JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 558:2025

STANDARD FOR SAFETY

Industrial Trucks, Internal Combustion Engine-Powered

Approved American National Standard

ANSI/UL 558-2025

SCC FOREWORD

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UL Standard for Safety for Industrial Trucks, Internal Combustion Engine-Powered, ANSI/CAN/UL 558

Eleventh Edition, Dated May 22, 2025

Summary of Topics

This new Eleventh edition of ANSI/CAN/UL 558 dated May 22, 2025 incorporates editorial changes including renumbering and reformatting to align with current style; as well as an adoption for a joint UL Standard for the United States and Canada.

The new requirements are substantially in accordance with Proposal(s) on this subject dated August 9, 2024 and February 7, 2025.

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MAY 22, 2025

ANSI/CAN/UL 558:2025

Standard for Industrial Trucks, Internal Combustion Engine-Powered

The first edition was titled the Standard for LP-Gas Industrial Trucks.

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Second Edition – September, 1961
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Eighth Edition – August, 1991
Ninth Edition – June, 1996
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Eleventh Edition

May 22, 2025

This ANSI/CAN/UL Safety Standard consists of the Eleventh Edition.

The most recent designation of ANSI/UL 558 as an American National Standard (ANSI) occurred on May 22, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This Standard has been designated as a National Standard of Canada (NSC) on May 22, 2025.

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Preface

This is the Eleventh Edition of ANSI/CAN/UL 558, Standard for Industrial Trucks, Internal Combustion Engine-Powered.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

This ANSI/CAN/UL 558 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

Annexes A, B, and C are identified as Normative, as such, form mandatory parts of this Standard.

Annex D, identified as Informative, is for information purposes only.

In Canada, there are two official languages, English and French. For this reason, where this Standard requires safety markings, it must provide a French translation of such markings. Annex D provides translations in French of the English safety markings specified in this Standard, for use wherever required in Canada.

This Eleventh Edition joint American National Standard and National Standard of Canada is based on, and now supersedes, the Tenth Edition of UL 558.

Comments or proposals for revisions on any part of the Standard may be submitted at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

This Edition of the Standard has been formally approved by the Technical Committee (TC) on Industrial Trucks, TC 583.

This list represents the TC 583 membership when the final text in this Standard was balloted. Since that time, changes in the membership may have occurred.

TC 583 Membership

Name	Representing	Interest Category	Region
Bablo, Joseph	UL Solutions	Testing & Standards Org.	USA
Bender, Curtis	Tennant Company	Producer	USA
Bhattacharya, Rana	Electrovaya	Supply Chain	Canada
Burch, Christopher	FM Approvals LLC	Testing & Standards Org.	USA
Coles, Michael	Advanced Motors And Drives INC	Supply Chain	USA
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Getzie, Travis	Coficab	Supply Chain	USA
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Henesy, Shannon	UL Standards & Engagement	TC Project Manager – Non-voting	USA
Hill, Ken	EnerSys Delaware INC	Supply Chain	USA
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Johnson, John	Johnson Engineering Services INC	General Interest	USA
Kamble, Sudesh	Intertek Testing Services	Testing & Standards Org.	USA
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McLachlan, Robert	Raymond Corp	Producer	USA
McNabb, Charon	National Carbon Monoxide Awareness Association	General Interest	USA
Merther, Christopher	Industrial Truck Association	Producer	USA
Nager, Urs	Anderson Power Products Inc	Producer	USA
Noakes, Steven	Pyroban LTD	Supply Chain	United Kingdom
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Riley, Rolland	US Army Ccdc Ground Vehicle Systems Center	Government	USA
Rupp, Mark	American Association Of Cleaning Equipment Manufacturers	Producer	USA
Sanders, K.	East Penn MFG CO INC	Producer	USA
Smith, R.	R K Smith Engineering INC	General Interest	USA
Spencer, Richard	Crown Equipment Corporation	Producer	USA
Sudler III, Samuel	SEA LTD	General Interest	USA
Tao, Luke	Hua Zhen(Guang Zhou) Standards Technical Services Co., Ltd	Testing & Standards Org.	China
Tepen, M.	Ford Motor CO	Commercial / Industrial User	USA
Wechsler, David	American Chemistry Council	General Interest	USA
Weidner, Gary	GW Technical Services	General Interest	USA
Xu, Michael	Cummins INC	Supply Chain	Canada

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This Standard is intended to be used for conformity assessment.

The intended primary application of this Standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

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INTRODUCTION

1 Scope

1.1 These requirements cover the fire safety aspects of industrial trucks with internal-combustion engines, such as tractors, platform-lift trucks, fork-lift trucks, and other specialized vehicles for industrial use. These requirements do not cover other possible safety aspects of such equipment.

1.2 These requirements do not cover farm or road vehicles or automotive vehicles for highway use.

1.3 The Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations, NFPA 505, identifies internal combustion engine powered industrial trucks as follows:

Types G, D, LP, CN, G/CN, and G/LP – A unit powered by gasoline (G), diesel (D), LP-gas (LP), compressed natural gas (CN), either gasoline or compressed natural gas (G/CN), or either gasoline or liquefied petroleum gas (G/LP), that has minimum acceptable safeguards against inherent fire hazards.

Types GS, DS, LPS, CNS, GS/CNS, and GS/LPS – A unit powered by gasoline (GS), diesel (DS), LP-gas (LPS), compressed natural gas (CNS), either gasoline or compressed natural gas (GS/CNS), or either gasoline or liquefied petroleum gas (GS/LPS) that, in addition to meeting all the requirements for Types G, D, LP, CN, G/CN, and G/LP, is provided with additional safeguards to the exhaust, fuel and electric systems.

Type DY – A diesel-powered unit that has all the safeguards of Type DS units and, in addition, any electric equipment is completely enclosed and equipped with temperature limitation features.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this Standard shall comply with the requirements for that component.

2.2 A component of a product covered by this Standard is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this Standard;

b) Is superseded by a requirement in this Standard; or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

2.3 Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

2.4 A component that is also intended to perform other functions such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable standard(s) that cover devices that provide those functions.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Referenced Publications

4.1 Any undated reference to a code or standard appearing in the requirements of this Standard shall be interpreted as referring to the latest edition of that code or standard.

4.2 Products covered by this Standard shall comply with the referenced installation codes and standards noted in this Section as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the installation codes and standards for all countries where it is intended to be used.

4.3 Throughout this Standard, the CSA standard references apply to products intended for use in Canada, while the UL standard references apply to products intended for use in the United States. Combined references are separated by a slash (" / ") to denote the difference between the applicable requirements specified for use in Canada and the United States.

4.4 The following publications are referenced in this Standard:

ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

ASTM D86, *Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure*

ASTM D471, *Standard Test Method for Rubber Property – Effect of Liquids*

ASTM D664, *Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration*

ASTM D6751, *Standard Specification for Biodiesel Fuel Blendstock (B100) for Middle Distillate Fuels*

ASTM E11, *Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves*

CFR 40 – Part 1039, *Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines*

CSA 8.1, *Elastomeric Composite Hose and Hose Couplings for Conducting Propane and Natural Gas*

CSA 8.3, *Thermoplastic Hose and Hose Couplings for Conducting Propane and Natural Gas*

CSA C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

CSA C22.2 No. 5, *Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures*

CSA C22.2 No. 49, *Flexible Cords and Cables*

CSA C22.2 No. 75, *Thermoplastic-Insulated Wires and Cables*

CSA C22.2 No. 96, *Portable Power Cables*

CSA C22.2 No. 117, *Room Air Conditioners*

CSA C22.2 No. 210, *Appliance Wiring Material Products*

CSA C22.2 No. 235, *Supplementary Protectors*

CSA/ANSI NGV 2, *Compressed Natural Gas Vehicle Fuel Containers*

CSA/ANSI NGV 3.1, *Fuel System Components for Compressed Natural Gas Powered Vehicles*

CSA/ANSI NGV 4.2, *Hose and Hose Assemblies for Compressed Natural Gas (CNG) Dispensing Systems for Natural Gas Vehicles (NGV)*

FMVSS No. 304, *Compressed Natural Gas Fuel Container Integrity*

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*

SAE J30, *Fuel and Oil Hoses*

SAE J553, *Circuit Breakers*

SAE J554, *Electric Fuses (Cartridge Type)*

SAE J1127, *Low Voltage Battery Cable*

SAE J1128, *Low Voltage Primary Cable*

SAE J1681, *Gasoline, Alcohol, and Diesel Fuel Surrogates for Materials Testing*

SAE J2044, *Quick Connect Coupling Specification for Liquid Fuel and Vapor/Emissions Systems*

SAE J2045, *Performance Requirements for Fuel System Tubing Assemblies*

SAE J2260, *Nonmetallic Fuel System Tubing with One or More Layers*

UL 21, *LP-Gas Hose*

UL 62, *Flexible Cords and Cables*

UL 66, *Fixture Wire*

UL 83, *Thermoplastic-Insulated Wires and Cables*

UL 87C, *Outline of Investigation for Power-Operated Dispensing Devices for Diesel Exhaust Fluid*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 157, *Gaskets and Seals*

UL 275, *Automotive Glass-Tube Fuses*

UL 275A, *Outline of Investigation for Automotive Blade Type Fuses*

UL 484, *Room Air Conditioners*

UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures*

UL 569, *Pigtails and Flexible Hose Connectors for LP-Gas*

UL 583, *Electric-Battery-Powered Industrial Trucks*

UL 746B, *Polymeric Materials – Long Term Property Evaluations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 758, *Appliance Wiring Material*

UL 1063, *Machine-Tool Wires and Cables*

UL 1077, *Supplementary Protectors for Use in Electrical Equipment*

UL 1276, *Outline of Investigation for Welding Cable*

UL 1337, *LP-Gas, Natural Gas, and Manufactured Gas Devices for Engine Fuel Systems*

UL 1426, *Electrical Cables for Boats*

UL 2003, *Outline of Investigation for LP-Gas Cylinder Assemblies*

UL 2726, *Outline of Investigation for Battery Lead Wire*

5 Glossary

5.1 For the purposes of this Standard, the following definitions apply.

5.2 In the text of this Standard, the term truck is used to mean an industrial combustion engine-powered industrial truck. The type or types of truck(s) to which a specific requirement applies is identified by the heading under which the requirement is located and by specific references in the text to the applicable requirements.

6 Samples

6.1 Unless otherwise expressly stated herein, the performance of an industrial truck shall be satisfied by the testing of a representative model or a new vehicle.

CONSTRUCTION

TYPES G, D, LP, AND CN

7 Electrical Systems

7.1 All wiring shall comply with one of the following, as applicable to the intended use which includes, but is not limited to, temperature, voltage, and current ratings for the wire:

a) UL 758 / CSA C22.2 No. 210;

b) UL 83 / CSA C22.2 No. 75;

c) UL 62 / CSA C22.2 No. 49;

d) SAE J1128;

e) UL 2726;

f) SAE J1127;

g) UL 1276 / CSA C22.2 No. 96;

h) UL 1426;

i) UL 1063; or

j) UL 66.

7.2 The wiring of a truck shall be rated for the particular application with respect to the temperature and voltage, exposure to oil or grease, and other conditions of service to which the wiring is subjected.

7.3 Wiring shall be protected against mechanical damage by:

a) Enclosing it in the body of the truck; or when mounted on masts, booms, lifts or similar parts, the wiring shall be installed so as to reduce the likelihood of mechanical damage and kinking;

b) Enclosing it in metal raceway, such as armored cable, rigid metal conduit, or electrical metallic and nonmetallic tubing, flexible nonmetallic conduit or nonmetallic insulated tubing; or

c) Other suitable method in which the wiring is protected sufficiently against mechanical damage.

7.4 Wiring and cables shall be installed with means for maintaining clearance from moving parts, hot engine parts, exhaust systems and fuel systems, and shall not be supported on surfaces that are subjected to accumulation of oil or grease as a result of servicing.

7.5 Wiring and cables shall not be located such to allow exposure to drippage of gasoline, diesel, oil, or grease, and shall not be supported on oil- or grease-retaining surfaces.

7.6 If an audible electrical warning device is employed, its coil and other electrical parts shall be enclosed in metal or an equivalent material. Among the factors that are to be taken into consideration when judging the equivalency of a nonmetallic enclosure are:

a) The mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability; and

f) Resistance to distortion at temperatures to which the material is subjected under conditions of normal or abnormal usage.

7.7 Each lighting-device, warning-device, or other auxiliary circuits shall be protected by a fuse or a circuit breaker, or a supplementary protector, of the size necessary to reduce the likelihood of overheating of the smallest conductor in the circuit. A fuse conforming with SAE J554, the applicable parts of the UL 248 series of standards and the CSA C22.2 No. 248 series of standards, UL 275, or UL 275A shall be

considered acceptable. A circuit breaker conforming to SAE J553 or UL 489 / CSA C22.2 No. 5 shall be considered acceptable. A supplementary protector conforming to UL 1077 / CSA C22.2 No. 235 shall be considered acceptable.

7.8 Electrical components located near foot-operated controls shall be located or protected so as to prevent damage to these components from the operator's feet during operation of the controls.

8 Exhaust Systems

8.1 The exhaust system beyond the manifold shall be supported at least 76 mm (3 inches) clear of flammable materials, excluding flexible mountings, and at least 50.8 mm (2 inches) clear of fuel- and electrical-system parts and shall not subject to drippage of fuel, oil, or grease. See also Section 22, Temperature Tests.

Exception: Lesser clearances shall be allowed when the maximum temperatures obtained during the Temperature Tests, Section 22, do not exceed the established rating of the component.

8.2 The exhaust system shall conform with the test requirements in Section 24, Exhaust System Test – Type G, GS, DS, LP, CN, LPS, CNS, G/LP, G/CN, GS/LPS, and GS/CNS.

8.3 A muffler, catalytic converter, diesel particulate filter, or other after-treatment device, shall be provided on each truck.

9 Fuel Systems – Gasoline and Diesel

9.1 Tanks and pumps

9.1.1 A fuel tank shall be constructed of painted mild steel having a minimum thickness of 0.8 mm (0.032 inch) or material equivalent in strength, rigidity, and resistance to fire and corrosion. The joints shall be welded, brazed, soldered, or bonded. If soldered or bonded, the joints shall be of a construction that will retain the heads if the solder or bonding melts. Fittings and fill pipe, if soldered or bonded, shall be mechanically secured to the tank in addition to soldering or bonding.

9.1.2 A fuel tank shall not be located directly over the engine. If a tank is within or contiguous to the engine compartment, the tank or fill arrangement, or both, shall be isolated from the electrical and exhaust systems by a separate enclosure or by baffles. The tank location and the facilities for filling shall be such that spillage or leakage will drain to the ground and not into the engine compartment or onto electrical- or exhaust-system parts.

9.1.3 A fuel tank and fill fitting shall be so located as to minimize the possibility of damage to the tank or its fittings.

9.1.4 A shut-off valve shall be provided in an accessible location near the tank on gravity-feed systems or on systems where the fuel in the tank is subject to discharge by siphon action if the fuel line breaks.

9.2 Fuel lines, tubing, and fittings

9.2.1 Metallic fuel lines, except those used in a high-pressure injection system, shall be of seamless annealed copper or steel tubing. Flexible tubing, hose, or a vibration loop shall be used where necessary to absorb vibration. Flexible tubing or hose shall be of the length necessary to span between the fixed and moving parts.

9.2.2 Nonmetallic fuel tubing or hoses shall be provided with appropriate traceability to validate conformance with SAE J2260 or SAE J30.

9.2.3 Fuel system assemblies (e.g. each fuel line and fitting configuration) shall be provided with appropriate traceability to validate conformance with SAE J2045.

Exception: Fuel system assembly (e.g. each fuel line and fitting configuration) shall not pull off fittings or fail when subjected to an 89 N (20 pound-force) axial pull test applied over a 1 minute period. The test shall be conducted at ambient conditions of 21 ±5 °C (70 ±9 °F) with tubing or hose wetted with fuel. Hose shall also be subjected to 70 hours at 100 °C (212 °F) aging and 48 hours of 3.18 mm (0.125 inch) amplitude vibration at 17 HZ before the pull test.

9.2.4 Fuel system assemblies that utilize quick connect fittings shall conform and be provided with appropriate traceability to validate conformance with SAE J2044.

Exception: Fuel system assembly (e.g. each fuel line and fitting configuration) shall not pull off fittings or fail when subjected to an 89 N (20 pound-force) axial pull test applied over a 1 minute period. The test shall be conducted at ambient conditions of 21 ±5 °C (70 ±9 °F) with tubing or hose wetted with fuel. Hose shall also be subjected to 70 hours at 100 °C (212 °F) aging and 48 hours of 3.18 mm (0.125 inch) amplitude vibration at 17 HZ before the pull test.

9.2.5 A body or fitting provided with tapered threads shall be threaded in accordance with ASME B1.20.1.

9.2.6 A fuel filter shall conform with the requirements in 30.3, Fuel filters. When the fuel confining parts are constructed of nonmetallic material, the assembly shall also conform with the requirements in 9.3, Nonmetallic parts.

9.2.7 Fuel lines shall be supported to minimize chafing and to maintain at least a 50.8 mm (2 inch) clearance from exhaust- and electrical-system parts.

Exception: If it can be demonstrated that the fuel lines and wiring are sufficiently supported to prevent the clearance from being reduced to less than 12.7 mm (1/2 inch), the clearance between fuel lines and electrical-system parts may be reduced.

9.2.8 Fuel feed lines, valves, and fittings shall be located so that any leakage will not run off or drip on electrical- or exhaust-system parts.

9.3 Nonmetallic parts

9.3.1 A nonmetallic part in contact with non-ethanol blended gasoline or diesel fuel shall not show excessive volume change or loss of weight, when considered on the basis of its intended function, following immersion for 70 hours at a temperature of 23 ±2 °C (73.4 ±3.6 °F) in the test liquid specified in Table 9.1.

Exception No. 1: This requirement does not apply to fuel lines that conform with 9.2.3.

Exception No. 2: This requirement does not apply to fuel system assemblies that conform with 9.2.4.

Exception No. 3: This requirement does not apply to quick connect fittings that conform with 9.2.5.

Exception No. 4: This requirement does not apply to gasketing and seals that have been investigated to UL 157.

Table 9.1
Test Liquids for Nonmetallic Materials

Liquid in contact with part	Test liquid
Gasoline	A and C Reference Fuels (ASTM D471)
Diesel Oil	IRM 903 Oil
Urea	DEF (Diesel Exhaust Fluid)[a]
[a] DEF test fluid shall be in accordance with the Test Fluids requirements in UL 87C.	

9.3.2 A change in volume of not more than 25 % swelling or 5 % shrinkage, and a weight loss (extraction) of not more than 10 % is considered as indicating compliance with 9.3.1.

9.3.3 A nonmetallic part in contact with ethanol blended gasoline or biodiesel fuel (B5 to B20) shall be evaluated in accordance with UL 157, modified as follows:

a) Volume Change and Extraction Test except for the following modifications:

1) The test duration shall be 1000 hours;

2) The applicable test fluids shall be as described in Annex C, Test Fluids; and

3) For all materials, the average volume change shall not exceed 40 % swell (increase in volume) or 1 % shrinkage (decrease in volume). In addition, the weight loss shall not exceed 10 %.

b) Compression Set Test except for the following modifications:

1) The test duration shall be 1000 hours;

2) The samples shall be immersed, at room temperature, in the test fluids (see item iii) while compressed for the entire test duration. No oven conditioning is required;

3) The applicable test fluids shall be as described in Annex C, Test Fluids;

4) The recovery period shall consist of removing the sample from the compression device and immersing it in the applicable test fluid for 30 minutes at room temperature. The sample shall not be allowed to dry out due to exposure to air. The 30-minute immersion should use the same fluid as the test fluid for each sample; and

5) For all materials, the average compressions set is calculated and shall not exceed 35 %.

Exception: This requirement does not apply to composite gasket materials as defined in accordance with UL 157.

9.4 Corrosion resistance

9.4.1 If corrosion of a ferrous part will interfere with the proper functioning of a part, the part shall be provided with a corrosion-resistant protective coating.

9.5 Carburetors and backfire preventers

9.5.1 An updraft carburetor, if used, shall be located so that overflow of gasoline due to excess choking will flow to ground and not contact electrical parts and exhaust system, or collect in an engine compartment. Nonmetallic drain hose, if used, shall be provided with appropriate traceability to validate conformance with SAE J30.

9.5.2 A downdraft carburetor, if used, having an external float bowl vent opening, shall have a vent overflow tube to direct fuel away from the engine in case of fuel overflow.

9.5.3 A backfire deflector shall be provided on each combustion air intake and, whether separate or a part of an air cleaner, shall conform with the requirements in Section 37, Backfire Deflector Element Test. If the backfire deflector enclosure is constructed of nonmetallic material, the material shall have a flammability rating of no less than V-1.

Exception: This requirement does not apply to material which complies with the 20 mm (3/4 inch) flame test in UL 746C / CSA C22.2 No. 0.17.

9.5.4 Nonmetallic hose employed for the connection of a carburetor air inlet to a backfire deflector air outlet shall be constructed so that its inner surface is of a flame retardant material. When the non-metallic hose is located so as to allow fuel to collect in the air intake hose, due to flooding of the carburetor, the inner hose material shall also meet the test requirements specified in 9.3.2, inclusive.

9.5.5 Components located within the engine compartment or forming a part of the engine compartment shall be constructed of metal, or if nonmetallic, shall be separated from the engine compartment by complete baffles or be of a flame retardant material. This requirement is not intended to apply to hydraulic hoses, water hoses, fuel hoses, wiring, battery, pulley belts or other small components.

10 Fuel Systems – LP & CN-Gas

10.1 General

10.1.1 Each vehicle shall have the complete fuel system installed at the factory.

Exception: Vehicles equipped to use a removable LP fuel container are permitted to be shipped without the fuel container if a metal nameplate that identifies the correct fuel container assembly to be used is attached adjacent to the container-mounting hardware. See 10.2.1.5.

10.1.2 A valve and its connections on a container shall be protected to reduce the likelihood of damage from unintentional contact with stationary objects or from loose objects thrown up from the road. A valve shall be protected to reduce the likelihood of damage from collision, overturning, or the like. A part of the vehicle is permitted to be used to provide such protection to a valve and its fittings.

10.1.3 Each applicable LP-Gas component, excluding fuel lines, hoses, and tanks, shall comply with the requirements in UL 1337.

10.1.4 Each applicable CN-Gas component shall comply with the requirements in CSA/ANSI NGV 3.1.

10.1.5 A fuel-system component shall be fastened to the vehicle to reduce the likelihood of loosening due to vibration.

10.1.6 If a removable LP fuel container is used, means shall be provided in the fuel system to reduce the likelihood of escape of fuel when the container is changed.

10.1.7 Fuel lines shall not be routed within the driver's compartment.

10.2 LP-Gas

10.2.1 Fuel containers

10.2.1.1 When a vehicle incorporates a non-removable ASME fuel container, the container shall have a maximum allowable working pressure (MAWP) of 2.15 MPa (312 psig). It shall be marked with the ASME "U" symbol and the design working pressure.

10.2.1.2 When a vehicle incorporates a non-removable DOT fuel container, the container shall be constructed, tested, and marked for a minimum service pressure of 1.7 MPa (240 psig). It shall bear the marking DOT-4B240, DOT-4BA240, DOT-4BW240, or DOT-4E240. A DOT fuel container assembly shall comply with the requirements in UL 2003.

10.2.1.3 A removable fuel container shall be constructed to engage a substantial positioning pin or an equivalent means to provide for intended positioning of the container when reinstalled so that the cylinder remains within in the plan view of the truck.

10.2.1.4 A removable-type container shall have the protection means for the fittings permanently attached to the container.

10.2.1.5 Vehicles equipped to use a removable fuel container are permitted to be shipped without the fuel container if a nameplate that identifies the following is attached adjacent to the container-mounting hardware:

a) Tank capacity (weight);

b) Type of mounting (horizontal or vertical);

c) Disconnect coupling (thread type); or

d) Type of withdrawal (liquid or gas).

10.2.1.6 A fuel container shall be installed at not less than the minimum road clearance of the vehicle in the area of the fuel container. This minimum clearance is to be measured to the bottom of the container or to the lowest fitting.

10.2.1.7 LP fuel container, if non-removable, and mounting assembly shall be secured in place on the vehicle so as to comply with the requirements in Section 25, LP-Gas Container Bracket Load Test – Types LP, LPS, G/LP, and GS/LPS.

10.2.2 Fuel lines and fittings

10.2.2.1 Piping from a fuel container to the first-stage regulator shall be iron, steel (black or galvanized), brass, or copper pipe; seamless copper or steel tubing; flexible LP-Gas hose; or other equivalent piping means.

10.2.2.2 Steel tubing shall have a minimum wall thickness of 1.25 mm (0.049 inch) and shall have a corrosion resistant exterior coating such as paint. Copper tubing shall have a minimum wall thickness of 0.81 mm (0.032 inch) and shall be annealed. Aluminum piping or tubing shall not be used.

10.2.2.3 A length of flexible hose of a type designated for use with LP-Gas shall be employed between a removable container and any fixed fuel-system parts, and between any high-pressure parts on the frame and parts that are mounted on the engine. Flexible hose longer than 1.5 m (60 inches) shall have stainless steel wire braid reinforcement. Flexible hose and hose assemblies shall comply with the requirements in UL 21 and UL 569, and either CSA 8.3 or CSA 8.1.

10.2.2.4 A tubing fitting or other fuel line fitting, including a pipe threaded fitting, shall be of a type designated for use with LP-Gas.

10.2.2.5 A cast fitting shall not be employed for either piping or tubing.

10.2.2.6 A fuel line shall be supported to reduce the likelihood of chafing and to maintain at least a 50.8 mm (2 inch) clearance from exhaust- and electrical-system parts.

Exception: If it can be demonstrated that the fuel lines and wiring are sufficiently supported to prevent the clearance from being reduced to less than 25.4 mm (1 inch), the clearance between fuel lines and electrical-system parts may be reduced.

10.2.2.7 Flexible hose passing through sheet metal shall be installed to reduce the likelihood of hose abrasion, such as by use of clamps and grommets.

10.2.2.8 A pipe-threaded fuel-system fitting, including a container fitting, shall be assembled using a pipe-joint sealing compound intended for use with LP-Gas. A fuel-system connection, including the container with any associated valve and fitting, shall be tested for leaks with a soap-and-water or equivalent solution while the system is under LP-Gas pressure.

10.2.2.9 The fuel container and associated valves and fittings are permitted to be tested separately using air pressure.

10.2.3 Vaporizers

10.2.3.1 Each vaporizer shall have a valve or plug located at or near the lowest portion of the section occupied by the water or other heating medium to permit substantially complete draining of the vaporizer. A vehicle cooling-system drain or water hose that completely drains the vaporizer is considered to comply with the intent of the requirement.

10.2.3.2 Each vaporizer shall be marked with the design working pressure in MPa (psi).

10.2.3.3 Engine exhaust gases shall not be used as a direct means of heat supply for the vaporization of fuel unless the materials used for parts of the vaporizer in contact with the exhaust gases are resistant to the corrosive action of the exhaust gases and the vaporizer system is constructed to prevent excessive pressure.

10.2.3.4 A vaporizer shall not be equipped with a fusible plug. A vaporizer shall comply with the requirements in UL 1337.

10.2.4 Safety-control and -relief devices

10.2.4.1 An automatic shut-off valve and all relief type valves shall be provided in the fuel system at some point ahead of the inlet of the first-stage regulator, constructed to prevent flow of fuel when the ignition is off and the engine not running or if the engine is to stop. This device shall permit the back flow of fuel from the vaporizer in the event of a pressure build-up in the vaporizer. Automatic shut-off valves shall comply with the requirements in UL 1337.

10.3 CN-Gas

10.3.1 Fuel containers

10.3.1.1 A fuel container shall comply with FMVSS No. 304 and CSA/ANSI NGV 2.

10.3.1.2 The CN fuel container and mounting assembly shall be secured in place on the vehicle so as to comply with the requirements in Section 25, LP-Gas Container Bracket Load Test – Types LP, LPS, G/LP, and GS/LPS.

10.3.1.3 The CN container shall be protected from damage from road hazards, loading and unloading cargo, direct sunlight, and exhaust heat.

10.3.1.4 The CN container shall be positioned to prevent contact with truck components such as frame members, body panels, brake lines and so forth that can lead to container fretting or abrasion over time.

10.3.1.5 Shields, if provided, shall be installed in a manner that prevents direct contact between the shield and the fuel container and the trapping of solid materials or liquids between the shield and the fuel container.

10.3.2 Fuel lines and fittings

10.3.2.1 Rigid fuel lines shall comply with CSA/ANSI NGV 3.1.

10.3.2.2 Flexible fuel lines shall comply with CSA/ANSI NGV 4.2.

10.3.2.3 When the fueling connection is separate of the CN fuel container, the connection shall withstand a force of 668 N (150 lbs-force) when tested in the load directions described in Section 25, LP-Gas Container Bracket Load Test – Types LP, LPS, G/LP, and GS/LPS.

11 Air Conditioning and Heating Systems

11.1 Refrigerant lines shall be routed to avoid operator exposure in the case of rupture.

Exception: Refrigerant lines are not required to be protected from operator exposure if the components are properly evaluated for hydrostatic characteristics defined in UL 484 / CSA C22.2 No. 117.

11.2 Refrigerant lines shall be routed to avoid damage during operation. Lines installed external to the frame or engine compartment shall have provisions to prevent coolant or refrigerant from contacting the operator or bystanders in case of failure.

11.3 Adequate pressure relief shall be located on the refrigeration system in case there is a fire. Acceptable pressure relief would be the use of rubber hoses that would melt in a fire and allow the refrigerant to be released. If metal tubing with metal fittings is used, an appropriate refrigerant pressure relief device shall be used.

TYPES GS, DS, LPS, AND CNS

12 Electrical Systems

12.1 The electrical system shall comply with 7.1 – 7.8 and 12.2 – 12.9.

12.2 Wiring terminals shall be protected by insulating boots or covers unless they are intentionally connected to ground on the truck frame when the truck is in operating condition.

12.3 Individual insulating boots shall be tight-fitting, completely enclose the terminal, and be acceptable for the temperatures to which they are exposed.

12.4 Reusable type boots shall be provided on other than crimped, soldered, or riveted terminals.

12.5 Covers employed in lieu of insulating boots shall be of metal or equivalent material. Among the factors taken into consideration are:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability; and

e) Resistance to distortion at temperatures to which the material is subjected under conditions of normal or abnormal usage.

12.6 Spacings between positive terminals and metallic enclosures employed in lieu of boots shall be a minimum of 12.7 mm (1/2 inch) or be separated by a nonconductive material not less than 0.8 mm (1/32 inch) thick that cannot be removed during normal operation or servicing.

12.7 Those portions of a component such as an alternator, motor, switch, relay, etc., which emit sparks shall be totally enclosed.

12.8 When a nonmetallic enclosure is used to comply with 12.7, the enclosure shall comply with the following requirements in UL 746C, Path II / CSA C22.2 No. 0.17:

a) Material that complies with the 20 mm Flame Test;

Exception: Material with a flammability rating no less than V-1 is not required to comply with the 20 mm Flame Test.

b) Mold Stress Relief; and

c) Impact Resistance.

Exception: When a component is determined to be suitably protected from incidental impact during use and servicing, it is not required to comply with Impact Resistance.

12.9 A manual-disconnect switch readily accessible to the operator when in his normal operating position shall be installed in the battery and charging circuits to permit quick disconnect in case of an electrical disturbance.

13 Exhaust Systems

13.1 The exhaust system shall comply with 13.2 – 13.5 in addition to the requirements in Section 8, Exhaust Systems.

13.2 The exhaust piping shall be formed of material having strength, rigidity, and resistance to corrosion equivalent to mild-steel tubing having a minimum thickness of 1.3 mm (0.053 inch). When exhaust piping is of multi-wall construction, one wall shall be formed of a solid metallic construction.

Exception: A corrosion resistant material, such as stainless steel, if used, may be less than 1.3 mm (0.053 inch) thick, but no less than 0.4 mm (0.015 inch) thick. It shall also be protected within the body of the truck, and comply with the requirements in Section 24, Exhaust System Test – Type G, GS, DS, LP, CN, LPS, CNS, G/LP, G/CN, GS/LPS, and GS/CNS.

13.3 A muffler, catalytic converter, diesel particulate filter, or other after-treatment device, shall be of welded or crimped seam steel construction, using single or multi-wall material having a minimum thickness of 1.3 mm (0.053 inch).

Exception: A corrosion resistant material, such as stainless steel, if used, may be less than 1.3 mm (0.053 inch) thick, but no less than 0.4 mm (0.015 inch) thick. It shall also be protected within the body of the truck, and comply with the requirements in Section 24, Exhaust System Test – Type G, GS, DS, LP, CN, LPS, CNS, G/LP, G/CN, GS/LPS, and GS/CNS.

13.4 An aspirator shall be of metal and have a backfire deflector securely connected to the fresh-air intake. The backfire deflector shall prevent the passage of flame during backfire conditions and shall be so located that, in the event its fastening means loosens, it shall remain securely connected to the air intake system.

13.5 The exhaust system shall conform with the test requirements in Section 24, Exhaust System Test – Type G, GS, DS, LP, CN, LPS, CNS, G/LP, G/CN, GS/LPS, and GS/CNS.

14 Fuel Systems – Gasoline and Diesel

14.1 The fuel system shall comply with the requirements in Section 9, Fuel Systems – Gasoline and Diesel, with the exceptions and additions detailed in 14.2 – 14.6.

14.2 A fuel tank shall be constructed of painted mild steel having a minimum thickness of 1.3 mm (0.053 inch) or material equivalent in strength, rigidity, and resistance to fire and corrosion. The joints shall be welded, brazed, soldered, or bonded. If soldered or bonded, the joints shall be of a construction that will retain the heads if the solder or bonding melts. Fittings and fill pipe, if soldered or bonded, shall be mechanically secured to the tank in addition to soldering or bonding.

14.3 The fuel tank shall have sufficient capacity for 8 hours of operation or shall have a reserve fuel supply valved from the main tank for emergency operation. See Section 23, Fuel-Consumption Test.

14.4 A valve employed for switching from a main fuel supply to a reserve fuel supply shall be permanently and legibly marked with the function of each valve-lever position.

14.5 A hand-priming pump, or equivalent, shall be provided on Type DS and DY trucks to assure delivery of fuel to the injector pump when restarting after the fuel supply has been exhausted.

14.6 A self-closing type fill and vent fitting shall be provided. A fuel gauge of low-level indicator visible to the operator shall be provided.

TYPES G/LP, G/CN, GS/LPS, AND GS/CNS

15 General

15.1 Types G/LP and G/CN industrial trucks shall comply with the requirements in Sections 7 – 10, inclusive, and Section 16, Fuel System.

15.2 Types GS/LPS and GS/CNS industrial trucks shall comply with the requirements in Sections 10 – 14, inclusive, and Section 16, Fuel System.

16 Fuel System

16.1 General

16.1.1 The gasoline tank shall be provided with a self-closing type fill and vent fitting provided with a means to lock it in the closed position in order to prevent accidental opening.

Exception: The fill cap for Type G/LP and G/CN trucks may be of the threaded type with a suitable gasket which is retained by a chain or other suitable means.

16.1.2 A gasoline fuel gauge shall be provided, visible to the operator during normal operation of the vehicle, and a permanent marking shall be located near the fuel gauge indicating one of the following (as applicable):

a) Gasoline tank must be at least one-quarter full when operating on LP-Gas; or

b) Gasoline tank must be at least one-quarter full when operating on CN-Gas.

16.1.3 A shutoff means designed for use with gasoline shall be located between the fuel pump and the intake. The fuel line between the shutoff means and the fuel pump shall be kept as short as possible.

16.2 LP and CN-Gas fuel system

16.2.1 Industrial trucks not employing permanently mounted LP-Gas fuel containers shall be provided with a storage means for the female portion of the LP-Gas quick-connect coupling for use when the truck is operated without the LP-Gas fuel container. The storage means shall be permanently mounted and so located that the quick-connect coupling and associated hose are maintained within the plan form of the vehicle. The storage means shall also prevent the accumulation of dirt and debris within the coupling.

16.2.2 A shut-off means designated for use with LP or CN-Gas shall be located between the fuel container and the vaporizer. The fuel line between the shutoff means and the vaporizer shall be kept as short as possible. The automatic shut-off valve required by 10.2.4.1 meets the intent of this requirement.

16.3 Fuel changeover – gasoline carburetor and LP or CN air valve

16.3.1 A fuel changeover means shall be provided that prevents operation of both fuels at one time except for the fuel remaining in the common fuel system components at the time of changeover.

16.3.2 The changeover control shall provide a three-way selector means or device providing individual selection of each of the fuels plus a position where both fuels are shut off. Each position shall be permanently marked with its function.

16.3.3 The changeover control shall be located so that it is readily accessible to the operator.

16.3.4 A permanent marking place located on or adjacent to the changeover control shall be provided with one of the following statements:

a) "CAUTION – Flammable liquids. When switching from LP-Gas to liquid fuel, be sure that there is no spillage of liquid fuel from the carburetor float system."; or

b) "CAUTION – Flammable liquids. When switching from CN-Gas to liquid fuel, be sure that there is no spillage of liquid fuel from the carburetor float system."

Exception: This requirement does not apply to EFI (electronic fuel injection) systems.

16.4 Fuel changeover – gasoline fuel injection and LP or CN air valve

16.4.1 A fuel changeover means shall be provided that prevents operation of both fuels at one time except for the fuel remaining in the common fuel system components at the time of changeover.

16.4.2 The changeover control shall provide a three-way selector means or device providing individual selection of each of the fuels, plus a position where both fuels are shut off. Each position shall be permanently marked with its function.

16.4.3 The changeover control shall be located so that it is readily accessible to the operator.

16.5 Fuel changeover – gasoline fuel injection and electronically controlled LP or CN air valve

16.5.1 A fuel changeover means shall be provided that prevents operation of both fuels at one time except for the fuel remaining in the common fuel system components at the time of changeover.

16.5.2 The changeover control shall provide a two-way selector means or device providing individual selection of each of the fuels. Each position shall be permanently marked with its function.

16.5.3 The changeover control shall be located so that it is readily accessible to the operator.

16.5.4 If the changeover control is located outside of the engine compartment and is located within a low voltage and limited power circuit, the tests in Section 29, Changeover Switch – Dual Fuel, are not applicable.

16.6 Fuel changeover – gasoline and LP fuel injection

16.6.1 A fuel changeover means shall be provided that prevents operation of both fuels at one time.

16.6.2 The changeover control shall provide a two-way selector means or device providing individual selection of each of the fuels. Each position shall be permanently marked with its function.

16.6.3 The changeover control shall be located so that it is readily accessible to the operator.

16.6.4 If the changeover control is located outside of the engine compartment and is located within a low voltage and limited power circuit, the tests in Section 29, Changeover Switch – Dual Fuel, are not applicable.

TYPE DY

17 Electrical Systems

17.1 No electrical wiring or components shall be employed on Type DY trucks.

17.2 Static grounding straps or electrically conductive wheels and tires shall be employed to discharge any build-up of static electricity.

17.3 All wheels shall be rubber-tired or constructed of nonsparking material. At least two tires and wheels shall be constructed of electrically conductive material, or equivalent static-discharge devices shall be provided. Nonmetallic conductive tires and wheels shall have a resistance of not more than 250,000 ohms when measured between the wheel hub and a metal plate on which the wheel rests.

17.4 Nonmetallic conductive tires shall conform with the requirements for nonmetallic conductive tires in UL 583.

17.5 If required, a minimum of two static grounding strips shall be used and shall have equivalent static discharge properties as referenced in 17.3.

18 Exhaust Systems

18.1 The exhaust system shall comply with the requirements in Section 13, Exhaust Systems, and with 18.2 and 18.3.

18.2 The exhaust system shall also comply with the temperature limitations specified in Section 20, Temperature Limitations.

18.3 Gaskets employed in the exhaust system shall be of metal construction. Asbestos gaskets with a metal exterior covering are also acceptable.

19 Fuel Systems

19.1 The fuel system shall comply with the requirements in Section 14, Fuel Systems – Gasoline and Diesel, and with 19.2.

19.2 Excess fuel drainage shall be confined within the fuel system with the exception of possible spillage of fuel at the fuel fill which shall be as indicated in Section 9, Fuel Systems – Gasoline and Diesel.

20 Temperature Limitations

20.1 All surfaces, including the exhaust system and brake drums, exposed to the atmosphere shall be limited to a maximum temperature of 175 °C (347 °F) based on a 25 °C (77 °F) ambient temperature.

20.2 Temperature tests, except the brake-heating test, are to be conducted as specified in temperature tests.

20.3 Brake-heating tests are to be conducted as specified in temperature tests except the truck is to be loaded to rated capacity, operated over a 121 m (400 foot) course and stopped abruptly every 15.2 m (50 feet). The test shall be continued until constant temperatures are reached on the external surfaces of the brake drums. The brakes shall not ignite or emit flame or hot particles.

21 Temperature Cutoffs

21.1 If temperature-limiting cutoffs are employed as a temperature-limiting device, they shall be investigated.

21.2 The factors involved in determining the acceptability of a temperature-limiting cutoff are as follows:

a) The switch functions as intended for 100,000 cycles;

b) The temperature setting of the switch is permanently sealed after final adjustment;

c) Failure of the switch shall leave it in the open position;

d) The safety mechanism must be completely enclosed and the enclosure provided with a locking means to prevent overriding of the device or starting of the truck after the device has tripped. The use of ordinary hand tools is not considered to be an effective locking means; and

e) A warning plate shall be installed on or near the reset lever with a warning to indicate that only authorized personnel are to reset the cutoff device.

21.3 If a water muffler, or water-filled exhaust system jacket is employed, a temperature-limiting cutoff shall be employed. This cutoff shall stop the engine before the exhaust system reaches 175 °C (347 °F) based on a 25 °C (77 °F) ambient temperature when tested in accordance with the requirements in Section 22, Temperature Tests.

PERFORMANCE – ALL TYPES

22 Temperature Tests

22.1 General

22.1.1 The materials employed in the construction of an industrial truck shall not be damaged by the temperatures attained during operation under the conditions of maximum rated load and under the conditions of overload maintained for a short period of time. The maximum temperature of any flammable material or electrical insulation shall not exceed 175 °C (347 °F); the maximum temperature of gasoline and diesel fuel in a tank shall not exceed 75 °C (167 °F); and the maximum pressure registered in an LP-Gas container shall not exceed 80 % of the design working pressure of an ASME fuel container and 120 % of the minimum service pressure of a DOT fuel container. If the test is conducted at an ambient temperature less than 25 °C (77 °F), the maximum temperature is adjusted accordingly. The test is to be continued until constant temperatures have been reached. A temperature is considered to be constant when readings taken during any continuous 1 hour period of the test indicate an increase of no more than 3 °C (5 °F).

22.1.2 Compliance of a truck with the requirements of 22.1.1 is to be determined by operating it under the conditions of operation as defined in 22.1.3 – 22.3.1 for the specific types of trucks indicated.

22.1.3 Test courses are to be smoothly paved with asphalt, concrete, or brick. A wood flooring is permitted to be employed for ramps or other portions of the test course.

22.1.4 The test course for a truck other than as mentioned in 22.1.5 is to include a ramp. The length of the ramp is to be a minimum of 12.2 m (40 feet) long. The grade of the ramp is to be 10 % or a percentage for which the truck is designed to ascend. For trucks designed to ascend lesser grades, the minimum grade of the ramp is 1 %. The total rise of a 10 % ramp shall not be less than 1.22 m (4 feet).

22.1.5 A truck designed for operation on a level surface and marked in accordance with 41.2 is to be tested on a level test course.

22.1.6 The temperature of the ambient air is not to be less than 10 °C (50 °F) nor more than 40 °C (104 °F).

22.1.7 Operating temperatures measured at any one time are to be related to the ambient temperature of the air at the same time and location.

22.1.8 Trucks employing water jacketed components to limit surface temperature as required by Section 20, Temperature Limitations, shall be tested with the components filled to various levels from empty to completely filled. If a temperature cutoff is employed, it shall be connected for this test.

22.2 Fork and platform trucks

22.2.1 The test course is to be 61 m (200 feet) long. The truck is to be operated over this course while hauling its full rated load. At the end of the course, the truck is to be turned at right angles, the load raised to full height, and then lowered to the hauling position. The truck is then to be returned to the starting point, where the load is again to be raised and lowered and deposited at right angles to the test course. The truck is then to be operated over the same course with no load and, at the end of the course, the forks (or platform) are to be raised to full height and lowered. The truck is then to be returned to the starting position, and the load picked up. These runs are then to be repeated, alternating between loaded and unloaded trips. The vehicle is to travel at the maximum safe practical speed.

22.3 Load-carrying trucks

22.3.1 The test course is to be any convenient length over 61 m (200 feet). If the length exceeds 91 m (300 feet), the truck is to be stopped and started at intervals of approximately 61 m. It is to be negotiated not less than six times per hour. The truck is to carry its rated load. The test is to be conducted in such a manner that the truck is in motion approximately 80 % of the time.

22.3.2 Two loads are to be provided for a tractor, consisting of two trains of trailers or trailing vehicles. One of the trains is to be loaded to such capacity as to require a draw-bar pull of the tractor. The other train is to consist of empty trailers equal in number to the loaded train. The tractor is to be operated over the test course pulling the loaded train of trailers and returning to the starting point, at which point the loaded train is to be uncoupled. The empty train is then to be coupled to the tractor and pulled over the same course. This cycle is to be repeated, alternating between loaded and unloaded trailers, allowing time at the starting point for normal coupling and uncoupling operations. If the length of the test course exceeds 91 m (300 feet), the truck is to be stopped and started at intervals of approximately 61 m (200 feet). The test course is to be negotiated not less than 6 times per hour.

22.3.3 Immediately after taking the final temperature readings, the tractor is to be operated for an additional 1 minute against a bumping post or other obstruction. This action is to cause the tractor to exert maximum draw-bar pull. During this additional 1-minute period, the enclosure surface temperatures of each component shall not exceed 175 °C (347 °F).

23 Fuel-Consumption Test

23.1 The rate of fuel consumption, based on a 2-hour test period of operation under the conditions of maximum rated load, shall be such that the fuel supply for a Type GS, DS, or DY truck will be sufficient for an 8-hour period of operation.

23.2 The fuel tank or container is to be filled to capacity prior to the start of each test. The fuel tank for a Type GS, DS, or DY truck is to be again filled to capacity at the end of the test period, the amount required for this purpose is to be accurately measured, and the fuel depletion for an 8-hour period is to be calculated. The appropriate test courses described for the temperature test are to be used for conducting fuel-consumption tests.

24 Exhaust System Test – Type G, GS, DS, LP, CN, LPS, CNS, G/LP, G/CN, GS/LPS, and GS/CNS

24.1 General

24.1.1 The exhaust system shall be tested with the maximum displacement engine.

24.1.2 The engine is to be continuously operated until the truck is in a heated state. This state is assumed to have been reached when the exhaust manifold has been heated to approximately 315 °C (600 °F).

Exception: If the exhaust manifold temperature of 315 °C (600 °F) cannot be reached, the engine shall be operated for no less than 10 minutes.

24.1.3 Ten backfires are to be obtained by alternately racing and idling the engine. An auxiliary spark plug may be installed as close as possible to the exhaust manifold. The spark plug shall be connected to a spark coil which can be energized from a battery through a momentary contact switch, to assist in creating a backfire in the following conditions:

a) The spark timing is to be advanced;

b) Spark plug leads are to be interchanged; or

c) The ignition switch is to be operated to alternately energize and de-energize the ignition system, or a switch can be added to the ground circuit leading directly to the coil to alternately energize and de-energize the ignition system.

Exception: If it is determined that the conditions above do not result in a backfire, the Exhaust System Test for Types G, LP, CN, G/LP, and G/CN can be waived.

24.1.4 If an exhaust turbo charger is utilized, the standpipe arrangement may be mounted as close as possible to the output of the turbo charger.

24.2 Types G, LP, and G/LP

24.2.1 The exhaust system including the muffler and tailpipe shall not rupture under conditions of backfire as described in 24.1, General.

24.3 Types GS, DS, LPS, GS/LPS and DY

24.3.1 An exhaust system including the after-treatment device and tailpipe, shall not rupture and shall prevent the emission of flame or sparks so as to cause charring, smoldering, or ignition of unmilled cotton waste under conditions of backfire as described in 24.1, General, with the introduction of spark-producing material into the exhaust system.

Exception: A diesel engine powered truck equipped with a wall-flow diesel particulate filter as a component of a system meeting EPA diesel exhaust emission requirements of the Code of Federal Regulations, (CFR) 40, Part 1039 shall be exempted from the heated particle test.

24.3.2 A valve and standpipe arrangement is to be mounted as close as possible to the exhaust manifold so that heated carbon particles can be introduced into the exhaust system while the engine is in operation. The standpipe is to be equipped with a cap.

Exception: If an exhaust turbo charger is utilized, the standpipe arrangement may be mounted as close as possible to the output of the turbo charger.

24.3.3 The tests are to be conducted in the following manner. Ten-gram samples of Mexican graphite, graded by size and weight as described in 24.3.4, or Cummings-Moore Grade 9C8 graphite are to be heated to incandescence. The heated particles are then to be dropped into the exhaust stream by opening the valve.

24.3.4 The Mexican graphite is to be graded in accordance with Table 24.1 using:

a) A single-eccentric-type mechanical shaker that imparts to the sieves a rotary motion and tapping action at a uniform speed of 300 ±15 gyrations and 150 ±10 taps of the striker per minute; and

b) U.S.A. Standard sieves.

Table 24.1
Graphite Size

Sieve size, ASTM E11		Percent retained (dry weight)
Passed by	Retained by	
4	8	10
8	16	20
16	30	30
30	40	30
40	Pan	10

24.3.5 Targets are to be constructed by hand packing unmilled cotton waste into a wood frame 610 ±76 mm (2 ±0.25 ft) square and 102 ±13 mm (4 ±0.5 in) deep. The frame is to be backed by expanded metal with the cotton held in place by poultry netting over the front.

24.3.6 Tests are to be conducted using a target positioned 152 ±13 mm (6 ±0.5 in) from the exit of the tailpipe. When the exhaust system design does not allow the target to be placed at 152 ±13 mm (6 ±0.5 in) from the exit of the tailpipe, the target shall be positioned flush against the exterior of the truck at the location affected to the greatest degree by the direction of the exhaust.

24.3.7 The target is to be removed briefly from the test areas throughout the test series and examined for evidence of burning or smoldering particles.

Exception: If it is determined that the conditions in 24.1.3 do not result in a backfire, then the heated carbon particles shall be introduced into the exhaust gases while racing the engine at maximum engine speed for no less 10 seconds.

25 LP-Gas Container Bracket Load Test – Types LP, LPS, G/LP, and GS/LPS

25.1 An LP-Gas fuel container shall be secured in place on the vehicle in a manner that will withstand, without visible permanent deformation, loadings in any direction equal to four times the filled weight of the container.

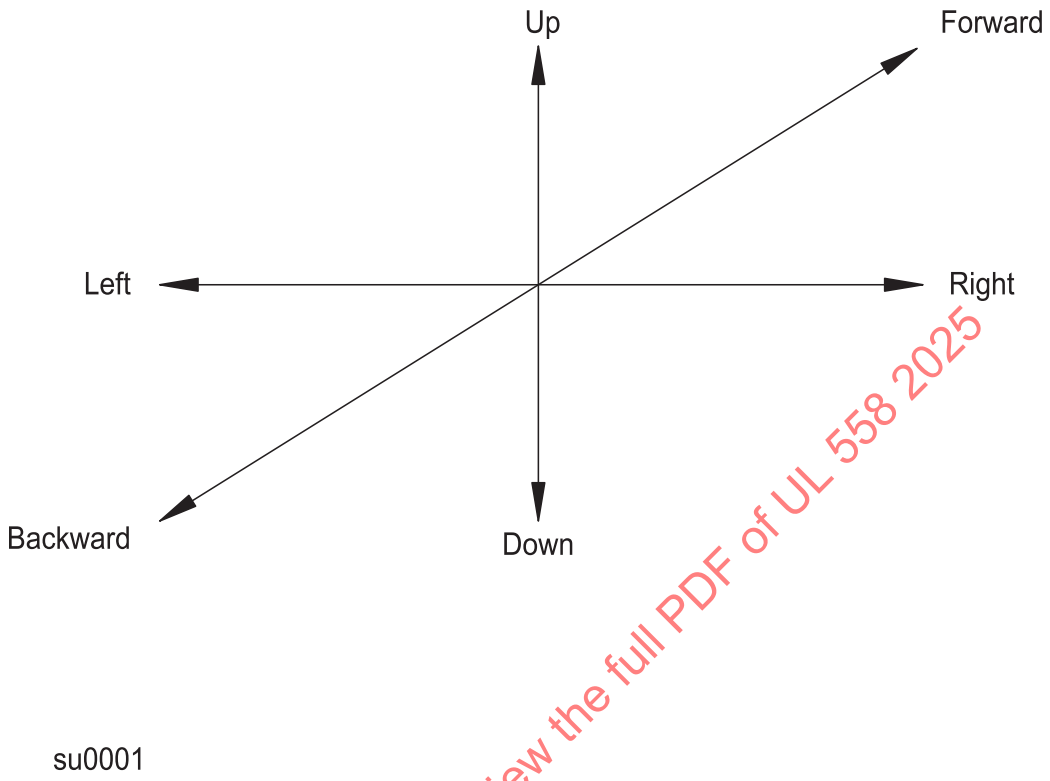
25.2 A CN-Gas fuel container shall be secured in place on the vehicle in a manner that will withstand, without visible permanent deformation, loadings in any direction equal to eight times the filled weight of the container.

25.3 For this test, the container is to be empty of fuel and is to be secured in the manner covered by the manufacturer's instructions. Loadings are to be applied in any convenient manner capable of being measured by gauges or weights. The load shall be applied in no less than the six directions shown in Figure 25.1, as applicable to the design.

Exception: When a design incorporates a swing-out, swing-down, or other similar construction, the load directions shall be adjusted accordingly to demonstrate compliance.

Figure 25.1

Load Directions



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AUTOMOTIVE-TYPE COMPONENTS

CONSTRUCTION

26 Electrically Operated Fuel Pumps

26.1 An electrically operated fuel pump shall be provided with a mounting bracket or provision for mounting bolts as an integral part of the assembly.

26.2 When the case and other component materials, of a fuel pump located outside of the fuel tank, are of metal and are not inherently resistant to corrosion, it shall be plated with:

a) Zinc having a thickness of not less than 0.013 mm (0.0005 inch); or

b) A coating other than zinc may be used that provides protection against corrosion at least equivalent to sheet steel having a zinc coating on each surface as specified in (a).

Exception: Parts where threads constitute the major portion of the area, the thickness of the zinc plating, or equivalent, shall not be less than 0.0038 mm (0.00015 inch).

26.3 When the case or other external components of a fuel pump located outside of the fuel tank are non-metallic, tests described in 9.3, Nonmetallic parts, and the following requirements in UL 746C, Path II / CSA C22.2 No 0.17 shall be conducted:

a) 20 mm (3/4 inch) Flame Test;

Exception: Material having a flammability rating of V-1 or better is not required to comply with the 20 mm (3/4 inch) Flame Test.

b) The end use shall not exceed the Relative Thermal Index for that material. If a material is used that is not described in UL 746B / CSA C22.2 No 0.17, then thermal aging may be necessary;

c) Impact Test; and

d) Mold-Stress Relief Distortion Test.

26.4 The fuel-containing portion of the pump shall be separated from the electrical compartment or components by metal partitions secured and sealed using soldered, welded, or brazed joints, or the pump assembly shall conform to the requirements in Section 33, Explosion Tests.

26.5 Vent holes are to be provided for the electrical enclosure when the fuel-containing portion of the pump is separated from the electrical compartment as described in 26.3.

26.6 Electrical connections shall be threaded terminal posts, spade type, or integral insulated lead wire, as constructed per the requirements in Section 7, Electrical Systems.

27 Fill and Vent Fittings – Self-Closing Type – Types GS, DS, GS/LPS, and GS/CNS

27.1 A self-closing type fill and vent fitting shall be provided with a means to lock it in the closed position in order to prevent accidental opening.

27.2 A venting orifice in the fitting shall have a diameter capable of venting when subjected to the pressure described in 31.3, Fill and vent fittings. Fuel shall not escape through the vent during the Temperature Test.

27.3 A fitting shall be made of 380 aluminum brass, bronze, steel, or malleable or modular iron castings. Nonductile (regular grey iron) cast iron shall not be used.

27.4 A ferrous metal part shall be provided with a protective coating of zinc plating to resist corrosion. Paint is not considered sufficient protection.

27.5 Zinc plating shall have a thickness of not less than 0.013 mm (0.0005 inch), except on parts where threads constitute the major portion of the area, in which case the thickness of the zinc plating shall be not less than 0.0038 mm (0.00015 inch).

Exception: A coating other than zinc may be used that provides protection against corrosion at least equivalent to sheet steel having a coating on each surface as specified in 27.5.

27.6 Gasket material shall be resistant to the action of gasoline or diesel fuel. See 9.3, Nonmetallic parts.

28 Manual-Disconnect Switches

28.1 A disconnect switch shall be designed to manually disconnect the battery from the electrical circuit and/or disconnect the field circuit of a generator or alternator.

28.2 All arcing parts shall be totally enclosed.

28.3 Terminals and terminal construction shall be of such size and shape as to provide the necessary capacity and mechanical support for the conductors connected to them. Terminals employing a threaded

screw or bolt for securing the conducting lug to a terminal plate shall provide a minimum of two full threads in the metal.

28.4 A disconnect switch is permitted to employ an indicator light, in which case it shall be separately fused. A fuse employed shall comply with the requirements of SAE J554.

28.5 A switch shall be designated for and marked with a minimum electrical rating, as follows:

Continuous:	40 amp, 6 v, dc
	20 amp, 12 v, dc
Momentary:	250 amp, 6 v, dc
	125 amp, 12 v, dc

28.6 The assembly shall be capable of resisting the effects of vibration. See 30.2.1.

28.7 The enclosure shall be of metal, molded-phenolic composition, or equivalent material evaluated in accordance with 28.8.

28.8 Among the factors that are to be taken into consideration when judging the equivalency of a nonmetallic enclosure are:

a) The mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability; and

f) Resistance to distortion at temperatures to which the material is subjected under any conditions of usage.

28.9 Spacings shall not be less than those indicated below:

a) 3.2 mm (1/8 inch) through air or oil, or 6.4 mm (1/4 inch) over surface between an uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded dead metal part other than the enclosure, or exposed dead part that is isolated (insulated);

b) 0.8 mm (1/32 inch) through air and 1.6 mm (1/16 inch) over surface between same polarity live parts on opposite sides of a switching mechanism, except at contact point; and

c) 6.4 mm (1/4 inch) shortest distance between wiring terminals, regardless of polarity, between a wiring terminal and a grounded dead metal part (including the enclosure) and between any uninsulated live parts and the walls of a metal enclosure.

28.10 The spacings between an uninsulated live part and the walls of a metal enclosure shall comply with 28.9 after the enclosure is subjected to the impact test in 28.11.

28.11 Each side of an enclosure is to be subjected to two impacts of 6.8 J (5 foot-pound-force). The impact is to be produced by dropping a steel sphere, 50.8 mm (2 inches) in diameter and weighing 0.54 kg (1.18 pounds-mass), through a vertical distance of 1.3 m (51 inches).

29 Changeover Switch – Dual Fuel

29.1 Terminals and terminal construction shall be of such size and shape as to provide the necessary capacity and mechanical support for the conductors connected to them. Terminals employing a threaded screw or bolt for securing the conducting lug to a terminal plate shall provide a minimum of two full threads in the metal.

29.2 The assembly shall be capable of resisting the effects of vibration. See 30.2.1.

29.3 The enclosure shall be of metal, molded-phenolic composition, or equivalent material evaluated in accordance with 29.4.

29.4 Among the factors which are to be taken into consideration when judging the equivalency of a nonmetallic enclosure are:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability; and

e) Resistance to distortion at temperatures to which the material is subjected under any conditions of usage.

29.5 The switch assembly shall function as intended and the contacts shall not weld together or show excessive pitting when operated for 6000 cycles at the electrical load it is intended to control.

29.6 The assembly shall comply with the requirements in Section 32, Dielectric Voltage-Withstand Test.

29.7 Spacings through air and over surfaces between uninsulated live parts of opposite polarity, and between uninsulated live parts and dead metal parts that are likely to become energized shall be a minimum of 1.2 mm (3/64 inch).

PERFORMANCE

30 Vibration Tests

30.1 Electric fuel pumps

30.1.1 A pump located outside of the fuel tank shall withstand the test described in 30.4, Test method, and shall operate without developing leaks, cracks, and the like, and without increasing the risk of fire or injury to persons.

30.1.2 The pump and all components, with the manufacturer's recommended fuel line attached, is to be mounted on a vibration machine so as to simulate as closely as possible an actual installation. The means used for such mounting shall be sufficiently rigid to preclude resonant frequencies of the mounting means.

30.2 Mechanical-disconnect switches

30.2.1 A mechanical-disconnect switch shall be capable of maintaining a closed circuit and shall not become loosened from its mounting, be otherwise damaged, or become inoperable, when subjected to 8

hours of vibration at an amplitude of 5.1 mm (0.2 inch) from its most vulnerable mounting position, at the frequency that produces maximum resonance.

30.3 Fuel filters

30.3.1 A fuel filter located outside of the fuel tank shall not become loosened from its mounting or be otherwise damaged from its normal mounting position under the conditions described in 30.4.1.

30.4 Test method

30.4.1 The sample shall be subjected to variable frequency vibration along each of three axes (horizontal, lateral, and vertical) for 8 hours in each plane (24 hours total) at a peak-to-peak amplitude of 1.3 ±0.00004 mm (0.040 ±0.001 in). The frequency of vibration is to be continuously varied, at a uniform rate, from 10 to 60 to 10 hertz every 4 minutes.

30.4.2 For this test, peak-to-peak amplitude is defined as the maximum displacement of sinusoidal motion (total table displacement).

31 Endurance Tests

31.1 Electric fuel pumps

31.1.1 An electric fuel pump shall deliver its rated output without overheating or evidence of damage when continuously operated for a period of 800 hours.

31.1.2 The pump is to be mounted in its normal position and connected to exert a constant suction lift established at the maximum recommended by the manufacturer. During the test, the discharge pressure is to be varied within the range recommended by the manufacturer, but in a manner to provide operation for 400 hours at the maximum discharge pressure and at the manufacturer's rated voltage.

31.1.3 At other periods throughout the test, the impressed voltage is to be varied between 90 and 110 % of the manufacturer's rated voltage.

31.2 Mechanical disconnect switches

31.2.1 A mechanical-disconnect switch shall be capable of opening and closing a 40 ampere, 6 volt direct-current load across the battery disconnect contacts and a 5 ampere load across the field contacts, if furnished, throughout 4000 cycles of operation, where each cycle of operation consists of 1 second with contacts closed and 5 seconds with contacts open.

31.3 Fill and vent fittings

31.3.1 A self-closing fill and vent fitting shall, following 100,000 cycles of opening and closing of the cap shall prevent venting up to a positive pressure of 24.5 kPa (3.5 psi).

31.3.2 At least two samples of each style and size of fittings are to be mounted to a cycling machine and subjected to continuous operation. One cycle is considered to be one opening and closing of the cap operated through the full travel limits of its attachment arm.

31.3.3 Following 100,000 cycles of operation, the samples are to be mounted on a simulated fuel tank fitted with a pressure gauge having ranges exceeding the values specified in 31.3.1 by at least 50 %. The tank is to be gradually subjected to air pressure and observations made of the positive air pressures associated with the operation of the fittings. The start-to-discharge pressure of the fill-cap assembly is to

be observed by identifying bubbling while immersing the assembly in water or by employing a soap-and-water solution to the vent outlet.

32 Dielectric Voltage-Withstand Test

32.1 An electric fuel pump assembly and a mechanical-disconnect switch shall withstand for 1 minute, without breakdown, the application of a 60 hertz alternating potential of 500 volts between live parts and dead metal parts.

33 Explosion Tests

33.1 An electric fuel pump assembly shall not permit the passage of sparks or flame from the interior of the casing to the outside surrounding atmosphere as the result of exploding a gasoline-air mixture within the assembly. As an alternative, this test is to be conducted with a propane-air mixture over the range of 3.0 to 7.0 % concentrations.

33.2 The gasoline used in this investigation is to be a nonleaded petroleum distillate consisting essentially of aliphatic hydrocarbon compounds. It is to have a specific gravity to 69°, API, at 15.6 °C (60 °F). The boiling point range of a typical sample of this gasoline, determined by ASTM D86, is shown in Table 33.1.

Table 33.1
Result of Distillation Test of Gasoline

Volume distilled, milliliters	Temperature, degrees °C	(°F)
Initial boiling point	48.0	(118)
5	63.0	(145)
10	66.0	(151)
20	70.0	(158)
30	74.0	(165)
40	77.5	(172)
50	81.5	(179)
60	85.5	(186)
70	90.0	(194)
80	96.0	(205)
90	106.5	(224)
95	116.5	(242)
Endpoint	126.5	(260)
Recovery, millimeters		98.5
Residue, milliliters		1.0
Distillation loss, milliliters		0.5
Barometric pressure, millimeters Hg		746.5

33.3 For the explosion tests, the pump is to be installed in a test chamber provided with gas-inlet and -outlet connections to the pipes carrying the explosive mixtures. The pump is to be drilled and tapped for connection to the inlet and outlet pipes carrying the explosive vapor-air mixture and also is to be tapped for attachment of the explosion-pressure recording device and spark plugs for ignition.

33.4 The explosive vapor-air mixture is to be allowed to flow into each enclosure and the surrounding test chamber until all of the original air has been displaced. Samples then are to be taken for analysis from the test chamber, the enclosure, and the line carrying the explosive vapor-air mixture. The mixture then is to be fired on the interior of the enclosure either by arcs produced by the device or by a spark from the spark plug.

33.5 A minimum of ten tests are to be conducted.

33.6 In the event that the fuel pump construction is such that an explosion does not occur when tested in accordance with 33.1 – 33.5, the fuel pump shall be considered acceptable.

34 Hydrostatic-Strength Test

34.1 An enclosure for an electric fuel pump located outside of the fuel tank shall be capable of withstanding, without rupture or distortion, a hydrostatic pressure of five times, for a duration of 1 minute, the maximum pressure recorded during the explosion test.

Exception: A fuel pump that complies with 33.6 is not required to comply with the Hydrostatic-Strength Test.

34.2 The samples of pumps previously subjected to the explosion test are to be connected to a source of hydrostatic pressure. A positive shut-off valve and a pressure indicating device are to be installed in the supplying piping. The pressure indicating device is to be installed in the piping between the shut-off valve and the test pump. The pressure indicating device shall comply with one of the following:

a) An analog gauge having a pressure range such that the test pressure is between 30 and 70 % of the maximum scale reading of the gauge;

b) A digital pressure transducer, or other digital gauge, that is calibrated over a range of pressure that includes the test pressure; or

c) Other device that is equivalent to the devices in (a) or (b).

35 Tube-Fitting Pull Test

35.1 Tubing and piping shall not pull out of a tube fitting, nor shall the tube fitting rupture, when the ultimate loads designated in Table 35.1 are applied axially to the fitting and its connection.

Table 35.1
Pull Strength Test

Tubing size, outside diameter, mm (inch)		Pull load, kN (pounds-force)	
3.2	(1/8)	1.11	(250)
4.8	(3/16)	1.78	(400)
6.4	(1/4)	2.22	(500)
7.9	(5/16)	2.89	(650)
9.5	(3/8)	3.56	(800)
11.1	(7/16)	4.00	(900)
12.7	(1/2)	4.45	(1000)

Table 35.1 Continued on Next Page

Table 35.1 Continued

Tubing size, outside diameter, mm (inch)		Pull load, kN (pounds-force)	
14.4	(9/16)	5.56	(1250)
15.9	(5/8)	6.45	(1450)
19.1	(3/4)	8.45	(1900)
22.2	(7/8)	10.7	(2400)
25.4	(1)	11.6	(2600)
28.6	(1-1/8)	12.7	(2850)
31.8	(1-1/4)	13.6	(3050)
34.9	(1-3/8)	14.6	(3250)
38.1	(1-1/2)	15.3	(3450)
41.3	(1-5/8)	16.2	(3650)
44.5	(1-3/4)	17.1	(3850)
47.6	(1-7/8)	18.0	(4050)
50.8	(2)	18.9	(4250)
54.0	(2-1/8)	20.0	(4500)

35.2 Two samples of each size fitting are to be used for this test.

35.3 Each end of a short length of annealed copper tubing is to be connected, in accordance with the manufacturer's instructions, to one of the two fittings to be tested. The tubing shall be the same as employed in service.

35.4 The female pipe threaded ends of the two sample fittings are to be fitted with lengths of steel pipe, exerting the turning efforts designated in Table 35.2. The male threads are to be lubricated with SAE No. 10 machine oil prior to assembly. The opposite ends of each section of pipe are to be arranged for securing to the members of a tensile testing machine.

Table 35.2
Torque Requirements for Threaded Connections

Nominal thread size, mm (inches)	Torque N·m (pound-inches)	
25.4 (1)	135.6	(1200)
31.75 (1-1/4)	163.8	(1450)
38.1 (1-1/2)	175.1	(1550)
50.8 (2)	186.4	(1650)
63.5 (2-1/2)	197.7	(1750)
76.2 (3)	203.4	(1800)

35.5 The load is to be increased at a uniform rate until rupture occurs or the tubing or piping pulls out of one of the fittings, or the required load is obtained.

36 Marking-Plate-Adhesion Tests

36.1 General

36.1.1 To determine if a marking plate secured by adhesion is in accordance with 41.6, representative samples are to be subjected to the tests of 36.2.1 – 36.4.1. In each test, three samples of the marking plates are to be applied to the same test surfaces as employed in the intended application.

36.1.2 The marking plate is considered to be in accordance with the requirements if, immediately following removal from each test medium and after being exposed to room temperature for 24 hours following removal from each test medium:

a) Each sample demonstrates good adhesion and the edges are not curled;

b) The marking plate resists defacement or removal as demonstrated by scraping across the test panel with a flat metal blade 1.6 mm (1/16 inch) thick, held at a right angle to the test panel; and

c) The printing is legible and is not defeated by rubbing with thumb or finger pressure.

36.2 Oven aging test

36.2.1 Three samples of the marking plates under test are to be placed in an air oven maintained at a temperature of 60 °C (140 °F) for 240 hours.

36.3 Immersion test

36.3.1 Three samples of the marking plates are to be placed in a controlled atmosphere maintained at 23 ±2 °C (72 ±3.6 °F) with a 50 ±5 % relative humidity for 24 hours. The samples are then to be immersed in water at a temperature of 23±2 °C (72 ±3.6 °F) for 48 hours.

36.4 Standard atmosphere test

36.4.1 Three samples of the test panels are to be placed in a controlled atmosphere maintained at 23 ±2 °C (72±3.6 °F) with 50 ±5 % relative humidity for 72 hours.

37 Backfire Deflector Element Test

37.1 Tests are not required on backfire deflectors employed on diesel engines.

37.2 A dry-type filter element shall be subjected to five consecutive washing and drying cycles. Washing shall consist of 60 up-down strokes at a rate of approximately one stroke per second, completely immersing and removing the sample from a distilled water bath maintained at 23 ±2 °C (73 ±4 °F). The samples shall then be allowed to dry for no less than 72 hours. The samples shall be dried in an environment maintained at 23 ±2 °C (73 ±4 °F) and 50 ±5 % relative humidity.

37.3 The side of the filter media normally exposed to backfire is then to be subjected to a flame source of sufficient intensity to cause the media to burn or glow. The flame source is then to be removed and an acceptable filter media is not to continue to burn or smolder.

37.4 The flame employed shall be produced by a 9.53 ±0.79 mm (3/8 ±1/32 in) diameter single tube Tirrill burner. The flame shall be adjusted to a height of 50.8 ±0.79 mm (2 ±1/32 in) and shall be essentially blue in color with no appreciable inner cone. Flame impingement shall be accomplished by laying the element horizontally on a level surface and applying the flame to the side normally exposed to backfire at an angle forming 45 ±5° with horizontal. The distance from the burner orifice to the sample shall be maintained at