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VEHICULAR PERFORMANCE

Recommendations for

AIRCRAFT RESCUE AND FIRE FIGHTING VEHICLES

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National Fire Protection Association

International

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection. Its membership includes national and regional societies and associations (list on outside back cover) and twenty thousand individuals, corporations, and organizations. Anyone interested may become a member; the annual dues are $15.00. Full membership information is available on request.

This is one of a large number of publications on fire safety issued by the Association. All NFPA standards and recommended practices, including this text, are prepared by the technical committees of the NFPA and adopted at an Annual Meeting of the Association. They are intended to prescribe reasonable measures for minimizing losses of life and property by fire.

This text and most other NFPA standards and recommended practices are published in the **National Fire Codes,** a compilation of NFPA's official technical material, issued in seven clothbound volumes. Full information on the availability of these Codes and other NFPA publications can be secured from the Association.

Official NFPA Definitions

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations, or that which is advised but not required.

APPROVED refers to approval by the authority having jurisdiction.

Units of measurements used here are U. S. standard. 1 U. S. gallon = 0.83 Imperial gallons = 3.785 liters. One foot = 0.3048 meters. One inch = 25.40 millimeters. One pound per square inch = 0.06805 atmospheres = 2.307 feet of water.

Approved Equipment

The National Fire Protection Association does not "approve" individual items of fire protection equipment, materials or services. The suitability of devices and materials for installation under NFPA standards is indicated by the listing of nationally recognized testing laboratories, whose findings are customarily used as a guide to approval by agencies applying these standards. Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada, the Factory Mutual Laboratories and the American Gas Association (gas equipment) test devices and materials for use in accordance with the appropriate standards, and publish lists which are available on request.

Discount Prices on this Pamphlet

The following schedule of discount prices for multiple copies of this pamphlet have been established:

6–11 copies: 10%	24– 47: 20%
12–23 copies: 15%	48–100: 25%

Over 100: Special Quotation

Vehicular Performance

Recommendations for

Aircraft Rescue and Fire Fighting Vehicles

NFPA No. 414 — 1962

The Vehicular Performance Recommendations for Aircraft Rescue and Fire Fighting Vehicles were developed by the Sectional Committee on Aircraft Rescue and Fire Fighting through the following Subcommittee:

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In 1960 a tentative edition of these recommendations was adopted by the Association. At the 1961 Annual Meeting, the Committee recommended adoption of a final edition, but at the NFPA Annual Meeting in that year, the report was returned to the sponsoring Committee for further study as a result of the submittal of a minority report and the presentation of criticisms at the open meeting. When the report was referred back, a recommendation was made that prior to resubmittal, the proposed recommendations should be coordinated with the NFPA Committee on Fire Department Equipment.

During the latter half of 1961 and early 1962, this report was further processed at meetings of the Subcommittee, the Sectional Committee on Aircraft Rescue and Fire Fighting, and the Steering Committee of the NFPA Committee on Fire Department Equipment. At the 1962 Annual Meeting, the revised draft of these proposals was approved by the NFPA membership. They incorporate the recommendations of the three Committees mentioned above as endorsed by the NFPA Committee on Aviation.

Attention is called to the companion publications of the Association dealing with Aircraft Rescue and Fire Fighting at Airports and Heliports, particularly NFPA Nos. 402, 403, 406 and 412. A listing of these publications and their brief titles is given on the inside back cover of this publication.

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Vehicular Performance Recommendations for Aircraft Rescue and Fire Fighting Vehicles

NFPA No. 414

PART I — SCOPE AND PURPOSE

11. Scope.

111. These vehicular performance recommendations apply to aircraft rescue and fire fighting vehicles intended to carry rescue and fire fighting equipment for rescuing occupants and combating aircraft fires in disabled or burning aircraft on, or in the vicinity of, an airport. For the purpose of simplification, these vehicles will hereinafter be referred to simply as "vehicles." The basic NFPA recommendations on the use and provision of this equipment are contained in "Suggested Standard Operating Procedures, Aircraft Rescue and Fire Fighting" (NFPA No. 402), and "Suggestions for Aircraft Rescue and Fire Fighting Services at Airports and Heliports" (NFPA No. 403).

12. Purpose.

121. These performance recommendations on the desired vehicular capabilities of aircraft rescue and fire fighting vehicles are proposed as a guide to airport operators intending to purchase such equipment. These recommendations do not cover the design and operating capabilities of the fire fighting equipment mounted thereon. Reference is made to the design and operating capabilities of the fire fighting equipment only to the extent that this equipment affects essential vehicle performance.

122. These performance recommendations are intended to outline features and components which, when assembled, will produce an efficient and capable vehicle for both on-and-off pavement performance. The features outlined herein affecting the vehicular capabilities of these vehicles are considered advisable for their proper operation on and off paved surfaces with particular emphasis on their off-pavement capability. This latter feature is particularly important to assure timely and effective response of these vehicles to aircraft accident sites across terrain

which might halt or delay standard highway equipment. The omission of any of the features outlined should be done only with complete knowledge of how it or they will affect the vehicle's performance capabilities.

123. The essential elements of vehicle construction and performance for this service are included herein. Drafting of complete specifications for bidding purposes is the responsibility of the user, who should take into consideration local problems, exercising care against inclusion of provisions which may conflict with the recommendations set forth herein.

124. Two categories of vehicles are described in these recommendations in accordance with the NFPA Suggestions for Aircraft Rescue and Fire Fighting Services at Airports and Heliports (NFPA No. 403).

1241. MAJOR FIRE FIGHTING VEHICLES with a gross weight of four (4) tons or more.

1242. LIGHT RESCUE VEHICLES with a gross weight of under four (4) tons.

1243. Because of the broad range covered by the category MAJOR FIRE FIGHTING VEHICLES, this category is divided into classes according to gross vehicle weight (see Part II, Paragraph 212). Certain recommendations, such as acceleration and tire size are adjusted in recognition of differing needs of the vehicles in the various classes.

13. Responsibility of Contractors (Suppliers).

131. The emergency nature of aircraft rescue and fire fighting services requires that a high level of competence, reliability, and experience be demanded of contractors building equipment for such service. Materials used in fabrication must be of superior character.

132. The contractor must assume complete responsibility for all component parts of the complete vehicle, even though major portions may be sub-contracted. This responsibility shall include design, construction, inspection, performance test, and servicing. The purchaser should ascertain that the contractor is capable of furnishing parts and technical assistance to the purchaser for the normal life of the vehicle (10 years).

NOTE: Responsibility for servicing shall not include those components supplied to the contractor by the customer, unless so specified in the contract.

133. The contractor shall also be responsible for assuring that the vehicular performance of the vehicle meets these recommendations (as they may be modified) and thus qualify as a well-designed aircraft rescue and fire fighting vehicle.

134. All major components shall have the manufacturer's rating for this type service and these ratings shall not be exceeded by actual imposed loads.

135. A one-year warranty shall be supplied by the contractor.

136. Bidders should be required to furnish with the bids a detailed description of the vehicles offered, and drawings showing general arrangement, weights, and dimensions. Data similar to that provided for in the Questionnaire contained in Part V should also be required.

14. Design Principles.

141. The vehicle design shall provide for rapid acceleration and high speed; maximum mobility on and off pavements in all seasons and under all weather conditions; ease of operation; safety; reliability; and accessibility for repairs and maintenance.

142. All-wheel drive for off-pavement operation is essential and shall be achieved without sacrificing any of the attributes of high performance, high speed vehicles. Weight shall be distributed substantially equal over all wheels with maximum tire loads limited to provide the highest practicable level of performance on soft, slippery or rough terrain.

143. Special design consideration shall be given to the saving of weight wherever possible, insofar as it can be accomplished while retaining a large factor of safety on wearing and stressed members. This can be accomplished through the use of light-weight construction wherever possible.

144. Performance requirements outlined in these Recommendations shall be met with the vehicle in an in-service condition.

PART II — MAJOR FIRE FIGHTING VEHICLES

21. General.

211. The category of major vehicles encompasses a gross vehicle weight range commencing at 4 tons (8,000 lbs.) and extending to over 45,000 lbs., and in some cases to over 60,000 lbs. Because the same performance cannot be expected of all vehicles within this range, it is necessary to classify vehicles into lesser weight ranges within which an equal level of performance is practicable.

212. Accordingly, the following weight ranges (lbs.) have been established in classes for the purposes of this specification:

Class	Vehicle Weight Range (Pounds)
1	8,000–15,000
2	15,000–20,000
3	20,000–25,000
4	25,000–30,000
5	30,000–35,000
6	35,000–40,000
7	40,000–45,000
8	45,000 and over

213. The weight of a vehicle for purposes of this classification is its gross weight, with all fire fighting and rescue equipment, full load of extinguishing agents, full load of fuel, and complete personnel complement, ready for service.

214. Because of the fact that definite differences in performance exist between classes, it is essential that specifications for purposes of bidding be drawn to limit the maximum gross weight.

NOTE: Variations in gross weight should be permitted because of differences in design and construction, provided the original performance recommendations as contracted for have been met.

22. Weights and Dimensions.

221. Weights.

2211. The gross vehicle weight rating of the chassis as furnished shall equal or exceed the actual gross weight of the fully loaded and equipped vehicle.

2212. Weight should be distributed as equally as possible

over the axles and tires under all conditions of loading. The variation in weight between any two tires or any one axle shall not exceed 5 per cent right and left, or 10 per cent between any two axles.

NOTE: Weight on individual tire shall be determined by weight scale measurement at the ground.

Weight variations between axles shall be based on the average loading of the axles and, between tires, shall be the average loading of the two tires of a given axle.

These recommendations favor the use of single tires and a drive to all wheels. The tires are also required to be of uniform size. Therefore, best performance and traction are possible only by equalizing the weight on individual tires.

Maintaining equalization of weight over the tires under conditions of light load is also essential for best performance, particularly since the load may be lightened so that the vehicle can traverse extremely soft ground.

The conditions of loading considered are those due to addition or discharge of the fire extinguishing medium such as water or chemicals.

2213. Center of gravity of the vehicle shall be kept as low as possible under all conditions of loading. The vehicle shall be capable of resting on a side slope equivalent to a 30 per cent grade without danger of capsizing.

NOTE: The maximum side slope on which a vehicle can rest without capsizing is an indication of its stability and location of center of gravity. Because of the combined effects of spring motion, tire deflection, speed and surface conditions, the ability to rest on a 30 per cent side slope should indicate the ability to operate on a side slope, up to 20 per cent, at slow speed.

A factor that cannot be measured by this test is the effect of movement of water in vehicle tanks while the truck is in motion on rough ground. Baffling of the water tank should mitigate the effect of such movement.

222. Dimensions.

2221. Under-clearances of the chassis shall be sufficient to permit the maximum mobility in soft ground and rough terrain which tire size, weight, and power make the vehicle potentially capable of traversing. The following are the minimum acceptable clearance dimensions and angles:

Angle of Approach	30 degrees
Angle of Departure	30 degrees
Interaxle Clearance Angle	12 degrees
Under-Chassis-Clearance Dimensions:	
Under 30,000 lbs. Gross Weight	12 inches
30,000 lbs. and over Gross Weight	14 inches

Under-chassis-clearance dimensions shall apply to all portions of the chassis except for tires and wheel-mounted brake drums provided that the drums shall not extend more than three inches from the tire line.

NOTE: Certain projections may extend below the minimum clearance provided they are hinged or otherwise constructed so that they will swing clear when striking an object. Generally, however, such projections should be avoided because, in spite of careful design, they are likely to be knocked off in service.

2222. Over-all height, length, and width of the vehicle shall be held to a minimum so as to provide greater maneuverability due to compactness and to facilitate movement on public highways.

NOTE: Over-all width should be checked with local jurisdiction.

2223. Chassis shall be so constructed and body and equipment so mounted that a driver of average height shall be able to see the ground 20 feet ahead when the driver is in his normal driving position without leaving or rising in his seat. He shall be able to see the ground immediately adjacent to the driver's side of the vehicle. It is recommended that mirrors, or other provisions, be made for vision on the opposite side of the vehicle.

NOTE: Best design dictates either a cab forward or cab-over-engine arrangement to insure that the driver is placed sufficiently far forward so that he can see the ground a short distance ahead of the vehicle.

23. Engine.

231. General Performance Recommendations and Arrangements:

2311. The vehicle shall be powered by means of an internal combustion engine(s), with a minimum cubic inch piston displacement as indicated in Paragraph 2313, capable of developing sufficient power under operating conditions to achieve the required rate of acceleration as specified in Paragraph 2312.

NOTE: Turbine-powered vehicles and "air-cushion" vehicles may be used when experience has been accumulated to permit evaluating the capabilities and limitations of vehicles of these types for this specialized service.

2312. The vehicle shall be consistently able, when fully

loaded, of accelerating from 0 to 50 miles per hour on dry level concrete pavement within the following maximum times:

Class	Gross Vehicle Weight (Pounds)	Time (Seconds)
1	8,000–15,000	30
2	15,000–20,000	30
3	20,000–25,000	35
4	25,000–30,000	40
5	30,000–35,000	45
6	35,000–40,000	50
7	40,000–45,000	55
8	45,000 and over	60

The above acceleration times shall be achieved in ambient temperatures varying from 0 degrees F to 100 degrees F and at elevations up to 2,000 feet above sea level unless a higher elevation is specified.

NOTE: The above acceleration requirements at elevations up to 2,000 feet above sea level are intended to ensure acceptable performance at the great majority of airports.

Airports above 2,000 feet should state the elevation at which the vehicle will operate in order to ensure the required performance.

2313. In addition to being capable of meeting the above acceleration requirements, the engine(s) shall also have the following minimum cubic inch piston displacement:

Class	Gross Vehicle Weight (Pounds)	Displacement (Cu. In.)
1	8,000–15,000	300
2	15,000–20,000	400
3	20,000–25,000	475
4	25,000–30,000	525
5	30,000–35,000	590
6	35,000–40,000	700
7	40,000–45,000	800
8	45,000 and over	900

2314. It is recommended that gasoline engines be used for aircraft rescue and fire fighting service due to their higher horsepower-to-weight ratio and greater acceleration capability.

NOTE: In some cases the acceleration time required can be met with engines with less displacement than specified above. Nevertheless, the minimum displacement is specified because of greater over-all performance obtained from larger displacement engines.

On the other hand, it may be that with certain types of engine design the required acceleration cannot be obtained even though engines meeting

the specified minimum displacement are used. In such cases, the acceleration time still stands as a minimum requirement.

The use of high compression or specially modified engines which require high octane or specially blended fuel, and requiring special maintenance, shall be avoided.

See Note following Paragraph 2311.

2315. Where the engine(s) is (are) used to power both the chassis and the fire fighting pumps, provision shall be made to ensure that the operation of the pump will not, under any circumstances, cause either:

a. the engine(s) to stall, or

b. more than a slight, and momentary reduction in engine speed and consequent drop in pump pressure.

The vehicle shall also be capable of full rated capacity while conducting a stipulated mud and sand test.

2316. The engine shall be equipped with a governor which shall be set at not more than the maximum permissible revolutions-per-minute recommended by the engine manufacturer under no-load condition.

2317. The provisions appearing in Sections 232, 233 and 234 contain recommendations for the engine and its accessories and systems which have proven desirable in vehicles for this type service.

232. Engine Cooling Systems.

2321. Liquid Cooled Engines.

a. The cooling system should be of the closed, forced-feed type using a circulating pump. The radiator, cylinder block, cylinder head, fan and water pump shall be of ample capacity to permit continuous flow with full load operation of the engine at both stationary and maximum vehicle speed without boiling the coolant under ambient temperature conditions up to 110 degrees F. The cooling system shall be provided with an automatic thermostat for prompt engine warming.

b. Radiator shutters, when furnished for cold climates, shall be of the automatic type, and be designed to open automatically upon failure.

2322. AIR-COOLED ENGINES.

a. Air-cooled engines shall be so designed and installed as to permit the vehicle to stand still and pump for indefinite periods without overheating.

b. Air-cooled engine design and installation shall provide for sufficient rate of flow and distribution of air to hold cylinder head and oil temperatures within manufacturer's prescribed limits under all operating conditions. This shall include full power operation for prolonged periods with ambient temperatures up to 110 degrees F, at both stationary and maximum vehicle speed.

c. Cylinder head and oil temperature gages that clearly indicate maximum permissible operating temperature shall be mounted in the cab and elsewhere, as required, to be plainly visible to the driver.

233. Fuel System.

2331. For gasoline engines, a complete fuel system should include a mechanically driven fuel pump, auxiliary electric fuel pump, fuel strainer and necessary piping, including a flexible fuel line from the fuel pump to the tank line. All fuel lines shall be protected from damage, exhaust heat, and exposure to ground fire.

2332. An accessible strainer shall be provided for each fuel line and a drain shall be provided at the bottom of the fuel tank.

2333. Fuel tanks shall not be installed in such a manner as to permit gravity feed to the carburetor.

2334. Fuel tanks shall be provided with an Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada, or Factory Mutual Engineering Division approved flame arrester relief fitting on the filler opening.

2335. Fuel tank capacity shall be sufficient to provide for two (2) hours pumping at rated capacity.

234. Exhaust System.

2341. The exhaust system shall be of such size as to avoid undue back pressure and shall be located and constructed in such a manner that entrance of exhaust gases into the cab will be minimized under all conditions of operation. Exhaust pipe, muffler and tailpipe shall be of high-grade, rust-resistant materials.

2342. The tailpipe and muffler shall be protected from damage due to traversing rough terrain. Tailpipe shall be designed to discharge to the rear and shall not be directed toward the ground.

24. Vehicle Electrical System.

241. Each gasoline engine shall be equipped with a complete and separate battery starting system. Where greater engine reliability is desired, a complete dual ignition may be required.

242. The vehicle shall be provided with a complete electrical system of either the 12 or 24 volt type.

243. An alternator and rectifier, capable of delivering a minimum of 100 amperes, 12 volts or 50 amperes, 24 volts, shall be provided.

244. Two independent battery systems shall be provided, with a selector switch located in the cab. For 12 volt systems, there shall be two (2) 12 volt batteries, 150 ampere hour capacity each, at 20 hour rate. For 24 volt systems, there shall be two (2) 24 volt batteries, 100 ampere hour capacity each, or four (4) 12 volt batteries, 100 ampere hour capacity each, at 20 hour rate.

245. Provisions shall be provided to permit plugging into local electric power supplies to maintain battery charging.

246. An engine coolant preheating device shall be provided as an aid to rapid starting and high initial engine performance.

247. The electrical system shall be insulated, waterproofed and protected against exposure from ground fires.

NOTE: Radio suppression of the electrical system, sufficient to assure positive operation of radio equipment without interference to any other communications on the airport, shall be furnished when specified.

25. Vehicle Drive.

251. The drive shall provide for the transmission of power from the engine flywheel to the wheels of the vehicle with such multiplication of torque that the vehicle is capable of traveling at all speeds necessary for effective aircraft rescue and fire fighting service. With respect to Classes 3 through 8, the drive shall provide for the continuous transmission of power from the engine through a torque converter or fluid coupling and transmission. The transmission shall have the ability to shift from

any selected ratio to another in sequence, either forward or reverse, without interruption of power transmission.

NOTE: See Note under Paragraph 2311.

252. The entire drive train shall be designed with sufficient torque capacity to slip the wheels of the fully loaded and balanced vehicle on pavement having a coefficient of friction of 0.6. The following drive line components shall be certified by the component manufacturer to be suitable for use in the drive line of the complete vehicle considered as a complete vehicle: clutch and/or torque converter, transmission, transfer case, propeller shaft, differentials and axles.

253. The transmission shall have sufficient range of gears to provide a top speed in highest gear of 50 mph and enough reduction in lowest gear to produce the tractive effort needed to ascend a 50 per cent grade. Spacing of intermediate gears shall provide an adequate number of speeds for all operating conditions without excessive overlap.

254. Positive drive to each wheel is required to negotiate soft ground, unimproved surfaces, snow or ice. Positive wheel drive may be achieved by the use of torque proportioning or no-spin differentials, or by means of other automatic devices which will ensure that each wheel of the vehicle is driven independently of the other wheels.

255. The transfer case may be either separate or integral with the transmission. It shall incorporate a drive to the front and rear axles which is engaged at all times during the intended airport service and which will not allow the vehicle to stall as long as the tires of any axle have traction.

256. Front and rear axles shall have adequate capacity to carry the maximum imposed load under all intended operating conditions. The variations in axle tread shall not exceed 20 per cent of the tire sectional width at rated load. Front and rear axles shall be provided with automatic locking or no-spin differentials or other automatic devices which will lock out differential action whenever any one tire loses traction. When interaxle differentials are furnished with bogie axles, they shall be either automatic locking or no-spin type or be locked out at all times during the intended airport service.

257. It is recommended that front axles be equipped with steering drive ends of the constant velocity type or other provision be made to eliminate objectionable cyclical fluctuations

in angular velocity of the wheels when they are cramped in the steering position.

26. Other Chassis Components.

261. Clutch. When a clutch is used, the actuation pedal pressure to obtain release shall not exceed 50 pounds with adequate displacement for wear prior to normal adjustment.

262. Transmission. Where a fire fighting pump is driven from the chassis engine, provision shall be made in design of the power take-off to allow uninterrupted transmission of power to the pump even though the transmission gears are being shifted, clutch is released, or the transmission is placed in any of its speed ranges.

263. Suspension.

2631. The suspension system shall be designed to allow the vehicles, loaded or unloaded, to travel at high speeds over improved road surfaces, and at moderate speeds over rough, unimproved terrain. Special consideration shall be given to the need for cushioning road shocks, providing adequate wheel motion, and reducing unsprung weight.

2632. Design of the axles and suspension system shall be such that the total unsprung weight of the vehicle will not be greater than 20 per cent of the gross weight of the vehicle when fully loaded.

NOTE: Unsprung weight is that portion of the vehicle weight not carried by the chassis springs.

2633. Design of axles and suspension system shall also provide for an individual wheel motion above level ground of not less than 10 inches for vehicles under 30,000 lbs. gross weight, and 12 inches for vehicles 30,000 lbs. and over gross weight without raising any other wheel off the ground.

2634. Suspension design shall be such that at least two inches of deflection remain before bottoming of suspension on the axle stops or bumpers when the vehicle is fully loaded and on level ground.

2635. Double acting hydraulic shock absorbers shall be furnished on front axles. Front and rear axles shall be furnished with stops for bottoming to prevent damage to axles, propeller shafts, engine oil pan, or any other portions of the chassis which may be damaged by wheel motion beyond allowable amounts.

264. Wheels, Tires and Rims.

2641. Wheels shall be single rim type with tires of identical size and same tread design.

2642. Tires and inflation pressures shall be selected to provide effective performance on the terrain encountered in the intended airport service. For normal terrain conditions, a maximum inflation pressure of 45 pounds per square inch is recommended. For more extreme terrain conditions, lower inflation pressure down to 30 pounds per square inch may be desirable for greater off-pavement mobility. The following Table sets forth recommended maximum loads per tire for standard tire sizes at inflation pressures of 30 pounds per square inch and 45 pounds per square inch.

TIRE LOAD RATINGS

Tire Size	Recommended Load at 30 lb. Inflation	Recommended Load at 45 lb. Inflation	Based on T & R A Table
9.00–16	1,950	2,475	LT–1B
8.25–20	2,390	3,030	EM—3D
9.00–20	2,840	3,590	"
10.00–20	3,200	4,050	"
11.00–20	3,540	4,480	"
12.00–20	4,020	5,080	"
12.00–24	4,520	5,720	"
14.00–20	5,620	7,100	"
14.00–24	6,270	7,920	"
16.00–25	8,200	10,400	"
18.00–25	10,670	13,520	"
18.00–33	12,640	16,000	"
21.00–25	13,640	17,280	"
21.00–29	14,820	18,770	"
24.00–25	16,860	21,340	"
20.5–25	9,590	12,170	WEM–1
23.5–25	12,440	15,760	"
26.5–25	15,530	19,700	"
26.5–29	17,090	21,650	"
29.5–25	19,160	24,210	"

NOTE: Adequate ply rating must be selected as determined by load and inflation to be used (refer T & R A Yearbook). T & R A refers to the Tire and Rim Association.

NOTE: For tire sizes not shown, current ratings may be obtained from the Tire and Rim Association, Inc. (2001 First National Tower, Akron 8, Ohio). The maximum loads in the Table are based on current Tire and Rim Association, Inc. ratings as shown in Tables LT-1B, EM-3D and WEM-1 of their 1961 Year Book.

2643. Actual inflation pressures of the tires with the vehicles in an in-service condition shall be as specified in the Table.

2644. If the vehicle is required to operate on the highway five or more miles beyond the immediate vicinity of the airport at sustained speeds above 30 miles per hour, inflation pressure should be increased to those levels recommended for highway service.

2645. An aggressive tire tread is recommended for general service. Tire manufacturers should be consulted for tread designs to meet special terrain conditions.

2646. Rim contours and sizes shall also be based on current practices of the Tire and Rim Association, Inc.

27. Controlling Mechanisms.

271. Brakes.

2711. Service brakes shall be of the all-wheel type. On vehicles less than 25,000 lbs. gross weight, service brakes may be of the hydraulic type with power booster or the air-mechanical type. On vehicles 25,000 lbs. or more gross weight, service brakes shall be of the air-over-hydraulic or air-mechanical type.

2712. If air-mechanical brakes are furnished, a brake chamber shall be provided for each wheel and shall be mounted so that no part of the brake chamber projects below the axle.

2713. Air brake systems shall include a compressor, release valve, brake control valve, treadle-type actuating pedal, air pressure gage, enclosed-type brake adjusters, low pressure warning, and all necessary connections.

2714. On vehicles less than 25,000 lbs. gross weight, and when supplied with air brakes, the air compressor shall be at least 7 cu. ft. capacity; on vehicles 25,000 lbs. or more gross weight, the air compressor shall be at least 12 cu. ft. capacity. Air compressors shall be lubricated and cooled by the engine lubrication and cooling system.

2715. Compressed air reservoirs will have a minimum capacity of 2,000 cu. in. and shall be equipped with drain and safety valves. Provision for quick build-up of pressure shall be furnished. Quick build-up of tank pressure from 5 lbs. to the pressure regulating valve setting shall be accomplished within 12 seconds.

2716. The service brakes shall be capable of holding the fully loaded vehicle on a 50 per cent grade, and capable of bringing the fully loaded vehicle to five (5) complete successive stops within 30 feet from a speed of 20 mph on dry, hard, approximately level road, free from loose material.

2717. The parking or emergency brake system shall be an entirely independent mechanical system or may be connected to the same brake shoes as the service brakes but through entirely separate mechanical means.

2718. The parking brakes shall be hand lever operated and shall be capable of holding the fully loaded vehicle on a 20 per cent grade.

272. Steering.

2721. All chassis shall be equipped with power assisted steering. The steering mechanism shall be so designed to permit manual steering sufficient to bring the vehicle to a safe stop in the event of failure of power assist.

2722. The power-assisted steering shall have sufficient capacity so that no more than 15 lbs. pull is required on the steering wheel in order to turn the steering wheel from lock to lock with the engine running.

28. Turning Diameter.

281. Wall-to-wall turning diameter of the fully loaded vehicle shall not be greater than three times its over-all length. In the event an 8 x 8 chassis is provided, the turning diameter shall not be greater than three-and-a-half times the over-all length.

PART III — LIGHT RESCUE VEHICLES

31. General.

311. The category of "light rescue vehicles" covers a vehicle with a gross weight of 7,999 pounds or less as indicated in Paragraph 1242 of Part I of these recommendations.

312. The weight of a vehicle for purposes of this classification is its gross weight, with all fire fighting and rescue equipment, full load of extinguishing agents, full load of fuel, complete personnel complement, ready for service.

32. Weights and Dimensions.

321. Weights.

3211. The gross vehicle weight rating of the chassis as furnished shall equal or exceed the actual gross weight of the fully loaded and equipped vehicle.

3212. The actual weight of the fully loaded and equipped vehicle should be distributed as equally as possible over the axles and tires. The variation in weight between any two tires of any one axle shall not exceed 10 per cent right and left nor shall any axle carry less than 40 per cent or more than 60 per cent.

NOTE: Weight on individual tire shall be determined by weight scale measurement at the ground.

This specification requires the use of single tires and a drive to all wheels. The tires are also required to be of uniform size. Therefore, best performance and traction are possible only by equalizing the weight on individual tires.

3213. Center of gravity of the vehicle shall be kept as low as possible under all conditions of loading. The vehicle shall be capable of resting on a side slope equivalent to a 30 per cent grade without danger of capsizing.

NOTE: The maximum side slope on which a vehicle can rest without capsizing is an indication of its stability and location of center of gravity.

Because of the combined effects of spring motion, tire deflection, speed and surface conditions, the ability to rest on a 30 per cent side slope should indicate the ability to operate on a side slope, up to 20 per cent at slow speed.

322. Dimensions.

3221. Under clearances of the chassis shall be sufficient to permit the maximum mobility in soft ground and rough terrain which tire sizes, weight, and power make the vehicle potentially capable of traversing. The following are the minimum acceptable clearance dimensions and angles:

Angle of Approach	30 degrees
Angle of Departure	30 degrees
Interaxle Clearance Angle	12 degrees
Minimum Ground Clearance	8 inches

Under-chassis-clearance dimensions shall apply to all portions of the chassis except for tires and brake drums.

3222. Over-all height, length, and width of the vehicle shall be held to an absolute minimum so as to provide maximum maneuverability due to compactness and to facilitate rapid movement on public highways.

3223. Chassis shall be so constructed and body and equipment so mounted that the vehicle driver shall be able to see the ground 20 feet ahead when a driver of average height is in his normal driving position without leaving or rising in his seat. He shall be able to see the ground immediately adjacent to the driver's side of the vehicle. It is recommended that truck-type mirrors, or other provisions, be made for vision to the opposite side of the vehicle.

33. Engine.

331. General Performance Recommendations and Arrangements.

3311. The vehicle shall be powered by means of an internal combustion engine capable of developing sufficient power under operating conditions to achieve the required performance characteristics.

NOTE: Turbine-powered vehicles and "air-cushion" vehicles may be used when experience has been accumulated to permit evaluating the capabilities and limitations of vehicles of these types for this specialized service.

3312. The vehicle shall be consistently able, when fully loaded, of accelerating from 0 to 50 miles per hour on dry level concrete pavement within 25 seconds. The above acceleration time shall be achieved in ambient temperatures varying from 0 degrees F to 100 degrees F and at elevations up to 2,000 feet above sea level, unless a higher elevation is specified.

NOTE: It is recommended that gasoline engines be used for aircraft rescue and fire fighting service due to their higher horsepower-to-weight ratio and greater acceleration capability. See Note under Paragraph 3311.

The requirement that the vehicle be capable of accelerating from 0 to 50 miles per hour within 25 seconds at elevations up to 2,000 feet above sea level is intended to ensure acceptable performance at the great majority of airports. Airports above 2,000 feet should state the elevation at which the vehicle will operate in order to ensure the same performance.

The use of high compression or specially modified engines which require high octane or specially blended fuel, and requiring special maintenance, shall be avoided.

3313. Where the engine is used to power both the chassis and the fire fighting pumps, provision shall be made to ensure that the operation of the pump will not, under any circumstances, cause either:

a. the engine to stall, or

b. more than a slight, and momentary reduction, in engine speed and consequent drop in pump pressure.

3314. The provisions appearing in Sections 332, 333 and 334 contain recommendations for the engine and its accessories and systems which have proven desirable in crash fire fighting vehicles.

332. Engine Cooling Systems.

3321. LIQUID COOLED ENGINES.

a. The cooling system should be of the closed, forced-feed type using a circulating pump. The radiator, cylinder block, cylinder head, fan and water pump shall be of ample capacity to permit continuous full load operation of the engine at both stationary and maximum vehicle speed without boiling the coolant under ambient temperature conditions up to 110 degrees F. The cooling system shall be provided with an automatic thermostat for prompt engine warming.

3322. AIR-COOLED ENGINES.

a. Air-cooled engines shall be so designed and installed as to permit the vehicle to stand still and pump for indefinite periods without overheating.

b. Air-cooled engine design and installation shall provide for sufficient rate of flow and distribution of air to hold cylinder head and oil temperature within manufacturer's prescribed limits under all operating conditions. This shall include full

power operation for prolonged periods with ambient temperatures up to 110 degrees F, at both stationary and maximum vehicle speed.

c. Cylinder head and oil temperature gages or warning lights that clearly indicate maximum permissible operating temperature shall be mounted in the cab and elsewhere, as required, to be plainly visible to the driver.

333. Fuel System.

3331. For gasoline engines, a complete fuel system should include an electric fuel pump located near the fuel tank to prevent vapor-lock, fuel strainer and necessary piping, including a flexible fuel line from the fuel pump to the tank line. All fuel lines shall be protected from damage, exhaust heat, and exposure to ground fire.

3332. A strainer shall be provided for each fuel line and a drain shall be provided at the bottom of the fuel tank.

3333. Fuel tanks shall not be installed in such a manner as to permit gravity feed to the carburetor.

3334. Fuel tanks shall be provided with an Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada, or Factory Mutual Engineering Division approved flame arrester relief fitting on the filler opening.

3335. Fuel tank capacity shall be sufficient for two hours' operation.

334. Exhaust System.

3341. The vehicle shall be furnished with an exhaust system, tailpipe, and muffler of such size as to avoid undue back pressure and shall be located and constructed in such a manner that entrance of exhaust gases into the cab will be minimized under all conditions of operation. Exhaust pipe, muffler and tailpipe shall be of high-grade, rust-resistant materials.

3342. The tailpipe and muffler shall be protected from damage due to traversing rough terrain. Tailpipe shall be designed to discharge to the rear and shall not be directed toward the ground.

34. Vehicle Electrical System.

341. The vehicle shall be provided with battery starting and a complete electrical system of the 12- or 24-volt type.

342. An alternator and rectifier, capable of delivering a minimum of 60 amps, 12 volts or equivalent power at 24 volts, shall be provided.

NOTE: Alternator capacity should be specified by the electrical load experienced at each airport.

343. A 70 ampere-hour, 12 volt battery or an equivalent in 24 volts shall be provided.

344. Provisions shall be provided to permit plugging into local electric power supplies to maintain battery charging.

345. The electrical system shall be insulated, splashproofed and protected against exposure from ground fires.

NOTE: Radio suppression of the electrical system, sufficient to ensure positive operation of radio equipment without interference to any other communications on the airport, shall be furnished when specified.

35. Vehicle Drive.

351. The drive shall provide for the transmission of power from the engine flywheel to all wheels of the vehicle with such multiplication of torque that the vehicle is capable of traveling at all speeds necessary for effective aircraft rescue and fire fighting service.

NOTE: See Note following Paragraph 3311 regarding turbine-powered and "air-cushion" vehicles.

352. The entire drive train shall be designed with sufficient torque capacity to slip the wheels of the fully loaded and balanced vehicle on pavement having a coefficient of friction of 0.6. The following drive line components shall be certified by the component manufacturer to be suitable for use in the drive line of the complete vehicle considered as a complete vehicle: clutch and/or torque converter, transmission, transfer case, propeller shaft, differentials and axles.

353. The transmission shall have sufficient range of gears to provide a top speed in highest gear of 60 miles per hour and enough reduction in lowest gear to produce the tractive effort needed to ascend a 50 per cent grade. Spacing of intermediate gears shall provide an adequate number of speeds for all operating conditions without excessive overlap.

354. It is recommended that front axles be equipped with steering drive ends of the constant velocity type or other provision be made to eliminate objectionable cyclical fluctuations

in angular velocity of the wheels when they are cramped in the steering position.

355. Rear axles shall be provided with automatic locking or no-spin differentials or other automatic locking devices which will lock out differential action whenever any one tire loses traction. It is recommended that the front axles be similarly equipped.

356. Transfer Case. The transfer case may be either gear or chain operated. If chain is employed, adequate provision shall be made for adjustment of the chain due to wear.

36. Other Chassis Components.

361. Suspension.

3611. The suspension system shall be designed to allow the vehicle, loaded or unloaded, to travel at high speeds over improved road surfaces, and at moderate speeds over rough, unimproved terrain. Special consideration shall be given to the need for cushioning road shocks, providing adequate wheel motion, and reducing unsprung weight.

3612. Design of the axles and suspension system shall be such that the total unsprung weight of the vehicle will not be greater than 15 per cent of the gross weight of the vehicle when fully loaded.

NOTE: Unsprung weight is that portion of the vehicle weight not carried by the chassis springs.

3613. Design of axles and suspension system shall provide for an individual wheel motion above level ground or not less than 8 inches without raising any other wheel off the ground.

3614. Spring design shall be such that at least one inch of spring deflection remains before bottoming of springs on the axle stops when the vehicle is fully loaded and on level ground.

3615. Double acting hydraulic shock absorbers shall be furnished on all axles. Front and rear axles shall be furnished with stops for bottoming to prevent damage to axles, propeller shafts, engine oil pan, or any other portions of the chassis which may be damaged by wheel motion beyond allowable amounts.

362. Wheels, Tires, and Rims.

3621. Wheels shall be single rim type with tires of identical size and same tread design.

3622. Tires and inflation pressures shall be selected to provide effective performance on the terrain encountered in the intended airport service. For normal terrain conditions, a maximum inflation pressure of 45 pounds per square inch is recommended. For more extreme terrain conditions, lower inflation pressure down to 30 pounds per square inch may be desirable for greater off-pavement mobility. The following Table sets forth recommended maximum loads per tire for standard tire sizes at inflation pressures of 30 pounds per square inch and 45 pounds per square inch.

TIRE LOAD RATINGS

Tire Size	Recommended Load at 30 lb. Inflation	Recommended Load at 45 lb. Inflation	Based on T & R A Table
7.00–16	1,250	1,580	LT–1B
7.50–16	1,430	1,815	"
9:00–16	1,950	2,475	"

NOTE: Adequate ply rating must be selected as determined by load and inflation to be used (refer T & R A Yearbook). T & R A refers to the Tire and Rim Association.

NOTE: For tire sizes not shown, current ratings may be obtained from the Tire and Rim Association, Inc. (2001 First National Tower, Akron 8, Ohio). The maximum loads in this table are based on current Tire and Rim Association, Inc. ratings as shown in Table LT-1B of their 1961 Year Book.

3623. Actual inflation pressures of the tires with the vehicles in an in-service condition shall be as specified in the Table.

3624. If the vehicle is required to operate on the highway five or more miles beyond the immediate vicinity of the airport at sustained speeds above 30 miles per hour, inflation pressure should be increased to those levels recommended for highway service.

3625. An aggressive tire tread is recommended for general service. Tire manufacturers should be consulted for tread designs to meet special terrain conditions.

3626. Rim contours and sizes shall also be based on current practices of the Tire and Rim Association, Inc.

37. Controlling Mechanisms.

371. Brakes.

3711. Service brakes shall be of the all-wheel hydraulic type. Power booster shall be furnished when specified.

3712. The service brakes shall be capable of holding the fully loaded vehicle on a 50 per cent grade, and shall be capable of consistently bringing the fully loaded vehicle to a complete stop within 30 feet from a speed of 20 miles per hour on dry, hard, approximately level road, free from loose material.

3713. The parking or emergency brake system shall be an entirely independent mechanical system or may be connected to the same brake shoes as the service brakes but through entirely separate mechanical means.

3714. The parking brakes shall be hand lever operated and shall be capable of holding the fully loaded vehicle on a 20 per cent grade.

372. Steering.

3721. Power steering, if furnished, shall not prevent normal steering in the event of failure of power assist system.

373. Turning Clearance Diameter.

3731. Wall-to-wall turning clearance diameter of the fully loaded vehicle shall not be greater than $3\frac{1}{2}$ times its over-all length.

PART IV — DEFINITIONS

Aggressive Tire Tread:

AGGRESSIVE TIRE TREAD is designed to provide a maximum of traction for all types of service. This would include sand, mud, snow, ice and hard surface, wet or dry.

Air-Cooled Engine:

AIR-COOLED ENGINE is one in which the heat given off from the cylinder walls is directly absorbed by the atmosphere rather than the heat being absorbed by a liquid coolant which acts only as a vehicle for transferring the heat from the engine to a radiator.

"Air-Cushion" Vehicle:

"AIR-CUSHION" VEHICLE is supported by the thrust reaction of a forced air stream acting on the earth's surface (land or water). It is intended to operate close to the surface and may travel over water and all types of level terrain.

Air-Mechanical Brakes:

AIR-MECHANICAL BRAKES are brakes in which the force from an individual air chamber is directly applied to the friction surfaces through a mechanical linkage.

Air Over Hydraulic Brakes:

AIR OVER HYDRAULIC BRAKES are brakes in which the force of a master air cylinder is applied to the friction surfaces through an intervening hydraulic system.

All Wheel Drive:

ALL WHEEL DRIVE is used to describe a vehicle which drives on all wheels such as b, d and e under the definition "Vehicle Types."

Ambient Temperature:

AMBIENT TEMPERATURE is the average temperature of the environment surrounding a vehicle.

Angle of Approach:

ANGLE OF APPROACH is intended to measure the steepest ramp that a fully-loaded vehicle can approach. It is determined by the horizontal ground line and the line tangent to the loaded radius of the front tire extended forward to that fixed point on the vehicle, which will form the smallest angle.

Angle of Departure:
ANGLE OF DEPARTURE is intended to measure the steepest ramp from which the fully-loaded vehicle can depart. It is determined by the horizontal ground line and the line tangent to the loaded radius of the rear tire extended rearward to that fixed point on the vehicle which will form the smallest angle.

Automatic Locking Differential:
AUTOMATIC LOCKING DIFFERENTIAL is a type of non-slip differential that automatically operates, usually by a clutch action in the differential to prevent slippage or loss of traction.

Axle Tread:
AXLE TREAD is the distance between the center of two tires or wheels on one axle. Where dual tires and wheels are used at each end of an axle, the tread is measured as the distance between centers of the pairs of tires or wheels.

Bogie:
BOGIE refers to a combination of two axles used to support the end of a vehicle; therefore, in a 6 x 6 vehicle we have two axles at the rear of the vehicle to support the weight on the rear. This two-axle combination is called a "rear bogie." With an 8 x 8 vehicle, we have two axles in the front and two axles in the rear; therefore, we have a front bogie and a rear bogie.

Center of Gravity:
CENTER OF GRAVITY is the point within a vehicle at which all of its weight may be considered to be concentrated. When a vehicle is tipped to a degree that a vertical line passing through the center of gravity falls on the ground outside the tire track, it is unstable and will turn over.

Chassis:
CHASSIS is the assembled frame, engine, drive train, and tires of a vehicle.

Constant Velocity Type:
CONSTANT VELOCITY TYPE identifies a type of universal joint that is free from cyclical variation in speed of the driven shaft for all angles of operation in relation to the speed of the driving shaft. Non-constant velocity universal joints may have a variation of 25% in speed at an angle of 28° which represents the cramp angle for driving front axles.

Cooling Preheater Device:

COOLING PREHEATER DEVICE is a device for heating the engine coolant so that the engine is maintained at a constant temperature. It usually consists of a coolant jacket and an electric heating element. The engine coolant flows through the preheater jacket and is heated by the heating element which obtains its power from an outside source, thereby holding the engine coolant at a constant temperature for fast starting.

Cubic Inch Piston Displacement:

CUBIC INCH PISTON DISPLACEMENT is intended to measure the total volume displaced by one complete stroke of all the pistons in an engine. It is defined by the following equation:

$$\text{Disp.} = 0.785\ B^2SN$$

Where B = Engine Bore, Inches
S = Engine Stroke, Inches
N = Number of Cylinders

Dual Ignition:

DUAL IGNITION (complete) may best be defined as an ignition system which has two spark plugs in each cylinder, two distributors, two coils, two sets of batteries and two ignition switches. Each system operates entirely independent of the other.

Fluid Coupling:

FLUID COUPLING is a turbine-like device which transmits power solely through the action of a fluid in a closed circuit without direct mechanical connection between input and output shafts, and without resulting in torque multiplication.

Individual Wheel Motion:

INDIVIDUAL WHEEL MOTION is the vertical motion or movement of one wheel on a vehicle without producing movement of any other wheel.

In-Service Condition:

IN-SERVICE CONDITION is a state or condition of readiness for intended duty. Usually an emergency vehicle properly serviced with all equipment properly loaded and ready for immediate response.

Intended Airport Service:

INTENDED AIRPORT SERVICE includes all aspects of aircraft rescue and fire fighting services, as set forth in NFPA No. 403 and in

NFPA No. 414, Paragraph 111. It is continuous and extends geographically to the areas defined in Paragraphs 131, 382, 383, and 384 of NFPA No. 403.

Interaxle Clearance Angle (Ramp Angle):

INTERAXLE CLEARANCE ANGLE, or RAMP ANGLE, is intended to measure the ability of a fully-loaded vehicle to negotiate a ramp without encountering interference between the vehicle and the ramp between any two axles. It shall be determined by the horizontal ground line and whichever of the following lines forms the smaller angle:

a. The line tangent to the loaded radius of the front tire, extended rearward to that fixed point on the vehicle, ahead of a vertical line midway between the two axles, which will determine the smallest angle.

b. The line tangent to the loaded radius of the rear tire extended forward to that fixed point on the vehicle, behind a vertical line midway between the two axles, which will determine the smallest angle.

Interaxle Differential:

INTERAXLE DIFFERENTIAL is a differential in the line of drive of any two axles. Its purpose is to eliminate tire slippage and excessive tire wear. Also to proportion the driving power in proportion to available traction.

Light Weight Construction:

LIGHT WEIGHT CONSTRUCTION is intended to indicate the use of non-ferrous metals or plasters or a reduction in weight by the use of advanced engineering practices resulting in a weight saving without sacrificing strength or efficiency.

No-Load Condition:

NO-LOAD CONDITION is an engine with standard accessories operating without an imposed load, with the vehicle drive clutches and any special accessory clutches in a disengaged or neutral condition.

"No-Spin" Differential:

"NO-SPIN" DIFFERENTIAL is a registered trade mark for a non-slip differential manufactured by Detroit Automotive Products Corporation. The name is generally used to describe or indicate a specific type of non-slip differential. The "No-Spin" differential is automatic in operation, providing equal power to

each wheel in an axle when equal traction is obtained. When traction on one wheel decreases in mud or snow or on a slippery surface, the differential automatically transfers driving power to the wheel having traction. Such power transfer can be as much as 100% of driving power or to the limit of traction.

Off Pavement Performance:

OFF PAVEMENT PERFORMANCE may best be defined as the vehicle's ability to perform or operate on other than paved surfaces. This other than paved surfaces includes dirt roads and trails, open cross country of all kinds. This ability factor is sometimes referred to as off road mobility or cross country mobility. All of these terms are synonymous.

Over-All Height, Length and Width:

OVER-ALL dimensions shall be determined with the vehicle fully loaded and equipped unless otherwise specified, and shall include all fixed protrusions which could in any way hinder the passage of the vehicle. Dimensions over movable protrusions shall be determined with the protrusion in its normally stored position.

Per Cent Grade:

PER CENT GRADE is the ratio of the change in elevation to the horizontal distance traveled multiplied by 100. A change in elevation of 50 feet over a horizontal distance of 50 feet is the equivalent of a 100% grade.

Power Assist Steering:

POWER ASSIST STEERING is a system using hydraulic or air power to aid in the steering assist. This system is supplementary to the mechanical system to preserve steering ability in event of power failure.

Radio Suppression:

RADIO SUPPRESSION consists of suppressing the ignition noises which normally interfere with radio transmission and reception. There are three common types of radio suppression, namely, SAE-RMA, MILITARY and HALLETT.

(a) SAE-RMA shielding consists only of resistors for spark plugs and distributor.

(b) MILITARY suppression includes metal shielding for spark plugs, metal box housing for coils and distributors and metal covered ignition wiring.