Proposed Revision to NFPA No.

414-T

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Aviation

Tentative Vehicular Performance Recommendations

for

AIRCRAFT RESCUE AND FIRE FIGHTING VEHICLES

May, 1961

May, 1961

NOTICE

This pamphlet circulates for review and comment the Proposed Revision to the NFPA Tentative Vehicular Performance Recommendations for Aircraft Rescue and Fire Fighting Vehicles, Part I, II and III, which were submitted *but not adopted* at the May 1961 NFPA Annual Meeting. Developed by the NFPA Sectional Committee on Aircraft Rescue and Fire Fighting, these proposed Tentative Recommendations were returned to the sponsoring committee for further study prior to requesting final adoption by the Association. The material is being published in this form to permit the widest possible circulation to receive comments from all interested persons.

Readers are warned that this text does *not* present official recommendations of the National Fire Protection Association in its present form. There have been a number of criticisms of the existing text and these, as well as any others received, will be considered by the Sectional Committee at its future meetings. Note should also be taken of the fact that some portions of these Tentative Recommendations have not been completed as yet.

Comments are solicited from all those interested. Such comments should be forwarded to the NFPA prior to September 15, 1961 to receive full Committee consideration.

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International

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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 over eighteen 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.

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Proposed 1961 Revision to the Tentative Vehicular Performance Recommendations for Aircraft Rescue and Fire Fighting Vehicles

NFPA No. 414-T — May 1961

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."

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 the most efficient and capable vehicle for both on-and-off highway performance known to industry today. 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-highway (runway or taxi-way) 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 for 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. Certain recommendations, such as acceleration and tire size are adjusted in recognition of differing needs of the vehicles within 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, as set forth in Paragraph*, 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 Paragraph *, 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. Automatic constant drive to all wheels for off-highway operation is essential (see Paragraph 254) and shall be achieved without sacrificing any of the attributes of high performance, high speed vehicles. Weight, under all conditions of loading, shall be substantially distributed over all wheels, as further described in Section 221, 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 lightweight construction wherever possible.

*Work to date on Paragraph referenced not completed.

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, under all conditions of loading.

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.

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.

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 the vehicle driver 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, 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: The use of turbine-powered vehicles and "air-cushion" vehicles cannot be specifically recommended at this time (1961) since not enough 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 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 insure 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 insure the required performance.

2313. In addition to being capable of meeting the above acceleration requirements, the engine 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	600
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 required 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 required minimum displacement are used. In such cases, the acceleration time still stands as a minimum requirement.

Special high compression "souped-up" engines should be avoided to allow the use of regular grade fuels, and to reduce the frequency and care required in engine tune-up.

See Note following Paragraph 2311.

2315. Where the engine(s) is (are) used to power both the chassis and fire fighting pumps, provision shall be made to insure that the operation of the pump will not, under any circumstances, either cause the engine(s) to stall or more than momentarily cause a slight drop in pressure. The vehicle shall also be capable of full rated capacity while conducting the mud and sand test as stipulated in Paragraph*.

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.

2317. The provisions appearing in Sections 232, 233, 234 and 235 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 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.

*Work to date on Paragraph referenced not completed.

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. or Factory Mutual Laboratory 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. Engine Crankshaft.

2341. Crankshaft shall be statically and dynamically balanced to the maximum permissible revolutions-per-minute established by the engine manufacturer.

235. Muffler.

2351. The vehicle shall be furnished with an exhaust system, tailpipe, and muffler of such size as to avoid undue increase in 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 shall be stainless steel and muffler shall be of high grade rust resistant materials and be equipped with a spark arrester.

2352. Location of the tailpipe and muffler shall be protected from damage due to traversing rough terrain.

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

247. The electrical system shall be insulated and waterproofed. All wiring in locations subject to possible ground fires shall have fire resistant covering.

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 constant 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. The drive shall incorporate a fluid coupling or torque converter.

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 prime manufacturer of the unit to be suitable for use in the drive line of the complete vehicle considered as a complete vehicle: engine, clutch and/or torque converter, transmission, transfer case, propeller shaft, differentials and axles.

253. Differentials, over-running clutches or other automatic devices shall be incorporated in the drive to permit differences in angular velocity between front and rear axles and driving wheels so that traction will not be destroyed nor drive shafts torsionally wound up due to variations in tire rolling radius and steering of wheels.

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 insure that each wheel of the vehicle is driven independently of the other wheels. This shall be accomplished without sacrificing the necessary differential action referred to in Paragraph 253.

NOTE: Drive from the engine flywheel to the wheels is usually accomplished by a drive train consisting of the following: torque converter, clutch, transmission, transfer case, propeller shafts, and axle drives. Some components of the drive train may be combined or eliminated.

In order to drive to the front and rear axles, or bogies as the case may be, and yet to provide for the required differential action, the transfer case incorporates an over-running clutch, center differential, or other automatic device accomplishing the same function.

Positive wheel drive requires that the automatic device referred to above prevents the vehicle from stalling because the wheels of the front or rear axles, but not both, lack traction.

Positive wheel drive also requires that axle differentials, and interaxle differentials when furnished, be of the no-spin or torque-proportioning type.

A properly designed positive wheel drive system makes it impossible to stall a vehicle as long as any wheel has traction.

255. 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.

NOTE: Spacing of transmission ratios shall not be more than 80 per cent of the converter torque multiplication ratio. On vehicles with a gross weight of 30,000 lbs. and above, the torque converter transmission shall be constant mesh or planetary type for shifting up or down throughout ranges provided.

The input torque capacity of the transmission must be increased proportional to the torque multiplication ratio of the converter. Because of the high input torque, sliding type transmission gears are not permitted for up or down shifting on any size vehicle.

256. Front and rear axles shall be of sturdy construction and shall have a gear reduction commensurate with the tire size used. With tires 14:00 x 24, or larger, double reduction type axles shall be furnished. With double reduction type axles the final reduction ratio shall not be less than 2 to 1.

NOTE: Experience in heavy-duty equipment has demonstrated that with larger diameter tires it is necessary to have a greater axle reduction in order to obtain the required over-all reduction in the drive line.

This larger axle reduction can best be obtained by two reductions instead of one, thereby reducing teeth loading and permitting greater clearance under the center of the axles.

The double reduction may be obtained either by means of two reductions in the differential carrier, or one reduction in the differential carrier and a second, or final, reduction beyond the differential.

257. All steering driving axles shall be equipped with steering drive ends of the constant velocity type, or other provision shall be made to completely eliminate cyclical fluctuations in the 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. 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.

264. Suspension.

2641. The suspension system shall be designed to allow the vehicles, loaded or unloaded, to travel at high speeds over im-

proved 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.

2642. 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.

2643. 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. Spring design shall be such that at least two inches of spring deflection remain before bottoming of springs when the vehicle is fully loaded and on level ground.

2644. 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.

265. Wheels and Tires.

2651. All vehicles shall be furnished with large diameter, single tires of the same size, same axle tread, and same tire tread design.

2652. Minimum tire size, depending on gross vehicle weight and number of axles used, shall be in accordance with the following table:

Gross Vehicle Weight (lbs.)	Type Drive 4 x 4	6 x 6	8 x 8
8,000–15,000	8:25 x 20	—	—
15,000–20,000	10:00 x 20	—	—
20,000–25,000	12:00 x 20	—	—
25,000–30,000	14:00 x 20	12:00 x 20	—
30,000–35,000	14:00 x 24	14:00 x 20	12:00 x 20
35,000–40,000	16:00 x 25	14:00 x 24	14:00 x 20
40,000–45,000	18:00 x 25	16:00 x 25	14:00 x 24
45,000 and over	21:00 x 25	18:00 x 25	16:00 x 25

NOTES:

(1) Tubeless tires of equivalent size may be substituted.

(2) Number of plies and inflation pressure shall be selected so that the load-carrying capacity of all tires according to current Tire and Rim Association, Inc., ratings will at least equal actual imposed load on level ground.

(3) Rim contours and sizes shall be based upon the current recommended practices of the Tire and Rim Association, Inc.

(4) Tread design shall depend on local terrain conditions. For mud or snow, a lug type tread is desirable, but should be furnished with a center rib for smoother travel at high speeds on paved surfaces. For sand, a diamond type tread has proven most effective.

(5) It is further recommended that spare wheel or rim, tire and tube be furnished with each vehicle, unmounted.

27. Controlling Mechanisms.

271. Brakes.

2711. Service brakes shall be of the all-wheel type. On vehicles less than 20,000 lbs. gross weight, service brakes may be of the hydraulic type with power booster or the air-mechanical type. On vehicles 20,000 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 20,000 lbs. gross weight, and when supplied with air brakes, the air compressor shall be at least 7 cu. ft. capacity; on vehicles 20,000 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 equal build-up of pressure shall be furnished.

2716. 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 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 provide for effective operation in the event of failure of power hydraulic assist.

2722. The power 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 at idling speed.

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, except in the case of 8 x 8 chassis, where 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. Gross 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 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 under all conditions of loading.

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 10 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 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: The use of turbine-powered vehicles and "air-cushion" vehicles cannot be specifically recommended at this time (1961) since not enough 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 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 assure 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 insure the same performance.

Special high compression "souped-up" engines should be avoided to allow the use of regular grade fuels, and to reduce the frequency and care required in engine tune-up.

3313. Where the engine is used to power both the chassis and fire fighting pumps, provision shall be made to insure that the operation of the pump will not, under any circumstances, either cause the engine to stall or more than momentarily cause a drop in pressure.

3314. The provisions appearing in Sections 332, 333, 334 and 335 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 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 automatically open upon failure.

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. or Factory Mutual Laboratory approved flame arrester relief fitting on the filler opening.

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

334. Engine Crankshaft.

3341. Crankshaft shall be statically and dynamically balanced to the maximum permissible revolutions-per-minute established by the engine manufacturer.

335. Muffler.

3351. The vehicle shall be furnished with an exhaust system, tailpipe, and muffler of such size as to avoid undue increase in 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 pipes and mufflers shall be of high-grade, rust-resistant materials and be equipped with a spark arrester.

3352. Location of the tailpipe and muffler shall be protected from damage due to traversing rough terrain.

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. An engine preheating device shall be provided when specified for cold climate operation as an aid to rapid starting and high initial engine performance.

346. The electrical system shall be insulated and splash-proofed. All wiring in locations subject to possible ground fires shall have fire resistant covering. 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 as 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 prime manufacturer of the unit to be suitable for use in the drive line of the complete vehicle considered as a complete vehicle: engine, clutch and/or torque converter, transmission, transfer case, propeller shaft, differentials and axles.