Results of the circulation of the first committee draft ISO/CD 16111 *Transportable gas storage devices — Hydrogen absorbed in reversible metal hydride*

	ISO/TC 197 doc. **N 332 Annex 1**
Date:2005-12-20	Reference: ISO/TC 197 doc. **N 304** and **N 308**

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MB[1]	**Clause No./ Subclause No./ Annex** (e.g. 3.1)	**Paragraph/ Figure/ Table/ Note** (e.g. Table 1)	**Type of comment**[2]	Comment (justification for change) by the MB	Proposed change by the MB	**Secretariat observations** on each comment submitted
CH			ge	We abstain.		
NL			ge	On document N 304 ISO/CD 16111 Transportable gas storage devices * Hydrogen absorbed in reversible metal hydride, the Netherlands vote positive without comments.		
SE			ge	We abstain.		
IT			ge	The thermal conductivity of the hydride bed material and between the hydride bed and the conditioning fluid is fundamental in the determination of good reaction kinetics. The CD does not take into account this important parameter: in particular, it does not indicates qualification tests for the evaluation of this parameter. We recommend to consider this point in the CD		16111 is a safety standard and not a performance standard. The effectiveness of the thermal conductivity is a performance issue and not a safety issue, therefore it was not addressed.
IT			ge	The CD does not give any indications concerning the apparatus for the thermal conditioning of the metal hydride reactor. No indications are given of qualification tests for the evaluation of the performance of these apparatus. We recommend to consider this point in the CD		16111 is a safety standard and not a performance standard. Thermal conditioning is a matter of the hydrogen-absorbing alloy and practices of the manufacturer and is related to performance not safety, therefore it was not addressed.
KR			te	Most of pressure vessels are required at least 1,5 times hydrostatic test pressure by ASME Code or other regulations.	The hydrostatic test pressure for the shell shall be greater than 1,5 times of the design pressure.	Section modified per later comment, statement removed.

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US	1.	2nd para.	te	This clause permits the use of alternate designs and requires "These alternatives shall be evaluated as to their ability to yield levels of safety and performance equivalent to those prescribed by this standard." Yet there is not guide as to how a user of the standard might demonstrate equivalent safety and performance.	Either (1) say the standard does not prohibit the use of alternate designs and delete the requirement that they be equivalent, or (2) add guidance on how the user is to demonstrate equivalence. (2) is preferred.	Accepted – Draft modified to require qualification testing of alternative design.
AT	2		ed	ISO 11119-1 title? MPa?		Accepted
AT	2		ed	Add the following references to section 2: ISO/DIS 11114-4 (cited in A.2 / p.17) ISO/PDTR 15916 (cited in 5.2.2 / p.5) ISO 16111-RCP (cited in 10.1 / p.14)		Accepted – except "ISO 16111-RCP" is a cylinder marking indicating compliance with this document – therefore not added to list.
AT	3		ed	Definitions in definition form, no articles, no full stop at the end		Accepted
AT	3		te	PRD is not defined	Pressure Relief Device (PRD) device which prevents a pre determined pressure from being exceeded (e.g. MAWP of a component) by releasing the pressure.	Modified Accepted: "Pressure Relief Devices (PRD) written out on first use. Normal definition is used therefore definition not required.
AT	3.2		ed	Simpler wording, more clearly stated requirement.	canister single complete hydrogen storage system, including shell, metal hydride, safety devices, shut-off valve and other components (e.g. for heat exchange, to prevent excessive stress on the shell walls due to hydride expansion)	Accepted
AT	3.3		te	In order to be compatible with ISO/DIS 13985.3, use the term "Maximum Allowable Working Pressure (MAWP)" instead of "design pressure" in this document. MAWP is mentioned in 5.1 / p.4	Maximum Allowable Working Pressure (MAWP) maximum pressure to which a component is designed to be subjected to and which is the basis for determining the strength of the component under consideration	The term MAWP is not used in all allowed reference standards and MAWP is not same as "design pressure (stress)," therefore suggested change not made.

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US	3.3		te	Treating the stress caused by expansion of the metal hydride material the same way as the stress caused by pressure will result in cylinders much heavier than they need to be when designed in accordance with some of the referenced standards. Allowing these loads to be considered separately according to the referenced standards is a preferred approach. One way to accomplish this is to use a different term in place of “design pressure”.	3.3 design ~~pressure~~ stress the sum of the stresses on the shell wall caused by hydrogen gas at maximum developed pressure, the metal hydride material at rated capacity, and other mechanical loadings,	Accepted
CA	4. Service Conditions	Item 4.6, Gas Purity and Quality, page 4	te	Rational for change: - ISO/TC 197 WG12 has developed Technical Corrigendum 2 to ISO 14687 to exclude PEM FC for road vehicles from the its scope; - As per ISO/TC 197 mandate WG12 is developing ISO/TS 14687-2 to address PEM FC for road vehicles; - US TAG for ISO/TC 197 has the intention to prepare a NWIP proposal to remove all fuel cell applications from ISO 14687 Standard; - CAC/ISO/TC 197 and US TAG for ISO/TC 197 are planning to discuss a NWIP to address PEM FC for stationary applications; - As a result of these actions, more Technical Corrigendums to ISO 14687 and Technical Specs will be developed in the near future.	Recommendation is to edit item 4.6 under Service Conditions on page 4 as follows: - Change the title to Hydrogen Quality - Modify text as follows: The recommended quality of the hydrogen gas that is used to fill a canister shall be specified by the manufacturer, such as per ISO 14687: 1999 "Hydrogen Fuel – Product Specification" and its Technical Corrigendums, and ISO 14687 Technical Specifications for fuel cell applications as applicable.	Accepted
AT	4.1.2		ed	Delete last sentence		Modified Accepted: “At a minimum” deleted, rest of sentence left.

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US	4.1.2			Change wording to separate consideration of the pressure and mechanical loads. Editorially delete “at a minimum”.	4.1.2 Rated Charging Pressure (RCP) The RCP shall be stipulated to aid in preventing charging excessive amount of hydrogen such that the maximum shell pressure (as determined by the design standard) or the design mechanical loads might be exceeded. ~~At a minimum t~~The RCP shall be given in units of MPa.	Modified Accepted – Wording simplified, intent accepted. Deleted “design mechanical loads” since it is covered by the design stress.
US	4.1.3		te	Revise to be consistent with clause 3.3.	Change to read: 4.1.3 Design ~~Pressure~~Stress The design ~~pressure~~ stress shall be determined from the alloy packing and expansion properties and the maximum developed pressure within the canister and other mechanical loadings.	Accepted
AT	4.2		ed	… litres …		Simplified according to 2nd AT comment on paragraph
US	4.2		ed	Clarification	Change to read: The manufacturer shall state the rated capacity of the canister. The rated capacity shall be stated by either mass (kg) or by volume (liters) (at standard conditions) (Note: standard conditions = 0℃, and seal level atmospheric pressure).	Simplified according to 2nd AT comment on paragraph
AT	4.2.		te	The related capacity shall be stated only by mass (kg). To state the capacity by volume (in litres) requires the values of temperature and pressure.	Related Capacity The manufacturer shall state the rated capacity of the container by mass (kg).	Modified Accepted – mass only, SI units not just kgs.
AT	4.3.2		ed	-40_℃ to + 75_℃, also in following t exts		Accepted

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AT	4.3.2		te	In order to compatible with ISO/DIS 13985.3, use the term “Ambient Temperature” instead of “Service Temperature Range“ in this document. For compatibility the maximum temperature should be increased from 70 ℃ to 85 ℃.	Ambient temperature The fuel tank shall be designed to withstand ambient temperatures ranging from –40 ℃ to 85 ℃.	Service temperature (which includes operating temperature) is not necessarily equal to ambient temperature, also ISO 13985.3 is a standard for liquid H2 land vehicular tanks and compliance with it is not required, therefore suggested change not made.
US	4.3.2		te	Specify the relationship between the operating temperature range and the service temperature range.	Change to read: The minimum and maximum temperature stipulated for the product during any normal service condition. This range shall include –40℃ to +75℃ and the operating temperature range.	Accepted
US	4.3.3		te	Specify requirements for the PRD activation temperature.	The temperature at which any thermally-actuated PRD is set to activate shall be greater than the maximum service temperature and shall be stipulated.	Accepted
US	4.4		te	Existing wording requires additional testing even for mundane environmental conditions.	Change to read: Canisters are expected to be exposed to a number of environmental conditions over their useful lifetimes, such as vibration and shock, varying humidity levels and corrosive environments. If a canister is to be used in service where specific environmental conditions are ~~known~~ beyond those accounted for in the required tests, then additional testing shall be performed to verify performance under those environmental conditions.	Accepted

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AT	5.1		ed	Define “MAWP”	(see proposal 3.3 in this document)	MAWP is not used in this document other than as an example term from another referenced standard, therefore a definition is not required.
KR	5.1		ed	maximum allowed operational pressure or MAWP - it is better to use one of them	maximum allowable working pressure for the shell	The design pressure (stress) is not equal to MAWP
US	5.1		te	This clause requires that the stresses due to pressure and those due to mechanical loads be combined. While this is an acceptable approach, a more sophisticated approach as permitted by the referenced standards could result is a lighter cylinder.	Change 2nd para. to read: One acceptable approach to design is using the design stress of the shell to determine the minimum shell wall thickness and the hydrostatic test pressure in accordance with the rules of the design standard.	Accepted, text modified to reflect intent of comment.
US	5.1 and elsewhere		ed	The statement asserts that the authority having jurisdiction is competent, which may not be the case.	Delete “competent”.	Accepted
US	5.2		te	Not all of the referenced standards for the shell have “safety factors” stipulated, nor are safety factors applicable to some of the components such as the PRD.	Change to read: Canister components should be made of materials that are suitable for the service life with the range of conditions expected during normal service. Components which are in contact with gaseous hydrogen and metal hydride material shall be sufficiently resistant to their chemical and physical action at ~~operating and~~ service conditions to maintain ~~recommended safety factors~~ operational and pressure containment integrity.	Accepted
US	5.2		Te	Not enough detail concerning the compatibility of elastomeric and polymeric parts with hydrogen.	The working group should review the work of other hydrogen committees to coordinate and harmonize test procedures for non-metallic components in the hydrogen gas stream.	Accepted, but currently there is no suitable standards to reference. A potential for further investigation.

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US	5.2.1		te	The statement requires that canister components be designed for conditions not anticipated…clearly impossible to comply with.	Change to read: Canister shells, valves, PRDs and other components shall be subjected to an environmental exposure or corrosion test as required by their individual qualification requirements. ~~When the canister is to be exposed to atmospheres or conditions not anticipated in the component design, such as extended duration within heat exchange fluid baths, either exterior protection shall be applied or the canister subjected to an exposure or corrosion test to verify satisfactory service~~ Resistance to these environmental conditions may be provided by using materials inherently resistant to the environment or by applying resistant coatings to the components…	Accepted
AT	5.2.3		ed	Delete "section"		Disagree with the deletion of this section, section modified as per 35
US	5.2.3		ed	This clause does not belong under “materials”.	Renumber and re-title the heading to: 5.~~2.~~3 Design strength ~~(mechanical properties)~~	Accepted
US	5.2.3		te	Change the wording to allow separate consideration of pressure and mechanical loads.	Change to read: ~~Design pressure for the~~ The shell design shall account for the total stress loadings, including: □ the Maximum Developed Pressure; □ thermal stress, including dissimilar rates of thermal expansion and contraction; □ weight of internals in any possible canister orientation; □ shock and vibration loading; □ stress due to material expansion; □ other mechanical loadings.	Accepted

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US	5.2.4 (NEW)			There are not enough detailed requirements covering the process of installation of the hydrogen-absorbing alloy into the canister	Propose new 5.2.4 Installation and settling process for the hydrogen-absorbing alloy into the canister shell shall be well defined and documented. Quality Control and Assurance Procedures shall be in place to ensure the consistent application of the material into the canister. Any change in material, manufacturing process, or installation procedure shall require repeating the hydrogen cycling and vibration test, Fire Test and Drop Test	Modified Accepted
US	5.3		ed	Put this clause where it belongs.	Renumber to 5.2.3.	Accepted
US	5.4		te	The second sentence sates a requirement that the user of the standard would have a difficult time understanding what to do to meet. Suggest deleting, or provided a better explanation in clause 6.1.	Delete: ~~The canister and any added insulation or protective material shall be designed collectively to ensure adequate safety during fire conditions in the test specified in 6.1.~~	Modified Accepted
US	5.5		ed	Clause is redundant with 5.6 and 6.2	Delete.	Accepted

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US	5.6		Te	Shutoff valves on the canister should comply with international standards	The working group should consider requiring that the shutoff valve comply with international standards such as ISO 14246 and/or ISO15500, Part 5.	Modified Accepted ~~–~~ Drafted modified to require conformance with an applicable standard, however ISO 15500 not accepted since its scope is for CNG vehicular systems and not appropriate for this standards scope. ISO 14246 not accepted since it is only applicable to industrial gas cylinder valves operated by a handwheel or key. These canisters will be used in consumer applications and may use quick-connect type valves.
US	6 Type Tests		ge	Type Tests constitute tests on a 'proof" copy of a product rather than a production copy. Tests should be conducted on production copies.	There should be a process where by canisters are randomly taken off the production line and tested in the manner described in the standard. Failure results in more frequent testing and too many failures result in redesign. The criteria for each should be determined by the WG experts.	Accepted - Added "Qualification" to section title.
US	6.1.1.2		ed	Simplify the wording.	Change to read: The data for all tests conducted are to be acquired using calibrated instruments. Temperature and pressure ~~readings~~ of the canister shall be monitored remotely and recorded at intervals of every 15 seconds or less. ~~A pressure indicating gauge or other suitable device shall be connected to the valve outlet to permit remote monitoring and recording of attained pressure levels within the canister.~~ A manual valve shall be installed ~~in the pressure monitoring system~~ to allow venting of the canister in the event of a test equipment or system malfunction.	Accepted

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US	6.1.1.2		te	Require that the temperature a pressure also be recorded.	Change to read: ~~As a minimum~~ In addition to the pressure and temperature readings, the following information shall also be recorded for each test:	Accepted
US	6.1.1.3	4th para.	te	The arrangement of fire temperature measuring thermocouples described here could result in none of the thermocouples being exposed to the fire.	Require that the thermocouples be exposed to the fire.	Disagree, fire source is to be 1,65 m in length, thermocouples are required at each end of canisters longer than 0,30 m, fire source is to be located at opposite end of canisters longer than 1,65 m, therefore at least one thermocouple is exposed to fire.
US	6.1.1.4	End of third sentence	TE		Change to vented to zero gauge pressure.	Language changed so venting not included.
AT	6.1.2		ed	at least 20 min_		Unsure as to what is meant here.
US	6.1.2		TE	Fires involving stacked storage material are not very reproducible unless the arrangement is explicitly defined. The present requirement does not accomplish this. Most fire tests are conducted using pool fires because they are easy to control and very reproducible.	Change the fire specification to limit the test fire to flammable liquid pools or gas burners.	Modified accepted – Wood fires should be allowed however eliminated paragraph that emphasized wood fire.
AT	6.1.3		ed	600_℃		Accepted
AT	6.1.3		te	In order to be compatible with ISO/DIS 13985.3 the temperature shall be at least 590 ℃ instead of 600 ℃.		Accepted – however compliance with ISO 13985.3 is not required since it is for Liquid H2 vehicle tanks and outside of the scope of this document.

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US	6.1.3		TE	The minimum indirect flame test requirement temperature of 600C is very low compared with the expected surface temperature for a flame test. A US test requirement uses a temperature of 800 C as the criteria to represent a fire immersion test (10 CFR 70, Type B Shipping Container).	Change the minimum required temperature to at least 800 C. Require this temperature at all temperature measurements.	Disagree, many cylinder and pressure vessel standards have fire test temperature requirements in the 590 to 650 ℃ range.
JP	6.1.4	Para.1	te	The acceptance criteria require the safety device to function to vent the initial pressure to zero gauge pressure and the canisters to withstand the fire for a minimum of 20 minutes and to remain intact. However, in the case of small canisters, for example, those for micro fuel cells, the amount of metal hydride is so small that the heat absorbed in the hydride due to the release of hydrogen gas is relatively little. Wall thickness of the shell is also relatively small in these canisters. Therefore, temperature of the canister can increase at a relatively high rate, and it is possible that the canister becomes open within 20 minutes because of partial melting. If the objective of fire testing is to demonstrate that the fire protection system will prevent the rupture of the canister under the specified fire conditions, as stated in the first paragraph of Clause 6.1, such static failure of the canister due to partial melting can be accepted as far as the PRD has functioned and the internal pressure has been reduced to zero gauge pressure. Therefore, the acceptance criteria should be described in a less restrictive expression,	For example, “the canister is not ruptured” instead of “the canister remains intact.”	Modified Accepted - Both venting to zero gauge pressure and remaining in fire for 20 min is not required, only one of the two conditions is required. Language modified to clarify this fact.
AT	6.2.2		ed	weight mass ±_2		Accepted

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US	6.2.3		TE	The test requirement for a drop of 1.8 m (6 feet) makes sense for large containers. For smaller containers storage at higher elevations is possible. A common storage limit is 3.7 m (12 feet).	Change the test drop height for smaller containers (i.e., containers weighing less than 11 kg [25 pounds) shall be drop tested from a height of 3.7 m.	Not accepted – 1.8 m is a common height for cylinders and transportation requirements for packing group 1 materials. When stored at higher heights, canisters are expected to be within outer protective packaging.
AT	6.2.4		ed	85_%, also in following clauses Title of figure 1 bold, no full stop		Accepted
AT	6.2.4		te	Prior to a leak test the canisters shall be visual inspected	All canisters that have undergone the drop impact tests shall be visual inspected, subjected to a leak test (section 6.3) and then hydrostatically pressurized to destruction. …	Accepted
AT	6.3.2		ed	std.ml not SI conform	1 ml/h in standard conditions?	Accepted – changed units to cm^3/h and stated standard conditions, increase acceptable limit to 10 cm^3/h which will not pose a safety hazard

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US	6.4.1	4th para.	te	Text changed to be consistent with use of “design stress” versus “design pressure”	The strain at ~~shell~~ design ~~pressure~~ stress shall be determined either by engineering calculations based on the shell design and material properties or empirically by internally applying either a pneumatic or hydrostatic pressure up to ~~at least equal to the shell design~~an equivalent gas pressure and measuring the strain. For any shell where the strain gages are applied to an outer layer and not directly to the shell or liner in contact with the metal hydride and hydrogen gas (such as type II, III and IV fiber-wrapped composite tanks) or for any shell that has been intentionally subjected to plastic deformation (i.e. autofrettage), the strain at design pressure for each gage shall be determined empirically prior to cycling the canisters with hydrogen. All strain gages shall be calibrated and the calibration periodically checked during testing.	Accepted
US	6.4.2	1st para., last sentence	ed	Change wording to reflect change in 3.3	If the measured strain on consecutive cycles exceeds that at design ~~pressure~~ stress or plastic deformation of the shell material occurs, the testing shall be discontinued.	Accepted
US	6.4.2	Para. 3	te	These devices are likely to be used to power portable equipment such as portable generators or UPS systems. The vibration tests should reflect the likely use of the canisters and be similar to those for portable generators and UPS systems. These tests seem similar to those for microelectronic applications. These canisters are not going to be used for that purpose.	Make vibration tests compatible with the equipment which it is most likely to be mated.	Modified accepted: these canisters will be used in microfuel cell applications and may transported aboard aircraft. A second vibrational sequence was included as an option for canisters that are too large to allowed aboard aircraft.

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US	6.4.3	throuohout	ed	Change wording to reflect change in 3.3	6.4.3 Acceptable Results (change "design pressure" to "design stress" in 4 places in this section)	Accepted
AT	6.5.2		ed	@ → at, 5 min Table 1 – Ball …, …litres		Accepted
AT	6.5.2		te	In order to be compatible with ISO/DIS 13985.3 the conditioning time shall be reduced from 4 to 3 hours.	… Each sample and the impact ball shall be conditioned for at least 3 hrs @ -40 ℃ …	Time requirement not changed, compliance with ISO 13985.3, a liquid H2 vehicle tank standard is not required~~.~~, also 4 hours is consistent with other standards.
AT	6.5.2	Table 1	ed	The word "water" used before "volume" is unnecessary and confusing.		Accepted
AT	6.5.2	Table 1	ed	Food-pounds is not a SI unit and should be removed		Accepted
US	8.2		ed	The AHJ may be local.	Change to Read: The initial fill and refill equipment shall be designed and constructed to meet the requirements of the ~~regional and national competent~~ authorities having jurisdiction.	Accepted
US	8.3.1		te, ed	Instructions for inspection must be provided for both the initial fill and refilling operations. Correct wording.	Change to read: Manufacturer shall specify ~~an~~ inspection procedures to be carried out prior to initial filling ~~or~~ and prior to refilling of the canister. ~~As a minimum, I~~ Items to be inspected shall include whether the canister is within service date, labels are legible and secure, damaged or missing components in the interface, and damage to the shell or valve, evidence of tampering or abuse~~, etc~~. Criteria shall be provided as to when refilling is allowed or when canisters shall be removed from service.	Accepted
US	8.3.2		ed		Delete redundant words "as a minimum".	Accepted

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US	8.3.3		te	Instructions for inspection must be provided for both the initial fill and refilling operations. Correct wording.	Manufacturer shall specify an inspection procedure to be carried out after the initial filling ~~or~~ and after refilling of the canister. ~~As a minimum, I~~tems to be inspected shall include leakage of hydrogen from the canister and damaged or missing components in the interface (e.g. damage to threads, damaged o-rings or seals).	Accepted
AR	9		Ed	In the first paragraph of the Requalification procedures, the expression: "The canister is permitted to be requalified in accordance the requirements of the code or standard ..." could be rewritten.	It's suggested to change the expression "in accordance" by "in accordance with".	Accepted
US	10.1		GE	The marking nomenclature states that the number shall include the pressure rating in units of MPa. If the design is “low” pressure (i.e, < 1 MPa) how should labelling be done?	Either the minimum rating should be specified as 1 MPa or higher, or a note should be provided on how to address this topic.	Allowed RCP to be marked with up to 2 decimal places if less than 1 MPa.
US	10.2		ed		Delete redundant words “as a minimum”.	Accepted
US	10.3		ed		Delete redundant words “as a minimum”.	Accepted
AT	10.3.1		ed	Change the title to “Material Safety Data Sheet (MSDS)”		Accepted
US	10.3.1		ed	Clarify MSDS required for both H2 and metal hydride.	Change to read: Material Safety Data Sheets shall be provided for both the hydrogen and the metal hydride for inclusion with all product shipments. The MSDS shall include ~~at a minimum,~~ safety and handling requirements to be followed in case of hydrogen leakage and~~/or~~ breach of the storage system, exposing the solid material.	Accepted

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AR	A.2		Te	Under the Subclause entitled "Metals and metallic materials", in the beginning of the eighth paragraph it's written that: "At temperatures above 473 ºC, many low-alloyed structural steels may suffer from hydrogen attack..." However, most of the low-alloyed structural steels may really commence to suffer from hydrogen attack at lower temperatures. That is to say at temperatures above 200 ºC or 220 ºC. Therefore, the lower temperature limit should be corrected considering the previous fact.	Rewrite the sentence as follows: "At temperatures above 200 ºC, many low-alloyed structural steels may suffer from hydrogen attack..."	Accepted
US	A.3		Te	ISO/PDTR 15916 and the NASA document do not provide test procedures and do not give sufficient information about the suitability of non-metallic materials. Further reference to ANSI/AGA 3.1-1995 is not appropriate because it refers to testing in compressor oils which is not appropriate for this application.	Remove reference to ANSI/AGA 3.1-1995. Add reference to ISO 11114-2.	Accepted
AT	A.4.5		ed	Delete dot		Accepted
AR	A.4.7		Te	The Technical Report ISO PDTR 15916 "Basic considerations for the safety of hydrogen systems" was officially published as ISO/TR 15916:2004 on February 15, 2004. Therefore, the cited reference, which corresponds to a draft document, should be corrected.	Change the Reference Number "ISO PDTR 15916" by "ISO/TR 15916: 2004" and the date 09-May-2002 by the correct one:15-Feb-2004.	Accepted
AT	A.4.8		ed	not European Standards	Standards from European Standards Organisations	Accepted