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**Hydrogen and Fuel Cell Vehicle GTR: 1st Meeting of the Sub-Group Safety
Bonn, Germany
September 20-21, 2007**

Welcome and Introductions:

1st meeting after the action plan was adopted.

Target completion date: 2010

Attendee list distributed.

Representatives from:

Germany, Japan, USA, India, France, Canada, Korea, Netherlands, Italy, Hungary, China, Spain, Sweden, UK
OICA, ISO and SAE

Organizational Issues:

Chairmanship: Mr. Narusawa (Japan) was elected Chairman of the subgroup Safety.

Co-chair and Secretary: US (Nha)

Weblink to page will be set up on the UNECE – WP29/GRSP

Update on Research and Rulemaking Activities:**Japan**

Japan established regulations for hydrogen fuel cell vehicles March 2005. Fuel cell bus technology was the next focus; have performed many tests to check the current regulation; Planned to revise the regulation for safety, but no change was made. Japan will give a detailed presentation on its regulation later.

European Commission

EC gave a presentation on its activity on establishing regulation type approval of hydrogen vehicles. Common requirements in all 27 member states; applicable to components and systems; drivers for this proposal: internal markets can function; support deployment of hydrogen technology; safety and environment.

Background: EIHP project – 2 draft proposals (LH2 and CH2). Split level approach will be used: regulation of the European Parliament (political part); Commission Regulation (technical part) which is easier than the political part. Containers and other components included in the hydrogen system. Hydrogen Working Group met 5 times since March 2006, all meeting docs are available online. The co-decision proposal is on the agenda for 10 October 2007. EC expects to have it adopted in one year.

Question: is this then a Directive, and how long is it to be in effect? It will be a regulation (directly applicable to all member states). It will be in effect until it is replaced by other regulation(s). With the two steps (1) legislative background (2) technical regulation – means that

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updating technical part will be easier. This is not a staged approach – the parts are performed in parallel.

US

NHTSA has started a four-year research program on hydrogen fuel cell vehicles: (1) electrical isolation; (2) FMEA for compressed HFCVs; (3) evaluation and comparative analysis of existing and draft regulations and standards; and (4) compressed hydrogen fuel container integrity testing.

- (1) Performed by Battelle, used low-pres hydrogen and hydrogen/helium mixes (safety concerns in using high-pressure hydrogen); draft should be on website soon (2 months)
- (2) Database established and will be updated frequently as required. It is in MS Access, but is not externally available yet – need to check the validity of the information.
- (3) FMVSS 304 type testing (bonfire, gunfire, etc)

NHTSA will issue a task-order contract to conduct system-level safety assessments on representative fuel systems, vehicles and to assess post crash fuel leakage and fire safety

Question: time frame for approval of FMVSS? Goal is to adopt the GTR – so there will be no internal rulemaking for hydrogen vehicles.

Question: what is the website for docket? The DOT system is changing, and the docket number will be changing; will keep the group informed with the new docket number.

Question: SAE and ISO efforts in developing standards – what happens with them? In the action plan, we will use the Japanese regulation as the basis, and we will consider all other standards (SAE, ISO, etc).

Korea

Korea gave a presentation on their research plans for HFCV rule-making process. Two stage approach; 2007-2010, \$50M. Work in safety, rulemaking, policy and harmonization; hydrogen safety; full vehicle safety; and electric safety. Comparative tables for Japan, EU, US, and Korea for gasoline, electric, hydrogen vehicles (additions to the tables generated in the HFVC GTR proposal).

Question: aim is to develop regulation based on the 5-year research program – how does this work together with the GTR development? Korea will introduce GTR to Korea regulation.

SAE

Phil Horton (GM) gave a presentation on current SAE activities on hydrogen vehicle safety. Cycling tests will use gas, rather than hydraulic fluids as is done with other testing (will see J-T temperature swings that are not seen in hydraulic tests). TIR SAE J2579 ready for balloting by the end of the year. SAE would like the HFCV subgroup Safety to consider this work in the development of the GTR. J2579 will be revised based on research to be conducted in 2007-2009.

Comment: J2579 approach to be considered – we will come back to in later in the Phase 1 of the GTR development (have to considered other standards rather than just the Japanese regulation)

ISO – ISO will present the full range of standards at the next meeting.

Presentation and Discussion of the GTR Action Plan:

Based on ECE/TRANS/WP.29/2007/41: Document has been slightly modified (correction to a table footnote) and published as AC/17 as posted on the UNECE website.

The action plan consists of phase 1 and phase 2. Phase 1 will establish a GTR by 2010; the Japanese regulation will be used as the basis for the GTR. In Phase 2, amend that GTR to update based on the then-current technology, and possible harmonization of whole vehicle crash testing.

Update on SGE (SubGroup Environment) – Mr. Adolfo (EC) chairs the SGE: The group will develop requirements for fuel and electrical consumption, emissions of hydrogen and water. SGE has not met for more than one year. SGE will reconvene to update the previous work. Propose to meet during the GRPE meeting in Geneva in January.

Comments on Action Plan:

- Detailed plan.
- Process and timeline: ambitious – by fixing a tight timeline, we may not be fully done and then have to rely on political decisions, rather than technical decisions. Have seen this in other GTRs, where votes are taken to compromise to meet the deadline. Good GTR later is better than a Bad GTR early (or on time). Pragmatism versus best result.
- Question: This GTR should only address the issues that are specific to hydrogen or the fuel cell, and to leave out the conventional components (this is the intent)?
- Detailed timeline will be developed:
 - o Problems
 - o Obstacles
 - o Interim report in 2008 and (or) 2009 to AC3 – assessment of ability to reach the 2010 target date. Mr. Albus will work closely with AC3, to keep them informed of the progress
- GTR will be a performance-based GTR, specific to hydrogen components at the system level

Phase 1 of the GTR Development:

Presentations of the Japanese Regulations and Standards (handouts)

General Guidance Presentation:

Scope: two parts: (1) road transportation vehicle law (type approval system); and (2) tank and component (high pressure gas safety law):

- Road transportation vehicle law is available in English and will be available in the UN/ECE website.
- Most important parts are Attachments 100 (CH₂ fuel system leakage in lateral collision) and 101 (fuel cell electrical system safety)
- Japan is also planning to make a new regulation on electrical safety for electric and hybrid vehicles (does not include fuel cell vehicles)

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Question: the scope of the high pressure gas safety law shows that the PRD is not included? It is included in Japanese standards (JARIS002). But in some cases, the PRD is inside the vessel – how is this handled? It is covered by this law, because it is part of the tank

Clarification: there are no plans for a post-crash regulation for electric safety of fuel cell vehicles.

Question: are we also addressing LH2 in this GTR (not covered by the Japanese regulation)?

LH2 is missing from this starting point, so we have to consider how we will develop comparable requirements for LH2. Very important task, need to make early decision. We could use the EIH/LH2 work as the basis – have to make a decision.

Technical Details of the Safety Regulation for FCV:

Considered four points (four years ago)

- Not for retrofits
- Performance based, with minimum design specification
- Fuel cell vehicle first, and then the hydrogen ICE
- LH2 not considered

Whole vehicle safety

- Allowable leakage
- Detection and warning to driver, followed by shutdown
- High pressure components

Comparison of CNG vehicle and CH2 vehicle

- Odorant not available, so need some other detection system for hydrogen
- Purge issue with HFCV (note: this will depend on manufacturer's system architecture and/or operation procedure – may not include a purge in the operating procedure)
- Allowable leakage is equivalent to the energy content equivalence in the gasoline case

Hydrogen embrittlement – only two materials are permitted in the high pressure hydrogen tank and component regulations (JARI S001 and S002) so far – stainless steel type 316L and aluminum type A6061-T6

Regulation prescribes use of hydrogen sensors (one per compartment, minimum)

Research results on hydrogen sensor placement – must be located properly to detect correct concentration of hydrogen.

Purged hydrogen is below LFL, and the location of the sensor has to be 100mm from purge outlet

Comparison of fire from massive release of hydrogen, NG, and gasoline – each visible fire has similar size, no difference in distance from flame for safety although fire temperature from hydrogen fire is largest.

Question: What tests are required for high pressure tanks?

Question: What is the reliability/durability of the sensors? Have requirement for periodic inspection

Question: How does the regulation handle the variation in system architectures? Not covered

Question: how does the regulation handle false positives (system shutdown for a sensor fault)? Not covered

Question: Page 7: high-pressure shut-off valve is required if a regulator cannot be attached upstream of the main stop valve – what is the reason for this? Will have to check on the experimental basis for this requirement. Will answer questions via email, since most of the work was done some time ago and they do not remember the details

Question: component certification – what are they using as the basis? Tank standard is almost the same as the US and Europe, but some discrepancies exist (i.e., they do not have the gunfire test).

Requirements under Discussion in Phase 1

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Hydrogen gas leakage requirements

- Page 3: Regulation is limited to a maximum pressure of 350 bar, but most OEMs are looking to 700 bar. The Japan states that this is actually not specifically written in the hydrogen fuel cell vehicle regulation, so it should not be a problem. But there are high pressure tank and component regulations, in which the pressure considered must be increased to 700 bar from 350 bar (because it specifically says 350 bar – JARI S001 and S002)
- Requirement to have no leaks – is there a time element? This is during the bubble test, which is the same as the European test (has a three minute time limit). Japan says there is no time limit (they will check and report back)
- How do they differentiate between leakage and permeation – from a Type 4 tank (polymer liner, carbon-fiber/composite wrapped), for example. Permeation is covered in the high pressure tank regulation.

No regulation of the middle and low-pressure parts – Europe does have requirements. Do we cover the whole range, or continue with the Japanese approach of only regulating the high-pressure parts?

Hydrogen embrittlement

- Material is not indicated in the hydrogen fuel cell vehicle regulation (it is not design-specific) – but only stainless steel or aluminum are allowed in the pressure tank regulation

Sensors

- Failure/reliability of the sensor, control unit and/or actuator is the question (false positives resulting in system shutdown? false negatives or time lag?)
- Look in Attachment 100 for the details
- Relying on sensors – too late by the time the sensors react to the leak?
- Did a study of available sensors and found (only) one that was reliable enough for the work (described in Attachment 100)
- Fundamental issue: this is a very design-specific requirement, and we want the GTR to be performance based. Are we going to mandate sensors in the GTR? Autos are against this design specification. OEMs want to stipulate the maximum allowable concentration in the occupant compartment (see SAE work).

Level of reliability of the safety system is tested through periodic inspection: inspection of the sensors is part of the periodic inspection regulation.

Hydrogen purge issue:

- measured using 1% hydrogen in nitrogen – sensed that percentage out to about 100mm, and then it drops off
- experimental results indicated that no water droplets are found at a distance of 100mm from the exhaust/purge point, so that is where the measurement is taken

PRD release:

- sometimes the PRD does not activate or does not empty the tank fast enough (happens with CNG tanks)
- localized fires (i.e., at one end of a long cylinder) that might not transfer the heat to the end with the PRD – the (component) bonfire test might not cover this event
- could be covered in a vehicle bonfire test (could be expensive)

Gas leakage in collision:

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- equivalent (energy basis) to gasoline leakage: 30g/min for 5 minutes
- hydrogen leakage over a longer period of time: 131 liters/min, but for 60 minutes
 - from the container or the whole system? From anywhere, but the hydrogen came from the cylinder, so it can be calculated by examining the change in the tank pressure.
- contracting parties will maintain their own crash criteria, and the GTR will only set the maximum allowable leakage rate.

Content, Structure, and Scope of the GTR

Decision was made to develop a table or list in a small group and present for discussion and elaboration tomorrow (see table below)

Comparison of the various storage standards to better understand the differences and overlaps

- Prescriptive (design-based) standards
- Performance-based standards
- Some combination of design-specific and performance-based
- Powertech has compared the various standards
- **ACTION:** US and Canada will put together the comparative table for the next meeting (Matt Coons from Transport Canada and Barbara Hennessey from NHTSA)

Content of GTR	Japanese Regulation	Comments	Discussion
Scope	Compressed gas Fuel Cell Vehicle and ICE	LH2, other storage systems Auxiliary power unit - Hydrogen-fueled - Other types of fuel cells	<ul style="list-style-type: none"> - LH2 available, so should be included - Keep GTR open enough to include other storage systems as they are developed - The APU may need a substantial amount of hydrogen, so it should be covered by GTR - May be a high-temperature fuel cell (SOFC) with internal reforming, so many additional issues
Application	Passenger vehicles, trucks, and buses (collision for passenger vehicles only)	2- and 3-wheelers to be covered? <ul style="list-style-type: none"> - 3-wheelers are much more similar to 4-wheelers - 2-wheelers covered by motorcycle (or similar) regulations in most countries/regions 	<ul style="list-style-type: none"> - In Europe, there are separate regulations and directives for 2- and 3-wheelers - Issues (vehicle safety-related) are different (expertise may not exist in this group) - India does not agree that the issues are different - Storage is probably similar, not sure about the rest of the system - Time scale is so tight for Phase 1, it might need to wait for Phase 2 - ACTION: contact IMMA (and other motorcycle associations), determine differences (presentation at next meeting?), take into account the tight GTR timing, then go to AC3 for a decision on whether or not to include 2- and/or 3-wheelers
Definition Section		Want this section added	<ul style="list-style-type: none"> - Need to make sure we are using the same terminology throughout the GTR, and that it is clear how the terms should be used (especially when in conflict with other standards and regulations such as ISO, EC Directives and SAE)

Content of GTR	Japanese Regulation	Comments	Discussion
Electrical Safety 1. In-use 2. Post crash		<p>Action Plan includes effort to harmonize hybrid and electric vehicle electrical safety</p> <p>Proposal: Bring idea to have a meeting between experts to coordinate with GRSP to AC3/WP.29 (in Nov) and then to discuss informally (in Dec) with GRSP – coordination with the GRSP activity to organize a small group on Electric Safety Group (to amend R100)</p> <ul style="list-style-type: none"> - Electrical isolation issues crosscut the various types of vehicles (electric shock) - R100 is being modified (Note: this is under the 1958 agreement – US is not a member) - <i>If there is consensus</i>, it could also be part of the GTR (this is the main conflict between 1958 and 1998 agreements) <p>This GTR effort covers fuel cell hybrids, but not ICE hybrids (but what about hydrogen ICE hybrids?)</p>	<ul style="list-style-type: none"> - Are there sufficient electrical safety experts in this group to effectively (technically) cover this in HFCV-SGS? - May need to include experts from the hybrid and EV GTR efforts - FMVSS 305 specifies electrical safety – has a consistent requirement for all high-voltage vehicles - There are existing documents that cover this subject, and they are well-aligned <ul style="list-style-type: none"> o ISO TC22/SC21 o SAE 1766 o EC R100 - KEY: Should this be separated from the hydrogen GTR? <ul style="list-style-type: none"> o Electric shock is the same for all these vehicles - Fuel cell vehicle has an additional issue that water is present (refrigerant electric safety)

Content of GTR	Japanese Regulation	Comments	Discussion
Hydrogen Leakage 1. In-use 2. Post crash	Leakage in use Sensors Purge gas measurement PRD discharge direction during fire Procedure for gas leakage after crash	<ul style="list-style-type: none"> - Should the GTR have a requirement for component tests for low- and medium-pressure components? Pressure classes are in the ISO and EIHP documents - Sensor failure and drift - Limit of hydrogen leakage for in-use and crash (for the entire system, regardless of the pressure) - Leakage requirement (amount, time, etc) - Requirement for sensors is a design-specific aspect – what is the performance issue that the sensor is addressing? 	<ul style="list-style-type: none"> - Leakage amount (on an energy-equivalent basis) is generally consistent throughout the various standards - Historical basis for comparative safety with conventional vehicles - In a regulation, we should not write that a sensor is to be used – we should only include what we want to achieve, and not the method of how to achieve - Leakage detection and appropriate reaction is the goal - Need some clear requirements to be able to show compliance (experts need to determine how this can be written down) <ul style="list-style-type: none"> o Sensor is only one option o Need to determine the criteria for safety (performance reqts) o What to do when the detection system fails
Hydrogen Storage	35 MPa Bonfire test Material restriction	<ul style="list-style-type: none"> - Higher pressure including 70 MPa - Localize fire - Fire protection (use PRD...) - Harmonization? - Material (embrittlement, permeability)? - Type of construction? 	<ul style="list-style-type: none"> - Important differences in the various standards (ISO, SAE, EC) - ISO has a LH2 standard - ISO is expecting to publish the CH2 standard (DIS) soon <ul style="list-style-type: none"> o Discussion about whether or not it should be a technical specification rather than a DIS (the general consensus (not unanimous) of WG6 is that it should be a TS – not technically ready to go as a DIS) o Will have a full discussion at the next meeting from ISO TC197

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Content of GTR	Japanese Regulation	Comments	Discussion
Others			<p>Functional safety Risk analysis Single-failure assessment (i.e., FMEA) Safety Chain (i.e., detector – control unit – actuator – valve) Electronic control units (EC draft has an annex for this purpose, and it is specific to the hydrogen system) General Comment:</p> <ul style="list-style-type: none"> - Want to keep the GTR as a performance-based regulation - Requirements for safety objectives, and leave the “how” to the discretion of the manufacturers, and for it to be open enough for technology development

GTR Text (structure is prescribed)

The GTR format is available on the UNECE site

Technical Report (this is not required)

Will use the website for documentation

- Post presentations
- Reports

Phase 2 of the GTR Development:

There is a short description of Phase 2 in the Action Plan

Comments at this point are very limited.

Is there a need to be working in parallel on Phase 2 during the Phase 1 work?

- Overview of research activities – how will new technologies impact the GTR?
- Crash test procedure harmonization is the main item in Phase 2, but there may be others
 - o This may not be the right group to harmonize crash test procedures

Should this be on the agenda of the next SGS meeting?

- Do not include explicitly for the next meeting, but keep it on the table (“Other Business”)

Draft Detailed Timeline and Deliverables for GTR

Note: report will be made at each WP29 meeting, but there are two important reports that are indicated in the timeline below:

- Report to WP29 in March 2008 – issues or problems that might result in a delay in the timeline
- Start drafting GTR in December 2007 – US has the lead to develop the outline and to begin filling in the details as the meetings progress
- Report to WP29 in March 2009 – issues or problems that might result in a delay in the timeline
- Informal document to GRSP in December 2009
- GTR approval in GRSP in May 2010
- GTR approval in WP29 in November 2010

Comments: Drafting should start earlier.

Any Other Business

Discussion on separating certain issues into separate GTRs

- Discussion on possible separation of the environmental aspects from the safety-related aspects

Update to R100 submitted to GRSP (under 1958 agreement) in January 2007

- Germany will send the proposal as an informal document to GRSP in December (no changes since January version)

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Action Items and Future Meetings

SGS will give a report to GRSP at the December meeting.

Prior to next meeting, the table needs to be completed and updated. Comments will be solicited from the Chair, and then will be distributed to the rest of the participants for additional comments.

Documents and presentations will be posted on the website

Proposed Meetings in 2008:

- 2nd meeting of SGS: for the convenience of the Chairman, proposal is to meet in Geneva during GRPE Week (January 14-16). SGE is meeting for ½ day. SGS would meet for 2.5 days. Decide on the timing of the 3rd meeting then – could be as early as April.
- 3rd meeting of SGS: Washington DC – possible in June? (note that the Hydrogen Program Review is the week of June 9th in Washington DC – open meeting that might be of interest to the members) or in Geneva
- 4th meeting in the Fall