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COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS AND ON THE GLOBALLY HARMONIZED SYSTEM OF CLASSIFICATION AND LABELLING OF CHEMICALS

Sub-Committee of Experts on the Transport of Dangerous Goods
(Twenty first session, 1-10 July 2002, agenda item 2)

ADDITIONAL PROVISIONS FOR THE TRANSPORT OF GASES

Transmitted by the expert from the United States of America

1. The annexes to this document include information which should be considered by the Pressure Receptacles and MEGCs Working Group.

Annex 1

Items to be considered by the Working Group on Pressure Receptacles and Multiple-Element Gas Containers during the July 2002 Working Group Meeting.

Issues	US Comments
1. Verification of the filling ratios in Table 2 of Packing Instruction P200.	The contract work by the National Institute of Standards and Technology (NIST) for filling ratio calculation is in progress. The US experts expect to present the NIST report at the July 2002 working group meeting in Geneva.
2. Standard for design and construction of composite gas receptacles.	The US has reviewed ISO 11119 part 1 &2 and submitted detailed comments to the ISO TC58/SC3 (see attached comments in Annex 1). The US is prepared to adopt ISO 11119-1 and 11119-2 standards into the Model Regulations with the following exception: All UN Certified Composite Pressure Receptacles shall be limited to a 15 year life limit until such time that a technical justification is provided to justify a longer or unlimited life. The UN needs to adopt this North American provision to ensure harmony and to provide an incentive for companies that are interested in an extended life to provide technical justification.
3. Standard for design and construction of welded drums.	The US has initiated a review and has provided some comments to ISO on the draft standard; ISO/TC 58 /SC3 N932, "Gas Cylinders - Welded steel drums up to 3000 litters capacity for the transport of gases - Design and construction" The US will further evaluate this ISO standard after its status becomes ISO-CD and ISO-FDIS will keep the UN working group informed of its position. We believe that the UN working group should consider the efforts of ASME to develop a technical standard for "multi-unit tank car tanks (DOT/TC 106A and 110AW commonly referred to as "ton tanks"). These tanks are fusion welded pressure receptacles and are used throughout the world for the transport of high hazard gases such as chlorine, dinitrogen tetroxide, stabilized, etc. The US will provide copies of the specifications for these pressure receptacles at the working group meeting.
4. Standard for design, construction and inspection of cryogenic receptacles.	The US has reviewed and commented on the ISO/CD 24421-1 (Large transportable vacuum insulation vessels - Part 1: Design, Fabrication, Inspection and Testing. Periodic inspection and test standards for cryogenic receptacles. ISO/CD 21029-1 (Transportable vacuum insulation vessels on no more than 1000 L Volume - Part 1: Design, Fabrication, Inspection and Testing. The US is prepared to adopt theses standards into the Model Regulations.
5. Standard for periodic inspection and test of welded receptacles and welded drums.	The US has reviewed and commented on the ISO/CD 10460 "Gas cylinders - Transportable welded carbon steel gas cylinders - Periodic inspection and testing" The US will further evaluate this ISO standard after its status becomes ISO-FDIS.

Issues	**US Comments**
6. Standard for periodic inspection and test of high strength seamless UN Certified Pressure Receptacles.	In section 6.2.2.4 “Periodic inspection and test” - Replace the ISO 6406:1992 with the latest ISO 6406 that includes comments from the US. - Include the following note in section 6.2.2.4, in the table where the ISO 6406 is listed: Note**:** All UN marked pressure receptacles constructed under ISO 9809-2:2000 must be tested ultrasonically as described in section 10 of the latest revision of ISO 6406. The US reviewed ISO 6406 for the five-year revision and submitted extensive comments and proposals to be included in section 10 of the standard (see Annex 3 attached).
7. Evaluation of ISO 22991" draft standard - Gas cylinders - Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) - Design and construction”	The US has reviewed and compared this draft standard (ISO/CD 22991) with the current version of ISO 4706 and the DOT standard for welded cylinders (DOT-4BW). Annex 2 provides a summary of the review a side by side comparison of ISO 22991, ISO 4706 and DOT-4BW standards. The side by side comparison will be provided to the working group members. We believe that UN LPG cylinders can be built in accordance with ISO 4706 which will be included in the UN Model regulations. The US does not support adopting ISO 22991 into the UN model regulations.
8. Proposed marking for welded steel receptacles	The US proposes the same marking requirements for welded steel receptacles as seamless steel receptacles, see section 6.2.2.6.

Annex 2 - US comments relative to composite cylinders (ISO 111191-2)

ISO 11119-2:2001(E)

Page No.	Section No.	Current Wording	Proposed Wording	Rational
1	1, 2nd paragraph	*** and design life from 10 years to non-limited life.	**** and a limited life of 15 years.	The US composite cylinder manufacturers still working to submit an acceptable plan in order to increase the cylinder's life beyond 15 years.
4	5, first paragraph	**** relevant regulations	***** with the competent authority or its authorized body	To clarify the authorized inspector
5	6.1.3	*** of the inspector	**** of the competent authority or its authorized body	To clarify the authorized inspector
5	6.2.3	****	Be removed	The cylinder manufacturer shall confirm the filament material and the resin.
6	7.1.5, 3rd paragraph	- for carbon- 2.4	- for carbon- 3.00	Current DOT-CFFC cylinders are designed with 3.4 stress ratio
7	7.2.4(f)	Cylinders with a test pressure of less than 60 bar (870 psi) shall have non-limited design life	Be removed or modified based on technical rational	The non-limited with any failure mode and effect analysis would cause a great safety concern
7	7.2.5, 4th paragraph	The fiber stress ratio (s) for the design shall exceed those stated in 7.1.5	The fiber stress ratio (s) for the design may be less than those stated in 7.1.5	Clarification
8	7.3.5	*** The manufacturer *** acceptable to inspector.	*** The manufacturer *** acceptable to the competent authority or its authorized body	To clarify the authorized inspector.
9	8.3.1, 8.3.2, 8.3.3 and 8.4.4, all through these sections	**** inspector.	**** competent authority or its authorized body.	To clarify the authorized inspector.

Annex 3

**SUMMARY OF THE COMPARISON OF ISO STANDARD 4706,
ISO DRAFT STANDARD 22991 AND DOT SPECIFICATION 4 BW**

INTRODUCTION

A detailed technical review and evaluation of (1) the ISO 4706 standard "Refillable welded steel gas cylinders", (2) the ISO 22991draft standard "Gas cylinders - Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) - Design and construction", and (3) DOT 4 BW "Specification 4BW welded steel cylinders with electric arc welded longitudinal seam" was carried out. These three standards all specify the requirements for the materials, design, construction, and testing of low pressure welded steel cylinders. The purpose of this review and evaluation was to determine if these three standards are functionally equivalent and can be used interchangeably.

SCOPE

The scope of the ISO 4706 standard and the ISO 22991 draft standard are virtually the same. The only slight difference is that the ISO 22991 draft standard has a minimum size limit of ½ liter whereas the ISO 4706 standard has a minimum size limit of 1 liter. This is not considered a significant difference between the ISO 4706 standard and the ISO 22991 draft standard

The scope of the DOT 4BW specification differs significantly from both the ISO 4706 standard and the ISO 22991 draft standard in that the DOT 4 BW specification (1) permits cylinders be constructed up to a maximum size of approximately 500 liters, compared with a maximum size of 150 liters for both of the ISO standards and (2) the DOT 4BW specification has a minimum service pressure of 225 psig (approximately 15 bar) and a maximum service pressure of 500 psig (approximately 35 bar), whereas the ISO standards do not specify a minimum or maximum service pressure.

MATERIALS

Both the ISO 4706 standard and the ISO 22991 draft standard require the cylinders to be made from steels that conform to the ISO 4978:1983 standard. The ISO 4706 standard permits the use of other suitable steels that those specified by the ISO 4978 standard if the steels which conform to the chemical composition requirements of section 4.2.1 of the ISO 4706 standard (subject to acceptance by the national authority of the country where the cylinder is to be used). All cylinders made to the requirements of the ISO 4706 standard and that use the steels specified in the ISO 4978 standard will satisfy all of the requirements of the ISO 22991 draft standard.

The steels that are permitted in the DOT 4BW specification are similar to the steels specified in the ISO 4978 standard. The chemical composition limits of the steels permitted in the DOT 4BW specification are slightly more restrictive than the chemical composition limits specified in the ISO 4978 standard. Therefore, cylinders made to the DOT 4 BW specification will satisfy the material requirements of both the ISO 4706 standard and the ISO 22991 draft standard.

Both the ISO 4706 standard and the ISO 22991 draft standard require that the cylinders be heat treated by normalizing or by stress relieving. The ISO 22991 draft standard permits an exception to the heat treatment requirement for specific three piece cylinders that are made from fine grain steel and that have additional fatigue tests done on sample from the cylinders. Because nearly all of the cylinders that are to be made to the ISO 22991 draft standard are delivered in the heat treated condition, the cylinders will satisfy both the ISO 4706 standard and the ISO 22991 draft standard.

The DOT 4BW specification requires that all cylinders be heat treated following all fabrication. Therefore, the cylinders that are made to the DOT 4 BW specification will also satisfy the heat treatment requirements of the ISO 4706 standard and the ISO 22991 draft standard.

DESIGN

For the design of the cylinders, the most significant step in the design of the cylinder is the calculation of the minimum wall thickness of the cylindrical part of the cylinder. For both the ISO 4706 standard and the ISO 22991 draft standard, the wall thickness of the cylindrical shell is calculated based on the guaranteed minimum yield strength of the material and the test pressure of the cylinder. Both the ISO 4706 standard and the ISO 22991 draft standard use the same basic formula to calculate the minimum wall thickness of the cylindrical shell.

The ISO 4706 standard requires that the minimum wall thickness of the cylindrical shell be calculated by the following equation:

$$a = \frac{Ph \times D}{\frac{20 \times Re \times J}{1{,}33}} + Ph \qquad (1)$$

Where:

a – Calculated minimum thickness, in millimetres, of the cylindrical shell

Ph – Test pressure, in bar, above atmospheric pressure

D – Outside diameter, in millimetres, of the cylinder

Re – Minimum value of yield stress, in newtons per square millimetre, guaranteed by the cylinder manufacturer for the finished cylinder

NOTE:Re has a maximum value of (1) 0,75 *Rg* for carbon steels with UTS < 490 N/mm2; or (2) 0,85.Rg for high-strength micro-alloy steels with UTS > 490 N/mm2.

Rg: Minimum value of tensile strength, In newtons per square millimetre, guaranteed by the cylinder manufacturer for the finished cylinder

J – Stress reduction factor (also known as the weld joint efficiency factor)

J = 1.0 for cylinders in which the longitudinal welds in each cylinder are 100 % radiographed

J = 0.9 for cylinders that are spot radiographed (only the intersection of the longitudinal and circumferential welds are radiographed in 1 cylinder out of each batch of 250 cylinders)

J = 0.7 for cylinders in which the welds are not radiographed

The ISO 22991 draft standard requires that the minimum wall thickness of the cylindrical shell be calculated by the following equation:

$$a = \frac{P_c \times D}{\frac{20 \times R_o \times J}{1{,}33}} + P_c \qquad (2)$$

Where:

a – Calculated minimum thickness, in millimetres, of the cylindrical shell

P_c -- calculation pressure, in bar (1 bar = 10^5 Pa = 10^5 N/m2), used to calculate the minimum required thickness of the cylindrical shell and ends

P_{tmin} -- minimum permissible test pressure, in bar

NOTE: $P_c = P_{tmin}$

R_o – minimum value of yield stress, in newtons per square millimetre, guaranteed by the cylinder manufacturer for the finished cylinder

NOTE: For calculation purposes, the value of the yield stress R_o is limited to a maximum of 0,85 Rg .

Rg: Minimum value of tensile strength, In newtons per square millimetre, guaranteed by the cylinder manufacturer for the finished cylinder

J – Stress reduction factor (also known as the weld joint efficiency factor)

J = 1.0	for cylinders without a longitudinal weld
J = 0.9	for cylinders with a longitudinal weld

NOTE: These cylinders that are spot radiographed (only the intersection of the longitudinal and circumferential welds are radiographed in 1 cylinder out of each batch of 250 cylinders)

It should be noted that the terminology is slightly different for the equation from the ISO 4706 standard (equation 1) and the equation from the ISO 22991 draft standard (equation 2). The cylinder test pressure (Ph) in the ISO 4706 standard is called the calculation pressure (P_c) in the ISO 22991 draft standard. However, because the calculation pressure (P_c) is defined as the minimum test pressure (P_{tmin}), the calculation pressure (P_{tmin}) in equation (2), above, is the same as the test pressure (Ph) in equation (1) above. Similarly, the minimum value of yield stress that is designated as (Re) in equation (1) is designated as (R_o) in equation (2).

The stress reduction factor (J) is the same in equation (1) and equation (2) for similar cylinders. In the ISO 4706 standard, the J value is 1.0 when the longitudinal weld is 100 % radiographed and this is equivalent to a cylinder without a longitudinal weld made in compliance with the ISO 22991 draft standard. For cylinders that have longitudinal welds that are spot radiographed, both standards specify that J = 0.9.

The ISO 4706 standard restricts the maximum yield strength (Re) used in the calculation of the wall thickness to 0,75 Rg for carbon steels (less than 490 N/mm^2 Rg) whereas the ISO 22991 draft standard permits the maximum yield strength (R_o) used in the calculations of the wall thickness to be 0,85 Rg for all steels that satisfy the ISO 4978:1983 standard. For higher strength steels, both standards permit the maximum yield strength (Re) or (R_o) used in the calculations of the wall thickness to be 0,85 Rg. This difference will result in cylinders made to the ISO 4706 standard having a slightly higher wall thickness than cylinders made to the ISO 22991 draft standard when both are made of lower strength carbon steel.

When the differences in terminology are taken into account, it can be seen that equation (1) from ISO standard 4706 and equation (2) from ISO draft standard 22991 become th same. It may appear that the wall thickness of the cylindrical shell calculated according to the ISO 22991 draft standard will be thinner than the wall thickness calculated according to the ISO 4706 standard because of the difference in the maximum yield strength used in the calculations (i.e. 0.85 Rg compared with 0.75 Rg). However, for many cylinders the wall thickness is controlled by the absolute minimum thickness requirement rather than the wall thickness calculated by the pressure stress equation (1 or 2, above). The wall thickness for most cylinders with a test pressure up to about 45 bar is controlled by the absolute minimum wall thickness requirement. As can be seen from the Table I, the absolute minimum wall thickness requirement for the ISO 22991 draft standard results in a wall thickness that is about 10 % less than the absolute minimum wall thickness permitted by the ISO 4706 standard.

For cylinders with higher test pressures (i.e. 45 or 60 bar) , the minimum wall thickness of the cylindrical shell calculated according to the ISO 22991 draft standard is about about 10 % less than the calculated minimum wall thickness of the cylindrical shell calculated according to ISO 4706 standard. Example of the calculated minimum wall thickness of the cylindrical shell are shown in the Table I.

For cylinders made according to the DOT 4 BW specification, the minimum wall thickness calculation is based on the defined wall stress and the service pressure of the cylinder. The defined wall stress is limited to either (1) 50 % of the minimum tensile strength or (2) an absolute maximum of 35,000 psi. This effect of this absolute maximum stress limit is to prevent taking advantages of steels with tensile strengths greater than approximately 470 N/mm^2 . In addition, the DOT 4 BW specification requires that the cylinders be hydrotested to a minimum test pressure of 2 times the service pressure. DOT 4 BW specification has an absolute minium wall thickness of 0.078 inches (1.98 mm) for any cylinder with a diameter larger than 6 inches (152 mm). The effect of these design parameters is to make the wall thickness of cylinders constructed according to the DOT 4 BW specification generally greater than the wall thickness of cylinders made according to the ISO 4706 standard and the ISO 22991 draft standard. The exception to this occurs only for cylinders made from the lowest strength steels, as shown in Table I.

In Table I , a comparison is made of the minimum wall thickness of the cylindrical part of the shell according to the design requirements of the ISO 4706 standard, the ISO 22991 draft standard, and the DOT 4 BW specification. The minimum wall thickness was calculated for representative cylinders that cover the range of cylinder sizes and steel strength levels for cylinders made according to these standards. The results shown in the Table I take into account any absolute minimum thickness requirements (shown as gray cells in the table) and any limitations on the maximum allowable stress level.

Table I Comparison of Calculated Wall Thickness

				ISO 4706		ISO 22991			DOT 4 BW
Ph (bar)	D (mm)	J	Rg (N/mm^2)	a (mm)	Min. a (mm)	a (mm)	Min. a (mm)	a (mm)	Min. a (mm)
30	100	0.9	400	0.733	1.500	0.648	1.1	0.709	____
30	100	0.9	490	0.600	1.500	0.529	1.100	0.607	____
30	100	0.9	600	0.433	1.500	0.433	1.100	0.607	____
30	250	0.9	400	1.834	1.800	1.619	1.700	1.772	1.980
30	250	0.9	490	1.499	1.800	1.323	1.700	1.518	1.980
30	250	0.9	600	1.082	1.800	1.082	1.700	1.518	1.980
30	300	0.9	400	2.200	1.800	1.943	1.900	2.126	1.980
30	300	0.9	490	1.799	1.800	1.588	1.900	1.822	1.980
30	300	0.9	600	1.298	1.800	1.298	1.900	1.822	1.980
30	400	0.9	400	2.934	2.600	2.591	2.300	2.835	1.980
30	400	0.9	490	2.398	2.600	2.118	2.300	2.430	1.980
30	400	0.9	600	1.731	2.600	1.731	2.300	2.430	1.980
30	500	0.9	400	3.667	3.000	3.239	2.700	3.543	1.980
30	500	0.9	490	2.998	3.000	2.647	2.700	3.037	1.980
30	500	0.9	600	2.164	3.000	2.164	2.700	3.037	1.980
45	100	0.9	400	1.096	1.500	0.968	1.100	1.063	____
45	100	0.9	490	0.897	1.500	0.792	1.100	0.911	____
45	100	0.9	600	0.648	1.500	0.648	1.100	0.911	____
45	250	0.9	400	2.740	1.800	2.421	1.700	2.658	1.980
45	250	0.9	490	2.242	1.800	1.980	1.700	2.278	1.980
45	250	0.9	600	1.619	1.800	1.619	1.700	2.278	1.980
45	300	0.9	400	3.289	1.800	2.905	1.900	3.190	1.980
45	300	0.9	490	2.690	1.800	2.376	1.900	2.734	1.980
45	300	0.9	600	1.943	1.800	1.943	1.900	2.734	1.980
45	400	0.9	400	4.385	2.600	3.874	2.300	4.253	1.980
45	400	0.9	490	3.587	2.600	3.168	2.300	3.645	1.980
45	400	0.9	600	2.591	2.600	2.591	2.300	3.645	1.980
45	500	0.9	400	5.481	3.000	4.842	2.700	5.316	1.980
45	500	0.9	490	4.483	3.000	3.960	2.700	4.556	1.980
45	500	0.9	600	3.239	3.000	3.239	2.700	4.556	1.980
60	100	0.9	400	1.456	1.500	1.287	1.100	1.418	____
60	100	0.9	490	1.192	1.500	1.053	1.100	1.215	____
60	100	0.9	600	0.862	1.500	0.862	1.100	1.215	____
60	250	0.9	400	3.641	1.800	3.218	1.700	3.545	1.980
60	250	0.9	490	2.980	1.800	2.633	1.700	3.038	1.980
60	250	0.9	600	2.154	1.800	2.154	1.700	3.038	1.980
60	300	0.9	400	4.369	1.800	3.861	1.900	4.254	1.980
60	300	0.9	490	3.576	1.800	3.160	1.900	3.646	1.980
60	300	0.9	600	2.585	1.800	2.585	1.900	3.646	1.980
60	400	0.9	400	5.825	2.600	5.149	2.300	5.673	1.980
60	400	0.9	490	4.768	2.600	4.213	2.300	4.861	1.980
60	400	0.9	600	3.447	2.600	3.447	2.300	4.861	1.980
60	500	0.9	400	7.281	3.000	6.436	2.700	7.091	1.980
60	500	0.9	490	5.960	3.000	5.266	2.700	6.077	1.980
60	500	0.9	600	4.309	3.000	4.309	2.700	6.077	1.980

Both the ISO 4706 standard and the ISO 22991draft standard require the minimum thickness in the torispherical and semi-elliptical ends of the cylinder to be calculated The equations for calculating the minimum wall thickness of the ends of the cylinders are identical to equations (1) and (2) shown above with an adjustment factor to account for the specific shape of the cylinder end. Both the ISO 4706 standard and the ISO 22991draft standard use exactly the same adjustment factor and the minimum wall thickness is the same for both standards. The DOT 4 BW specification has only a general requirement that the ends of the cylinders should be concave to the pressure and that the thickness of the ends should not be less than 90 % of the thickness of the sidewall of the cylinder. Because the DOT 4 BW specification does not have more specific requirements for the minimum wall thickness in the ends of the cylinders no detailed comparison could be made with the ISO 4706 standard and the ISO 22991draft standard.

CONSTRUCTION AND WORKMANSHIP

Both the ISO 4706 standard and the ISO 22991draft standard have detailed requirements for (1) welding procedure qualification, (2) welded joint configuration, (3) geometric tolerances, (3) attachments to the cylinders, and (4) valve protection. The requirements for construction and workmanship in both the ISO 4706 standard and the ISO 22991draft standard are functionally the same. The requirements specified in the ISO 4706 standard are slightly more detailed and specific than the the requirements specified in the ISO 22991draft standard. Cylinders made according to the ISO 4706 standard should satisfy all of the requirements of the ISO 22991draft standard.

The general requirements for construction and workmanship in the DOT 4 BW specification are functionally similar to the requirements of the ISO 4706 standard and the ISO 22991draft standard.

TESTING

The frequency of testing (batch lot size) for the mechanical property tests and the hydrostatic tests is the same for both the ISO 4706 standard and the ISO 22991draft standard (see Figure 7 in ISO 4705 and Figure 11 in ISO 22991). Mechanical property tests and hydrostatic tests are required to be taken on 1 out of 250 cylinders or up to 1 out of 1000 cylinders, depending on the size of the production run. The requirements for retesting when the cylinders fail to meet the batch test requirements are exactly the same in both the ISO 4706 standard and the ISO 22991draft standard. The DOT 4 BW specification requires that the mechanical property tests and hydrostatic tests be carried out on 1 cylinder from each lot of 200 cylinders. This testing rate is more frequent that the testing rate required by both the ISO 4706 standard and the ISO 22991draft standard.

For radiographic testing, the ISO 4706 standard requires either every cylinder to be inspected if the design takes advantage of the joint efficiency (J) equal to 1.0 or for 1 out of every 250 cylinders to be inspected if a joint efficiency of 0.9 is used in the design. By comparison, the ISO 22991 draft standard requires only 1 cylinder out of each 250 cylinders to be inspected by spot radiography and only permits a joint efficiency (J) of 0.9 to be used in the design. The two standards are similar except that the ISO 4706 standard has the additional requirement that allows the use of the higher joint efficiency when the longitudinal joint is radiographed 100 %. The 4 BW specification is similar to the ISO 4706 standard in that it allows a joint efficiency (J) of 1.0 when the longitudinal weld is radiographed 100 % but only a J = 0.9 when spot radiography is used. However, for spot radiography, the DOT 4 BW specification requires that 1 cylinder out of 50 be inspected instead of the 1 out of 250 as required by the ISO 4706 standard.

The mechanical property tests (tensile tests and bend tests) required by both the ISO 4706 standard and the ISO 22991draft standard are functionally the same. Both standards require the tensile specimens and bend specimens to be taken from the same locations in the parent metal and the weld metal. For the tensile tests, the ISO 4706 standard has specific values for the minimum elongation required whereas the ISO 22991draft standard only requires that the values meet those guaranteed by the manufacturer. In the bend test the ISO 4706 standard and the ISO 22991draft standard require very slightly different ratios of the former diameter to thickness. ratio (see Table 2 in each standard). Identical fatigue tests are required to be carried out on prototype cylinder designs by both the ISO 4706 standard and the ISO 22991draft standard. The mechanical property tests (tensile test and bend tests) required by the DOT 4 BW specification are similar to the tests required by both the ISO 4706 standard and the ISO 22991draft standard and are functionally equivalent. However, the specific tests and acceptance requirements required by the DOT 4 BW specification are not exactly the same as those required by the ISO 4706 standard and

the ISO 22991draft standard. Therefore, satisfying the requirements of the DOT 4 BW specification will not satisfy the requirements of the ISO 4706 standard and the ISO 22991draft standard.

In both the ISO 4706 standard and the ISO 22991draft standard, the hydrostatic pressure test is carried out to the marked test pressure (2 times the service pressure) on each cylinder The hydrostatic burst test is carried out on 1 cylinder per batch. The hydrostatic burst test procedures are the same in both the ISO 4706 standard and the ISO 22991draft standard. However, there are slight differences between the two standards in the requirements for the burst press (Pb) of the cylinder and in the volumetric expansion requirements. In the ISO 4706 standard the required burst pressure in the hydrostatic test is based on the calculated minimum thickness, the guaranteed tensile strength and the diameter of the cylinder. In the ISO 22991draft standard, the required burst strength is fixed at 9/4 of the calculation pressure (P_c). In all cases examined, the ISO 4706 standard requires a slightly higher burst pressure than the ISO 22991draft standard. For the volumetric expansion test, the ISO 22991draft standard permits slightly larger expansion values than the ISO 4706 standard. The DOT 4 BW specification requires that each cylinder be hydrostatically tested to a pressure equal to two times the service pressure and that 1 cylinder out of 500 be tested to burst and that the burst pressure should not be less than 4 times the service pressure. The volumetric expansion is limited to 10 % when the pressure is two times the service pressure. No hydrostatic burst test on a cylinder from each batch is required by the DOT 4 BW specification.

SUMMARY AND CONCLUSIONS

1. Cylinders made according to the ISO 4706 standard will meet all requirements of the ISO 22991draft standard. However, a few of the requirements in the ISO 22991 draft standard are less restrictive than the requirements in the ISO 4706 standard, so cylinders produced according to the ISO 22991draft standard will not be in full compliance with the requirements of the ISO 4706 standard.

2. Cylinders made according to the DOT 4 BW specification will satisfy the material requirements and in most cases the design requirements of both the ISO 4706 standard and the ISO 22991draft standard. However, the specific tests and acceptance criteria required by the DOT 4 BW specification are different than the specific tests and acceptance criteria required by the ISO 4706 standard and the ISO 22991draft standard. Therefore, cylinders made according to the DOT 4 BW specification will not fully satisfy the requirements of the ISO 4706 standard and the ISO 22991draft standard

3. Cylinders made according to the DOT 4 BW specification will not be in full compliance with either the ISO 4706 standard or the ISO 22991 draft standard

Date: 2001-11-26

Member body	Clause/ subclause	Paragraph/ Figure/ Table	Type of comment (general/ technical/editorial)	Comment	Proposed change
USA	10	All	General	Terminology clarification	Change "probe" to "transducer" where it occurs.
"	"	10.3.1 -2nd Para line 1	Editorial	Delete "in Annex E"	Insert "below"
"	"	10.3.2.1 line 1	Tech	No known problems exist in this area	Delete" ~~the transition to the shoulder~~"
"	"	10.3.2.2, - 5th paragraph	Tech	Guided wave usage would be prohibited if normal probes were required.	Replace first sentence with; "The cylinder wall shall be tested using UT transducers capable of detecting the specified minimum wall thickness."
"	"	10.3.4 last sentence	Tech	The front wall can be larger than the flaw signal, and the flaw can still be detected. The problem is when the front wall signal falls into the area that is gated for the flaw signals	Change last sentence to; "An ultrasonic test is only meaningful when the noise signals caused by the surface do not interfere with the signals from the flaws."
"	"	10.4.1 line 3	Tech	The use of min wall must be used because nom wall could be difficult or impossible to establish by the re-tester.	Replace "~~nominal~~" with "minimum"
"	"	10.4.1	Tech	Since this is an International Specification a range of allowable diameter/min wall changes should be permitted when calibrated to a specific design.	If this concept were acceptable a table would be provided.
"	"	10.4.2 -6th indention	Tech	Notch depths for low and high strength shall be different.	Delete; ~~- Depth (D: 5+/-0.75)% of nominal wall thickness S;~~ Insert: - Depth D: less than or equal to 6% of minimum wall thickness S; for cylinders with design tensile strength greater than or equal to 950 MPa - Depth D: less than or equal to 10% of minimum wall thickness S; for cylinders with design tensile strength less than 950 MPa
"	"	10.4.2 -7th indention	Tech	Allowable notch width is excessive.	Change "~~Width less than or equal to 2D~~" to "Width is less than or equal to 0.6 mm"

Member body	Clause/ subclause	Paragraph/ Figure/ Table	Type of comment (general/ technical/editorial)	Comment	Proposed change
"	"	10.4.2	Tech	Add 8th indention to include an isolated pit feature.	Insert; Inner flat bottom hole (FBH) with the following dimensions: Depth: less than or equal to 30% minimum wall thickness S for cylinders with design tensile strength less than 950 MPa Depth: less than or equal to 20% minimum wall thickness S for cylinders with design tensile strength greater than or equal to 950 MPa Diameter d: 6mm
"	"	10.4.2 -3rd para after first sentence	Tech	A minimum alarm level must be established.	Insert after the first sentence; "This alarm level shall be set to at least 80% of the screen height."
"	'	"	Tech	To insure dynamic calibration on mechanized systems	Insert new third sentence. "On mechanized systems this step shall be performed dynamically."
"	"	10.4.2 -4th para	Tech	We believe increased sensitivity to the test should be accomplished by reducing the notch size not increasing the gain because a 6db change in gain from one system to the next may have different results.	
"	"	10.4.3 – first sentence	Tech	Clarify the detection size of general corrosion.	After the comma delete~~; an area with a diameter no less than that of the probe~~" and insert "a local thin area (LTA) with a diameter equal to at least two (2) times the transducer diameter"
"	"	10.5.1- first sentence	Tech	See 10.3.2.1 comment	Delete "~~the transitions to the shoulder and~~" insert " the transition"
"	"	10.5.3	Tech / Editorial	Nominal should be normal however this would preclude the use of guided waves therefore a more general statement is proposed.	The cylindrical part must be examined 100% for wall thinning.

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