

World Forum for Harmonization of Vehicle Regulations (WP.29)

Working Party on Passive Safety (GRSP)
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**UNITED STATES OF AMERICA COMMENTS ON DRAFT GLOBAL
TECHNICAL REGULATION ON PEDESTRIAN HEAD AND LEG
PROTECTION (TRANS/WP.29/GRSP/2005/3)**

Transmitted by the expert from the United States of America

The United States of America (U.S.) has reviewed the February 20, 2005 draft proposal for a global technical regulation (gtr) on pedestrian head and leg protection (TRANS/WP.29/GRSP/2005/3). This paper provides suggestions on areas of the technical rationale and regulatory text of the draft gtr.

In general:

- With regards to the Technical Rationale section, some of the comments provided in this paper recommend a more detailed discussion of the issues already presented. In many cases, this more detailed information is referenced and available in the documents that have been introduced by the informal working group on pedestrian safety. We have some concerns that in the long term, these informal documents may become difficult to access, and therefore suggest that these details be included in the technical rationale or as an Appendix to the gtr.
- If data or information is not available to allow a more detailed discussion of an issue, this lack of data should be addressed in the Technical Rationale.
- In some sections, the regulatory text is overly vague or subjective. It is recommended that it be written in more specific terms to ensure objectivity of the tests and associated results.
- It is hoped that the constructive comments provided in this paper will help focus where more information may still be needed to make a data-driven, science-based decision on the proposed gtr.

Given the above, the following specific comments are provided. Additionally, U.S. has also attached a brief overview of limited testing it has conducted to date using the draft gtr test procedures and has attached a number of suggested revisions regarding the test procedure specifications.

1) **Introduction (Discussion of the safety need)**

- a) Pedestrian Accident situation and its analysis.
 - i) More information on the distribution of injuries is recommended. Actual numbers should be provided, in addition to references to percentages or frequencies.
- b) Distribution of the injuries. More information about the portion of the pedestrian safety problem being addressed by the regulation is recommended.
 - i) More detailed information is recommended to provide a perspective of the overall pedestrian safety problem.
 - ii) Data on head and leg injuries should be separately presented rather than grouped.
 - (1) Head Impact Protection
 - (a) Data is recommended on the number of pedestrian deaths and head injuries, by Abbreviated Injury Scale (AIS) level occurring annually, analyzed by age of the victim, by type of striking vehicle, by speed of striking vehicle, by the most harmful injury source (e.g., vehicle hood, fender, windshield, or ground), and by the body region of the most harmful injury.
 - (b) Can it be shown that these injuries aren't duplicated by injuries from other injury sources (such as the ground) or to other parts of the body so as to negate the benefits of the regulation? (That is, suppose pedestrians would suffer head injury anyway when their head hit the ground after hitting the more protective hood.)
 - (c) How many injuries (by AIS level) are caused by the bonnet/wing (hood/fender) and windscreen area?
 - (d) For the typical child and adult suffering a head to hood impact, what injuries to other body regions are typically suffered and what are the AIS levels of those other injuries? (Would any of the pedestrians saved from fatal or serious head injury by this regulation have died anyway due to other injuries?)
 - (2) Leg Impact Protection
 - (a) Data is recommended on the number of pedestrian leg injuries (by AIS level) occurring annually, analyzed by age and height of the victim, by type of striking vehicle, and by speed of striking vehicle.
 - (b) How many adult leg injuries are caused by the front bumper?
 - (c) How many pedestrian leg injuries result from crashes replicated by the gtr legform test?
 - (d) Can it be shown that these injuries aren't duplicated by injuries from other injury sources (such as the ground) or to other parts of the body so as to negate the benefits of the rule? (That is, suppose pedestrians would suffer leg injury anyway when they hit the ground after hitting a more forgiving bumper.)
 - (e) Can it be shown that mitigating a leg injury benefits the overall health and safety of pedestrians?

- c) Crash Speeds: More detailed information is recommended to show which of these injuries and fatalities would be addressed by the gtr.
- (1) Head
 - (a) How many pedestrian head impacts result from: a head-to-hood impact; a 40 km/h or less crash speed; and a head impact to an area on the vehicle that would be covered by the gtr?
 - (b) The draft gtr states that the cumulative frequency of the crash speeds shows that a crash speed of up to 40 km/h can cover more than 75% of total pedestrian accidents in all regions. How many crashes occur at different speeds up to 40 km/h?
 - (2) Leg
 - (a) How many pedestrian leg impacts result from: a leg-to-bumper impact; a 40 km/h or less crash speed; and a leg impact to an area on the vehicle that would be covered by the gtr?
 - (b) How many crashes occur at different speeds up to 40 km/h?
- d) Applicability. The draft gtr is unclear as to which vehicles it would apply. Is there a stronger rationale as to which vehicles the gtr should apply, such as real world data on the vehicle types that are actually causing injury to pedestrians? Do some particular types of vehicles cause leg injury while others are more likely to cause head injury?
- e) Definitions
- i) Excluded test areas.
 - (1) Head: The draft gtr excludes certain areas of the windscreen from the proposed requirements, such as the A-pillar. The information in brackets on p. 9 refers to a lack of “technology” to apply to these areas.
 - (a) What technology exists today and why cannot it be applied to the excluded areas?
 - (b) How does the excluded areas affect the target population and benefits analysis?
 - (c) Application Section 2.5. states: “At the time of acceptance of the regulation by any party contracting to the regulation, that contracting party will be required to accept the alternatives available at that time.” The clause is unclear and too broad. The “alternatives available” should probably be expressly listed.
 - (2) Leg: The draft gtr states that the lower leg impactor has some limitations dependent on the bumper height.
 - (a) Accordingly, the draft gtr proposes that test points above [500] mm will be tested with the upper leg to bumper test, and test points below [500] mm will be tested with the lower legform to bumper test.
 - (i) What are the limitations that are the basis for this demarcation, and why will the limitations be addressed by the 500 mm demarcation?

2) General Requirements

The draft gtr states that the FlexPLI legform should be adopted as the sole legform in the future, and states that a Technical Evaluation Group will decide by a date in the future whether the FlexPLI legform is to replace the TRL legform and the dates for the implementation of the FlexPLI legform.

- a) This language should be revised, otherwise it predetermines the actions of GRSP and AC.3. Suggested text is:

the FlexPLI legform **is recommended as** the sole legform in the future, and ... a Technical Evaluation Group will decide by a date in the future whether the FlexPLI legform **will be recommended** to replace the TRL legform and **recommend** dates for the implementation of the FlexPLI legform.

3) Performance Requirements

- a) **Head Protection:** The draft gtr proposes that a test vehicle hood will be subject to a minimum of 9 impacts with the child headform and a minimum of 9 tests with the adult headform. The impacts would be “at positions judged to be the most likely to cause injury.” The impacts must be contained within the specified child test zone and the adult test zone measured on the vehicle, and must be a minimum of 165 mm apart. HIC₁₅ must be limited to 1000, although “it was agreed, however, that another threshold value could be used for a certain limited test areas [sic] from a consideration of feasibility (INF GR/PS/94, 102 and 103).”
- i) Basis for determining impact points. The draft gtr excludes certain areas of the hood by specifying (Section 7.3.3.), for example, that the test points for the child headform test must be a minimum of 82.5 mm inside the defined bonnet side reference lines. What is the basis for the exclusions?
- (1) Are child and adult pedestrian head impacts evenly spread out along the hood, or are they concentrated in a certain area?
 - (2) If the latter, should the impacts be focused on those areas most likely to be contacted?
- ii) HIC requirement.
- (1) What is the reasoning behind the HIC₁₅ 1000 requirement? This is not a commonly used injury threshold. (i.e. In U.S. FMVSS No. 208, HIC₁₅ is 700, and in U.S. FMVSS No. 213, HIC₃₆ is 1000.)
 - (2) The provision about using “another threshold value” is vague. What is the value, where are the limited areas, and who would decide (e.g., testing authority or a manufacturer) that it could be used? What is the basis for the value?
- b) **Leg Protection:**
- i) How would meeting the gtr affect other standards and regulations, such as FMVSS No. 208 (air bag sensors) and ECE R.94 Frontal Offset Protection?
- (1) Would meeting the regulation affect vehicle compatibility and fuel economy?
- ii) Lower leg protection. The draft gtr discusses what the thresholds would be if the Flex-PLI legform were used. This discussion should be removed until such time the Flex-PLI is proposed.

iii) Upper leg protection for high bumpers. The draft gtr suggests copying the requirements from the EU directive. The proposed limits are: [7.5] kN for the impact force and [510] Nm for the bending moment.

(a) An examination of the merits of the requirements is recommended.

4) Test Conditions

a) Head Protection

- i) Impact test device. In proposing the child and adult headforms for use in a regulation an explanation is recommended on why the impact devices are appropriate. The draft gtr states that the child headform represents a 6-year-old child because the majority of pedestrian victims are 5 or 6 years old.
 - (1) What type of pedestrian is represented by the adult pedestrian (e.g., 50th percentile male) and why was that pedestrian type chosen?
 - (2) Can it be shown that using these headforms will drive countermeasures that benefit pedestrians of other sizes?
 - (3) Are tests using the headform repeatable and reproducible?
- ii) Impact speeds. An explanation is recommended on why 40 km/h was chosen.
 - (1) What are the dynamics of the crash event between the pedestrian and the vehicle hood that are replicated using the 40 km/h impact speed?
- iii) Impact angle. The draft gtr states that the “head impact conditions (speed and angle) are affected by the frontal shape of the vehicle.”
 - (1) How are they affected?
 - (2) “[D]ifferent headform impact angles could be used for reach type of vehicle frontal shape.” Why should the angles differ?
 - (3) What angle is most representative of real-world head impacts?
 - (4) Does the angle affect the test results, and if so, how?
 - (5) Why the angle of impact differ depending on the angle (7.3.6.2) or height (7.3.6.3) of the bonnet (p. 49)?

b) Leg Protection

- i) Impact Test Device
 - (1) What type of adult pedestrian leg is represented by the TRL legform?
 - (2) How well does the legform represent the legs of other struck adult pedestrians?
 - (3) Can it be shown that using the legform will drive countermeasures that benefit pedestrians of other sizes?
 - (4) Is the legform biofidelic? Does it produces repeatable and reproducible results?
- ii) Impact Speed: An explanation is recommended as to why 40 km/h was chosen.
 - (1) What is the correlation of the proposed 40 km/h legform test to the dynamics of an actual pedestrian in an accident?

5) **Test Procedure**

- a) **Head Impact**
 - i) **Impact speeds.**
 - (a) How does the test procedure replicate a vehicle-to-pedestrian event involving pedestrian head-to-hood injury?
 - ii) **Impact angle.**
 - (1) How is the headform angled when impacting the bonnet/hood and why was that angle chosen?
 - iii) **Number of Impacts:**
 - (1) How many impacts can be made on a particular hood in testing before the hood has to be replaced?
 - (2) How many hoods are needed to conduct a test?
- b) **Legform Impact.** How does the test procedure replicate a vehicle-to-pedestrian event involving pedestrian leg injury?
 - i) **Impact speeds.**
 - (1) Why was 40 km/h chosen?
 - ii) **Number of Impacts**
 - (1) How many impacts can be made on a particular bumper in testing before the bumper has to be replaced?
 - (2) How many bumpers are needed to conduct a test?

6) **Regulatory Impact and Economic Effectiveness**

- a) The studies discussed refer to other requirements (EEVC, EU Phase 1, EU Phase 2). How do these other requirements relate to the requirements in the gtr? How are the study results applicable to the gtr?
- b) What types of changes to non-compliant vehicles will be needed to allow them to pass the requirements in the draft gtr? What are the expected costs of these changes?
- c) It is stated that vehicles are performing well below the proposed requirements with respect to the lower legform testing. How will any benefits be realized?
- d) In the discussion of the TRL study, pedal cyclists are included in the numbers of lives saved. How do the dynamics of pedal cyclist impacts relate to pedestrian impacts? Are they impacting the vehicle at the same angles and speeds as the pedestrians?

ATTACHMENT: Overview of testing conducted by the U.S. to date

- The U.S. estimates that approximately 12,000 pedestrian injuries and 1,300 pedestrian fatalities in the U.S. could be influenced annually by injury reduction measures in the hood and windshield areas of vehicles.
- In leg-to-bumper tests on five vehicles from the U.S. fleet, each of the vehicles failed at least one of the three EuroNCAP pedestrian leg injury criteria (shear displacement, bending angle, tibia acceleration). However, the European versions of the same vehicle models did not perform significantly better overall.
- The FlexPLI 2004 legform was more sensitive to vehicle shape but significantly less durable than the TRL/EEVC legform.
- So far, 19 of 25 (76%) draft gtr head impact tests had HIC < 1000 on four vehicles (2 passenger cars (PC), 1 minivan (MV), 1 full-size van (FSV): model years 2001-2004).
- Only one of the four vehicles (25%) had HIC < 1000 for all test points (full-size van). The pass rates were 57% (PC1), 71% (MV), 83% (PC2), and 100% (FSV).
- The average hood HIC was 789 (21 tests) and the average windshield HIC was 539 (4 tests).
- HIC values have ranged from 347 to 1759. The overall average HIC was 749.
- Twelve of these tests were done at approximately the average Wrap Around Distance (WAD) for the vehicle type/age combinations found in the U.S. pedestrian field data. If this WAD happened to be outside of the draft gtr test zone, the impact was done on the test zone boundary nearest to that WAD. The other 13 tests were judged to be hard or soft points beforehand by the test engineer. Three more vehicles will be tested in this series.

ATTACHMENT: Suggested revisions to test procedure specifications

- Section 3.20 - "Nominal ride attitude" - A 75 kg mass is required at the driver's position and the passenger position. More specificity is recommended on the location of these seats, placing a 75 kg weight at full forward could produce a different nominal ride attitude than when the seat is full rearward. It is suggested that the text be revised as follows:
 - Section 3.20 – “**Normal ride attitude**” means the vehicle attitude that is attained when the test vehicle, in the following condition, is placed on a test surface that meets section 6.1.2.
 - All fluids necessary for operation of the vehicle are filled to maximum capacity.
 - Each tire inflated to manufacturer recommended pressures.
 - The fuel tank is filled to any level from 90 to 95 percent of capacity with Stoddard solvent having the physical and chemical properties of type 1 solvent, Table I ASTM Standard D484-71, “Standard Specifications for Hydrocarbon Dry Cleaning Solvents.”
 - The fuel system other than the fuel tank is filled with Stoddard solvent to its normal operating level.
 - The seat is placed at the nominal mid-track position.
 - With 136 kg or the rated cargo and luggage capacity weight, whichever is less, secured in the load carrying area.
 - With variable suspension systems set in their “nominal” position in accordance with the owner’s manual or manufacturer specifications.
 - Work-performing accessories are removed.
 - Retractable antennas are in their fully extended (non-retracted) position.
 - “Pop-up” or retractable headlights shall be tested both with the headlights Off (retracted position) and headlights ON
 - Hood ornaments are not removed.
- Section 6.1.1.1 and 6.1.1.2 - The text needs to provide a specific amount of time that the test devices and the vehicle have to be temperature conditioned in order to have stabilized temperatures. While the U.S. has not conducted any tests to determine how much time is needed to stabilize the leg-form and head-form test devices or test vehicle, a 4-hour time frame is specified for free motion headform (FMH) impacts in U.S. FMVSS No. 201.
- Section 6.2.1.1 - The requirement must state that the vehicle is secured to a test frame or is on its own suspension. This condition cannot be an option.

- Section 7.1.1.1 states: “Manufacturers might apply for derogation concerning an exemption zone for a removable towing hook.” This clause is not appropriate for U.S. regulations because we do not have this type of exemption authority. Instead, the regulation should simply exclude the appropriate areas on the bumper.
- Section 7.1.1.1 and 7.3.3 - Is there a minimum time between impacts? This question applies to both the vehicle and the test device. Consistent with current U.S. FMVSS No 201 FMH impacts, the U.S. suggests that any impacts within 300 mm of each other cannot occur in less than a 30-minute time period.
- Section 7.1.1.3 is vague in stating: “When setting the height of the propulsion system, an allowance must be made for the influence of gravity during the period of free flight of the impactor.” What type of allowance is it referring to, and how much of an allowance is appropriate?
- Section 7.3.4 - Impact target points throughout this section should be specified as target circles. This is a lesson the U.S. has learned from FMVSS 201. The U.S. recommends defining a 25 mm diameter circle about each designated impact point for the headform tests. This will define the tolerance for impact precision. Markers placed on the headform device will leave trace marks within the circle for post-test verification.
- Section 7.3.6.4 states: “The effect of gravity shall be taken into account when the impact angle is obtained from measurements taken before the time of first contact.” The meaning of the provision is unclear, and the provision appears to introduce subjectivity into the angle measurement.

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