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COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS
Sub-Committee of Experts on the Transport of Dangerous Goods
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MISCELLANEOUS DRAFT AMENDMENTS TO THE MODEL REGULATIONS ON THE TRANSPORT OF DANGEROUS GOODS

Gas Cylinders and other gas receptacles

Submitted by the Expert from the United States of America

The expert from the United States has reviewed the proposal by the European Industrial Gas Association and offers the following comments for consideration by the Sub-Committee and the Gas Receptacle Working Group:

General Comments

1. The work to introduce gas cylinder requirements into the UN Model Regulation will be a major undertaking that the expert from the US anticipates will take more than one biennium to complete. To carry out this work in an orderly fashion it will be necessary to prioritize the work on the basis of the significance to international trade and the availability of internationally agreed (ISO) standards. On this basis, the expert from the US believes that the work in the current biennium should focus on requirements for seamless steel and aluminum gas cylinders, small welded cylinders with a capacity less than 150 liters, acetylene cylinders and MEGCs. Work on cryogenic gas containers, pressure drums (welded gas receptacles with a capacity greater than 150 liters) and cylinders made of materials other that steel or aluminum (i.e., composite cylinders) should be delayed until the following biennium or at least until the work on cylinders is substantially completed.

2. While it is recognized that there are a vast quantity of cylinders currently in existence that in some way must be dealt with in the modal regulations, the Committee consistent with the approach for portable tanks, should direct its effort to include requirements for new cylinders that may be transported internationally. Use of existing cylinders should at this point be left to the modes with the Committee perhaps giving some guidance on how they should be dealt with once requirements for new cylinders are completed. Requirements to be included in the Model Regulation may of course take account of requirements in existing regulations. Limiting the scope of the work to new "internationally transportable" cylinders will vastly enhance the ability of the working group to complete the work of developing requirements for the Model Regulation.

3. The scope of the work on gas cylinders should include design and construction standards, quality assurance provisions applicable to the manufacture cylinders, cylinder marking requirements, reinspection requirements and selection and use limitations for individual gases. The US is conducting an analysis of test frequency requirements, filling limits and special requirements for cylinders used to transport specific gases and would prefer to delay development of packing instructions until later in the biennium when this work is completed.

4. As evidenced in the documents by ISO and Canada considerable international effort has already been directed toward the establishment of suitable international requirements. To the greatest extent possible the work of the Committee should avail itself of the standards developed by ISO. However, in limited instances, when it is found that no ISO standards exist for a particular requirement or when the requirements in an applicable ISO standard are found unacceptable other standards should be used. When necessary, deviations from the ISO standards should be entered in the UN Model Regulation. Certain requirements such as marking, periodic test intervals, minimum test pressures, filling requirements and cylinder approval provisions are regulatory issues and should be covered in the UN Model Regulation

Specific Comments

1. **Definitions** - A definition for test pressure should be developed. The definition in the previous draft for settled pressure should be incorporated (***Settled pressure***- the pressure of the content of the pressure receptacle when the temperature of the contained gas is 15˚C.). We do not agree that working pressure should be defined as a function of settled pressure. Working pressure should be defined as follows:

Working pressure is the maximum pressure to which a receptacle may be pressurized while being transported. The working pressure shall not exceed two-thirds of the test pressure at 65 ºC.

The definition for "Compressed gas" should be revised as follows:

Compressed gas - a permanent gas or gas mixture with a critical temperature below -10ºC.
This is considered to be more consistent with the ISO 11622 definition.

The definition for "Liquefied gas " should be revised as follows:

Liquefied gas - a gas or gas mixture which is partially liquid at temperatures above -10°C. A distinction is made between:

High pressure liquefied gas - gases with a critical temperature between -10°C and 70°C

Low pressure liquefied gas - gases with a critical temperature above 70°C.

2. **Valve protection** - In addition to the requirements proposed in 4.1.6.1.4 of the EIGA proposal, we believe that for toxic and flammable gases a performance test should be adopted to ensure that the valves are adequately protected when they are not overpacked, placed in a protective frame or placed inside the neck of the pressure receptacle and protected by a screw-threaded plug. Review of accidents between 1988 through 1997 involving cylinders in the US revealed that damaged valves accounted for more than 30% of the accidental releases from seamless cylinders in transportation. The test would encompass a drop as specified in ISO 11117 except that we would prefer a drop height more consistent with the one specified for PG I packagings (i.e. 1.8 metres). The text would state "Except when valves are protected as specified in (a), (e) and (f), pressure receptacles used for gases meeting the criteria of Divisions 2.1 and 2.3 shall be fitted with valves which are protected in a manner capable of withstanding the performance test specified in ISO 11117 at a drop height of 1.8 metres.

3. **Reference to technical standards** - The US does not agree with the approach EIGA has taken in incorporating the standards into the UN Model Regulation. EIGA proposes that only essential safety standards be incorporated into the Model Regulation and proposes a statement that "The following requirements of the general conditions of packing are considered to have been complied with if the following standards, as relevant are applied.". The US finds this text extremely vague and unacceptable from a regulatory perspective since it would be very difficult to enforce.

The US agrees that only essential safety requirements need be incorporated into the Model regulation, but believes that the technical standards for design and construction of pressure receptacles provide essential safety standards. We believe that the standards need to be incorporated by reference in each case where conformance to the standard or a specific part of the standard is required. The EIGA approach of listing all the standards in paragraph 6.2.2 is not specific enough for purposes of defining cylinder design, construction and use requirements from a regulatory and enforcement perspective. Some of the standards referenced do not apply to design and construction. In some cases not all of the requirements in a particular standard are necessary to be met and in other cases the standards do not provide an adequate level of safety. This will need to be indicated in the Model Regulation with specific reference to which parts of a particular standard do not apply. Provisions for deviating from the standards when the latest scientific and technological advances offer equivalent safety should be also be included in the Model Regulation.

4. **Pressure Relief Devices (PRDs)** - The US notes that there is a difference in philosophy in the use of PRDs between Europe and the rest of the world. Careful consideration involving consultation with emergency responders, gas receptacle users and manufacturers will be necessary in order to develop consensus on the use of PRDs. A detailed and comprehensive risk analysis may need to be performed to weigh the safety aspects of amending current PRD requirements. A systematic approach to specifying forbidden, optional or mandatory use of PRDs for types of gases and cylinder types and sizes will need to be developed. The US has not yet finalized its position in this regard. The US believes that large pressure receptacles such as 3000 litre tubes due to the stored potential energy should be fitted with a pressure relief device in all instances. The working group should consider a volume limit for which PRDs should be mandatory and should consider a systematic approach to specifying the types of gases which may or may not have PRDs.

5. **Maximum filling ratios** - The US is not convinced that filling ratios/densities need to be included in the Model regulation. In contrast, we would prefer that performance criteria for determining filling ratios be included in the Model Regulation. Industry could publish filling ratios on the basis of the performance criteria to their customers to ease the burden on fillers from having to calculate filling density. The US is considering the filling formulas provided in the EIGA proposal based on ISO 11622 for non-permanent gases. These formulas in some cases yield less conservative values than those for substances where the properties are well known and values are specified in current regulations. The US is studying these formulas and may propose alternative formulas for establishing filling limits. The US has compared the maximum filling ratios in the EIGA proposal with those in 49 CFR and in ISO 11622 for permanent gases and has found that the values are fairly consistent. The US will provide specific comments relevant to the permanent gas filling ratios which are not consistent once it has completed its work in this regard.

6. **Gas tables (packing instructions)** - The gas table in P200 will need careful review and consideration. The table provides minimum test pressures, filling ratios, test intervals, and special requirements. The US is in the process of reviewing the requirements in the table and will provide comments once the review is completed.

7. **Design and construction requirements** - Some of the requirements provided in 6.2.1.1, Design and construction are not necessary since they are covered in the technical standards. The technical standards should be incorporated by reference directly in the design and construction section. Only deviations from the standards which are required for regulatory safety reasons should be included in this section (i.e. that is if from a regulatory/transportation safety perspective it is deemed necessary to provide more or less severe requirements). Another concern is that ISO standard 11120, 9809-1 and 9809-2 allow regional international agreements to establish critical design formula constants (i.e. the "F" factor). This must be addressed in the regulations. There is also a provision to allow a proof pressure test in lieu of the jacket test at time of manufacture. This needs to be considered.

8. **Periodic inspection** - The US would prefer not to specify that Non-Destructive Examination (NDE) testing may only be used when approved by the competent authority. This approach will not promote harmonization and the unrestricted transport of gas receptacles. The US believes this section needs to provide greater detailed requirements concerning the use of NDE methods. For instance, Ultrasonic Examination (UE) should be mandatory for high strength pressure receptacles designed and constructed in accordance with ISO 9809-2 and optional for those designed in accordance with 9809-1, 7866 and 11120. Since there is no acceptable ISO standard available for UE or acoustic emissions (AE) testing, other standards such as ASTM and CEN standards may need to be referenced. The Compressed Gas Association is currently developing guidance documents for conducting requalification of cylinders using acoustic emissions and ultrasonic inspection procedures. In addition, the Model Regulation should incorporate requirements for the certification of NDT personnel for inspection of cylinders/tubes. The working group should consider American Society for Nondestructive Testing, Inc. Rcommended Practice No. ASNT TC-1A or other equivalent standards (e.g. BS) as a minimum requirement for NDT personnel qualification/certification. Inspectors should be certified to at least Level II requirements. Recommended criteria for conducting UE during periodic inspection and procedures for personnel qualification for performing UE are provided in Annex 2 of this paper.

The following are suggested references to ISO standards for periodic inspection of pressure receptacles:

- Refillable steel receptacles with tensile strength less than 950 MPa shall be periodically inspected in accordance with ISO 6406:1992.

- Refillable seamless steel receptacles with tensile strength equal to or greater than 950 MPa shall be periodically inspected in accordance with ISO 6406:1992 except ultrasonic examination described in section 6.2.1.5.4 (see Annex 2) must be used in lieu of hydraulic test and internal visual inspection.

- Refillable seamless aluminium receptacles shall be periodically inspected in accordance with ISO 10461:1993

- Refillable acetylene receptacles shall be periodically inspected in accordance with ISO 10462:1994

- Ultrasonic examination may be used as an alternative to hydrostatic testing and internal visual inspection of steel and aluminium receptacles with tensile strength less than 950 MPa.

- ASTM 1419 provides acoustic emission test procedures.

9. **Periodic Retest Intervals** - There are differences in the RID/ADR and 49 CFR retest

intervals. The test intervals will need to be considered by the working group and harmonized on the basis of a systematic approach taking into account the periodicity requirements for different groups of gases and the types of pressure receptacle. However, some cylinders, especially those used in the United States are used for a wide variety of different types of gases (corrosive or non-corrosive gases). This makes it difficult to base retest intervals solely on the type of gases being transported. The US does not support a 3 year interval for corrosive gases. Studies on the effects of wall thickness and corrosion do not justify the 3 year test interval. The US intends to provide justification for use of a 5 year test interval for corrosive gases. The US requirements differ from the European requirements in that the US requirements establish test intervals on the basis of the gas and the type of cylinder used to transport the gas. The US believes that the cylinder type (e.g. seamless or welded, high strength or low strength) should be a factor in determining the retest interval. For instance in our view a welded cylinder may require more frequent inspections as compared to a seamless cylinder dependent on the types of gases it is used to transport.

10. **Markings** - The US proposes use of a universal UN permanently stamped mark for cylinders. The proposed UN mark is similar to the package certification markings required on other UN packagings (see Annex 1).

11. **Approval of pressure receptacles** - The US believes that requirements on the approval of cylinder designs and construction should be included in the UN Model Regulation. Work by ISO TC58/WG9 in this regard along with the text proposed by EIGA could be used as a basis for this work.

Annex 1

Proposed Manufacturers Cylinder Markings:

(a) UN mark; 

(b) the number of the technical standard (e.g. ISO 9809-1) to which the pressure receptacle is designed and constructed;

(c) test pressure in bar;

(d) the date (month and year) of the initial inspection;

(e) the country authorizing the mark;

(f) the name or the registered mark of the manufacturer*;

(g) the serial number of the pressure receptacle provided by the manufacturer;

(h) the identifying mark of the authorized body who carried out the tests and inspections;

These marks shall be permanently stamped, engraved or etched on the pressure receptacle. The markings shall be on the shoulder, top head or neck of the pressure receptacle or on a permanently affixed component of the pressure receptacle (e.g welded collar). Other markings 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 shall not conflict with required markings.

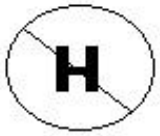
The following two items may be useful markings but should not be part of the certification marking. The tare weight may change dependent on the service equipment fitted on a cylinder. This information could be marked elsewhere on the cylinder and may not need to be marked in a permanent manner.

- the tare of the pressure receptacle (for acetylene cylinders, the tare shall include the mass of the porous material, the solvent, and saturation gas) in kilograms;

- the water capacity in litres;

- service pressure in bar.

It may be useful to include an additional mark on seamless cylinders designed to ISO 9809-1 which have a tensile strength greater than 950 Mpa to indicate that they are not suitable for the transport of gases that can cause hydrogen embrittlement. We are considering a mark such as:



The registered marks could be maintained by the UN Secretariat and published on the UN Transport web site for ease of access.

Annex 2

6.2.1.5.4 ***Test Method for Ultrasonic Examination of Seamless Metal Receptacles***

This test method covers a procedure for detecting and evaluating discontinuities such as area corrosion, isolated pits, line corrosion and fatigue crack in metal receptacles using pulse-reflection ultrasonic contact immersion straight and angle beam techniques.

- *Ultrasonic Testing Equipment*

The ultrasonic equipment (UT) equipment shall consist of a pulse-echo test instrument that is capable, at a minimum, of generating, receiving, and presenting high energy pulses in an A-scan, B-scan, or C-scan display. It shall have a frequency range of 1 MHz to 10 MHz. The UT equipment must continually monitor the acoustic coupling to assure 100% receptacle sidewall coverage during the testing and automatically terminate testing or alarm the UT system if the coupling is lost. If coupling is lost, the UT operator has the option of terminating the test to determine the problem and re-examining the areas where the coupling was lost. The equipment shall be capable of providing a comparison of crack depth to that of a known reference reflector. The equipment calibration shall be performed for each type of receptacle to be examined using the standardization reference (calibration standard) to testing. At a minimum, the equipment calibration shall be verified at the beginning of each work shift, at 4 hour intervals, and at the end of the work shift. If the calibration is found to be less conservative after any verification check, all receptacles tested since the last acceptable calibration shall be reexamined. Calibration shall also be verified when there is a change of UT operators, when transducers are changed, when coaxial cables are changed, if a power failure occurs, or if the UT equipment is turned off for any reason. The UT transducer assembly shall be arranged so that the ultrasonic beams are aimed at a single location in the receptacle wall and all beams exit and re-enter the transducer at their respective locations. The shear wave beams shall be oriented in four opposing directions consisting of two opposing longitudinal and two opposing transverse examinations. A straight beam search unit consists of a piezoelectric crystal(s) mounted to a fixture that introduces the ultrasonic beam(s) perpendicular to the longitudinal axis of the receptacle. Each shear wave search unit consists of a piezoelectric crystal(s) mounted to a fixture that are set at a sufficient incident angle to introduce shear waves into the receptacle between 401 and 601 inclusive. A search unit frequency of 2.25MHz to 10MHz shall be used. The equipment shall be calibrated to detect each artificial defect in the standardization reference receptacle.

- ***Standardization Reference (Calibration Standard)***

A cylindrical section from a receptacle or an actual receptacle shall be used for a standardization reference. The standardization reference receptacle shall be similar in diameter (±10%), surface finish, metallurgical and acoustical properties, and specification as the receptacle to be tested. The standardization reference shall be machined with features that simulate defects such as pits, fatigue cracks, and reduced wall thickness. The size of these features shall be such that represent the applicable pass-fail criteria identified in Table A for requalification of each receptacle or as identified in the applicable receptacle specifications. The minimum wall thickness and defect sizes in the standardization reference shall be confirmed by mechanical measurements and certified by a person who holds a nationally recognized certification such as ASNT NDT Level III certificate in UT. The dimensions of each artificial defect in the standardization reference shall be measured every five years to confirm that the defect sizes have not changed. The artificial defects shall be

produced by an electrical discharge machine, sawing, drawing, or machining. The artificial defects representing pits and reduced wall thickness shall be located on the internal diameter of the receptacle. The notches representing fatigue cracks and linear defects shall be located on the outer and inner diameter of the receptacle. All artificial defects shall be located such that there is no interface from any other defect in the standardization reference.

- ***Couplant***

The same couplant that was used for standardization (calibration) shall be used for testing.

- ***UT procedure and reporting requirements***

The UT procedure and reporting requirements shall be in accordance with ASTM E 797 for wall thickness, ASTM E 213 for shear wave examinations and following:

(a) The surface of the receptacle to be inspected shall be free of extraneous loose material such as scale, loose paint and dirt.

(b) The rotational speed of the receptacle under examination shall not exceed the rotational speed used during standardization.

(c) The UT results shall be evaluated in accordance with the pass-fail criteria identified in table A for requalification of each receptacle.

(d) The UT program shall be approved by the competent authority.

- ***Personnel Qualifications and Responsibilities***

Each facility where testing is to be performed must be under the managerial direction of a Senior Review Technologist (SRT)

(a) The SRT shall define the overall test program, provide supervisory training and technical guidance to the UT operators, review and certify test results and maintain proof of qualification for each "qualified tester". The SRT shall hold a level III certification in UT in accordance with ASNT-SNT-TC-1A or British Standards PCN certification program.

(b) The person(s) performing UT, the "qualified tester", shall hold a level I certification in UT in accordance with ASNT-SNT-TC-1A or British Standards PCN certification program. The "qualified tester" may perform a system startup, check standardization, and review and validate test results.

(c) Each "qualified tester" shall have written procedures for conducting UT and proof of his/her qualifications. The written procedure shall include an operation manual of the equipment, the written test procedure, and records of all tests performed at the facility where testing is performed

Table A - Criteria for Ultrasonic Examination Used During Periodic Inspection

Metal Receptacle Specifications	*Coverage area of receptacle by straight beam and angle beam*	*Rejectable crack depth in sidewall (depth based on % of wall thickness) (see note 2 and 3)*	*Rejectable crack length in sidewall (multiple of wall thickness)*	*Rejectable Pit Dimensions*		*Rejected area for reduced wall thickness (t) reduced wall t = any value less that design min. wall thickness [1] D = diameter of the Receptacle. Which ever is greater*
				Rejectable pit remaining wall thickness, measured from the bottom of the pit (see note 4)	*Rejectable pit diameter*	
				Remaining Wall	*Diameter*	
tensile strength >950 Mpa	*100% of sidewall*	*20% of wall thickness*	*4 times wall thickness*	*‡ 0.667 design wall thickness but £ 0.95 design wall thickness* *< 0.667 design wall* *£ design wall thickness but ‡ 0.95 design wall thickness*	*14 mm>D>6.4 mm* *D £ 6.4 mm* *D ‡ 14 mm*	*161 mm^2 or 0.009D^2*
tensile strength =<950 Mpa	*100% of sidewall*	*25% of wall thickness*	*5 times wall thickness*	*‡ 0.667 design wall thickness but £ 0.95 design wall thickness* *< 0.667 design wall* *£ design wall but ‡ 0.95 design wall*		*323 mm^2 or 0.009D^2*

[1] Term wall thickness in this table means the minimum design wall thickness used to calculate the maximum allowable wall stress and provided by the manufacturer.

[2] Crack depth is determined by comparing the amplitude of actual indications to the amplitude of stated notch. If amplitude of indication is greater than stated notch amplitude, the cylinder is rejected. If the indication can be removed by surface conditioning and the minimum design wall is not exceeded, the cylinder may be accepted.

[3] *Standardization (calibration) notch depth shall be ≤ rejectable crack depth.*