Summary of Proposed Amendment to gtr 9

(Explanation to Interested Parties)

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Informal document No. **GRSP-45-11**
(45th GRSP, 25-29 May 2009,
agenda item 4(a))

Transmitted by the expert from Japan

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- Table of Contents amended: A new section on the method of introducing the FlexPLI (effective date, period for alternative usage of RIGID/TRL, end date of such period) is inserted as A10.

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- Table of Contents amended: A new paragraph on the FlexPLI certification test is inserted as B8.2.

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Transport Research Laboratory (TRL) in the United Kingdom. However, it is known to also have certain limitations regarding the biofidelity and the repeatability of the test results. Therefore, Japan proposed to use a completely new legform, the so-called Flexible Pedestrian Legform Impactor (FlexPLI). As the FlexPLI legform is considered by some to have high biofidelity and an excellent ability to assess potential leg injuries, the FlexPLI should be considered to replace the TRL lower legform impactor in the future. However, because of the lack of experience in using the FlexPLI as a certification tool, a further confirmation process is needed. Therefore, a Technical Evaluation Group (TEG) was established to evaluate the reliability of the FlexPLI as a certification tool (TRANS/WP.29/GRSP/36). The TEG is currently assessing the FlexPLI and will advise GRSP by the end of 2007 as to the suitability of the FlexPLI for testing and compliance verification purposes (TRANS/WP.29/GRSP/37). The TEG is also expected to provide its recommendation as to the effective date of entry into force and the date on which the FlexPLI could replace the rigid lower legform impactor. TEG will also consider a transitional period during which the FlexPLI and the rigid lower legform impactor can be used as alternatives.

Several years passed after the above situation, then the TEG finalised their technical evaluation on the FlexPLI by a majority of the TEG members in [2009], therefore, this gtr also includes the FlexPLI requirements as well as the RIGID/TRL legform impactor requirements.

- Preamble amended: The statement that this gtr also includes the FlexPLI requirements since the evaluation on FlexPLI was finalised by the majority of the TEG members in [2009] is added.

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101. At the same time, the informal group believes that high bumpers should be more energy absorbing, and for that reason adopts in this gtr the upper legform test for vehicles with a lower bumper height of more than 500 mm.

102. For vehicles that have a lower bumper height between 425 mm and 500 mm, the gtr provides that the vehicle manufacturer can elect to perform either a lower legform test or an upper legform test. Investigations conducted with vehicles with lower bumper heights between 400 and 500 mm indicate that a large majority of these vehicles have features for off-road capability. For these off-road vehicles, it is technically not feasible to have a countermeasure that will enable the vehicle to support the tibia part of the lower legform. That is, data show (see INF GR/PS/175/Rev.2) that the absence of a lower structure to support the lower part of the leg, due to the necessary off road capacities, make it very difficult for these vehicles to meet the proposed lower leg criteria, especially the bending angle. Therefore, the group recommends to use the upper legform to bumper test as an optional alternative to the lower legform to bumper test for these vehicles. **The test methods for high bumper vehicles can be applied not only to the case of using the RIGID/TRL lower legform impactor but also to the case of using the FlexPLI.**

- Preamble amended: The statement that the same test procedures for high bumper vehicles (using the upper legform impactor as an alternative, etc.) can be applied to testing using the FlexPLI is added.

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(b) Lower legform test

(i) Impactor

106. It was agreed to recommend using the legform impactor developed by TRL, for the time being, to evaluate the performance of vehicles in protecting the lower leg. However, it was also recommended to consider the possible future use of the Flex-PLI, which is considered by some to be more biofidelic and expected to be highly usable and repeatable, following the evaluation to be conducted by the Technical Evaluation Group **(TEG)** (INF GR/PS/106) 19/. **Several years passed, then the TEG finalised their technical evaluation on the FlexPLI by a majority of the TEG members in [2009], therefore, this gtr also includes the FlexPLI requirements as well as the RIGID/TRL legform impactor requirements.**

- Preamble amended: The statement that this gtr also includes the FlexPLI requirements since the evaluation on FlexPLI was finalised by the majority of the TEG members in [2009] is added.

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informal group determined that a value close to the upper limit (21°) of this range should be considered, and not the average. The absence of muscle tone in the PMHS tests reduced the knee stiffness of the subjects, and the high rigidity of the impactor bones transferred to the knee joint a part of the impact energy normally absorbed by the deformation of human long bones. For these reasons, a bending limit of 19° **for the RIGID/TRL lower legform** was selected for this gtr. **As for the Flex-PLI, a limit of medial collateral ligament (MCL) elongation at the knee was set as [20 mm] based on the TEG discussions.**

111. With regard to knee shearing limits, the informal group selected a limit of 6 mm **for the RIGID/TRL lower legform impactor**, based on the analysis of PMHS by EEVC WG17 and WG10 that showed that a 6 mm shear displacement corresponds to a 4 kN shear force. The 4 kN shear force in the TRL device approximates the 3 kN average peak shearing force acting at the knee joint level that was found associated in the PMHS tests with diaphysis/metaphysis failure. **As for the FlexPLI, a limit of anterior cruciate ligament (ACL) elongation and a limit of posterior cruciate ligament (PCL) elongation at the knee are both set as [12.7] mm only for monitoring purposes because ACL or PCL injury without MCL rupture is very rare in car-pedestrian accidents.**

112. With regard to limiting the maximum acceleration on the tibia, results of a series of pedestrian PMHS tests performed with modern cars suggests that the maximum tibia acceleration for the PMHS sustaining a tibia fracture was 170g to 270g, with the average value of 222g. A value of 200g would correspond to a 50 percent injury risk. To protect a higher proportion of the population at risk, the informal group recommends a maximum lateral tibia acceleration limit of 170g **for the RIGID/TRL lower legform impactor. As for the FlexPLI, the limit of tibia bending moment is set as [312] Nm based on the TEG discussions.**

113. In summary, it was concluded that the acceptance levels for the lower legform test should be set at the following limits:

For RIGID/TRL lower legform impactor

Maximum lateral knee bending angle ≤ 19.0°;
Maximum lateral knee shearing displacement ≤ 6.0 mm;
Maximum lateral tibia acceleration ≤ 170g.

For FlexPLI

Maximum MCL elongation ≤ [20] mm;
Maximum Tibia bending moment ≤ [312] Nm;
Maximum ACL and PCL elongation ≤ [12.7] mm only for monitoring purposes.

- Preamble amended: FlexPLI injury limits are added.

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115. In order for the vehicle to provide adequate occupant protection in frontal crashes, portions of the vehicle bumper structure will have to be stiff enough to enable the vehicle to absorb a sufficient amount of the impact energy. In addition, the bumper structure contains towing hooks and other devices. Because of these factors, certain portions of the bumper will not be able to meet the maximum lateral tibia acceleration limit of 170g across the full length of the bumper. For feasibility reasons, this gtr allows manufacturers to nominate bumper test widths up to 264 mm in total where the acceleration measured at the upper end of the tibia **of the RIGID/TRL lower legform impactor** shall not exceed 250g. The relaxation zone of 264 mm corresponds to an area that is twice the width of the legform. **[As for the FlexPLI, for feasibility reasons, TEG proposed to allow manufacturers to nominate bumper test widths up to 264 mm in total where the tibia bending moment of the FlexPLI shall not exceed TBD Nm and the MCL elongation of the FlexPLI shall not exceed TBD mm].**

- Preamble amended: Descriptions on relaxations of the required FlexPLI injury limits are added.

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10. METHOD OF INTRODUCING THE FLEX-PLI

133. As for the new lower legform impactor, FlexPLI, introduction to the each contracting party, the TEG provided its recommendation as follows;

Effective date of the amendment 1 to the original version entry into force at each contracting party: from the date when this gtr is adopted by the [WP29].

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TEG also proposed to finish the period of alternative using impactors of RIGID/TRL lower legform impactor or FlexPLI by [20XX] [[XX] months after the date of entry into force].

- Preamble amended: Descriptions on the method of introducing the FlexPLI (effective date, period for alternative usage of RIGID/TRL, end date of such period) are added.

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5. PERFORMANCE REQUIREMENTS

5.1. Legform to bumper:

5.1.1. When tested in accordance with paragraph 7.1.1. (RIGID/TRL lower legform to bumper) or paragraph 7.1.2. (Flex-PLI to bumper) according to the choice of manufacturers, the results shall comply with 5.1.1.1 or 5.1.1.2 respectively.

5.1.1.1 When tested in accordance with paragraph 7.1.1., the maximum dynamic knee bending angle shall not exceed 19°, the maximum dynamic knee shearing displacement shall not exceed 6.0 mm, and the acceleration measured at the upper end of the tibia shall not exceed 170g. In addition, the manufacturer may nominate bumper test widths up to a maximum of 264 mm in total where the acceleration measured at the upper end of the tibia shall not exceed 250g.

5.1.1.2 When tested in accordance with paragraph 7.1.2., the maximum dynamic medial collateral ligament elongation at knee shall not exceed [20 mm], and the dynamic bending moments at tibia shall not exceed [312 Nm]. The maximum dynamic anterior cruciate ligament and posterior cruciate ligament elongation shall be monitored with a reference value of [12,7] mm. [In addition, the manufacturer may nominate bumper test widths up to a maximum of 264 mm in total where the tibia bending moment of the FlexPLI shall not exceed TBD Nm and the MCL elongation of the FlexPLI shall not exceed TBD mm]

- Text of the Regulation amended: A description on the alternative usage of the current RIGID/TRL legform impactor and the FlexPLI is added.

- Text of the Regulation amended: Descriptions on the required FlexPLI injury limits are added.

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6.3.1.2. Flexible pedestrian lower legform impactor (FlexPLI):

The lower legform impactor shall consist of flesh, flexible long bone segments (representing femur and tibia), and a knee joint as shown in Figure 13.

The overall length of the impactor shall be 928 ± [3] mm, having a required mass of 12.95 ± [0.4] kg including flesh. The length of the femur, knee joint, and tibia shall be 339 ± [2] mm, 185 ± [1] mm, and 404 ± [2] mm respectively. The knee joint centre position shall be 94 ± [1] mm from the top of the knee joint.

- Text of the Regulation amended: Descriptions on the FlexPLI specifications and requirements are added.

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7.1.2. FlexPLI to bumper test procedure

Each test shall be completed within two hours of when the impactor to be used is removed from the controlled storage area.

7.1.2.1. The selected target points shall be in the bumper test area.

7.1.2.2. The direction of the impact velocity vector shall be in the horizontal plane and parallel to the longitudinal vertical plane of the vehicle. The tolerance for the direction of the velocity vector in the horizontal plane and in the longitudinal plane shall be ± 2° at the time of first contact. The axis of the impactor shall be perpendicular to the horizontal plane with a tolerance of ± 2° in the lateral and longitudinal plane. The horizontal, longitudinal and lateral planes are orthogonal to each other (see Figure 23).

- Text of the Regulation amended: Descriptions on the vehicle test procedures for FlexPLI (basically the same as those for RIGID/TRL, except that the impact height is changed) are added.

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8.2. Flex-PLI certification

8.2.1. Static certification tests

8.2.1.1. The femur and tibia of the lower legform impactor shall meet the requirements respectively specified in paragraph 8.2.1.2. when tested as specified in paragraph 8.2.1.4. The knee joint of the lower legform impactor shall meet the requirements specified in paragraph 8.2.1.3. when tested as specified in paragraph 8.2.1.5. The stabilised temperature of the impactor during the certification tests shall be 20° ± 2°C.

The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 5 kN for the applied external load. For these tests low-pass filtering at an appropriate frequency is permitted, to remove higher frequency noise without significantly affecting the measurement of the response of the impactor.

- Text of the Regulation amended: Descriptions on the FlexPLI certification test are added.