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CGA G-19.2—2019

**STANDARD FOR NATURAL GAS
TRANSPORTATION AND
TRANSFER**

FIRST EDITION



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1 Introduction

This publication provides standards for the safe transfer and transportation of compressed natural gas (CNG) and liquefied natural gas (LNG). This publication addresses filling, transporting, and delivering/dispensing. At a minimum, it covers regulatory compliance, source gas, transportation equipment, equipment inspection, maintenance and repair, operations, and training.

These guidelines are based on applicable regulations and best industry practices. Parties engaging in activities related to the transfer and transportation of natural gas shall perform risk analysis specific to the application and ensure compliance with the appropriate regulatory authorities.

2 Scope

This publication provides general information concerning the transportation and transfer of natural gas. It is intended to provide direction for regulatory reference, safety and health hazards, and equipment intended for the transport and delivery of natural gas and is limited to the equipment that is onboard during transportation. For information regarding the additional equipment required for the specific application, see [CGA G-19.1, Standard for Natural Gas Supply Systems](#) [1].¹

This publication also gives general knowledge of maintenance, inspection and repair of natural gas transport equipment. It is intended for natural gas users, shippers, fillers, carriers, distributors, safety administrators and anyone seeking an introduction to mobile natural gas applications. More precisely it covers the following:

- transfer from the supply to the transport vehicle;
- transportation between the supply and customer facility;
- transfer from the transport vehicle to a customer facility; and
- ISO tank containers and multiple-element gas containers (MEGCs).

This publication does not cover natural gas vehicular systems or transport of natural gas by rail. The different purity grades for LNG used in transportation versus LNG to be used for pipeline gas supply are not addressed in this publication.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2 Technical definitions

3.2.1 Compressed natural gas (CNG)

Natural gas that has been cleaned to meet a required quality standard, odorized, and compressed to a specific pressure into an appropriate container

3.2.2 Confined space

Space not normally occupied by personnel that has limited or restricted openings for entry and exit, can lack adequate ventilation, and can contain or produce dangerous air contamination.

3.2.3 Container

Portable compressed gas cylinder or liquid container made in accordance with the U.S. Department of Transportation (DOT), Transport Canada (TC), or American Society of Mechanical Engineers (ASME) specifications.

3.2.4 CNG cylinder types

3.2.4.1 Type I

All metal (steel or aluminum) cylinder.

3.2.4.2 Type II

Cylinder with a metallic (steel or aluminum) load-sharing liner with a composite or wire hoop “wrap” to provide reinforcement.

3.2.4.3 Type III

Cylinder with a metallic liner that is completely wrapped in a composite.

3.2.4.4 Type IV

Cylinder with a non-metallic, non-load sharing liner that is completely wrapped in a composite.

3.2.5 Cryogenic

Temperatures below -130°F (-90°C).

3.2.6 Design pressure

Most severe condition of coincident pressure and temperature expected in normal operation.

NOTE—This considers the maximum allowable working pressure (MAWP), static head of the product, and the vacuum if vacuum jacketed.

3.2.7 Emergency response plan

Pre-established plan to be used as a guide in the event of an emergency.

3.2.8 Flammable

Degree to which a material is easily ignited in an oxidizing atmosphere.

3.2.9 Gas detector

Device designed to detect the presence of specific gases that could harm individuals if exposed to unacceptable concentrations.

3.2.10 Liquefied natural gas (LNG)

Cryogenic natural gas in the liquid form.

3.2.11 Maximum allowable working pressure (MAWP)

Maximum gauge pressure permissible at the top of a container in its operating position for a designated temperature.

3.2.12 Overpressure

Pressure that exceeds the MAWP or design pressure of a system.

3.2.13 Personal protective equipment (PPE)

Equipment worn by personnel to decrease the risk of injury due to exposures to process hazards.

3.2.14 Pipeline quality natural gas

Natural gas that has been analyzed or conditioned to ensure that the hydrocarbon constituents and impurity levels are suitable for introduction into a pipeline.

NOTE—The physical properties of natural gas vary with composition. The heating value of pipeline natural gas can vary by as much as 20% within the range of representative compositions. Other physical properties such as density, saturation temperature, etc. can also vary. See Table 1 from [CGA G-19, Guideline for Natural Gas Safe Handling and Operations](#), and the National Institute of Standards and Technology (NIST) Standard Reference Database 23, *Reference Fluid Thermodynamic and Transport Properties Database* (REFPROP) [2, 3].

3.2.15 Pressure relief system

Safeguards installed to prevent overpressure of equipment.

3.2.16 Purge

Elimination of an undesirable fluid by displacement with another fluid.

3.2.17 Source gas

Product that is used to manufacture either LNG that eventually is used to fill LNG transportation equipment or natural gas that is used to fill CNG transportation equipment.

NOTE—See Section 6.

4 Regulatory compliance

In the U.S., the Department of Transportation's (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) regulates the use of natural gas, see Title 49 of the U.S. *Code of Federal Regulations* (49 CFR Part 192) [4]. Additional information is also provided in [CGA G-19.1](#) [1].

In addition to federal regulations, certain state entities (e.g., public utility commissions) can have local requirements. For example, in Texas, the Railroad Commission regulates practices involving natural gas.

In Canada, Transport Canada (TC) references CSA B339, *Cylinders, spheres, and tubes for the transportation of dangerous goods*, CSA B340, *Selection and use of cylinders, spheres, tubes, and other containers for the transportation of dangerous goods, class 2*, CSA B341, *UN pressure receptacles and multiple-element gas containers for the transport of dangerous goods*, CSA B342, *Selection and use of UN pressure receptacles and multiple-element gas containers for the transport of dangerous goods, Class 2*, in the *Transportation of Dangerous Goods Regulations (TDG Regulations)* for CNG, and CSA B620 *Highway tanks and portable tanks for the transportation of dangerous goods* and CSA B622, *Selection and use of highway tanks, TC portable tanks, and ton containers for the transportation of dangerous goods, Class 2*, for LNG [5, 6, 7, 8, 9, 10, 11].

4.1 Transfer of compressed natural gas

When transferring CNG, it may involve transferring from a stationary CNG system/station such as ASME ground storage, or a portable CNG storage system such as a DOT approved CNG tube trailer. In these situations, there is specific, personal protective equipment (PPE) that shall be used and operational practices that shall be followed, see [CGA G-19](#) [2]. The design, installation, operation, and maintenance of these types of facilities shall be in accordance with NFPA 55, *Compressed Gases and Cryogenic Fluids Code* [12]. State public utility commissions such as the Railroad Commission in Texas, or local agencies may have regulatory requirements related to CNG.

4.2 Transfer of liquefied natural gas

When transferring LNG either in loading or unloading, it may involve transferring from a stationary LNG system such as a plant/tank system, or a portable LNG system such as an LNG tanker. In either of these situations there is specific PPE that shall be used and operational practices that shall be followed, see G-19 [2]. For portable and stationary LNG applications refer to NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, for design, operation, and other related aspects [13].

4.3 Transportation of natural gas

In the United States, the transport of natural gas over the road is covered under Title 49 of the U.S. *Code of Federal Regulations* (49 CFR) [4]. The Hazardous Materials Table in 49 CFR 172.101 provides a summary of important information for each hazardous material or general category of hazardous materials [4]. In Canada, the transportation of natural gas by road is covered in the *TDG Regulations* with Schedule 1 of the *TDG Regulations* providing key information for each Dangerous Good [9]. These tables also provide a description of the material and the proper shipping name used on all shipping documents/bills of lading for a particular shipment, as well as unique numbers, placarding requirements and other information, so that the material can be safely transported from the manufacturer/supplier to the customer for use or for resale to consumers.

The following products are listed under methane in the Hazardous Materials Table of 49 CFR 172.101 [4]:

- methane, compressed (UN 1971);
- natural gas, compressed (UN 1971);
- methane, refrigerated liquid (cryogenic liquid) (UN 1972); and
- natural gas, refrigerated liquid (cryogenic liquid) (UN 1972).

For the purpose of this publication, transportation over the road is accomplished using either tube trailers for CNG or insulated cargo tanks for LNG.

These transport containers are provided with specific decals, placards, labeling, and other information as required for the transportation of the product. The information on the exterior of the trailers provides regulators, police, safety personnel, and emergency responders with information as to the contents of the trailer to ensure the safety of the general public.

For additional information on marking and placarding requirements in the United States, see 49 CFR 172 [4]. In Canada, *TDG Regulations* refer to CSA B620 for marking and placarding requirements [9, 10].

All drivers transporting hazardous materials require additional training, see 10.2.

Depending on the quantity of or the specific material being transported, the shipper can be required by regulation to have a transportation security plan in place. Drivers and shippers shall be familiar with the requirements of the security plan. For additional information, see [CGA P-51](#), *Transportation Security Standard for the Compressed Gas Industry* [14].

5 Health hazards

For additional information on the health hazards related to natural gas, see [CGA G-19](#) [2].

6 Source gas

Natural gas is a hydrocarbon gas mixture that is generated as a byproduct of the natural decay of organic materials buried underground and exposed to heat over a long period of time. Natural gas is composed primarily of methane, but can also contain varying amounts of heavier hydrocarbons such as ethane, propane, butane, and pentane. In addition to the hydrocarbons, natural gas can also contain smaller amounts of other substances such as carbon dioxide, hydrogen sulfide, nitrogen, and water, which are typically classified as impurities or contaminants in the gas.

The final composition of natural gas can vary depending on the location, source of the gas, and the methods used for processing it. In general, natural gas that has been processed for transportation via pipeline is referred to as pipeline quality natural gas. Once in the pipeline, the gas is transported to various points of consumption ranging from large power generation plants to residential customers. When the need to transport natural gas beyond the reach of the pipelines arises, there are two common options available: LNG and CNG.

Source gas is defined as natural gas that is supplied to the liquefaction process to manufacture LNG or natural gas that is supplied to the compressor to fill CNG tube trailers. In both situations, the best industry practice is to start with pipeline quality natural gas.

In the case of LNG, differences in the boiling points of the various constituents of the natural gas cause many of the heavier hydrocarbons and less desirable components of the feed gas to be separated during the liquefaction process.

For CNG, source gas supplied for compression should, at a minimum, be sourced from pipeline quality natural gas supply as recognized by the U.S. natural gas distribution industry. Unlike the liquefaction process for LNG, which tends to separate the contaminants from the gas, the contaminants in the source gas for CNG are compressed along with the methane. For this reason, it can be necessary for the source gas to undergo additional processing prior to compression. For example, water vapor present in the source gas at low pressure can condense into the liquid form at the higher storage pressures used for CNG. This liquid water can react with other contaminants like carbon dioxide or hydrogen sulfide to create conditions in the cylinder or tubes, which are corrosive or embrittling to the material from which the cylinder or tubes are made. To minimize the potential for this type of reaction, it is often necessary to process the source gas to reduce the water content below the low-pressure pipeline requirement to prevent the condensation of liquid water at the higher storage pressure in the cylinder or tubes.

In addition to industry practice, the design specifications for the containers can include requirements for the composition of the gas being transported in addition to manufacturing requirement specific to cylinder or tubes in CNG service. For example, DOT Special Permit SP-8009 covering transportation of CNG in DOT 3AAX trailer tubes provides strict requirements for the contaminant levels in the gas as well as additional inspection and testing requirements for the tubes [15]. Similar tubes made to ISO 11120, *Gas cylinders—Refillable seamless steel tubes for compressed gas transport, of water capacity between 150 l and 3000 l—Design construction and testing* under DOT approval required compliance with different gas compatibility requirements found in ISO 11114-1, *Gas cylinders—Compatibility of cylinder and valve materials with gas contents—Part 1: Metallic materials* [16, 17].

In general, sulfur and water are two contaminants that should be given special consideration when present in CNG, but the actual requirements for these contaminants may vary depending on the authority having jurisdiction (AHJ) over the particular transportation scenario. If uncertainty exists, the user is encouraged to consult with the container manufacturer and/or the AHJ for clarification.

DANGER: *The composition of untreated well head gas can change over time resulting in high concentrations of water or hydrogen sulfide leading to internal corrosion and potential embrittlement, resulting in possible degradation of the structural integrity of the cylinder. The composition of such gases shall be verified to be compliant with regulations specific to the cylinder(s) or tube(s) in use prior to each fill. Failure to follow this procedure can cause catastrophic failure of the cylinder.*

7 Transport equipment design

7.1 Compressed natural gas equipment

In the United States, the packaging requirements for natural gas, as with any hazardous material, are listed in the Hazardous Materials Table found in 49 CFR 172.101 [4]. In the table, compressed natural gas (with high methane content) is included under methane, compressed which references 49 CFR 173.302 for the requirements of both non-bulk and bulk packages [4]. For a compressed gas, the threshold between non-bulk and bulk packaging is 1000 lb water capacity per individual cylinder. 49 CFR 173.302 includes the additional requirements of 173.301a, 173.302a, and 173.305 as applicable based on the specification of the cylinder being used [4]. Within these standards are the specifications for high pressure tubes, manifolding, pressure relief devices (PRDs), structural integrity, and authorized tube types.

In general, equipment specified for the transportation of CNG is designed in accordance with 49 CFR 173.301 [4]. For equipment utilizing DOT specification cylinders longer than 2 m (6.5 ft), the cylinders are mounted horizontally and the framework meets the requirements of [CGA TB-25](#), *Design Considerations for Tube Trailers* [18].

In Canada, *TDG Regulations* refer to CSA B339, CSA B340, CSA B341, and CSA B342 for CNG [9, 5, 6, 7, 8].

The trailer and/or system design shall include tow-away protection. A tow-away incident is the movement of a trailer while still connected to fixed equipment which can result in hose rupture with product release, damage to

the fixed piping, and damage to the trailer. This damage usually results in disruption of service. For tow-away protection strategies, see [CGA P-49, Prevention of Tow-Away Incidents](#) [19].

7.1.1 Compressed natural gas equipment using DOT 3AAX tubes

DOT 3AAX tubes are only permitted for use in CNG service when they are manufactured and marked in accordance with DOT Special Permit (SP) 8009 [16]. This special permit includes requirements in addition to those of the DOT 3AAX specification including a maximum limit on the tensile strength of the steel, hardness testing, and ultrasonic inspection. Tubes made in accordance with this special permit are stamped with the letters “CNG” following the service pressure. The special permit also requires that the tubes be equipped with an internal drain tube, it places very specific requirements on the composition of the natural gas being transported, and it limits the service pressure of the tubes to 4000 psi (27 500 kPa).²

7.1.2 Compressed natural gas equipment using UN cylinders and tubes

UN cylinders and tubes are permitted for use in CNG service under the provisions of 49 CFR 173.301b [4]. Unlike DOT SP-8009, the regulation does not place any specific requirements on the composition of the natural gas transported in the UN pressure receptacles. However, 173.301b(a)(2) does require that the gas or mixture of gases be compatible with the material of construction as prescribed in ISO 11114-1 [4, 17]. Since the constituents of the natural gas and their respective quantities can vary greatly based on the source of the natural gas, UN pressure receptacles should be manufactured using applicable provisions for embrittling gas service and the maximum tensile strength of the material be limited to 950 MPa (137 750 psi). Pressure receptacles manufactured to the embrittling gas requirements include an “H” mark in the UN marking. Additionally, all UN pressure receptacles should be equipped with an internal drain tube and the moisture content and concentration of corroding components shall conform to the requirements of 173.301b(a)(2) [4].

7.1.3 Compressed natural gas equipment using composite cylinders

CNG may also be transported in composite cylinders. Under DOT regulation, all composite cylinders, with the exception of UN composite cylinders are manufactured by special permits. Each special permit is written for a specific composite cylinder and/or manufacturer and can contain requirements for the equipment in which the cylinder is installed in addition to the cylinder itself. The user of the equipment is responsible for ensuring that their specific application is in compliance with all applicable provisions of the special permit.

7.2 Liquified natural gas equipment

7.2.1 Trailer design regulations

Equipment specified for the transportation of LNG shall be designed in accordance with 49 CFR Part 178.338, and Parts 393-396, *ASME Boiler & Pressure Vessel Code* Section XII, or CSA B620 (TC-338) [4, 21, 11].

Within these regulations are specific design requirements including but not limited to material specifications, fabrication and examination, structural integrity, PRDs, marking, and certification.

The trailer and/or system design shall include tow-away protection. A tow-away incident is the movement of a trailer while still connected to fixed equipment, which can result in hose rupture with product release, damage to the fixed piping, and damage to the trailer. This damage usually results in disruption of service. For tow-away protection strategies, see [CGA P-49](#) [19].

7.2.2 ISO container regulations

Framed containers for the portable delivery of LNG are governed by portable container regulations. Such containers are often referred to as ISO containers. Specific reference to UN T75 is noted in 49 CFR 172.101 (Special Provision T75). The basic regulation for portable containers is found in 49 CFR 178.277 and the UN specific requirements in 49 CFR 178.274. ISO containers have been built to cargo tank requirements (49 CFR 178.338) under special permit. These may remain in service, but are not authorized for new construction [4].

² kPa shall indicate gauge pressure unless otherwise noted as (kPa, abs) for absolute pressure or (kPa, differential) for differential pressure. All kPa values are rounded off per [CGA P-11, Guideline for Metric Practice in the Compressed Gas Industry](#) [20].

Additional requirements based on where the tanks are used can also come from:

- *European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR)* [22];
- *Regulations Concerning the International Carriage of Dangerous Goods by Rail (RID)* [23];
- *International Maritime Dangerous Goods Code (IMDG Code)* [24];
- EN 13530-2, *Cryogenic vessels. Large transportable vacuum insulated vessels. Design, fabrication, inspection and testing* [25]; and
- ISO 1496-3, *Series 1 freight containers—Specification and testing—Part 3: Tank containers for liquids, gases and pressurized dry bulk* [26].

7.2.3 Piping and controls for liquefied natural gas equipment

Details of the operational design and considerations for gauging devices, valves and piping, discharge control devices, pump damage protection, accident damage protection, and thermal performance are outlined in the regulations and standards listed in 7.2.1 and 7.2.2.

7.2.3.1 Liquid level gauges

A liquid level gauge shall be installed on the trailer. The gauge shall be visible from the area where an operator would normally load or unload LNG. A calibration chart converting the liquid level gauge reading to LNG gallons shall also be installed in this location. A shutoff valve shall be installed on all phase lines routed to the liquid level gauge to facilitate gauge calibration and maintenance.

7.2.3.2 Electrical

Some electrical equipment is only used for transportation purposes. Transportation related electrical equipment may be of general electrical service. During the active loading or unloading of LNG from the equipment, such electrical systems shall not be powered.

Electrical systems that are designed to be powered during active loading or unloading of LNG shall be rated for the zone classification based on their proximity to the piping and potential leak sources. See Figure 5.10.4(d) of NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, as a reference [27].

7.2.3.3 Pressure relief valves

Spring-loaded pressure relief valves shall be provided with threaded or flanged connections. The threaded connections shall not be seal soldered or welded. For threaded relief valves, mechanical connections such as flanges or unions shall be installed in the relief devices inlet and outlet lines for easy removal of the valve.

Relief valves shall not be equipped with a lift lever and shall be sealed with a stainless-steel wire to prevent resetting of the set pressure without breaking the wire seal.

Relief valves serving trailers shall have a start to discharge pressure that complies with the code of construction of the trailer. Relief valves serving piping systems shall have a start to discharge pressure that complies with the applicable standards (e.g., [ASME B31.3](#), *Process Piping*) [28].

The relief valve shall be suitable for the intended service (liquid, gas, or both). Relief capacity tables/formulas should support the intended service (liquid, gas, or both). The relief valve shall be designed for the range of temperatures and pressures to which it is subjected. For more information, see [CGA S-1.2](#), *Pressure Relief Device Standards—Part 2—Portable Containers for Compressed Gases* [29].

Inlet piping to the relief valve shall not be smaller than the relief valve inlet.

Outlet piping from the relief valve shall not be smaller than the relief valve outlet.