



WORKING PAPER

**DANGEROUS GOODS PANEL (DGP)
MEETING OF THE WORKING GROUP OF THE WHOLE**

Auckland, 4 to 8 May 2009

Agenda Item 3: Development of recommendations for amendments to the *Supplement to the Technical Instructions for the Safe Transport of Dangerous Goods by Air (Doc 9284)* for incorporation in the 2011/2012 Edition

PACKING INSTRUCTIONS FOR DIVISION 2.3 GASES

(Presented by D. Brennan)

SUMMARY

This paper proposes a revision to two packing instructions in the Supplement to align the content with the Technical Instructions and the UN Model Regulations.

Action by the DGP-WG is in paragraph 2.

1. INTRODUCTION

1.1 The Supplement currently contains two packing instructions for gases, Packing Instruction 207, which applies to UN 1062, **Methyl bromide** and Packing Instruction 213, which applies to all other Division 2.3 gases.

1.2 These packing instructions have been in the Supplement, almost unchanged, since 1984. In the intervening period there have been significant changes to the provisions in the Technical Instructions with respect to gases with the adoption of the revised Packing Instruction 200 with effect the 2003-2004 edition of the Technical Instructions.

1.3 The provisions contained in Packing Instruction 207 for UN 1062 do not align with any requirements contained in the UN Model Regulations for UN 1062, and it is therefore questioned if it is appropriate to have such provisions in the Supplement, which would be used by competent authorities to approve transport on passenger and/or cargo aircraft.

1.4 On that basis it is suggested that Packing Instruction 207 in the Supplement be deleted and requirements for UN 1062 be consolidated into the provisions for all other gases in Division 2.3.

1.5 For the existing Packing Instruction 213, as there is a Packing Instruction 213 in the Technical Instructions that applies to UN 1044, fire extinguishers, it is suggested that Packing

Instruction 213 in the Supplement be replaced with Packing Instruction 200. Packing Instruction 200 would contain almost the same provisions as Packing Instruction 200 in the Technical Instructions, with the addition of requirements specific to Division 2.3 gases based on the provisions of P200 in the UN Model Regulations.

2. ACTION BY THE DGP-WG

2.1 The DGP-WG is invited to:

- a) delete Packing Instruction 207 from the Supplement;
- b) revise the entry for UN 1062, methyl bromide in Table S-3-1, columns 10/11 and 12/13 to read “See 200”.
- c) replace existing Packing Instruction 213 in the Supplement with Packing Instruction 200 as set out below. The attention of the DGP-WG is drawn to those items that are shown in square brackets to ensure that the text is valid and appropriate, or deleted if not appropriate:

200	PACKING INSTRUCTION 200	200
<p>General requirements</p> <p>For cylinders, the general packing requirements of Part 4, Chapter 1.1 and Part 4, Chapter 4.1.1 of the Technical Instructions must be met.</p> <p>Cylinders as specified in Part 6, Chapter 5 of the Technical Instructions are authorized for the transport of a specific substance when specified in Table 1 and Table 2. 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:</p> <ol style="list-style-type: none"> 1) [Cylinders containing toxic substances with an LC₅₀ less than or equal to 200 mL/m³ (ppm) as specified in the table must not be equipped with any pressure relief device] 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), liquefied and dissolved gases (Table 2). They provide: <ol style="list-style-type: none"> a) the UN number, name and description, and the classification of the substance; b) the LC₅₀ for toxic substances; c) the maximum test period for periodic inspection of the cylinders; <p style="text-align: center;"><i>Note.— For cylinders which make use of composite materials, the periodic inspection frequencies must be as determined by the competent authority which approved the cylinders.</i></p> d) the minimum test pressure of the cylinders; e) the maximum working pressure of the cylinders for compressed gases or the maximum filling ratio(s) for liquefied and dissolved gases; f) 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, except where special packing provision "o" applies, provided that:

- i) the criterion of special packing provision "r" is met when applicable; or
- ii) the above criterion is met in all other cases.

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 kg/m³)
 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 = 8.31451×10^{-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 and gas mixtures for which relevant 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).

4) Keys for the column "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 pressure receptacles are used, only those bearing the "H" mark are permitted.

Requirements for toxic substances with an LC₅₀ less than or equal to 200 mL/m³ (ppm)

- k) Valve outlets must be fitted with gas tight plugs or caps.

Cylinders must not be equipped with any pressure relief device.

Cylinders must not exceed a maximum water capacity of 85 litres.

Each valve must have a taper threaded connection directly to the cylinder and be capable of withstanding the test pressure of the cylinder.

Each valve must either be of the packless type with non-perforated diaphragm, or be of a type which prevents leakage through or past the packing.

Each cylinder must be tested for leakage after filling.

Gas specific provisions

- l) UN 1040 **Ethylene oxide** may also be packed in hermetically sealed glass 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.
- n) Cylinders must not contain more than 5 kg of the gas.
- o) In no case must the working pressure or filling ratio shown in the table be exceeded.
- p) Not used.
- q) The valves of cylinders for pyrophoric gases or flammable mixtures of gases containing more than 1% of pyrophoric compounds must be fitted with gas-tight plugs or caps.
- r) The filling ratio of this gas must be limited such that, if complete decomposition occurs, the pressure does not exceed two thirds of the test pressure of the cylinder.

Periodic inspection

- u) The interval between periodic tests may be extended to 10 years for aluminium alloy pressure receptacles when the alloy of the pressure receptacle has been subjected to stress corrosion testing as specified in ISO 7866:1999.
- v) The interval between periodic inspections for steel cylinders may be extended to 15 years if approved by the competent 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 (3).

Toxic substances with an LC₅₀ less than or equal to 200 ml/m³ must not be transported in tubes, pressure drums or MEGCs and must meet the requirements of special packing provision "k". [However, UN 1975 Nitric oxide and dinitrogen tetroxide mixture may be transported in pressure drums.]

For cylinders containing pyrophoric gases or flammable mixtures of gases containing more than 1% pyrophoric compounds, the requirements of special packing provision "q" must be met.

The necessary steps must be taken to prevent dangerous reactions (i.e. polymerisation or decomposition) during transport. If necessary, stabilisation or addition of an inhibitor is required.

Mixtures containing UN 1911 diborane, must be filled to a pressure such that, if complete decomposition of the diborane occurs, two thirds of the test pressure of the cylinder must not be exceeded.

Mixtures containing UN 2192 germane, other than mixtures of up to 35 per cent germane in hydrogen or nitrogen or up to 28 per cent germane in helium or argon, must be filled to a pressure such that, if complete decomposition of the germane occurs, two thirds of the test pressure of the cylinder is not exceeded.

Additional Requirements for division 2.3 gases

Small quantities of gases in Division 2.3, including mixtures of gases, may be carried in an aircraft under the following conditions:

- 1) The maximum quantity of gas permitted per package must be determined using the following formula:

$$\text{Permitted mass} \leq 10^{-3} (\text{RMM}) (\text{LC}_{50})$$

where: RMM = relative molecular mass

LC₅₀ expressed in mL/m³ as defined in Part 2, Chapter 6 of the Technical Instructions

Permitted mass expressed in grams.

For mixtures of toxic gases, where the LC50 of the mixture or its mass per unit volume at NTP are unknown, the following formula must be used to determine the permitted mass of the mixture:

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where NTP is normal temperature and pressure

(RMM) = relative molecular mass of component 1 ... n

This latter formula makes no allowance for any synergistic effect of the mixture and it should not be used where the toxic effects are other than additive.

- 2) The gas must be contained in a gas cylinder which meets the requirements of this packing instruction [or an IP.8 glass ampoule, provided it is compatible with the gas].

[The maximum quantity of gas permitted in a glass ampoule is determined by the above formula but is further limited to not more than 100 g.]

- 3) The [glass ampoule or] gas cylinder must be tightly packed as to prevent movement in an outer metal pressure vessel containing inert absorbent and cushioning material. The outer metal pressure vessels must be designed to contain the total quantity of gas in case of leakage of the [ampoule or] cylinder. The outer metal pressure vessel must meet the requirements of this packing instruction. Special care must be taken to prevent corrosion of the inner wall of the outer metal pressure vessels.

- 4) The outer metal pressure vessel must be tightly packed, so as to prevent movement, in a strong outside packaging.

Table 1. COMPRESSED GASES

UN No.	Name and description	Class or Division	Subsidiary risk	LC ₅₀ mL/m ³	Test period, years	Test pressure, bar *	Maximum working pressure, bar *	Special packing provisions
1016	Carbon monoxide, compressed	2.3	2.1	3 760	5			u
1023	Coal gas, compressed	2.3	2.1		5			
1045	Fluorine, compressed	2.3	5.1, 8	185	5	200	30	a, k, n, o
1071	Oil gas, compressed	2.3	2.1		5			
1612	Hexaethyl tetraphosphate and compressed gas mixture	2.3			5			z
1660	Nitric oxide, compressed	2.3	5.1, 8	115	5	225	33	k, o
1953	Compressed gas, toxic, flammable, n.o.s.	2.3	2.1	≤ 5 000	5			z
1955	Compressed gas, toxic, n.o.s.	2.3		≤ 5 000	5			z
2190	Oxygen difluoride, compressed	2.3	5.1, 8	2.6	5	200	30	a, k, n, o
3303	Compressed gas, toxic, oxidizing, n.o.s.	2.3	5.1	≤ 5 000	5			z
3304	Compressed gas, toxic, corrosive, n.o.s.	2.3	8	≤ 5 000	5			z
3305	Compressed gas, toxic, flammable, corrosive, n.o.s.	2.3	2.1, 8	≤ 5 000	5			z
3306	Compressed gas, toxic, oxidizing, corrosive, n.o.s.	2.3	5.1, 8	≤ 5 000	5			z

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

Table 2. LIQUEFIED GASES AND DISSOLVED GASES

UN No.	Name and description	Class or Division	Subsidiary risk	LC ₅₀ mL/m ³	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
1005	Ammonia, anhydrous	2.3	8	4 000	5	29	0.54	b
1008	Boron trifluoride	2.3	8	387	5	225 300	0.715 0.86	
1017	Chlorine	2.3	5.1, 8	293	5	22	1.25	a
1026	Cyanogen	2.3	2.1	350	5	100	0.70	u
1040	Ethylene oxide, or Ethylene oxide with nitrogen up to a total pressure of 1 MPa (10 bar) at 50° C	2.3	2.1	2 900	5	15	0.78	l
1048	Hydrogen bromide, anhydrous	2.3	8	2 860	5	60	1.51	a, d
UN No.	Name and description	Class or Division	Subsidiary risk	LC ₅₀ mL/m ³	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
1050	Hydrogen chloride, anhydrous	2.3	8	2 810	5	100 120 150 200	0.30 0.56 0.67 0.74	a, d a, d a, d a, d
1053	Hydrogen sulphide	2.3	2.1	712	5	48	0.67	d, u
1062	Methyl bromide	2.3		850	5	10	1.51	a
1064	Methyl mercaptan	2.3	2.1	1 350	5	10	0.78	d, u
1067	Dinitrogen tetroxide (Nitrogen dioxide)	2.3	5.1, 8	115	5	10	1.30	k
1069	Nitrosyl chloride	2.3	8	35	5	13	1.10	k
1076	Phosgene	2.3	8	5	5	20	1.23	k
1079	Sulphur dioxide	2.3	8	2 520	5	12	1.23	
1082	Trifluorochloroethylene, stabilized	2.3	2.1	2 000	5	10	1.13	u

UN No.	Name and description	Class or Division	Subsidiary risk	LC ₅₀ mL/m ³	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
1581	Chloropicrin and methyl bromide mixture	2.3		850	5	10	1.51	a
1582	Chloropicrin and methyl chloride mixture	2.3			5	17	0.81	a
1589	Cyanogen chloride stabilized	2.3	8	80	5	20	1.03	k
1741	Boron trichloride	2.3	8	2 541	5	10	1.19	
1749	Chlorine trifluoride	2.3	5.1, 8	299	5	30	1.40	a
1859	Silicon tetrafluoride	2.3	8	450	5	200 300	0.74 1.10	
1911	Diborane	2.3	2.1	80	5	250	0.07	d, k, o
1967	Insecticide gas, toxic, n.o.s.	2.3			5			z
1975	Nitric oxide and dinitrogen tetroxide mixture (Nitric oxide and nitrogen dioxide mixture)	2.3	5.1, 8	115	5			k, z
2188	Arsine	2.3	2.1	20	5	42	1.10	d, k
2189	Dichlorosilane	2.3	2.1, 8	314	5	10 200	0.90 1.08	
2191	Sulphuryl fluoride	2.3		3 020	5	50	1.10	u
2192	Germane	2.3	2.1	620	5	250	0.064	d, q, r
2194	Selenium hexafluoride	2.3	8	50	5	36	1.46	k
2195	Tellurium hexafluoride	2.3	8	25	5	20	1.00	k
2196	Tungsten hexafluoride	2.3	8	160	5	10	3.08	a, k
2197	Hydrogen iodide, anhydrous	2.3	8	2 860	5	23	2.25	a, d
2198	Phosphorus pentafluoride	2.3	8	190	5	200 300	0.90 1.25	k k
2199	Phosphine	2.3	2.1	20	5	225 250	0.30 0.45	d, k, q d, k, q
2202	Hydrogen selenide, anhydrous	2.3	2.1	2	5	31	1.60	k
2203	Silane	2.1			10	225 250	0.32 0.36	q q
2204	Carbonyl sulphide	2.3	2.1	1 700	5	30	0.87	u
2417	Carbonyl fluoride	2.3	8	360	5	200 300	0.47 0.70	
2418	Sulphur tetrafluoride	2.3	8	40	5	30	0.91	k
2420	Hexafluoroacetone	2.3	8	470	5	22	1.08	
2421	Nitrogen trioxide	2.3	5.1, 8	57	5			k
2534	Methylchlorosilane	2.3	2.1, 8	600	5			z
2548	Chlorine pentafluoride	2.3	2.1, 8	122	5	13	1.49	a, k
2676	Stibine	2.3	2.1	20	5	200	0.49	k, r
2901	Bromine chloride	2.3	5.1, 8	290	5	10	1.50	a
3057	Trifluoroacetyl chloride	2.3	8	10	5	17	1.17	k
3083	Perchloryl fluoride	2.3	5.1	770	5	33	1.21	u
3160	Liquefied gas, toxic, flammable, n.o.s.	2.3	2.1	≤ 5 000	5			z
3162	Liquefied gas, toxic, n.o.s.	2.3		≤ 5 000	5			z
UN No.	Name and description	Class or Division	Subsidiary risk	LC ₅₀ mL/m ³	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
3300	Ethylene oxide and carbon dioxide mixture with more than 87% ethylene oxide	2.3	2.1	More than 2 900	5	28	0.73	
3307	Liquefied gas, toxic, oxidizing, n.o.s.	2.3	5.1	≤ 5 000	5			z
3308	Liquefied gas, toxic, corrosive, n.o.s.	2.3	8	≤ 5 000	5			z
3309	Liquefied gas, toxic, flammable, corrosive, n.o.s.	2.3	2.1, 8	≤ 5 000	5			z
3310	Liquefied gas, toxic, oxidizing, corrosive, n.o.s.	2.3	5.1, 8	≤ 5 000	5			z

UN No.	Name and description	Class or Division	Subsidiary risk	LC ₅₀ mL/m ³	Test period, years	Test pressure, bar	Filling ratio	Special packing provisions
3318	Ammonia solution , relative density less than 0.880 at 15° C in water, with more than 50% ammonia.	2.3	8		5			b
3355	Insecticide gas, toxic, flammable, n.o.s.	2.3	2.1		5			z

- d) in Table S-3-1, columns 10/11 and 12/13 replace “See 213” with “See 200” for the entries listed in Table 1 and Table 2.

— END —