9.1.3.2 With the engine shut off, the total continuous electrical load shall be activated and shall continue to be applied until the excessive battery discharge alarm activates.

9.1.3.3 The battery voltage shall be measured at the battery terminals.

9.1.3.4 The test shall be considered a failure if the alarm does not sound in less than 140 seconds after the voltage drops to 11.70 V for a 12 V nominal system, 23.4 V dc for a 24 V nominal system, or 35.1 V for a 42 V nominal system.

9.1.3.5 The battery system shall then be able to restart the engine.

9.1.3.6 Failure to restart the engine shall be considered a test failure.

9.2* Line Voltage Electrical Systems Test.

9.2.1 The wiring and associated equipment shall be tested by the ambulance manufacturer or the installer of the line voltage system.

9.2.3* The electrical polarity of all permanently wired equipment, cord reels, and receptacles shall be tested to verify that wiring connections have been properly made.

9.2.4 Electrical continuity shall be verified from the chassis or body to all line voltage electrical enclosures, light housings, motor housings, light poles, switch boxes, and receptacle ground connections that are accessible to personnel in normal operations.

9.2.5 If the ambulance is equipped with a transfer switch, it shall be tested to verify operation and that all nongrounded conductors are switched.

9.2.6 Electrical light towers, floodlights, motors, fixed appliances, and portable generators shall be operated at their full rating or capacity for 30 minutes to ensure proper operation.

9.2.7* Certification Test of Power Source.

9.2.7.1 The ambulance manufacturer or installer of the power source shall perform a certification test on each power source.

9.2.7.2 The testing of any power source greater than 3 KW shall be witnessed, and the results of the tests of the power source shall be certified by an independent third-party certification organization.

9.2.7.3 Test Procedure.

9.2.7.3.1 The prime mover shall be started from a cold start condition, and the unloaded voltage and frequency shall be recorded.

9.2.7.3.2 The line voltage electrical system shall be loaded to at least 100 percent of the continuous rated wattage stated on the power source specification label. Testing with a resistive load bank shall be permitted.

9.2.7.3.3 The power source shall be operated in the manner specified by the ambulance manufacturer as documented on instruction plates or in operation manuals.

9.2.7.3.4 The power source shall be operated at a minimum of 100 percent of the continuous rated wattage as stated on the power source specification label for a minimum of 2 hours.

9.2.7.3.4.1 The load shall be adjusted to maintain the output wattage at or above the continuous rated wattage during the entire 2-hour test.

9.2.7.3.4.2 The following conditions shall be recorded at least every ½ hour during the test:

(1) The power source output voltage, frequency, and amperes
(2) The prime mover's oil pressure, water temperature, and transmission temperature, if applicable
(3) The power source hydraulic fluid temperature, if applicable
(4) The ambient temperature and power source air inlet temperature

9.2.7.3.4.3 The following conditions shall be recorded once during the test for power sources driven by dedicated auxiliary internal combustion engines:

(1) Altitude
(2) Barometric pressure
(3) Relative humidity

9.2.7.3.5 If the generator is driven by the chassis engine and the generator allows for operation at variable speeds, the chassis engine speed shall be reduced to the lowest rpm allowed for generator operation and the voltage and frequency shall be recorded.

9.2.7.3.6 The load shall be removed, and the unloaded voltage and frequency shall be recorded.

9.2.7.3.7 Voltage shall be maintained within ±10 percent of the voltage stated on the power source specification label during the entire test.

9.2.7.3.8 Frequency shall be maintained within ±3 Hz of the frequency stated on the power source specification label during the entire test.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.4 It is not intended that this standard be applied retroactively to existing ambulances. However, if major renovations are made to an existing ambulance, it is suggested that the ambulance be brought into line with this standard as closely as possible.

A.1.6 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter, a unit that is outside of but recognized by SI, is commonly used in international fire protection. Table A.1.6(a) and Table A.1.6(b) provide U.S.-to-SI conversion factors and SI-to-U.S. conversion factors as an aid to the user. Table A.1.6(c) provides other conversion factors that could be useful to the reader. Table A.1.6(d) provides a list of the abbreviations used in this standard and their meanings.

Table A.1.6(a) Conversion Factors: U.S. Units to SI Units

U.S. Units		SI Units
1 gallon per minute (gpm)	=	3.785 liters per minute (L/min)
1 imperial gallon per minute (igpm)	=	4.546 liters per minute (L/min)
1 pound per square inch (psi)	=	6.895 kilopascals (kPa)
1 inch of mercury (in. Hg) at 60°F (15.6°C)	=	3.377 kilopascals (kPa)
1 inch (in.)	=	25.40 millimeters (mm)
1 foot (ft)	=	0.305 meter (m)
1 cubic foot (ft^3)	=	0.0283 cubic meter (m^3)
1 square inch ($in.^2$)	=	645.2 square millimeters (mm^2)
1 mile per hour (mph)	=	1.609 kilometers per hour (km/hr)
1 pound (lb)	=	0.454 kilogram (kg)
1 horsepower (hp)	=	0.746 kilowatt (kW)
1 candlepower (cp)	=	12.566 lumens
1 pound per cubic foot (lb/ft^3)	=	16 kilograms per cubic meter (kg/m^3)
1 footcandle (fc)	=	10.764 lux (lx)
1 footlambert	=	3.427 candela/m^2

Table A.1.6(b) Conversion Factors: SI Units to U.S. Units

SI Units		U.S. Units
1 liter per minute (L/min)		0.264 gallon per minute (gpm)
1 liter per minute (L/min)	=	0.22 imperial gallon per minute (igpm)
1 kilopascal (kPa)	=	0.145 pound per square inch (psi)
1 kilopascal (kPa)	=	0.2962 in. Hg at 60°F (15.6°C)
1 millimeter (mm)	=	0.0394 inch (in.)
1 meter (m)	=	3.281 feet (ft)
1 cubic meter (m^3)	=	35.31 cubic feet (ft^3)
1 square millimeter (mm^2)	=	0.00155 square inch ($in.^2$)
1 kilometer per hour (km/hr)	=	0.6214 mile per hour (mph)
1 kilogram (kg)	=	2.2 pounds (lb)
1 kilowatt (kW)	=	1.34 horsepower (hp)
1 lumen	=	0.08 candlepower (cp)
1 kilogram per cubic meter (kg/m^3)	=	0.062 pound per cubic foot (lb/ft^3)
1 lux (lx)	=	0.092 footcandle (fc)
1 candela/m^2	=	0.292 footlambert

Table A.1.6(c) Other Useful Conversion Factors

1 gallon per minute (gpm)	=	).833 imperial gallon per minute (igpm)

1 imperial gallon per minute (igpm)	=	1.2 gallons per minute (gpm)
1 foot (ft) of water	=	0.433 pound per square inch (psi)
1 pound per square inch (psi)	=	2.31 feet (ft) of water
1 metric ton (mton)	=	1000 kilograms (kg)
1 kilopascal (kPa)	=	0.01 bar
1 bar	=	100 kilopascals (kPa)

Table A.1.6(d) Abbreviations Used in This Standard

Abbreviation	Term
ac	alternating current
C	Celsius
cd	candela(s)
dc	direct current
EM SP	Emergency Medical Services Provider
F	Fahrenheit
fc	footcandle(s)
ft	foot (feet)
gpm	gallon(s) per minute
hp	horsepower
in.	inch(es)
in. Hg	inch(es) of mercury
kg	kilogram(s)
km/hr	kilometer(s) per hour
kPa	kilopascal(s)
kW	kilowatts(s)
L	liter(s)
L/m	liter(s) per minute
in	
lx	lux
m	meter(s)
mm	millimeter(s)
mph	mile(s) per hour
NH	National Hose
psi	pound(s) per square inch
rms	root mean square
V	volt(s)

A.2.3.17 Use of the **"STAR OF LIFE"** symbol must be in accordance with the purpose and use criteria set forth in published guidelines by the National Highway Traffic Safety Administration, an operating administration of the U.S. Department of Transportation.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do

their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Contractor. The contractor might not necessarily manufacture the fire apparatus or any portion of the fire apparatus but is responsible for the completion, delivery, and acceptance of the entire unit.

Electronic Siren. Varied types of warning sounds can be produced by electronic sirens, such as a wail, yelp, or simulated air horn.

GAWR (Gross Axle Weight Rating). It is a requirement of the National Highway Traffic Safety Administration (NHTSA) that the GAWR be posted in the vehicle on a permanently affixed label. The axle system includes, but is not limited to, the axle, tires, suspension, wheels, frame, brakes, and applied engine torque.

GCWR (Gross Combination Weight Rating). A combination vehicle is the combination of a towing vehicle and one or more towed units (trailers). When a trailer is detachable, the GCWR limits the maximum loaded weight for any replacement trailer. The in-service weight or gross combination weight, including any connected trailer, should always be equal to or less than the GCWR.

Grade. A 45-degree slope is equal to a 100-percent grade.

GVWR (Gross Vehicle Weight Rating). It is a requirement of the National Highway Traffic Safety Administration (NHTSA) that the GVWR of a vehicle be posted in the vehicle on a permanently affixed label. The GVWR can be equal to or less than the sum of the front GAWR and the rear GAWR. The in-service weight or gross vehicle weight should always be equal to or less than the GVWR.

Optical Source. An optical source can consist of a single optical element or a fixed array of any number of optical elements whose geometric positioning relative to each other is fixed by the manufacturer of the optical source and is not intended to be modified.

Substantially Similar Ambulance. It is not practical to test every production vehicle to validate performance compliance. The substantially similar definition allows those requirements that call for a test on a substantially similar ambulance to be performed once, rather than on every production vehicle.

Turning Clearance Radius. An aerial fire apparatus might have a larger overall clearance diameter if measured at the forwardmost point of the aerial device.

A.4.8.1 The engine compartment and the underside of the vehicle are not considered areas of normal nonmaintenance operation.

A.4.9.2 All required signs, instruction plates, and labels should be highly visible and placed on the vehicle where they are not subject to damage from wear and tear.

A.4.11.1 The attachment of electric, air, hydraulic, and other control lines and hoses should be with removable mechanically attached fastening devices. The attachment of such equipment with adhesive or glue-on clamps or clips has been found to be inadequate for long-term performance on ambulance. The use

of plastic ties to bundle wire harnesses and hose is permissible, but ties should not be used to attach such items to a cab, body, frame, or other major structure.

A.4.12.3 The interior of the ambulance patient compartment should be maintained at a minimum temperature of 50°F (10°C)when the ambulance is prepared for immediate response. The purchaser should consider how this will be accomplished. If the ambulance will not be housed in a heated facility, then other means may be required to ensure that this requirement is met. This requirement does not apply to ambulances that are fully operational but being held in reserve or ambulances that are not fully operational.

The ambulance and all systems, components and equipment shall be capable of being stored at 32° F to 95° F (0°C to 35°C) without damage or deterioration.

A.4.13.4 Although this standard recognizes the need for the ambulance to be able to accelerate to a high speed while traveling on public roads, caution should be taken with regard to how fast the ambulance can travel.

Where the ambulance has to operate off paved roads, all-wheel drive, a two-speed rear axle, an auxiliary transmission, an automatic transmission, or any combination of these might enhance the ambulance off-road capability.

A.4.16 It is important for the purchaser and the contractor to agree on the format in which the documentation is to be delivered. It is also important that the purchaser consider the long-term ramifications of changing media technology if electronic format is used for delivery of the documentation. Software and hardware will need to be maintained over the years to utilize electronic documentation.

A.4.16.2 It is critical that the purchaser provide the manufacturer the equipment inventory and mounting locations for equipment on the ambulance. This information should include existing equipment and estimated future equipment to be carried. The projections of total equipment payload and mounting locations are essential for proper engineering of a new ambulance. It is the responsibility of the purchaser to properly load the ambulance and place equipment to comply with the GVWR, the front-to-rear weight distribution, and the right-to-left load balance requirements of this standard.

A.4.17.2.3 Suppliers of components and equipment installed or supplied by the contractor often supply operations and maintenance documents with those components or equipment. This standard requires that the contractor deliver these documents to the purchaser. The purchaser should specify if multiple copies of these documents are required.

A.4.17.3.1 The label shown in Figure 4.17.3.1 is a suggested format. Deviations in dimensions are acceptable.

A.4.17.4.1 The form shown in Figure 4.17.4.1 is a suggested format. Deviations in dimensions are acceptable.

A.5.1.4.2 It is important for apparatus drivers to understand the height, length, and weight of the vehicle compared to their personally owned vehicles. It is also important that this information be accurate. Because the height of the apparatus could change after delivery, depending on what equipment might be added, the department must note such changes on the plate. Suggested wording for the plate is shown in Figure A.5.1.4.2.

PLEASE ADD FIGURE FROM 1906 DRAFT 1906:A.5.1.5.1

A.5.2 Weight Distribution Measurement and Calculation Methods Payload Determination

Subtract the total curb weight of the completed vehicle from the GVWR. Any permanently attached, optional items of equipment specified by the customer are to be included in the curb weight of the completed vehicle. Any other items of optional equipment (i.e., not permanently attached and/or removable) are to be included in the payload requirement.

A.5.2.2 The projections of total equipment payload and mounting locations are essential for proper engineering of a new ambulance. The purchaser of the ambulance should maintain the side-to-side loading requirement in 5.2.2 as equipment is loaded or installed on the ambulance.

The percentage difference in side-to-side tire load should be calculated as shown in the following formula:

$$\frac{(\text{Heavier weight} - \text{Lighter weight})}{\text{Total weight}} \times 100 = \text{Percent difference}$$

A.5.4.1 An increase in engine speed provides increased alternator output, increased engine cooling, increased air conditioner output, and increased output or performance from other devices that derive their power from the chassis engine.

A.5.5.1 Where local environmental extremes exist — that is, high humidity and temperatures or extreme low temperatures — the purchaser should state specifically under what environmental conditions the ambulance is expected to operate.

A.5.7.3 Purchasers of ambulances with a GVWR less than 36,000 lb (16,300 kg) should also consider equipping the ambulance with an auxiliary braking system. Ambulances commonly make repeated stops from high speeds that cause rapid brake lining wear and brake fade, sometimes leading to accidents.

Auxiliary braking systems are recommended on ambulances that are exposed regularly to steep or long grades, operate in congested areas where repeated stops are normal, or respond to a high number of emergencies.

Examples of auxiliary braking systems include engine retarders, transmission retarders, exhaust retarders, and driveline retarders. These devices have various levels of effectiveness on braking. In addition, the systems can be activated by various means and settings, both automatic and manual in operation. The purchaser should carefully evaluate all auxiliary braking systems based on vehicle weight, terrain, duty cycle, and many other factors.

Some auxiliary braking devices should be disconnected when the apparatus is operated on slippery surfaces. Follow the auxiliary braking device manufacturer's recommendations for proper instructions.

A.5.8.1 The angle of approach or departure affects the road clearance of the vehicle going over short steep grades such as would be found in a driveway entrance, crossing a high crowned road at a right angle, or off-road service. Too low an angle of approach or departure will result in the vehicle scraping the ground. Figure A.5.8.1 shows the method of determining the angle of departure. The angle of approach (front of vehicle) is measured in the same fashion.

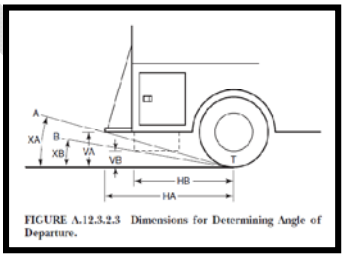


FIGURE A.12.3.2.3 Dimensions for Determining Angle of Departure.

STAFF – Please Use this Figure from NFPA 1901 but delete the diagonal line that extends from the rear bumper up to the body. This will be a fine representation of an ambulance.

In Figure A.5.8.1, the line AT represents the circumstance in which the rear bumper is the determining lowest point. The line BT represents a circumstance in which the rear bumper is not the lowest point (in this case, the lowest point is a fuel tank). The angle of departure is shown as XA or XB. To determine the angle of departure, place a thin steel strip against the rear of the tires where they touch the ground or stretch a string tight from one rear tire to the other at the rear of where they touch the ground. Determine the lowest point (the bumper, fuel tank, or other equipment or component) that would make the smallest angle of departure. Hang a plumb bob from the lowest point and mark the point on the ground where the point of the plumb bob touches. Measure the vertical distance from the ground to the point where the plumb bob was hung (distance V). Measure the horizontal distance from the plumb bob point to the front of the steel

strip or to the string running from rear tire to rear tire (distance H). Divide the vertical distance (V) by the horizontal distance (H). The ratio of V/H is the tangent of the angle of departure. If this ratio is known, the angle of departure can be determined from a table of trigonometric functions of angles or from a math calculator.

A.5.8.2 Traction control features may include positive locking differential, limited slip differential, electronic traction control, etc…

A.5.9.6 Proper tire inflation is essential to the safe operation of any motor vehicle. Proper inflation improves the handling characteristics and minimizes the risk of rollover.

A.5.10 *Electronic Stability Control (ESC)* uses a steering wheel position sensor, a vehicle yaw sensor, a lateral accelerometer, and individual wheel brake controls in conjunction with the antilock brake system (ABS). The system tracks the direction that the driver intends to steer and uses brake application at individual wheels to help straighten out the vehicle. While the design and features of the vehicle are important to safe driving, the most important aspect of crash prevention is the skill and experience of the operator. The operator's attitude, training, experience, qualifications, and the application of those qualities are the most important elements in crash prevention. The operator must ensure that the physical limits of the vehicle are not exceeded. Driver skill is developed only through training and practice.

A.5.11.1 The purchaser may wish to specify front and/or rear tow hooks or tow eyes be attached to the frame structure to allow towing (not lifting) of the ambulance without damage.

A.5.14 Purchasers may wish to consider specifying that all mirror head faces be independently adjustable from the driver's position when this feature is available from the OEM.

A.6.11.5 The intent of step size and placement requirements is to ensure that the foot is supported when it is placed on the step in the normal climbing position. In some cases the most natural method of mounting a step may not be perpendicular to the leading edge (common on chassis where it would be natural not to open the door completely to the 90 degree point and enter the door opening at a diagonal from the rear). In these cases the clearance measurement can be taken diagonally across the step in the natural direction of climb.

A.6.17 MEASURING GUIDELINES: CABINETS & COMPARTMENTS [Consider making this a separate annex. The amount of info and level of detail would be best suited as an annex]

Cabinet Depth: The dimension from the cabinet inside back wall to the outside cabinet face.

Compartment Depth: The dimension from the compartment inside back wall to the outside compartment face.

Door OD: The door overall outside thickness (dimension).

Depth ID: The actual interior depth ether measured or figured by subtracting the Door OD from the cabinet or compartment measured depth.

Height ID: The dimension from the interior bottom surface to the interior surface of the cabinet or compartment top.

Width ID: The dimension from one interior surface to the next interior surface of the cabinet or compartment.

Sliding Window Track: The track used for sliding cabinet windows.

Sliding Cabinet Windows: The sliding doors used on interior cabinets.

Interior cabinet with sliding doors or roll-up doors (Figure 1).

a. Measuring from the back of the rear wall to the back of the sliding window track, record that dimension for Depth ID.

b. Measuring from cabinet interior wall to wall, record that dimension for Width ID.

c. Measuring from the interior top to bottom, record dimension. This is the Height ID.

d. Multiply Height ID x Width ID x Depth ID = then divide by 1,728 to get cubic feet.

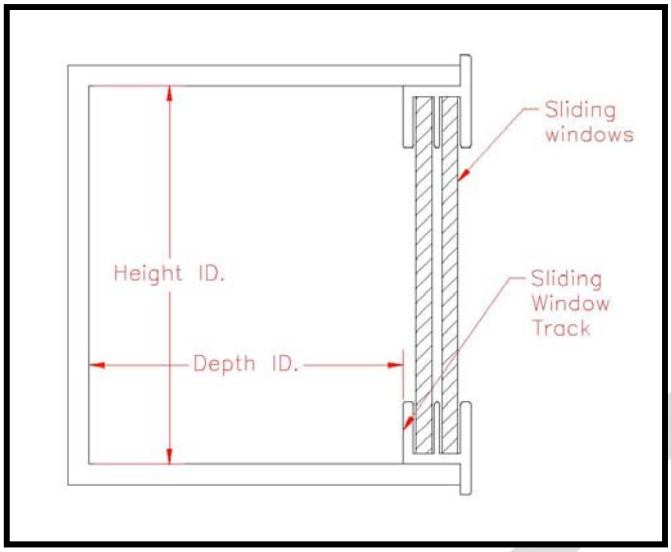


Figure 1

Interior cabinets with hinged doors (Figure 2).

a. Measure from the back of the door to the face of the door and record that dimension for Door OD.

b. Measure from the back of the rear wall to the cabinet face and record that dimension for cabinet depth.

c. Subtract the Door OD from the cabinet depth to get Depth ID.

d. Measure from cabinet interior wall to wall and record that dimension for Width ID.

e. Measure from the interior top to bottom and record dimension. This is the Height ID.

f. Multiply Height ID x Width ID x Depth ID = then divide by 1,728 to get cubic feet.

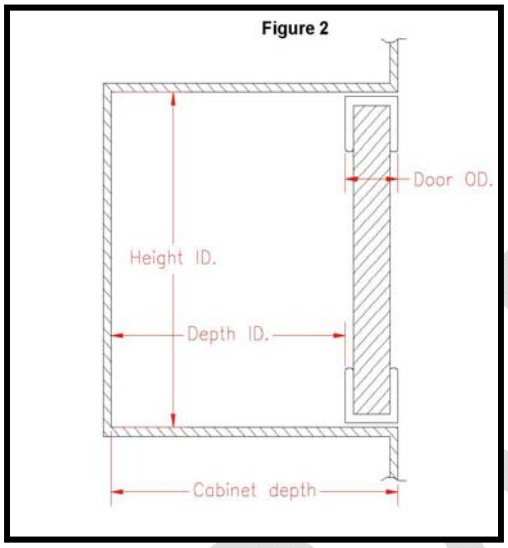


Figure 2

Exterior Compartments with hinged doors (Figure 3).

a. Measure from the back of the door to the face of the door and record that dimension for Door OD.

b. Measure from the back of the rear wall to the cabinet face and record that dimension for cabinet depth.

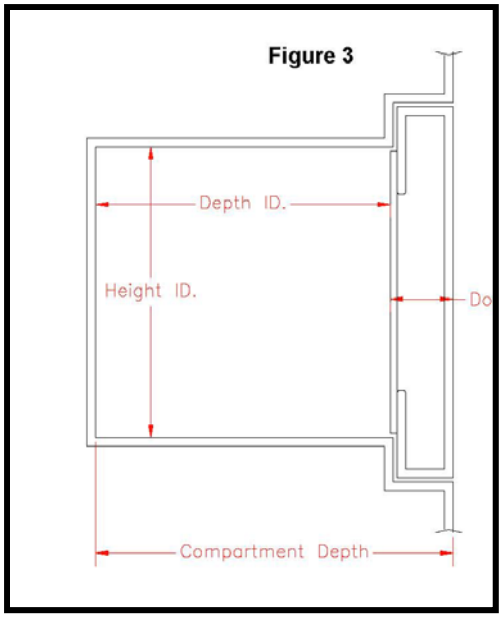
c. Subtract the Door OD from the cabinet depth to get Depth ID.

d. Measure from cabinet interior wall to wall and record that dimension for Width ID.

e. Measure from the interior top to bottom and record dimension this is the Height ID.

f. Multiply Height ID x Width ID x Depth ID = then divide by 1,728 to get cubic feet.

NOTE: Subtract any notches for spring shackles or fuel systems from the total to get the correct total cubic feet.



A.6.24.2 It is not recommended that SCBA packs be stored in the patient compartment because of the risk of contamination. If the purchaser does specify SCBA storage in seat backs, then they should meet the requirements found in NFPA 1901.

A.6.24.3.1 Purchasers may wish to consider specifying seat belt colors such as bright red or bright orange. Bright belt colors are easier to see on drive-cam videos or by observation through the window when enforcing seat belt use compliance.

FMVSS 210 S4.3.1.1 requires that the lap portion of the belt in any Designated Seating Position does not constrain the occupant high across the belly.

FMVSS 210-S5.1 requires that seat belt anchorages for side facing seatbelt assembly shall withstand a minimum of 1134 kg (2,500 lbs.) force.

A.6.29 The purchaser should specify whether the striping required under this standard will be provided by the manufacturer on delivery of the apparatus or will be installed by the purchaser or its designee following delivery. In any event, the required striping must be installed before the unit is placed in emergency service.

A.6.29.1 If the purchaser specifies exterior doors, consideration should be given to affixing the stripe of reflective material in a location that will not be obscured or lost when the doors are open.

A.7.1 This chapter defines the requirements for alternators, batteries, load management, and instrumentation to detect incipient electrical system failure. The intent is to require an electrical system that will operate the ambulance using power supplied by the alternator, shed nonessential electrical loads where necessary, and provide early warning of electrical failure in time to permit corrective action.

A.7.2.1.1 The 125 percent requirement for wiring and circuits is intended to provide reduced voltage drop over wire rated based on ampacity due to heating. In low voltage wiring, voltage drop becomes a problem before the thermal limit of current carrying capacity of a wire is reached. This requirement also ensures that the circuit protection will prevent damage to the wire in the event of a short or an overload. It is not the intent of this requirement to have the final-stage manufacturer replace the chassis manufacturer's original equipment wiring to meet the 125 percent requirement. It is also not the intent of this requirement to have electrical accessories purchased by the ambulance manufacturer rewired to meet the 125 percent requirement. Electrical device manufacturer–supplied wiring can be used to the point where it connects to the ambulance manufacturer's installed wiring.

A.7.2.2.9 It is the intent of 7.2.2.9 to provide a unique means of identifying a wire or circuit to prevent confusing it with another wire or circuit if electrical system repairs become necessary. If a color coding

scheme is used instead of some other unique identification, that color should not be reused for a wire in any unrelated circuits within the same harness. However, 7.2.2.9 covers low voltage wiring only and does not apply to shielded cables commonly used for communication purposes or wiring used in line voltage circuits.

A.7.3.2 The minimum alternator size is developed using the loads required to meet the minimum continuous electrical load. Most ambulance will actually have loads exceeding the minimum requirements of this standard. The purchaser should review the maximum current output of the alternator versus the load study supplied for the ambulance from the manufacturer for on-scene and responding modes.

A.7.4.1(10) The purchaser should analyze the electrical loads that need to be maintained to fulfill the mission of the ambulance and define those loads for the manufacturer of the ambulance. The purchaser needs to understand, however, that there is a limit to the output capacity of an alternator system on the ambulance's engine and that this standard requires that the ambulance be capable of maintaining the minimum continuous electrical load under the conditions defined in 7.3.2. When that load is exceeded and larger alternators are not available, the purchaser and the manufacturer need to work together to determine how to reduce the minimum continuous electrical load to that which can be sustained under the conditions defined in 7.3.2.

A.7.4.3 The unexpected shutdown of an ambulance during a response can place patients in mortal danger and seriously affect the life saving ability of the crew. With computer-controlled engines and transmissions as well as other controls, an electrical system failure could result in an immediate and total shutdown of the ambulance. The low voltage monitoring system is intended to provide an early warning of an impending electrical failure and provide enough time to permit operator intervention.

A.7.5.1 Electrical loads on ambulances frequently exceed the alternator capacity. Exceeding alternator capacity will result in the deep discharge of the ambulance batteries. Automatic load management is intended to protect the batteries and electrical system from needless damage while maintaining the operation of essential devices.

It is important that the priority of all managed loads be specified by the purchaser so that, as electrical loads are disconnected from the ambulance's electrical systems, they are shed in an order least likely to affect emergency operations. Optical warning devices in excess of the minimum required in this standard can and should be load managed.

A.7.6 Batteries usually have two ratings: "cold cranking amperes," which determine the size engine that can be started, and "reserve capacity," which provides a measure of the total power that can be provided at a much lower constant rate of discharge. Ambulance batteries should be sized to have enough cold cranking amperage and reserve capacity to restart the engine after being substantially discharged.

A.7.6.3.3 Overheating of a battery will cause rapid deterioration and early failure; evaporation of the water in the battery electrolyte can also be expected.

A.7.6.5 The power cord from the onboard charger or battery conditioner should be plugged only into a receptacle protected by a ground-fault circuit interrupter (GFCI) at the shoreline origination point.

A.7.6.7. The purchaser might want to add an illuminated "Module Disconnect" switch which could control all electrical loads for the module. The illuminated switch could control a solenoid. If the switch is specified it should be located in the driver's compartment, be legibly marked, illuminated when "ON," and rated to carry at least 125 percent of the circuit's maximum current, unless it operates a solenoid. If the switch operates a solenoid then the solenoid should be rated for 125 percent of the circuit's maximum current. The module disconnect switch or device shall be different in feel from other switches, or be physically isolated from them.

A.7.8 SAE J551/1 provides test procedures and recommended levels to assist engineers in the control of broadband electromagnetic radiation and in the control of radio interference resulting from equipment installed on the ambulance Adherence to the recommended levels will minimize the degradation effects of potential interference sources in the communication equipment or other devices susceptible to electromagnetic interference.

Procedures are included to measure the radiation from a single device or the entire ambulance. Compliance could be determined through actual tests on the completed ambulance or predictions based on tests previously conducted on similarly equipped apparatus. If compliance certification is required, it should be so indicated in the ambulance specifications.

A.7.9.1 The upper-level optical warning devices provide warning at a distance from the ambulance and the lower-level optical warning devices provide warning in close proximity to the apparatus. *(See Figure A.7.9.1.)*

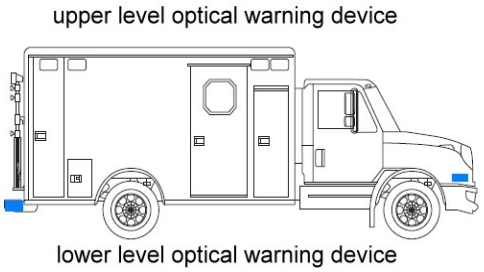


FIGURE A.7.9.1 Upper- and Lower-Level Optical Warning Devices.

We need to change this figure to an ambulance

A.7.9.7.3 Under typical conditions, the specified optical warning system provides effective, balanced warning. In some situations, however, the safety of the ambulance can be increased by turning off some warning devices. For example, if other vehicles need to pass within close proximity to the parked ambulance, the possibility of distracting other drivers can be reduced if the headlights and lower-level warning lights are turned off. In snow or fog, it might be desirable to turn off forward-facing strobes or oscillating lights to reduce visual disorientation of the ambulance driver.

The intent of the warning light system is to provide full coverage signals through the operation of a single master switch when the ambulance is either responding or blocking the right-of-way. There is no intent to prevent the use of lower levels of warning when the ambulance driver believes such reductions are appropriate, given the vehicle's mission, the weather, or other operational factors. Additional switches downstream of the master switch can be specified by the purchaser to control individual devices or groups of devices.

Purchasers might want to specify traffic flow–type lighting such as amber directional indicators for use in alerting approaching motorists of blocked or partially blocked highways.

A.7.9.10 When a component such as a flasher or power supply is used to operate more than one optical source, the optical sources should be connected so that the failure of this component does not create a measurement point without a warning signal at any point in any zone on either the upper or lower level. Although a single optical source can be used to provide warning signals into more than one zone, the possibility of a total signal failure at a measurement point is increased when the same flasher or power supply is used to operate multiple optical sources, each providing signals into more than one zone.

A.7.9.12 Flashing headlights are used in many areas as warning lights and provide an inexpensive way to obtain additional warning to the front of the ambulance. Daylight flashing of the high beam filaments is very effective and is generally considered safe. Nighttime flashing could affect the vision of oncoming drivers as well as make driving the ambulance more difficult.

In some jurisdictions, headlight flashing is prohibited or limited to certain types of emergency vehicles. If flashing headlights are employed on ambulance, they are to be turned off when the ambulance headlights are on. They should also be turned off along with all other white warning lights when the apparatus is in the blocking mode.

Steady burning headlights are not considered warning lights and can be illuminated in the blocking mode to light the area in front of the ambulance. Consideration should be given, however, to avoid shining lights into the eyes of oncoming drivers.

A.7.9.13 The minimum optical warning system should require no more than an average of 40 A for the operation of the upper-level and lower-level devices in the blocking mode. On ambulance whose length requires midship lights, no more than 5 A of additional current should be required for the operation of each set of midship lights. Optical warning systems drawing more than 40 A might necessitate modification of the electrical system specified in Section 7.3 in order to supply the additional power required.

See Figure A.7.9.13(a) and Figure A.7.9.13(b) for illustrations of an optical warning system on a large fire apparatus.

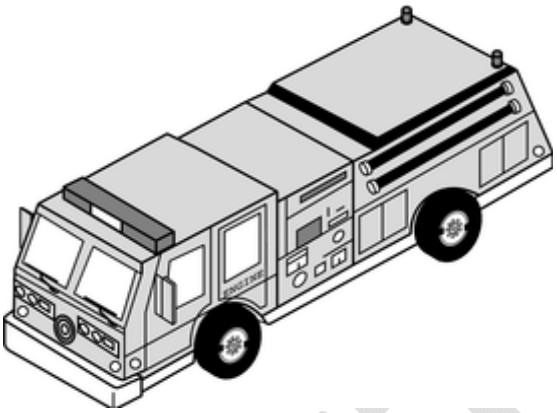


FIGURE A.7.9.13(a) Front and Left Side of an Apparatus with an Optical Warning System.

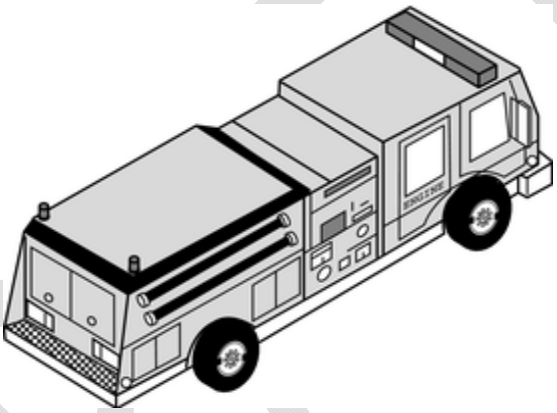


FIGURE A.7.9.13(b) Rear and Right Side of an Apparatus with an Optical Warning System.

Larry please change diagrams to ambulances

A.7.9.13.5 The zone totals reflect the combined performance of the individual optical warning devices oriented as intended on the ambulance when viewed along the perimeter of a circle of 100 ft (30.5 m) radius from the geometric center of the ambulance

The zone total is the sum of the optical power of all optical sources projecting signals of permissible color into the zone as measured at 5 degree increments along the horizontal plane passing through the optical center *H* throughout the 90 degrees included in the zone (19 data points). The calculation of zone totals assumes that all optical sources are mounted at the geometric center of the ambulance. With the optical center of each optical source oriented as installed, the optical power contributed by every optical source at a given point is taken from the test report, and they are added together to determine the total optical power at that point. The zone total is the sum of the optical power at the 19 measurement points in the zone. The upper- and lower-level optical sources are calculated independently.

The engineering basis of Section 7.9 permits both the design and the certification of an optical warning system by mathematical combination of the individual test reports for any number of optical warning devices of different color, flash rate, optical source, and manufacturer.

Using the test reports provided by the device manufacturer, the contribution of optical energy from each optical source is determined for every data point. The total candela-seconds per minute of optical energy is determined at each point, and then the zone totals are calculated and compared to Table 7.9.13.5.

A.7.9.14 The minimum optical warning system should require no more than an average of 35 A for the operation of the devices in the blocking mode.

A.7.9.16 In a few cases, a manufacturer might wish to type certify by actual measurement of the optical warning system on an ambulance.

Certification of the actual measurement of the performance of the optical warning system is made with each optical source either mounted on the ambulance or on a frame duplicating the mounting of the device on the ambulance. The performance of the system can be directly measured along the perimeter of a circle with a 100 ft (30.5 m) radius from the geometric center of the ambulance. Each optical warning device used should be certified by its manufacturer as conforming to all the requirements of this standard pertaining to mechanical and environmental testing. Photometric testing of the system should be performed by qualified personnel in a laboratory for such optical measurements.

The test voltages and other details should be as called for in this standard for the photometric testing of individual optical warning devices. The elevation of the photometer, however, could be set at the elevation that maximizes the performance of the upper-level devices and at a second, different elevation that maximizes the performance of the lower-level devices.

With the optical center of each device oriented as installed, the sum of the actual value of the optical power contributed by every optical source is then determined at each measurement point. The zone total is the sum of the optical power at the 19 measurement points in the zone.

Measurements are made to determine all the optical requirements of this standard, including the optical power at each of the required measurement points, the zone totals at the horizontal plane passing through the optical center, and the zone totals at 5 degrees above and 5 degrees below the horizontal plane passing through the optical center. Any upper-level warning devices mounted above the maximum height specified by the manufacturer(s) should be tested to demonstrate that at 4 ft (1.2 m) above level ground and 100 ft (30.5 m) from the mounted device, the optical energy exceeds 50 percent of the minimum required at the horizontal plane passing through the optical center.

A.7.10.1.2 If the purchaser wishes to have the siren controls within convenient reach of persons riding in both the right and left front seat positions, that should be specified. In some ambulance's, multiple control switches might be necessary to achieve convenient reach from the two positions. If other signal devices, such as an additional siren, bell, air horn(s), or buzzer are desired, the type of device and its control location also should be specified.

A.7.11.6.1 The user may want to consider a map light or additional task lighting in the cab

A.7.1.6.3 The purchaser might want to add "checkout lights" which may be controlled by a timer or switch wired directly to the batteries. These "checkout" lights are usually fluorescent lights wired to the line voltage shoreline and may be wired so that the ambulance ignition or battery switch need not be turned on.

A.7.11.6.2.4 .2 The purchaser should consider light color temperatures when specifying interior lighting. Different temperature lights could effect the operation and diagnoses of patients. A temperature closer to daylight would give the best results, but might not be feasible with the available lights. A good range seems to be between 2500 and 4500 Kelvin, see Figure A.7.11.6.2.4.2 below.

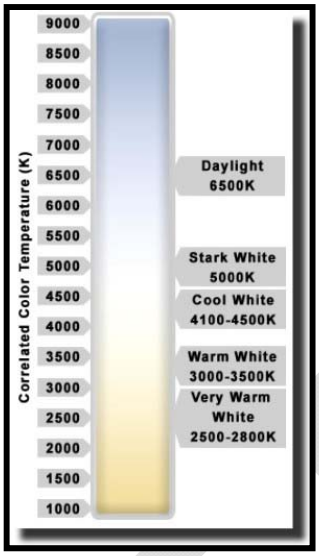


Figure A.7.11.6.2.4.2 Light Color Tempurature Scale.

A7.12.1 Electronic displays that are visible in all ambient light, that projects narrative information may be used in lieu of discrete, colored, indicator/ warning lights provided the projected message is at least as visible as the basic required warning light.

A.7.13 The purchaser might wish to add camera(s) at the sides or rear of a vehicle with cab monitoring screens or automatic vehicle-stopping devices that sense an obstruction at the rear of the vehicle. In addition, angled backup lights mounted in the wheel well areas will provide additional scene lighting for personnel who might be at the side of the vehicle or lighting of folding tanks or other obstacles on the side of the ambulance. Any such devices will improve safety while vehicles are backing.

A 7.15.2 The purchaser should specify the appropriate features to accommodate their communication equipment, including but not limited to metal ground planes, grounding, coaxial cable and antenna placement

A.8.2.2.1 The purchaser should specify the location on the apparatus for the power Inlet. Consideration should be given to placement of the power inlet so that it disconnects if the apparatus is moved forward or an auto-eject device may be utilized. The shoreline and circuit breaker should be sized for the anticipated electrical load.

A.8.2.5.3 Portable line voltage electrical equipment added by the ambulance service should also be listed and utilized only in accordance with the manufacturer's instructions.

A.8.2.6.4 Although a splash shield will lessen the amount of road spray that reaches the generator, it will not protect the generator if the ambulance is driven through deep water. Care should also be taken if the ambulance is driven off-road, because a splash shield is not a skid pan and will not protect the generator from physical abuse.

A.8.3.1 It is important that all metal parts of the ambulance and the electrical system be bonded to the vehicle chassis. Any electrical boxes, conduits, or fixtures that are not permanently mounted to the metal body should be bonded to the protective ground wire. It is especially important that the metal light fixtures or housings of pole lights, light towers, and portable lights be grounded through the protective ground wire. *NFPA 70, National Electrical Code*, requires the following:

The normally non–current-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are connected to the generator frame. [***70*:**250.34(A)(2), 250.34(B)(3)]

Use of a ground rod on ambulance is not recommended. If one is used, the requirements of *NFPA 70*, Article 250, should be followed. These requirements are difficult to achieve in a portable application.

Supplying a building electrical system from an ambulance is not recommended, because it commits the ambulance to the task and requires a significantly different grounding scheme, at least while being used for this application, in accordance with *NFPA 70*, 250.20, "Alternating-Current Systems to Be Grounded"; 250.30, "Grounding Separately Derived Alternating-Current Systems"; and other applicable sections of *NFPA 70*. In this situation, the grounding allowed by 250.34 is no longer applicable.

A.8.3.1.4 This refers to the protective ground (green wire), not the "neutral" wire. The ground is the chassis/body of the vehicle, not a connection to an earth ground.

A.8.4 Ground fault circuit interrupters (GFCIs) are intended to provide protection from electrical shock, but experience in the emergency services has pointed out several considerations about using them:

(1) GFCIs integrated into outlets or circuit breakers or as stand-alone devices may be used.

(2) Where possible, GFCIs should be located at the end of cords (i.e., in the distribution box at the end of a cord reel) to reduce tripping associated with long cord lengths and to put the reset function closer to the user.

(3) GFCIs might not be compatible with 120/240 volt 4-wire cord reels frequently used in emergency services unless the GFCI is located at the end of the cord.

(4) Many plugs and receptacles used in the emergency services are twist lock instead of standard nonlocking household plugs and receptacles, and in these cases, the GFCIs integrated with an outlet cannot be used, requiring circuit breaker GFCIs or standalone GFCIs.

A.8.5.4.1 The 120°F (49°C) requirement is for air inlet temperature to the power source. The completed ambulance is required to operate at an ambient temperature of 110°F (43°C). This difference of only 10°F (6°C) is difficult to achieve due to heat produced by the ambulance. The installer should take this temperature into consideration in selecting a location for the power source. If the ambulance is intended to operate at high temperatures, the purchaser may want to specify a larger nameplate rating on the generator and derate it to allow for a higher temperature capability. Consult with the power source manufacturer for more information on extended temperature range operation. In the testing required in Chapter 9.9 the ambient and air inlet temperatures are recorded, giving a measure of the temperature difference in actual operation.

The following factors could be relevant to power source testing, depending on the type of power source:

(1) *Sampling.* The selection of test unit(s) should be representative of the construction and settings for units that will be supplied to the ambulance manufacturer. The standard does not require that all production units be tested; however, the power source manufacturer should test as needed to maintain confidence in its declaration of the continuous duty rating for all production.

(2) *Clearances, cooling, and ventilation.* Testing should be conducted at the worst-case clearance (usually minimum clearance or minimum compartment size) and worst-case ventilation conditions (minimum inlet/outlet dimensions and maximum inlet/outlet restrictions) specified in the literature. If not in the literature, the power source manufacturer's declaration should indicate the clearances, compartment size, and ventilation that are applicable to the declared continuous duty rating.

(3) *Test duration.* "Continuous" ratings are usually established by tests run until thermal stabilization is achieved. A minimum test of 2 hours, matching the in ambulance test duration indicated in 9.9, is recommended.

(4) *Air inlet temperature.* Power sources should be tested in a chamber or room where the air temperature supplied to all inlet ducts (radiators, engine induction, windings, heat sinks, etc.), and the air surrounding the test unit, is maintained at 120°F (49°C).

(5) *Barometric pressure.* Pressure (air density) varies with changes in altitude and weather. Its effect is generally greatest on engines, where it affects combustion and cooling efficiency. There is a lesser effect on wound machines due to cooling only. To show compliance with the 2,000 ft (600 m) requirement, a test in a chamber simulating 2,000 ft (600 m) would be ideal, but it is not expected. Alternatively, connecting more or less than the rated load can be used to simulate/demonstrate that the

engine is capable of the power required for rated output at 2,000 ft (600 m). (Several standards organizations, such as SAE and ISO, have standards that describe how to compute load/output correction factors for barometric pressure.)

(6) *Fuel temperature.* Fuel supply for the test should be stabilized at 120°F (49°C) before testing. Increases in fuel tank temperature that can occur as a result of fuel returned to the tank should be controlled so as to provide a result that is representative of expected fuel temperature conditions for the ambulance (7) *Intake and exhaust restrictions, accessories, hydraulic pumps, and reservoirs.* Components and accessories that might reduce engine power available for electrical output or that consume electrical output from the power source should be installed and be of the type used for the model that will be ordered for ambulance use, or their effect should be separately determined and reflected in the certified output.

(8) *Break-in.* Acceptance of a reduced output rating until completion of an in-use break-in period is subject to the prior agreement of the ambulance manufacturer, who might request test evidence. When applicable, the reduced output amount and duration of the break-in period should be indicated in the power supply literature.

(9) *Voltage and frequency.* Tests should be run while maintaining the ±10 percent voltage and ±3 Hz frequency required by 8.4.2.1. Furthermore, settings for voltage and frequency should be representative of production units.

(10) *Engine speed and hydraulic flow/pressure.* The engine speed and/or hydraulic flow and pressure ranges indicated in the power source's literature should be used to verify that the declared ratings are achievable.

(11) *Hydraulic fluid temperature.* The entire hydraulic power supply system, including hydraulic fluid piping and reservoir, should be located within a test chamber where temperature is controlled to maintain 120°F (49°C). Hydraulic fluid reservoirs should be stabilized at the ambient air test temperature [120°F (49°C)] prior to the testing.

(12) *Component and material temperatures.* Although not specified in the standard, when a power supply designed for light-duty use in open air is proposed for fixed ambulance use, the power source manufacturer should evaluate the components to determine whether they will operate within their rated or design temperature limits.

A.8.5.7.3 The instrumentation should be protected from vibration, which can lead to false readings. Particular attention should be paid to reed-type frequency indicators. Digital electronic instrumentation should be selected that incorporates sample times and intervals that accurately report system performance under varying conditions

A.8.5.9 The indicator lights and interlocks specified in this section are minimums. Some manufacturers or users might choose to add additional indicator lights or interlocks.

A.8.5.9.3 Generators are operated from the side, top, front, or rear of the ambulance, and stationary operation requires that no power is applied to the wheels while operating. Therefore, it is essential that any generator system controls that shift the ambulance out of the road mode of operation to place the generator system in operation be equipped with a means to prevent dislocation of the control from its set position in the power generation mode.

A.8.6.1 A PTO generator system typically consists of a propulsion engine, a controller to regulate the propulsion engine's speed (if required), an appropriate PTO arrangement, drivetrain components, a generator, and other miscellaneous parts.

Where possible, the generator PTO system should be prevented from engaging if engine speed is above idle.

PTO gear ratios and engine governor components should be selected and matched to provide an engine speed high enough to maintain rated performance of the alternator and air conditioning system (if provided). Engine speed should be high enough to maintain rated performance of the low voltage electrical system. Continuous excessive engine speed will result in premature generator drivetrain component failure and unnecessary fuel consumption.

The purchaser should consider specifying a means to automatically disconnect the generator or reduce engine speed to idle in the event of engine overspeed.

A.8.6.2 A hydraulic generator system generally consists of a variable displacement hydraulic pump deriving its power from the propulsion engine, a controller to regulate the hydraulic fluid flow rate, a hydraulic motor driving the generator, hydraulic fluid cooler, reservoir, and other miscellaneous parts.

All hydraulic generator systems have a window of operation (speed range). When selecting the power output of the hydraulic generator system, its speed range should be compared to the operating window of the ambulance's engine and the PTO ratios available. By selecting the hydraulic generator system and PTO ratio to match the application, electrical power can be provided over a wide operating range.

The selected PTO should have a gear ratio that will allow the widest possible range of engine speeds without overspeeding the hydraulic pump.

Where possible, engagement of the generator PTO system should be prevented if engine speed is above idle.

A.8.6.2.1 The means can be a mechanical, hydraulic, or electronic device.

A.8.6.3 Engine-driven generator systems use an internal combustion engine close-coupled to a generator. Some installations are capable of producing power while the ambulance is in motion. Generators used in these applications should be specifically designed for mobile applications. Remote generator controls in the driving compartment should be considered and specified if desired

A.8.6.3.2 The purchaser should consider the following additional remote instruments where a prime mover, other than the propulsion engine, is used to drive a generator:

(1) Oil pressure gauge and low pressure indicator light and audible alarm

(2) Engine temperature gauge and high temperature indicator light and audible alarm

The purchaser might want to specify a high temperature indicator to help troubleshoot automatic shutdowns.

A. 8.6.3.9.1 Emissions from exhaust discharge pipes should be directed away from any tools or equipment, because such emissions contain an oily substance that could make the tools difficult to handle and possibly dangerous to use.

A.8.6.4 Brief descriptions of several different types of systems follow. All of these systems can overload the low voltage electrical system and cause the load management system to terminate the generation of line voltage. As a result, the amount of line voltage power that can be supplied at any given time is totally dependent on the other, higher priority demands placed on the low voltage system.

Dynamic Power Inverter. A dynamic power inverter converts alternator output power to 120 volts ac (or 120/240 volts ac). Power is electronically inverted to ac. Usually the largest system of this type is 7,500 watts. Voltage and frequency control are typically very good. These types of systems may be suited to providing electric power while the ambulance is in motion.

Static Power Inverter. A static power inverter converts 12 volt to 14 volt dc power to 120 volt ac (or 120/240 volts ac) power. Power is electronically inverted to ac. Usually the largest system of this type is 2000 watts. Voltage and frequency control are typically very good. These types of systems are suited to providing electric power while the ambulance is in motion.

Motor-Driven Generators. A motor-driven generator system converts 12 volt dc power to 120 volt ac (or 120/240 volts ac) power. The 12 volt dc motor drives an ac generator. Typical power ratings are less than 1600 watts. Voltage and frequency control are less precise than some of the other systems available. These types of systems are suited to providing electric power while the ambulance is in motion.

Transformers. Transformer systems convert energy from the alternator, which is then rectified to 120 volt dc power. Typical installations provide 1000 watts. Output voltage is directly dependent on input voltage. Input voltage is dependent on engine and alternator speed.

In most cases, other power sources that do not draw power from the low voltage system are preferable.

A.8.6.4.2 In order to provide adequate power, it may be necessary to provide a means to advance engine speed as described in 8.6.5.

A.8.6.5.3 Operations in conjunction with any other component driven off the ambulance's engine could require special or alternate interlock systems.

A.8.6.6 Devices that produce modified sine waves may be less expensive than devices that produce pure sine waves. Power from electric utilities and most traditional mechanical generators are close to a pure sine wave. A modified sine wave output is satisfactory for many types of equipment but may cause problems with some types of equipment, including the following:

(1) Some computer and electronic equipment
(2) Some fluorescent lights with electronic ballasts
(3) Some tools with variable speed motor controls
(4) Some battery chargers
(5) Some medical equipment
(6) Some other equipment

The purchaser should identify what equipment is intended to be powered from the power source and verify with the equipment manufacturers that the equipment is compatible with modified sine wave power sources before specifying such a power source.

A.8.7 Portable generator systems are generally designed with an integral fuel tank and controls in one modular package. This allows the system to be picked up and transported to a remote location from the ambulance. Generators designed for portable use should be accessible for removal. These generators are generally not suited for "enclosed" compartment operation or should be mounted on a slide-out tray for adequate ventilation. Such installations require interlocks or a high temperature alarm to ensure that the generator is operated in slide-out condition.

The generator performance specifications should be evaluated carefully to ensure that the required level of performance can be met. Article 445, "Generators," of *NFPA 70, National Electrical Code*, requires that overcurrent protection be provided on portable generators

A.8.9.3 Where the wire could be exposed to temperatures above 194°F (90°C), higher temperature rated wire should be used.

A.8.10.3.4 Similar fixed loads should be paired on opposite legs of the power source where practical. If pairs of receptacles are provided on the same side of the ambulance or on the front or rear of the ambulance, they should be connected to opposite legs of the power source. If two 120 volt cord reels are provided, they should be connected to opposite legs of the power source. 120/240 volt cord reels should always be connected to both legs of the power source.

A.8.11 Where the wire could be exposed to temperatures above 194°F (90°C), higher temperature rated wire should be used.

A.8.11.6.1 Locations in which flexible cord might be damaged include but are not limited to compartment walls and floors, exposed outside areas, and exposed interior areas near equipment or walkways.

A.8.12.3 Common connectors and terminations that comply with these requirements include but are not limited to the following:

(1) Welded or brazed connectors
(2) Crimped connectors
(3) Soldered connections that are mechanically secured before soldering
(4) Screw-type positive pressure connectors
(5) Ring terminals
(6) Hooks
(7) Upturned spade
(8) Crimped-on pins

A.8.12.4 The following switch terminology can be helpful in understanding the different types of switches.

One Pole (1P) or Single Pole (SP). A switch device that opens, closes, or changes connections in a single conductor of an electrical circuit.

Two Pole (2P) or Double Pole (DP). A switch device that opens, closes, or changes connections in both conductors of the same circuit.

Two Circuit (2 CIR). A switch device that opens, closes, or changes connections In a single conductor of two independent circuits.

Single Throw (ST). A switch that opens, closes, or completes a circuit at only one of the extreme positions of its actuator.

Double Throw (DT). A switch that opens, closes, or completes a circuit at both extreme positions of its actuator.

Normally Open (NO). A switch in which one or more circuits are open when the switch actuator is at its normal or rest position.

Normally Closed (NC). A switch in which one or more circuits are closed when the switch actuator is at its normal or rest position.

Switches are rated for the type of load they are designed to control. Switch ratings include the following:

(1) Resistive
(2) Inductive
(3) Horsepower (i.e., motor loads)
(4) Tungsten (i.e., incandescent lamp loads)
(5) Alternating current
(6) Direct current

The ampere rating of a given switch is dependent on the type of load. In particular, switches used to control dc circuits should have the appropriate dc rating.

A.8.12.4.2 In lieu of a switch-rated circuit breaker, a standard circuit breaker could be used with a separate switching device.

A.8.12.5 The purchaser should specify the number and location of receptacles that are needed to operate the devices to be powered by the system. The purchaser should specify the NEMA number (if applicable), manufacturer, and style of the receptacles desired. For other than NEMA-type receptacles, the purchaser should additionally specify the wiring configuration

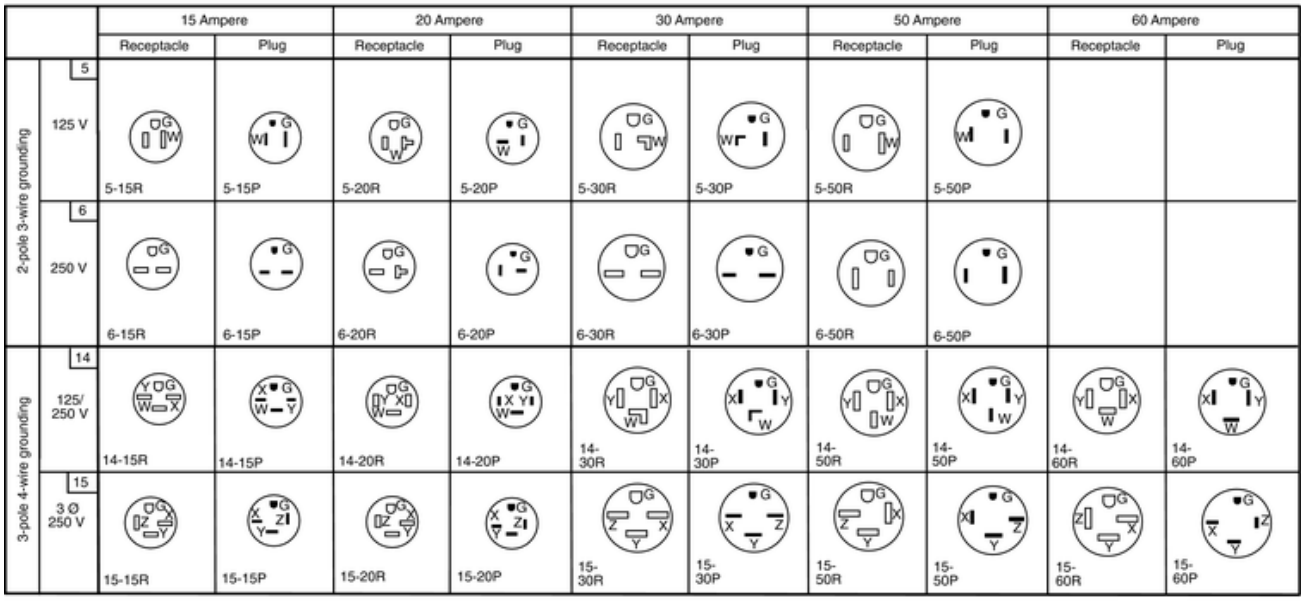
A.8.12.5.6.3 If the off-road ambulance is to ford water, the receptacle distance should be increased above 30 in. (750 mm). The purchaser should review the proposed height for any receptacles on the ambulance and specify a higher mounting height if desired.

A.8.12.5.11 While NEMA configurations as defined in NEMA WD 6, *Wiring Devices — Dimensional*

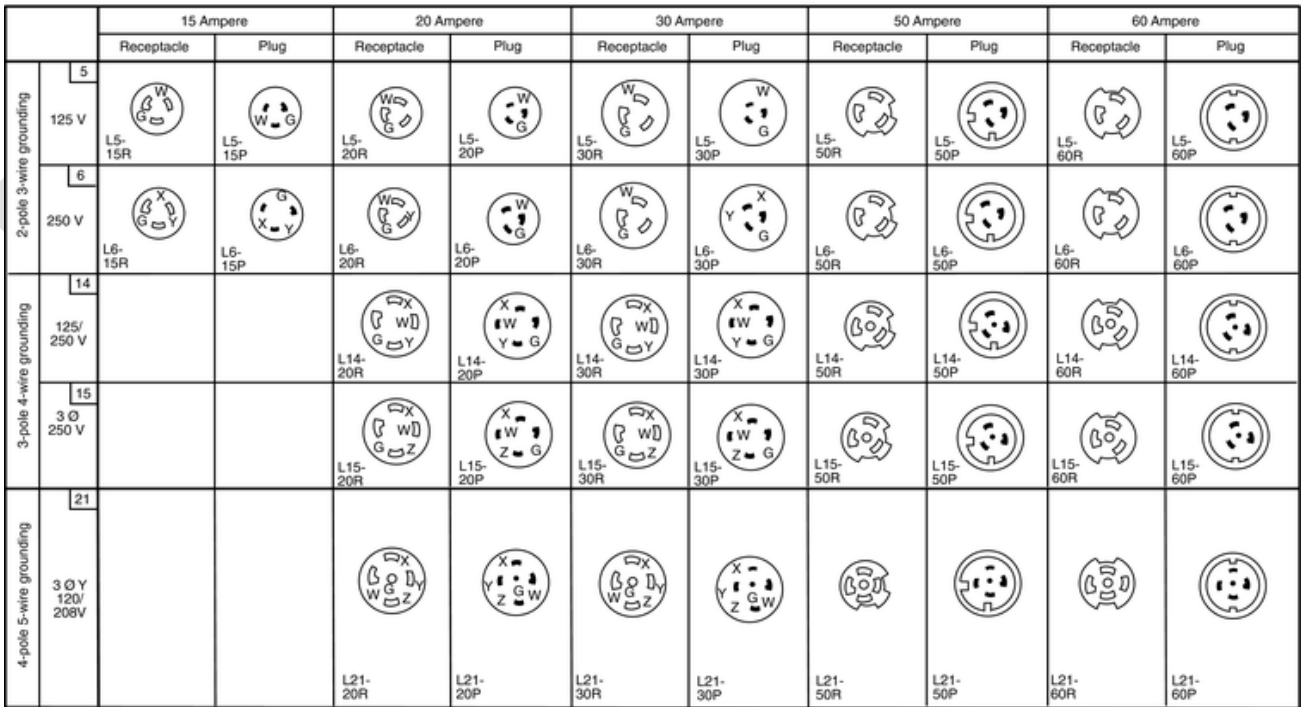
Requirements, are recommended to promote compatibility of equipment during mutual aid operations, other configurations are in use and have been adopted by various ambulance services .

Acceptable NEMA-type plug and receptacle configurations for various ac voltage and current ratings are shown in Figure 8.12.5.7.

NONLOCKING PLUGS AND RECEPTABLES



LOCKING PLUGS AND RECEPTACLES



NEMA WD-6, Wiring Devices—Dimensional Requirements, by permission of National Electrical Manufacturers Association. Copyright 2002 by National Electrical Manufacturers Association.)

The letter “R” following the configuration number indicates a receptacle, and the letter “P” denotes a plug. For example, the nonlocking, 15-ampere, grounding receptacle found in most homes is configuration 5-15R and accepts a three-prong plug in the configuration of 5-15P.

Locking-type plugs and receptacles are designed to prevent accidental disconnection when subjected to moderate pull-apart loads. Neither locking nor nonlocking connectors are designed to withstand the loads that can be created when pulling long cords up buildings and stairs.

A.8.13.5 A suggested minimum capacity of a reel is at least 100 ft (30 m) of cord rated to carry 20 amps at 120 volts ac. When sizing the reel, extra capacity should be provided when multiple receptacles are attached to the cord stored on the reel.

A cord reel to supply a single 120 volt circuit requires three collector rings and three conductors in the cord, for line, neutral, and ground. If the power source has 120/240 volt outputs, as most power sources do, a second equivalent circuit with the same rating requires only one additional conductor, because the neutral and ground can be common to both circuits. Thus, with approximately 25 percent more reel space and cord cost, the cord reel can supply twice the number of lights or other loads.

A.8.13.6 Table A.8.13.6 lists the suggested cord size for cord reels based on the desired circuit ampacity and the cord length. All cord reels with one or more outlets should be rated at 15 amps or greater.

Table A.8.13.6 Wire Size (AWG) for Various Electrical Cord Lengths

Circuit Ampacity	Cord Length					
	50 ft (15 m)	100 ft (30 m)	150 ft (45 m)	200 ft (60 m)	250 ft (75 m)	300 ft (90 m)
15	12	12	12	12	10	10
20	12	12	12	10	10	8
25	12	12	10	10	8	8
30	10	10	10	8	8	6
35	8	8	8	8	6	6
40	8	8	8	8	6	6
50	6	6	6	6	6	4

For heavy loads such as large smoke fans and hydraulic rescue tool power plants, the purchaser should consider 240 volt units instead of 120 volt units. This will allow the use of smaller cords and reels. For example, a 200 ft (60 m) reel to supply a hydraulic rescue tool (HRT) power plant that draws 15 amps at 240 volts would require 12 gauge wire. The same power unit in a version to run on 120 volts would draw 30 amps and would require 8 gauge wire.

Cord reels for three-phase power or other specialized applications should be designed with the assistance of a qualified electrical engineer.

A.8.13.7 The purchaser may want to specify that the cord on the reel be provided with a disconnect means within 18 in. (457 mm) from the reel for cord removal if the cord is 8 AWG or smaller. A disconnect makes it easier to replace damaged cord or to use the cord to extend another cord, although it reduces the capacity of the reel and makes it harder to coil the cord on the reel.

A.8.13.8 The purchaser might want to color code the cord or cord reel to identify the voltage.

A.8.13.9.2 It might be advantageous to specify a remote power distribution box that has a provision for hanging the unit from a door or ladder

A.8.13.9.5 The lamps used in this application should be rough-service type. Scene lighting around the remote power distribution box can be provided with an integral, mechanically protected light fixture

A.8.13.9.5.1 For increased visibility, reflective tape can be applied to the distribution box

A.9.1.1 The purchaser might wish to have the entire low voltage electrical system and warning device system certified by an independent third-party certification organization.

A.9.2 The purchaser should consider the range of temperatures in which the power source is to be operated. If extreme conditions are anticipated, the purchaser should specify the test conditions that are desired.

A.9.2.3 The purchaser should check the polarity of the wiring in a building prior to interconnecting the ambulance mounted electrical system to the electrical system in a building.

A.9.2.7 It is important that the power source meet the purchaser's requirements for output. Power sources may be advertised with power ratings for operating conditions that are more favorable than the conditions that might be encountered in ambulance use. Some power sources are advertised at peak output or intermittent duty ratings and not the continuous duty output required for ambulances. The power source manufacturer and ambulance manufacturer might need to establish a reduced rating that is appropriate for ambulances. The standard calls for two steps. The power source manufacturer provides a declared rating for 120°F (49°C) air inlet temperature and 2,000 ft (600 m) altitude for the minimum clearance and ventilation indicated on the declaration *(see 8.5.10)*. Then the ambulance manufacturer verifies that the rating printed on the power source specification label can be attained during the line voltage load test *(see 9.2.7)*.

Generator Set Rating. Auxiliary engine–powered generator sets are the type of power source most likely to require a reduction from advertised ratings, and generator set literature usually provides rating correction factors for altitude and temperature. These factors could be based on standards for engines, such as ISO 3046-1, *Reciprocating internal combustion engines — Performance — Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods — Additional requirements for engines for general use*, and SAE J1349, *Engine Power Test Code — Spark Ignition and Compression Ignition — Net Power Rating*; standards for generators, such as NEMA MG 1, *Motors and Generators*; or manufacturer testing. As an example of how altitude and temperature affect output capability, consider a typical 10 kW generator set with 0.8 generator efficiency and naturally aspirated diesel engine that is rated at 500 ft (150 m) and 85°F (30°C) for continuous operation without overload or reserve capacity. ISO 3046-1 indicates a factor of -2.1 percent output per 10°F (5.5°C) ambient increase, and a -2.6 percent per 1000 ft (300 m) altitude increase. Generator output is also affected by temperature [about -0.5 percent per 10°F (5.5°C)] and altitude (small and ignored in this example). There is also an effect from combining engine and generator into a generator set due to each heating the other. This may require an additional factor of -1 to -4+ percent per 10°F (5.5°C), depending on the effectiveness of the cooling system and temperature (the factor increases with increasing temperature). Altogether, these factors suggest the 10 kW generator set in this example is capable of about 8.8 kW at the maximum temperature of 110°F (43°C) and altitude of 2,000 ft (600 m) specified in the standard. Another way to view this result is that an 11.4 kW generator set would be required to provide 10 kW at 110°F (43°C) and 2,000 ft (600 m).

Where there is concern that installation or operational circumstances could cause power source intake air to heat above 120°F (49°C) or where the flow of cooling, induction, or exhaust air is more restricted than what is allowed by the manufacturer's literature, advance consultation with the power source manufacturer(s) could help in the selection of a power source that will pass the ambulance test with an output that meets the purchasers needs. Also, weather, like altitude, can affect air density and thus engine and generator set output. The combined effect of altitude and weather is reported as barometric pressure on local weather reports. Low barometric pressure will reduce engine and generator set output capability. High barometric pressure (usually clear cold days) will increase engine and generator set output capacity.

Other Power Source Types. Some output correction factors described in the generator set example apply to other types of power sources, depending on circumstances. For example, PTO and hydraulically driven generators also rely on engine power, but the engine will usually have substantial reserve power, so increased altitude or temperature will not affect their power supply rating. Regardless, best practice for longest life and lowest

maintenance is to provide unrestricted airflow at the lowest temperature.

Annex B Informational References

B.1 Referenced Publications.

B.1.1 NFPA Publications.

B.1.2 Other Publications.

B.2 Informational References.

B.3 References for Extracts in Informational Sections.