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INFORMATION PAPER

DANGEROUS GOODS PANEL (DGP)

MEETING OF THE WORKING GROUP OF THE WHOLE

Montreal, 18 to 22 April 2005

Agenda Item 2: Development of recommendations for amendments to the Technical Instructions for incorporation in the 2007/2008 edition

2.4: Packing Instructions

2.6 Packing Nomenclature, Marking, Requirements and Tests

CRYOGENIC RECEPTACLES

(Presented by D. Raadgers)

1. INTRODUCTION

1.1 DGP/19 had the intention to incorporate the requirements for cryogenic receptacles from the UN-Recommendations on the Transport of Dangerous Goods into the Technical Instructions (TIs). DGP/19 also had the intention to replace the existing Packing Instruction for cryogenic receptacles (PI202) by the Packing Instruction from the UN-Recommendations, which was presented as PI 2XX in DGP/19-WP/7.

1.2 The TIs already contained requirements on cryogenic receptacles and it therefore the question was which parts of these requirements can could be deleted or should be kept and/or modified, taking into account the new UN-provisions.

1.3 For this purpose the existing requirements for cryogenic receptacles as given in chapter 5.5 and in packing instruction PI 202 were reviewed, taking into account the comments which were made by a project group which was established in order to enable industry to give its view on this matter. The analysis was based on the assumption that at least the same safety level should be kept.

1.4 As a result of the analysis the following conclusions were drawn:

- It must be made clear that the requirements in chapter 5 not only relate to cylinders, but also to closed cryogenic receptacles.
- The requirements of the UN-Recommendations of chapter 6.2.1.3.6 should be incorporated as 6;5.1.3.6 (TIs).
- The requirements of chapter 5.5 are covered in chapter 5.1 and PI 2XX with the incorporation of the requirements of the UN-Recommendations.
- The division in the existing PI 202 Technical Instructions among non-pressurised, low-pressurised and high-pressurised receptacles is not very meaningful. The distinction between open and closed cryogenic receptacles (as in P 2XX) is sufficient.
- The specific requirement in the existing PI 202 for air transport on the minimum pressure for safety relief devices should be retained in view of the possibility of pressure decrease during air transport.

- The existing requirements for open cryogenic (non-pressurised) receptacles must be kept, but a maximum capacity for these types of receptacles would be meaningful, taking into account the air transport safety; a maximum of 50 litres is proposed.
- No changes are proposed for the type of liquids which are allowed to be transported in cryogenic receptacles, except that helium can be allowed in closed cryogenic receptacles.
- The UN text of PI 2XX may be taken as a basis for a new text for PI 202. It is proposed to have only one requirement for the degree of filling for all types of gases, which corresponds to the requirement for flammable refrigerated liquefied gases. In this way it is avoided that leakage of liquid would occur at higher temperatures than the filling temperature. It is also proposed to require at least two pressure-relief devices, of which one should not be a frangible discs.
- The construction requirements in the existing PI 202 are covered in chapter 5.1 with the incorporation of the UN-provisions. The remaining text is included in the new P 2XX, which will replace the existing PI 202.

1.5 The analysis showed that the formulation of requirements for equipment with refrigerated liquefied gases (e.g. MRI equipment) should be dealt with separately. This can be left to the national competent authority for the moment. The DGP is invited to discuss the possibility to submit a proposal to the UN-Sub-Committee of Experts on the Transport of Dangerous Goods on this matter.

2. PROPOSAL

2.1 Amend Chapter 5 as follows:

a) Replace “cylinder(s)” by “cylinder(s) and closed cryogenic receptacle(s) or by closed cryogenic receptacle(s)” at the appropiate places in chapter 5.
b) Insert chapter 5.1.3.6 (chapter 6.2.1.3.6 of the UN-Recommendations)
c) Delete chapter 5.5 and replace the reference to chapter 5.5 by 5.1.1.8 in Note 2 of 5.1.

2.2 The new PI 202 is obtained by replacing the existing PI 202 by PI 2XX with the following amendments:

- Insert “open and” after “liquefied gases in”
- Delete the second sentence
- Insert headings for open and closed cryogenic receptacles
- At “2. Degree of filling”: delete the first sentence and delete in the second sentence “For flammable refrigerated liquefied gases”.
- At “3. Pressure-relief devices”: replace “at least one pressure-relief device” by “at least two pressure-relief devices, of which two devices are not of the frangible disc type”.
- Insert the following, amended parts of the existing PI 202:

“Air, argon, carbon dioxide, helium, krypton, neon, nitrogen, nitrous oxide, oxygen, trifluoromethane and xenon refrigerated liquids may be carried to the extent permitted in these Instructions and in packagings meeting the requirements as set. These requirements also apply to empty packagings unless all parts are at ambient temperatures.”

“Open cryogenic receptacles must be metal vacuum insulated vessels or flasks vented to the atmosphere to prevent any increase in pressure within the package. The use of safety relief valves, check valves, frangible discs or similar devices in the vent lines is not permitted. Fill and discharge openings must be protected against the entry of foreign materials which might increase the internal pressure. The maximum capacity is 50 litres. Open cryogenic receptacles are not permitted for air, carbon dioxide, helium, neon, nitrous oxide, oxygen and trifluoromethane refrigerated liquids.”

“Closed cryogenic receptacles must be designed for and equipped with safety relief devices set at an absolute pressure above 275 kPa (175 kPa gauge pressure)”.

2.3 An alternative for the incorporation of the requirements for open cryogenic receptacles into P 202 is to have a separate packing instruction for open cryogenic receptacles. DGP is invited to discuss this matter.

As a result of these proposed amendments, chapter 5 and the Packing Instruction PI202 now read as follows:

Chapter 5

REQUIREMENTS FOR THE CONSTRUCTION AND TESTING OF ~~CYLINDERS~~CYLINDERS AND CLOSED CRYOGENIC RECEPTACLES, AEROSOL DISPENSERS AND SMALL RECEPTACLES CONTAINING GAS (GAS CARTRIDGES)

5.1 GENERAL REQUIREMENTS

Note 1.— For aerosol dispensers and small receptacles containing gas (gas cartridges) see 5.4.

Note 2.— For packagings for refrigerated liquefied gases see 5.1.1.8 and 5.1.3.6 ~~and 5.5~~.

5.1.1 Design and construction

5.1.1.1 ~~Cylinders~~Cylinders and closed cryogenic receptacles and their closures 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 normal conditions of transport.

5.1.1.2 In recognition of scientific and technological advances, and recognizing that ~~cylinders~~cylinders and closed cryogenic receptacles other than those that are marked with a UN certification marking may be used on a national or regional basis, ~~cylinders~~cylinders and closed cryogenic receptacles conforming to requirements other than those specified in these Instructions may be used if approved by the appropriate national authorities in the countries of transport and use.

5.1.1.3 In no case must the minimum wall thickness be less than that specified in the design and construction technical standards.

5.1.1.4 For welded ~~cylinders~~cylinders and closed cryogenic receptacles, only metals of weldable quality must be used.

5.1.1.5 The test pressure of cylinders must be in accordance with packing instruction P200. The test pressure for closed cryogenic receptacles must be in accordance with packing instruction P202.

+ 5.1.1.6 Not used.

+ 5.1.1.7 Contact between dissimilar metals which could result in damage by galvanic action must be avoided.

5.1.1.8 The following additional requirements apply to the construction of closed cryogenic receptacles~~cylinders~~ for refrigerated liquefied gases.

5.1.1.8.1 The mechanical properties of the metal used must be established for each closed cryogenic receptacle~~cylinder~~, including the impact strength and the bending coefficient;

5.1.1.8.2 The ~~——~~closed cryogenic receptacles~~cylinders~~ must be thermally insulated. The thermal insulation must be protected against impact by means of a jacket. If the space between the closed cryogenic receptacle~~cylinder~~ and the jacket is evacuated of air (vacuum-insulation), the jacket must be designed to withstand without permanent deformation an external pressure of at least 100 kPa (1 bar) calculated in accordance with a recognized technical code or a calculated critical collapsing pressure of not less than 200 kPa (2 bar) gauge pressure. If the jacket is so closed as to be gas-tight (e.g. in the case of vacuum-insulation), a device must be provided to prevent any dangerous pressure from developing in the insulating layer in the event of inadequate gas-tightness of the closed cryogenic receptacle~~cylinder~~ or its fittings. The device must prevent moisture from penetrating into the insulation.

+ 5.1.1.8.3 Closed cryogenic receptacles intended for the transport of refrigerated liquefied gases having a boiling point below –182°C at atmospheric pressure must not include materials that may react with oxygen or oxygen-enriched atmospheres in a dangerous manner, when located in parts of the thermal insulation where there is a risk of contact with oxygen or oxygen-enriched liquid.

+ 5.1.1.8.4 Closed cryogenic receptacles must be designed and constructed with suitable lifting and securing arrangements.

5.1.2 Materials

5.1.2.1 Construction materials of ~~cylinders~~cylinders and closed cryogenic receptacles and their closures which are in direct contact with dangerous goods must not be affected or weakened by the dangerous goods intended and must not cause a dangerous effect (e.g. catalysing a reaction or reacting with the dangerous goods).

5.1.2.2 ~~Cylinders~~Cylinders and closed cryogenic receptacles and their closures must be made of the materials specified in the design and construction technical standards and the applicable packing instruction for the substances intended for transport in the ~~cylinder~~ cylinder and closed cryogenic receptacle. The materials must be resistant to brittle fracture and to stress corrosion cracking as indicated in the design and construction technical standards.

5.1.3 Service equipment

5.1.3.1 Except for pressure relief devices, valves, piping, fittings and other equipment subjected to pressure, must be designed and constructed to withstand at least 1.5 times the test pressure of the ~~cylinders~~cylinders and closed cryogenic receptacles.

5.1.3.2 Service equipment must be configured or designed to prevent damage that could result in the release of the ~~cylinder~~cylinder and closed cryogenic receptacle contents during normal conditions of handling and transport. The filling and discharge valves and any protective caps must be capable of being secured against unintended opening. Valves must be protected as specified in 4;4.1.1.8.

5.1.3.3 ~~Cylinders —~~Cylinders and closed cryogenic receptacles that are not capable of being handled manually or rolled, must be fitted

with devices (skids, rings, straps) ensuring that they can be safely handled by

- mechanical means and arranged so as not to impair the strength of, nor cause undue stresses, in the ~~cylinder~~ cylinder and closed cryogenic receptacle.

- 5.1.3.4 Individual ~~cylinders~~cylinders and closed cryogenic receptacles must be equipped with pressure relief devices as specified in packing instruction P200(1) or P 202, 5.1.3.6.4 and 5.1.3.6.5. Pressure relief devices must be designed to prevent the entry of foreign matter, the leakage of gas and the development of any dangerous excess pressure.

- 5.1.3.5 ~~Cylinders~~Cylinders and closed cryogenic receptacles whose filling is measured by volume must be provided with a level indicator.

5.1.3.6 Additional requirements for closed cryogenic receptacles

5.1.3.6.1 Each filling and discharge opening in a closed cryogenic receptacle used for the transport of flammable refrigerated liquefied gases must be fitted with at least two mutually independent shut-off devices in series, the first being a stop-valve, the second being a cap or equivalent device.

5.1.3.6.2 For sections of piping which can be closed at both ends and where liquid product can be trapped, a method of automatic pressure-relief must be provided to prevent excess pressure build-up within the piping.

5.1.3.6.3 Each connection to a closed cryogenic receptacle must be clearly marked to indicate its function (e.g. vapour or liquid phase).

5.1.3.6.4 Pressure-relief devices

5.1.3.6.4.1 Every closed cryogenic receptacle must be provided with at least one pressure-relief device. The pressure-relief device must be of the type that will resist dynamic forces including surge.

5.1.3.6.4.2 Closed cryogenic receptacles may, in addition, have a frangible disc in parallel with the spring loaded device(s) in order to meet the requirements of 5.1.3.6.5.

5.1.3.6.4.3 Connections to pressure-relief devices must be of sufficient size to enable the required discharge to pass unrestricted to the pressure-relief device.

5.1.3.6.4.4 All pressure-relief device inlets must under maximum filling conditions be situated in the vapour space of the closed cryogenic receptacle and the devices must be so arranged as to ensure that the escaping vapour is discharged unrestrictedly.

5.1.3.6.5 Capacity and setting of pressure-relief devices

NOTE: In relation to pressure-relief devices, MAWP means the maximum effective gauge pressure permissible at the top of a loaded closed cryogenic receptacle in its operating position including the highest effective pressure during filling and discharge.

5.1.3.6.5.1 The pressure-relief device must open automatically at a pressure not less than the MAWP and be fully open at a pressure equal to 110% of the MAWP. It must, after discharge, close at a pressure not lower than 10% below the pressure at which discharge starts and must remain closed at all lower pressures.

5.1.3.6.5.2 Frangible discs must be set to rupture at a nominal pressure which is the lower of either the test pressure or 150% of the MAWP.

5.1.3.6.5.3 In the case of the loss of vacuum in a vacuum-insulated closed cryogenic receptacle the combined capacity of all pressure-relief devices installed must be sufficient so that the pressure (including accumulation) inside the closed cryogenic receptacle does not exceed 120% of the MAWP.

5.1.3.6.5.4 The required capacity of the pressure-relief devices must be calculated in accordance with an established technical code recognized by the competent authority. (See for example CGA Publications S-1.2-1995 and S-1.1-2001)

5.1.4 Initial inspection and testing

5.1.4.1 New cylinders~~, other than closed cryogenic receptacles,~~ must be subjected to inspection and testing during and after manufacture in accordance with the applicable design standards including the following:

On an adequate sample of cylinders:

a) testing of the mechanical characteristics of the material of construction;

b) verification of the minimum wall thickness;

c) verification of the homogeneity of the material for each manufacturing batch;

d) inspection of the external and internal conditions of the cylinders;

e) inspection of the neck threads;

f) verification of the conformance with the design standard;

For all cylinders:

g) a hydraulic pressure test. Cylinders must withstand the test pressure without expansion greater than that allowed in the design specifications;

Note.— With the agreement of the appropriate national authority, the hydraulic pressure test may be replaced by a test using a gas, where such an operation does not entail any danger.

h) Inspection and assessment of manufacturing defects and either repairing them or rendering the cylinders unserviceable. In the case of welded cylinders, particular attention must be paid to the quality of the welds;

i) an inspection of the markings on the cylinders;

j) in addition, cylinders intended for the transport of UN 1001 **Acetylene, dissolved**, and UN 3374 **Acetylene, solvent free**, must be inspected to ensure proper installation and condition of the porous mass and, if applicable, the quantity of solvent.

+ 5.1.4.2 On an adequate sample of closed cryogenic receptacles, the inspections and tests specified in 5.1.4.1 a), b), d) and f) must be performed. In addition, welds must be inspected by radiographic, ultrasonic or another suitable non-destructive test method on a sample of closed cryogenic receptacles according to the applicable design and construction standard. This weld inspection does not apply to the jacket.

5.1.4.3 Additionally, all closed cryogenic receptacles must undergo the inspections and tests specified in 5.1.4.1 g), h) and i), as well as a leakproofness test and a test of the satisfactory operation of the service equipment after assembly.

5.1.5 Periodic inspection and testing

5.1.5.1 Refillable cylinders must be subjected to periodic inspections and tests by a body authorized by the appropriate national authority, in accordance with the following:

a) Check of the external conditions of the cylinder and verification of the equipment and the external markings;

b) Check of the internal conditions of the cylinder (e.g. internal inspection, verification of minimum wall thickness);

c) Checking of the threads if the fittings are removed;

d) A hydraulic pressure test and, if necessary, verification of the characteristics of the material by suitable tests.

Note 1.— With the agreement of the appropriate national authority, the hydraulic pressure test may be replaced by a test using a gas, where such an operation does not entail any danger.

Note 2.— With the agreement of the appropriate national authority, the hydraulic pressure test of cylinders may be replaced by an equivalent method based on acoustic emission or ultrasound.

5.1.5.2 For cylinders intended for the transport of UN 1001 **Acetylene, dissolved**, and UN 3374 **Acetylene, solvent free**, only the external condition (corrosion, deformation) and the condition of the porous mass (loosening, settlement) must be examined.

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5.1.6 Approval of ~~cylinders~~cylinders and closed cryogenic receptacles

5.1.6.1 The conformity of ~~cylinders~~cylinders and closed cryogenic receptacles must be assessed at the time of manufacture as required by the appropriate national authority. ~~Cylinders~~Cylinders and closed cryogenic receptacles must be inspected, tested and approved by an inspection body. The technical documentation must include full specifications on design and construction, and full documentation on the manufacturing and testing.

5.1.6.2 Quality assurance systems must conform to the requirements of the appropriate national authority.

5.1.7 Requirements for manufacturers

5.1.7.1 The manufacturer must be technically able and must possess all ~~manufacture of cylinders; this relates in particular to qualified personnel:~~
resources required for the satisfactory manufacture of ~~cylinders~~ and closed cryogenic receptacles ; this relates in particular to qualified personnel:

a) to supervise the entire manufacturing process;

b) to carry out joining of materials; and

c) to carry out the relevant tests.

5.1.7.2 The proficiency test of a manufacturer must in all instances be carried out by an inspection body approved by the appropriate national authority of the country of approval.

5.1.8 Requirements for inspection bodies

Inspection bodies must be independent from manufacturing enterprises and competent to perform the tests, inspections and approvals required.

5.2 REQUIREMENTS FOR UN CYLINDERS

In addition to the general requirements of 5.1, UN cylinders must comply with the requirements of this section, including the standards, as applicable.

Note.— With the agreement of the appropriate national authority, more recently published versions of the standards, if available, may be used.

5.2.1 Design, construction and initial inspection and testing

5.2.1.1 The following standards apply for the design, construction, and initial inspection and test of UN cylinders, except that inspection requirements related to the conformity assessment system and approval must be in accordance with 5.2.5:

ISO 9809-1:1999	Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 1: Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa.
	Note.— The note concerning the F factor in section 7.3 of this standard must not be applied for UN cylinders.
ISO 9809-2:2000	Gas cylinders — Refillable seamless steel gas cylinders — ~~a) to supervise the entire manufacturing process;~~ ~~b) to carry out joining of materials; and~~ ~~c) to carry out the relevant tests.~~ Design, construction and testing — Part 2: Quenched and tempered steel cylinders with tensile strength greater than or equal to 1 100 MPa.
ISO 9809-3:2000	Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 3: Normalized steel cylinders.
ISO 7866:1999	Gas cylinders — Refillable seamless aluminium alloy gas cylinders — Design, construction and testing.
	Note.— The note concerning the F factor in section 7.2 of this standard must not be applied for UN cylinders. Aluminium alloy 6351A — T6 or equivalent must not be authorized.
ISO 11118:1999	Gas cylinders — Non-refillable metallic gas cylinders — Specification and test methods.
+ ISO 11119-1:2002	Gas cylinders of composite construction — Specification and test methods — Part 1: Hoop wrapped composite gas cylinders.
+ ISO 11119-2:2002	Gas cylinders of composite construction — Specification and test methods — Part 2: Fully wrapped fibre reinforced composite gas cylinders with load-sharing metal liners.
	Note.— After the first 15 years of service, composite cylinders manufactured according to these standards, may be approved for extended service by the appropriate national authority which was responsible for the original approval of the cylinders and which will base its decision on the test information supplied by the manufacturer or owner or user.

5.2.1.2 Not used.

5.2.1.3 The following standards apply for the design, construction and initial inspection and test of UN acetylene cylinders except that inspection requirements related to the conformity assessment system and approval must be in accordance with 5.2.5.

For the cylinder shell:

ISO 9809-1:1999 Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 1: Quenched and tempered steel Cylinders with tensile strength less than 1 100 MPa.

Note.— The note concerning the F factor in section 7.3 of this standard must not be applied for UN cylinders.

ISO 9809-3:2000 Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 3: Normalized steel cylinders.

ISO 7866:1999 Gas cylinders — Refillable seamless aluminium alloy gas cylinders — Design, construction and testing.

Note.— The note concerning the F factor in section 7.2 of this standard must not be applied for UN cylinders. Aluminium alloy 6351A — T6 or equivalent must not be authorized.

ISO 11118:1999 Gas cylinders — Non-refillable metallic gas cylinders — Specification and test methods.

For the porous mass in the cylinder:

ISO 3807-1:2000 Cylinders for acetylene — Basic requirements — Part 1: Cylinders without fusible plugs.

ISO 3807-2:2000 Cylinders for acetylene — Basic requirements — Part 2: Cylinders with fusible plugs.

ISO 10462:1994 Cylinders for dissolved acetylene — Periodic inspection and maintenance.

5.2.2 Materials

In addition to the material requirements specified in the cylinder design and construction standards, and any restrictions specified in the applicable Packing Instruction for the gas(es) to be transported (e.g. Packing Instruction 200), the following standards apply to material compatibility:

ISO 11114-1:1997 Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials.

ISO 11114-2:2000 Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials.

5.2.3 Service equipment

The following standards apply to closures and their protection:

ISO 11117:1998 Gas cylinders — Valve protection caps and valve guards for industrial and medical gas cylinders — Design, construction and tests.

ISO 10297:1999 Gas cylinders —Refillable gas cylinder valves — Specification and type testing.

5.2.4 Periodic inspection and test

 The following standards apply to the periodic inspection and testing of UN cylinders:

ISO 6406:1992 Periodic inspection and testing of seamless steel gas cylinders.

ISO 10461:1993 Seamless aluminium — Alloy gas cylinders — Periodic inspection and testing.

+ ISO 11623:2002 Transportable gas cylinders — Periodic inspection and testing of composite gas cylinders.

5.2.5 Conformity assessment system and approval for manufacture of cylinders

5.2.5.1 *Definitions*

For the purposes of this section:

Conformity assessment system: a system for appropriate national authority approval of a manufacturer, by cylinder design type approval, approval of manufacturer's quality system and approval of inspection bodies.

Design type: a cylinder design as specified by a particular cylinder standard.

Verify: confirm by examination or provision of objective evidence that specified requirements have been fulfilled.

5.2.5.2 *General requirements*

Appropriate national authority

5.2.5.2.1 The appropriate national authority that approves the cylinder must approve the conformity assessment system for the purpose of ensuring that cylinders conform to the requirements of these Instructions. In instances where the appropriate national authority that approves a cylinder is not the appropriate national authority in the country of manufacture, the marks of the approval country and the country of manufacture must be indicated in the cylinder marking (see 5.2.6 and 5.2.7).

5.2.5.2.1.1 The appropriate national authority of the country of approval must supply, upon request, evidence demonstrating compliance

to this conformity assessment system to its counterpart in a country of use.

5.2.5.2.2 The appropriate national authority may delegate its conformity assessment system functions in whole or in part.

5.2.5.2.3 The appropriate national authority must ensure that a current list of approved inspection bodies and their identity marks and approved manufacturers and their identity marks is available.

Inspection body

5.2.5.2.4 The inspection body must be approved by the appropriate national authority for the inspection of cylinders and must:

a) have a staff with an organizational structure, capable, trained, competent, and skilled, to satisfactorily perform its technical functions;

b) have access to suitable and adequate facilities and equipment;

c) operate in an impartial manner and be free from any influence which could prevent it from doing so;

b) apply for design type approvals in accordance with 5.2.5.4;

c) select an inspection body from the list of approved inspection bodies maintained by the appropriate national authority in the country of approval; and

d) maintain records in accordance with 5.2.5.6.

Testing laboratory

5.2.5.2.7 The testing laboratory must have:

a) staff with an organizational structure, sufficient in number, competence, and skill; and

b) suitable and adequate facilities and equipment to perform the tests required by the manufacturing standard to the satisfaction of the inspection body.

5.2.5.3 *Manufacturer's quality system*

5.2.5.3.1 The quality system must contain all the elements, requirements, and provisions adopted by the manufacturer. It must be documented in a systematic and orderly manner in the form of written policies, procedures and instructions.

The contents must in particular include adequate descriptions of:

a) the organizational structure, responsibilities, and power of the management with regard to design and product quality;

b) the design control and design verification techniques, processes, and systematic

d) ensure commercial confidentiality of the commercial and proprietary activities of the manufacturer and other bodies;

e) maintain clear demarcation between actual inspection body functions and unrelated functions;

f) operate a documented quality system;

g) ensure that the tests and inspections specified in the relevant cylinder standard and these instructions are performed; and

h) maintain an effective and appropriate report and record system in accordance with 5.2.5.6.

5.2.5.2.5 The inspection body must perform design type approval, cylinder production testing and inspection, and certification to verify conformity with the relevant cylinder standard (see 5.2.5.1 and 5.2.5.4).

Manufacturer

5.2.5.2.6 The manufacturer must:

a) operate a documented quality system in accordance with 5.2.5.3;

actions that will be used when designing the cylinders;

c) the relevant cylinder manufacturing, quality control, quality assurance, and process operation instructions that will be used;

d) quality records, such as inspection reports, test data, and calibration data;

e) management reviews to ensure the effective operation of the quality system arising from the audits in accordance with 5.2.5.3.2;

f) the process describing how customer requirements are met;

g) the process for control of documents and their revision;

h) the means for control of non-conforming cylinders, purchased components, in-process and final materials; and

i) training programmes and qualification procedures for relevant personnel.

5.2.5.3.2 *Audit of the quality system*

The quality system must be initially assessed to determine whether it meets the requirements in 5.2.5.3.1 to the satisfaction of the appropriate national authority.

The manufacturer must be notified of the results of the audit. The notification must contain the conclusions of the audit and any corrective actions required.

Periodic audits must be carried out, to the satisfaction of the appropriate national authority, to ensure that the manufacturer maintains and

applies the quality system. Reports of the periodic audits must be provided to the manufacturer.

5.2.5.3.3 *Maintenance of the quality system*

The manufacturer must maintain the quality system as approved in order that it remains adequate and efficient.

The manufacturer must notify the appropriate national authority that approved the quality system, of any intended changes. The proposed changes must be evaluated in order to determine whether the amended quality system will still satisfy the requirements in 5.2.5.3.1.

5.2.5.4 *Approval process*

Initial design type approval

 5.2.5.4.1 The initial design type approval must consist of the approval of the manufacturer's quality system and the approval of the cylinder design to be produced. An application for an initial design type approval must meet the requirements of 5.2.5.3, 5.2.5.4.2 to 5.2.5.4.6 and 5.2.5.4.9.

 5.2.5.4.2 A manufacturer desiring to produce cylinders in accordance with a cylinder standard and these Instructions must apply for, obtain, and retain a Design Type Approval Certificate issued by the appropriate national authority in the country of approval for at least one cylinder design type in accordance with the procedure given in 5.2.5.4.9. This certificate must, on request, be submitted to the appropriate national authority of the country of use.

5.2.5.4.3 An application must be made for each manufacturing facility and must include:

iii) a list of the standards necessary to fully define the manufacturing process;

iv) design calculations and material specifications; and

v) design type approval test reports, describing the results of examinations and tests carried out in accordance with 5.2.5.4.9.

5.2.5.4.4 An initial audit in accordance with 5.2.5.3.2 must be performed to the satisfaction of the appropriate national authority.

5.2.5.4.5 If the manufacturer is denied approval, the appropriate national authority must provide written detailed reasons for such denial.

 5.2.5.4.6 Following approval, changes to the information submitted under 5.2.5.4.3 relating to the initial approval must be provided to the appropriate national authority.

Subsequent design type approvals

5.2.5.4.7 An application for a subsequent design type approval must encompass the requirements of 5.2.5.4.8 and 5.2.5.4.9, provided a manufacturer is in possession of an initial design type approval. In such a case, the manufacturer's quality system according to 5.2.5.3 must have been approved during the initial design type approval and must be applicable for the new design.

5.2.5.4.8 The application must include:

a) the name and registered address of the manufacturer and in addition, if the application is submitted by an authorized representative, its name and address;

b) the address of the manufacturing facility (if different from the above);

c) the name and title of the person(s) responsible for the quality system;

d) the designation of the cylinder and the relevant cylinder standard;

e) details of any refusal of approval of a similar application by any other appropriate national authority;

f) the identity of the inspection body for design type approval;

g) documentation on the manufacturing facility as specified under 5.2.5.3.1; and

h) the technical documentation required for design type approval, which must enable verification of the conformity of the cylinders with the requirements of the relevant cylinder design standard. The technical documentation must cover the design and method of manufacture and must contain, as far as is relevant for assessment, at least the following:

i) cylinder design standard, design and manufacturing drawings, showing components and sub-assemblies, if any;

ii) descriptions and explanations necessary for the understanding of the drawings and intended use of the cylinders;

Procedure for design type approval

5.2.5.4.9 The inspection body must:

a) examine the technical documentation to verify that:

i) the design is in accordance with the relevant provisions of the standard; and

ii) the prototype lot has been manufactured in conformity with the technical documentation and is representative of the design;

b) verify that the production inspections have been carried out as required in accordance with 5.2.5.5;

c) select cylinders from a prototype production lot and supervise the tests of these cylinders as required for design type approval;

d) perform or have performed the examinations and tests specified in the cylinder standard to determine that:

i) the standard has been applied and fulfilled; and

ii) the procedures adopted by the manufacturer meet the requirements of the standard; and

e) ensure that the various type approval examinations and tests are correctly and competently carried out.

After prototype testing has been carried out with satisfactory results and all applicable requirements of 5.2.5.4 have been satisfied, a Design Type Approval Certificate must be issued which must include the name and address of the manufacturer, results and conclusions of the examination, and the necessary data for identification of the design type.

 If the manufacturer is denied a design type approval, the appropriate national authority must provide written detailed reasons for such denial.

5.2.5.4.10 *Modifications to approved design types*

The manufacturer must inform the issuing appropriate national authority of modifications to the approved design type as specified in the cylinder standard. A subsequent design type approval must be requested where such modifications constitute a new design according to the relevant cylinder standard. This additional approval must be given in the form of an
5.2.5.6 *Records*

Design type approval and certificate of compliance records must be retained by the manufacturer and the inspection body for not less than 20 years.

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5.2.6 Approval system for periodic inspection and test of cylinders

5.2.6.1 *Definitions*

For the purposes of this section:

Approval system: means a system for the appropriate national authority approval of a body performing the periodic inspection and test of cylinders (hereinafter referred to as “periodic

amendment to the original Design Type Approval Certificate.

5.2.5.4.11 Upon request, the appropriate national authority must communicate to any other appropriate national authority, information concerning design type approval, modifications of approvals, and withdrawn approvals.

5.2.5.5 *Production inspection and certification*

5.2.5.5.1 An inspection body, or its delegate, must carry out the inspection and certification of each cylinder. The inspection body selected by the manufacturer for inspection and testing during production may be different from the inspection body used for the design type approval testing.

5.2.5.5.2 Where it can be demonstrated to the satisfaction of the inspection body that the manufacturer has trained and competent inspectors, independent of the manufacturing operations, inspection may be performed by those inspectors. In such a case, the manufacturer must maintain training records of the inspectors.

5.2.5.5.3 The inspection body must verify that the inspections by the manufacturer and tests performed on those cylinders, fully conform to the standards and requirements of these Instructions. Should non-conformance in conjunction with this inspection and testing be determined, the permission to have inspection performed by the manufacturer’s inspectors may be withdrawn.

5.2.5.5.4 The manufacturer must, after approval by the inspection body, make a declaration of conformity with the certified design type. The application of the cylinder certification marking must be considered a declaration that the cylinder complies with the applicable cylinder standards, the requirements of this conformity assessment system and these Instructions. The inspection body must affix or delegate the manufacturer to affix the cylinder certification marking and the registered mark of the inspection body to each approved cylinder.

5.2.5.5.5 A certificate of compliance, signed by the inspection body and the manufacturer, must be issued before the cylinders are filled.

inspection and test body”), including approval of that body’s quality system.

5.2.6.2 *General requirements*

Appropriate national authority

5.2.6.2.1 The appropriate national authority must establish an approval system for the purpose of ensuring that the periodic inspection and test of cylinders conform to the requirements of these Instructions. In instances where the appropriate national authority that approves the body performing periodic inspection and test of a cylinder is not the appropriate national authority of the country approving the manufacture of the cylinder, the marks of the approval country of periodic inspection and test must be indicated in the cylinder marking (see 5.2.7).

The appropriate national authority of the country of approval for the periodic inspection and test

must supply, upon request, evidence demonstrating compliance with this approval system, including the records of the periodic inspection and test, to its counterpart in a country of use.

The appropriate national authority of the country of approval may terminate the approval certificate referred to in 5.2.6.4.1 upon evidence demonstrating non-compliance with the approval system.

5.2.6.2.2 The appropriate national authority may delegate its functions in this approval system, in whole or in part.

5.2.6.2.3 The appropriate national authority must ensure that a current list of approved periodic inspection and test bodies and their identity marks is available.

Periodic inspection and test body

5.2.6.2.4 The periodic inspection and test body must be approved by the appropriate national authority and must:

a) have a staff with an organizational structure, capable, trained, competent and skilled to satisfactorily perform its technical functions;

b) have access to suitable and adequate facilities and equipment;

c) operate in an impartial manner and be free from any influence that could prevent it from doing so;

d) ensure commercial confidentiality;

e) maintain clear demarcation between actual periodic inspection and test body functions and unrelated functions;

f) operate a documented quality system in accordance with 5.2.6.3;

g) apply for approval in accordance with 5.2.6.4;

h) ensure that the periodic inspections and tests are performed in accordance with 5.2.6.5; and

i) maintain an effective and appropriate report and record system in accordance with 5.2.6.6.

5.2.6.3 *Quality system and audit of the periodic inspection and test body*

5.2.6.3.1 *Quality system*

The quality system must contain all the elements, requirements and provisions adopted by the periodic inspection and test body. It must be documented in a systematic and orderly manner in the form of written policies, procedures and instructions.

The quality system must include:

a) a description of the organizational structure and responsibilities;

b) the relevant inspection and test, quality control, quality assurance and process operation instructions that will be used;

c) quality records, such as inspection reports, test data, calibration data and certificates;

d) management reviews to ensure the effective operation of the quality system arising from the audits performed in accordance with 5.2.6.3.2;

e) a process for control of documents and their revision;

f) a means for control of non-conforming cylinders; and training programmes and qualification procedures for relevant personnel.

5.2.6.3.2 *Audit*

The periodic inspection and test body and its quality system must be audited in order to determine whether it meets the requirements of these Instructions to the satisfaction of the appropriate national authority.

An audit must be conducted as part of the initial approval process (see 5.2.6.4.3). An audit may be required as part of the process to modify an approval (see 5.2.6.4.6).

Periodic audits must be conducted, to the satisfaction of the appropriate national authority, to ensure that the periodic inspection and test body continues to meet the requirements of these Instructions.

The periodic inspection and test body must be notified of the results of any audit. The

5.2.6.3.3 *Maintenance of the quality system*

The periodic inspection and test body must maintain the quality system as approved in order that it remains adequate and efficient.

The periodic inspection and test body must notify the appropriate national authority that approved the quality system, of any intended changes, in accordance with the process for modification of an approval in 5.2.6.4.6.

5.2.6.4 *Approval process for periodic inspection and test bodies*

Initial approval

5.2.6.4.1 A body desiring to perform periodic inspection and test of cylinders in accordance with a cylinder standard and these Instructions must apply for, obtain and retain an Approval Certificate issued by the appropriate national authority.

This written approval must, on request, be submitted to the appropriate national authority of a country of use.

5.2.6.4.2 An application must be made for each periodic inspection and test body and must include:

a) the name and address of the periodic inspection and test body and, if the application is submitted by an authorized representative, its name and address;

b) the address of each facility performing the periodic inspection and test;

c) the name and title of the person(s) responsible for the quality system;

d) the designation of the cylinders, the periodic inspection and test methods and the relevant cylinder standards encompassed by the quality system;

e) documentation on each facility, the equipment and the quality system as specified under 5.2.6.3.1;

f) the qualifications and training records of the periodic inspection and test personnel; and

g) details of any refusal of approval of a similar application by any other appropriate national authority.

5.2.6.4.3 The appropriate national authority must:

a) examine the documentation to verify that the procedures are in accordance with the requirements of the relevant cylinder standards and these Instructions; and

b) conduct an audit in accordance with 5.2.6.3.2 to verify that the inspections and tests are carried out as required by the relevant cylinder standards and these Instructions, to the satisfaction of the appropriate national authority.

notification must contain the conclusions of the audit and any corrective actions required.

5.2.6.4.4 After the audit has been carried out with satisfactory results and all applicable requirements of 5.2.6.4 have been satisfied, an Approval Certificate must be issued. It must include the name of the periodic inspection and test body, the registered mark, the address of each facility and the necessary data for identification of its approved activities (e.g. designation of cylinders, periodic inspection and test method and cylinder standards).

5.2.6.4.5 If the periodic inspection and test body is denied approval, the appropriate national authority must provide written detailed reasons for such denial.

Modifications to periodic inspection and test body approvals

5.2.6.4.6 Following approval, the periodic inspection and test body must notify the issuing appropriate national authority of any modifications to the information submitted under 5.2.6.4.2 relating to the initial approval.

The modifications must be evaluated in order to determine whether the requirements of the relevant cylinder standards and these Instructions will be satisfied.

An audit in accordance with 5.2.6.3.2 may be required.

The appropriate national authority must accept or reject these modifications in writing, and an amended Approval Certificate must be issued as necessary.

5.2.6.4.7 Upon request, the appropriate national authority must communicate to any other appropriate national authority, information concerning initial approvals, modifications of approvals and withdrawn approvals.

5.2.6.5 *Periodic inspection and test and certification*

The application of the periodic inspection and test marking to a cylinder must be considered a declaration that the cylinder complies with the applicable cylinder standards and the requirements of these Instructions. The periodic inspection and test body must affix the periodic inspection and test marking, including its registered mark, to each approved cylinder (see 5.2.7.7).

A record certifying that a cylinder has passed the periodic inspection and test must be issued by the periodic inspection and test body before the cylinder is filled.

5.2.6.6 *Records*

The periodic inspection and test body must retain records of the periodic inspection and test of cylinders (both passed and failed), including the location of the test facility, for not less than 15 years.

The owner of the cylinder must retain an identical record until the next periodic inspection and test unless the cylinder is permanently removed from service.

5.2.7 Marking of UN refillable cylinders

Refillable UN cylinders must be marked clearly and legibly with certification, operational and manufacturing marks. These marks must be permanently affixed (e.g. stamped, engraved or etched) on the cylinder. The marks must be on the shoulder, top end or neck of the cylinder or on a permanently affixed component of the cylinder (e.g. welded collar or corrosion-resistant plate welded to the outer jacket of a closed cryogenic receptacle). Except for the UN packaging symbol, the minimum size of the marks must be 5 mm for cylinders with a diameter greater than or equal to 140 mm and 2.5 mm for cylinders with a diameter less than 140 mm. The minimum size of the UN packaging symbol must be 10 mm for cylinders with a diameter greater than or equal to 140 mm and 5 mm for cylinders with a diameter less than 140 mm.

5.2.7.1 The following certification marks must be applied:

a) The UN packaging symbol

This symbol must only be marked on cylinders that conform to the requirements of these Instructions for UN cylinders;

b) The technical standard (e.g. ISO 9809-1) used for the design, construction and testing;

c) The character(s) identifying the country of approval, as indicated by the distinguishing signs of motor vehicles in international traffic;

d) The identity mark or stamp of the inspection body that is registered with the appropriate national authority of the country authorizing the marking;

e) The date of the initial inspection, the year (four digits) followed by the month (two digits) separated by a slash (i.e. "/").

5.2.7.2 The following operational marks must be applied:

f) The test pressure in bar, preceded by the letters "PH" and followed by the letters "BAR";

g) The mass of the empty cylinder including all permanently attached integral parts (e.g. neck ring, foot ring, etc.) in kilograms, followed by the letters "KG". This mass must not include the mass of valve, valve cap or valve guard, any coating, or porous mass for acetylene. The mass must be expressed to three significant figures rounded up to the last digit. For cylinders of less than 1 kg, the mass must be expressed to two significant figures rounded up to the last digit;

h) The minimum guaranteed wall thickness of the cylinder in millimetres followed by the letters "MM". This mark is not required for cylinders with a water capacity less than or equal to 1 litre or for composite cylinders or for closed cryogenic receptacles;

 i) In the case of cylinders for compressed gases, UN 1001 **Acetylene, dissolved**, and UN 3374 **Acetylene, solvent free**, the working pressure in bar, preceded by the letters "PW". In the case of closed cryogenic receptacles, the maximum allowable working pressure preceded by the letters "MAWP";

 j) In the case of cylinders for liquefied gases and refrigerated liquefied gases, the water capacity in litres expressed to three significant figures rounded down to the last digit, followed by the letter "L". If the value of the minimum or nominal water capacity is an integer, the digits after the decimal point may be neglected;

 k) In the case of cylinders for UN 1001 **Acetylene, dissolved**, the total of the mass of the empty receptacle, the fittings and accessories not removed during filling, the porous mass, the solvent and the saturation gas expressed to two significant figures rounded down to the last digit followed by the letters "KG";

 l) In the case of cylinders for UN 3374 **Acetylene, solvent free**, the total of the mass of the empty receptacle, the fittings and accessories not removed during filling and the porous mass expressed to two significant figures rounded down to the last digit followed by the letters "KG".

 5.2.7.3 The following manufacturing marks must be applied:

 m) Identification of the cylinder thread (e.g. 25E). This mark is not required for closed cryogenic receptacles;

n) The manufacturer's mark registered by the appropriate national authority. When the country of manufacture is not the same as the country of approval, then the manufacturer's mark must be preceded by the character(s) identifying the country of manufacture, as indicated by the distinguishing signs of motor vehicles in international traffic. The country mark and the manufacturer's mark must be separated by a space or slash;

o) The serial number assigned by the manufacturer;

p) In the case of steel cylinders and composite cylinders with steel liner intended for the transport of gases with a risk of hydrogen embrittlement, the letter "H" showing compatibility of the steel (see ISO 11114-1:1997).

+ b) the registered mark of the body authorized by the appropriate national authority for performing the periodic inspection and test;

+ c) the date of the periodic inspection and test, the year (two digits)

 5.2.7.4 The above marks must be placed in three groups:

— Manufacturing marks must be the top grouping and must appear consecutively in the sequence given in 5.2.7.3.

 — The operational marks in 5.1.2.7.2 must be the middle grouping and the test pressure f) which must be immediately preceded by the working pressure (i) when the latter is required.

— Certification marks must be the bottom grouping and must appear in the sequence given in 5.2.7.1.

The following is an example of the markings applied to a cylinder:

m) 25E	n) D MF	o) 765432	p) H	
i) PW200PH	f) 300BAR	g) 62.1KG	j) 50L	h) 5.8M
a)	b) ISO 9809-F1	c)	d) IB	e) 2000/12

 5.2.7.5 Other marks are allowed in areas other than the side wall, provided they are made in low stress areas and are not of a size and depth that will create harmful stress concentrations. In the case of closed cryogenic receptacles, such marks may be on a separate plate attached to the outer jacket. Such marks must not conflict with required marks.

+ 5.2.7.6 Cylinders of composite construction with limited life must be marked with the letters "FINAL" followed by the expiry date, the year (four digits) and the month (two digits).

 5.2.7.7 In addition to the preceding marks, each refillable cylinder that meets the periodic inspection and test requirements of 5.2.4 must be marked indicating:

+ a) the character(s) identifying the country authorizing the body performing the periodic inspection and test. This marking is not required if this body is approved by the appropriate national authority of the country approving manufacture;

followed by the month (two digits) separated by a slash (i.e."/"). Four digits may be used to indicate the year.

+ The above marks must appear consecutively in the sequence given.

5.2.8 Marking of non-refillable UN cylinders

5.2.8.1 Non-refillable UN cylinders must be marked clearly and legibly with certification and gas or cylinder specific marks. These marks must be permanently affixed (e.g. stencilled, stamped, engraved, or etched) on the cylinder. Except when stencilled, the marks must be on the shoulder, top end or neck of the cylinder or on a permanently affixed component of the cylinder (e.g. welded collar). Except for the "UN" mark and the "DO NOT REFILL" mark, the minimum size of the marks must be 5 mm for cylinders with a diameter greater than or equal to 140 mm and 2.5 mm for cylinders with a diameter less than 140 mm. The minimum size of the "UN" mark must be 10 mm for cylinders with a diameter greater than or equal to 140 mm and 5 mm for cylinders with a diameter less than 140 mm. The minimum size of the "DO NOT REFILL" mark must be 5 mm.

5.2.8.2 The marks listed in 5.2.6.1 to 5.2.6.3 must be applied with the exception of g), h), and m). The serial number o) may be replaced by the batch number. In addition, the words "DO NOT REFILL" in letters of at least 5 mm in height are required.

5.2.8.3 The requirements of 5.2.6.4 must apply.

Note.— Non-refillable cylinders may, on account of their size, substitute this marking by a label.

5.2.8.4 Other marks are allowed provided they are made in low stress areas other than the side wall and are not of a size and depth that will create harmful stress concentrations. Such marks must not conflict with required marks.

5.3 REQUIREMENTS FOR NON-UN CYLINDERS

5.3.1 ~~Cylinders~~ Cylinders and closed cryogenic receptacles not designed, constructed, inspected, tested and approved according to the requirements of 5.2 must be designed, constructed, inspected, tested and approved in accordance with the provisions of a technical code recognized by the appropriate national authority and the general requirements of 5.1.

5.3.2 ~~Cylinders~~ Cylinders and closed cryogenic receptacles designed, constructed, inspected, tested and approved under the provisions of this section must not be marked with the UN packaging symbol.

5.3.3 For metallic cylinders, the construction must be such that the minimum burst ratio (burst pressure divided by test pressure) is:

1.50 for refillable cylinders,
2.00 for non-refillable cylinders.

5.3.4 Marking must be in accordance with the requirements of the appropriate national authority of the country of use.

5.4 REQUIREMENTS FOR AEROSOL DISPENSERS AND SMALL RECEPTACLES CONTAINING GAS (GAS CARTRIDGES)

5.4.1 Each receptacle must be subjected to a test performed in a hot water bath; the temperature of the bath and the duration of the test must be such that the internal pressure reaches that which would be reached at 55°C (50°C if the liquid phase does not exceed 95 per cent of the capacity of the receptacle at 50°C). If the contents are sensitive to heat or if the receptacles are made of plastics material which softens at this test temperature, the temperature of the bath must be set at between 20°C and 30°C but, in addition, one receptacle in 2 000 must be tested at the higher temperature.

5.4.2 No leakage or permanent deformation of a receptacle may occur, except that a plastic receptacle may be deformed through softening provided it does not leak.

~~5.5 PACKAGING FOR REFRIGERATED LIQUEFIED GASES~~

~~5.5.1 Structural considerations~~

~~5.5.1.1 *Service pressure*~~

~~a) The service pressure is the maximum gauge pressure permitted in the packaging at operating conditions. If the inner vessel is surrounded by a vacuum insulated jacket, design should be based upon service pressure plus 98 kPa.~~

~~b) The minimum service pressure must be 176 kPa gauge.~~

~~c) The maximum service pressure must not exceed 2 480 kPa gauge.~~

~~5.5.1.2 *Service temperature*~~

~~The service temperature is the minimum temperature at which the inner vessel may be used.~~

~~5.5.1.3 *Filling density*~~

~~The filling density is the percentage ratio of the mass of the contents in the packaging to the water capacity. For example, a filling density of 10 indicates that the packaging may contain 10 per cent of its water capacity as contents. A filling density of 110 indicates that the packaging may contain 110 per cent of its water capacity as contents. The filling density of the indicated deeply refrigerated gases must not exceed the values given in the table below.~~

~~5.5.1.4 *Material selection*~~

~~Materials selected for the inner vessel must be in accordance with the requirements or codes of the appropriate national authority.~~

Setting of pressure controlling valve (kPa)	*Maximum permitted filling density by mass (per cent)*						
	Helium	*Neon*	*Argon*	*Nitrogen*	*Krypton*	*Xenon*	*Air*
a) Packaging having a water capacity of 454 L or less:							
0-176	12.5	116	136	78			
177-314	*	113	133	76			
315-520	*	110	130	74			
521-726	*	107	127	72			
727-1 178	*	102	122	70			
1 179-1 590	*	98	119	69			
1 591-2 030	*	94	115	68			
2 031-2 480	*	90	113	65			
b) Packaging having a water capacity greater than 454 L:							
0-176	12.5	113	133	76			
177-314	*	109	129	74			
315-520	*	104	125	71			
521-726	*	100	121	67			
727-1 178	*	92	115	64			
1 179-1 590	*	85	110	60			
1 591-2 030	*	77	105	56			
2 031-2 480	*	—	101	53			

* Since liquid helium is so volatile and is a very compressible fluid, a filling density of 12.5 should be used throughout.

Note. — Values for krypton, xenon and air will be developed later.

They must meet or exceed design requirements based on the service temperature of the packaging. A deeply refrigerated gas may be packaged in an inner vessel whose service temperature is lower than that required for the goods.

5.5.1.5 *Pressure vessel design*

a) The inner vessel of the packaging for deeply refrigerated gases must be designed, constructed and tested in accordance with the requirements and codes of the appropriate national authority in effect at the time of its manufacture. The inner vessel of packagings having a water capacity in excess of 30 L, and whose service pressure is above 275 kPa, must be of welded construction.

b) All materials of the packaging which may contact the product must not be subject to any deterioration by the product.

c) Packagings for deeply refrigerated gases must not be seriously damaged or destroyed by any concentrated stresses which might be created at supports due to shear, bending or torsion imposed through the inner vessel's support system.

5.5.1.6 *Supports and shock absorption systems*

a) 1) Packagings up to 50 kg gross mass must withstand a free fall of 150 mm onto a rigid, non-resilient, flat and horizontal surface (such as concrete or steel) in any direction without damage to the supports or inner receptacle.

2) Packaging over 50 kg and up to 250 kg gross mass must withstand a vertical drop of 150 mm onto a rigid, non-resilient, flat and horizontal surface (such as steel or concrete), in the vertical direction, without damage to the supports or inner vessel. If the vertical to horizontal aspect ratio is greater than four, the packaging must also withstand a tip-over fall.

3) Packagings greater than 250 kg gross mass must withstand a corner drop of 150 mm onto a rigid, non-resilient flat and horizontal surface (such as concrete or steel) with the opposite corner on the ground, without damage to the supports or inner vessel.

b) Connections for tie-down cables must be capable of withstanding aircraft design loads.

5.5.1.7 *Outer jacket*

a) The outer jacket may be constructed of steel, stainless steel, aluminium or other material meeting the requirements of 5.1.1, 5.1.2 and

5.1.4. The outer jacket must be capable of withstanding internal vacuum and normal handling. It must maintain vacuum integrity.

b) The outer jacket must be at least 1.5 mm thick for diameters up to 250 mm. For diameters greater than 250 mm up to 510 mm its thickness must be at least 1.9 mm. Above 510 mm the outer jacket must be capable of withstanding a minimum critical collapsing pressure of 206 kPa. The minimum critical collapsing pressure is the minimum pressure at which buckling of the outer jacket begins to occur when that pressure is applied uniformly over the outside of the jacket.

5.5.1.8 *Insulation*

The packaging must be designed so that the total heat transfer from the atmosphere at 21°C to the product does not exceed 464 joule per hour.litre (J/h.L) of water capacity.

5.5.2 Piping and safety relief devices

5.5.2.1 *General requirements*

a) All valves, fittings, safety relief devices and other packaging accessories must be protected against damage in handling and should be designed to discourage tampering in transit.

b) All piping components must be manufactured from materials suitable for the service temperature of the packaging.

c) The bursting strength of all piping components must be at least four times the service pressure of the packaging. All joints between piping components must have comparable strength.

d) Provision must be made to prevent damage to piping due to thermal expansion and contraction, jarring and vibration.

e) The assembled piping must be proved free from leaks at not less than the packaging service pressure.

Note. — It may be necessary to remove relief devices for this test.

f) Each portion of liquid piping which can be closed at both ends must be provided with a relief device.

g) No intervening shut-off valves must be used between the product compartment and its relief devices.

h) Outlets of relief devices must be shielded from the weather and be so designed as to prevent the accumulation of foreign material and prevent decreasing flow below required capacity.

i) An inner vessel relief device must have direct communication with its vapour space. Relief device piping must avoid excessive pressure drop.

j) Relief valves must have suitable seating characteristics to prevent back-leakage to the packaging in the event that the ambient pressure should exceed the pressure of the packaging through descent of the aircraft.

k) With the exception of gauging devices, safety relief devices, manual vents and pressure controlling valves or devices, each pipe from the liquid packaging must be either:

1) closed with a plug, cap bolted flange or plate; or

2) provided with a shut-off valve located as close to the tank as is practicable.

l) All tank inlets and outlets, except safety relief valves, must be marked to designate whether they communicate with vapour or liquid when the tank is filled to the maximum permitted filling density.

m) Connections to safety relief devices and discharge piping must be of sufficient size to provide the required rate of discharge through the safety relief devices and lines.

n) Each safety relief device associated with the tank itself must be plainly and permanently marked with the pressure in kilopascals at which it is set to discharge, with the actual rate of discharge of the device in cubic metres per second of air at 15.6°C and atmospheric pressure, and with the manu facturer's name or trade mark and catalogue number. The start-to-discharge value must be visible when the device is installed. The rated discharge capacity of the device must be determined at a pressure not to exceed 120 per cent of the set pressure of the device.

5.5.2.2 *Safety relief devices for refrigerated liquefied gas*

a) Packaging for service temperature at or above 27 K:

1) Each inner vessel of "low pressure" and "pressurized" packagings must be equipped with a safety relief valve set to open at a pressure which does not exceed 110 per cent of the packaging service pressure (unless otherwise specified by the

appropriate national authority), and which has a minimum flow capacity of:

$$Q_a = \frac{91.83\,UA\,(327.5 - T)}{LC}\sqrt{\frac{ZT}{M}}$$

Note. — The value of "U" is to be determined at the average temperature between 327.5 K and "T" and the air or contained gas in the insulation space at a pressure of 100 kPa absolute, whichever results in the higher value for "U".

2) Each inner vessel of "low pressure" and "pressurized" packagings must also be equipped with a second relief device having a minimum flow capacity of:

$$Q_a = 5.85 \times 10^{-4}\,Gi\,UA^{0.82}$$

If the relief device is a safety relief valve, its set-to-open pressure should not exceed 110 per cent of the service pressure (unless otherwise specified by the appropriate national authority). If a frangible disc is used, its setting shall not exceed 150 per cent of the packaging service pressure (plus 98 kPa if vacuum insulation is used) or the packaging test pressure, whichever is lower (unless otherwise specified by the appropriate national authority).

3) The relief device specified in 2) above for refrigerated liquid neon packagings must have a path to the inner vessel separate from that used for the relief valve specified in 1) above. For "low pressure" shipments of refrigerated liquid neon, the relief valve specified in 1) above must be of the absolute pressure type.

b) Packagings for service temperature below 27 K:

1) For "low pressure" packagings:

The inner vessel must be equipped with an absolute pressure safety relief valve set to open at a pressure which does not exceed either 110 per cent of the packaging service pressure (unless otherwise specified by the appropriate national authority) or an absolute pressure of 275 kPa.

The inner vessel should also be provided with a second relief valve which communicates with the inner vessel by means of a separate path. This relief valve should be set to open at a pressure which does not exceed 110 per cent of the packaging service pressure (unless otherwise specified by the appropriate national authority). Unlessthe second relief valve is of the absolute pressure type, its setting shall be a minimum of 48 kPa higher than that of the absolute pressure relief valve.

Frangible discs may be used to provide supplemental relief capacity on packagings having a nominal capacity of 550 L or less. Frangible discs may not be used in packagings having a capacity in excess of 550 L. If a frangible disc is used, its setting shall not exceed 150 per cent of the packaging service pressure (plus 98 kPa if vacuum insulation is used) or the packaging test pressure, whichever is lower (unless otherwise specified by the appropriate national authority).

The combined flow capacity of the relief devices should equal or exceed:

$$Q_a = 8.05 \times 10^{-3} UA$$

where the value of "U" is based on one atmosphere of helium gas in the insulation space at an average temperature of 160 K.

2) Jacket relief device:

The insulation jacket must be provided with a pressure actuated device which will function at a gauge pressure of not more than 176 kPa and provide a discharge area of 0.1 706 mm^2 per litre of water capacity of the packaging.

3) Other relief device sizing considerations:

Where greater inner vessel relief device capacity may be required due to other modes of heat transfer, these effects must be considered in sizing the liquid compartment relief devices (for example, liquid nitrogen or condensed air heat transfer to a straight vacuum insulated liquid helium or liquid neon compartment).

5.5.3 Nomenclature

Q_a Flow capacity in m^3/s of free air at 120 per cent of the set-to-open pressure of the safety relief device.

~~U — Total thermal conductance of the packaging insulating material saturated with air or contained gas at atmospheric pressure in joules per second.square metre.kelvin (J/s.m^2.K) whichever is greater, at 37.8□C (use value at 37.8□C unless otherwise noted).~~

~~A — Total outer surface area of liquid packaging in m^2.~~

~~T — Temperature of the liquid gas contained at set-to-open pressure of safety relief device, in K.~~

~~L — Latent heat of the liquid gas contained at set-to-open pressure of safety relief device, in J/kg.~~

~~Z — Compressibility factor at the liquid temperature and set-to-open pressure of the safety relief device.~~

~~M — Molecular weight of the liquid gas contained.~~

~~Gi — Insulation factor = 12.2 (dimensionless).~~

~~C — Constant for gas or vapour related to the ratio of specific heats.~~

~~*Note. When "k" is not known, 315 is a safe value for "C".*~~

$$C = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\left(\frac{k+1}{k-1}\right)}}$$

~~k — Ratio of specific heat at constant pressure to specific heat at constant volume at standard conditions of 0□C and 101.325 kPa.~~

P202~~XX~~ PACKING INSTRUCTION P202~~XX~~

This instruction applies to Class 2 refrigerated liquefied gases in open and closed cryogenic receptacles. ~~Refrigerated liquefied gases in open cryogenic receptacles must conform to the construction, testing and filling requirements approved by the appropriate national authority.~~

Open cryogenic receptacles

Open cryogenic receptacles must be metal vacuum insulated vessels or flasks vented to the atmosphere to prevent any increase in pressure within the package. The use of safety relief valves, check valves, frangible discs or similar devices in the vent lines is not permitted. Fill and discharge openings must be protected against the entry of foreign materials which might increase the internal pressure. The maximum capacity is 50 litres. Open cryogenic receptacles are not permitted for air, carbon dioxide, helium, neon, nitrous oxide, oxygen and trifluoromethane refrigerated liquids.

Closed cryogenic receptacles

For closed cryogenic receptacles, the general requirements of Part 4, Chapter 1 must be met.

Closed cryogenic receptacles constructed as specified in Part 6, Chapter 5 are authorized for the transport of refrigerated liquefied gases.

The closed cryogenic receptacles must be so insulated that they do not become coated with frost.

Air, argon, carbon dioxide, helium, krypton, neon, nitrogen, nitrous oxide, oxygen, trifluoromethane and xenon refrigerated liquids may be carried to the extent permitted in these Instructions and in packagings meeting the requirements as set. These requirements also apply to empty packagings unless all parts are at ambient temperatures.

1. 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.

2. Degree of 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.~~

~~For flammable refrigerated liquefied gases~~ T~~t~~he degree of filling must remain below the level at which, the volume of the liquid phase would reach 98 per cent of the water capacity at that temperature, if the contents were raised to the temperature at which the vapour pressure equalled the opening pressure of the relief valve.

3. Pressure-relief devices

Closed cryogenic receptacles must be fitted with at least ~~one~~ two pressure-relief devices, of which two devices are not of the frangible disc type.

Closed cryogenic receptacles must be designed for and equipped with safety relief devices set at an absolute pressure above 275 kPa (175 kPa gauge pressure).

4. 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, (i.e. with a subsidiary risk
of 5.1) these materials must not react with these gases in a dangerous manner.

- END -