

4.2 PACKING INSTRUCTIONS

Packing Instruction 200

For cylinders, the general packing requirements of 4;1.1 and 4;4.1.1 must be met.

Cylinders, constructed as specified in 6;5 are authorized for the transport of a specific substance when specified in the following tables (Table 1 and Table 2). Cylinders other than UN marked and certified cylinders may be used if the design, construction, testing, approval and marks conform to the requirements of the appropriate national authority in which they are approved and filled. The substances contained must be permitted in cylinders and permitted for air transport according to these Instructions. Cylinders for which prescribed periodic tests have become due must not be charged and offered for transport until such retests have been successfully completed. Valves must be suitably protected or must be designed and constructed in such a manner that they are able to withstand damage without leakage as specified in Annex B of ISO 10297:1999. Cylinders with capacities of one litre or less must be packaged in outer packaging constructed of suitable material of adequate strength and design in relation to the packaging capacity and its intended use, and secured or cushioned so as to prevent significant movement within the outer packaging during normal conditions of transport. For some substances, the special packing provisions may prohibit a particular type of cylinder. The following requirements must be met:

- 1) Pressure relief devices must be fitted on cylinders used for the transport of UN 1013 **Carbon dioxide** and UN 1070 **Nitrous oxide**. Other cylinders must be fitted with a pressure relief device if specified by the appropriate national authority of the country of use. The type of pressure relief device, the set to discharge pressure and relief capacity of pressure relief devices, if required, must be specified by the appropriate national authority of the country of use. Manifolding of cylinders is not permitted.
- 2) The following two tables cover compressed gases (Table 1) and liquefied and dissolved gases (Table 2). They provide:
 - a) the UN number, name and description, and classification of the substance;
 - b) the LC₅₀ for toxic substances;
 - c) the types of cylinders authorized for the substance, shown by the letter "X";
 - d) the maximum test period for periodic inspection of the cylinders;

Note.— For cylinders which make use of composite materials, the maximum test period must be five years. The test period may be extended to that specified in Tables 1 and 2 (that is, up to ten years), if approved by the appropriate national authority of the country of use.
 - e) the minimum test pressure of the cylinders;
 - f) the maximum working pressure of the cylinders for compressed gases (where no value is given, the working pressure must not exceed two-thirds of the test pressure) or the maximum filling ratio(s) dependent on the test pressure(s) for liquefied and dissolved gases;
 - g) special packing provisions that are specific to a substance.
- 3) In no case must cylinders be filled in excess of the limit permitted in the following requirements:
 - a) For compressed gases, the working pressure must be not more than two-thirds of the test pressure of the cylinders. Restrictions to this upper limit on working pressure are imposed by special packing provision "o". In no case must the internal pressure at 65°C exceed the test pressure.
 - b) For high pressure liquefied gases, the filling ratio must be such that the settled pressure at 65°C does not exceed the test pressure of the cylinders.

The use of test pressures and filling ratios other than those in the table is permitted provided that the above criterion is met, except where special packing provision "o" applies.

For high pressure liquefied gases and gas mixtures for which relevant data are not available, the maximum filling ratio (FR) must be determined as follows:

$$FR = 8.5 \times 10^{-4} \times d_g \times P_h$$

where FR = maximum filling ratio
 d_g = gas density (at 15°C, 1 bar)(in g/l)
 P_h = minimum test pressure (in bar).

If the density of the gas is unknown, the maximum filling ratio must be determined as follows:

$$FR = \frac{P_h \times MM \times 10^{-3}}{R \times 338}$$

where FR = maximum filling ratio
 P_h = minimum test pressure (in bar)
 MM = molecular mass (in g/mol)
 $R = 8.31451 \times 10^{-2}$ bar.l/mol.K (gas constant).

For gas mixtures, the average molecular mass is to be taken, taking into account the volumetric concentrations of the various components.

- c) For low pressure liquefied gases, the maximum mass of contents per litre of water capacity must equal 0.95 times the density of the liquid phase at 50°C; in addition, the liquid phase must not fill the cylinder at any temperature up to 60°C. The test pressure of the cylinder must be at least equal to the vapour pressure (absolute) of the liquid at 65°C, minus 100 kPa (1 bar).

For low pressure liquefied gases for which filling data is not provided in the table, the maximum filling ratio must be determined as follows:

$$FR = (0.0032 \times BP - 0.24) \times d_1$$

where FR = maximum filling ratio
 BP = boiling point (in Kelvin)
 d_1 = density of the liquid at boiling point (in kg/l).

- d) For UN 1001, **Acetylene, dissolved**, and UN 3374 **Acetylene, solvent free**, see p).
 e) For liquefied gases charged with compressed gases, both components – the liquefied gas and the compressed gas – have to be taken into consideration in the calculation of the internal pressure in the cylinder.

The maximum mass of contents per litre of water capacity must not exceed 0.95 times the density of the liquid phase at 50°C; in addition, the liquid phase must not completely fill the cylinder at any temperature up to 60°C.

When filled, the internal pressure at 65°C must not exceed the test pressure of the cylinders. The vapour pressures and volumetric expansions of all substances in the cylinders must be considered. When experimental data is not available, the following steps must be carried out:

- i) Calculation of the vapour pressure of the liquefied gas and of the partial pressure of the compressed gas at 15°C (filling temperature);
- ii) Calculation of the volumetric expansion of the liquid phase resulting from the heating from 15°C to 65°C and calculation of the remaining volume for the gaseous phase;
- iii) Calculation of the partial pressure of the compressed gas at 65°C considering the volumetric expansion of the liquid phase;

Note.— The compressibility factor of the compressed gas at 15°C and 65°C must be considered.

- iv) Calculation of the vapour pressure of the liquefied gas at 65°C;
- v) Calculation of the total pressure, which is the sum of the vapour pressure of the liquefied gas and the partial pressure of the compressed gas at 65°C;
- vi) Consideration of the solubility of the compressed gas at 65°C in the liquid phase.

The test pressure of the cylinder must not be less than the calculated total pressure minus 100 kPa (1bar).

If the solubility of the compressed gas in the liquefied phase is not known for the calculation, the test pressure can be calculated without taking the gas solubility (sub-paragraph (vi)) into account.

- 4) Gas mixtures containing any of the following gases must not be offered for transport in aluminium alloy cylinders unless approved by the appropriate national authority of the State of Origin and the State of the Operator:

UN 1037 **Ethyl chloride**
 UN 1063 **Methyl chloride**
 UN 1063 **Refrigerant gas R 40**
 UN 1085 **Vinyl bromide, stabilized**
 UN 1086 **Vinyl chloride, stabilized**
 UN 1860 **Vinyl fluoride, stabilized**
 UN 1912 **Methyl chloride and methylene chloride mixture**

- 5) The filling of cylinders must be carried out by qualified staff using appropriate equipment and procedures. The procedures should include checks of:

- a) the conformity of cylinders and accessories with these Instructions;
- b) their compatibility with the product to be transported;
- c) the absence of damage which might affect safety;
- d) compliance with the degree or pressure of filling, as appropriate; and
- e) marks and identification.

These requirements are deemed to be met if the following standards are applied:

ISO 10691: 2004	Gas cylinders – Refillable welded steel cylinders for liquefied petroleum gas (LPG) – Procedures for checking before, during and after filling.
ISO 11372: 2011	Gas cylinders – Acetylene cylinders – Filling conditions and filling inspection
ISO 11755: 2005	Gas cylinders – Cylinder bundles for compressed and liquefied gases (excluding acetylene) – Inspection at time of filling
ISO 13088: 2011 + Amd 1:2020	Gas cylinders – Acetylene cylinder bundles – Filling conditions and filling inspection
ISO 24431:2016	Gas cylinders – Seamless, welded and composite cylinders for compressed and liquefied gases (excluding acetylene) – Inspection at time of filling

- 6) “Special packing provisions”:

Material compatibility

- a) Aluminium alloy cylinders are forbidden.
- b) Copper valves are forbidden.
- c) Metal parts in contact with the contents must not contain more than 65 per cent copper.
- d) When steel cylinders or composite cylinders with steel liners are used, only those bearing the “H” mark in accordance with 6;5.2.7.4 p) are permitted.

Gas specific provisions:

- l) UN 1040 **Ethylene oxide** may also be packed in hermetically sealed glass ampoules or metal inner packagings suitably cushioned in fibreboard, wooden or metal boxes meeting the Packing Group I performance level. The maximum quantity permitted in any glass inner packaging is 30 g, and the maximum quantity permitted in any metal inner packaging is 200 g. After filling, each inner packaging must be determined to be leak-tight by placing the inner packaging in a hot water bath at a temperature, and for a period of time, sufficient to ensure that an internal pressure equal to the vapour pressure of ethylene oxide at 55°C is achieved. The maximum net mass in any outer packaging must not exceed 2.5 kg. When cylinders are used, they must be of the seamless or welded steel types that are equipped with suitable pressure relief devices. Each cylinder must be tested for leakage with an inert gas before each refilling and must be insulated with three coats of heat retardant paint or in any equally efficient manner. The maximum net quantity per cylinder must not exceed 25 kg.

- m) Cylinders must be filled to a working pressure not exceeding 5 bar.

- o) In no case must the working pressure or filling ratio shown in the table be exceeded.

- p) For UN 1001 **Acetylene, dissolved**, and UN 3374 **Acetylene, solvent free**: cylinders must be filled with a homogeneous monolithic porous mass; the working pressure and the quantity of acetylene must not exceed the values prescribed in the approval or in ISO 3807-1:2000, ISO 3807-2:2000 or ISO 3807:2013, as applicable.

For UN 1001 **Acetylene, dissolved**, cylinders must contain a quantity of acetone or suitable solvent as specified in the approval (see ISO 3807-1:2000, ISO 3807-2:2000 or ISO 3807:2013, as applicable); cylinders fitted with pressure relief devices must be transported vertically.

The test pressure of 52 bar applies only to cylinders fitted with a fusible plug.

- ra) Ethyl chloride may be carried in securely sealed glass ampoules (IP.8) containing not more than 5 g of ethyl chloride with a ullage of not less than 7.5 per cent at 21°C. Ampoules must be cushioned with efficient non-combustible material in partitioned cartons with not more than 12 ampoules per carton. The cartons must be tightly packed to prevent movement in wooden boxes (4C1, 4C2), plywood boxes (4D), reconstituted wood boxes (4F), fibreboard boxes (4G) or plastic boxes (4H1, 4H2) that meet the performance testing requirements of 6;4 at the Packing Group II performance level. Not more than 300 g of ethyl chloride is permitted per package.

s) Aluminium alloy cylinders must be:

- i) Equipped only with brass or stainless steel valves; and
- ii) Cleaned in accordance with ISO 11621:1997 and not contaminated with oil.

Periodic inspection:

- u) The interval between periodic tests may be extended to 10 years for aluminium alloy cylinders when the alloy of the cylinder has been subjected to stress corrosion testing as specified in ISO 7866:2012 + Cor 1:2014.
- v) The interval between periodic inspections for steel cylinders may be extended to 15 years if approved by the appropriate national authority of the country of use.

Requirements for N.O.S. descriptions and for mixtures:

- z) The construction materials of the cylinders and their accessories must be compatible with the contents and must not react to form harmful or dangerous compounds therewith.

The test pressure and filling ratio must be calculated in accordance with the relevant requirements of PI 200.

The necessary steps must be taken to prevent dangerous reactions (that is, polymerization or decomposition) during transport. If necessary, stabilization or addition of an inhibitor may be required.

Note.— For the carriage of oxygen to provide life support to aquatic animals, see Note 7 of the Introductory Notes to this Part.

Table 1. COMPRESSED GASES

UN No.	Name and description	Class or Division	Subsidiary hazard	LC ₅₀ ml/m ³	Cylinders	Test period, years	Test pressure, bar*	Maximum working pressure, bar*	Special packing provisions*
1002	Air, compressed	2.2			X	10			
1006	Argon, compressed	2.2			X	10			
1046	Helium, compressed	2.2			X	10			
1049	Hydrogen, compressed	2.1			X	10			d
1056	Krypton, compressed	2.2			X	10			
1065	Neon, compressed	2.2			X	10			
1066	Nitrogen, compressed	2.2			X	10			
1071	Oil gas, compressed	2.3	2.1		X	5			
1072	Oxygen, compressed	2.2	5.1		X	10			s
1954	Compressed gas, flammable, n.o.s.	2.1			X	10			z
1956	Compressed gas, n.o.s.	2.2			X	10			z
1957	Deuterium, compressed	2.1			X	10			d
1964	Hydrocarbon gas mixture, compressed, n.o.s.	2.1			X	10			z
1971	Methane, compressed or natural gas, compressed with high methane content	2.1			X	10			
2034	Hydrogen and methane mixture, compressed	2.1			X	10			
3156	Compressed gas, oxidizing, n.o.s.	2.2	5.1		X	10			z

* Where the entries are blank, the working pressure must not exceed two-thirds of the test pressure.

Table 2. LIQUEFIED GASES AND DISSOLVED GASES

UN No.	Name and description	Class or Division	Subsidiary hazard	LC ₅₀ ml/m ³	Cylinders	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
1001	Acetylene, dissolved	2.1			X	10	60 52		c, p
1009	Bromotrifluoromethane (refrigerant gas R 13b1)	2.2			X	10	42 120 250	1.13 1.44 1.60	
1010	Butadienes, stabilized (1,2-butadiene)	2.1			X	10	10	0.59	
1010	Butadienes, stabilized (1,3-butadiene)	2.1			X	10	10	0.55	z
1010	Butadienes and hydrocarbon mixture, stabilized containing more than 20% butadienes	2.1			X	10			v z
1011	Butane	2.1			X	10	10	0.52	v
1012	Butylene (butylenes mixture)	2.1			X	10	10	0.50	z
1012	Butylene (1-butylene)	2.1			X	10	10	0.53	
1012	Butylene (cis-2-butylene)	2.1			X	10	10	0.55	
1012	Butylene (trans-2 butylene)	2.1			X	10	10	0.54	
1013	Carbon dioxide	2.2			X	10	190 250	0.68 0.76	
1018	Chlorodifluoromethane (refrigerant gas R 22)	2.2			X	10	27	1.03	
1020	Chloropentafluoroethane (refrigerant gas R 115)	2.2			X	10	25	1.05	
1021	1-Chloro-1,2,2,2-tetrafluoroethane (refrigerant gas R 124)	2.2			X	10	11	1.20	
1022	Chlorotrifluoromethane (refrigerant gas R 13)	2.2			X	10	100 120 190 250	0.83 0.90 1.04 1.11	
1027	Cyclopropane	2.1			X	10	18	0.55	
1028	Dichlorodifluoromethane (refrigerant gas R 12)	2.2			X	10	16	1.15	
1029	Dichlorofluoromethane (refrigerant gas R 21)	2.2			X	10	10	1.23	
1030	1,1-Difluoroethane (Refrigerant gas R 152 a)	2.1			X	10	16	0.79	
1032	Dimethylamine, anhydrous	2.1			X	10	10	0.59	b
1033	Dimethyl ether	2.1			X	10	18	0.58	
1035	Ethane	2.1			X	10	95 120 300	0.25 0.30 0.40	
1036	Ethylamine	2.1			X	10	10	0.61	b
1037	Ethyl chloride	2.1			X	10	10	0.80	a, ra
1039	Ethyl methyl ether	2.1			X	10	10	0.64	

UN No.	Name and description	Class or Division	Subsidiary hazard	LC ₅₀ ml/m ³	Cylinders	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
1041	Ethylene oxide and carbon dioxide mixture with more than 9% ethylene oxide but not more than 87%	2.1			X	10	190 250	0.66 .75	
1043	Fertilizer ammoniating solution with free ammonia	2.2			X	5			b, z
1055	Isobutylene	2.1			X	10	10	0.52	
1058	Liquefied gases , non-flammable, charged with nitrogen, carbon dioxide or air	2.2			X	10			
1060	Methylacetylene and propadiene mixture, stabilized	2.1			X	10			c, z
1060	Methylacetylene and propadiene mixture, stabilized (propadiene with 1% to 4% methylacetylene)	2.1			X	10	22	0.52	c
1061	Methylamine, anhydrous	2.1			X	10	13	0.58	b
1063	Methyl chloride (refrigerant gas R 40)	2.1			X	10	17	0.81	a
1070	Nitrous oxide	2.2	5.1		X	10	180 225 250	0.68 0.74 0.75	
1075	Petroleum gases, liquefied	2.1			X	10			v, z
1077	Propylene	2.1			X	10	27	0.43	
1078	Refrigerant gas, n.o.s.	2.2			X	10			z
1080	Sulphur hexafluoride	2.2			X	10	70 140 160	1.06 1.34 1.38	
1081	Tetrafluoroethylene, stabilized	2.1			X	10	200		m, o
1083	Trimethylamine, anhydrous	2.1			X	10	10	0.56	b
1085	Vinyl bromide, stabilized	2.1			X	10	10	1.37	a
1086	Vinyl chloride, stabilized	2.1			X	10	12	0.81	a
1087	Vinyl methyl ether, stabilized	2.1			X	10	10	0.67	
1858	Hexafluoropropylene (refrigerant gas R 1216)	2.2			X	10	22	1.11	
1860	Vinyl fluoride, stabilized	2.1			X	10	250	0.64	a
1912	Methyl chloride and methylene chloride mixture	2.1			X	10	17	0.81	a
1952	Ethylene oxide and carbon dioxide mixture with not more than 9% ethylene oxide	2.2			X	10	190 250	0.66 0.75	
1958	1,2-dichloro-1,1,2,2-tetrafluoroethane (refrigerant gas R 114)	2.2			X	10	10	1.30	
1959	1,1-difluoroethylene (refrigerant gas R 1132a)	2.1			X	10	250	0.77	

UN No.	Name and description	Class or Division	Subsidiary hazard	LC ₅₀ ml/m ³	Cylinders	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
1962	Ethylene	2.1			X	10	225 300	0.34 0.38	
1965	Hydrocarbon gas mixture, liquefied, n.o.s.	2.1			X	10			v, z
1968	Insecticide gas, n.o.s.	2.2			X	10			z
1969	Isobutane	2.1			X	10	10	0.49	v
1973	Chlorodifluoromethane and chloropentafluoroethane mixture with fixed boiling point, with approximately 49% chlorodifluoromethane (refrigerant gas R 502)	2.2			X	10	31	1.01	
1974	Chlorodifluorobromomethane (refrigerant gas R 12b1)	2.2			X	10	10	1.61	
1976	Octafluorocyclobutane (refrigerant gas R C318)	2.2			X	10	11	1.32	
1978	Propane	2.1			X	10	23	0.43	v
1982	Tetrafluoromethane (refrigerant gas R 14)	2.2			X	10	200 300	0.71 0.90	
1983	1-chloro-2,2,2-trifluoroethane (refrigerant gas R 133a)	2.2			X	10	10	1.18	
1984	Trifluoromethane (refrigerant gas R 23)	2.2			X	10	190 250	0.88 0.96	
2035	1,1,1-trifluoroethane (refrigerant gas R 143a)	2.1			X	10	35	0.73	
2036	Xenon	2.2			X	10	130	1.28	
2044	2,2-dimethylpropane	2.1			X	10	10	0.53	
2073	Ammonia solution , relative density less than 0.880 at 15°C in water, with more than 35% but not more than 40% ammonia	2.2			X	5	10	0.80	b
	with more than 40% but not more than 50% ammonia				X	5	12	0.77	b
2193	Hexafluoroethane (refrigerant gas R 116)	2.2			X	10	200	1.13	
2200	Propadiene, stabilized	2.1			X	10	22	0.50	
2419	Bromotrifluoroethylene	2.1			X	10	10	1.19	
2422	Octafluorobut-2-ene (refrigerant gas R 1318)	2.2			X	10	12	1.34	
2424	Octafluoropropane (refrigerant gas R 218)	2.2			X	10	25	1.04	
2451	Nitrogen trifluoride	2.2	5.1		X	10	200	0.50	
2452	Ethylacetylene, stabilized	2.1			X	10	10	0.57	c
2453	Ethyl fluoride (refrigerant gas R 161)	2.1			X	10	30	0.57	
2454	Methyl fluoride (refrigerant gas R 41)	2.1			X	10	300	0.63	
2517	1-chloro-1,1-difluoroethane (refrigerant gas R 142b)	2.1			X	10	10	0.99	

UN No.	Name and description	Class or Division	Subsidiary hazard	LC ₅₀ ml/m ³	Cylinders	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
2599	Chlorotrifluoromethane and trifluoromethane azeotropic mixture with approximately 60% chlorotrifluoromethane (refrigerant gas R 503)	2.2			X	10	31 42 100	0.12 0.17 0.64	
2601	Cyclobutane	2.1			X	10	10	0.63	
2602	Dichlorodifluoro-methane and difluoroethane azeotropic mixture with approximately 74% dichlorodifluoromethane (refrigerant gas R 500)	2.2			X	10	22	1.01	
3070	Ethylene oxide and dichlorodifluoro-methane mixture with not more than 12.5% ethylene oxide	2.2			X	10	18	1.09	
3153	Perfluoro(methyl vinyl ether)	2.1			X	10	20	0.75	
3154	Perfluoro(ethyl vinyl ether)	2.1			X	10	10	0.98	
3157	Liquefied gas, oxidizing, n.o.s.	2.2	5.1		X	10			z
3159	1,1,1,2-tetrafluoroethane (refrigerant gas R 134a)	2.2			X	10	18	1.05	
3161	Liquefied gas, flammable, n.o.s.	2.1			X	10			z
3163	Liquefied gas, n.o.s.	2.2			X	10			z
3220	Pentafluoroethane (refrigerant gas R 125)	2.2			X	10	49 35	0.95 0.87	
3252	Difluoromethane (refrigerant gas R 32)	2.1			X	10	48	0.78	
3296	Heptafluoropropane (refrigerant gas R 227)	2.2			X	10	13	1.21	
3297	Ethylene oxide and chlorotetrafluoroethane mixture with not more than 8.8% ethylene oxide	2.2			X	10	10	1.16	
3298	Ethylene oxide and pentafluoroethane mixture with not more than 7.9% ethylene oxide	2.2			X	10	26	1.02	
3299	Ethylene oxide and tetrafluoroethane mixture with not more than 5.6% ethylene oxide	2.2			X	10	17	1.03	
3337	Refrigerant gas R 404a	2.2			X	10	36	0.82	
3338	Refrigerant gas R 407a	2.2			X	10	32	0.94	
3339	Refrigerant gas R 407b	2.2			X	10	33	0.93	
3340	Refrigerant gas R 407c	2.2			X	10	30	0.95	
3354	Insecticide gas, flammable, n.o.s.	2.1			X	10			z
3374	Acetylene, solvent free	2.1			X	5	60 52		c, p

Packing Instruction 201

The general packing requirements of 4;1 must be met.

Hydrocarbon gas-powered small devices, including replacement cartridges, and lighters for cigarettes and lighter refills must comply with the requirements of the country in which they are filled. They must be provided with protection against inadvertent discharge. Lighters must not contain more than 10 g of liquefied petroleum gas. Hydrocarbon gas-powered small devices and lighter refills must not contain more than 65 g of liquefied petroleum gas. The liquid portion of the gas must not exceed 85 per cent of the capacity of the fuel vessel at 15°C. The articles, including closures, must be capable of withstanding an internal pressure of twice the pressure in the fuel vessel at 55°C. Where refill cartridges are in the form of aerosol dispensers, the pressure in the aerosol must not exceed 1 500 kPa at 55°C and the requirements of subparagraphs b) to e) of Packing Instruction 203 must be met. The articles must be tightly packed to prevent inadvertent operation in wooden boxes (4C1, 4C2), plywood boxes (4D), reconstituted wood boxes (4F), fibreboard boxes (4G) or plastic boxes (4H1, 4H2) of Packing Group II. The net quantity of liquefied petroleum gas in each package must not exceed 1 kg on passenger aircraft and 15 kg on cargo aircraft. Articles which meet the above requirements are permitted only when the valve and ignition mechanisms are designed or securely sealed, taped or otherwise fastened to prevent operation or leakage of contents during transport.

Articles permitted under this packing instruction may also include, within the same outer packaging, replacement cartridges exceeding 65 g each, containing liquefied petroleum gas, provided such cartridges comply with all the requirements of Packing Instruction 200, they are not manifolded or connected to the article and they cannot cause the failure or functioning of the article during transport. Such consignments must be carried on cargo aircraft.

Packing Instruction 202

This instruction applies to Class 2 refrigerated liquefied gases in open and closed cryogenic receptacles.

Requirements for closed cryogenic receptacles

- 1) The general requirements of 4;1 and 4;4.1 must be met.
- 2) The requirements of 6;5 must be met.
- 3) The closed cryogenic receptacles must be so insulated that they do not become coated with frost.
- 4) Test pressure

Refrigerated liquids must be filled in closed cryogenic receptacles with the following minimum test pressures:

- a) For closed cryogenic receptacles with vacuum insulation, the test pressure must not be less than 1.3 times the sum of the maximum internal pressure of the filled receptacle, including during filling and discharge, plus 100 kPa (1 bar);
- b) For other closed cryogenic receptacles, the test pressure must be not less than 1.3 times the maximum internal pressure of the filled receptacle, taking into account the pressure developed during filling and discharge.

5) Filling

For non-flammable, non-toxic refrigerated liquefied gases, the volume of liquid phase at the filling temperature and at a pressure of 100 kPa (1 bar) must not exceed 98 per cent of the water capacity of the pressure receptacle.

6) Pressure-relief devices

Every closed cryogenic receptacle, having a nominal capacity in excess of 550 L, must be provided with at least 2 pressure-relief devices. The pressure-relief device must be of the type that will resist dynamic forces including surge.

Closed cryogenic receptacles, having a nominal capacity of 550 L or less, must be provided with at least 1 pressure-relief device, and may in addition have a frangible disc in parallel with the spring loaded device in order to meet the requirements of 6;5.1.3.6.5. The pressure-relief device must be of the type that will resist dynamic forces including surge.

Note.— The pressure-relief devices must meet the requirements of 6;5.1.3.6.4 and 6;5.1.3.6.5.

Packing Instruction 202

7) Compatibility

Materials used to ensure the leakproofness of the joints or for the maintenance of the closures must be compatible with the contents. In the case of receptacles intended for the transport of oxidizing gases (that is, with a subsidiary hazard of 5.1), these materials must not react with these gases in a dangerous manner.

8) Periodic inspection

The periodic inspection and test frequencies of pressure relief valves must not exceed five years.

Note.— Insulated packagings containing refrigerated liquid nitrogen fully absorbed in a porous material are not subject to these Instructions when carried as cargo provided they meet the requirements of Special Provision A152.

Requirements for open cryogenic receptacles

Open cryogenic receptacles must be constructed to meet the following requirements:

1. The receptacles must be designed, manufactured, tested and equipped in such a way as to withstand all conditions, including fatigue, to which they will be subjected during their normal use and during normal conditions of transport.
2. The maximum water capacity for metal receptacles is 50 L and for glass receptacles it is 5 L.
3. The receptacle must have a double wall construction with the space between the inner and outer wall being evacuated (vacuum insulation). The insulation must prevent the formation of hoar frost on the exterior of the receptacle.
4. The materials of construction must have suitable mechanical properties at the service temperature.
5. Materials which are in direct contact with the dangerous goods must not be affected or weakened by the dangerous goods intended to be transported and must not cause a dangerous effect, such as catalysing a reaction or reacting with the dangerous goods.
6. Receptacles of glass double wall construction must have an outer packaging with suitable cushioning or absorbent materials which can withstand the pressures and impacts liable to occur under normal conditions of transport.
7. The receptacle must be designed to remain in an upright position during transport (such as have a base whose smaller horizontal dimension is greater than the height of the centre of gravity when filled to capacity or be mounted on gimbals).
8. Receptacles must be metal or glass vacuum insulated vessels or flasks vented to the atmosphere to prevent any increase in pressure within the package and the openings must be fitted with devices allowing gases to escape, preventing any splashing out of liquid and so configured that they remain in place during transport.
9. Open cryogenic receptacles must bear the following marks permanently affixed, such as by stamping, engraving or etching:
 - a) the manufacturer's name and address;
 - b) the model number or name;
 - c) the serial or batch number;
 - d) the UN number and proper shipping name of gases for which the receptacle is intended; and
 - e) the capacity of the receptacle in litres.

Note.— The size of the mark must be as set out for cylinders in Part 6;5.2.7.1. Open cryogenic receptacles manufactured prior to 1 January 2012 are not required to be so marked.

10. Open cryogenic receptacles are permitted for nitrogen, argon, krypton, neon and xenon refrigerated liquids.

Packing Instruction 203

Passenger and cargo aircraft for UN 1950 and 2037 only

The general packing requirements of 4;1 must be met.

For the purposes of this packing instruction, a receptacle is considered to be an inner packaging.

Note.— “Receptacle” has the same meaning as set out in 1;3. Any reference in this packing instruction to receptacle will include “aerosols” of UN 1950 and “receptacles, small, containing gas” and “gas cartridges” of UN 2037.

Aerosols and receptacles, small, containing gas (gas cartridges) must meet the requirements of Part 6;5.4.

The capacity of metal receptacles must not exceed 1 000 mL; plastics receptacles must not exceed 500 mL.

UN number and name	Net quantity per package	
	Passenger	Cargo
UN 1950 Aerosols , flammable	75 kg	150 kg
UN 1950 Aerosols , flammable (engine starting fluid)	Forbidden	150 kg
UN 1950 Aerosols , non-flammable	75 kg	150 kg
UN 1950 Aerosols , non-flammable (tear gas devices)	Forbidden	50 kg
UN 2037 Gas cartridges	1 kg	15 kg
UN 2037 Receptacles, small, containing gas	1 kg	15 kg

ADDITIONAL PACKING REQUIREMENTS

- Packagings must meet Packing Group II performance requirements.
- Release valves on aerosols must be protected by a cap or other suitable means to prevent inadvertent release of the contents during normal conditions of air transport.
- Receptacles must be packed so as to prevent excessive movement and inadvertent discharge during normal conditions of transport.

OUTER PACKAGINGS (see 6;3.1)

Boxes

Aluminium (4B)
Fibreboard (4G)
Natural wood (4C1, 4C2)
Other metal (4N)
Plastics (4H1, 4H2)
Plywood (4D)
Reconstituted wood (4F)
Steel (4A)

Drums

Aluminium (1B2)
Fibre (1G)
Other metal (1N2)
Plastics (1H2)
Plywood (1D)
Steel (1A2)

Packing Instruction Y203

Passenger and cargo aircraft for UN 1950 and 2037 only

The requirements of 3;4 must be met.

For the purposes of this packing instruction, a receptacle is considered to be an inner packaging.

Note.— “Receptacle” has the same meaning as set out in 1;3. Any reference in this packing instruction to receptacle will include “aerosols” of UN 1950 and “receptacles, small, containing gas” and “gas cartridges” of UN 2037.

Aerosols and receptacles, small, containing gas (gas cartridges) must meet the requirements of Part 6;5.4.

The capacity of metal receptacles must not exceed 1 000 mL; plastics receptacles must not exceed 500 mL.

Non-refillable aerosols and non-refillable receptacles containing gas (gas cartridges) containing toxic substances must not exceed 120 mL capacity.

<i>UN number and name</i>	<i>Total gross mass per package</i>
UN 1950 Aerosols, flammable	30 kg G
UN 1950 Aerosols, non-flammable	30 kg G
UN 2037 Gas cartridges	1 kg
UN 2037 Receptacles, small, containing gas	1 kg

ADDITIONAL PACKING REQUIREMENTS

- Release valves on aerosols must be protected by a cap or other suitable means to prevent inadvertent release of the contents during normal conditions of air transport.
- Receptacles must be packed so as to prevent excessive movement and inadvertent discharge during normal conditions of transport.

OUTER PACKAGINGS (see 6;3.1)

Boxes

Aluminium
Fibreboard
Natural wood
Other metal
Plastics
Plywood
Reconstituted wood
Steel

Drums

Aluminium
Fibre
Other metal
Plastics
Plywood
Steel

Packing Instruction 206

Passenger and cargo aircraft for UN 3167, UN 3168 and UN 3169 only

General requirements

Part 4, Chapter 1 requirements must be met, including:

A gas sample may only be accepted for transport as a non-pressurized gas providing it is at a pressure corresponding to ambient atmospheric pressure at the time the containment system is closed and this must not exceed 105 kPa absolute.

Cylinders and gas receptacles conforming to the construction, testing and filling requirements approved by the appropriate national authority are permitted.

1) Compatibility requirements

— Substances must be compatible with their packagings as required by 4;1.1.3.

2) Closure requirements

— Closures must meet the requirements of 4;1.1.4.

COMBINATION PACKAGINGS						SINGLE PACKAGINGS
UN number and proper shipping name	Inner packaging (see 6;3.2)	Inner packaging quantity (per receptacle) – passenger	Total quantity per package – passenger	Inner packaging quantity (per receptacle) – cargo	Total quantity per package – cargo	
UN 3167 Gas sample, non-pressurized, flammable, n.o.s.	Glass	1.0 L	1.0 L	2.5 L	5.0 L	No
	Metal	1.0 L		2.5 L		
UN 3168 Gas sample, non-pressurized, toxic, flammable, n.o.s.	Glass	Forbidden	Forbidden	1.0 L	1.0 L	No
	Metal			1.0 L		
UN 3169 Gas sample, non-pressurized, toxic, n.o.s.	Glass	Forbidden	Forbidden	1.0 L	1.0 L	No
	Metal			1.0 L		

ADDITIONAL PACKING REQUIREMENTS FOR COMBINATION PACKAGINGS

- Inner packagings must be hermetically sealed.
- Packagings must meet the Packing Group II performance requirements.
- Inner packaging(s) must be packed so as to prevent movement in the outer packaging.

OUTER PACKAGINGS OF COMBINATION PACKAGINGS (see 6;3.1)

Boxes

Aluminium (4B)
Fibreboard (4G)
Natural wood (4C1, 4C2)
Other metal (4N)
Plastics (4H1, 4H2)
Plywood (4D)
Reconstituted wood (4F)
Steel (4A)

Drums

Aluminium (1B1, 1B2)
Fibre (1G)
Other metal (1N1, 1N2)
Plastics (1H1, 1H2)
Steel (1A1, 1A2)

Jerricans

Aluminium (3B1, 3B2)
Plastics (3H1, 3H2)
Steel (3A1, 3A2)

Packing Instruction 208

The general packing requirements of 4;1 must be met.

Articles, pressurized pneumatic or hydraulic containing a non-flammable, non-liquefied and non-toxic gas and constructed from materials which will not fragment under pressure, may be carried under the following conditions:

- a) when installed in construction equipment and assembled machinery, articles must be designed and constructed with a burst pressure of not less than 5 times their charged pressure at 21°C when shipped;

Note.— Labelling, marking, dangerous goods transport document and information to pilot-in-command are not required.

- b) when tightly packed to prevent movement in strong outer packagings and charged to not more than 1 380 kPa at 21°C, the following conditions also apply:

- 1) each article must have a fluid space not exceeding 41 L under stored pressure;
- 2) each article must be tested without failure or damage to at least 3 times its charged pressure at 21°C but not less than 830 kPa before initial shipment and before each refilling and re-shipment;

- c) when tightly packed to prevent movement in strong outer packagings and charged with a pressure exceeding 1 380 kPa at 21°C the following conditions also apply:

- 1) each article must have a fluid space not exceeding 41 L under stored pressure;
- 2) each article must be tested without failure or damage to at least 3 times its charged pressure at 21°C, but not less than 830 kPa before initial shipment and before each refilling and re-shipment;
- 3) each article must be designed and constructed with a burst pressure of not less than 5 times its charged pressure at 21°C when shipped.

Packing Instruction 211

The general packing requirements of 4;1 must be met.

Refrigerating machines or components containing non-toxic liquefied gases or Ammonia solutions (UN 2672) must meet the following requirements:

- a) each cylinder must not contain more than 450 kg of a Division 2.2 gas without subsidiary hazard or 25 kg of Ammonia solutions (UN 2672);
- b) machines or components having two or more charged cylinders may not contain an aggregate of more than 910 kg of a Division 2.2 gas without subsidiary hazard or more than 45 kg of Ammonia solutions (UN 2672);
- c) each cylinder must be equipped with a safety device meeting the requirements of a recognized national standard;
- d) each cylinder must be equipped with a shut-off valve at each opening except openings used for safety devices and with no other connection. These valves must be closed prior to and during transport;
- e) cylinders must be manufactured, inspected and tested in accordance with a recognized UN or national standard;
- f) all parts subject to refrigerant pressure during shipment must be tested in accordance with a recognized UN or national standard;
- g) the liquid portion of the refrigerant, if any, must not completely fill any pressure vessel at 55°C;
- h) the amount of refrigerant, if liquefied, must not exceed the filling density prescribed by applicable State regulations.

Packing Instruction 213

The general packing requirements of 4;1 must be met.

Fire extinguishers with compressed or liquefied gas must be packed in strong outer packagings so that they cannot be accidentally activated.

Fire extinguishers may include installed actuating cartridges (cartridges, power device of Division 1.4C or 1.4S), without changing the classification of Division 2.2, provided the total quantity of deflagrating (propellant) explosives does not exceed 3.2 g per extinguishing unit.

Large fire extinguishers may also be transported unpackaged provided that the requirements of S-4;3.1.2 a) to e) are met, the valves are protected by one of the methods in accordance with 4;4.1.1.8 a) to c) and other equipment mounted on the fire extinguisher is protected to prevent accidental activation. For the purpose of this packing instruction, "large fire extinguishers" means fire extinguishers as described in sub-paragraphs c) to e) of Special Provision A19.

Packing Instruction 214

Cargo aircraft only for UN 3468 only

This Instruction applies to storage systems containing hydrogen absorbed in a metal hydride (UN 3468) individually or when contained in equipment and apparatus when transported on cargo aircraft.

- 1) For metal hydride storage systems, the general packing requirements of 4;4.1 must be met.
- 2) Only cylinders not exceeding 150 L in water capacity and having a maximum developed pressure not exceeding 25 MPa are covered by this packing instruction.
- 3) Metal hydride storage systems meeting the applicable requirements of 6;5 for the construction and testing of cylinders containing gas may be used for the transport of hydrogen only.
- 4) When steel cylinders or composite cylinders with steel liners are used, only those bearing the "H" mark, in accordance with 6;5.2.9.2 j) are permitted.
- 5) Metal hydride storage systems must meet the service conditions, design criteria, rated capacity, type tests, batch tests, routine tests, test pressure, rated charging pressure and provisions for pressure relief devices for transportable metal hydride storage systems specified in ISO 16111:2008 or ISO 16111:2018, and their conformity and approval must be assessed in accordance with 6;5.2.5.
- 6) Metal hydride storage systems must be filled with hydrogen at a pressure not exceeding the rated charging pressure shown in the permanent mark on the system as specified in ISO 16111:2008 or ISO 16111:2018.
- 7) The periodic test requirements for a metal hydride storage system must be in accordance with ISO 16111:2008 or ISO 16111:2018 and carried out in accordance with 6;5.2.6, and the interval between periodic inspections must not exceed five years. See 6;5.2.4.2 to determine which standard is applicable at the time of periodic inspection and test.
- 8) Storage systems with a water capacity of less than 1 L must be packaged in rigid outer packagings constructed of suitable material of adequate strength and design in relation to the packaging capacity and its intended use. They must be adequately secured or cushioned so as to prevent damage during normal conditions of transport.
- 9) Maximum net quantity per package for cargo aircraft is 100 kg of metal hydride storage systems, including when such storage systems are packed with equipment or contained in equipment.

Packing Instruction 215

Passenger and cargo aircraft for UN 3478 and 3479 only

General requirements

Part 4;1.1.1, 1.1.2 and 1.1.8 requirements must be met, including:

1) Compatibility requirements

- Substances must be compatible with their packagings as required by 4;1.1.3.

<i>UN number and name</i>	<i>Quantity – passenger</i>	<i>Quantity – cargo</i>
UN 3478 Fuel cell cartridges containing liquefied flammable gas	1 kg of fuel cell cartridges	15 kg of fuel cell cartridges
UN 3479 Fuel cell cartridges containing hydrogen in metal hydride		

ADDITIONAL PACKING REQUIREMENTS

- Fuel cell cartridges must be securely cushioned in the outer packagings.
- Packagings must meet the Packing Group II performance requirements.

OUTER PACKAGINGS

Boxes

Aluminium (4B)
Fibreboard (4G)
Natural wood (4C1, 4C2)
Other metal (4N)
Plastics (4H1, 4H2)
Plywood (4D)
Reconstituted wood (4F)
Steel (4A)

Drums

Aluminium (1B2)
Fibre (1G)
Plastics (1H2)
Plywood (1D)
Steel (1A2)

Jerricans

Aluminium (3B2)
Plastics (3H2)
Steel (3A2)

Packing Instruction Y215

Limited quantities for UN 3478 and 3479 only

General requirements

Part 3;4 requirements must be met.

Single packagings are not permitted for limited quantities.

For the purpose of this packing instruction, a fuel cell cartridge is considered an inner packaging.

1) Compatibility requirements

- Substances must be compatible with their packagings as required by 4;1.1.3.

<i>UN number and name</i>	<i>Maximum quantity per package</i>
UN 3478 Fuel cell cartridges containing liquefied flammable gas	0.5 kg of fuel cell cartridges
UN 3479 Fuel cell cartridges containing hydrogen in metal hydride	

ADDITIONAL PACKING REQUIREMENTS

- Fuel cell cartridges must be securely cushioned in the outer packagings.
- Fuel cell cartridges must not exceed 120 ml water capacity each.

Packing Instruction Y215		
OUTER PACKAGINGS		
<i>Boxes</i>	<i>Drums</i>	<i>Jerricans</i>
Aluminium Fibreboard Natural wood Other metal Plastics Plywood Reconstituted wood Steel	Aluminium Fibre Plastics Plywood Steel	Aluminium Plastics Steel

Packing Instruction 216											
Passenger and cargo aircraft for UN 3478 and 3479 (contained in equipment) only											
General requirements											
Part 4;1.1.1 and 1.1.8 requirements must be met, including:											
1) Compatibility requirements											
— Substances must be compatible with their packagings as required by 4;1.1.3.											
<table> <tr> <th><i>UN number and name</i></th><th><i>Quantity – passenger</i></th><th><i>Quantity – cargo</i></th></tr> <tr> <td>UN 3478 Fuel cell cartridges contained in equipment, containing liquefied flammable gas</td><td>1 kg of fuel cell cartridges</td><td>15 kg of fuel cell cartridges</td></tr> <tr> <td>UN 3479 Fuel cell cartridges contained in equipment, containing hydrogen in metal hydride</td><td></td><td></td></tr> </table>			<i>UN number and name</i>	<i>Quantity – passenger</i>	<i>Quantity – cargo</i>	UN 3478 Fuel cell cartridges contained in equipment , containing liquefied flammable gas	1 kg of fuel cell cartridges	15 kg of fuel cell cartridges	UN 3479 Fuel cell cartridges contained in equipment , containing hydrogen in metal hydride		
<i>UN number and name</i>	<i>Quantity – passenger</i>	<i>Quantity – cargo</i>									
UN 3478 Fuel cell cartridges contained in equipment , containing liquefied flammable gas	1 kg of fuel cell cartridges	15 kg of fuel cell cartridges									
UN 3479 Fuel cell cartridges contained in equipment , containing hydrogen in metal hydride											
ADDITIONAL PACKING REQUIREMENTS											
— Fuel cell cartridges that are contained in equipment must be protected against short circuit and the equipment must be protected against inadvertent operation. — Equipment must be securely cushioned in the outer packagings. — Fuel cell systems must not charge batteries during transport. — On passenger aircraft, each fuel cell system and each fuel cell cartridge must conform to IEC 62282-6-100 Ed. 1, including Amendment 1, or a standard approved by the appropriate authority of the State of Origin.											
OUTER PACKAGINGS											
<i>Boxes</i>	<i>Drums</i>	<i>Jerricans</i>									
Strong outer packagings											

Packing Instruction 217

Passenger and cargo aircraft for UN 3478 and 3479 (packed with equipment) only

General requirements

Part 4;1.1.1 and 1.1.8 requirements must be met, including:

1) Compatibility requirements

- Substances must be compatible with their packagings as required by 4;1.1.3.

<i>UN number and name</i>	<i>Quantity – passenger</i>	<i>Quantity – cargo</i>
UN 3478 Fuel cell cartridges packed with equipment , containing liquefied flammable gas	1 kg of fuel cell cartridges	15 kg of fuel cell cartridges
UN 3479 Fuel cell cartridges packed with equipment , containing hydrogen in metal hydride		

ADDITIONAL PACKING REQUIREMENTS

- When fuel cell cartridges are packed with equipment, they must be packed in intermediate packagings together with the equipment they are capable of powering.
- The maximum number of fuel cell cartridges in the intermediate packaging must be the minimum number required to power the equipment, plus 2 spares.
- The fuel cell cartridges and the equipment must be packed with cushioning material or divider(s) or inner packaging so that the fuel cell cartridges are protected against damage that may be caused by the movement or placement of the equipment and the cartridges within the packaging.

OUTER PACKAGINGS

Boxes

Drums

Jerricans

Strong outer packagings

Packing Instruction 218

General requirements

The general requirements of 4;4.1 applicable to cylinders must be met. Cylinders, constructed as specified in 6;5 are authorized for the transport of UN 3500, UN 3501, UN 3502, UN 3503, UN 3504 and UN 3505. Cylinders other than UN marked and certified cylinders may be used if the design, construction, testing, approval and marks conform to the requirements of the appropriate national authority of the State in which they are approved and filled. The substances contained must be permitted in cylinders and permitted for air transport according to these Instructions. Cylinders for which prescribed periodic tests have become due must not be charged and offered for transport until such retests have been successfully completed.

Compatibility requirements

- The construction materials of the cylinders and their accessories must be compatible with the contents and must not react to form harmful or dangerous compounds therewith.
- The necessary steps must be taken to prevent dangerous reactions (that is, polymerization or decomposition) during transport. If necessary, stabilization or addition of an inhibitor may be required.

Periodic inspection

- The maximum test period for periodic inspection of the cylinders must be 5 years.

ADDITIONAL PACKING REQUIREMENTS

- a) Cylinders must be so filled that at 50°C the non-gaseous phase does not exceed 95% of their water capacity, and they are not completely filled at 60°C. When filled, the internal pressure at 65°C must not exceed the test pressure of the cylinders. The vapour pressures and volumetric expansion of all substances in the cylinders must be taken into account.
- b) Spray application equipment (such as a hose and wand assembly) must not be connected during transport.
- c) The minimum test pressure must be in accordance with Packing Instruction 200 for the propellant but must not be less than 20 bar.
- d) Non-refillable cylinders used may have a water capacity in litres not exceeding 1 000 L divided by the test pressure expressed in bars provided capacity and pressure restrictions of the construction standard comply with clause 1 of ISO 11118:2015 + Amd 1:2019, which limits the maximum capacity to 50 L.
- e) For liquids charged with a compressed gas, both components – the liquid and the compressed gas – have to be taken into consideration in the calculation of the internal pressure in the cylinder. When experimental data is not available, the following steps must be carried out:
 - i) Calculation of the vapour pressure of the liquid and of the partial pressure of the compressed gas at 15°C (filling temperature);
 - ii) Calculation of the volumetric expansion of the liquid phase resulting from the heating from 15°C to 65°C and calculation of the remaining volume for the gaseous phase;
 - iii) Calculation of the partial pressure of the compressed gas at 65°C considering the volumetric expansion of the liquid phase;

Note.— The compressibility factor of the compressed gas at 15°C and 65°C must be considered.

 - iv) Calculation of the vapour pressure of the liquid at 65°C;
 - v) Calculation of the total pressure, which is the sum of the vapour pressure of the liquid and the partial pressure of the compressed gas at 65°C;
 - vi) Consideration of the solubility of the compressed gas at 65°C in the liquid phase.

The test pressure of the cylinders must not be less than the calculated total pressure minus 100 kPa (1 bar).

If the solubility of the compressed gas in the liquid phase is not known for the calculation, the test pressure can be calculated without taking the gas solubility (sub-paragraph vi)) into account.

- f) For fire extinguishing agents assigned to UN 3500, the maximum test period for periodic inspection must be ten years.

Packing Instruction 218		
OUTER PACKAGINGS		
<i>Boxes</i>	<i>Drums</i>	<i>Jerricans</i>
Strong outer packagings		

Packing Instruction 219
<p>For cylinders, the general packing requirements of 4;1.1 and 4;4.1.1 must be met.</p> <p>This Instruction applies to Class 2 adsorbed gases.</p> <ol style="list-style-type: none"> The following packagings are permitted provided the general packing requirements of 4.1.1 are met: <ol style="list-style-type: none"> Cylinders constructed as specified in 6;5.2 and in accordance with ISO 11513:2011, ISO 11513:2019, ISO 9809-1:2010 or ISO 9809-1:2019; and Cylinders constructed before 1 January 2016 in accordance with 6;5.3 and a specification approved by the appropriate national authorities of the countries of transport and use. The pressure of each filled cylinder must be less than 101.3 kPa at 20°C and less than 300 kPa at 50°C. The minimum test pressure of the cylinder is 21 bar. The minimum burst pressure of the cylinder is 94.5 bar. The internal pressure at 65°C of the filled cylinder must not exceed the test pressure of the cylinder. The adsorbent material must be compatible with the cylinder and must not form harmful or dangerous compounds with the gas to be adsorbed. The gas in combination with the adsorbent material must not affect or weaken the cylinder or cause a dangerous reaction (such as a catalyzing reaction). The quality of the adsorbent material must be verified at the time of each fill to assure the pressure and chemical stability requirements of this packing instruction are met each time an adsorbed gas package is offered for transport. The adsorbent material must not meet the criteria of any of the classes or divisions in these Instructions. The filling procedure must be in accordance with Annex A of ISO 11513:2011 (applicable until 31 December 2024) or Annex A of ISO 11513:2019. The maximum period for periodic inspections is five years. The construction materials of the cylinders and their accessories must be compatible with the contents and must not react to form harmful or dangerous compounds therewith.

Packing Instruction 220

Cargo aircraft only for UN 3529 only

(See Packing Instruction 378 for flammable liquid-powered engines or machinery, Packing Instruction 950 for flammable liquid-powered vehicles, Packing Instruction 951 for flammable gas-powered vehicles, Packing Instruction 952 for battery-powered equipment and vehicles or Packing Instruction 972 for engines or machinery containing only environmentally hazardous fuels)

General requirements

Part 4, Chapter 1 requirements must be met, including:

Compatibility requirements

- Substances must be compatible with their packagings as required by 4.1.1.3.

UN number and proper shipping name		Quantity – passenger	Quantity – cargo
UN 3529	Engine, internal combustion, flammable gas powered or Machinery, internal combustion, flammable gas powered or Engine, fuel cell, flammable gas powered or Machinery, fuel cell, flammable gas powered	Forbidden	No limit

General

- 1) The engine or machinery, including the means of containment containing dangerous goods, must be in compliance with the construction requirements specified by the appropriate national authority;
- 2) The engines or machinery must be oriented to prevent inadvertent leakage of dangerous goods and secured by means capable of restraining the engines or machinery to prevent any movement during transport which would change the orientation or cause them to be damaged.

ADDITIONAL PACKING REQUIREMENTS

If the engine or machinery is constructed and designed so that the means of containment containing the dangerous goods affords adequate protection, an outer packaging is not required. Dangerous goods in engines or machinery must otherwise be packed in outer packagings constructed of suitable material, and of adequate strength and design in relation to the packaging capacity and its intended use, and meeting the applicable requirements of 4.1.1.1, or they must be fixed in such a way that they will not become loose during normal conditions of transport, such as in cradles or crates or other handling devices.

Flammable gas vessels

- 1) for flammable gas-powered machines or equipment, pressurized vessels containing the flammable gas must be completely emptied of flammable gas. Lines from vessels to gas regulators, and gas regulators themselves, must also be drained of all trace of flammable gas. To ensure that these conditions are met, gas shut-off valves must be left open and connections of lines to gas regulators must be left disconnected upon delivery of the engine or machinery to the operator. Shut-off valves must be closed and lines reconnected at gas regulators before loading aboard the aircraft;

or alternatively,

- 2) flammable gas-powered machines or equipment that have pressure receptacles (fuel tanks) equipped with electrically operated valves that close automatically in case the power is disconnected, or with manual shut-off valves, may be transported under the following conditions:
 - i) the tank shut-off valves must be in the closed position and in the case of electrically operated valves, power to those valves must be disconnected;
 - ii) after closing the tank shut-off valves, the equipment or machinery must be operated until it stops from lack of fuel before being loaded aboard the aircraft;
 - iii) in no part of the closed system must the remaining pressure of compressed gases exceed 5 per cent of the maximum allowable working pressure of the pressure receptacle (fuel tank) system, or more than 2 000 kPa (20 bar), whichever is the lower.

Packing Instruction 220

Batteries

All batteries must be installed and securely fastened in the battery holder of the machine or equipment and must be protected in such a manner so as to prevent damage and short circuits. In addition:

- ≠ 1) If spillable batteries are installed, and it is possible for the machine or equipment to be handled in such a way that batteries would not remain in their intended orientation, they must be removed and packed according to Packing Instruction 870.
- 2) If lithium batteries are installed:
 - i) lithium batteries identified as being damaged or defective in accordance with Special Provision A154 are forbidden for transport; and
 - ii) lithium batteries must meet the provisions of Part 2;9.3, except that pre-production prototypes of lithium batteries or cells, when these prototypes are transported for testing, or low production runs of lithium batteries or cells that have not been tested to the requirements in Part III, subsection 38.3 of the UN Manual of Tests and Criteria may be transported aboard cargo aircraft if approved by the appropriate authority of the State of Origin and the State of the Operator. A copy of the document of approval must accompany the consignment.
- ≠ 3) If metallic sodium or sodium alloy batteries are installed, they must conform to the requirements of Special Provision A94.

Other operational equipment

- 1) Dangerous goods required for the operation or safety of the machine or equipment, such as fire extinguishers, tire inflation canisters or safety devices, must be securely mounted in the machine or equipment.

Internal combustion or fuel cell engine shipped separately (not installed)

- 1) When internal combustion engines or fuel cell engines are being shipped separately, all fuel, coolant or hydraulic systems remaining in or on the engine must be drained as far as practicable and all disconnected fluid pipes must be sealed with leakproof caps, which are positively retained.
- 2) This requirement also applies to machines or equipment containing internal combustion engines or fuel cell engines which are being shipped in a dismantled state such that fuel lines have been disconnected.

Packing Instruction 222

Passenger and cargo aircraft for UN 3538 only

Introduction

This packing instruction is only permitted for articles which do not have an existing proper shipping name and which contain only gases of Division 2.2 without a subsidiary hazard, but excluding refrigerated liquefied gases and gases forbidden for transport on passenger aircraft, where the quantity of the Division 2.2 gas exceeds the quantity limits for UN 3363 as prescribed in Packing Instruction 962. In addition to the Division 2.2 gas, the article may also contain lithium cells or batteries that comply with Section II of Packing Instruction 967 or Section II of Packing Instruction 970, as applicable.

General requirements

Part 4;1.1.1, 4;1.1.3, 4;1.1.12 and 4;2 requirements must be met.

<i>UN number and proper shipping name</i>	<i>Maximum net quantity of gas – passenger</i>	<i>Maximum net quantity of gas – cargo</i>
UN 3538 Articles containing non-flammable, non-toxic gas, n.o.s.*	75 kg	150 kg

ADDITIONAL PACKING REQUIREMENTS

- Packagings must meet the Packing Group II performance requirements.
- Receptacles within articles containing gases must meet the requirements of 4;4.1.1 and 6;5 as appropriate or meet a national or regionally recognized pressure receptacle standard such as the European Pressure Equipment Directive (2014/68/EU) or ASME Section VII, Div. 1 R that is capable of providing an equivalent level of protection as Packing Instructions 200 or 219.
- Articles must be packed to prevent movement and inadvertent operation during normal conditions of transport.

ROBUST ARTICLES

Robust articles may alternatively be transported in strong outer packagings constructed of suitable material and of adequate strength and design in relation to the packaging capacity and its intended use. The packagings must achieve a level of protection that is at least equivalent to that provided by 6;1. Articles may be transported unpackaged or on pallets when the dangerous goods are afforded equivalent protection by the article in which they are contained. In such cases the additional requirement related to Packing Group II performance requirements and the requirement for UN specification packagings do not apply.

OUTER PACKAGINGS (see 6;3.1)

Boxes

Aluminium (4B)
Fibreboard (4G)
Natural wood (4C1, 4C2)
Other metal (4N)
Plastics (4H1, 4H2)
Plywood (4D)
Reconstituted wood (4F)
Steel (4A)

Drums

Aluminium (1B2)
Fibre (1G)
Other metal (1N2)
Plastics (1H2)
Plywood (1D)
Steel (1A2)

Jerricans

Aluminium (3B2)
Plastics (3H2)
Steel (3A2)