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Pressure control valve setting (maximum start-to-discharge pressure psig)	Maximum permitted filling density (percent by weight)					
	Air	Argon	Nitrogen	Oxygen	Helium	Neon
45	82.5	133	76	108	12.5	109
75	80.3	130	74	105	12.5	104
105	78.4	127	72	103	12.5	100
170	76.2	122	70	100	12.5	92
230	75.1	119	69	98	12.5	85
295	73.3	115	68	96	12.5	77
360	70.7	113	65	93	12.5	
450	65.9	111	61	91	12.5	
540	62.9	107	58	88	12.5	
625	60.1	104	55	86	12.5	
Design service temperature (°F.)	−320	−320	−320	−320	−452	−411

(3) Hydrogen (minimum 95 percent parahydrogen) must be loaded and shipped as follows:

Column 1	Column 2
Design service temperature	Minus 423 °F. or colder.
Maximum permitted filling density, based on cylinder capacity at minus 423 °F (see Note 1).	6.7 percent.
The pressure control valve must be designed and set to limit the pressure in the cylinder to not more than.	17 psig.

NOTE 1: The filling density for hydrogen, cryogenic liquid is defined as the percent ratio of the weight of lading in a packaging to the weight of water that the packaging will hold at minus 423 °F. The volume of the packaging at minus 423 °F is determined in cubic inches. The volume is converted to pounds of water (1 lb. of water = 27.737 cubic inches).

(i) Each cylinder must be constructed, insulated and maintained so that during transportation the total rate of venting shall not exceed 30 SCF of hydrogen per hour.

(ii) In addition to the marking requirements in § 178.35 of this subchapter, the total rate of venting in SCF per hour (SCFH) shall be marked on the top head or valve protection band in letters at least one-half inch high as follows: ''VENT RATE**SCFH'' (with the asterisks replaced by the number representing the total rate of venting, in SCF per hour).

(iii) Carriage by highway is subject to the conditions specified in § 177.840(a) of this subchapter.

(d) *Mixtures of cryogenic liquid*. Where charging requirements are not specifically prescribed in paragraph (c) of this section, the cryogenic liquid must be shipped in packagings and under conditions approved by the Associate Administrator.

[Amdt. 173–166, 48 FR 27695, June 16, 1983, as amended by Amdt. 173–166, 49 FR 24314, June 12, 1984; Amdt. 173–180, 49 FR 42735, Oct. 24, 1984; Amdt. 173–201, 52 FR 13041, Apr. 20, 1987; Amdt. 173–250, 61 FR 25942, May 23, 1996; Amdt. 173–261, 62 FR 24741, May 6, 1997; 66 FR 45379, Aug. 28, 2001; 67 FR 16013, Sept. 27, 2002; 68 FR 75742, Dec. 31, 2003; 69 FR 54046, Sept. 7, 2004]

§ 173.318 Cryogenic liquids in cargo tanks.

(a) *General requirements*. (1) A cargo tank may not be loaded with a cryogenic liquid colder than the design service temperature of the packaging.

(2) A cargo tank may not be loaded with any material that may combine chemically with any residue in the packaging to produce an unsafe condition (see § 178.338–15).

(3) The jacket covering the insulation on a tank used to transport a cryogenic liquid must be made of steel if the cryogenic liquid:

(i) Is to be transported by vessel (see § 176.76(g) of this subchapter); or

(ii) Is oxygen or a flammable material.

(4) A valve or fitting made of aluminum with internal rubbing or abrading aluminum parts that may come in contact with oxygen in the cryogenic liquid form may not be installed on any cargo tank used to transport oxygen, cryogenic liquid unless the parts are anodized in accordance with ASTM Standard B 580 (IBR, see § 171.7 of this subchapter).

(5) An aluminum valve, pipe or fitting, external to the jacket that retains lading during transportation may not be installed on any cargo tank used

to transport oxygen, cryogenic liquid or any flammable cryogenic liquid.

(6) A cargo tank used to transport oxygen, cryogenic liquid must be provided with a manhole (see § 178.338–6 of this subchapter).

(b) *Pressure relief systems and pressure control valves*—(1) *Types of pressure relief systems*—(i) *Tanks in oxygen and flammable cryogenic liquid service.* Except as otherwise provided in this paragraph, each tank in oxygen and flammable cryogenic liquid service must be protected by two independent pressure relief systems which are not connected in series, namely:

(A) A primary system of one or more pressure relief valves; and

(B) A secondary system of one of more frangible discs or pressure relief valves. For a tank in carbon monoxide service, the secondary system must be pressure relief valves only.

(ii) *Tanks in helium and atmospheric gas (except oxygen) cryogenic liquid service.* For a tank used in helium and atmospheric gas (except oxygen) cryogenic liquid service, the tank must be protected by at least one pressure relief system consisting of:

(A) One or more pressure relief valves; or

(B) A combination of one or more pressure relief valves and one or more frangible discs.

(2) *Capacities of pressure relief systems*—(i) *Tanks in oxygen or flammable cryogenic liquid service.* For tanks in oxygen or flammable cryogenic liquid service, the primary system and the secondary system of pressure relief devices must each have a flow capacity equal to or greater than that calculated by the applicable formula in paragraph 5.3.2 or paragraph 5.3.3 of CGA S–1.2 (IBR, see § 171.7 of this subchapter). In addition:

(A) The primary pressure relief system must have a total flow capacity at a pressure not exceeding 120 percent of the tank's design pressure.

(B) The secondary pressure relief system must have a total flow capacity at a pressure not exceeding 150 percent of the tank's design pressure.

(C) The flow capacity and rating must be verified and marked by the manufacturer of the device in accordance with CGA Pamphlet S–1.2.

(ii) *Tanks in helium and atmospheric gas (except oxygen) cryogenic liquid service.* For tanks in helium and atmospheric gas (except oxygen) cryogenic liquid service, the pressure relief system must have a flow capacity equal to or greater than that calculated by the applicable formula in paragraphs 5.3.2 or 5.3.3 of CGA Pamphlet S–1.2. If the pressure relief system consists of a combination of pressure relief valves and frangible discs, the pressure relief valves must have a total venting capacity equal to or greater than that calculated by the applicable formula in paragraph 4.1.10.1.1 of CGA Pamphlet S–1.2. The pressure relief system must have this total flow capacity at a pressure not exceeding 150 percent of the tank's design pressure. The flow capacity and rating must be verified and marked by the manufacturer of the device in accordance with CGA Pamphlet S–1.2.

(3) *Type and construction of pressure relief devices.* (i) Each pressure relief device must be designed and constructed for a pressure equal to or exceeding the tank's design pressure at the coldest temperature reasonably expected to be encountered.

(ii) Pressure relief devices must be either spring-loaded pressure relief valves or frangible discs. Pressure relief valves must be of a type that automatically open and close at predetermined pressures.

(4) *Setting of pressure relief devices.* (i) On a tank used in oxygen or flammable cryogenic liquid service, the pressure relief devices must perform as follows.

(A) Each pressure relief valve in the primary relief system must be set-to-discharge at a pressure no higher than 110 percent of the tank's design pressure.

(B) Each pressure relief device in the secondary pressure relief system must be designed to commence functioning at a pressure no lower than 130 percent and no higher than 150 percent of the tank's design pressure.

(ii) On a tank used in helium and atmospheric gas (except oxygen) cryogenic liquid service, the pressure relief devices in the pressure relief system must be designed to commence functioning at no higher than 150 percent of the tank's design pressure.

(5) *Optional pressure relief devices and pressure control valves.* In addition to the required pressure relief devices, a cargo tank in cryogenic liquid (except carbon monoxide) service may be equipped with one or both of the following:

(i) One or more pressure control valves set at a pressure below the tank's design pressure.

(ii) One or more frangible discs set to function at a pressure not less than one and one-half times or more than two times the tank's design pressure.

(6) *Maximum filling rate.* (i) For a tank used in oxygen and flammable cryogenic liquid service, the maximum rate at which the tank is filled must not exceed the liquid flow capacity of the primary pressure relief system rated at a pressure not exceeding 120 percent of the tank's design pressure.

(ii) On a tank used in helium and atmospheric gas (except oxygen) cryogenic liquid service, the maximum rate at which the tank is filled must not exceed the liquid flow capacity of the pressure relief valves rated at 150 percent of the tank's design pressure.

(7) *Arrangement and location of pressure relief devices.* (i) The discharge from any pressure relief system must be directed upward and be unobstructed to the outside of the protective housing in such a manner as to prevent impingement of gas upon the jacket or any structural part of the vehicle.

(ii) Each pressure relief valve must be arranged or protected to prevent the accumulation of foreign material between the relief valve and the atmospheric discharge opening in any relief piping. The arrangement must not impede flow through the device.

(iii) Each pressure relief valve must be designed and located to minimize the possibility of tampering. If the pressure setting or adjustment is external to the valve, the valve adjustment must be sealed.

(iv) Each pressure relief device must have direct communication with the vapor space of the tank at the midlength of the top centerline.

(v) Each pressure relief device must be installed and located so that the cooling effect of the contents during venting will not prevent the effective operation of the device.

(8) *Connections.* (i) Each connection to a pressure relief device must be of sufficient size to allow the required rate of discharge through the pressure relief device. The inlet connection must be not less than one-half inch nominal pipe size.

(ii) A shut-off valve may be installed in a pressure relief system only when the required relief capacity is provided at all times.

(9) *Pressure relief devices for piping hose and vacuum-insulated jackets.* (i) Each portion of connected liquid piping or hose that can be closed at both ends must be provided with either a hydrostatic pressure relief valve without an intervening shut-off valve, or a check valve permitting flow from the pipe or hose into the tank. If used, the relief valve must be located so as to prevent its discharge from impinging on the tank, piping, or operating personnel.

(ii) On a vacuum-insulated cargo tank the jacket must be protected by a suitable relief device to release internal pressure. The discharge area of this device must be at least 0.00024 square inch per pound of water capacity of the tank. This relief device must function at a pressure not exceeding the internal design pressure of the jacket, calculated in accordance with Section VIII of the ASME Code (IBR, see § 171.7 of this subchapter), or 25 psig, whichever is less.

(10) *Tank inlet, outlet, pressure relief device and pressure control valve markings.* (i) Each tank inlet and outlet, except pressure relief devices and pressure control valves, must be permanently marked to indicate whether it communicates with ''vapor'' or ''liquid'' when the tank is filled to the maximum permitted filling density.

(ii) Each pressure relief valve must be plainly and permanently marked with the pressure, in psig, at which it is set-to-discharge, the discharge rate of the device in SCF per minute (SCFM) of free air, and the manufacturer's name or trade name and catalog number. The marked set-to-discharge pressure valve must be visible with the valve in its installed position. The rated discharge capacity of the device must be determined at a pressure of 120

percent of the design pressure of the tank.

(iii) Each pressure control valve must be plainly and permanently marked with the pressure, in psig, at which it is set-to-discharge.

(c) *Weight of lading requirements.* The weight of a cryogenic liquid in the tank must be determined by weighing or by the use of a liquid level gauging device authorized in § 178.338–14(a) of this subchapter, and may not exceed the lesser of:

(1) The weight of lading in the tank, based on the water capacity stamped on the nameplate (§ 178.338–18(a)(4) of this subchapter) and the appropriate maximum permitted filling density specified in paragraph (f) of this section; or

(2) The maximum weight of lading for which the cargo tank was designed, as marked on the specification plate (see § 178.338–18(b) of this subchapter).

(d) *Outage.* Except for a cargo tank containing helium, cryogenic liquid, a cargo tank offered for transportation must have an outage of at least two percent below the inlet of the pressure relief device or pressure control valve, under conditions of incipient opening, with the tank in a level attitude.

(e) *Temperature.* A flammable cryogenic liquid in a cargo tank at the start of travel must be at a temperature sufficiently cold that the pressure setting of the pressure control valve or the required pressure relief valve, whichever is lower, will not be reached in less time than the marked rated holding time for the cryogenic liquid (see paragraph (g)(3) of this section and § 178.338–9(b) of this subchapter).

(f) *Specification MC–338 (§ 178.338 of this subchapter) cargo tanks* are authorized for the shipment of the following cryogenic liquids subject to the following additional requirements:

(1) For purposes of this section, ''filling density'' is defined as the percent ratio of the weight of lading in the tank to the weight of water that the tank will hold at the design service temperature (one pound of water=27.737 cubic inches at 60 °F., or one gallon of water = 231 cubic inches at 60 °F. and weighs 8.32828 pounds).

(2) *Air, argon, helium, nitrogen, and oxygen, cryogenic liquids* must be loaded and shipped in accordance with the following table:

PRESSURE CONTROL VALVE SETTING OR RELIEF VALVE SETTING

Maximum set-to-discharge pressure (psig)	Maximum permitted filling density (percent by weight)				
	Air	Argon	Helium	Nitrogen	Oxygen
26			12.5.		
30	80.3	129	12.5	74	105
40	79.2		12.5.		
50	78.0		12.5.		
55	77.3	125	12.5	71	102
60	76.9		12.5.		
80	75.3		12.5.		
85	75.1	121	12.5		99
100	73.0		12.5.		
105	73.7		12.5	67.	
120	72.2		12.5.		
140	71.4		12.5.		
145	70.9	115	12.5	64	94
180	68.3		12.5.		
200	67.3	110	12.5	61	91
250	63.3	106	12.5	57	87
275	62.3	105	12.5	56	86
325	59.4	101		53	83
Design service temperature.	−320 °F	−320 °F	−452 °F	−320 °F	−320 °F

(3) *Carbon monoxide, hydrogen (minimum 95 percent para-hydrogen), ethylene, and methane or natural gas, cryogenic liquids* must be loaded and shipped in accordance with the following table:

PRESSURE CONTROL VALVE SETTING OR RELIEF VALVE SETTING

Maximum set-to-discharge pressure (psig)	Maximum permitted filling density (percent by weight)			
	Carbon monoxide	Ethylene	Hydrogen	Methane or natural gas
13			6.6.	
15	75.0		6.6	40.5
17	74.0		6.6.	
20		53.5		40.0
25	73.0.			
30	72.0	52.7	6.3	39.1
35.				
40		52.0		38.6
45	71.5.			
50		51.4	6.0	38.2
55.				
60		50.8.		
70		50.2	5.7	37.5
90		49.2.		
95.				
100		48.4	5.4	36.6
115		48.2.		
125			5.0.	
150			4.5.	
175	62.5	45.8.		
285	56.0.			
Design service temperature.	−320 °F	−155 °F	−423 °F	−260 °F

(4) *Mixtures of cryogenic liquid*. Where charging requirements are not specifically prescribed in this paragraph (f), the cryogenic liquid must be shipped in packagings and under conditions approved by the Associate Administrator.

(g) *One-way travel time; marking*. The jacket of a cargo tank to be used to transport a flammable cryogenic liquid must be marked on its right side near the front, in letters and numbers at least two inches high, ''One-Way-Travel-Time ____ hrs.'', with the blank filled in with a number indicating the one-way travel time (OWTT), in hours, of the cargo tank for the flammable cryogenic liquid to be transported. A cargo tank that is partially unloaded at one or more locations must have additional marking ''One-Way-Travel-Time ____ hrs. ____ psig to ____ psig at ____ percent filling density,'' with the second blank filled in with the pressure existing after partial unloading and the third blank filled in with the set-to-discharge pressure of the control valve or pressure relief valve, and the fourth blank with the filling density following partial unloading. Multiple OWTT markings for different pressure levels are permitted. The abbreviation ''OWTT'' may be used in place of the words ''One-way-travel-time'' in the marking required by this paragraph.

(1) OWTT is based on the marked rated holding time (MRHT) of the cargo tank for the cryogenic liquid to be transported in the cargo tank. If the MRHT for the flammable cryogenic liquid is not displayed on or adjacent to the specification plate, this MRHT may be derived.

(2) The MRHT is converted to OWTT, in hours, as follows:

(i) For a tank with an MRHT of 72 hours or less,

$$OWTT = (MRHT - 24) / 2$$

(ii) For a tank with an MRHT greater than 72 hours,

$$OWTT = MRHT - 48$$

(3) Each cargo tank motor vehicle used to transport a flammable cryogenic liquid must be examined after each shipment to determine its actual holding time. The record required by §177.840(h) of this subchapter may be used for this determination. If the examination indicates that the actual holding time of the cargo tank, after adjustment to reflect an average ambient temperature of 85 °F, is less than 90 percent of the marked rated holding time (MRHT) for the cryogenic liquid marked on the specification plate or

adjacent thereto (see § 178.338–18(b) of this subchapter), the tank may not be refilled with any flammable cryogenic liquid until it is restored to its marked rated holding time value or it is remarked with the actual marked rated holding time determined by this examination. If the name of the flammable cryogenic liquid that was transported and its marked rated holding time is not displayed on or adjacent to the specification plate, this requirement may be met by deriving the MRHT of the cargo tank for that flammable cryogenic liquid and comparing that derived MRHT with the actual holding time after adjustment.

[Amdt. 173–166, 48 FR 27696, June 16, 1983]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting § 173.318, see the List of CFR Sections Affected, which appears in the Finding Aids section of the printed volume and at *www.fdsys.gov*.

§ 173.319 Cryogenic liquids in tank cars.

(a) *General requirements*. (1) A tank car containing a flammable cryogenic liquid may not be shipped unless it was loaded by, or with the consent of, the owner of the tank car.

(2) The amount of flammable cryogenic liquid loaded into a tank car must be determined, either by direct measurement or by calculation based on weight, to verify that the tank has not been filled to a level in excess of the limits specified in paragraph (d)(2) of this section. The weight of any flammable cryogenic liquid loaded, except hydrogen, must be checked by use of scales after disconnecting the loading line.

(3) The shipper shall notify the Federal Railroad Administration whenever a tank car containing any flammable cryogenic liquid is not received by the consignee within 20 days from the date of shipment. Notification to the Federal Railroad Administration may be made by e-mail to *Hmassist@fra.dot.gov* or telephone call to (202) 493–6229.

(4) A tank car may not be loaded with any flammable cryogenic liquid:

(i) That may combine chemically with any residue in the tank to produce an unsafe condition,

(ii) That is colder than the design service temperature of the tank,

(iii) If the average daily pressure rise in the tank exceeded 3 psig during the prior shipment,

(iv) Unless it is marked with the name of contents, in accordance with § 172.330 of this subchapter.

(b) When a tank car containing a flammable cryogenic liquid is offered for transportation:

(1) At least 0.5 percent outage must be provided below the inlet of the pressure relief or pressure control valve at the start-to-discharge pressure setting of the valve, with the tank car in a level attitude, and

(2) The absolute pressure in the annular space must be less than 75 microns of mercury.

(c) *Temperature*. A flammable cryogenic liquid must be loaded into a tank car at such a temperature that the average daily pressure rise during transportation will not exceed 3 psig (see paragraph (a)(4)(iii) of this section).

(d) A Class DOT-113 tank car is authorized for the shipment of the following cryogenic liquids subject to the following additional requirements:

(1) For purposes of this section, ''filling density'' is defined as the percent ratio of the weight of lading in the tank to the weight of water that the tank will hold at the design service temperature (one pound of water = 27.737 cubic inches at 60 °F., or one gallon of water = 231 cubic inches at 60 °F. and weighs 8.32828 pounds).

(2) *Ethylene, and hydrogen (minimum 95 percent parahydrogen), cryogenic liquids* must be loaded and shipped in accordance with the following table:

PRESSURE CONTROL VALVE SETTING OR RELIEF VALVE SETTING

Maximum start-to-discharge pressure (psig)	Maximum permitted filling density (percent by weight)			
	Ethylene	Ethylene	Ethlyene	Hydrogen
17				6.60.
45	52.8.			
75		51.1	51.1.	