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An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

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Superseding ARP1247C

Aircraft Ground Support Equipment — General Requirements

RATIONALE

This ARP has been revised to define and clarify exsisting requirements, add additional requirements, and to include references to European Standards applicable to GSE manufacturing requirements

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) outlines the basic general design requirements for ground support equipment used in the civil air transport industry. It is intended to assist the airlines in standardizing requirements for various configurations of equipment. For procurement of equipment, sections of this document should be specified with due consideration of the functional and environmental requirements of the equipment, and to the relative cost of satisfying those requirements.

2. REFERENCES

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of the other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 Applicable Documents

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and canada) or 724-776-4970 (outside USA), www.sae.org.

JIO	Automotive and Off-Highway Air Brake Reservoir Performance and Identification Requirements – Truck and Bus
J377	Vehicular Traffic Sound Signaling Devices (Horns)
J512	Automotive Tube Fittings
J514	Hydraulic Tube Fittings
J517	Hydraulic Hose
J524	Seamless Low-Carbon Steel Tubing Annealed for Bending and FlaringJ533Flares for Tubing
J537	Storage Batteries
J561	Electrical Terminals – Eyelet and Spade Type
J844	Nonmetallic Air Brake System Tubing
J858	Electrical Terminals Blade Type
J919	Sound Measurement – Off-Road Work Machines – Operator – Singular Type
J928	Electrical Terminals – Pin and Receptacle Type
J1127	Low Voltage Battery Cable
J1128	Low Voltage Primary Cable
J1401	Road Vehicle – Hydraulic Brake Hose Assemblies for Use With Nonpetroleum-Base Hydraulic Fluids
J1402	Automotive Air Brake Hose and Hose Assemblies
J1403	Vacuum Brake Hose

2.1.1 (Continued)

J1703 Motor Vehicle Brake Fluid

J2031 High Tension Ignition Cable

ARP836 Design and Safety Criteria for Passenger Boarding Stairways

ARP1052 Selection Criteria for Internal Combustion Engines Used in Ground Support Equipment

ARP1328 Aircraft Ground Support Equipment - Wind Stability Determination

ARP1330 Welding of Structures for Ground Support Equipment

AIR1336 Vehicle Electric Systems

AIR1375 Minimum Safety Requirements for Special Purpose Airline Ground Support EquipmentAIR 1558Aircraft Interface Protective Devices

ARP1801 Measurement of Exterior Sound Level of Specialized Aircraft Ground Support Equipment

2.1.2 ANSI Publications

Available from American National Standards Institute, 25 West 42nd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI B56.1 Safety Standard for Powered Industrial Trucks

ANSI A92.7 Airline Ground Support Vehicle – Mounted Vertical Lift Devices

2.1.3 U.S. Government Publications

Available from Document Automation and Production Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-STD-461 Electromagnetic Interference Characteristics Requirements for Equipment

MIL-STD-1472 Human Engineering Design Criteria for Military Systems, Equipment, and Facilities

MIL-DTL-3950 Switch, Toggle, General Specification for

A-A-870 Antifreeze, Ethylene Glycol, Inhibited

Various Standards – United States Public Health Service Standards Code of Federal Regulations

- Title 29, Part 1910 - 0ccupational Safety and Health Standards (OSHA)
- Title 49, Part 393 - Parts and Accessories Necessary for Safe Operation
- Title 49, Part 571 - Federal Motor Vehicle Safety Standards (FMVSS)

2.1.4 Other Publications

American Welding Society – Applicable chapters/sections of welding codes Section VIII – ASME Unfired Pressure Vessel Code

ATA Spec. 101 – Specification for Ground Equipment Technical Data

E.U. Machinery Directive

NOTE: For intended GSE operation in Europe, EU Machinery Directive (Directive 2006/42/EC of 17 May 2006) requirements apply. They can be met by complying with the general requirements of the EN 1915 Parts as well as requirements specific to each GSE type covered by EN 12312-1 to -20 standards. ISO 6966-1 and 6966-2 provide general requirements common to ARP 1247D and the ENs for worldwide application. However, they are not sufficient to ensure compliance with the E.U. Machinery Directive.

a) EN 1915-1:2001 – Aircraft ground support equipment – General requirements – Part 1: Basic safety requirements

b) EN 1915-2:2001 – Aircraft ground support equipment – General requirements – Part 2: Stability and strength requirements, calculations and test methods

c) EN 1915-3:2004 – Aircraft ground support equipment - General requirements - Vibration measurement methods and reduction

d) EN 1915-4:2005 – Aircraft ground support equipment – General requirements - Part 4: Noise measurement methods and reduction

e) ISO 6966-1:2005 – Aircraft ground equipment – Basic requirements — Part 1: General requirements

f) 6966-2:2005 – Aircraft ground equipment – Basic requirements — Part 2: Safety requirements

g) EU Low Voltage Directive - LV 72/23/EEC

NFPA No. 70 – National Fire Prevention Association Standard No. 70, "National Electric Code"

NFPA No. 505 – Standard for the Use, Maintenance and Operation of Industrial Trucks. Fire Safety for Powered Industrial Trucks

Various Standards – Caster & Manufacturer's Association Standards

3. REQUIREMENTS

3.1 Performance

The equipment, properly maintained, shall be designed to perform its intended function for its "Total Life" period (see 3.5).

3.2 Operability

3.2.1 The equipment shall be designed for continuous operation at rated load for the period indicated in a functional specification provided by the purchaser as a controlling document herein referred to as a "controlling specification."

3.2.2 The equipment shall operate satisfactorily at any angle up to 10 degrees (0.175 rad.) fore and aft and 5 degrees (0.0873 rad.) sideways. In the event that this requirement imposes significant design constraints, the manufacturer shall define and propose a design suitable for the intended application.

3.3 Reliability

The equipment and its accessories shall be designed and constructed with reliability of operation a primary consideration. The minimum reliability design requirementis that the equipment be designed to operate between periodic preventive maintenance periods of 200 operating hours or 8 weeks, whichever occurs first. The above interval does not apply to components in those cases where the component manufacturer recommends more frequent maintenance intervals. (For the purpose of this document, normal servicing of fuel, oil, tire pressure, battery, and water are not considered preventive maintenance.)

3.4 Maintenance Requirements

3.4.1 Maintainability

Not applicable.

3.4.2 Maintenance Repair Cycle

Not applicable

3.4.3 Service and Access

3.4.3.1 Equipment components and systems requiring routine and frequent inspection and maintenance shall be readily accessible. Suitable access doors or removable enclosures shall be provided for this purpose.

3.4.3.2 Access doors, covers, and protective guards shall be designed for quick removal or opening. Access holes in protective guards for lubrication are acceptable only when lubrication is required on intervals exceeding twice annually but shall be held to a minimum quantity and the minimum size required for the pressurized fitting only. Access doors, panels, and protective guards shall be designed for quick opening or removal by personnel wearing arctic gloves or mittens, using standard mechanics tools.

3.4.3.3 Access panels and doors normally used during aircraft servicing shall be designed to structurally withstand wind blasts up to 90 mph (145 km/h) in both open and closed position.

3.4.3.4 Access panels shall be hinged, pinned, etc., to prevent loss from the unit. Large panels of over 4 foot (1.219 m) in both height and width which are normally removed only for heavy maintenance; i.e., major component overhaul or removal, may be designed to be removed from the equipment when hinging or pinning is not practical.

3.4.3.5 All hinged doors shall be provided with devices to secure them in the open and closed positions such that they will not be blown by jet blast or ambient winds. Stops or bumpers shall be installed so that the doors (or stops), do not mark or scratch the paint work. Where possible, at least 8 inches (203 mm) of clearance above the ground shall exist when any door is open.

3.4.3.6 Major assemblies and components shall be capable of being disconnected and removed from the equipment without the necessity for extensive disassembly of other components. Standard automotive practice is acceptable.

3.4.3.7 Parts requiring removal for replacement, service, or maintenance shall be fastened with removable fasteners or latching devices.

3.4.3.8 Weight of removable enclosures, or replaceable units, designed for one-man handling must be less than 30 pound (14 kg). Units exceeding 30 pound (14 kg) to a maximum of 80 pound (36 kg) must be designed for two-man handling.

3.4.3.9 All components that exceed 80 pound (36 kg), or that exceed 30 pound (14 kg) if only one man has access to the unit for handling, shall have provisions for attaching lifting or handling devices such as slings, hoists, or forklift tines. The minimum design safety factor of such provisions, based on the ultimate strength of the material shall be 5 to 1.

3.4.3.10 Any vital, unattached parts such as tractor hitch pins and lock pins which might otherwise be easily lost shall be secured to the equipment with cable or chain of durable size and material.

3.4.3.11 Pressure lubrication fittings shall be provided at all points where heavy loads, close tolerance, relative rotary or linear motion of parts occurs. This will normally include pivots, guides, bearings, and journals except sealed ball and roller bearings. Where access to the fittings is difficult, they shall be brought to a common lubrication panel.

3.4.3.12 Fastener heads and nuts shall be provided with adequate clearance for wrenches and drivers.

3.4.3.13 A means of positively securing lift devices at a convenient height for service and access shall be provided with each unit.

3.4.3.14 On lift types of equipment, the manufacturer shall provide alternate means of raising the hoist in event of failure of the primary power source if any components that could cause failure are not accessible while the hoist is in the down position.

3.4.3.15 On lift bed types of equipment a means shall be provided for a mechanic to raise and lower the hoist while working at ground level.

3.4.3.16 Chain and belt drives shall have provisions for adjusting the tension to the manufacturer's specified value. A positive means to hold the adjustment shall be provided.

3.5 Total Life

"Total Life" is defined to be the hours of use from time of delivery of the equipment to the using activity until its identity is destroyed by classifying it as salvage and/or subject to cannibalization. The "Total Life" for which the equipment is designed, assuming it is used and maintained in accordance with the manufacturer's recommendation, shall be specified.

3.6 Environmental

3.6.1 The entire unit shall be designed and equipped to start easily and operate satisfactorily under temperature conditions ranging from -20 to +123° F (-29 to +52° C) after soaking at either of the stated temperature extremes for 24 h. For vehicles to be routinely operated at higher and/or lower temperatures, applicable operating temperature limits should be specified in the procurement document.

3.6.2 The equipment shall be designed to operate satisfactorily after exposure to the following sequence of conditions

a. 4 hours soak at +20 °F (-6.7 °C)

b. Thorough wetting of the exterior of the equipment with a fine spray of +40 °F (4.4 °C) water

c. 4 hours soak at +20 °F (-6.7 °C)

3.6.3 The equipment and all its components shall be designed to operate satisfactorily after 6 hours exposure to heavy rainfall (0.30 in/h) (0.76 cm/h) driven by a 25 mph (4002 km/h) wind in any horizontal direction.

3.6.4 Components shall be protected from mechanical, electrical, and corrosion damage and impairment of operation due to rain, snow, ice, sand, grit, and deicing fluids.

3.6.5 Operators' compartments shall be designed to preclude excessive temperature from heat sources such as engine and exhaust system. Insulation and ventilation shall be provided, if necessary, to limit compartment temperatures in any operational mode, to a maximum of 100 °F (37.8 °C) on a calm, 85 °F (29.4 °C), full sunlight day.

3.7 Transportability

3.7.1 The unit shall be designed for over-the-road unrestricted transportation insofar as possible. The manufacturer shall identify any constraints applicable to transportation or shipment of the unit or any subassemblies.

3.7.2 Units required, as outlined in the controlling specification, to operate on public highways or to be capable of being licensed for use on public highways shall meet the requirements of Chapter V – National Highway Safety Bureau, Department of Transportation, Title 49 of the Code Federal Regulations in effect on the date of manufacture. The unit shall be manufactured in a manner and equipped to be capable of operation in accordance with Part 393, subparts A, B, C, D, E, and G of Chapter III – Federal Highway Administration, Department of Transportation, Title 49 of the Code of Federal Regulations.

3.7.3 Units which may be licensed to operate on public highways shall have the minimum capability to accelerate on a level surface, from 0 to 40 mph (0 to 64.4 km/h) within 60 s with full payload.

3.8 Safety

3.8.1 It shall be the responsibility of the manufacturer to ensure that the equipment contains all the safety features required to protect the equipment, the operator(s), the load, and the aircraft serviced, in accordance with AIR1375 - Minimum Safety Requirements for Special Purpose Airline Ground Support Equipment, and Title 29 CFR Part 1910 - 0ccupational Safety and Health Standards (OSHA).

3.8.2 Powered Industrial Trucks (as defined by Section 1910.178 of OSHA) shall meet the design and construction requirements established in ANSI B56.1, Part II. In the event of conflict between this document and B56.1, Part II, B56.1 shall apply.

3.8.3 Vehicles equipped with vertical lift devices shall meet the design and construction requirements established in ANSI A92.7, Safety Requirements for Airline Ground Support Vehicle-Mounted Vertical Lift Devices. In the event of conflict between this document and A92.7, A92.7 shall apply.

3.9 Personnel Safety

3.9.1 Unless specifically excluded by the purchasing agreement, a windshield shall be provided on all motorized vehicles designed for operation at speeds above 5 mph (8.1 km/h). Powered windshield wipers shall be provided on all motorized vehicles which are equipped with a windshield. A powered wiper shall also be provided on any rearview window of each motorized vehicle required to approach aircraft in a reverse direction. Wiper motors and mechanical linkage must be protected against damage with wipers in a stalled condition. Window washing and wiping systems shall conform to FMVSS No. 104. "Windshield Wiping and Washing Systems". Unless otherwise stated in the specification, washing systems need not be provided on vehicles not equipped for highway travel.

3.9.2 On units where rear vision is restricted, outside mirrors shall be provided on each side of the cab as specified by the controlling specification. The mirrors shall be adequately braced to preclude accidental loss of adjustment or visual distortion due to vibration of vehicle. If specified, the mirror(s) shall have down vision capability.

3.9.3 An electric horn which meets the requirements of SAE J377 shall be provided. The horn shall be supplied with control button located in the center of the steering wheel.

3.9.4 Control pedals shall be designed and located to permit safe operation if heavy overshoes are worn by the operator. Spacing between the brake pedal and accelerator shall follow standard automotive industry practice. In no case shall they be located so that the accelerator can be depressed accidentally while applying the brakes with a booted foot. The use of pedal surface material which inhibits "slippage" of shoes when wet is required.

3.9.5 A crash barrier which, when rigidly supported in a horizontal position, is capable of withstanding the impact of a 100 pounds (45.4 kg) solid hardwood cube (or equivalent) dropped at random from a distance of 5 feet (1.5 m) 10 times, without fracture or permanent deflection exceeding 0.75 inch (1.9 cm) shall be installed on each vehicle designed to carry loose cargo to prevent injuring the operator with such cargo in the event of a collision.

3.9.6 Where required, heat shields or guards shall be installed to protect personnel operating the equipment or performing routine periodic maintenance on the equipment against accidental contact with exposed parts which are subject to high operating temperatures. This does not apply to exhaust systems in commercial vehicle engine compartments. Warning devices shall be added where applicable.

3.9.7 Suitable guards shall be provided for all moving parts located where operating personnel may make accidental contact with them. In general, standard automotive practice is acceptable. Warning decals shall be added where applicable.

3.9.8 Vehicles shall have the operator and adjacent front seat positions equipped with seat belts conforming to FMVSS No. 207, "Seating Systems"; No. 208, "Occupant Crash Protection"; and No. 209, "Seat Belt Assemblies".

3.9.9 Exposure of operating and maintenance personnel to electric shock hazards shall be minimized by the provision of suitable interlocks, grounding means, or protective devices.

3.9.10 Guards or enclosures shall be provided for all exposed portions of electrical equipment.

3.9.11 Elevating devices shall be protected against uncontrolled movement or actuation in the event of a power source failure of any type (i.e., hydraulic, electrical, pneumatic, or engine).

3.9.11.1 Hydraulic lift cylinders shall have pilot operated check or counterbalance valves connected directly to their base fittings to prevent accidental lowering in the event of failure of any line in the system.

3.9.11.2 Electrical or pneumatic lifts shall be equipped with brakes to lock the system in the event of power failure or malfunction.

3.9.11.3 An emergency lowering system, operationally independent of the prime power source and operable from the ground, shall be provided on all lift units.

3.9.11.4 The location of emergency lowering controls must be easily identified and shall be located so as not to create a potential hazard to the operator or equipment during operation.

3.9.12 All pinch and shear points, sharp edges and protruding objects must be eliminated wherever possible and practical. If elimination is not possible, adequate guarding must be achieved to prevent injury and/or damage exposure.

3.9.13 Push/pull forces required to move other than control handles and access doors shall be limited to 60 pound (27.2 kg), when the operator is standing upright.

3.9.14 Stairs, ladders, scaffolds, platforms, etc. shall comply with the applicable OSHA requirements.

3.9.15 Stairs used by the general public for access to and from the aircraft shall conform to ARP836.

3.9.16 Where practical and possible, access to work areas shall be provided by means of a protected lift platform or stairs. Ladders shall be used only where use of stair is not practical and possible. In this case, telescoping ladders, elements of which move in relation to each other, shall be used only where the use of fixed ladders is not possible.

3.9.17 Stair risers, treads and stair and ladder angles shall conform to OSHA promulgated standards and documents for Industrial Operations. Critical angles shall be avoided where practical and possible.

3.9.18 Steps and ladder rungs shall be of open, nonskid material.

3.9.19 Nonslip surfaces shall be provided in all areas where personnel will be required to walk or work during normal operations.

3.9.19.1 Serrated grating panels may be used where personnel will not be required to kneel or sit, and smoother surfaces are not required for rolling of casters. Protection shall be provided to prevent objects from falling on personnel and moving parts below such platforms.

3.9.19.2 Smoother nonslip materials shall be installed on personnel work areas as required by the operation. Abrasive impregnated aluminum or steel plate, adhesive applied abrasive sheet or painted on abrasive coatings shall be used only as approved by the purchaser.

3.9.20 Handrails and/or cages shall be installed on all stairs, ladders, and platforms when required by OSHA regulations. Removable railings shall be avoided where practical and possible. Removable railings shall be positively retained on the unit.

3.9.21 Working surfaces with removable handrails shall incorporate provisions for the attachment of personnel safety harnesses.

3.9.22 Equipment having an effect on public health, such as food or drinking water or lavatory service equipment, shall comply with and be certified by the United States Department of Health, Education, and Welfare.

3.9.23 No component, door, stair, towbar, or other item whose weight is balanced by a spring device shall be erected upward under the sole effect of the spring if the locking device fails.

3.9.24 Vehicles using pneumatic tires on split rim wheels shall have nuts and bolt heads on hardware securing the split rims together painted bright red. A warning placard shall be placed in the immediate vicinity of all wheel wells that shall warn the operator of potentially dangerous conditions and the red painted hardware is not to be loosened or removed when an inflated tire is mounted. Personnel injury and equipment damage may ensue.

3.10 Equipment Safety

3.10.1 If required, the type, location, and color of reflecting devices will be specified by the controlling specification.

3.10.2 Consideration should be given for protection of lamps and reflectors against damage if dictated by normal design practice; i.e., likelihood of damage.

3.10.3 Non-marking cushion devices shall be installed on all equipment intended to be used in direct contact with or close proximity to aircraft to prevent damage to the aircraft. Such cushion devices shall be tubular or "D" section rubber bumpers of suitable length with an outside diameter and wall thickness as specified by the controlling specification. Reference AIR1558.

3.10.4 All components and systems shall be fail-safe wherever practical.

3.10.5 Powered mobile equipment shall be designed with operator visibility a primary consideration.

3.10.6 All lift device mobility and/or positioning controls shall be of the "deadman" type.

3.10.7 Relief valves shall be provided in all hydraulic and pneumatic systems to prevent sustained pressures in excess of rated working pressure.

3.10.8 If required, the type, size, and location of fire extinguisher(s) will be stipulated in the controlling specification.

3.10.9 If stabilizers, outriggers, or spring lockouts are used, the following shall be provided:

3.10.9.1 An interlock shall be provided so that the stabilizing device used cannot be retracted or disconnected with the unit in a raised position.

3.10.9.2 An interlock shall be provided so that the unit cannot be raised above the maximum height at which the vehicle stability remains guaranteed without the stabilizing device locked in the down position.

3.10.9.3 Any stabilizing device used that extends beyond the unit profile or that could create an employee injury hazard shall be painted high visibility yellow or alert orange (purchaser to specify) and have the corners rounded.

3.10.9.4 A stabilizer device warning light shall be provided in clear view of the operator to show that the stabilizer device is not fully retracted.

3.10.9.5 A means to retract the stabilizer when the engine is not operating shall be provided.

3.10.9.6 Stabilizer ground contact pads, at maximum design loading, shall not produce a ground contact pressure in excess of 150 psi (1.034 MPa).

3.10.9.7 A flashing red warning light shall be provided in clear view of the operator to show that the platform is not in the fully lowered position.

3.11 Noise and Vibration

3.11.1 The maximum average sound level generated by the equipment, when operated at rated capacity or load, shall not exceed 85 dbA (A-weighing network) when measured at the operator's position and at a distance of 15 feet (4.57 m) from the equipment at a minimum of 8 positions at 45 degrees (0.785 rad) radials. If a more restrictive noise level is required, it shall be so noted in the purchasing agreement.

3.11.2 Sound level measurements and techniques shall be in accordance with SAE J919 for the operator's position and in accordance with ARP1801 for the radial measurements.

3.11.3 The unit shall be designed and constructed to prevent parts from working loose in service. It shall be built to withstand the stresses, jars, vibrations, and other conditions incident to shipping, storage, installation, and service. Suitable and durable vibration isolators shall be used between the engine and structural mounts and to include all other structural mountings to protect the operator, instruments, components, hydraulics, and structure from vibration transmission.

3.12 Equipment Definition

To be specified in the controlling specification.

3.12.1 Interface Requirements

Interface requirements will be specified in the controlling specification.

3.12.2 Customer Furnished Property List

Not applicable.

3.12.3 Manuals/Publications

The requirements for manuals and other documents will be provided in a controlling specification. All manuals must be available in accordance with ATA Specification 101 or in a format approved by the purchasing activity.

3.12.4 Tools and Test Equipments

Insofar as possible only standard tools shall be required for normal maintenance of any parts of the equipment. Any special tools or test equipment required for overhaul or performance checking shall be identified and drawings or source of manufacture documented.

3.12.5 Training

Operational and maintenance training requirements beyond that which are considered standard automotive practice shall be made available by the equipment manufacturer if required by the purchaser.

3.13 Design and Construction

3.13.1 General Design Features

It shall be the manufacturer's responsibility to recognize and comply with all codes and standards applicable to the design and construction of this type of equipment which are generally accepted and used as good practice in the industry.

3.13.1.1 Mechanical Design

3.13.1.1.1 The stress levels for design shall be based on the total of structural weight plus maximum carried load. Consideration will be made for anticipated dynamic loads. In the case of units with scissor lifts or similar load carrying structures, the design shall be based on the highest stress occurring over the full range of motion with the load in the least favorable position(s). Scissor lifts and similar items shall incorporate relief valves or other devices to prevent lifting loads which exceed the rated capacity.

3.13.1.1.2 Structural members manufactured of ductile material shall be designed with a minimum factor of safety of 3 relative to the yield strength.

3.13.1.1.3 Structural members manufactured of non-ductile materials shall be designed such that the maximum working stress does not exceed one-fourth of the ultimate strength of the material or the manufacturer's published recommended allowable working stress, whichever is lower.

3.13.1.1.4 In determining the design factor of safety, weld efficiencies as designated by the American Welding Society or applicable design codes shall be included in determination of the factor of safety for welded joints.

3.13.1.1.5 Joint efficiencies shall be included in determination of the factor of safety for bolted connections.

3.13.1.1.6 Wire rope installations shall be designed with a minimum factor of safety of 5 based on rated breaking strength for lifts not required to carry personnel and minimum factor of safety of 10 for lifts carrying personnel.

3.13.1.1.7 All lifting devices except wire rope shall be designed with a minimum factor of safety of 5 based on ultimate strength.

3.13.1.1.8 The unit shall be designed with sufficient structural rigidity that deflections due to load, wind, and motions of working parts do not create interferences, cause malfunctioning of the equipment, or present safety hazards to personnel, aircraft, or the unit itself.

3.13.1.1.9 In the case of standard chassis or component assemblies used by the end product manufacturer, certification of the application by the component manufacturer will constitute structural acceptability of such components.

3.13.1.1.10 Shoulder bolts, bearings, or bushings shall be used when attaching parts having relative rotary or linear motion.

3.13.1.1.11 Caster and wheel types and applications shall conform to the standards of the Caster and Floor Truck Manufacturer's Association.

3.13.1.1.12 The wheels used on all mobile equipment shall be of a type and size which will not damage or cause undue wear to the surface over which they will normally operate.

3.13.1.2 Electrical Design and Equipment

3.13.1.2.1 Unless otherwise specified, electrical systems incorporating a storage battery shall have a nominal rating of 12 or 24 V DC. Storage batteries used for cranking gasoline engines up to 300 inches^3 displacement shall have a minimum capacity of 70 amperes-hour at a 20 hour rate per SAE J537. Batteries used for cranking diesel engines, or gasoline engines exceeding 300 inches^3 (4900 cm^3) displacement, shall be of appropriately larger capacity, following conservative design practice. Battery capability for cold temperature engine starting should be specified in 0 °F (-17.8 °C) cold cranking amps (CCA). Electrical system design shall be documented by the manufacturer.

3.13.1.2.2 The negative pole of any storage battery shall be securely grounded to the vehicle engine and to the vehicle frame.

3.13.1.2.3 Toggle switches shall be of MIL-S-3950 quality or equivalent, and rated for the loads which they control.

3.13.1.2.4 All circuits except starting motors shall have suitable overload protection. Fuses and circuit breakers shall be grouped in convenient locations and suitably marked for size and function. Logical grouping of circuits is anticipated. Headlight circuits shall be independently protected. Protection devices shall be sized to protect wiring and motors from damage due to overload.

3.13.1.2.5 All wiring shall be in conduit or loomed and shall be routed away from heat sources and fuel lines. Wiring shall be adequately supported to protect it from damage, snow and ice buildup, bumping, kinking, and flexing.

3.13.1.2.6 Common wire splices shall not be used. Connections shall be made using terminal strips and staked lugs or by patent connectors. Terminals shall meet the applicable requirements of SAE J561, J858, and J928.

3.13.1.2.7 Wiring shall meet the applicable requirements of SAEJ878, J1127, J1128, and J2031.

3.13.1.2.8 Each conductor shall be sized to have current carrying capacity as allowed by the National Electrical Code equal to or greater than the capacity of the fuse or circuit breaker provided in its circuit. Optional and add-on components shall be considered in sizing and in the number of conductors provided.

3.13.1.2.9 Grommets and suitable anti-chafe material shall be used where wires are required to pass through a firewall or other similar relief or opening which exposes the wire to possible chafing.

3.13.1.2.10 Each wiring conductor shall be identified by color or number in accordance with a wiring diagram accessibly displayed in the equipment and/or in an accompanying document.

3.13.1.2.11 Any concealed wiring running within van walls or other inaccessible areas shall be contained in conduit for the length of the run and shall be terminated on a terminal strip at each end of the conduit or otherwise installed in a manner approved by the purchasing activity.

3.13.1.2.12 Wiring terminals shall be protected by insulating boots or heat shrinkable tubing.

3.13.1.2.13 Quick disconnect fittings, where required, shall be MS standard receptacles and plugs, or equivalent.

3.13.1.2.14 All electrical connections, including terminal strips and battery terminals, shall be protected with suitable covers or enclosures to prevent accidental contact and short circuiting.

3.13.1.2.15 Electrical interlocks shall be of a fail-safe design. Fail-safe is to be defined as **"**Incorporating some feature for automatically counteracting the effect of an anticipated possible source of failure".

3.13.1.2.16 Electrical devices including lights, switches, relays, wiring, and terminals, when located in an area exposed to weather, shall be of weatherproof design or protected by weatherproof enclosures.

3.13.1.2.17 Spark producing electrical components shall be located at least 18 inches (457 mm) above ground level wherever possible. All such components located below this level shall comply with the National Electrical Code requirements for Class 1, Division 2, Group D equipment.

3.13.1.2.18 A minimum of 5 foot-candles (54 lx) of illumination shall be provided

a. On all controls and placards in a glare free manner

b. At all operator positions and work areas by means of flood, spot, or dome lights

3.13.1.2.19 Lights, electrical apparatus, and wiring on units required to operate in hazardous locations shall comply with Article 500 of the National Electrical Code.

3.13.1.2.20 All lamps shall be heavy-duty type.

3.13.1.2.21 The following lighting equipment shall be provided on motorized vehicles intended for use and frequent travel on airport ramps and roadways and shall comply with the appropriate provisions of the Uniform Vehicle Code and Federal Motor Vehicle Safety Standards. Lighting equipment for vehicles of lower speeds will be specified on the detail specification for each of type equipment.

a. Two sealed-beam headlamps with high and low beams and a beam indicator.

b. Two red combination tail and stop lamps, visible from the rear of the vehicle.

c. Directional turn signals.

d. Dual backup lights controlled by the transmission shift lever

3.13.1.2.22 On vehicles equipped for highway use, lighting conforming to FMVSS Title 23, Chapter 2, Standard No. 108 "Lamps, Reflective Devices, and Associated Equipment" shall be provided.

3.13.1.2.23 When possible headlights shall be located on the unit so that they are 22 inches (559 mm) below the operator's eye level.

3.13.1.3 Hydraulic, Pneumatic Design

The following requirements shall apply to hydraulic systems other than the chassis brake system.

3.13.1.3.1 The hydraulic system shall be designed to operate over an ambient temperature range as specified in 3.6.1.

3.13.1.3.1.1 The hydraulic fluid desired will be specified by the controlling specification. A nameplate stating the type of hydraulic fluid used and the total tank capacity shall be installed adjacent to the reservoir filler neck.

3.13.1.3.2 The preferred maximum system pressure required by an operation is 3000 psi (20.7 MPa). Higher system pressures may be utilized if approved by the purchaser.

3.13.1.3.3 Maximum allowable flow velocity through any hose, tube, or pipe shall be determined from Table 1:

TABLE 1 – MAXIMUM ALLOWABLE FLOW VELOCITY

Service	V (FPS)	V(M/S)
Suction	4	1.2
Pressure – continuous duty	15	4.6
Pressure – intermittent (up to 50- duty)	25	7.6
Pressure – infrequent (up to 20% duty)	40	12.2

In cases where pressure drop due to tube and hose length becomes excessive with the flow specified above, such tubes and hoses shall be made of a larger diameter to reduce the pressure drop.

3.13.1.3.4 Hydraulic components shall be protected from flows in excess of manufacturer's published ratings.

3.13.1.3.5 The hydraulic fluid reservoir shall have a minimum reserve of 25% of displaced hydraulic fluid, making the capacity equal to 1.25 times the total maximum displaced volume of the hydraulic components including that contained in the hydraulic lines, accumulators, and cylinders. The reservoir design is to include the following:

3.13.1.3.5.1 Weatherproof breather with 10 µm filtering, having airflow capacity adequate to maintain essentially atmospheric pressure in the reservoir under maximum flow conditions.

3.13.1.3.5.2 A magnetic drain plug is to be incorporated in a sump located at the return end of the tank. The tank should be arranged such that the sump and drain are at the lowest point.

3.13.1.3.5.3 Full range fluid level indicator with adequate protection from breakage and located in an easily observable area.

3.13.1.3.5.4 A strainer type filler neck with attached cap.

3.13.1.3.5.5 The tank outlet to the pump and the major return port are to be located at opposite ends of the tank and 1 inch (25.4 mm) above the tank bottom. Any pump case, seal leakage, or other gravity drains are to be returned to the top of the tank with the actual discharge below that level at which oil should be added to the tank to prevent aeration.

3.13.1.3.5.6 An access opening to allow full access to interior for cleaning. Access cover is to be gasketed and fastened leak-tight.

3.13.1.3.5.7 Reservoir to be thoroughly cleaned and protected from contamination during assembly of the unit. Material and construction to conform to commercial quality and adequately protected against corrosion. Coated tanks are unacceptable unless approved by the buyer.

NOTE Items such as strainers, check valves, relief valves, filters, or any other item requiring periodic inspection or repair shall not be located inside the tank, but outside where they can be serviced easily.

3.13.1.3.6 A filter canister or a "y" type suction strainer of at least 60 mesh Monel or stainless steel screen shall be located between the tank and pump system. Easy accessibility to the cleanout port shall be provided.

3.13.1.3.7 Pumps are to be chosen so that their capacity will meet peak system demands within manufacturers' capacity ratings of flow, pressure, and revolutions per minute. Where system reliability and/or pump manufacturers' specifications require it, a boost pump and low pressure filter with a differential pressure indication will be provided.

3.13.1.3.8 The system pump(s) and components are to be protected by a relief valve(s) which have a capacity equal to or greater than pump capacity. Relief valve(s) shall dump directly to tank.

3.13.1.3.9 The hydraulic fluid temperature during continuous operation shall not exceed 150 °F (66 °C) on a 115 °F (46 °C) day and in no case shall exceed the hydraulic system components manufacturers' recommendations.

3.13.1.3.10 Dynamic pressure surges, spikes, and fluctuations shall be minimized with use of accumulators if necessary. Precharge information tags shall be attached adjacent to charge fitting.

3.13.1.3.11 The material for all hydraulic lines shall be specified. Flexible lines shall be made of hydraulic fluid resistant material. The lines shall be supported and protected from chafing and binding. Hydraulic lines shall be routed so that, where possible, structural members will provide protection. Lines shall be supported so that fittings, tubing and hoses are separated from engine exhaust systems, and are not subject to damage from heat, external loads, and vibration. If necessary, heat barriers or shields shall be installed. Lines shall be protected from kinking and abrasion.

3.13.1.3.12 All hydraulic fittings will be in accordance with SAE J514. If flared, the 37 degrees (0.646 rad) flare with "B" nut and sleeve is to be used. Flared copper seats are not to be applied to fittings for sealing purposes.

3.13.1.3.13 All pipe threads are to be joined with a suitable pipe sealant.

3.13.1.3.14 Hydraulic systems are to incorporate such devices as hydraulic fuses, pilot check valves, holding valves, accumulators where necessary, and interlock systems to eliminate uncontrolled action of mechanisms (i.e., the fall of booms, platforms, etc.) in the event of energy failure. Manual actuation of systems shall be provided to return systems to a safe condition should energy failure occur.

3.13.1.3.15 Hydraulic systems shall include such devices as necessary to prevent damage to pumps and/or motors during towing of vehicle.

3.13.1.3.16 Hydraulic rams shall be installed so that bending loads are not imposed on the piston rod. They shall not be used directly as jacks or ground locks to stabilize mobile equipment unless approved by the purchaser.

3.13.1.3.17 Test port locations shall be provided at points in the hydraulic system requiring access for pressure adjustments and troubleshooting. Each port shall be plugged with a ¼ in NPT plug or closest standard metric equivalent if applicable.

3.13.1.3.18 The hydraulic tank filler and breather and lines shall be located away from engine and exhaust system components to prevent oil from splashing onto hot surfaces in the event of overflow, leak, or component failure.

3.13.1.3.19 Hydraulic hoses shall conform to the quality of the SAE 100R1 through 100R7, per SAE J517, as applicable.

3.13.1.3.20 All components which are capped when received from suppliers shall have the protective caps left in place until connection is made to each port.

3.13.1.3.21 When charging the hydraulic system with oil, the manufacturer shall take steps to ensure that the oil is free from contamination. The supply container shall be protected from water and dirt contamination during storage. All transfer containers and fittings shall be thoroughly cleaned and dried prior to use to prevent contamination from dirt, water, and other fluids.

3.13.1.3.22 The manufacturer shall operate all segments of the hydraulic system for a period of 1 hour to thoroughly circulate the hydraulic fluid, remove the hydraulic filter element, examine for contaminants, and replace with a new element. This shall be repeated until the used filter shows no evidence of contaminants. In the case of dead end lines to actuators, provisions for bleeding shall be made and measures shall be taken to ensure that fluid not normally being recirculated shall be made to do so during the cleansing period to ensure that all fluid, lines, and components are clean.

3.13.1.3.23 Pressure vessels such as air receivers shall comply with all applicable requirements of the ASME Unfired Pressure Vessel Code, Section VIII. Such equipment shall bear an ASME "U" Code Label and certification.

3.13.1.3.24 Adequate self-draining filters shall be provided in all pneumatic systems.

3.13.1.3.25 Manufacturers shall furnish sufficient details of their proposed hydraulic and pneumatic systems to allow an engineering evaluation.

3.13.1.4 Engines and Related Equipment

3.13.1.4.1 All engines shall be selected, rated, and certified for continuous duty in accordance with the criteria of ARP1052. Any deviation from this requirement must be expressly specified by the controlling specification.

3.13.1.4.2 Liquid coolant systems shall be rated for maximum engine loads under the above conditions, or at the conditions of maximum intermittent output approved by the engine manufacturer, whichever criterion results in the largest heat transfer capacity.

3.13.1.4.3 A dry cartridge intake air filter shall be securely mounted in position and shall prevent the emission of flames under backfire conditions. If the engine is to be operated under load in a stationary condition, consideration shall be given to drawing intake air from outside the engine compartment enclosure. Pressure drop across the air filter at rated speed and load shall meet the engine manufacturers' recommendations.

3.13.1.4.4 A full flow oil filter shall be installed for the engine oil system.

3.13.1.4.5 All liquid fillers, drains, dipsticks, and filters shall be readily accessible for convenient servicing.

3.13.1.4.6 Where practical, all driven equipment shall be installed so that the engine is unloaded during cranking (starting). Exceptions shall be noted and explained.

3.13.1.4.7 The support documents listed in paragraph 9 of ARP1052 shall be provided for each engine application.

3.13.1.4.8 Spark plugs and other ignition system components shall be readily accessible for maintenance. Molded weatherproof boots on the ignition wiring for installation over the spark plugs shall be provided.

3.13.1.4.9 An engine driven alternator shall be installed for charging storage batteries. The alternator capacity shall supply at least 100% of the maximum expected vehicle electrical steady load at engine idle, and at least 120% at 1000 engine rpm.

3.13.1.4.10 The engine shall be equipped with emission and noise control devices required by Federal Law as of the date of manufacture of the engine.

3.13.1.4.11 Gasoline powered engines shall meet performance requirements without requiring premium grades of fuel. Diesel powered engines shall be certified for low sulfur or ultra low sulfur (ULSD) diesel fuel. LPG engines shall be certified for (Natural Gas Producers Association) HD-5 motor fuel. Similar considerations should be given for use of alternate fuels currently being used in other industries and those in development, e.g. ethanol or bio-diesel.

3.13.1.4.12 Engine coolant antifreeze shall be ethylene glycol base. The mixture shall be of adequate strength to give protection down to -30 °F (-34 °C). The manufacturer must obtain written approval to use other than Federal Specification O-A-548a, Type II, antifreeze, or equivalent. For vehicles to be operated at lower temperatures, greater protection should be specified in the procurement document.

3.13.1.4.13 Each engine shall be equipped with an hour meter, hour meter vibration dampener, and oil pressure switch.

3.13.1.4.14 An emergency engine kill switch shall be provided at a location other than in the vehicle cab when the cab is equipped with a standard engine ignition switch. For vehicles with an auxiliary engine, an emergency engine kill switch shall also be provided in the cab. Activation of an emergency engine kill switch shall immediately shutdown all power sources. Switch circuitry shall be such that once activated, and until manually reset, restarting and/or cranking of the engine starter(s) shall be impossible.

Emergency stop switches shall be suitably identified, red mushroom, push to operate type buttons. They shall be conveniently located and easily accessible but not so as to provide a potential for accidental activation.

3.13.1.4.15 During stationary operation when power and speed (rpm) is not required to be constant, a demand throttle actuated by the control functions will be installed.

3.13.1.4.16 Diesel engines must be equipped with a fuel shutoff or an air box shutoff actuated by the emergency kill switch(s).

3.13.1.5 Fuel System Design

3.13.1.5.1 Gravity feed fuel systems shall not be used.

3.13.1.5.2 Fuel lines shall be of seamless annealed copper or steel tubing. Copper tubing shall have a wall thickness not less than 0.035 inch (0.89 mm). Steel tubing shall have a wall thickness not less than 0.028 inch (0.71mm) and shall have a corrosion resistant exterior coating.

3.13.1.5.3 Fuel lines shall be well supported with adequate clearance from exhaust lines and electrical system parts.

3.13.1.5.4 Flexible tubing shall be used to absorb vibration and prevent fatigue due to vibration. This is especially applicable for fuel line connections between the frame and flexible mounted engine. Such connections shall be designed so as to prevent siphoning in the event of failure of a flexible section.

3.13.1.5.5 The fuel tank shall have sufficient capacity to permit operation of the vehicle for a normal 8 hour shift.

3.13.1.5.6 Fuel tanks shall be located and installed so that any overflow during filling, or any leakage from the tank, lines, or fittings will not impinge on the engine, exhaust system or electrical equipment, or enter the operator's compartment. Fuel tanks and lines shall be located so as to be protected from damage in the event of collision or during parking or docking.

3.13.1.5.7 All custom-made fuel tanks shall be equipped with a drain plug on the bottom of at least 0.250 inch (6.35 mm) diameter.

3.13.1.5.8 Fuel tank fillers shall comply with Federal Standards for automotive equipment and shall be accessible from ground level at the outside of the equipment. A permanent placard shall be installed adjacent to the filler indicating the type fuel to be used.

3.13.1.5.9 All fuel tank fill openings shall be equipped with a self-closing fill and attached vent cap. The filler and tank shall be designed to provide a minimum fill rate of 10 gallons per minute (0.63 L/s) through the fill cap and filler neck without splash back for tanks of up to 25 gallon (95 L) capacity. Larger tanks shall have a minimum fill rate of 20 gallons per minute (1.26 L/s).

3.13.1.5.10 A nonfluctuating type fuel quantity indicator shall be provided in a location readily visible to the operator. When fuel for more than one system is supplied from a single tank, the tank outlets shall be designed so that the propulsion engine is the last system affected as the tank approaches empty.

3.13.1.5.11 The installation of the fuel system shall conform to applicable requirements of Sections 393.65, "All Fuel Systems", and 393.67, "Liquid Fuel Tanks", Title 49, Code of Federal Regulations in effect at the time of manufacture.

3.13.1.6 Exhaust System Design

3.13.1.6.1 Engine back pressures introduced by the complete exhaust system shall not exceed the engine manufacturers' recommendations.

3.13.1.6.2 If specified in the controlling specification, engine exhaust systems shall be equipped with flame and spark arresting mufflers.

3.13.1.6.3 The exhaust system shall be routed clear of all fluid lines and fuel and electrical system components. If routed through areas where leakage of oil, grease, or fuel could occur, the exhaust system shall be shielded from direct contact by such leakage.

3.13.1.6.4 Exhaust system arrangement and routing shall be planned so as to optimize the acoustical requirements outlined in 3.11.1.

3.13.1.6.5 Wherever possible flexible exhaust tubing is not to be used.

3.13.1.6.6 Piping and components shall be installed so that susceptible items such as tires, hoses, etc. are not exposed to undesirable heat.

3.13.1.6.7 The exhaust system discharge shall be located so that gases will not enter the operator's position or compartment whether the equipment is stationary or in motion. The discharge shall not be directed toward the pavement or the aircraft.

3.13.1.6.8 The exhaust pipe shall terminate a minimum of 18 inches (457 mm) above the ground when possible.

3.13.1.7 Self-Propelled Vehicles

Where possible and practical, the following requirements apply to units with conventional automotive truck chassis and to those with specialized nonautomotive chassis.

3.13.1.7.1 Structure and Running Gear

3.13.1.7.1.1 Where practical, the minimum ground clearance shall be 8 inches (203 mm) when the vehicle is loaded to its normal operating weight.

3.13.1.7.1.2 Where practical, the chassis frame rails shall be lower than any part of the engine, transmission or driveline except the differential housing to protect the components against high crowning damage.

3.13.1.7.1.3 Attachment to frame members shall be made following the chassis manufacturers' recommended processes.

3.13.1.7.1.4 Components attached to the chassis shall be located such that ground and approach clearances are not reduced.

3.13.1.7.1.5 The frame rails shall be designed so that a minimum calculated factor of safety of 3, based on specified yield strength, is maintained under the most severe static load condition.

3.13.1.7.1.6 Extensions of truck chassis frame lengths are permissible only when such alterations are behind the rear hanger of the rear spring and shall not be for the purpose of extending the wheelbase.

3.13.1.7.1.7 Holes in top or bottom flanges of truck chassis frame side rails are not permitted except as provided in the original chassis frame.

3.13.1.7.1.8 Where practical, under full rated load, the minimum approach angle shall be 16 degrees (0.279 rad.), the ramp breakover angle 10 degrees (0.175 rad.), and the departure angle 10 degrees (0.175 rad.).

3.13.1.7.1.9 Where practical, no portion of the vehicle shall contact the ground with any combination of flat tires. Suitable jack points shall be provided.

3.13.1.7.1.10 The spring suspension system shall be adequate to prevent chassis bottoming under normal operating conditions with a full rated load.

3.13.1.7.1.11 The power train gear ratio (transmission, differential, and driving axle) shall be selected to provide optimum conditions for the engine in respect to engine speed, loads, and fuel economy in accordance with the engine manufacturers' recommendations. Unless otherwise stated, the vehicle design speed for ramp operations shall be considered to be 20 mph (32.2 km/h).

3.13.1.7.1.12 Drive shafts and other rotating mechanisms shall be guarded wherever their failure could result in a fuel tank rupture or cause injury to the operator or persons riding on the vehicle.

3.13.1.7.1.13 Driving axles shall be designed to prevent release of the wheel in the event of axle failure.

3.13.1.7.1.14 Driving wheels shall have sufficient clearance (2.5 inches (63.5 mm) minimum) under normal load to permit the installation of tire chains.

3.13.1.7.1.15 A power steering system shall be provided on all vehicles having a steering axle load of 9000 pounds (4082 kg) or more.

3.13.1.7.1.16 All wheels shall be equipped with fenders or other suitable devices to protect personnel and cargo from mud and spray.

3.13.1.7.1.17 Tires shall not be loaded in excess of the tire manufacturer's load rating.

3.13.1.7.1.18 The design of seats, windshields, and structure shall afford the maximum vision practical for the driver.

3.13.1.7.1.19 Each vehicle intended for normal operation in the sitting position shall be equipped with a full seat within the standard height range, including backrest, for the operator. Each passenger station shall be similarly equipped. Each seat or supporting structure shall be designed to prevent the transmission of excessive vibration or road shock to the occupant. On non-cab equipped vehicles, a hip guard shall be installed on the outside edge of the seat.

3.13.1.7.1.20 Each vehicle operator or passenger station shall have an adequate support, brace, or floor for a footrest.

3.13.1.7.2 Braking Systems

3.13.1.7.2.1 All motorized units shall be equipped with brake systems meeting the requirements of Title 49, Code of Federal Regulations applicable to that class of vehicle and shall meet the requirements of Section 393.51, "Warning Devices and Gauges", with no exceptions.

3.13.1.7.2.2 Power brakes shall be supplied as needed to meet the minimum performance requirements of Section 393.52, "Brake Performance", Title 49, Code of Federal Regulations, with less than 100 pound (45.4 kg) of effort required on the brake pedal.

3.13.1.7.2.3 The parking brake system shall meet the requirements of Section 393.41, "Parking Brake System", Title 49, Code of Federal Regulations unless otherwise specified in the controlling specifications.

3.13.1.7.2.4 The secondary brakes shall be applied by an over-center operating lever actuated by a pulling motion from the operator's normal position or by a ratchet type foot operated device. Lever mechanism adjustments shall not be available to the operator. Minute adjustments provided by some brake levers must be equipped with a positive lock.

3.13.1.7.2.5 The secondary brakes shall be used as an emergency brake in case of failure of the primary brake even though the latter may be comprised of two separate systems. The secondary brakes shall remain applied after initial actuation without further energy input.

3.13.1.7.2.6 Hydraulic four-wheel brake systems shall incorporate a tandem master cylinder to split the hydraulic brakes into two separate systems.

3.13.1.7.2.7 All vacuum brake hose shall conform to SAE J1403.

3.13.1.7.2.8 Air brake systems shall conform to SAE J844, J1402, and J10.

3.13.1.7.2.9 All hydraulic brake hoses shall conform to SAE J1401.

3.13.1.7.2.10 Hydraulic brake fluids shall conform to SAE J1703.

3.13.1.7.2.11 Hydraulic brake line material shall meet or exceed the requirements of SAE J524. Tubing shall be routed, where possible, so that structural members will provide protection from damage. Tubing shall be firmly anchored to prevent vibration.

3.13.1.7.2.12 Brake line tubing shall be formed, bent, and flared using hand or powered tools specifically designed for this application. Hand bending without the use of forming tools is not acceptable.

3.13.1.7.2.13 Brake line connections shall incorporate 45 degree (0.785 rad) double flared tubing (SAE J533) mating with inverted flare type automotive tube fittings (SAE J512).

3.13.1.7.2.14 Brake lines shall be routed away from high temperature areas such as engine block and exhaust system.

3.13.1.7.2.15 Sleeving used to protect the brake lines from abrasion shall be of non-moisture absorbent material.

3.13.1.7.3 Vehicle Cabs

3.13.1.7.3.1 Self-propelled equipment on vendor built chassis shall, where practical, include provisions for equipping the vehicle with an operator's cab. The following specifications apply to cab designs, when the cab is not an integral part of the vehicle as furnished by the automotive chassis manufacturer.

3.13.1.7.3.2 Insofar as possible, the cab should be an aesthetically pleasing adjunct to the vehicle, contributing to, not detracting from, the styling.

3.13.1.7.3.3 The installed height shall be kept to a minimum. A minimum of 3 inches (76.2 mm) of headroom shall be maintained when an operator of normal height and build (approximately 5 feet 9 inches) (1.75 m) is seated erect.

3.13.1.7.3.4 The cab shall be fabricated of rigid structural material, strong enough to provide the occupant with a degree of protection that is appropriate to the configuration and intended function of the vehicle, and to its operational environment.

3.13.1.7.3.5 Bare window area shall be as large as practicable.

3.13.1.7.3.6 The interior finish shall be smooth and impervious to water.

3.13.1.7.3.7 If turn signals are specified, the rear signal lamps may be specified as mounted high on the rear of the cab. Therefore, suitable wiring should be provided and stubbed off. This also would be true of provisions for clearance lights.

3.13.1.7.3.8 The cab shall be provided with rugged, rigid doors removable for summer operation. Doors shall have a minimum swing of 75 degrees between the closed and open positions.

3.13.1.7.3.9 Door handles, latches, and hinges shall be rugged, positive, and easily maintainable on all equipment, and shall conform to the requirements of FMVSS, Title 23, Chapter 2, Standard No. 206 "Door Latches and Door Hinge Systems – Passenger Cars" on units equipped for highway travel.

3.13.1.7.3.10 At least 50% of the door glazing shall be capable of being opened. This may be done with vertically split windows, sliding on horizontal tracks, or dropping down into the door controlled by more conventional crank and regulator mechanisms.

3.13.1.7.3.11 All glazing shall conform to the requirements of FMVSS No. 205, "Glazing Materials". Expensive plane or compound curved glazing is to be avoided.

3.13.1.7.3.12 A cab heater and a defroster for the entire windshield, of the heated air/blower type is to be provided on all units with cab. Installation and sizing should conform to FMVSS No. 103, "Windshield Defrosting and Defogging Systems".

3.13.1.7.3.13 Standard automotive interior mirrors shall be provided on all cab units on which vision through the rear window is not blocked by body or van.

3.13.1.7.3.14 Cab design shall preclude sharp edges or corners or protrusions which could cause injury to operators during operation.

3.13.1.8 Instruments and Controls

3.13.1.8.1 Controls and controlling circuits shall be designed such that any failure within a control or its circuitry will not introduce an unsafe operating condition.

3.13.1.8.2 Controls shall be grouped and located so as to be convenient to the operator when at their normal operating station but shall be located so as not to permit clothing to catch accidentally on them. Controls for operating the vehicle from the driver's seat shall be located and identified as specified in FMVSS No. 101, "Controls and Displays".

3.13.1.8.3 Controls shall be designed in accordance with the requirements of MIL-STD-1472.

3.13.1.8.4 Controls shall be designed for satisfactory operation when the operator is wearing heavy arctic type gloves and overshoes.

3.13.1.8.5 Controls shall be identified with permanently affixed and non-fading placards.

3.13.1.8.6 Controls shall be placarded in sharp color contrast in large enough letters or pictograms to be easily read from the operator's position indicating the function and direction of motion of the control.

3.13.1.8.7 Control panels shall provide easy accessibility of controls and instruments and shall contain all items necessary for the safe operation and control of the equipment. The panel controls and instruments shall be suitably identified and distinctly divided between prime mover and any ancillary equipment.

3.13.1.8.8 All instruments and control panels shall be lighted to a level of 5 foot-candles (54 lx) of illumination, and shall not produce a glare to the operator.

3.13.1.8.9 Instruments and controls exposed to the weather shall be of a ruggedized, weatherproof type and shall be protected from ice and snow accumulations.

3.13.1.8.10 No more than 33 pound (146.8 N) of force shall be required to actuate any hand control. No more than 100 pound (444.8 N) of force shall be required to actuate any pedal control.

3.13.1.8.11 Controls, except transmission selector levers, shall move and operate in the direction of travel of the controlled function.

3.13.1.8.12 ON-OFF switches shall be ON when in the up or forward position.

3.13.1.8.13 Transmission selector levers shall conform with requirements of FMVSS No. 102, "Transmission Shift Lever Sequence, Starter Interlock, and Transmission Brake Effect", as applicable; or shall move from Reverse to Neutral to Drive when moved toward the driver. Park position shall be provided unless otherwise specified in controlling documents.

3.13.1.8.14 Motion controls, except the transmission selector lever, shall be of the deadman type, returning to Neutral position when released.

3.13.1.9 Equipment Stability

The stability of the unit will be stated in terms of Stability Ratio. The Stability Ratio is defined as the ratio of the restoring moment to the overturning movement. If the ratio is greater than one, the unit is increasingly stable as the ratio increases. If the ratio is less than one, the unit will overturn.

3.13.1.9.1 The unit in operating condition, in its most unstable configuration, shall have a minimum stability ratio of at least 1.2 when exposed to a wind load or jet blast of 19.4 pound/feet^2 (928.9 Pa) (80 mph) (128.7 km/h) applied from the direction most likely to cause instability. It must also withstand a wind load of 24.4 pound/feet^2 (1168.3 Pa) (90 mph) (144.8 km/h) without overturning. Wind or jet blast unit forces shall be based on:

$$F = .00252V^2C_D \quad \text{Eq. 1)}$$

where: C_D is the drag coefficient, assumed to be 1.20, $0.00252V^2$ is the stagnation pressure of dry air at 68 °F (20 °C) and standard atmospheric pressure with velocity of V miles per hour, and F is the unit force in pounds per square foot.

3.13.1.9.2 The manufacturer shall maintain calculations and/or test data per ARP1328 which indicates the stability of the unit.

3.13.1.9.3 If stabilizers, outriggers, and/or spring lockouts are used or combinations of same or similar devices to gain stability, calculations or test data shall be developed both with and without the devices.

3.13.1.10 Options

Manufacturers shall design the following options as a minimum group. Inclusion of the options on specific equipment will be specified in the controlling specification.

3.13.1.10.1 The fuel tank(s) shall have standpipes of different heights and a manual reserve cut-in valve so that the vehicle has approximately a 5 gallon fuel reserve capacity. The minimum distance between the low standpipe and the bottom of the fuel tank is to be 0.50 inch (12.70 mm) to provide a sump area for contaminates.

3.13.1.10.2 Engines which operate at governed speed to drive equipment other than the vehicle propulsion system shall be equipped with a tachometer which is greenlined within the correct operating revolutions per minute range and red lined above this range. The tachometer shall be permanently mounted on the engine instrument panel.

3.13.1.10.3 The engine(s) shall be equipped with an adjustable speed limiting governor. The type used shall be designated in the controlling specification.

3.13.1.10.4 Low engine oil pressure and low coolant level devices equipped to do either or both of the following as defined in the controlling specification.

a. Shut down the engine

b. Indicate on an annunciator the nature of the malfunction

3.13.1.10.5 The hydraulic system shall have a high pressure filter of 20 µm abs rating or less according to pump or component manufacturer's specification on maximum particle size. The filter shall be provided with a differential pressure indication actuated or "redlined" at maximum allowable pressure differential.

3.13.1.10.6 A hot water or hot oil (for use with oil cooled engines) heat-exchanger cab heater capable of producing approximately 5000 Btu (5.3 MJ) per hour.

3.13.1.10.7 Tropical treatment for moisture and fungus resistance.

3.13.1.10.8 Engine speed controls for operating lifts, belts, etc. shall be on a demand throttle basis to a predetermined operating speed.

3.13.1.10.9 Provision for towing fore and aft.

3.13.1.10.10 Cab skylights of maximum practical size.

3.13.1.10.11A starter motor circuit cutout to prevent damage to the starter or ring gear once the engine is running.

3.13.1.10.12Magnetic drain plugs shall be installed in the engine crankcase, transmission and differential.

3.13.1.10.13Flame and spark arresting muffler.

3.13.1.10.14On lift equipment, an emergency lowering system operable from the aerial device.

3.13.1.10.15All hydraulic conductors shall be number coded at each coupling point such as manifolds, valves, motors, etc. The line code shall be noted on the hydraulic schematic supplied in the maintenance manual.

3.13.1.10.16A shutoff valve shall be incorporated in the supply line between the reservoir and the pump or filter as applicable.

3.13.2 Materials, Parts, and Processes

3.13.2.1 All parts and materials needed to fabricate, assemble, and finish the equipment shall be furnished by the manufacturer unless otherwise specified.

3.13.2.2 All materials and components assembled or fabricated into the equipment shall be new and unused, of high grade quality, of current production, and free from all defects or imperfections which might affect the serviceability or appearance of the finished product.

3.13.2.3 Fire resistant and nonmoisture absorbing materials shall be used wherever possible.

3.13.2.4 Supplier shall advise whether metric or U.S. standard (inches) hardware will be provided.

3.13.2.5 All bolted, screwed, and threaded fastenings shall incorporate adequate locking devices. Safety wiring shall be incorporated in critical applications.

3.13.2.6 Weldments requiring alignment with assemblies, interchangeability, fit, and flatness shall be fabricated with the use of fixtures capable of maintaining dimensions in the finished part within design tolerance.

3.13.2.7 Specified sections and weld design and application shall be such that heat distortion of plates and members is minimized in the final weldment.

3.13.2.8 Components must be installed per the manufacturers' recommendations. Modification of the component which could affect its performance must be approved in writing from the manufacturer of the component and the purchaser so advised. Any modified component should be identified as such to the purchaser for purposes of interchangeability.

3.13.2.9 All components shall be chosen to be within their manufacturer's published ratings under most severe conditions of operation. This shall include but not be limited to the following:

a. Hydraulic Components: Pressure, temperature, flow ratings for hydraulic components, and fluid.

b. Chassis Components: Load rating of tires, axles, springs, transmission, driveline, engine, and power takeoff.

c. Mechanical Components: Speed, torque, force, environment, lubrication means, and expected service life of chains, belts, sheaves, sprockets, shafts, bearings, gears, etc.

d. Electrical Components: Voltage, current, load characteristics, and duty cycle of electrical components.

e. Others: For components proprietary to the manufacturer, design shall conform to established industry practices.

3.13.2.10 Fastener heads shall not be located on rub or wear surfaces unless recessed below the surface.