

Compilation of comments received on the second committee draft ISO/CD 16111
Transportable gas storage devices — Hydrogen absorbed in reversible metal hydride

Date:2006-07-03

Reference Document:
 ISO/CD 16111.2
 ISO/TC 197 doc. N 332

1	2	(3)	4	5	(6)	(7)
MB ¹	Clause No./ Subclause No./ Annex	Paragraph/ Figure/ Table/ Note	Type of comm ent ²	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
FR			ge	France does not approve this project because it does not take into account the pyrophoric nature and the reaction of metal hydrides with water		The approach taken has been to minimize potential exposure to air and water and thus mitigate hazards from the solid material by design and testing. Also this is the approach that has been used by the UN SCETDG with the dangerous goods listing UN 3468
FR			ge	How do we handle multiple hydride storages in parallel : the fire test shall concern to the entire storage set		The standard covers portable systems up to the first shut-off valve. If multiple systems are manifolded together before the first shut-off they must past the design and test criteria. If they are manifolded together after the first shut-off, they are outside the scope of the document.
FR			ge	This standard does not take into account the risk of reaction of metal hydrides with air,water and cooling fluid, although it's the main safety weak point of this storage medium	The standard should deal with compatibility with air, water and cooling fluid. Tests should be proposed to study this aspect	The approach taken has been to minimize potential exposure of the solid to air, water or other fluids by engineering and test requirements, thus mitigating potential hazards. A requirement has been added to the cycle and strain measurement test to utilize any active cooling system, with inadvertent leakage between the canister and cooling system considered to be a failure of that test.
KR	Contents		ed	Unify the capital letter for each word		

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TC58/SC3 US	General			<p>This document includes good information relating to the preparation of a cylinder for hydrogen absorbed in reversible metal hydride but it is lacking fundamental design qualification and lot (batch) requirements for manufacturing of this specific type of cylinder. For example, Sections 6.1 and 6.4 allow for the manufacturer to bypass fire testing and cycling and strain measurement testing for newly designed cylinder. It states that "manufacturers can use data and engineering calculations ... to demonstrate that the new design does not require additional testing." We object to this because we do not have extensive experience with the effect that design changes may have on the cylinder's ability to meet the performance requirements. Testing will provide consistency from manufacturer to manufacturer, since we do not know what calculations and acceptable results each may provide. The addition of a clear definition for "design change" will prevent excessive testing for minor changes to the design.</p> <p>This document should be an ISO Technical report (TR), and not a standard.</p>		<p>The comments concerning the allowed exceptions to performing the fire and cycle/vibration testing is valid. The exception in the fire test of 6.2 has been limited and removed in the cycle and strain measurement test of 6.5.</p>
TC58/SC3 US	General			<p>If the document was considered for TR, the following comments apply:</p> <ol style="list-style-type: none"> 1. Replace "canister" with cylinder in all sections. 		<p>The term "canister" has been specifically chosen and is used to identify these systems as unique systems and to avoid potential confusion with simple cylinders, therefore this suggestion is rejected by the working group. Clarification has been added in the definition section.</p>
KR	2		ed	<p>Unify the same format in Italy stile. ISO 11114-2:2000 – Transportable~</p>	ISO 11114-2:2000 <i>Transportable~</i>	

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KR	2		ed	Unify the same format in Italy stile. ISO 11114-4:2005 – Transportable~	ISO 11114-4:2005 <i>Transportable~</i>	
KR	2		ed	Unify the same format in Italy stile. ISO/TR 15916:2004 – Basic~	ISO/TR 15916:2004 <i>Basic~</i>	
TC58/SC3 JP	2 Normative reference s		ge & te	The transportable gas storage canisters, treated in this ISO/CD, are not simple “gas cylinders” for storage and transportation, but they work as “heat-exchangers” and “reactors” in service gas charging - discharging cycles. They cannot, therefore, be designed or certified by the standards for simple “seamless metallic gas cylinders” such as ISO 7866, ISO 9809-1, ISO 9809-3, nor by the standards for “wrapped fiber reinforced composite cylinders” such as ISO 11119-1, or 11119-2. It is to be noted that the design and certification of the canister is much more complicated than those of simple “gas cylinder”. The conditions of the fabrication (temperature and stresses in sintering of alloy storage material, etc) and the service of the canister (heating and cooling for charging and discharging of gas, etc) should be carefully examined for the certification. Material characteristics should be assured in whole the service temperature range, -40 to 75 °C.	ISO 7866:1999, ISO 9809-1:1999, ISO 9809-3:2000, ISO 11119-1:2002 and ISO 11119-2:2002 shall be delete.	The standards cited were selected by the working group experts as the most appropriate for use with metal hydride systems. The objective of the working group was to use existing cylinder/pressure vessel standards and then insure that the metal hydride systems stay within the service conditions of the cylinder/pressure vessel. The working group does feel that the use of standard “cylinders” are appropriate as long as the service conditions of the metal hydrides remain within the bounds of the cylinders. Therefore the cited standards have not been deleted, however language has been added to ensure that service temperature ranges are considered as well as the strain/stress levels.

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FR	3.1		te	Definition of Maximum Allowable Work Pressure is not given. It should be given as we need this data for the design of pressure relief devices	To add the common definition of Maximum Allowable Working Pressure MAWP	Maximum Allowable Working Pressure is not used in 16111 except as an example of a term used in pressure vessel standards. Further clarifying language was added to the definition section.
TC58/SC3 UK	3.6			Definitions should be standardised with respect to existing ISO documents - please refer to ISO 10286. For example, MDP is normally referred to as MAWP (Maximum Allowable Working Pressure).		Maximum Developed Pressure is unique to this document and metal hydrides, it is NOT the same as for cylinders and pressure vessels.
FR	4.1.4		te	The PRD activation pressure shall be given as a function of the MAWP	The PRD activation pressure shall be function of the MAWP (refer to standards dedicated to design of PRDs like for example API 520)	MAWP is not used in this document due to the very different relationship of gas pressure and temperature with metal hydrides versus compressed gas. Instead it is specified in relation to the more appropriate MDP
TC58/SC3 UK	4.3.2			The temperature range ie plus 60oC is inconsistent with other ISO standards and additional testing and/or special precautions may need to be taken at extreme temperatures.		The range of -40 to +75°C was chosen to be consistent with ranges found in a number of other standards.

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FR	4.5		te	As this standard concerns only transportable canisters, which will be used by public people, how can we make sure that it will not be used beyond service life ?		If refuelling is carried out by trained personnel, then a requirement is to ensure they are within the service life. If "home refuelling" is allowed, then it cannot be guaranteed. This is the same case as with standard cylinders today. The expiration date is required to be marked on the shell (Section 8.1f)
TC58/SC3 JP	5.1 Shell Requirements		ge & te	The transportable gas storage canisters, treated in this ISO/CD, are not simple "gas cylinders" for storage and transportation, but they work as "heat-exchangers" and "reactors" in service gas charging - discharging cycles. They cannot, therefore, be designed or certified by the standards for simple "seamless metallic gas cylinders" such as ISO 7866, ISO 9809-1, ISO 9809-3, nor by the standards for "wrapped fiber reinforced composite cylinders" such as ISO 11119-1, or 11119-2. It is to be noted that the design and certification of the canister is much more complicated than those of simple "gas cylinder". The conditions of the fabrication (temperature and stresses in sintering of alloy storage material, etc) and the service of the canister (heating and cooling for charging and discharging of gas, etc) should be carefully examined for the certification. Material characteristics should be assured in whole the service temperature range, -40 to 75 °C.	The shell should be designed and certified according to standards registered in accordance with ISO 16528 , as applicable , ...	The working group feels that gas "cylinders" are appropriate for use, in fact most commercial systems today use cylinders and not "pressure vessels." The ISO 16528 is a "pressure vessel" registration document and not applicable for gas cylinders. Therefore the cited standards have not been deleted, however language has been added to ensure that service temperature ranges are considered as well as the strain/stress levels.

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TC58/SC3 US	5.1			In section 5.1, several ISO standards are referenced as being appropriate for storage of metal hydrides. This standard offers no basis for selecting a pressurized gas cylinder for use as a metal hydride storage cylinder, and offers no specifics of how the operating conditions may vary, such as the fact that metal hydride storage may induce local stresses. There is also a concern that a particular metal hydride container should be limited to a specific design/application, as another system design may have different specific requirements.		The cited ISO documents were selected by the working group based on their consensus knowledge of hydrogen compatibility and the most appropriate type of cylinders – this selection criteria was not explicitly explained in the document. The manufacturer is charged with placing the allowable service condition limits on the system and ensuring that the system is appropriate over that range. The document includes performance-based type tests to ensure safety over the range of operating conditions.
TC58/SC3 UK	5.5			Where did 0.125 litres come from? Stored energy should be taken into consideration, not just the water capacity.		This volume was selected to be consistent with the IEC Micro Fuel Cell standard (IEC 62282-6-1), other related activities and established regulatory precedence. Note volume changed to 0,12 l. For compressed gas regulations, a volume limit is normal versus a contained energy limit.
TC58/SC3 UK	5.5			Need consistency - PRV and PRD - these also need to be in the definitions.		Definitions added to section 3.

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FR	6.1.1.2		te	is there any effect on tests results if canister has been cycled before ?	eventually include number if cycles in canister tests in the list of information to be collected for the test	The fire test is designed to test the ability of the PRD to relieve gas pressure and prevent rupture. It is critical that the material be fully "activated" and store its expected maximum capacity. There may be credence to the argument that extensively cycled canisters should be tested to ensure that decrepitated powders will not reduce the flow through PRDs and therefore effect their performance. For this reason, the working group has added an additional acceptance criteria to the cycle and strain measurement test that at least one canister from each orientation tested must also pass the fire test.
FR	6.1.1.3	1 st §	te	For portable equipment, it's not possible to accept only a single position of the canister. We should consider all orientations likely to occur during the use and transport of the canister	To remove the second sentence of the paragraph considering only a single orientation for tests	Particularly for larger systems, they may be mounted such that only one orientation is possible (such as with a tube trailer) and therefore only one orientation is required. Sentence deleted to remove redundancy.

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FR	6.1.1.3	2 nd §	te	Where the maximum length of 1,65 m originates from ? is it relevant for transportable storage		It is consistent with a number of other standards. It is apparently related to the standard maximum length for common industrial gas cylinders.
US	6.1.3		Te	<p>The indirect flame impingement temperature seems very low (590°C). A commonly used value is 800°C. Although there have been discussions about the 800°C not being conservative, it has a regulatory basis.</p> <p>This comment was rejected based in the prior cycle. The justification was many cylinder and pressure vessel standards have fire test temperature requirements in the 590 to 650°C range. It is expected that these temperatures include inherent assumptions about the cylinder contents and the heat transfer through the vessel wall.</p> <p>Maximum time averaged flame temperatures in pool fires are reported in the range of 770 to 1200°C (SFPE handbook, 3rd ed, pp 3-290). The temperature of the exterior of the vessel will be dependent on how well energy is transferred from the outer surface to the interior. For steel tanks that are liquid filled the inner wall temperature will approach the boiling temperature of the contents. The wall temperature will likely be somewhere between this boiling temperature and the flame temperature. (If water at one atmosphere this would be between 100 and 1000°C. The mid point would be 550 °C which is close to the 590°C value.)</p> <p>For composite cylinders heat transfer through the outer wall is expected to be poor, as compared to steel. Thus, the outer wall temperature could be much higher. In addition, getting good heat transfer in metal hydride designs has been a challenge. It is expected that heat transfer from the exterior of the cylinder to the metal</p>	Change the temperature of 590°C to 800°C.	<p>Deleted the indirect flame impingement test option. No temperature specified in direct flame test.</p> <p>From experience significant pressure rises in metal hydrides have been observed in fire tests that do meet the requirements of the test procedures in the document.</p>

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				hydride might also be poor. This would further increase the expected exterior temperature when exposed to flame. It is recommended that the technical basis for any cited temperature below 800°C be reviewed for applicability. The other approach is to subject a few limited cylinder types to direct flame impingement tests and empirically establish necessary surface temperature to be used for non-flame impingement tests. It is expected that different temperatures will need to be used for different cylinder materials of construction (e.g., steel vs. composite).		
TC58/SC3 UK	6.1.3			Query 590 oC and whether you need the final sentence.		Deleted section
FR	6.1.4			How do we take into account the fact that hydride may be expelled when the valve opens or when the canister ruptures (without any noticeable overpressure effect) ?		6.1.4 is the acceptance criteria for the fire test. If solid material is expelled from the canister into the fire, it was not considered by the working group to be a safety issue as long as there is no rupture of the canister since it would be only adding fuel to an existing fire as would be hydrogen gas. Criteria added to prevent "projectiles."
AT	6.2.3		ed	... 45° angle ... (no space)		
FR	6.2.3	a)	ed	"On the on the end opposite" ... repetition	To delete "on the"	
AT	6.2.4		ed	Delete "Section". There seems to be a misunderstanding: if we claim "delete", we mean the word and not the subclause, since reference shall be made to clause 8, but to 8.7 (with neither "clause" nor "section").		

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TC58/SC3 UK	6.2.4			Assuming the drop test is to demonstrate ongoing integrity, we recommend a fatigue test is carried out after the drop test. General comment - the drop test need to be standardised with other ISO standards.		The drop test tests for integrity by requiring each canister to be visual inspected, leak tested and burst tested with a minimum of 85% of original burst pressure. Metal hydride systems are unique therefore the drop test does not need to be standardized with other non-metal hydride drop tests.
KR	6.3.2		ed	101.325	101,325	
TC58/SC3 US	6.4			In section 6.4 include the requirements of measuring strain and plotting strain-stress curve before filling the cylinder with hydrogen, after it is fully charged and upon completion of the cycling test.		While potentially generating useful information, the data generated is not used in the acceptance criteria and would therefore require additional work without changing test outcome.
TC58/SC3 UK	6.4.1			Gauges is spelt incorrectly throughout - it is spelt 'gages'. General comment - the editing is not appropriate to ISO rules.		"gages" changed to "gauges"
AT	6.4.2	1 st para 3 rd para: 1 st indent 2 nd indent	ed	5 % (space) <i>g_n</i> (italics) 0,8 mm Decimal commas, ±		

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TC58/SC3 UK	6.4.2			Test procedures - should be 1 centimetre cubed per hour per litre water capacity ISO/DIS 15869		ISO/DIS 15869 is a standard for road vehicle hydrogen tanks, including composite tanks. The rate in that document is probably a measurement of permeability which is surface area dependent. In 16111, the rate is a leakage rate from a valve and independent of system size. The concern is hydrogen leakage into the surroundings regardless of system size. Rate took into account creation of a flammable air/hydrogen mixture in a realistic storage/use environment.
TC58/SC3 UK	6.4.2			Helium leak test 1 x 10 (to -6) millibar litres per second		The test in 6.3 allows for helium, hydrogen or a blend of the two and the leak rate is consistent with other documents.
AT	6.4.3		ed	50 % (3 times)		
TC58/SC3 US	6.4.3			In section 6.4.3 include a design confirmation prototype physical test (e.g. tensile test) to confirm the calculation.		Requirement added to carry out a fire test post cycle/strain measurement test.
AT	6.5		ed	Delete "section"		
AT	6.5.2	1 st para 2 nd para table 1	ed	... 4 h at ... Delete "section" (also onwards). ... scch ... in SI units? V in italics		

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FR	6.5.2	2 nd §	te	The unit for leakage rate shall be the same as it used in 6.3.2	Use the unit cm ³ /h instead of scch	
KR	6.5.2	2	ed	What is the "1 scch" in last sentence?		
TC58/SC3 UK	6.5.2			last sentence - what is 'scch'?		
FR	7	1 st §		Routine tests should be performed during the service life of the canister, which is considered to be 20 years in 4.5	The manufacturer shall [...]for not less than 20 years.	Record maintenance requirements changed to the longer of a minimum of 10 years or 1.5 times service life.
TC58/SC3 UK	7			10 years is not consistent with existing practice		Record maintenance requirements changed to the longer of a minimum of 10 years or 1.5 times service life.
TC58/SC3 UK	9			SC4 should also review this document		
TC58/SC3 US	9			In section 9, delete the option of hydrostatic testing for the requalification. We already know that a hydro test is not an appropriate test method. Consider the use of UE as described in ISO 6406 and 10461 combined with strain measurement testing at the time of periodic inspection and testing.		Section 9 warns against the use of hydrostatic testing however that option was not eliminated in case some manufacturer develops a material and system which can be hydrostatically tested. UE methods are given as an example of an alternative method.
AT	10.1		ed	1 MPa in the same line		

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FR	10.3.1			It's useful to consider MSDS and risks associated with hydrides in general but we need also to consider compatibility with air, water, cooling fluid, since this is a foreseeable degraded mode : information should be given to know if the storage will be held safely for all these situations.		The document does require that the MSDS cover the hazards related to exposure of the solid. The working group revised the text to more explicitly call out the hazards related to the solid being exposed to air, water or other fluids.
AT	A.2	10 th para	ed	... 250 °C ... (space)		