at a sufficient engine speed to drove the generator to full output. This output is attained while battery(ies) are being loaded with a carbon pile.
American Trucking Associations (ATA) Data Link	A two-wire electrical connection for communication with other microprocessor-based devices that are compatible with the ATA and SAE Standards (J1587 and J1708) such as trip recorders, electrical dashboards, power train controls and maintenance systems. The Data Link is also the serial communication medium used for programming and troubleshooting. See J1587.
American Wire Gauge (AWG)	A measure of the diameter (and therefore the current carrying ability) of electrical wire. The smaller the AWG number, the larger the wire.
Amerage (AMPS, Current)	The unit of measurement for electrical current.
Ampere-Hour (AH)	The unit of measure for a battery's electrical storage capacity obtained by multiplying the current in amperes by the time in hours of discharge. A battery that delivers 5 amperes for 20 hours has 100 amp hours of capacity. NOTE: This simple calculation can only be used as a reference for low discharge rates higher than typically eight amps and may be battery type or manufacturer dependent. The calculation is not linear above typically eight amps. The amount of time a battery can supply current is also reduced as temperature decreases.
AMP (Amperage, Current)	The unit of measurement for electrical current.
Auxiliary Low Beam	Auxiliary low beams headlamps are—as their name implies—connected to the vehicles regular low beam, but operate on an independent circuit. The beam pattern provides a more even spread of light to the immediate front of the truck producing an extended range towards the right side of the road—without increasing glare to oncoming drivers.
Battery	A DC voltage source which converts chemical, nuclear, thermal or solar energy into electrical energy.

Battery Capacity

Battery capacity is a unit of measure that is calculated by multiplying the current in amperes (amps) by the time in hours of discharge to 1.75 volts per cell @ 80˚F. The units are ampere-hours (Ah). The capacity varies with the rate of discharge. Common capacity ratings for various applications are 20-hour, 10-hour, 8-hour, 5-hour, 3-hour and 1-hour.

Example of how mAH capacities work: A 10,000mAH (10AH) battery is capable or suppling 10,000mA (10 Amps) for 1 hour, or 5,000mA (5 Amps), or even 20,000mA (20 Amps) for half an hour.

Battery Reserve Capacity Rating

Reserve Capacity (RC) is the number of minutes a battery can supply 25 amperes of current at 80˚F (27˚C), then be discharged at a constant 25 amperes for a specific time in minutes while maintaining at least 1.75 volts per cell. This test simulates a condition of nighttime operation with a minimum of electrical loads and no alternator output. This discharge rate is the “Reserve Capacity”, which measures the battery’s ability to supply a lower rate of constant discharge.

Battery State of Charge

The percentage of usable power left in the battery.

Battery Voltage Under Proper Load

The battery voltage while a battery test provides a proper load (current draw). The proper current draw for a battery load test is determined by dividing the Cold Cranking Rating of the battery in half. Acceptable minimum voltages based upon the ambient temperature of the battery which is being tested.

Calibrate

To measure against and adjust to a standard.

Calibration

As used here, is an electronic adjustment of a sensor signal.

Circuit

An electric circuit is the path of electric current. A closed circuit has a complete path. An open circuit has a broken or disconnected path.

Circuit, Series

A circuit which has only one path for the current to flow. Batteries arranged in series are connected with the negative of the first to the positive of the second, negative of the second to the positive of the third, etc. This will create a voltage equal to the sum of the voltage of each battery.

Circuit, Parallel

A circuit which provides more than one path for the current to flow. Batteries arranged in parallel are connected negative to negative and positive to positive. Voltage will be the same as each battery but the capacity would be the sum of the total batteries.

Class 1 Truck	Truck with gross vehicle weight (GVW) of 6,000 pounds or less.
Class 2 Truck	Truck with gross vehicle weight (GVW) of 6,001 pounds - 10,000 pounds.
Class 3 Truck	Truck with gross vehicle weight (GVW) of 10,001 pounds - 14,000 pounds.
Class 4 Truck	Truck with gross vehicle weight (GVW) of 14,001 pounds - 16,000 pounds.
Class 5 Truck	Truck with gross vehicle weight (GVW) of 16,001 pounds - 19,500 pounds.
Class 6 Truck	Truck with gross vehicle weight (GVW) of 19,501 pounds - 26,000 pounds.
Class 7 Truck	Truck with gross vehicle weight (GVW) of 26,001 pounds - 33,000 pounds.
Class 8 Truck	Truck with gross vehicle weight (GVW) of 33,001 pounds and over.
Classification of Trucks by Ground Contact	Trucks are classified by the number of wheels and the number of driving wheels. If a truck is designated as a 4 X 2, it has four wheels and two driving wheels. A 4 X 4 truck has four wheels and 4 driving wheels. A 6 X 4 truck has six wheels and 4 driving wheels. Wheels are considered a unit whether they have single or dual tire.
Connector	A device that supplies electrical continuity between two points in one or more circuits.
Copper Corrosion	A measure of fuel's tendency to corrode copper, bronze or brass components.
Corrosion Inhibitors	Corrosion inhibitors, sometimes called metal deactivators, are additives that keep corrosive agents away from the nonferrous parts being protected.
Current (Amperes, Amps)	The unit of measurement for electrical current.
Data Link Cable	A twisted pair of insulated data wires that are covered by a metalized foil shield with a drain wire and are enclosed under a insulating jacket. The data link cable meets the SAE-specific characteristics impedance of 120 ohms. Maintaining this impedance level by the use of proper materials and procedures is critical to the integrity of the data signal. Never splice "regular" automotive wire (such as GXL, SXL, TXL) into the data link cable.

Data Wires	Insulated copper conductors. In contrast, the data link cable refers to the entire package of data wires, metalized foil shield, and drain wire, all under a common insulating jacket. The data wires are green and yellow. The yellow wire is referred to as CAN_H and the green wire is CAN_L in SAE J1939/11.
Dielectric	A material, which is an electrical insulator.
Electrical Circuit	An electrical circuit includes all of the components and connecting cables, starting from the electrical energy source, going through the function component(s) and the return route.
Electrical Circuit Diagram	A drawing using standardized symbols to depict the relationship and interconnections of components and conductors of an electrical circuit.
Electronic Control Module (ECM) or Electronic Control Unit (ECU)	A computer used to control an electronic engine or transmission or other device. It receives input signals from sensors and provides outputs for control of external devices. Additionally the ECM or ECU is used to provide diagnostic information to the technician. ECM is usually used to denote the engine control module; ECU is usually used to denote other on board control units.
Electronic Data Interchange (EDI)	A communication standard that allows different types of computers to share information.
Flooded Battery	A battery that has the electrolyte in a free-flowing form. All batteries covered in the RP are flooded batteries with the exception of the VRLA family of batteries, which are classified as AGM or gel type.
Headlamp	A lighting device providing an upper and/or lower beam used for providing illumination forward of the vehicle. (SAE J1383, Jun. 90, Section 2.2.1.)
Headlight Aim Test Machine	An optical or photoelectric device used to aim or check the aim of forward lighting devices. It is a device that optically and/or photometrically simulates the results obtained by the aiming screen method without the need for extensive floor space. (SAE J600, Feb. 1993, Section 2.2.1.)

Heat Reflective Wrap

Tubing or wrap, which is a reflective product, designed to provide thermal protection for components contained in an area of high-radiated heat. These materials are designed to operate in temperatures above 300˚F and offer good abrasion protection.

Incandescent Lamp

An incandescent lamp is essentially a piece of wire in a bottle. Every incandescent lamp contains a tungsten filament wire. When current flows through the filament wire, it encounters resistance and the wire heats up and glows very brightly. Over time, the tungsten evaporates and the filament wire burns out. Generally, this failure occurs between 200 and 15,000 hours—depending on the type of incandescent bulb.

Light Emitting Diode Technology

A single LED is a solid-state electronic component. When current flows through the semiconductor compounds, light is emitted. Because there is no evaporation of components, and because it is solid state, LED service life is significantly longer than that of incandescent bulbs. On average, an individual LED remains an effective light source for approximately 100,000 hours. A typical LED lighting device may contain many LEDs.

Load (electrical)

A device that draws power from an electrical source such as a battery to perform a function: lights, motors, heating coils, etc. Electrical loads are rated in either amperes (amps) or Wattage (watts).

Load Cell

A device used to measure a load.

Load Tester

An instrument which draws current (discharges) from a battery using a variable resistance while measuring voltage. It determines the battery's ability to perform under actual load.

Line Voltage Drop (Voltage Drop)

The amount of voltage loss between two component parts such as the battery and the starter or the alternator and the battery at a specific current flow. Maximum voltage drop allowed in a circuit or system is defined by the manufacturers. Loss of voltage is due to high resistance and can be caused by bad ground connections, insufficient contact due to loose connections and corrosion, improper wire sizing, broken wires, etc.

Low-Beam

A (headlamp) beam intended to illuminate the road ahead of the vehicle when meeting or following another vehicle. (SAE J1383, June 90, Section 2.2.20.)

Low-maintenance Battery	A battery that has filler caps but uses a lessor amount of water.
Lumen	Unit of luminous flux equal to the luminous flux emitted per solid angle by a uniform point source of one candella.
Maintenance-free Battery	A lead-calcium flooded battery that is constructed with enough electrolyte to cover the usable service life. It may or may not have removed filler caps and may require addition of water under certain conditions. The addition of water is not necessary for normal vehicle service.
Multi Meter	An instrument used to measure electrical voltage, current, and resistance.
Ohm	A unit for measuring electrical resistance.
Ohm's Law	Expresses the relationship between volts (V or E), amps (I), in an electrical circuit with resistance (R). It can be expressed as: E=IR, I=E/R, or R=E/I. If any two values are known, the unknown value can be calculated using these equations.
Potentiometer	A voltmeter that reads the extremely low voltage developed at the thermocouple junction and thus shows the temperature. Usually read directly in degree of temperature.
Primary Connector	The receptacle and cable plug that provides power to safety lighting and the ABS as required by FMVSS 108 and FMVSS 121 (From SAE J560).
Relay	An electromagnetic switching device using low current to open or close a high current circuit.
Resilience	Capacity of rubber to recover its original size and shape after deformation.
Reserve Capacity	The reserve capacity (RC) rating indicates what power can be expected from a battery when supplying reasonable load without assistance from the generating system. This rating is expressed in minutes.
Ripple Voltage	The alternator produces alternating current (AC) and is rectified to the needed direct current (DC). Ripple voltage is described as the leakage of the instantaneous variations of alternating current to the direct current output due to AC peaks.

Shore Power — Typical name for the electrical service outlet in a marine application. Mostly referred to as an external source from the grid.

Short Circuit — An unintended contact in an electrical device or wiring, generally very low in resistance and thus allowing a large amount of current to flow.

Starter Draw — The amount of current, measured in amps, that flows from the battery to the starter during cranking. Normally, fuel systems or ignition systems are shut off during this test.

State of Charge (SOC) — A method to describe the level of “state: of charge in a battery as a percentage. For instance a battery that is completely charged is said to be 100 percent SOC.

Supply Voltage — A constant voltage supplied to a component to provide electrical power for its operation. It may be generated by an ECM/ECU, or it may be vehicle battery voltage supplied by vehicle wiring.

Vehicle Maintenance Reporting Standard (VMRS) — An industry standard for cost equipment reporting maintained by the Technology & Maintenance Council (TMC) of American Trucking Association (ATA)

Volt — The unit of measure for electrical potential.

Watt — The unit of measuring electrical power. Formula is Watts=Volts x Amps.

Preventative Maintenance

Pre/Post Trip Inspection

Without an effective Preventative Maintenance Program even the newest equipment can cost you. A consistent and effective PM program along with diligent pre and post trip equipment inspections is critical to keeping costs under control and maximizing uptime. Actions taken before a failure occurs can save hundreds of dollars. An effective PM program with diligent pre and post trip inspections are critical to the early detection of what could be costly issues.

Inspect for...

- Wiring hanging down, not properly secured.
- Damaged wiring, temporary repairs that could cause corrosion issues.
- Light not working or dim.
- Routing/Clipping/Chaffing Wiring.
- Lamp lenses and housing that are cracked or fatigued.

Don't forget lighting!

Corrosion is the one of the leading causes of lighting failures. DO NOT damage the wire insulation by puncturing with a test probe (test light). Any damage to the wire insulation will cause moisture and water intrusion to begin. Use of multimeter is recommended over a test probe (test light).

All wiring repairs should be completed in accordance with TMC RP 186, Wire and Cable repair guidelines.

Maintenance

How can Fleet and Drivers Prevent lighting-related Maintenance issues.

A conscientious inspection program can prevent an out-of-compliance condition before it occurs. Maintenance personnel should go beyond just verifying that lights are illuminated. They should regularly look for:

- Lamp lenses and housing that are cracked or fatigued.
- Harness or pigtail conductors that are brittle, chaffed, stripped or badly kinked.
- Corroded terminal or plugs.
- The failure of individual diodes within an LED lamp assembly, which could be an early indication of moisture or corrosion intrusion.

In addition, always follow these good maintenance practices:

- Periodically use dielectric grease to protect bare metal terminals (if they are not otherwise sealed from wire and corrosive chemicals).
- Periodically use an Multi Meter to evaluate the general condition of the harness wiring.
- NEVER use a test probe by puncturing the insulation jackets of the wires.
- When repairs have to be made, splice wires together using glue-filled, heat shrink crimp connectors to affect a completely sealed connection.

Troubleshooting

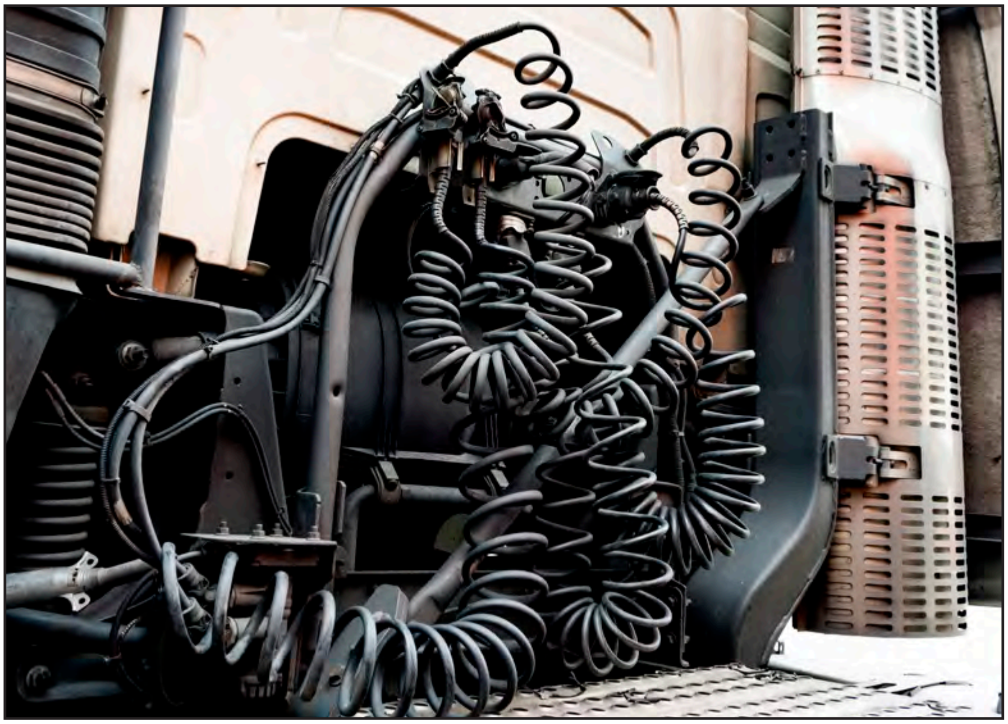
Troubleshooting Section

Tractor Trailer Connection

Isolate the lighting problem to the tractor or trailer/dolly. TMC recommended practice RP 159, Installation and Inspection Guidelines for Seven Conductor Truck-Trailer/Converter Dolly Jumper Cable and Connector, is included in the guidebook and should be used as a resource.

Begin by ensuring you have the correct electrical current (power) through the 7-way cord from the tractor to the trailer.

Perform System inspections. One light out/multiple lights out? Determine the part of the electrical system or circuit that has the problem. See flow chart in TMC RP 1406.



Checklist

☐ No power at 7-way?	Possible Solutions: Inspect loose or damaged - needing replacement Inspect tractor fuses Inspect for Good Ground Inspect connector damaged by excessive corrosion. Clean and repair.
☐ Check for voltage at tail light	Voltage should be between 10-16 Volts Begin tracing wire to find corrosion or break in wiring harness. Watch for locations where the wiring harness could be chaffing the frame and cross members.
☐ Broken or Missing lamps	Lamps with cracked lenses will allow moisture accumulation. Needs to be replaced.
☐ Check for other lights operating on the same circuit	This will aid in determining where the issue is located.

*See TMC R.P 159; Inspection check list

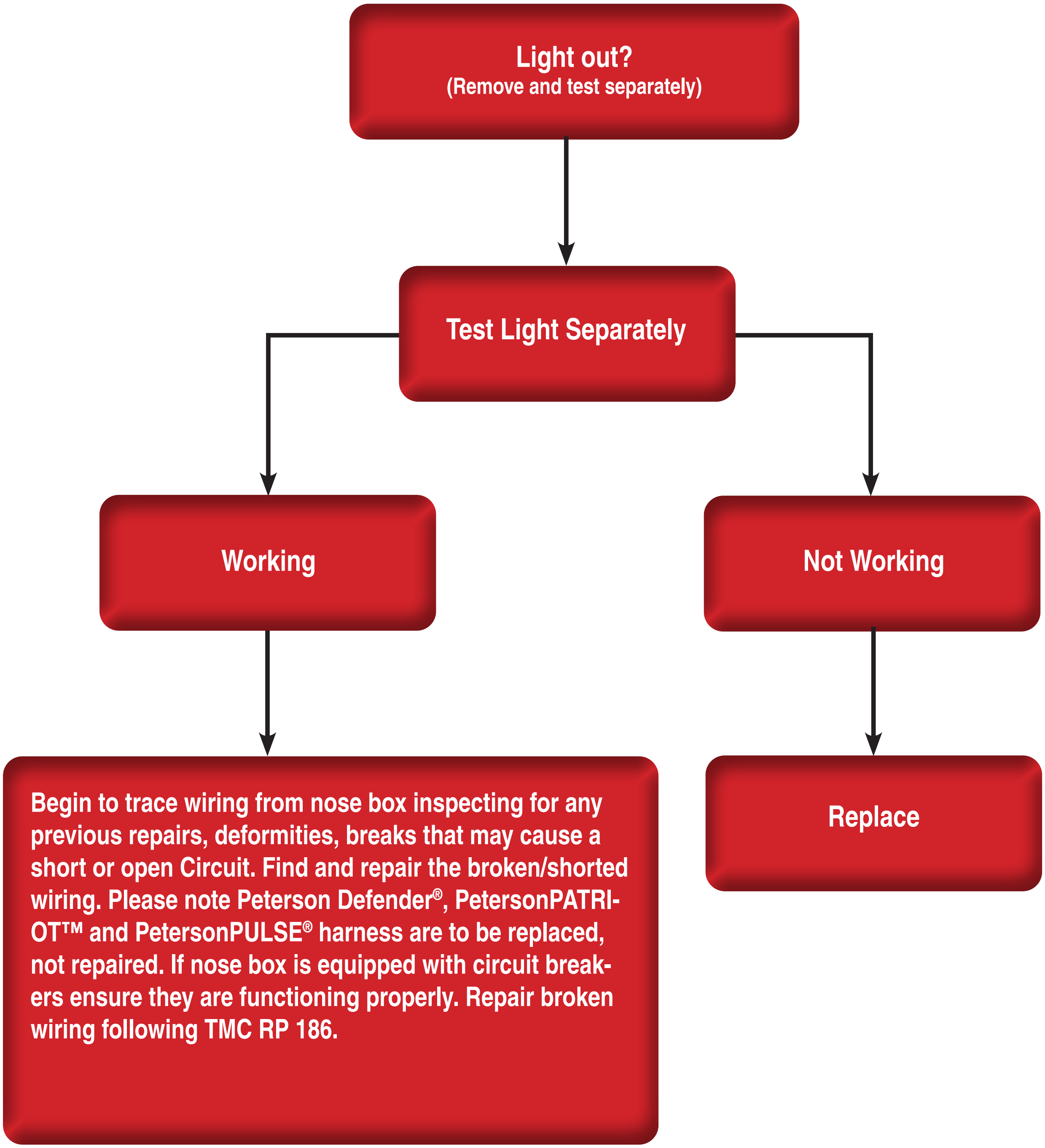
Peterson Manufacturing Company

The following questions are frequently asked about automotive lighting in general and about Peterson's products in particular.

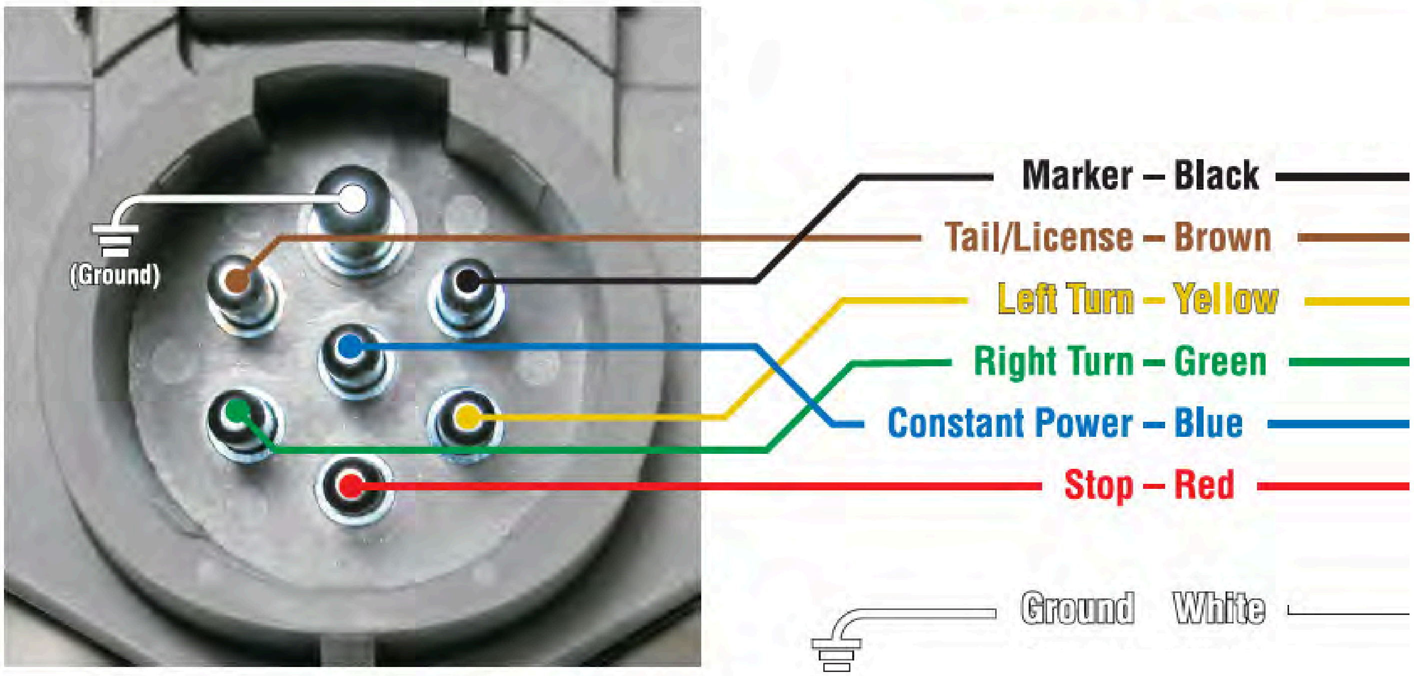
LAMP TROUBLE-SHOOTING CHART

PROBLEM	POSSIBLE CAUSE	POSSIBLE CORRECTIVE ACTIONS
Lamp won't light	Bulb is burnt out	- Replace bulb if bulb can be replaced
		- Replace lamp if bulb cannot be replaced
	Bad connection to ground	- Tighten grounding connection (screw or nut on grounding stud)
		- Remove dirt, film, paint or rust from grounding surface
		- Replace lamp
	Bulb not in socket correctly	- Put bulb in socket correctly if possible
		- Replace lamp
	Bad or loose lamp terminal(s)	- Tighten or replace terminal connection if possible
		- Replace lamp
	Bad or loose connection inside the lamp	- Tighten or replace terminal connection if possible
		- Replace lamp
	Low or no voltage to lamp	- Evaluate vehicle wiring
	Incorrect bulb in lamp	- Replace bulb with correct bulb if possible
		- Replace lamp
Lamp is dim	Bad connection to ground	- Tighten grounding connection (screw or nut on grounding stud)
		- Remove dirt, film or paint from grounding surface
		- Replace lamp
	Bulb not in socket correctly	- Put bulb in socket correctly if possible
		- Replace lamp
	Bad or loose lamp terminal(s)	- Tighten or replace terminal connection if possible
		- Replace lamp
	Low voltage to lamp	- Evaluate vehicle wiring and wiring harnesses
		- Consider adding a relay to vehicle wiring to operate lamp(s)
	Incorrect bulb in lamp	- Replace bulb with correct bulb if possible
		- Replace lamp
Lamp life is short	Voltage to lamp is higher than lamp rating	- Replace lamp with lamp with correct voltage rating
	High vibration	- Evaluate lamp to see if lamp is correct lamp for application
		- Replace lamp with lamp of higher vibration capabilities if available
	Rated life of bulb in lamp is low	- Evaluate bulb to see if bulb is correct bulb for application
		- Replace bulb with higher life bulb if available
Lamp blows out fuse	Vehicle wiring to lamp is shorting to ground	- Evaluate vehicle wiring
	Ground wire is connected to the wrong place	- Evaluate connections of ground wires for correct connections to ground.
	Lamp is shorting to ground	- Evaluate lamp wiring, remove short to ground if possible
		- Replace lamp
	Fuse value is too low	- Replace fuse with correct value
		- Consider operating lamp(s) on a separate fuse
	Too many lamps for current vehicle fuse	- Consider operating lamp(s) on a separate fuse
		- Consider adding a relay to vehicle wiring to operate lamp(s)
Lamp switch melts	Defective switch	- Replace switch
	Value of inline fuse is too high	- Replace fuse with correct value
		- Consider operating lamp(s) on a separate fuse
	No inline fuse connected to switch	- Add a fuse inline to the switch
	Too many lamps are connected to switch	- Consider adding a relay to vehicle wiring to operate lamp(s)
		- Consider adding a second switch to vehicle wiring to operate some of the lamp(s)
	Lamp(s) are operating continuously for long periods of time	- Consider adding a relay to vehicle wiring to operate lamp(s)

Troubleshooting Flow Chart



Test voltage at pigtail with multi-meter, should be 10 to 16 volts.



J560
Receptacle

FMVSS 108

Federal Motor Vehicle Safety Standard

Federal Motor Vehicle Safety Standards (FMVSS) identify mandatory minimum safety performance requirements for motor vehicles and certain motor vehicle equipment in the United States. FMVSS have the goal of protecting the public in minimizing traffic crashes and deaths and injuries resulting from traffic crashes.

Federal Motor Vehicle Safety Standard 108 regulates all automotive lighting, signaling and reflective devices in the United States. Like all other Federal Motor Vehicle Safety Standards, FMVSS 108 is administrated by the United States Department of Transportation's National Highway Traffic Safety Administration.

What is FMVSS108

- Vehicular and trailer lighting requirements regulated by the National Highway Traffic Safety Administration.
- Standard is based in SAE Recommended Practices.
- Sets the type, function, and placement of lamps.
- Width - Under/Over 80”
- Length - Under/Over 30’
- Weight Rating - 10,00 LBS. GVWR or more.

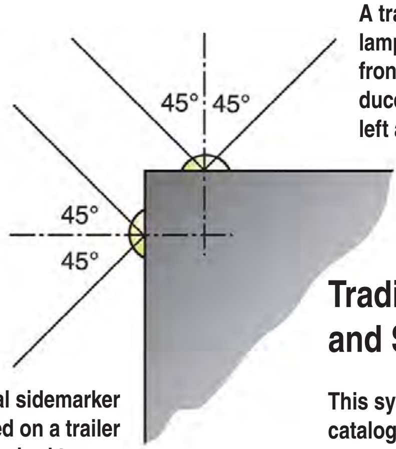
As Marked on Approved Lamps

SAE Lighting Identification Codes and Standards

A = Reflex
I = Turn Signal
S = Stop Lamps
T = Tail Lamps (rear position)
R = Backup
L = License
P2 = Marker Light
PC = Combination Marker and Clearance

Where clearance lamps are installed at locations other than on the front and rear due to the necessity to indicate the overall width of the vehicle, or for protection from damage during normal operation of the vehicle, they need not meet the photometric intensity requirement at any point that is 45˚ inboard.

SAE PC RATING EXPLAINED

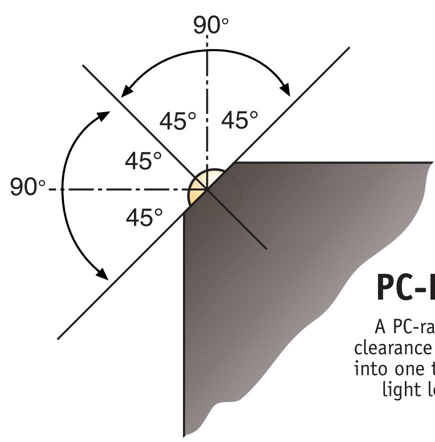


A traditional clearance lamp mounted on a trailer front is required to produce a 45° angle of light left and right of center

A traditional sidemarker lamp mounted on a trailer front is required to produce a 45° angle of light left and right of center

Traditonal Clearence and Sidemarker Lights

This symbol appears throughout the catalog to designate lights that meet the PC rating requirements



PC-Rated Lights

A PC-rated lamp combines the clearance and sidemarker functions into one to produce a 90° angle of light left and right of center

S6.3.3 - No clearance lamp is permitted to be optically combined with any taillamp

- Optically combined means a lamp having a single or two filament light source or two or more separate light sources that operated in different ways, and has its optically functional lens area wholly or partially common to two or more lamp functions.

S6.4.1 - Effective projected luminous lens area. Each turn signal lamp, stop lamp, high-mounted stop lamp, and school bus signal lamp must meet the applicable effective projected luminous lens area requirement specified in Tables IV-a, IV-b and IV-c.

- Effective projected luminous lens area means that area of the projected on a plane perpendicular to the lamp axis of that portion of the light-emitting surface that directs light to the photometric test patten, and does not include mounting hole bosses, reflex reflector area, beads or rims that may glow or produce small areas or increase intensity as a result of uncontrolled light from small areas (1/2 degree radius around the text point).
- NOTE: less that 75sq. cm of effective, projected luminous lens area.
  For use in vehicles under 80” wide unless used in pairs per side.

DOT Dry Van Lighting Requirements

IMPORTANT NOTE: Every lamp, reflex reflector, and conspicuity treatment must be permanently attached in the location specified below and must comply with all applicable requirements prescribed for it by FMVSS/CMVSS 108. The face of any device on the front/rear and sides should be, respectively perpendicular and parallel to the vehicle's centerline, unless it is photometrically certified at installation angle. No part of the vehicle shall prevent any device from meeting its prescribed requirements unless an auxiliary device meeting all prescribed requirements is installed.

IN CANADA: Manufacturers and importers of vehicles must have the proper certification test records demonstrating compliance of lighting components with all prescribed requirements.

BASIC EQUIPMENT REQUIRED ON ALL TRAILERS

DESCRIPTION				MANDATORY REQUIREMENTS			
Area	Equipment	SAE Lens Coding	Functional Purpose	Quantity	Color	Location	Height mm(in.) from the ground
1	Tail Lamps	(T)	Indicate vehicle's presence and width	Minimum 2	Red	On the rear - symmetrical as far apart as practicable	380-1830 (15-72)
	Stop Lamps	(S)	Indicate braking	Minimum 2	Red	On the rear - symmetrical as far apart as practicable	380-1830 (15-72)
	Rear Turn Signal Lamps	(I)	Indicate direction of turn	Minimum 2	Red or Yellow	On the rear - symmetrical as far apart as practicable	380-2110 (15-83)
	Rear Reflex Reflectors	(A)	Indicate vehicle's presence and width	Minimum 2	Red	On the rear - symmetrical as far apart as practicable facing rearward	380-1530 (15-60)
2	License Plate Lamp(s)	(L)	Illuminates license plate	Minimum 1	White	On the rear - above or at the sides of license plate	No requirement
3	Rear Side Marker Lamps *photometrically certified at installation angle	(P2, PC* or) P3, PC2*)	Front and rear side marker lamps / side reflex reflectors indicate vehicle's presence and length	Minimum 2	Red	Each side at rear as far back as practicable	380-1530 (15-60) no max. for veh. under 2032mm (80") wide
	Rear Side Reflex Reflectors	(A)		Minimum 2	Red	Each side at rear as far back as practicable facing sideward	380-1530 (15-60)
4 a†	Front Side Marker Lamps *photometrically certified at installation angle	(P2, PC* or P3, PC2*)		Minimum 2	Yellow	Each side at front as far forward as practicable	380 (15) minimum
4 b	Front Side Reflex Reflectors	(A)		Minimum 2	Yellow	Each side at front as far forward as practicable facing sideward	380-1530 (15-60)

†not required on trailers less than 6 ft in length

ADDITIONAL EQUIPMENT FOR TRAILERS EXCEEDING THE FOLLOWING PARAMETERS

Length 9.1m (30 ft.) or longer

DESCRIPTION				MANDATORY REQUIREMENTS			
Area	Equipment	SAE Lens Coding	Functional Purpose	Quantity	Color	Location	Height mm(in.) from the ground
5 a	Intermediate Side Marker Lamps	(P2 or P3)	Indicate presence of a long vehicle	Minimum 2	Yellow	Each side near center facing sideward	380 (15) minimum
5 b	Intermediate Side Reflex Reflectors	(A)	Indicate presence of a long vehicle	Minimum 2	Yellow	Each side near center facing sideward	380-1530 (15-60)

Width 2032mm (80 in.) or wider

DESCRIPTION			MANDATORY REQUIREMENTS				
Area	Equipment	SAE Lens Coding	Functional Purpose	Quantity	Color	Location	Height
6	Rear Clearance Lamps *photometrically certified at installation angle	(P2, PC* or P3, PC2*)	Show vehicle's width MAY NOT be combined with tail lamps	Minimum 2	Red	At widest point - symmetrical on the rear or near the rear facing rearward	As high as practicable may be lower only if ID lamps are at the top
7	Rear Identification (ID) Lamps	(P2 or P3)	Indicate presence of a wide vehicle	Exactly 3	Red	On the rear - center horizontally spaced 150mm (6 in.) to 300mm (12 in.) apart facing rearward	**In Canada:** at the top - may be lower if door header narrower than 25mm **In USA:** as high as practicable
8	Front Clearance Lamps *photometrically certified at installation angle	(P2, PC* or P3, PC2*)	Show vehicle's width	Minimum 2	Yellow facing forward	At widest point - symmetrical on the front or near the front	As high as practicable

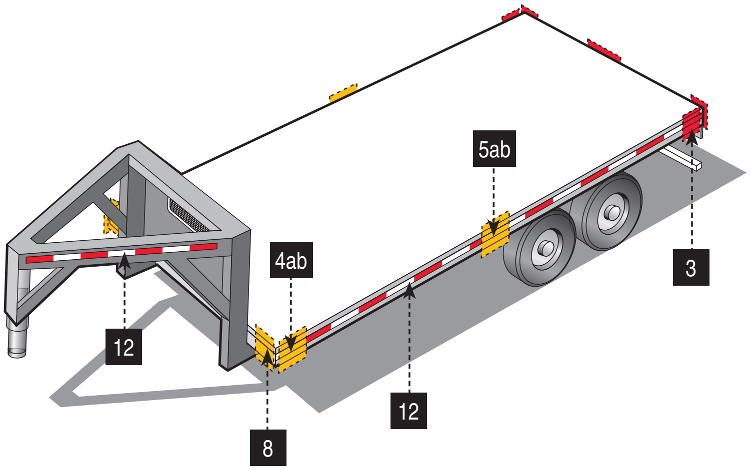
Width 2032mm (80 in.) or wider *AND* GVWR 4536 kg (10,000 lb.) or more

DESCRIPTION		MANDATORY REQUIREMENTS					
Area	Conspicuity Treatment	DOT Coding	Quantity	Color	Location	Height	Options
9	Rear Upper Body Markings	DOT-C DOT-C2 DOT-C3 DOT-C4	Exactly 2 pairs of 300mm long strips	White	On the rear upper corners facing rearward	At the top	Reflex reflectors may not be required if they are replaced in their required location with conspicuity treatment. **Optional in Canada:** Rear lower body and side conspicuity treatment may also be solid white, solid yellow, or white and yellow.
10	Bumper Bar Marking		Continuous	Red/White	On the rear bumper bar's horizontal element full width - facing rearward	No requirement	
11	Rear Lower Body Marking		Continuous	Red/White (see options)	On the rear full width of the vehicle facing rearward	As horizontal as practicable and as close as practicable to the range of 375 to 1525mm from the ground	
12	Side Marking		(see location)	Red/White (see options)	Each side - facing sideward continuous, or evenly spaced over minimum of 50% of length starts and ends as close to the front and rear of the vehicle as practicable	As horizontal as practicable and as close as practicable to the range of 375 to 1525mm from the ground	

The information provided on pages 15–19 summarizes lighting equipment requirements contained in Federal/Canada Motor Vehicle Safety Standard 108.
For complete compliance requirements consult Title 49 - Code of Federal Regulations, Section 571.108 (USA) and Section 108 of the Motor Vehicle Safety Regulations (Canada).
State or Provincial regulations, where they may apply, have not been included. Data and illustrations provided courtesy of NHTSA.

NHTSA People Saving People http://www.nhtsa.dot.gov

Transport Canada http://www.tc.gc.ca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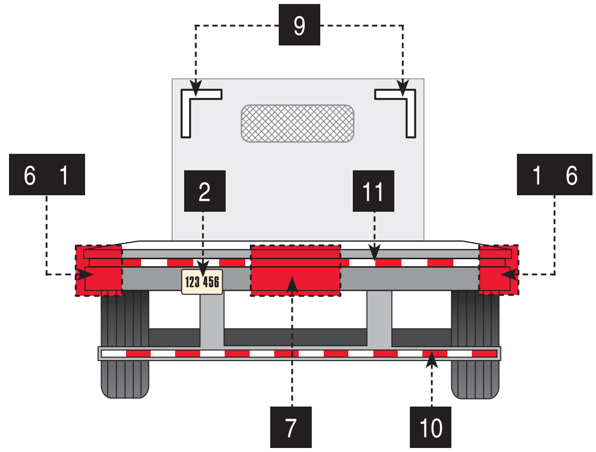
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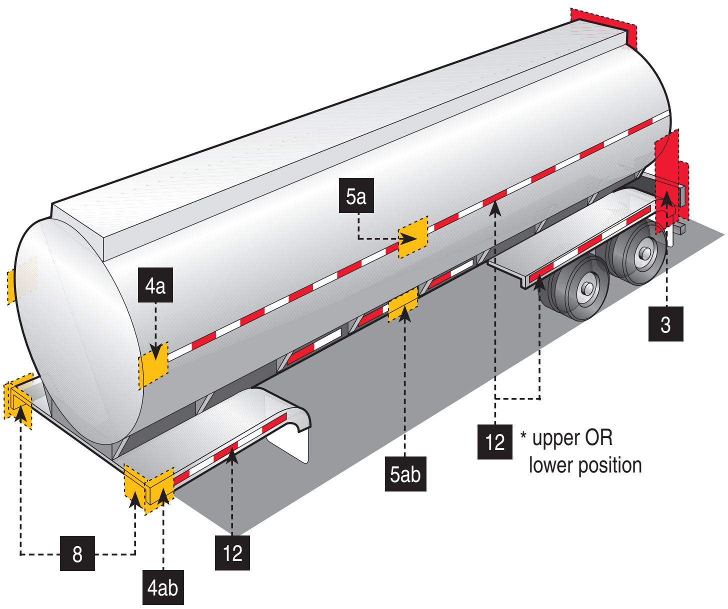
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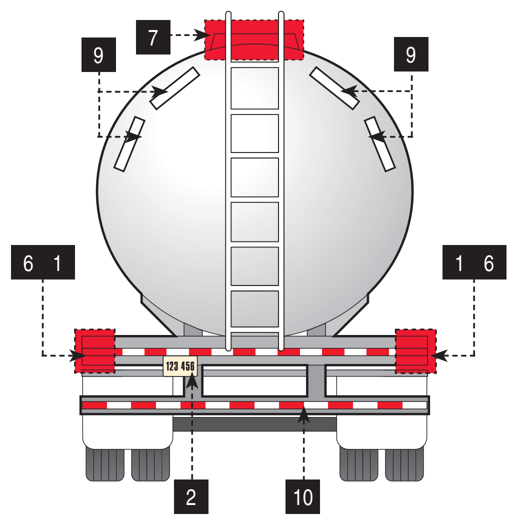
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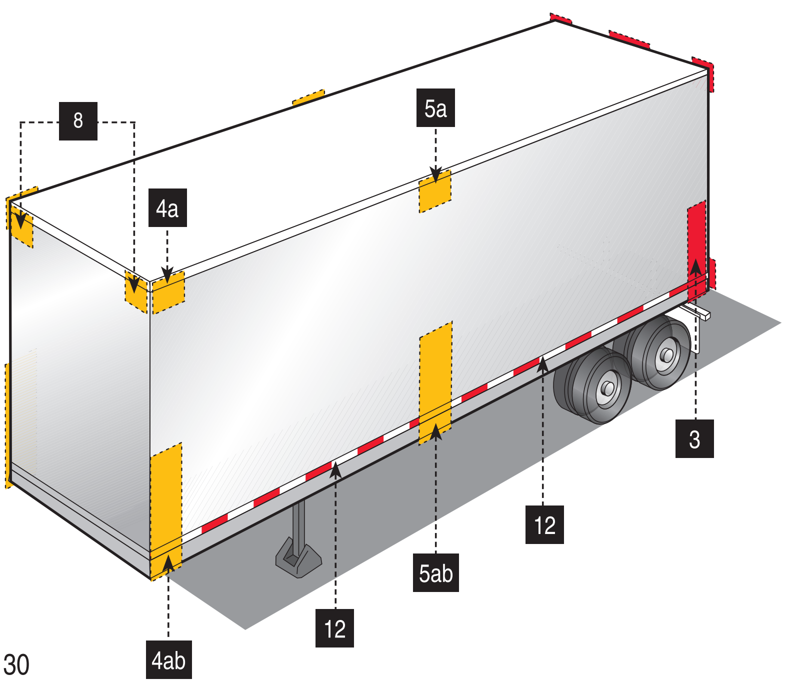
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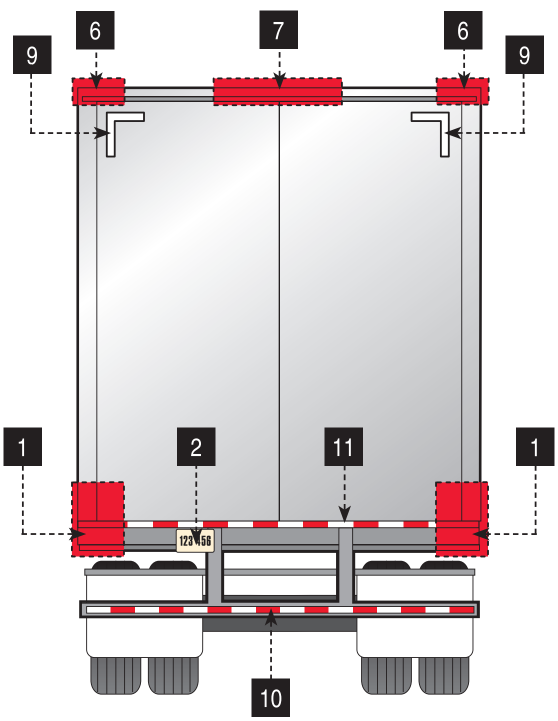
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Lighting Replacement Guide For Trucks and Trailers

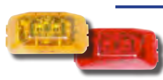
PETERSON

Lighting Replacement Guide for Trucks & Trailers

CLEARANCE/MARKER LIGHTS

DIRECT REPLACEMENTS FOR ALL CLEARANCE/MARKER LIGHTS

OLD STYLE



2.5" Rectangular

4" Rectangular

2" or 2.5" Round

Replace existing clearance/marker lights with the following NEW STYLE LED lights for appropriate application on each trailer.

Use PM-103T Dielectric Grease when connecting .180 bullets.

(Never grease AMP style silicone-sealed plugs)

NEW STYLE

3/4" Round 176 Series

176 Series in Retrofit Adaptors 2" or 2.5" (176-14 or 176-16)

176 Series in Brush Guard Bracket (176-10 or 176-13)

LED Clearance/Side Marker Lights

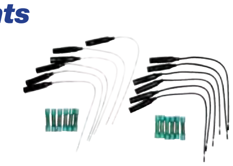
176-16 2½" Adaptor

176-14 2" Adaptor

176-13 Curved

176-10 Flat

Kits include grommet



176-496 (24 piece pack)

PMV2260GT (25 piece pack)

176KA & 176KR

1-Diode LED Clearance/Side Marker Lights. Can be used with either 176-10 / 176-13 Brush Guard Brackets *or* 176-14 / 176-16 Adaptor Flanges for 2" or 2.5" grommet mount retrofit. Use 176-496 Wiring Kit or PMV2260GT heat-shrink butt connectors for installation.

ABS Light & Label

Includes grommet

176KA-ABS

1-Diode LED Clearance/Side Marker Light with self-adhesive, NHTSA-compliant ABS label

Compatible with all mounting options for 176 Series shown above

Lighting Replacement Guide For Trucks and Trailers (Con't.)

PETERSON

Lighting Replacement Guide for Trucks & Trailers

LED Stop/Turn/Tail Light (Round)

Rear View

426-18 Grommet

817R-7
4" Round 7-Diode LED Stop, Turn & Tail Light with Integrated AMP-Compatible Connector.

LED Back-Up Light (Round)

Rear View

426-18 Grommet

817C-7
4" Round 7-Diode LED Back-Up Light with Integrated AMP-Compatible Connector.

LED Stop/Turn/Tail Light (Oval)

Rear View

421-18 Grommet

820R-7
6" Oval 7-Diode LED Stop, Turn & Tail Light with Integrated AMP-Compatible Connector.

LED Mid-Turn Light (Oval)

Rear View

421-18 Grommet

356A
6" Oval LED Mid-Turn with Internal Reflector & Integrated AMP-Compatible Connector.

AMP Plugs for Round & Oval Lights

417-49
AMP to stripped

417-491
AMP to PL3

LED License Plate Lights

291KC-BT2

153C-BT2

150-14

153C-BT2 & 291KC-BT2
1-Diode LED White License Plate Lights Hardwired with .180 Bullets

PETERSON

Peterson Manufacturing Co.
4200 E. 135th Street • Grandview, MO 64030
Ph. 1-800-821-3490 • Ph. 816-765-2000 • Fax 816-761-6693
Contact: Info@pmlights.com

Which Peterson Connector Is Right For You?

No matter what your needs are, Peterson has lights that will match your requirements and exceed your expectations

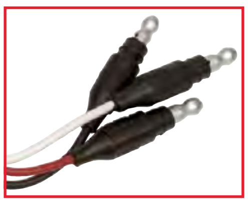
4" Round Stop/Turn/Tail light with 3-pole AMP-style plug

2½" Round clearance/marker light with 2-pole AMP-style plug

BEST CONNECTION – AMP-COMPATIBLE INTEGRATED RECEPTACLE

Silicone-sealed AMP-style plugs are unsurpassed at fighting moisture intrusion and corrosion between the light and the harness. Peterson's superior ***Insert-Molded*** manufacturing technology creates the highest quality environmental seal between the receptacle and the circuit board. 3-conductor receptacles are used on rear Stop/Turn/Tail lights, mid-turn lights, and other lights with high and low intensity functions. Two-conductor receptacles are common on 2" and 2.5" diameter round PM LED clearance/marker lights. ***Never apply grease to silicone-sealed plugs and receptacles.***

4" Round Stop/Turn/Tail light showing insert molded, hardwired leads



Hardwired leads terminated with exclusive sealed bullets

BETTER / BEST CONNECTION – HARDWIRED WITH .180 BULLETS

Insert-Molded hardwired leads are used throughout the Peterson LED product line. These leads may be partially stripped for easy splicing, but are often equipped with industry-standard .180 bullet plugs. Our plugs feature PM / Maxi-Seal's exclusive ***Integrated Moisture Barrier.*** When paired with Maxi-Seal harness components, our exclusive ***detent ring*** provides positive seating and the best environmental seal available. ***High-quality dielectric grease should be used to protect .180 bullet connections.***

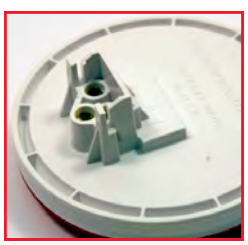
Round clearance/marker light showing PL10 receptacle

Our exclusive steel retaining clip

INDUSTRY STANDARD – PL10

Many ***Insert-Molded*** Peterson LED clearance/marker lights feature an integrated industry-standard PL10 receptacle. These lights fit a wide variety of applications at low cost with basic corrosion protection. In order to enhance the performance of the standard PL10 plug, many Peterson PL10 receptacles can accept an optional ***steel retaining clip***, which keeps the plug firmly seated in the receptacle.
High-quality dielectric grease should be used to protect PL10 connections.

4" Round Stop/Turn/Tail light showing integrated PL3 receptacle



PL3 style light with integral locking tabs

INDUSTRY STANDARD – PL3

Many ***Insert-Molded*** Peterson LED Stop/Turn/Tail lights, mid-turn lights, and other lights with high and low intensity functions have an industry-standard PL3 receptacle built right into the housing of the light. These lights fit a wide variety of applications at low cost with basic corrosion protection. In order to enhance the performance of the standard PL3 plug, some harsh environment Peterson lights have ***integral locking tabs*** to keep the PL3 plug firmly seated in the receptacle.
High-quality dielectric grease should be used to protect PL3 connections.

SAE Lighting Identification Codes & Standards

A	Reflex reflectors
A2	Wide angle reflex reflectors
C	Motorcycle auxiliary front lamps
D	Motorcycle and motor-driven cycle turn signal lamps
E	Side turn signal lamps – vehicles 12 m or more in length
E2	Side turn signal lamps – vehicles less than 12 m in length
F	Front fog lamps
F2	Fog tail lamps
G	Truck cargo lamps
H	Sealed beam headlamps
HG	Discharge forward lighting headlamps
HH	Sealed beam headlamp housings
HR	Replaceable bulb headlamps
I	Turn signal lamps
I3	Turn signal lamps spaced from 75 mm to less than 100 mm from headlamp
I4	Turn signal lamps spaced from 60 mm to less than 75 mm from headlamp
I5	Turn signal lamps spaced less than 60 mm from headlamp
I6	Rear mounted turn signal lamps and front mounted turn signal lamps mounted 100 mm or more from the headlamp, for use on vehicles 2032 mm or more in overall width
I7	Front mounted turn signal lamps mounted less than 100 mm from the headlamp, for use on vehicles 2032 mm or more in overall width
K	Front cornering lamps
K2	Rear cornering lamps
L	License plate lamps
M	Motorcycle and motor-driven cycle headlamps – motorcycle type
N	Motorcycle and motor-driven cycle headlamps – motor-driven cycle type
O	Spot lamps
P	Parking lamps
P2	Clearance, side marker and identification lamps
P3	Clearance, side marker and identification lamps for use on vehicles 2032 mm or more in overall width
PC	Combination clearance and side marker lamps
PC2	Combination clearance and side marker lamps for vehicles 2032 mm or more in overall width
Q	Turn signal operating units, Class A

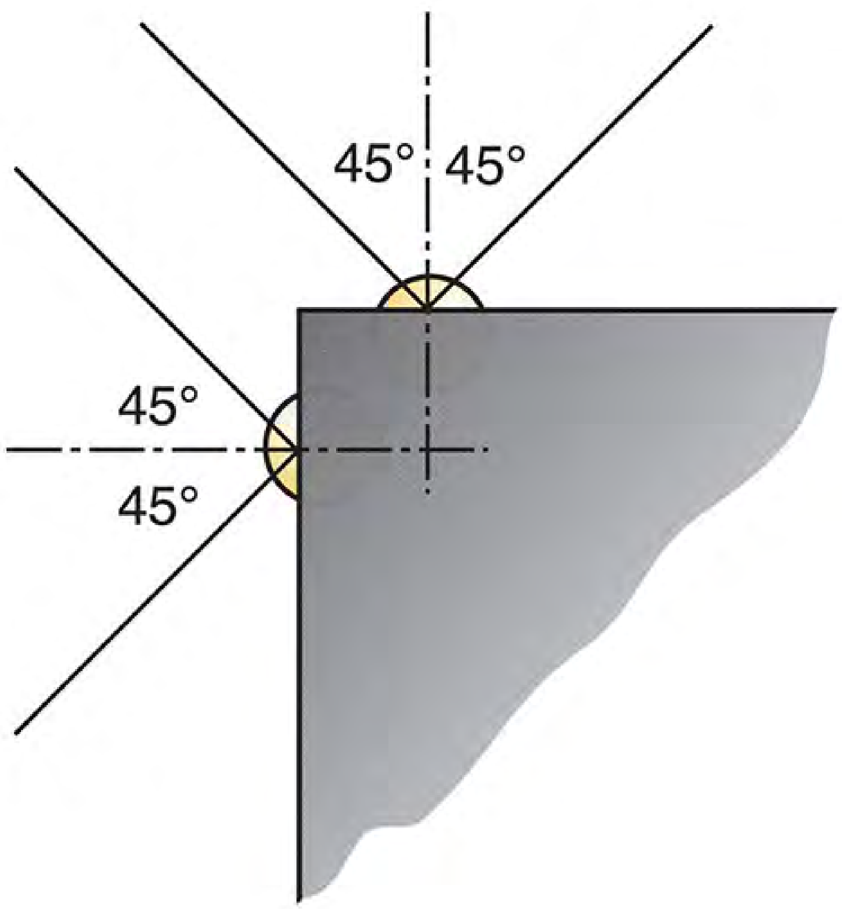
SAE Lighting Identification Codes & Standards
(Con't.)

QB	Turn signal operating units, Class B
QC	Vehicular hazard warning signal operating unit
R	Backup lamps
S	Stop lamps
S2	Stop lamps for use on vehicles 2032 mm or more in overall width
T	Tail lamps (rear position lamps)
T2	Tail lamps (rear position lamps) for use on vehicles 2032 mm or more in overall width
U	Supplemental high-mounted stop and turn lamps
U2	Supplemental high-mounted stop and turn lamps for use on vehicles 2032 mm or more in overall width
U3	Center high-mounted stop lamps for passenger cars, light trucks and MPVs
W	Warning lamps for emergency, maintenance and service vehicles
W2	Warning lamps for school buses
W3	360-degree emergency warning lamps
W4	Emergency warning devices
W5-1	360-degree gaseous discharge lamps, Class 1
W5-2	360-degree gaseous discharge lamps, Class 2
W5-3	360-degree gaseous discharge lamps, Class 3
Y	Driving lamps
Y2	Daytime running lamps
Z	Auxiliary low beam lamps
J590	Turn signal flashers
J595	Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles
J845	Omni-directional Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles
J914	Side Turn Signal Lamps for Vehicles Less than 12 m in Length
J945	Vehicular Hazard Warning Flashers – Canceled July 1999
J1054	Warning Lamp Alternating Flashers
J1318	Gaseous Discharge Warning Lamp For Authorized Emergency,Maintenance, And Service Vehicles
J1690	Vehicular Hazard Warning Flashers
J2039	Side Turn Signal Lamps for Vehicles 12 m or More in Length

SAE Ratings Explained

Traditional clearance and side marker lights

A traditional side marker is mounted to the side of the vehicle and is required to produce an angle of light 45° towards the front and rear of the vehicle. A traditional clearance light is mounted to the front of the vehicle or trailer and is required to produce an angle of light 45° to the left of and right of center.



VMRS Codes

TMC/ATA Vehicle Maintenance Reporting Standards RP802F

Code System

X0X	**Cab, Climate Control, Instrumentation & Aerodynamic Device Group**
001	Air Conditioning, Heating & Ventilating System
002	Cab & Sheet Metal
003	Instruments, gauges, Warning & Shutdown Devices & Meters
004	Aerodynamic Devices
X1X	**Chassis Group**
011	Axles - Non-Driven, Front
012	Axles - Non-Driven, Rear
013	Brakes
014	Frame
015	Steering
016	Suspension
017	Tires, Tubes, Liners & Valves
018	Wheels, Rims Hubs & Bearings
019	Automatic/Manual Chassis Lubricator
111	Undercarriage
112	Stabilization
X2X	**Drivetrain Group**
021	Axles - Driven, Front Steering
022	Axles - Driven, Rear
023	Clutch
024	Driveshaft
025	Transfer Case
026	Transmission - Main, Manual
027	Transmission - Main, Automatic
028	Auxiliary Transmission
029	Auxiliary Section - Main Transmission, Manual
X3X	**Electrical Group**
031	Charging System
032	Cranking System
033	Ignition System
034	Lighting System
X4X	**Engine/Motor Systems Group**
041	Air Intake System

X4X	**Engine/Motor Systems Group**
041	Air Intake System
042	Cooling System
043	Exhaust System
044	Fuel System
045	Power Plant
046	Electric Propulsion System
047	Filter Kits - Multi System (040 - 046)
X5X	**Accessories Group**
051	General Accessories
052	Electrical Accessories
053	Expendable Items
054	Horns & Mountings & Reverse Signal Alarms
055	Cargo Handling, Restraints & Lift Systems
056	Power Take Off
057	Spare Wheel Mounting
058	Winch
059	Vehicle Coupling System
X6X	**Special Applications Group**
061	Terminal Equipment - Multi Applications
063	Satellite Communications System
065	Hydraulic Systems - Multifunction
066	Blades
067	Buckets
068	Booms
069	Rollers
161	Brooms
162	Spreaders
163	Chippers
164	Blowers
165	Vacuums
166	Trenchers
167	Tillers
168	Mowers
169	Rippers
261	Rakes
262	Breakers

263	Hammers
264	Grapples
265	Magnets
266	Forks
267	Drilling and Boring
268	Lifting and Pulling
361	Air Compressors
X7X	**Bodies & Vessels Group**
071	Body
072	Rear Wall & Door
073	Shell - Tank Vessel, Inner
074	Jacket - Tank Vessel, Outer
075	Manholes
076	Rings & Bolsters
077	Trailer Frame & Support
078	Trim & Miscellaneous Hardware
079	Safety Devices
171	Mixers
172	Compaction Bodies
173	Tilt Bodies
X8X	**Heating & Refrigeration Group**
081	Heating Unit
082	Mechanical Refrigeration Unit
083	Nitrogen Refrigeration Unit
084	Hold Over Plate Refrigeration
X9X	**Bulk Product Transfer Systems Group**
091	Blowers, Conveyors & Vibrators
092	Compressors - Bulk Product Systems
093	Bulk Storage Systems
094	Lines, Tubes, Hoses & Fittings - Bulk Product Transfer Systems
095	Manifold
096	Power Shaft - Power Take-Off
097	Pump - Product Transfer
098	Valves & Controls - Bulk Product Transfer Systems

Appendix

TMC Recommended Practices Included

RP 159 - Installation and Inspection Guidelines for Seven Conductor Truck-Trailer/Converter Dolly Jumper Cable and Connector
RP186 - Wire repair guidelines
RP 1406 - Basic Electrical/Electronic Diagnostic Procedures
RP 1204A -Technician Electrical Skill Evaluation

NOTES

RECOMMENDED PRACTICES MANUAL

REPRINT

Featuring

RP 159	Installation and Inspection Guidelines for Seven Conductor Truck-Trailer/Converter Dolly Jumper Cable and Connector
RP 186	Wire and Cable Repair Guidelines
RP 1204A	Technician Electrical Skill Evaluation
RP 1406	Basic Electrical/Electronic Diagnostic Procedures

Courtesy of:

PETERSON
Vehicle Lighting & Harness Systems

COUNCIL OF ATA

TECHNOLOGY & MAINTENANCE COUNCIL

Turning Experience Into Practice

DISCLAIMER

The Recommended Practices contained herein reflect the consensus of the members of the Technology & Maintenance Council (TMC) on those items and methods that have delivered the best performance record based on the experience of those present at meetings of the Council. **Recommended Engineering Practices** are voluntary practices that assist equipment users, vehicle/component manufacturers, and other industry suppliers in the design, specification, construction and performance of commercial vehicle equipment. TMC's **Recommended Maintenance Practices** assist equipment users, vehicle/component manufacturers, and other industry suppliers in the maintenance of commercial vehicle equipment. Recommended Maintenance Practices also include test methodologies and informational documents that cover technical aspects of maintenance, equipment and supporting technologies. TMC established these separate categories of Recommended Practices in 1997.

The Practices contained herein are not exclusive. TMC cannot possibly know, evaluate, or advise the transportation industry of all conceivable ways in which a practice may be undertaken or of the possible consequences of each such practice. Other practices or methods may be as good, or better, depending upon the particular circumstances involved.

All who use the Recommended Practices contained herein must first satisfy themselves thoroughly that neither the safety of their employees or agents, nor the safety or usefulness of any products, will be jeopardized by any method selected.

The following Recommended Practices are not intended nor should they be construed as an endorsement of any particular person, organization, or product.

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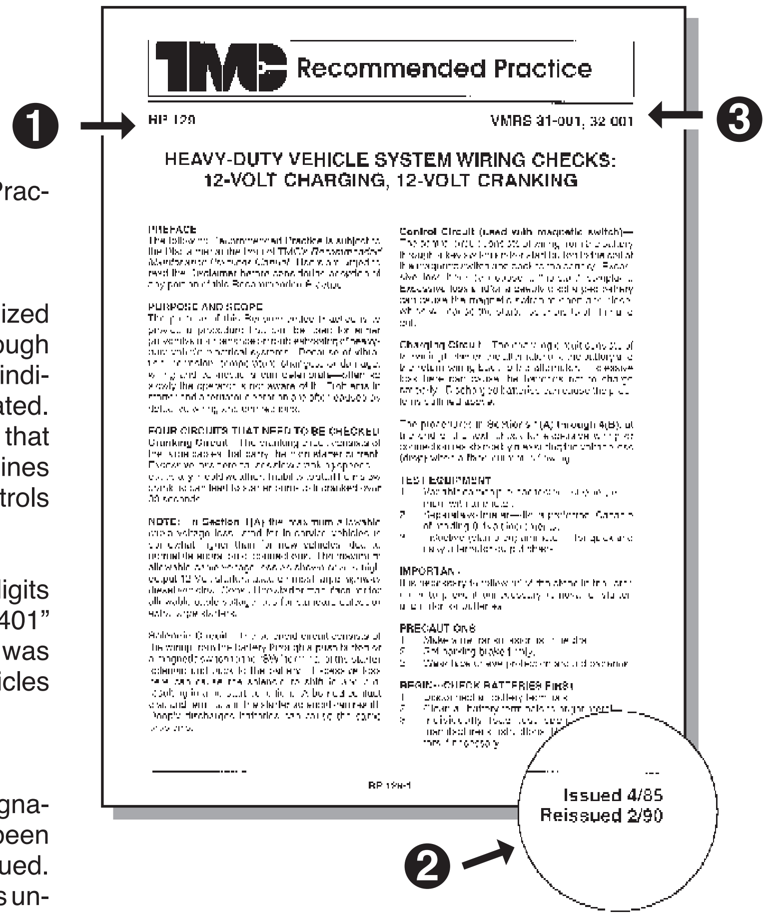
A WORD ON
TMC RECOMMENDED PRACTICE NOTATION



❶ PREFIXES, NUMERICAL DESIGNATIONS, AND SUFFIXES

PREFIXES

The prefix "RP" stands for Recommended Practice.

NUMERICAL DESIGNATIONS

Recommended Practices are numerically organized by TMC Study Group. For Study Groups S.1 through S.9, the first digit of the numerical designation indicates from which Study Group the RP originated. For example, "RP 326" indicates to the reader that this particular RP was created by the S.3 Engines Study Group; "RP 419," in the S.4 Cab & Controls Study Group and so on.

For Study Groups S.11 and higher, the first two digits denote the Study Group. For example, "RP 1401" indicates to the reader that this particular RP was created by the S.14 Light and Medium-Duty Vehicles Study Group.

SUFFIXES

An alphabetical suffix on an RP numerical designation indicates to the reader that the RP has been revised at some point since it was originally issued. For example, RP 105B indicates that RP 105 has undergone two revisions since original publication.

The suffix "(T)" indicates the RP is proposed, but not officially adopted. RPs that are in draft, ballot, or appeal stages feature this designation. For example, "RP 145(T)." Only officially adopted RPs appear within this manual.

❷ ISSUED, REISSUED, AND REVISED DATES

RP issue, reissue and revision history can be found on the lower right-hand corner of the first page of each TMC Recommended Practice. Three terms are used to convey RP publication history: issued, reissued, and revised.

All TMC RPs are subject to review at five year intervals.

"Issued" dates indicate when the RP was originally published.

"Reissued" dates indicate the date that the RP was reviewed and readopted by TMC without changes from the immediately previous published version.

"Revised" dates indicate the date that the RP was reviewed and revised.

❸ VMRS CODING SYSTEM

Above and to the right of each Recommended Practice title appears the Vehicle Maintenance Reporting Standards (VMRS) code or codes. VMRS is an equipment and maintenance management information system based on standard data codes developed by TMC/ATA. These codes describe and identify vehicle systems, assemblies, subassemblies, and individual components discussed in each Recommended Practice. See RP 802B, Vehicle Maintenance Reporting Standards, for a discussion of the "VMRS 2000" Coding System.

Recommended Practice

RP 159 **VMRS 034-003-000**

INSTALLATION AND INSPECTION GUIDELINES FOR SEVEN CONDUCTOR TRUCK-TRAILER/CONVERTER DOLLY JUMPER CABLE AND CONNECTOR

PREFACE

The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Maintenance Practices Manual.* Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

PURPOSE AND SCOPE

This Recommended Practice (RP) offers installation and inspection guidelines for coiled and straight electrical tractor-to-trailer hookup lines used on Class 7-8 combination vehicles. See TMC RP 435, *Installation and Inspection Guidelines for Pneumatic Tractor-Trailer Hookup Lines*, for procedures covering trailer-trailer pneumatic brake system hookup lines.

See TMC RP 107C, *Seven Conductor Truck-Trailer/ Converter Dolly Jumper Cable and Connector Selection*, for selection guidelines for coiled and straight electrical hookup lines. See TMC RP 417, *Selection Guidelines for Pneumatic Tractor-Trailer Hookup Lines*, for guidance when choosing trailer-trailer pneumatic brake system hookup lines.

INSTALLATION

1. Line Installation on the Tractor:

1.1—In many cases, a three or four-hole clamp that will accommodate the cable(s) as well as the air lines will be used. Be sure that the clamp is durable and that the inside diameter of each of the holes is adequate to clamp the outside diameters of the lines. (See **Figure 1**.)

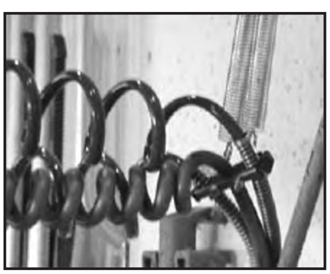


Figure 1

1.2—Where needed, use a hose suspension spring (or springs) sized to keep electrical lines safely supported above the deck plate.

Incorrect storage of disconnected trailer plugs and gladhands will cause damage to the lines and may create hazards to surrounding equipment or personnel.

Figure 2

Figure 3

1.3—Be sure to install the lines in a manner that prevents them from coming into contact with the vehicle's exhaust system or any other source of high temperatures.

2. Plug Storage:

2.1 There must be some means of securely stowing the plugs and the attached electrical lines when the tractor is not connected to a trailer to ensure that these parts are protected from abrasion, cutting, chafing, high temperature surfaces and dirt. (See **Figures 2 and 3**.)

INSPECTION

NOTE: Periodically inspect the installation to ensure that it remains according to the above guidelines and inspect the lines along their full section for the conditions noted below. Replace any lines that exhibit the conditions noted.

Figure 4

3. Electrical Line Inspection:

3.1—Abrasions, cuts, cracks or voids in the cable jacket should not be present. The inner insulated conductors should not show through the cable jacket. (See **Figure 4**.)

3.2—The sun's ultraviolet rays may eventually fade the cable jacket. If the cable jacket is faded significantly, it is likely brittle and hairline cracks may be present. Inspect the cable closely for these.

3.3—A coiled cable assembly should not exhibit excessive sag that may place it in a position where it can become snagged, chafed, cut or abraded on the frame rails, catwalk, deckplate or even the driveline.

3.4—Frequently inspect connector terminals for dirt and corrosion. Remove any dirt and corrosion with a wire brush and cleaner. Apply a corrosion preventative material—as per TMC RP 155, *Selection and Application of Corrosion Preventive Materials for Electrical Terminals and Connectors*— to fully coat the plug and socket terminals.

3.5—Inspect for loose or poorly made wire-to-terminal connections and repair or replace these.

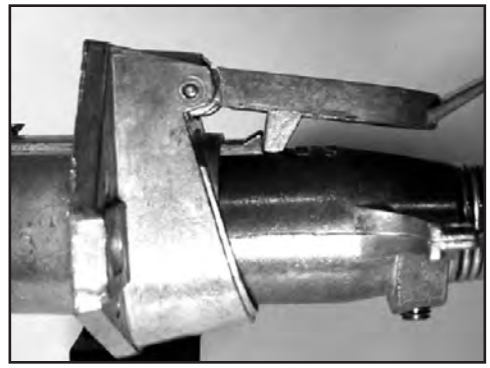
Figure 5

(See **Figure 5**.)

3.6—Where practical, with assemblies made with short leads, reverse the assembly so that the trailer plug that has endured many coupling and uncoupling cycles and has been exposed to weather, chemicals and dirt, is connected to the tractor socket, giving the other plug equal time of use.

3.7—Inspect the cable-to-connector strain relief clamp or other mechanisms to ensure that the cable has not begun to pull out of the connector. (See **Figure 5**.)

3.8—Check that the latching lug and spring force on the socket lid and the latching lug on the plug provide adequate latching force. (See **Figure 6**.)



The condition of the index lug on the plug housing and the latch and socket lid spring are the primary things to check in an electrical plug and socket.

Figure 6

3.9—Inspect the spring-loaded female terminals in the plug and the wear, condition and position of the male socket pins to ensure proper electrical contact.

3.10—Inspect for proper operation of lamps, ABS system and other electrical devices on the trailer. Ideally, voltage checks should be performed. Seven-way circuit checkers may be useful in isolating incomplete or intermittent circuits.

3.11—Any weather-sealing mechanisms at the back end of the plug or socket housings should be intact providing an adequate seal. Trapped moisture will facilitate corrosion.

4. Inspection of Springs, Clamps And Hose Suspension Devices:

4.1—Rusted, worn or damaged springs exhibiting any sharp edges should be replaced. Clamps that have become loose or damaged or have slid onto unprotected tubing should be replaced. Rusted bolts and/or nuts may become dislodged during operation.

4.2—Ensure that a pogo stick remains upright but will flex enabling movement of the lines during turns.

4.3—Ensure that slider bars allow the unobstructed sideways movement of suspended lines during turns.

5. Inspection Checklist:

5.1—The following inspection checklist should be used as part of the regular preventative maintenance schedule.

INSPECTION CHECKLIST

Isolate faults and repair or replace faulty components where applicable. Consult guidelines where needed.

______ **Electrical function**—Check operation of all lights, ABS modules and other electrical devices.

______ **Cable selection**—Confirm green cable marked SAE J2394 for ABS-equipped trailers.

______ **Auxiliary hookup**—Confirm that any auxiliary electrical lines are connected to the correct receptacles.

______ **Chafes, cuts and cracks**—Check along length of electrical lines for wear. Inspect faded lines closely for fine cracks or brittleness in the outer cover.

______ **Connector terminals**—Check plug and socket terminals for wear & corrosion. Apply anti-corrosion grease. Where short leads are present on both cable ends, (no clamps), reverse the assembly end-for-end to "even out" the wear on the trailer connection.

______ **Strain relief**—Confirm that a functioning strain relief method is in place at the plug/cable attachment.

______ **Connector mating**—Check that mated plugs and sockets are not loose-fitting and that the socket lid spring and plug/socket latching mechanisms function properly.

______ **Assembly working lengths**—Check that no evidence of stress exists on electrical lines or connections due to insufficient working lengths.

______ **Sag and snag**—Confirm that electrical lines are not sagging, dragging or snagging as a result of poor coil memory, insufficient line suspension off the tractor deck or poor routing of lines around obstructions.

______ **Proximity to heat**—Check that lines are not routed near any high heat surfaces.

______ **Line suspension**—Check that tender springs, clamps, pogo sticks or slider bars are installed and functioning properly.

______ **Tangles**—Untangle lines to ensure free movement unless lines are purposely joined or gathered together.

Comments: ____

Recommended Practice

RP 186 **VMRS 034-004**

WIRE AND CABLE REPAIR GUIDELINES

PREFACE
The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Maintenance Practices Manual*. Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

PURPOSE AND SCOPE
The purpose of this Recommend Practice (RP) is to provide the technician with useful advice and guidance when making everyday wire repairs on commercial vehicles. Environmental and physical conditions, such as excessive heat, vibration, corrosion, and routing issues, can cause wires and cables to be damaged. It can also cause terminals, seals, and connector bodies to be damaged.

These failures often lead to expensive component failures and/or unnecessary removals. If not repaired correctly, and the causes(s) of the original wire damage eliminated, repeat failures/issues may occur. While the exact repair methods cannot be covered in their entirety in this RP, good maintenance practices and rules are covered that apply to all wire and cable repairs.

INTRODUCTION
The primary cable used on a heavy-duty truck, tractor, or trailer electrical system is the medium through which all power and signal is transmitted to the vehicle's electrical components. As such, special attention must be paid to proper cable construction and selection when electrical wiring repair is required.

TMC RP 166, *Low-Voltage Primary Electrical Cable Specification for Heavy-Duty Electrical Repair,* is recommended for use when wire repair is required. It will define the terminology and specifications needed for low-voltage primary cable identification and selection.

SAE International (SAE) J1128, "Low-Voltage Primary Cable" – Type GXL and SXL cable, is a good overall choice to cover most wire repair service needs.

MECHANICAL WIRE REPAIR
Two methods exist for mechanically connecting wires as a repair.

The first method consists of utilizing the existing wires to be repaired and the act of twisting the ends together to form the foundation of the repair.

The second method of connecting wires for repair utilizes the addition of a butt connector, sometimes called a barrel connector, to make the repair.

Regardless of the method used, the repair elements should include soldering and a form of insulating the final repair to avoid degradation, water entry, and electrical contact with surrounding metal or wires.

The final step is to test the success of the completed repair.

NOTE: The wire repairs outlined in this section are for SAE J1128 primary wire as specified in TMC RP166. The gauge size shall not exceed 10 gauge. For wires bigger than 10 gauge, TMC recommends replacement of the wire or harness. This RP also assumes that the person performing the repair is proficient in proper soldering technique.

TWIST METHODS FOR REPAIRING WIRES
This method consists of utilizing the existing wires to be repaired and the act of twisting the ends together to form the foundation of the repair.

Required Tools:
- Wire cutters
- Wire strippers (see **Reference** Section for details)
- Soldering Iron (see **Reference** Section for details)
- Solder (see **Reference** Section for details of process)
- Dual Wall Polyolefin Heat Shrink Tubing rated 257° F/125° C
- Heat Shrink gun

J-Hook Method

- Remove all damaged or corroded wire.
- Push on heat shrink over one end of the wire (see **Heat Shrink** section for how to select and apply).
- Ensure the heat shrink will not be melted by the soldering process.
- Strip 3/8” insulation off each wire. Be careful not to nick or damage wire strands.
- Form “J” hooks with both wires (see **Fig. 1**).

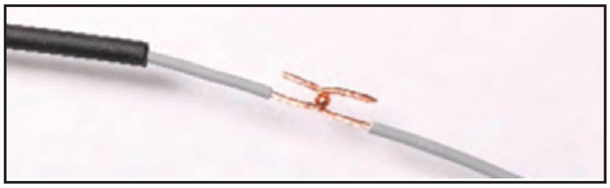


Figure 1

- Twist remaining wire ends over the opposing wire (see **Figure 2)**.

Figure 2

- Pull on the two wires to test for strength of the connection.

Lineman Splice Method

- Remove all damaged or corroded wire.
- Push on heat shrink over one end of the wire. (See the **Heat Shrink** section for how to select and apply.)
- Ensure heat shrink will not be melted by the soldering process.
- Strip 1/2” insulation off each wire. Be careful not to nick or damage wire strands.
- Cross the two wires (see **Figure 3**).
- Bend wire ends over each other (see **Figure 4**).

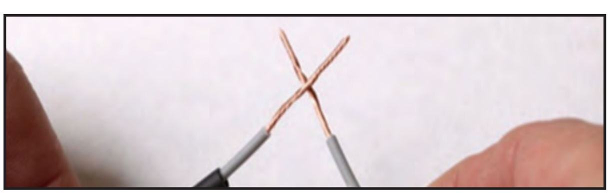


Figure 3

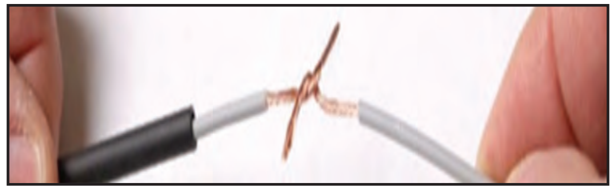


Figure 4

- Wrap one wire end completely around the other wire (the more turns, the better). Repeat the wrapping on the other side until both are securely wrapped around each other (see **Figure 5**).
- Pull on the two wires to test for strength of the connection.

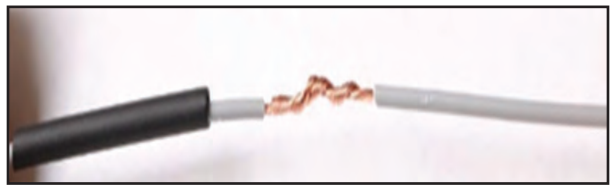


Figure 5

Soldering The Twisted Wire Repairs

Soldering Safety:

- Work in a well-ventilated area.
- Wear proper eye protection.
- Wear proper personal protection equipment to avoid burns from any solder splatter.
- Do ***not*** use open flame soldering devices.
- Avoid breathing solder smoke or vapors.

Soldering Process:

- Turn on the soldering iron and allow it to fully heat. Set to manufacturers recommendations for solder type and wire size.
- Place the soldering iron tip to twisted bare wire repair area (see **Figure 6**).

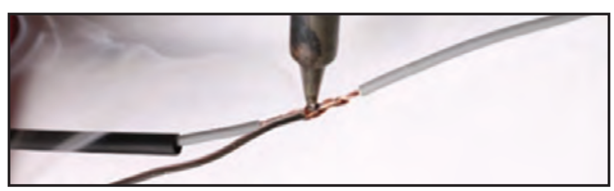


Figure 6

- Apply solder to the twisted wire repair area and assure solder flows on cooper conductors and covers the entire area of exposed wire (see **Figure 7**).

Figure 7

- Allow the solder to cool and harden.
- Remove any burrs.

Step Heat Shrink
- Slide heat shrink over repair area.
- Use heat gun to completely shrink the heat shrink tubing. Glue should ooze out of ends so that repair area is completely sealed (see **Figure 8)**.

Figure 8

Test The Repair
Test the repaired circuit to ensure a proper repair. To properly test the repair, the circuit that contains the repair must be energized, and current must be flowing. See the Final Inspection segment of the Reference section for complete details on testing.

METHOD FOR REPAIRING WIRE WITH BUTT- OR BARREL-TYPE CONNECTORS
The butt connector method relies on a conductive metal barrel (butt connector) in which the stripped wire ends are placed in either end of the barrel. Force applied by crimping allows for the wires to be secured. As in all cases, soldering the connection after crimping will result in a secure mechanical and electrical bond. The repair is then covered with a heat shrink material.

Within the butt-type connectors are choices:
- non-insulated crimp type,
- crimp-type with heat shrink as part of the butt connector, and;
- a butt connector that has heat shrink and solder already in the barrel as part of the connector.

NOTE: Because of the critical nature of the repair joint, simple vinyl-coated butt connectors, such as those shown in **Figure 9**, are ***not*** recommended.

Figure 9

Required Tools:
- Wire cutters
- Wire strippers (see **Reference** section)
- Crimpers (see **Reference** section for details)
- Butt splice or barrel terminals
- Heat gun
- Soldering iron (only on un-insulated butt splice; see **Reference** section for details)
- Solder (only on un-insulated butt splice; see **Reference** section for details)

NOTE: As with all butt- or barrel-type connectors, you must match the butt connector being used to the wire gauge being repaired. Equally critical is the absolute need to use the proper high-quality crimping and stripping tools. In addition, the finished repair should be well insulated and electrically and mechanically sound.

Non-Insulated Butt Connectors
- Cut off all damaged/corroded wire. If the wire has failed due to corrosion, the corrosion may have traveled a considerable length of the wire. All corroded wire must be removed.
- Utilize the same size wire (if needed) and the butt splice that matches the wire size.
- Strip back the insulation, careful to not damage wire (see **Figure 10A**).

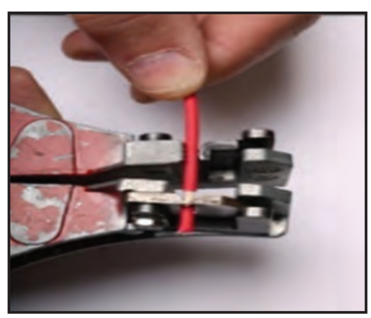


Figure 10A

- Insert the wire into the butt splice barrel (wires all the way to the stop) in the butt splice (see **Figure 10B**).

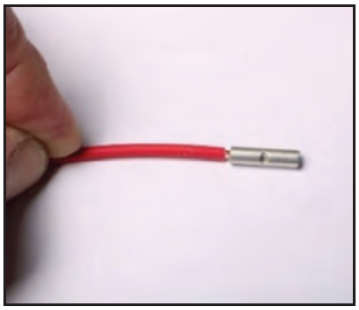


Figure 10B

- Utilizing the correct style of crimpers with correct jaw position, crimp the butt splice onto the wire (see **Figure 10C**).

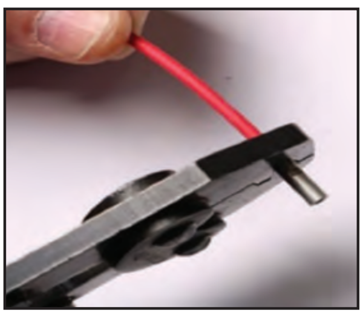


Figure 10C

- Slide heat shrink over wire; ensure heat shrink will not be melted by soldering process (see **Figure 10D**).

Figure 10D

- Strip other end of wire, careful not to damage wires.
- Insert the end into the butt splice until wires hit the stop in the butt splice (see **Figure 10E**).
- Utilizing the correct style of crimpers with correct jaw position, crimp the butt splice onto the wire.
- Pull the wires to ensure the crimp is solid and strong.
- Using a soldering iron, heat the butt splice and apply solder. When solder flows, it will

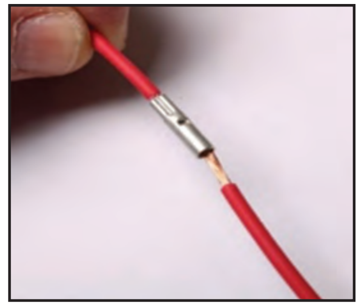


Figure 10E

wick into the butt splice and fill all voids (see **Figure 10F**).

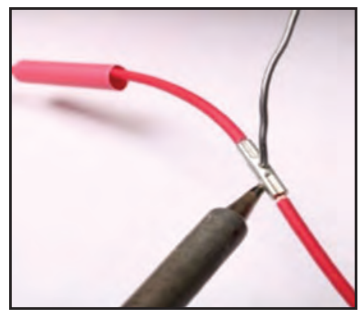


Figure 10F

- Allow solder to cool and harden (see **Figure 10G**).

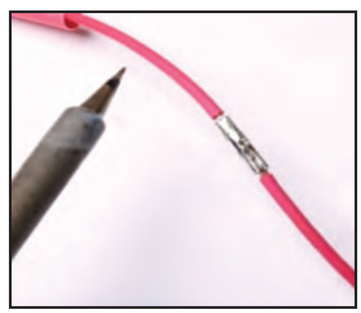


Figure 10G.

- Move heat shrink to cover complete repaired area and use a heat gun to shrink heat shrink around repaired area (see **Figure 10H)**.

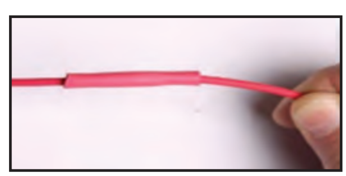


Figure 10H

Insulated Butt Splice

- Cut off all damaged/corroded wire.
- Utilize the same size wire (if needed) and the butt splice that matches the wire size.
- Strip back the insulation, careful to not damage wire.
- Insert the wire into the butt splice barrel (wires all the way to the stop in the butt splice (see **Figure 11A**).

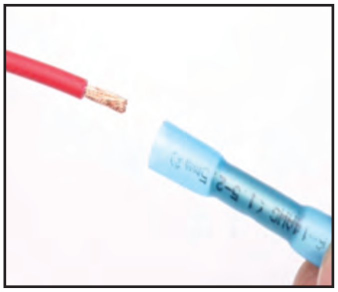


Figure 11A

- Utilizing the correct style of crimpers with correct jaw position, crimp the butt splice onto the wire (see **Figure 11B**).

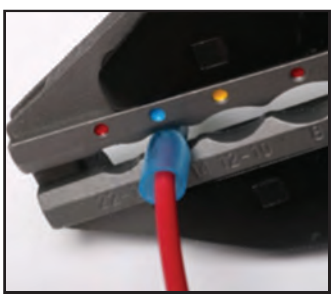


Figure 11B

- Pull the wires to ensure the crimp is solid and strong (see **Figure 11C**).

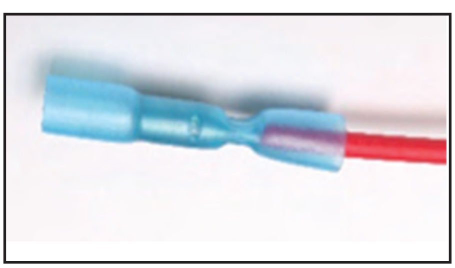


Figure 11C

- Repeat for the second wire end (see **Figures 11D and 11E**).

Figure11D

Figure 11E

- Using a heat gun, apply heat to the heat shrink covering the insulated butt splice. Start in the middle and work your way to the outside, completely sealing the repair (see **Figures 11F, 11G and 11H**).

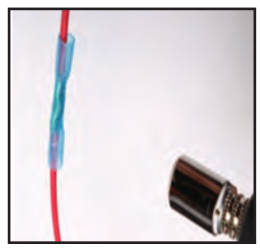


Figure 11F

Figure 11G

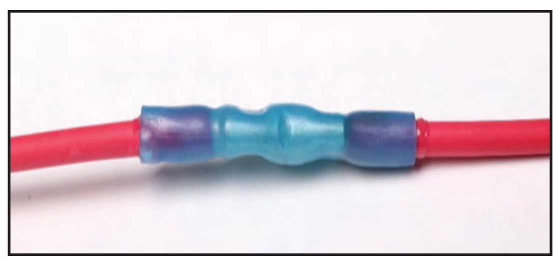


Figure 11H

Insulated Butt Splice With Solder

- Cut off all damaged/corroded wire.
- Utilize the same size wire (if needed) and the butt splice that matches the wire size.
- Strip back the insulation, careful to not damage wire.
- Insert the wire into the butt splice barrel (push both wires together and ensure the wires are under the solder ring). (See **Figure 12A**.)
- Using a heat gun, apply heat to the heat shrink covering the insulated butt splice. Start in the

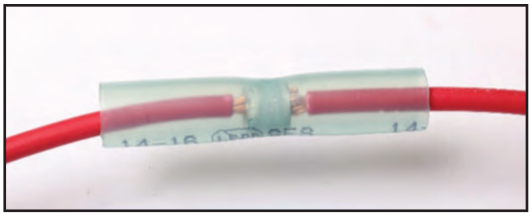


Figure 12A

middle to ensure solder flows. Work your way to the outside, completely sealing the repair (see **Figure 12B**).

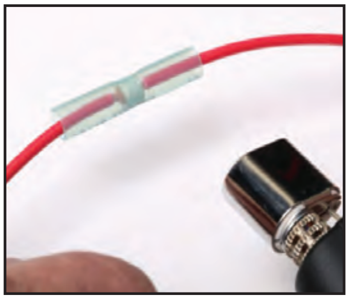


Figure 12B

- Pull the wires to ensure the solder flowed and the connect is secure (see **Figure 12C)**.

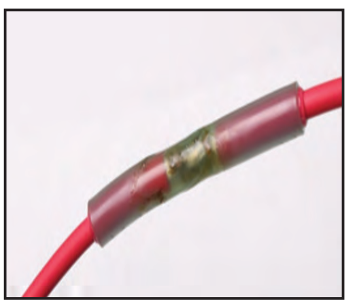


Figure 12C

Test The Repair
Test the repaired circuit to ensure a proper repair. To properly test the repair, the circuit that contains the repair must be energized, and current must be flowing. See the Final Inspection segment of the Reference section for complete details on testing.

REFERENCE SECTION

FINAL INSPECTION
After you have made a wire repair, it should be tested to confirm its effectiveness. To test the repair, current must be flowing through it and the voltage drop measured. This can be done in a three-step process:
- Apply a load to the circuit (so current is flowing through the repair).
- Measure voltage at the source (A) and at the device (B).
- Determine if voltage loss in the repaired circuit (the voltage drop) is within specification.

Applying the Load
An easy way to apply a load to the repaired circuit is to turn on the electrical device in the circuit and allow it to provide the load. If this is not possible, the load will have to be measured or estimated and a comparable load applied to the circuit. For example, if the repair circuit operated three lights in parallel, and each light draws 1.33 amps, the total load is four amps. A device that draws four amps can be used to apply a load to the circuit.

Measuring Voltage Loss (Voltage Drop)
Voltage loss can be measured in one of two ways (see **Figure 13**):
- Measure from the source to ground [A] and then the end to ground [B]. The difference in the values (A – B) equals the voltage drop in the repaired circuit.

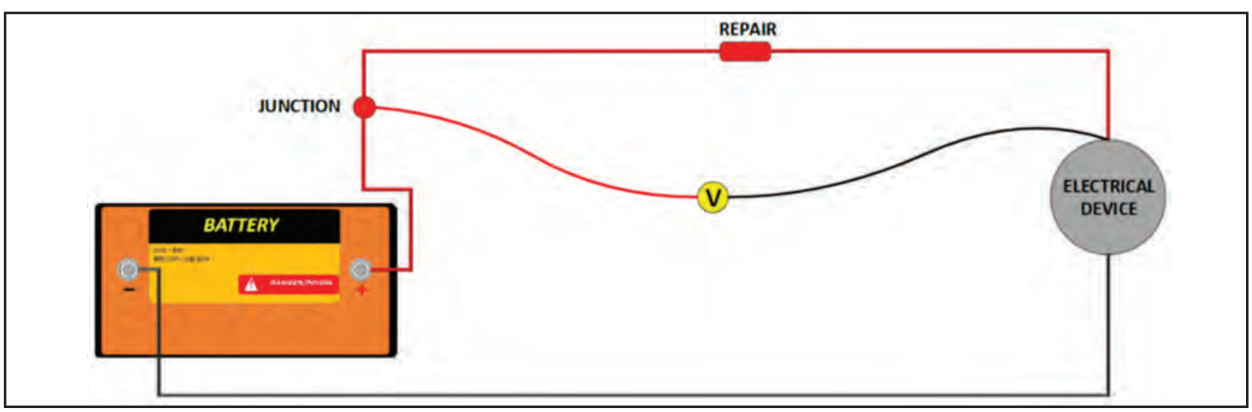


Figure 13

- Measure the source voltage [A] with the red positive lead of your voltmeter and the ending voltage [B] with the black negative lead of your voltmeter. The value on the voltmeter screen is the voltage drop in the repaired circuit.
- If a voltage loss specification for the circuit is not known, any reading of 30mV or less can be used as a rule of thumb for an effective wire repair.

HEAT SHRINK

Choosing the Proper Heat Shrink Tubing

There are many types of heat shrink tubing available; however, choosing the proper heat shrink tubing for the repair is important. Dual-wall polyolefin heat shrink tubing is the recommended choice, as it provides two walls of protection. The outer wall protects against mechanical damage, protects against abrasion, and provides strain relief. The inner wall has a unique hot-melt adhesive that is formulated to adhere to all major types of automotive wire insulation, forms a protective barrier against automotive fluids and moisture, and protects against corrosion and water wicking.

Determine Heat Shrink Tubing Size and Length

- Measure the diameter of the underlying material to be covered at the widest part; select a size 20-30 percent larger than the underlying material.
- Measure the area being covered and add an additional 1” to account for length loss during the recovery process so that the repair is adequately covered. (See **Figure 14**).

Required Tools

- Safety Glasses
- Heat Source – Heat Gun or Butane Torch

Figure 14

Heat Shrink Process

- Determine size and length of Heat Shrink Tubing.
- Remove any sharp edges from solder joints and/or crimp joints.
- Position the Heat Shrink Tubing on the area to be covered.
- Heat from the middle of the Heat Shrink Tubing and work your way to each end while rotating your heat source (see **Figure 15**).

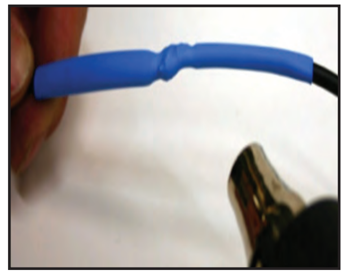


Figure 15

Inspection When Finished

- Ensure that Heat Shrink Tubing covers all exposed wires.
- Ensure that hot melt is extruding from each end of the Heat Shrink Tubing. (See **Figure 16**).

Figure 16

SOLDERING

Soldering, done right, will result in a low-resistance electrical and mechanical bond in the repair joint. TMC makes no recommendation on the type of solder and/or flux (except as noted below) to be used but encourages the technician to consult with one of the major solder manufacturers for recommendations. The following hand-soldering short-course is used here with permission from the Kester Solder Company.

Hand-Soldering Short-Course

Tools required for testing:

- Safety Glasses
- Exhaust fan to pull soldering fumes away from the operator during soldering operation.

- Soldering iron designed for the alloy being soldered with largest tip possible. Typically 300°C (600°F) for Leaded and 375°C (700°F) for lead-free alloys.
- Proper tip for alloy. Lead-free alloy tip will have a thicker layer of tin.

Process:

- Read the information on the roll of solder to ensure it is the correct material. Do ***not*** use acid-based solder.
- If using extra flux, ensure that it is in the same family as the cored wire (e.g., ROLO, ORLO, ORMO).
- Never use a squirt bottle to apply extra flux. Use a flux pen or dip the solder wire in extra flux prior to bringing it to the solder joint. This will ensure all of the flux sees the heat of the soldering process.
- Any sponges used should be wet using de-ionized water only. (Regular water contains chlorine/chloride which can pose a long-term reliability issue.)
- Place the soldering iron on the connection to be soldered.
- Remove the solder wire from the joint before removing the heat (iron).

WIRE STRIPPER SELECTION

There are many quality wire strippers available on the market. The way to choose the correct stripper is to choose one that will cut through the outside insulation of the wire without nicking or scarring the wire below. Using a tool that is designed only to cut wires, like side-cutting pliers or a utility knife, will damage the wire strands under the insulation and cause the current going through the wire to have to jump the nick, which will increase resistance and reduce current flow.

Self-adjusting wire strippers do a much better job at cutting the outside insulation without damaging the wire strands than wire cutters used for bare wires. The self-adjusting strippers senses the thickness of the insulation on the wire and strip the insulation without hitting the wire strands. Some self-adjusting strippers are pre-set while others allow the bare length to be adjusted. Depending on the barrel depth of the chosen connector — these depths vary by manufacture and terminal style — self-adjusting wire strippers bare the wire approximately 3/8” to 1/2”. In most applications, having up to 1/8” of bare wire outside of the barrel of the heat shrink style connector will not harm the termination and will seal moisture out of the connection once the heat shrink material is properly heated and sealed.

Recommended (see Figures 17A, 17B and 17C):

Figure 17A

Figure 17B

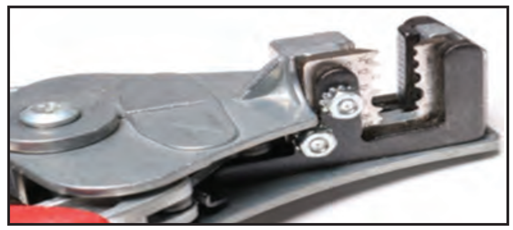


Figure 17C

Not Recommended (see Figures 18A and 18B):

Figure 18A

Figure 18B

PROPER AND IMPROPER CRIMPER STYLES

Choosing the proper crimping tool is essential to a proper crimp when crimping non-insulated or heat-shrink-style connectors. The two most important factors of choosing a crimping tool are that the tool:

- offers a wide crimping area that will not puncture the membrane of the heat shrink materia
- has a mechanical stop to prevent over-crimping and to secure the wire in the terminal without distorting, smashing, or breaking wires within the connection (see **Figure 19**).

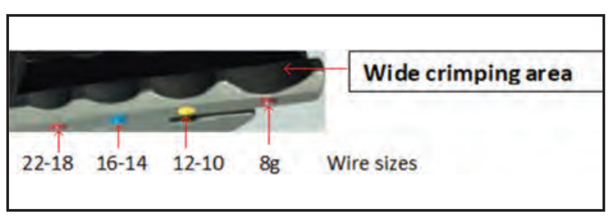


Figure 19

There are many ratcheting crimpers on the market that offer both of these attributes. These crimpers also offer color-coated crimping areas to easily find the correct crimping position for the terminal size being crimped. Choosing the wrong crimper with a narrow or piercing crimp area that does not offer a mechanic stop option may punctured the heat shrink material that will loosen when heated and will make inconsistent crimps and over-crimped terminals. This damage will have a negative impact on the terminal's ability to completely seal the connection. This could lead to water intrusion and corrosion.

Recommended (see Figures 20A, 20B, and 20C):

Figure 20A

Figure 20B

Figure 20C

Not Recommended (see Figs. 21A, 21B and 21C):

Figure 21A

Figure 21B

Figure 21C

TMC Recommended Practice

RP 1204A **VMRS 003, 031, 032, 034**

TECHNICIAN ELECTRICAL SKILL EVALUATION

PREFACE
The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Maintenance Practices Manual*. Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

PURPOSE AND SCOPE
This Recommended Practice (RP) was developed to help fleets evaluate the electrical skill level of their technicians, with the results being used to determine what required training programs are needed in preparation for the maintenance of truck electronic control systems. This skill evaluation is not intended to be used as a pass/fail exam in grading the skill level of individual technicians.

The multiple choice questions in this RP were prepared to assist in the evaluation of a technician's knowledge in the following areas:

1. Understanding of basic electrical concepts.
2. Reading simple electrical wiring diagrams with electrical symbols.
3. Performing circuit measurements with a volt-ohm meter.
4. Solving basic circuit equations using Ohm's Law.
5. Understanding essential concepts related to the databus.

The multiple choice questions have been divided into four categories as outlined on the answer sheet. These categories are "Fundamental," "Application," "Advanced", and "Databus." The answer sheet also provides sample solutions for selected questions. In the "Fundamental" section, questions address basic electrical topics such as conductors and insulators. In the "Application" section, questions stress familiarity with and ability to use an volt-ohm meter. The "Advanced" section question can generally be considered beyond the required knowledge for a technician to do electronic system maintenance on trucks. The "Databus" section evaluates an understanding of concepts specific to the SAE J1939 databus.

In general, technicians who have responsibilities for truck electrical system maintenance should achieve a minimum of 85 percent correct responses to both the "Fundamental," "Application," and "Databus" category questions. Technicians who score 85 perent on the "Advanced" questions have demonstrated an excellent understanding of basic electrical theory. A working knowledge of both electrical fundamentals and the use of a volt-ohm meter are considered prerequisites for performing service maintenance on truck electrical systems. It should also be noted that a good score on this evaluation does not, in itself, ensure that the technician has the required skills for troubleshooting truck electrical systems.

TMC TECHNICIAN ELECTRICAL SKILL EVALUATION

Fleet: ________________________________

Name: ________________________________

Date: ________________________________

FUNDAMENTAL SECTION

1. Electricity flows easily in:
- a. conductors
- b. insulators
- c. air
- d. open circuits

2. Insulation on wires ______ carry electricity easily.
- a. does
- b. does not
- c. will
- d. should

3. The flow of electricity is called:
- a. electric current
- b. pressure
- c. an open circuit
- d. resistance

4. Current is defined as:
- a. the potential to do work
- b. directed electron flow
- c. positive and negative battery charges
- d. the opposition to electron movement

5. The resistance of two resistors in series is ______ the resistance of each resistor.
- a. greater than
- b. less than
- c. the same as
- d. equal to

6. Current in a circuit that always flows in the same direction is called:
- a. electron current
- b. indirect current
- c. direct current
- d. AC current

7. Voltage:
- a. is the force that moves electrons through an electrical circuit
- b. is the measure of resistance
- c. cannot exist in an open circuit
- d. is measured with an ohmmeter

8. The unit of measure for potential difference is the:
- a. ohm
- b. ampere
- c. ion
- d. volt

9. To have current in a closed circuit we need:
- a. open contacts
- b. schematic diagram
- c. voltage
- d. insulation

10. Which of the following is not another name for the force we call voltage?
- a. electromotive force
- b. potential difference
- c. EMF
- d. current
- e. volts

11. The device that converts chemical energy to electrical energy is called:
- a. piezoelectric device
- b. thermocouple
- c. solar cell
- d. battery
- e. capacitor

12. Resistance causes ______ when electrons flow in a circuit.
- a. an open circuit
- b. heat
- c. no current
- d. no voltage

13. Circuit components that are designed to produce large voltage drops or to reduce the circuit current are called:
- a. good conductors
- b. resistors
- c. poor insulators
- d. current switches

14. Copper wire is a good conductor because:
- a. it has a few free electrons
- b. it can be made into different shapes
- c. it has low resistance
- d. it is an insulator

15. What is a milliamp?

a. one tenth of an amp
b. one hundred of an amp
c. one thousandth of an amp
d. one million amps
e. a bug with many legs

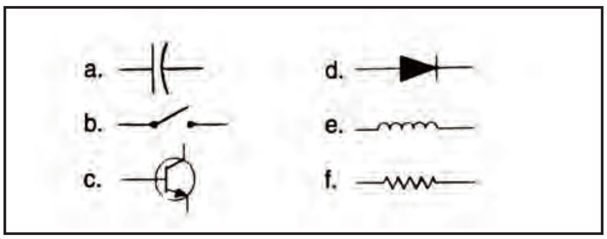
16. The purpose of a battery is to:

a. convert mechanical motion into AC current for powering accessories
b. convert kinetic energy into potential energy for powering components
c. convert chemical energy into electrical energy or electrical energy into chemical energy

17. When batteries cannot push current through a material, the material is:

a. a good conductor
b. an insulator
c. a direct-current conductor
d. full of free electrons

Figure 1: Circuit component schematic symbols for use with questions 18 through 20.



18. What is the schematic symbol for a capacitor (see Figure 1 above)? _____

19. What is the schematic symbol for a resistor (see Figure 1 above)? _____

20. What is the schematic symbol for a diode (see Figure 1 above)? _____

21. A drawing that illustrates the components in an electric circuit is called:

a. closed circuit
b. parts diagram
c. parts list
d. schematic diagram

APPLICATION SECTION

22. The purpose of an ohmmeter is to:

a. measure the watts of the battery circuit
b. measure resistance by applying a known voltage to the circuit
c. measure voltage difference between two points
d. measure amperes by applying 12 volts to the circuit

23. The purpose of the voltmeter is to:

a. measure volts by applying a known voltage to the circuit
b. measure ohms through the ammeter
c. measure the voltage difference between two points
d. measure amperes by applying 12 volts to the circuit

OHMS LAW

Ohms Law states that the current flow through a circuit is directly proportional to the potential difference across it — i.e., if you double the voltage, twice as much current will flow in the circuit.

The resistance of a circuit is calculated by the equation R (in ohms) = V (voltage drop) divided by the current in I (amperes) or R = V/I.

Ohms law is often defined as:

V (volts) = I (amps) x R (ohms)

24. The voltmeter is generally easier to use than either the ammeter or the ohmmeter because:

a. you need not observe polarity when using the meter
b. you need not break the circuit under test to measure the voltage
c. you need not observe safety precautions when using the voltmeter
d. voltage drops can be measured without applying power to the circuit under test
e. a voltmeter cannot be used in a 'live circuit'

25. 2.2 kΩ is another way to write:

a. 2.2 ohms
b. 22 ohms
c. 220 ohms
d. 2,200 ohms
e. 22,000 ohms

26. 9.98MΩ is another way to write:

a. 0.00998 ohms
b. 9.8 ohms
c. 9,800 ohms
d. 9,980,000 ohms

27. Kilo is often abbreviated 'k'. Thus, 100-kilo ohms may be expressed as 100kΩ. Mega is abbreviated as 'M'. Therefore, 10 megaohms may be expressed as:

a. 10 Ω
b. 10 Ω
c. 10 milli Ω
d. 10 MΩ
e. 10 kΩ

28. Figure 2 is the schematic for a:

a. series circuit
b. parallel circuit
c. combination circuit
d. series-parallel circuit

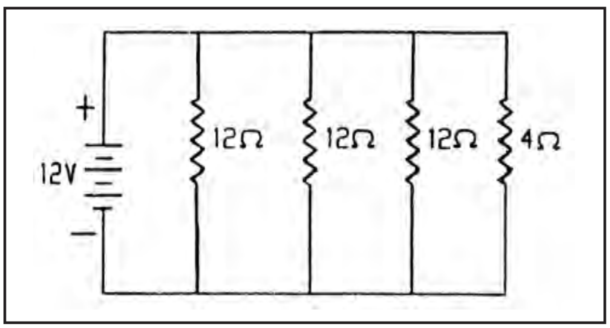


Figure 2

29. A high resistance connection has the effect of:

a. increasing source voltage
b. increasing circuit current
c. reducing circuit current
d. blowing any circuit protection device

30. Adding resistors in parallel with the source voltage will:

a. increase circuit current
b. decrease circuit current
c. not affect circuit current
d. impossible to tell without knowing the resistance

31. The parallel circuit:

a. has a separate current path for each component
b. increases its current draw as additional branches are added
c. reduces its total resistance as additional branches are added
d. all of the above statements are true

32. The bulb in the circuit of Figure 3 is very dim. The voltage readings are taken as follows:

V1: 0.20 volts
V2: 8.0 volts
V3: 7.80 volts

The first technician says that the wiring from the positive battery terminal to the lamp is good. The second technician says that the lamp has a poor ground. Who is right?

a. First technician only
b. Second technician only
c. Both technicians are correct
d. Neither technician is correct

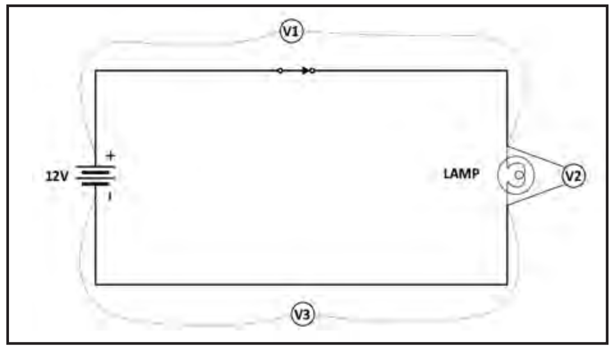


Figure 3

33. Refer to Figure 4. The switch is on and the lamp is dim. The voltage readings are as follows:

V1 = 0.2 volts
V2 = 3.8 volts
V3 = 4.0 volts

What is most likely the problem?

a. a defective switch
b. a burned-out bulb
c. an open circuit
d. an open ground

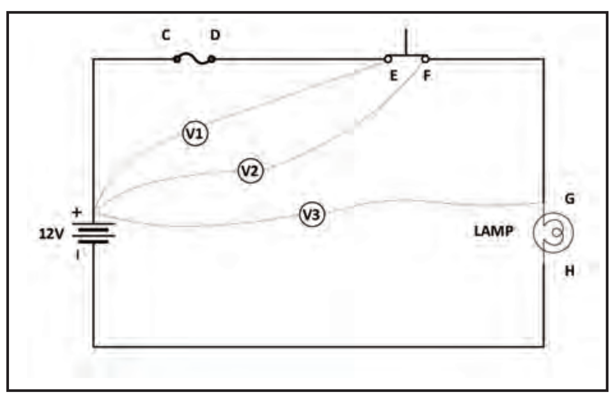


Figure 4

34. Refer to the meter connection in Figure 5. Technician A says the meter is being used to check voltage. Technician B says the meter is connected as an ammeter. Who is right?

a. A only
b. B only
c. both A and B
d. neither A nor B

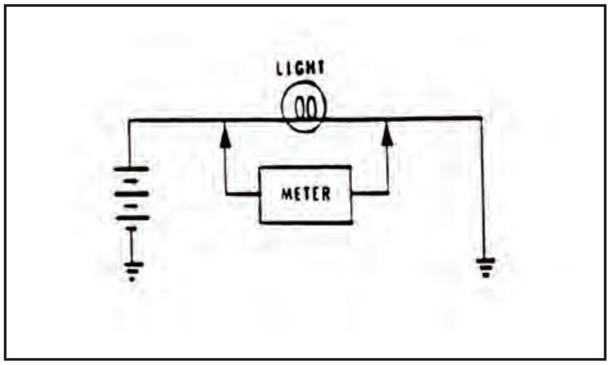


Figure 5

35. A technician is checking a circuit using the setup in Figure 6. Which of the following correctly identifies the two meters?

a. meter X is an ammeter and Y is a voltmeter
b. meter X is an ohmmeter and Y is an ammeter
c. meter X is a voltmeter and Y is an ammeter
d. meter X is a voltmeter and Y is an ohmmeter

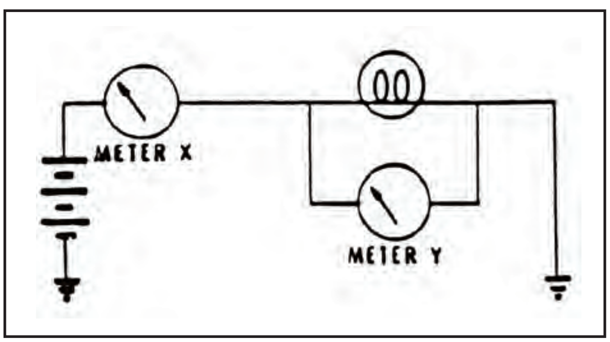


Figure 6

36. In the modern alternator, AC is converted to DC by the: I. Slip Rings or II. Diodes

a. I only
b. II only
c. both I and II
d. neither I nor II

37. Refer to Figure 7. Each bulb draws three (3) amps. Technician A measures the voltage across the circuit breaker with the lights off to measure the voltage drop across the circuit breaker. Technician B turns the lights on then measures the voltage drop across the circuit breaker. Who is correct?

a. A only
b. B only
c. both A and B
d. neither A nor B

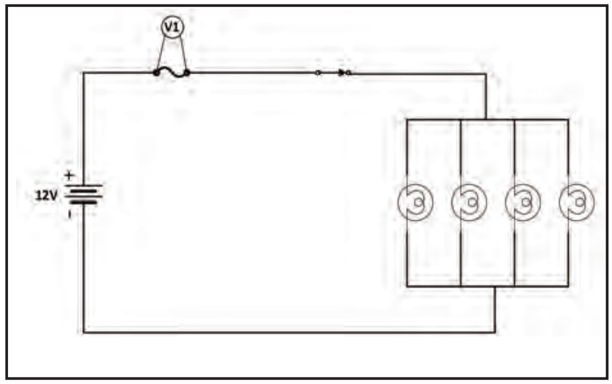


Figure 7

38. An ohmmeter is:

a. always connected in series with the circuit
b. not to be used to check continuity
c. always connected to a circuit with power applied
d. never connected to a circuit when power is applied

ADVANCED SECTION

39. Ohm's Law states that:
- a. current increases as resistance increases
- b. current decreases as voltage increases
- c. current increases as voltage increases
- d. resistance increases as voltage increases

40. If a simple circuit with a 12-volt battery has 6 amperes of current flowing through it, what is the circuit resistance?
- a. 1/2 ohm or 0.5 ohm
- b. 2 ohms
- c. 72 ohms
- d. need more information to solve problem

41. In a circuit with constant voltage, if the resistance is reduced, the current will:
- a. remain constant
- b. increase
- c. decrease
- d. alternate

42. How much current will flow in the circuit depicted in Figure 8, below, if a 12-volt potential is applied between points "A" and "B" ?
- a. 120A
- b. 0.1A
- c. there is not enough resistance for current to flow
- d. there is too much resistance for current to flow

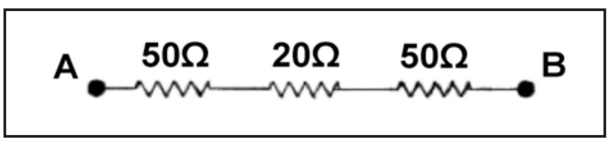


Figure 8

43. What is the circuit current in Figure 9?
- a. 0.75A
- b. 1.3A
- c. 2A
- d. 6A

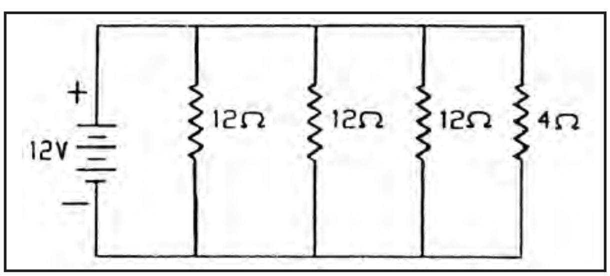


Figure 9

44. Determine what the voltmeter will read in Figure 10.
- a. 2 volts
- b. 6 volts
- c. 12 volts
- d. 72 volts
- e. 1.2 volts

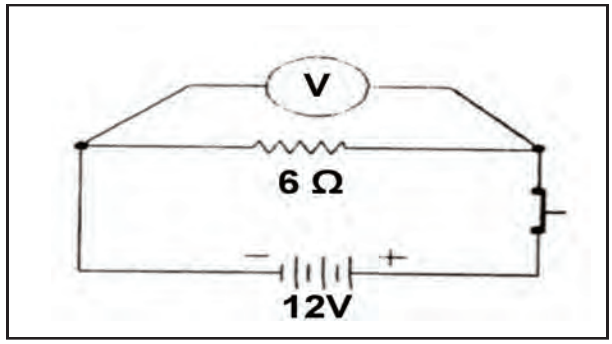


Figure 10

45. What will the voltmeter read in Figure 11?
- a. 12 volts
- b. 0 volts
- c. 6 volts
- d. 72 volts
- e. 2 volts

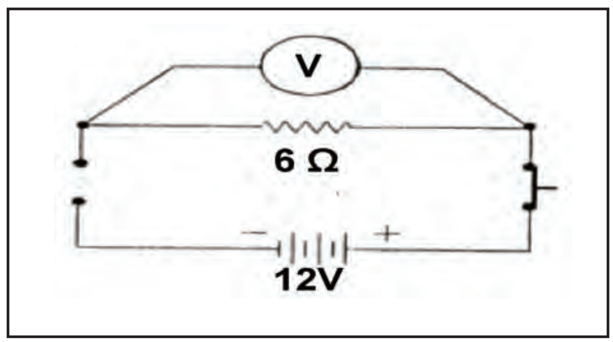


Figure 11

46. What will the ohmmeter read in Figure 12?

a. 12 Ω
b. 72 Ω
c. 6 Ω
d. 0 Ω
e. never hook an ohmmeter to a "live circuit," because the meter may be damaged

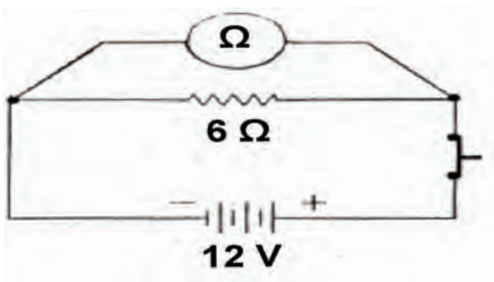


Figure 12

47. What will the ohmmeter read in Figure 13?

a. 10 Ω
b. 15 Ω
c. 20 Ω
d. 45 Ω
e. Never hook an ohmmeter up in this manner; the extra resistance may damage it

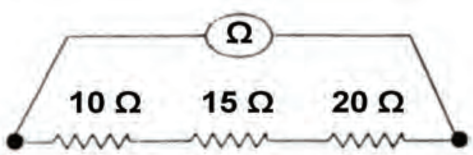
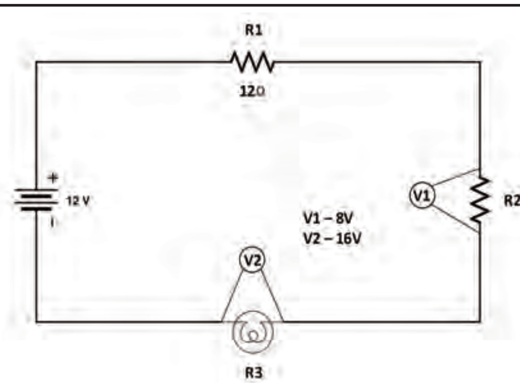


Figure 13

Figure 14. For use with questions 48 -50.



48 What is the circuit current in Figure 14?

a. 0.75A
b. 1.3A
c. 2A
d. 6A

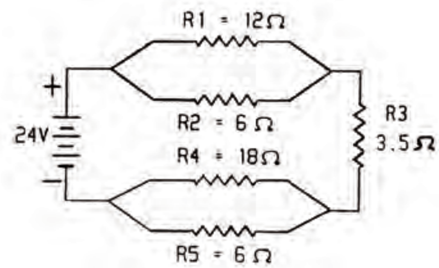
49. What is the total voltage drop in Figure 14?

a. 8V
b. 16V
c. 24V
d. 48V

50. What is the total circuit resistance in Figure 14?

a. 12Ω
b. 24Ω
c. 48Ω
d. 36Ω

Figure 15. For use with questions 51 and 52.



51. If resistor R1 in Figure 15 were to have an internal short:

a. source voltage increases eight volts
b. circuit resistance increases four ohms
c. current does not change
d. circuit resistance decreases four ohms

52. What is the voltage drop across resistor R3 in Figure 15?:

a. 1.75V
b. 3.5V
c. 7V
d. 14V

53.What is the voltage across lamp L1 in Figure 16?

a. 0V
b. 3V
c. 4V
d. 12V

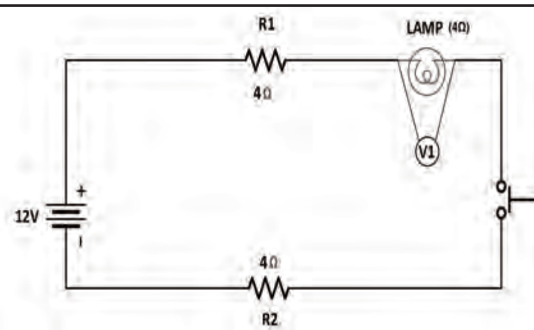


Figure 16

DATABUS SECTION

54. The cable used to repair an SAE J1939 databus circuit is defined in both SAE J1939-11 and SAE J1939-15. Which statements are true?

a. 1939-11 – Jacketed twisted shielded 2 wire cable
b. 1939-15 – Jacketed unshielded twisted 2 wire cable
c. The twisted pair can be assembled with 18-gauge cable
d. The twisted pair can be assembled with 20-gauge cable
e. All of the above

55. The SAE J1939 databus has 2 terminating resistors. One resistor at each end of the databus backbone. What is the resistance value of these resistors?

a. 5 Ohms
b. 50 Ohms
c. 100 Ohms
d. 120 Ohms

56. Identification markings on an ECU case shown as a type 11 has what meaning?

a. Voltage value of 24 volts
b. Negative ground
c. Contains a terminating resistor
d. ECM has specialized programming

57. The databus line is comprised of a CAN H (high) and a CAN L (low). What color cable is CAN H and CAN L?

a. CAN H = blue and CAN L = green
b. CAN H = yellow and CAN L = green
c. CAN H = white and CAN L = blue
d. CAN H = yellow and CAN L = white

58. If a resistance measurement is taken between CAN H and CAN L of a circuit (ignition off) with both terminating resistors in place, what is the resistance?

a. 12 Ohms
b. 20 Ohms
c. 30 Ohms
d. 60 Ohms

59. What TMC RP defines a databus repair procedure?

a. RP 142
b. RP 129
c. RP 135
d. RP 141

60. What is the maximum length of the databus backbone for both 1939-11 and 15?

a. 10 meters
b. 20 meters
c. 30 meters
d. 40 meters

61. Nodes or stub lengths are the ECU cable interconnects to the databus backbone cable. The cable stub/node length is 3 meters for 1939-15 and 1 meter for 1939-11.

a. True
b. False

62. Can a new stub/node be added to an existing stub/node?

a. A stub/node can be added to an existing node if stub/nodes have different lengths
b. A stub/node must always be added to the backbone cable
c. A stub/node can be added to an existing stub/node if splice is made 1/2 meter away from the backbone cable

63. The 1939-11 can contain 30 nodes and a 1939-15 can contain 10 nodes.

a. True
b. False

64. What is the distance between stub/nodes on a databus backbone?

a. 1 meter
b. 1/10 meter
c. 2 meters
d. no specific

TMC TECHNICIAN ELECTRICAL SKILL EVALUATION ANSWER KEY

NOTE: F = Fundamental, APP = Application, ADV = Advanced, and DB = Databus

Problem #	Answer	Category
1	a	F
2	b	F
3	a	F
4	b	F
5	a	F
6	c	F
7	a	F
8	d	F
9	c	F
10	d	F
11	d	F
12	b	F
13	b	F
14	c	F
15	c	F
16	c	F
17	b	F
18	a	F
19	f	F
20	d	F
21	d	F
22	b	APP
23	c	APP
24	b	APP
25	d	APP
26	d	APP
27	d	APP
28	b	APP
29	c	APP
30	a	APP
31	d	APP
32	c	APP
33	a	APP
34	a	APP
35	a	APP
36	b	APP
37	b	APP
38	d	APP
39	c	ADV
40	b	ADV
41	b	ADV
42	b	ADV
43	d	ADV
44	c	ADV
45	b	ADV
46	e	ADV
47	d	ADV
48	c	ADV
49	d	ADV
50	b	ADV
51	d	ADV
52	c	ADV
53	c	ADV
54	e	DB
55	d	DB
56	c	DB
57	b	DB
58	d	DB
59	a	DB
60	d	DB
61	a	DB
62	b	DB
63	a	DB
64	b	DB

CALCULATIONS

Problem #18-20 illustration key

a. capacitor
b. switch
c. transistor
d. diode
e. inductor
f. resistor

Problem #40

Ohm's Law
E(volts) = I(amps) X R(ohms)
12 = 6 X R
12/6 = 2 = R(ohms)

Problem #42

Resistors in series are additive.
R(total) = R1 + R2 + R3
R(total) = 50 + 20 + 50
R(total) = 120 ohms
E(volts) = I(amps) X R(ohms)
12 = I(amps) X 120
12/120 = I(amps)
0.1 = I(amps)

Problem #44

Method A—Algebraic sum of all voltages in a closed circuit = 0.
V1 + V2 = 0
12 + V2 = 0
V2 = -12 Volts
Method B
E(volts) = I(amps) X R(Ohms)
E1 = I(amps) X R(ohms)
12 = I(amps) X 6
12/6 = I(amps)
V2 = I(amps) X R(ohms)
V2 = 2 X 6
V2 = 12 volts

Problem #45

Current does not flow in an open circuit; therefore, the voltage drop across the 6 ohm resistor can be calculated by:
E(volts) = I(amps) X R(ohms)
E(volts) = 0 X 6
E(volts) = 0

Problem #47

Resistors in series are additive
R(total) = R1 + R2 + R3
R(total) = 10 + 15 + 20
R(total) = 45 ohms

Problem #51

Parallel Resistance
1/R(1,2) = 1/R1 + 1/R2
1/R(1,2) = 1/12 + 1/6 = 3/12
R(1,2) = 12/3 = 4 ohms
If R1 is shorted, the current will take the path of least resistance and bypass R2, therefore, the circuit resistance is effectively reduced by R(1,2) or 4 ohms.

Problem #52

R(total) = R(equiv)(1,2) + R3 + R(equiv)(4,5)
R(equiv)(1,2) = 4 ohms (see Prob #44)
R(equiv)(5,6) = 1/(1/18 + 1/6) = 4.6 ohms
R(total) = 4 + 4.5 + 3.5 = 12 ohms
E(volts) = I(amps) X R(ohms)
24 = I(amps) X 12
24/12 = I(amps) = 2
E3(volts) = 2 (amps) X 3.5 (ohms)
E3(volts) = 7

Problem #53

R(total) = R1 + R(lamp) + R2
R(total) = 4 + 4 + 4 = 12 ohms
E(volts) = I(amps) X R(total)(ohms)
12 = I(amps) X 12 ohms = 1 amp
E(lamp) = I(amps) X R(lamp)
E(lamp) = 1 X 4 = 4 volts

TMC Recommended Practice

RP 1406 **VMRS 031 through 034**

BASIC ELECTRICAL/ELECTRONIC DIAGNOSTIC PROCEDURES

PREFACE
The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Maintenance Practices Manual.* Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

PURPOSE AND SCOPE
The purpose of this Recommended Practice is to describe for service technicians the diagnostic and repair processes for electrical and electronic systems for Class 2-6 vehicles.

DIAGNOSTIC PHILOSOPHY
The purpose of this section is to describe the diagnostic philosophy which will provide the technician with a plan of action for each specific diagnostic situation. **Chart 1** describes this diagnostic philosophy. The following sections explains in detail the process outlined within **Chart 1**.

1. Verify customer/driver concern.
This step establishes the connection between the symptom and the root cause of the problem. Use vehicle manufacturers' recommended information collection methods for verification.

2. Perform preliminary checks.
- Operational
- Visual
- Audio

These checks are easy to perform, typically do not require the use of special tools and may result in a quick diagnosis. This is a critical step in the diagnostic process.

3. Refer to service information
Vehicle manufacturers provide service procedures which must be followed to ensure repair integrity. Training/service information is readily available from various sources such as:
- Bulletins
- Service Newsletters
- Videotapes
- Service Manuals
- OEM "Help Line Phone Numbers"
- Troubleshooting Guides

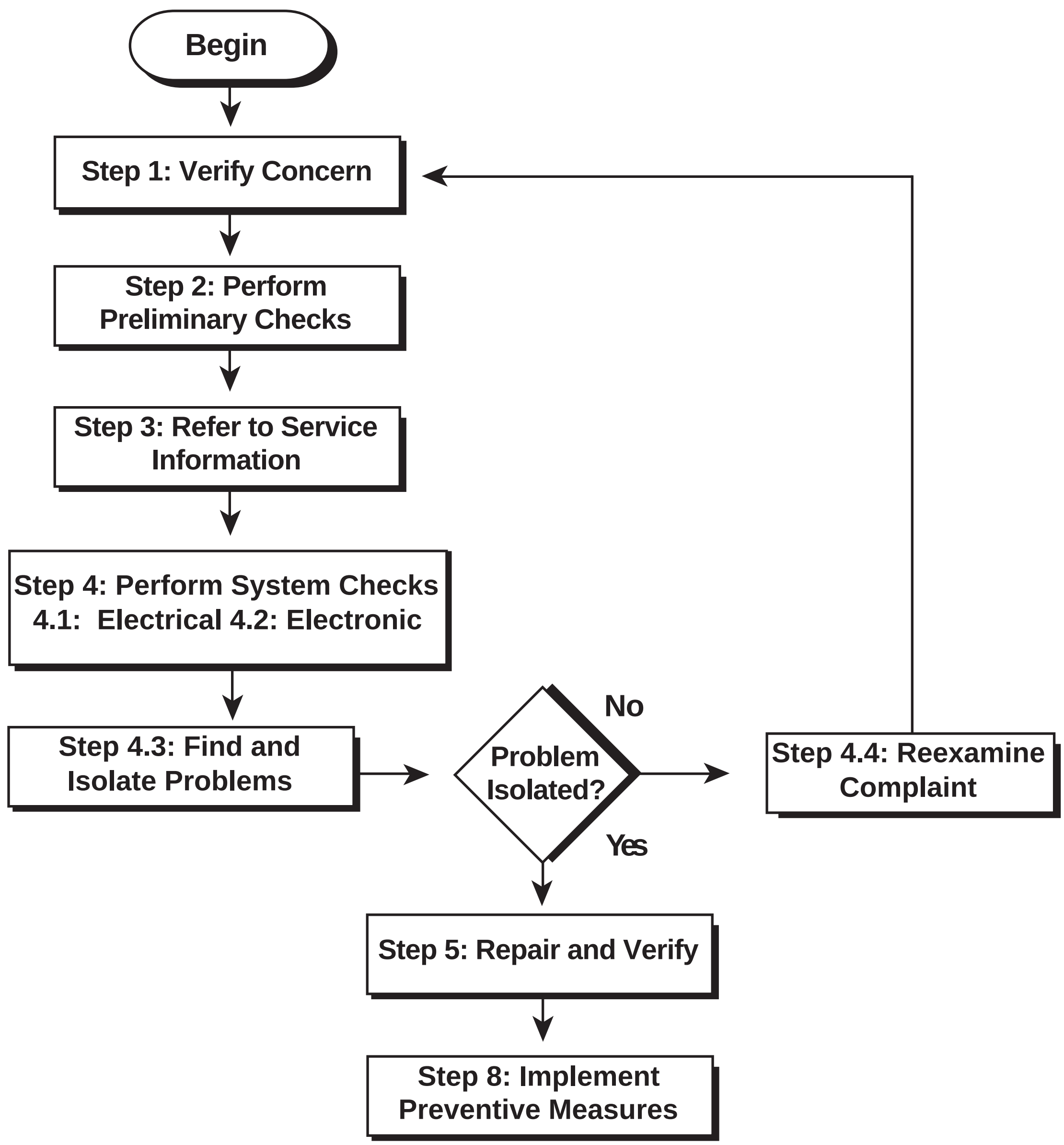
Be sure to confirm that the reference material is applicable to the specific problem or vehicle being diagnosed. Also, ensure information is current. OEM service information—specifically bulletins and newsletters—are very effective and may help shorten diagnosis.

Hands-on training may also be available from the vehicle manufacturer at dealer locations or onsite at the fleet.

4. Perform systems checks
Systems checks in the service manual provide a systematic approach to identifying the probable cause of a system fault. This step is important to properly define the correct approach for the repair and to avoid unneeded time consuming repairs. Additionally, systems checks will help to define what the problem is *not*. System checks may require the use of original equipment manufacturer (OEM) service tools and should isolate a particular component in the system as a probable cause.

4.1 Electrical diagnosis procedures (starting and charging systems)
Because electrical components of Class 2-6 vehicle starting and charging systems operate identically to the systems present on Class 7 and 8 vehicles, the following TMC Recommended Practices should be used for diagnostic procedures:
- RP 109A, "Battery Ratings and Engine Cranking Requirements."
- RP 129, " Heavy Duty Vehicle Systems Wiring Checks"
- RP 130, "Guidelines to Determine Requirements of Charging Systems"
- RP 132, "Battery Charging, Testing, and Handling."
- RP 133, "High CCA Battery Applications."

CHART 1: BASIC ELECTRICAL/ELECTRONIC DIAGNOSTIC PROCEDURE FLOWCHART



Other references for diagnosing starting and charging systems can be readily obtained from component, vehicle, and test equipment manufacturers.

4.2 Electronic diagnosis

The electronic system consists of vehicle components which are connected to or diagnosed by an Electronic Control Unit (ECU). Multiple ECUs may be present on the vehicle. To diagnose an electronic system properly, specialized test equipment approved by the electronic system manufacturer may be required. Failure to use the correct diagnostic tool may result in inaccurate or incomplete diagnosis or cause damage to the ECU.

4.3 Find and isolate problem

For an active problem the diagnosis should narrow the possible causes and eliminate unrelated possible causes. Find and isolate the part of the system or circuit with the problem into smaller pieces. For an inactive problem attempt to simulate/recreate the problem by reproducing conditions where the problem would exist, under controlled conditions. Monitor suspect circuits and components to pinpoint the probable cause while the problem is occurring.

4.4 Reexamine complaint

Review all information describing the complaint. When did the problem occur? What conditions are present when the symptom occurs. (e.g. engine temperature, weather conditions, driving conditions, etc.) Contact the customer/driver, if necessary, to gather more information or to arrange a "show me" or test drive interview.

For driveability concerns, monitor ECM values that are within the suspect subsystem for clues. Use the ECM values as a window to the problem area, but not necessarily to indict the ECM as the root problem.

5. Repair and verify

Once the suspect component is found—for an active problem—carefully disconnect the old component and inspect its connections to the harness. If the component connections are OK, temporarily connect a known good component, (without installing) to ensure the problem is corrected.

5.1 Verify the repair

After the problem is corrected with the known good component, reconnect the suspect component to make sure the problem returns. Temporarily connecting a known good component, and then reconnecting the suspect component will help reduce replacement of incorrect components. If reconnecting the suspect component does not cause the problem to recur, thoroughly inspect the connectors and harnessing for the cause of the problem. Reconnect the suspect component and move (jiggle) the harness while monitoring for the problem to return.

If the problem returns with the connection of the suspect component, permanently install the new component.

For components that are easily installed and removed, remove the suspect component and temporarily install it on a vehicle with a known good component to see if the problem follows the suspect component—instead of connecting the known good component in place of a suspect component. If the problem follows the suspect component, replace the component.

5.2 Clear fault codes.

Clear any codes stored in the ECU identifying the problem.

5.3 Implement any possible preventive measures.

Review the vehicle maintenance schedule for required service intervals and perform necessary maintenance. Check for other areas of apparent concern and notify customer/driver/fleet manager—or fix—prior to release of vehicle.

ELECTRICAL/ELECTRONIC INTERCONNECTIONS

A. Wiring Termination Techniques

Termination is the process of either ending a wire or attaching a device to be used at the end of a wire. Wiring terminations are made in a variety of ways. Wires can be terminated with butt splices, the application of a terminal, and by simply "tinning" or sealing the wire's end.

The primary considerations during a termination are mechanical strength, vibration resistance, electrical integrity, and environmental protection.

- *Mechanical strength*—Whenever a wire is terminated, the mechanical strength of the termination should meet or exceed the mechanical strength of the conductor without the termination.
- *Vibration Protection*—Always place conductors back in any holding device which they were in prior to the modification/repair or attach the conductors to the vehicle in a manner which will prevent the conductor from vibrating during operation.
- *Electrical Integrity*—The termination must be able to fulfill the electrical needs of the circuit (i.e. , current carrying capability, minimal voltage drop, etc.). Whenever a termination or splice is made in a conductor, an inherent voltage drop will be present. Special connectors are available to minimize the voltage drop, but these connectors normally are cost prohibitive. Terminations made carefully normally provide an acceptable voltage drop.
- *Environmental Protection*—Whenever a termination is made in a conductor which disturbs the integrity of the insulation on the conductor, measures must be taken to ensure that the termination is not susceptible to moisture damage or other damage which may result from the conductor or termination being exposed to its normal operating environment.

Additionally, consideration must be given to the type of insulating material being used to ensure that it has an acceptable heat range and is compatible with the intended environment.

For terminations which are made to a threaded stud which is exposed to salt spray or other corrosive environments, a suitable coating material should be applied to the connection to insure adequate service life.

Conventional Terminations
Conventional terminations are terminations made using commercially available terminals such as ring terminals, spade terminals, etc. Terminals of this type are available through many different outlets. Selection of good quality terminals is crucial to a dependable connection. The selection should include the considerations mentioned in "Termination Techniques." as well as specific considerations about the location of the termination on the vehicle (i.e., heat exposure, etc.).

Some fleets have established specific methods for making terminations. These methods were developed to ensure consistent terminations which will yield an acceptable service life. These recommendations should be followed when applicable.

Proprietary Terminations
Proprietary terminations are terminations made using proprietary terminals and connector bodies. These terminations are very common on commercial vehicles and come in a variety of configurations. Multiple connections in one connector body are typical. Also, various types of proprietary terminations on the same vehicle are common. When repairing or replacing these terminations, special techniques are needed. These techniques include tools, special assembly methods and many times, special training.

When servicing special connectors, use of OEM recommended tools is critical to making a good termination. Repair or replacement of these special terminations should not be attempted without the specific tools recommended. Manufacturers' service manuals and bulletins typically detail the techniques to be used for proper repair.

Butt Splices
A butt splice is any splice where wires are joined together "end-to-end." In this case, the wires may be either twisted together and soldered, or crimped together using a commercially available terminal. Butt splices should always be covered with insulation and a heat shrink tubing which has a meltable inner liner or another suitable protective insulation. The use of pressure sensitive tape is not recommended as the tape will likely deteriorate with time.

Conductor Terminations
Terminations of conductors are made to attach the conductor to another conductor or to a device on the vehicle. These terminations must be carefully made in order to provide acceptable serviceability. Attaching a wire to another wire (not using a butt splice) is an example of a conductor termination.

Terminations Without Terminals
Occasionally a wire is terminated without a terminal to facilitate the attachment of the wire to an accessory. If this situation is unavoidable, the wire should be "tinned" to prevent fraying and breakage at the point of connection. Using a heat shrink process at the end of the wire is also acceptable.

B. Grounding Recommendations
Grounding problems occur in a variety of ways (i.e., corrosion, inadequate current carrying capacity, etc.). As a result, grounding terminations should be coated with a suitable material to prevent corrosion as a result of exposure to salt spray or other corrosive environments.

Whenever an additional grounding point is to be established on the vehicle, the vehicle manufacturer should be consulted to ensure that the planned alteration does not result in an inadequate ground path for other components on the vehicle. This is especially important when establishing a grounding point between chassis and body.

C. Vehicle Repairs - Special Care
Many times vehicle repairs include various types of welding operations. All welding on a vehicle should be done using methods and techniques which are acceptable to the OEM in order to avoid damage to the electrical and electronic system of the vehicle. This damage normally occurs due to unwanted circuit paths or to voltage spikes created in the electrical and electronic systems which cause part failure.

Other damage may occur to vehicle systems as a result of heat generated during the welding process. Special care must be taken to ensure that heat buildup does not melt conductors and other susceptible electrical components.

Mechanical damage to wiring must also be avoided during repairs to other parts of the vehicle. Insulation cuts and "pinch points" are common problems which may cause vehicle failure.

Piercing of conductor insulation while troubleshooting electrical problems is a practice which should not be used. Piercing of the protective covering usually results in unwanted corrosion which can result in complete circuit failure. If piercing of the insulation is unavoidable, a suitable insulation must be used at the point where the conductor was pierced to avoid water entry.

D. Authorized Connecting Points

All vehicle connections must be researched to ensure that the OEM will authorize the connection. These types of connections may include the addition of special equipment or the rerouting of existing wiring to allow the addition of special equipment. A connection which is made without proper planning can result in circuit overloads, undesired circuits and consequently vehicle or component failure.

E. Parallel Circuits

When aftermarket equipment is added to a vehicle, research must be done to ensure that the connecting points chosen are safe. Many times a component is added to a connecting point without the technician knowing what other components are connected to the same point. This can result in undesirable parallel circuits which may cause component failure. An example of this situation would be a solenoid added to a circuit which happened to be connected in parallel to other inductive components. This action may cause an imbalance problem which could result in all of the components in the parallel circuits malfunctioning.

F. Communications Equipment

Communications equipment requires special knowledge, materials, and tools which are beyond the scope of this document.

G. Miscellaneous

The use of "star washers" in the electrical path is discouraged. Often, an open circuit or high resistance results when the "points" of the washer are exposed to salt spray and other corrosive materials. If the use of star washers cannot be avoided, a suitable protective material should be applied to the connections to insure as much protection from corrosion as is possible.

GLOSSARY

This section defines terminology which is applicable to this Recommended Practice.

A. Common Electrical Terms

Amperage (Amps, Current)—The unit of measurement for electrical current.

Alternator—An AC generator that produces alternating current which is internally rectified to DC current before being used.

Alternating Current (AC)—An electrical current that moves first in one direction and then in the other (positive to negative and then negative to positive).

Circuit—An electric circuit is the path of electric current. A closed circuit has a complete path. An open circuit has a broken or disconnected path.

Circuit, Series—A circuit which has only one path for the current to flow. Batteries arranged in series are connected with the negative of the first to the positive of the second, negative of second to the positive of the third, etc. This will create a voltage equal to the sum of the voltage of each battery.

Circuit, Parallel—A circuit which provides more that one path for current flow. Batteries arranged in parallel are connected negative to negative and positive to positive. Voltage will be the same as each battery but the capacity would be the sum of the total batteries.

Cold Cranking Amps Rating (CCA)—Rating of batteries defined as the number of amperes a battery at 0°F can deliver for 30 seconds and maintain at least 1.2 volts per cell.

Direct Current (DC)—An electrical current that flows in one direction only.

Fuse—A plug in protector with a filament that melts or "opens" when overloaded.

Fusible Link—A wire section with fewer strands of wire than the rest of the circuit. It melts or "opens" when overloaded.

Ground—In vehicular use, the result of attaching one battery cable (usually the negative) to the body or frame which is used as a path for completing a circuit instead of a direct wire from a component.

Hydrometer—An instrument with a float housed in a glass tube that measures the specific gravity of a liquid.

Load Tester—An instrument which draws current (discharges) from a battery using a variable resistance while measuring voltage. It determines the battery's ability to perform under actual load.

Ohm—A unit for measuring electrical resistance.

Ohm's Law—Expresses the relationship between volts (V or E), amps (I), in an electrical circuit with resistance (R). It can be expressed as: E=IR, I=E/R, or R=E/I. If any two values are known, the unknown value can be calculated using these equations.

Open Circuit Voltage—The voltage of a battery when it is not delivering or receiving power. It is 2.12 volts per cell for a fully charged battery.

Polarity—The condition of being polar. That is, either positive or negative.

Relay—An electromagnetic switching device using low current to open or close a high current circuit.

Reserve Capacity Rating—The time in minutes that the battery will deliver 25 amps at 80°F and maintain a voltage of 10.5 volts or more. The rating represents the time the battery will continue to operate essential accessories in a vehicle when not being charged by an alternator.

Resistance—The opposition to free flow of current in a circuit. This is measured in ohms.

Specific Gravity—The density of the battery electrolyte as compared to the density of water. This measurement is made with a hydrometer and will determine the sulfuric acid content of the electrolyte.

Short Circuit—An unintended contact in an electrical device or wiring, generally very low in resistance and thus allowing a large amount of current to flow.

Volt—The unit of measure for electrical potential.

Watt—The unit for measuring electrical power. Formula is Watts=Volts x Amps

B. Common Vehicle Test Measurements
(Check component manufacturer specifications to confirm proper measurements)

Battery State of Charge—The percentage of useable power left in the battery.

Battery Voltage Under Proper Load—The battery voltage while a battery tester provides a proper load (current draw). The proper current draw for a battery load test is determined by dividing the Cold Cranking Rating of the battery in half. Acceptable minimum voltages are based upon the ambient temperature of the battery which is being tested.

Line Voltage Drop (Voltage Drop)—The amount of voltage loss between two component parts such as the battery and the starter or the alternator and the battery at a specific current flow. Maximum voltage drop allowed in a circuit or system is defined by the manufacturers. Loss of voltage is due to high resistance and can be caused by bad ground connections, insufficient contact due to loose connections and corrosion, improper wire sizing, broken wires, etc.

Starter Draw—The amount of current, measured in amps, that flows from the battery to the starter during cranking. Normally, fuel systems or ignition systems are shut off during this test.

Charging Voltage—The amount of voltage produced by the alternator during recommended idle speed as measured at the battery(ies)

Alternator Maximum Amperage Output—The amount of current, measured in amps, that an alternator will produce while running at a sufficient engine speed to drive the generator to full output. This output is attained while the battery(ies) are being loaded with a carbon pile.

Ripple Voltage—The alternator produces alternating current (AC) and is rectified to the needed direct current (DC). Ripple voltage is described as the leakage of the instantaneous variations of alternating current to the direct current output due to AC peaks.

Resistance Measurement—The measurement in ohms of the amount of restriction of current flow between two points in a circuit.

C. Common Diagnostic Terms

ATA (American Trucking Associations) Data Link—A two-wire electrical connection for communication with other microprocessor-based devices that are compatible with the ATA and SAE Standards (J1587 and J1708) such as trip recorders, electronic dashboards, powertrain controls, and maintenance systems. The Data Link is also the serial communication medium used for programming and troubleshooting. See SAE J1587.

Active Diagnostic Code—Describes a condition that is currently present to alert the driver or service technician of an abnormal condition. Refer to Diagnostic Fault Code.

Actuator Harness—The wiring harness used to connect actuators to the engine.

Alligator Harness—An electrical test clip attached to the end of a wire.

American Wire Gauge (AWG)—A measure of the diameter (and therefore the current carrying ability) of electrical wire. The smaller the AWG number, the larger the wire.

Bypass Circuit—A circuit, usually temporary, to substitute for an existing circuit, typically for test purposes.

Calibration—As used here, is an electronic adjustment of a sensor signal.

Check Engine Lamp—Sometimes referred to as the Diagnostic Lamp or Service Engine Soon Lamp, it is used to alert the operator of the presence of an active event and is used to flash a diagnostic code.

Clutch Switch—Typically an adjustable limit switch mounted near the pedal used to prevent starter engagement and/or disengage cruise control.

Connector—A device that supplies electrical continuity between two points in one or more circuits.

Cruise Control Range—The range that the cruise control can operate within. Usually limited to the speed range anticipated on the open road. It is programmable using the Low Cruise and High Cruise Limits.

Customer Specified Parameter—A parameter value that can be changed and whose value is set by the customer. Protected by customer passwords.

Data Link—Serial communications used to communicate information between microprocessor based devices.

Diagnostic Connector—See TMC RP 1202.

Diagnostic Fault Code—Sometimes referred to as a "fault code". These codes indicate an electronic system malfunction or problem with the truck.

Diagnostic Flash Code—These codes, normally unique to components manufacturers, are flashed out to indicate an electronic system malfunction detected by the ECM/ECU.

Duty Cycle—Refer to Pulse Width Modulation.

(ECM) Electronic Control Module or (ECU) Electronic Control Unit—A computer used to control an electronic engine or transmission or other device. It receives input signals from sensors and provides outputs for control of external devices. Additionally the ECM or ECU is used to provide diagnostic information to the technician.

Electronically Controlled Unit Injector (Diesel)—The injection pump which is mechanically actuated, electronically controlled unit injector combining the pumping, electronic fuel metering and injecting elements in a single unit.

Engine Protection or Monitoring—A system that monitors various engine sensors to alert the operator of detected problems, the system may de-rate or shut down the engine when a problem is detected.

Failure Mode Identifier (FMI)—Type of failure the component experienced (adopted from SAE standard J1587 diagnostics).

(FMI)	Description
0	Data valid but above normal operational range
1	Data valid but below normal operational range
2	Data erratic, intermittent, or incorrect
3	Voltage above normal or shorted high
4	Voltage below normal or shorted low
5	Current below normal or open circuit
6	Current above normal or grounded circuit
7	Mechanical system not responding properly
8	Abnormal frequency, pulse width, or period
9	Abnormal update

10 Abnormal rate of change
11 Failure mode not identifiable
12 Defective device or component
13 Uncalibrated device or component
14 Reserved for future assignment
15 Reserved for future assignment

Fast Idle—Fast Idle RPM determines the preset Fast Idle engine rpm as controlled using the Fast Idle Enable Switch. Fast Idle operates similarly to cruise control, except it governs engine rpm with the vehicle stationary, or at low vehicle speeds.

Flash Programming—A way of programming or updating an ECM/ECU with an Electronic Service Tool over the data link instead of replacing components.

Gear Down Protection—Programmable High Gear Limits used to promote driving in higher gears for increased fuel economy.

Harness—The wiring bundle (loom) connecting all components of the Electronic System.

Hertz (Hz)—Measure of frequency in cycles per second.

Hydraulic Electronic Unit Injector (HEUI)—The injection pumping is hydraulically actuated, electronically controlled injector combining the pumping, fuel metering and injecting elements in a single unit.

Idle RPM Limit—Programmable parameter which indicates the maximum allowable engine rpm when an engine rpm is set using the Cruise Control On/Off switch and SET/RESUME switch.

Idle Shutdown Time—Programmable parameter which indicates time (in minutes) that the engine will idle before shutting down.

Idle/PTO Bump RPM—Programmable parameter indicating the amount which the engine RPM will be incremented/decremented when the Accel/Decel switches are briefly toggled.

Idle Validation Switch—Provides verification independent of accelerator pedal that the throttle pedal is on or off idle.

Injection Actuation Pressure Control Valve—This is an electronically controlled dump valve maintaining the high pressure for the high pressure oil manifold. The valve outputs controlled pressure depending on inputs from the ECM. The control valve regulates the high pressure oil to the injectors through the high pressure manifold to provide the actuation force to determine the injection pressure for the engine.

Injector Solenoid—The ECM uses the solenoid to control fuel metering and injection timing.

Inlet Air Heater—The Inlet Air Heater is used to improve the cold start capability of the engine and to reduce white smoke.

J1587 -J1708 ATA Datalink—A two-wire electrical connection for communication with other microprocessor based devices that are compatible with the ATA and SAE standards (J1587 and J1708) such as trip recorders, electronic dashboards, powertrain controls, and maintenance systems. The Data Link is also the serial communication medium used for programming and troubleshooting.

Logged Diagnostic Codes–Describes codes which are stored in memory. They are meant to be an indicator of possible causes for intermittent problems. Refer to Diagnostic Fault Code.

Open Circuit—Condition where an electrical wire or connection is broken or a switch is open, so that the signal or the supply voltage can no longer reach its intended destination.

Original Equipment Manufacturer (OEM)—Original manufacturer of a vehicle or component as installed on vehicle from factory.

Parameter Identifier (PID)—Two or three digit code which is assigned to each component to identify data via data link to ECM/ECU.

Progressive Shifting—Shifting up through the lower gears quickly by not using excessive engine rpm in each gear. Shifts are made above peak torque but below rated rpm. Using excessive engine (higher) rpm ranges before shifting to the next gear wastes fuel and fails to take advantage of the torque rise of the engine. Electronic engines can be programmed to promote this driving technique.

Pulse Width Modulation (PWM)—A signal consisting of variable width pulses at fixed intervals, whose ratio of “TIME ON” versus total “TIME OFF” can be varied (also referred to as “duty cycle”)

Return Line (wire)—A wire with a more or less constant voltage of 0 volts.

Sensor—A device used to detect and convert a change in pressure, temperature, or mechanical movement into an electrical signal.

- Ambient Air Pressure Sensor —measures the atmospheric or barometric pressure of the air surrounding the engine.
- Boost pressure sensor—measures the pressure of the turbocharged air in the intake manifold.
- Engine coolant temperature sensor —measures the temperature of the engine coolant.
- Engine Position/Speed Sensor — is a sensor that measures camshaft CPM, or crankshaft CKP position, direction of rotation and engine RPM.
- Engine oil pressure sensor —measures engine oil pressure.
- Injection Actuation Pressure Sensor—a sensor used to detect and convert mechanical oil pressure in the high pressure manifold to an electrical signal.
- Intake manifold Air Temperature Sensor —detects the engine intake manifold air temperature
- Oil temperature sensor —measures the temperature of the oil in the engine or transmission.
- Accelerator position sensor —senses the position of the accelerator pedal.
- Throttle position sensor —senses the position of accelerator or throttle pedal.
- Vehicle Speed Sensor —is an electromagnetic pickup that measures vehicle speed from the rotation of gear teeth in the drivetrain of the vehicle. Active pickup requires an external power supply and provides a conditioned electronic output signal. Passive sensor provides an unconditioned electrical signal without the need of an external power source.

Service Brake Switch—A switch tied to service brake pedal to disengage cruise control.

Service Engine Soon Lamp—Refer to Check Engine Lamp.

Signal Line (Wire)—A wire with a varying voltage (signal)

Supply Line (Wire)—A wire with a more or less constant voltage other than 0 volts. This is typically +5 or +12 volts.

Speed/Timing Sensor—A sensor that measures crankshaft position, direction of rotation and engine rpm and sends signal to ECM.

Standard SAE Diagnostic Communications Data Link—Refer to J1587.

Supply Voltage—A constant voltage supplied to a component to provide electrical power for its operation. It may be generated by an ECM/ECU, or it may be vehicle battery voltage supplied by the vehicle wiring.

"T" Harness—A test harness designed to connect into vehicle or engine harness which allows normal circuit operation while providing a breakout or "T" to measure signals.

Throttle Position—The ECM interpretation of the signal from the Throttle Position Sensor.

Trip Recorder—An after market device dedicated to recording vehicle and engine operating parameters during vehicle service. Used to analyze driving habits and produce driver logs.

Vehicle Speed Calibration—Programmable parameter used by the ECM to scale the vehicle speed signal into miles per hour (or kilometers per hour).

REFERENCES

- TMC RP 109A, "Battery Ratings and Engine Cranking Requirements."
- TMC RP 129, "Heavy Duty Vehicle System Wiring Checks"
- TMC RP 130, "Guidelines to Determine Requirements of Charging Systems"
- TMC RP 132, "Battery Charging, Testing, and Handling"
- TMC RP 133, "High CCA Battery Applications for Class 2 to 6 Commercial Vehicles"
- SAE J1930, "Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations and Acronyms" Sept. '91

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