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### Economic Commission for Europe

#### Inland Transport Committee

#### World Forum for Harmonization of Vehicle Regulations

#### Working Party on Passive Safety

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Item 4(a) of the provisional agenda

#### **Global technical regulation No. 9 (Pedestrian safety) – Phase 2 of the global technical regulation**

### **Proposal for Amendment 2 (DRAFT-ver.121206)**

#### **Submitted by the chairperson of informal working group on Global technical regulation No. 9 (Pedestrian safety)-Phase 2\***

The text reproduced below was prepared by the chairperson of informal working group on Global technical regulation No.9 (Pedestrian safety)-Phase 2 proposing the use of the flexible pedestrian lower legform impactor in the Global technical regulation No. 9 (pedestrian safety) Phase 2. It supersedes ECE/TRANS/180/Add.9. The modifications to the current text of gtr No. 9 on pedestrian safety are marked in bold for new or strikethrough for deleted characters.

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\* In accordance with the programme of work of the Inland Transport Committee for 2010–2014 (ECE/TRANS/208, para. 106 and ECE/TRANS/2010/8, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

## I. Proposal

### A. Statement of technical rationale and justification

*Paragraph 64.*, amend to read:

"64. The lower legform ...in the United Kingdom, and then called as **European Enhanced Vehicle-safety Committee (EEVC) pedestrian lower legform impactor (called as "EEVC lower legform impactor" hereafter)**. 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 (**called as "Flexilbe lower legform impactor" hereafter**). As the **Flexible lower legform impactor FlexPLI legform** is considered by some to have high biofidelity and an excellent ability to assess potential leg injuries, the **Flexible lower legform impactor FlexPLI** should be considered to replace **Lower legform I lower legform impactor** in the future. However, because of the lack of experience in using the **Flexible lower legform impactor FlexPLI** as a certification tool **at the timing of 2004**, a further confirmation process **was is** needed. Therefore, a Technical Evaluation Group (TEG) was established to evaluate the reliability of the **Flexible lower legform impactor FlexPLI** as a certification tool (TRANS/WP.29/GRSP/36). The TEG **had been worked to assess is currently assessing** the **Flexible lower legform impactor until 2010 FlexPLI** and will advise GRSP by the end of 2007 as to the suitability of the **Flexible lower legform impactor FlexPLI** for testing and compliance verification purposes (TRANS/WP.29/GRSP/4837). 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. **[After the TEG activity, GRSP considered ECE/TRANS/WP.29/GRSP/2011/13 and GRSP-49-15 concerning the introduction of the Flexible lower legform impactor into the gtr in May 2011. However, the expert from the United States of America made a presentation (GRSP-49-23) showing the outcome of a comparison research study conducted in his country between the Flexible lower legform impactor and the current EEVC lower legform impactor. He concluded that additional research, testing and additional world fleet data is needed to address the injury criteria concerns and to justify the introduction of the Flexible lower legform impactor. The expert from Japan gave a presentation (GRSP-49-24), showing that the Flexible lower legform impactor and the current legform have a totally different structure and injury criteria. Therefore, he concluded that direct comparison between the two legforms would take misleading results. GRSP agreed that pending issues should be addressed by an informal group, Germany (chair), Japan (vice-chair) and OICA (secretariat), and aimed at finalizing proposals for the introduction of the Flexible lower legform impactor into the gtr and in the draft Regulation on pedestrian safety in the same time. The informal working group is named "informal working group on Global technical regulation No.9 Phase 2 (IG GTR9-PH2)". The IG had been worked by [March 2013], then developed a draft Global technical regulation No.9 Phase 2 using Flexible lower legform impactor.]"**

*Paragraph 102.*, amend to read:

"102. For vehicles...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 IG GTR9-PH2 also agreed on that the test methods for high bumper**

vehicles can be applied not only when using both the **EEVC lower legform impactor** as well as the **Flexible lower legform impactor**.]"

Paragraph 106., amend to read:

"106. It was agreed....However, it was also recommended to consider the possible future use of the **Flexible lower legform impactor** ~~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).<sup>19</sup> **[The TEG had finalized their technical evaluation activity on the Flexible lower legform impactor in 2010, then informal working group on Global technical regulation No.9 Phase 2 (IG GTR9-PH2) was developed a draft Global technical regulation No.9 Phase 2 using the Flexible lower legform impactor in [March 2013].]**"

"110. These studies.....For these reasons, a bending limit of 19° was selected for the **EEVC lower legform impactor** for GTR9 Phase 1 ~~this-gtr~~. With regards to the **Flexible lower legform impactor** for GTR9 Phase 2, a limit of medial collateral ligament (MCL) elongation at the knee was set at 22 mm based on the agreement of the TEG from a biomechanical point of view (based on Bundesanstalt fuer Strassenwesen (BASt – German Federal Highway Research Institute) correlation study and Japan Automobile Manufacturers Association (JAMA) biomechanical study, TEG-127). **[IG GTR9-PH2 had carefully reviewed then agreed on that.]**"

Paragraph 111., amend to read:

"111. With regard to knee shearing limits, the informal group selected a limit of 6 mm for the **EEVC lower legform impactor** for GTR9 Phase 1, 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 **EEVC lower legform impactor** ~~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. **With regards to the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) elongations for the Flexible lower legform impactor for GTR9 Phase 2, [IG GTR9-PH2 carefully reviewed TEG discussions (TEG-127) then agreed ACL and PCL elongations shall not exceed 13 mm based on available a few number of PMHS test data].**"

Paragraph 112., amend to read:

"112. With regard.....To protect a higher proportion of the population at risk, the informal group recommends a maximum lateral tibia acceleration limit of 170g for the **EEVC lower legform impactor** for GTR9 Phase 1. **With regards to the limit of tibia bending moment for the Flexible lower legform impactor for GTR9 Phase 2 is set at 340 Nm based on the agreement of the TEG from a biomechanical point of view (TEG-127). [IG GTR9-PH2 had carefully reviewed then agreed on that].**"

Paragraph 113., amend to read:

"113. In summary...at the following limits:

**EEVC lower legform impactor (for GTR9 Phase 1)**

Maximum lateral knee bending angle  $\leq 19.0^\circ$ ;

Maximum lateral knee shearing displacement  $\leq 6.0$  mm;

Maximum lateral tibia acceleration  $\leq 170g$ .

**Flexible lower legform impactor** (for GTR9 Phase 2)

Maximum MCL elongation  $\leq 22$  mm;

Maximum Tibia bending moment  $\leq 340$  Nm;

Maximum ACL and PCL elongation  $\leq 13$  mm.

"

*Paragraph 114.*, amend to read:

"114. These values **for the EEVC lower legform impactor for GTR9 Phase 1** are identical to those **that were** under consideration by the EC in its review of the Phase 2 requirements of the European directive."

*Paragraph 115.*, amend to read:

"115. In order.....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 EEVC lower legform impactor for GTR9 Phase 1** shall not exceed 250g. The relaxation zone of 264 mm corresponds to an area that is twice the width of the legform. **With regards to the Flexible lower legform impactor for GTR9 Phase 2, on the need for a tibia relaxation zone for the bumper area, TEG proposes to introduce relaxation zones with a total width of 264 mm, allowing a maximum tibia bending moment of 380 Nm. [IG GTR9-PH2 had carefully reviewed then agreed on that.]**"

*Insert a new section 10.*, to read:

**"10. METHOD OF INTRODUCING THE FLEXIBLE LOWER LEGFORM IMPACTOR**

**133. As for the smooth introduction of the new lower legform impactor, Flexible lower legform impactor**, by each Contracting Party, the Working Party on Passive Safety (GRSP) and some TEG members provided the following recommendations:

- (a) GRSP recommended that if a Contracting Party chooses to use the **Flexible lower legform impactor** in its national legislation, the Contracting Party shall consider setting a recommended minimum period of lead time based upon considerations of reasonableness and practicability (see paragraph 4.1.3.3. of Article 4 of the 1998 Agreement).
- [(b) Some TEG **as well as IG GTR9-PH2** members propose that a vehicle model once certified using the **EEVC lower legform impactor** based on GTR9 Phase 1, would not need to be re-certified using the **Flexible lower legform impactor**."]

Section 10 (former), renumber as section 11 and amend to read:

"...

INF GR/PS/188	Draft meeting minutes of the 10th meeting
INF GR/PS/189	Attendance list 10th meeting
GRSP-47-18/Rev.2	(USA) Proposal for amendments to global technical regulation No. 9 (Pedestrian safety)

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**A list of working papers used by the FlexTEG group is available on the UNECE WP.29 website:  
[www.unece.org/trans/main/wp29/wp29wgs/wp29grsp/pedestrian\\_FlexPLI.html](http://www.unece.org/trans/main/wp29/wp29wgs/wp29grsp/pedestrian_FlexPLI.html)**

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*Number of working  
paper*

*Title of Flex TEG document*

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<b>TEG-001</b>	<b>Agenda for 1st Meeting of Flex PLI Technical Evaluation Group.doc</b>
<b>TEG-002</b>	<b>Flex-G_General_Information_050904.pdf</b>
<b>TEG-003</b>	<b>Flex-G_Preparation_Manual_050904.pdf</b>
<b>TEG-004</b>	<b>2005.09.02 - BAST Flex-G Test Programme.pdf</b>
<b>TEG-005</b>	<b>Revised Agenda for 1st Flex-G_MT.pdf</b>
<b>TEG-006</b>	<b>2005_06_ESV_JAMA-Flex.pdf</b>
<b>TEG-007</b>	<b>2005_06_ESV_JMLIT-Flex.pdf</b>
<b>TEG-008</b>	<b>2005_06_ESV_NHTSA_TRL-Flex.pdf</b>
<b>TEG-009</b>	<b>Attendance list 1<sup>st</sup> Flex-PLI Meeting</b>
<b>TEG-010</b>	<b>Draft minutes 1st Flex PLI meeting_051011.pdf</b>
<b>TEG-010-R1</b>	<b>Modified_Minutes 1st Flex PLI meeting_051122.pdf</b>
<b>TEG-011</b>	<b>Agenda for 2nd Meeting of Flex-TEG.pdf</b>
<b>TEG-011-R1</b>	<b>Modified_Agenda for 2nd Meeting of Flex-TEG.pdf</b>
<b>TEG-012</b>	<b>Flex-G_Minor_Modifications_onto_SN01_051122.pdf</b>
<b>TEG-013</b>	<b>Flex Repeatability and Reproducibility for Thigh Leg Knee.pdf</b>
<b>TEG-014</b>	<b>Flex_Assembly_Test_Results_and_Tentative_Corridors_051122.pdf</b>
<b>TEG-015</b>	<b>Report_on_Flex-G_Car_Test_Results_051122_final.pdf</b>
<b>TEG-016</b>	<b>Flex-TEG_Schedule_051115.pdf</b>
<b>TEG-016-R1</b>	<b>Flex-TEG_Schedule_051122.pdf</b>
<b>TEG-017</b>	<b>Attendance list 2nd Flex-PLI .pdf</b>
<b>TEG-018</b>	<b>DRAFT Minutes 2nd Flex-TEG_060228.pdf</b>

<i>Number of working paper</i>	<i>Title of Flex TEG document</i>
TEG-018-R1	FINAL Minutes 2nd Flex-TEG_060424.pdf
TEG-019	Draft Agenda for 3rd Meeting of Flex-TEG_060327.pdf
TEG-020	Status Report on Action Items_060424.pdf
TEG-021	Flex-GT-alpha_General_Information_060424.pdf
TEG-022	Flex-GT-alpha_Injury_Assessment_Ability_060424.pdf
TEG-023	TRL-LFI_Retry_Test_060424.pdf
TEG-024	Flex-GT-alpha_Typical_Dynamic_Assembly_Calibration_Test_Result_060424.xls
TEG-025	Attendance list 3rd Flex-TEG_060424.pdf
TEG-026	DRAFT Minutes 3rd Flex-TEG
TEG-026-R1	Final_Minutes_3rd_Flex-TEG_MT_070402.pdf
TEG-027	ACEA_draft_comments_Flex-GT-alpha_060530.pdf
TEG-028	Chairperson_Answer_on_the_ACEA_draft_comments_Flex-GT-alpha_060606.pdf
TEG-029	Draft_Agenda_on_4th_Flex-TEG_Meeting_070316.pdf
TEG-029-R1	Final_Agenda_on_4th_Flex-TEG_Meeting_070402.pdf
TEG-030	Status_Report_on_Action_Items_070402.pdf
TEG-031	Development of an FE Biofidelic Flexible Pedestrian Legform Impactor Model (FLEX-GT-prototype Model)
TEG-032	Development of a Biofidelic Flexible Pedestrian Legform Impactor Type GT (FLEX-GT)
TEG-033	Information on Flexible Pedestrian Legform Impactor Type GT (FLEX-GT)
TEG-034	Flexible Pedestrian Legform Impactor Type GT (FLEX-GT) Evaluation Test Results
TEG-035	Flexible Pedestrian Legform Impactor Type GT (FLEX-GT) Car Test Results
TEG-036	Flex-GT-alpha BAsT/ACEA Tests
TEG-037	Handling and Usage (Flex-GT-alpha)
TEG-038	Certification Histories (Flex-GT-alpha)
TEG-039	ACEA Preliminary Test Results with FlexPLI-alpha
TEG-040	Attendance list of 4th Flex-TEG meeting
TEG-041	Draft minutes of 4th Flex-TEG meeting

<i>Number of working paper</i>	<i>Title of Flex TEG document</i>
TEG-041-Rev.1	Finalized_the_4th_Flex-TEG_Meeting_Minutes_071207
TEG-042	FlexPLI Comments ACEA 20070808 TFPapproved
TEG-043	ACEA/BASt Joint Project Report on Tests with the Flexible Pedestrian Legform Impactors Flex GT alpha and Flex GT
TEG-044	5th_Flex-TEG_Meeting_DRAFT_Agenda
TEG-044-Rev.1	Revised 5th Flex-TEG Meeting DRAFT Agenda_071204
TEG-044-Rev.2	Finalized 5th Flex-TEG Meeting Agenda 071207
TEG-045	J-MLIT Flex-GT Simplified Car Test Results 071129
TEG-045-Rev.1	J-MLIT Flex-GT Simplified Car Test Results 080331
TEG-046	JAMA-JARI Answer for the ACEA Comments Sep 2007 071129
TEG-047	Flex-GT Full Calibration Test Procedures 071129
TEG-048	Review of Injury Criteria and Thresholds for Flex 071129
TEG-049	Evaluation of Protection Level Provided by Flex-PLI 071129
TEG-050	Status of Action Items 071130
TEG-051	BAST/ACEA Joint Project Preliminary Report on Flex-GT Repeatability and Reproducibility of Assembly Certification and inverse test results
TEG-052	FTSS Design Review of Flex-GT and FLEX-GTR Development dec14-07
TEG-053	Draft Minutes of the 5th Flex-TEG Meeting, 080124
TEG-053-Rev.1	Final Minutes of the 5th Flex-TEG Meeting, 080331
TEG-054	Flex-GTR_Mechanical_Design_080229
TEG-054-Rev.1	Flex-GTR_Mechanical_Design_080331
TEG-055	Flex-GTR_Instrumentation_Electrical_Design_080229
TEG-055-Rev.1	Flex-GTR_Instrumentation_Electrical_Design_080331
TEG-056	Flex-GTR_Full_Calibration_Test_Procedure_080229
TEG-056-Rev.1	Flex-GTR_Full_Calibration_Test_Procedure_080331
TEG-057	Flex-GTR_Optional_Instrumentation_080304
TEG-057-Rev.1	Flex-GTR_Optional_Instrumentation_080327
TEG-058	M=BUS_Onboard_DAS_Information_080305
TEG-058-Rev.1	M=BUS_Onboard_DAS_Information_080331
TEG-059	Slice_Onboard_DAS_Information_080331
TEG-060	Draft_Agenda_6th_Flex-TEG_Meeting_080314

<i>Number of working paper</i>	<i>Title of Flex TEG document</i>
TEG-060-Rev.1	Final_Agenda_6th_Flex-TEG_Meeting_080331
TEG-061	Status of the Action Items_080331
TEG-062	BASSt Proposal for a Full Assembly Certification Test_080331
TEG-063	NHTSA_Flex-GT_Test_summary_080331
TEG-064	NHTSA_Flex-GT_Certification_Tests_080331
TEG-065	NHTSA_Design_Upper_Body_Mass_080331
TEG-066	TIPS_for_Measurement_Cable_Repairment_080331
TEG-067	Repeatability_of_Dynamic_Assembly_Test_Stopper_Material_080331
TEG-068	Draft Minutes of the 6th Flex-TEG Meeting
TEG-068-Rev.1	Finalized_Minutes_of_the_6th_Flex-TEG_Meeting_081208
TEG-069	Draft_Agenda_7th_Flex-TEG_Meeting_081208
TEG-069-Rev.1	Finalized_Agenda_7th_Flex-TEG_Meeting_081208
TEG-070	Status_Action_Items_081208
TEG-070-Rev.1	Finalized_Status_Action_Items_081208
TEG-071	FTSS_Flex_GTR_prototype_Development_071208
TEG-071-Add.1	Bone_Core_Durability_Improvement_081208
TEG-071-Add.2	Develop_Dynamic_Assy_Calibration_Test_Methods
TEG-072	Japan_Flex-GTR-prototye_Evaluation_Report
TEG-072-Rev1	Japan_Flex-GTR-prototye_Evaluation_Test Result
TEG-073	MESSRING_ISO_MME_corde_Flex_Proposal
TEG-073-Rev1	MESSRING_Suggest_ISO_MME_corde_Flex
TEG-074	FTSS_Flex_Pendulum_Dynamic_Calbration_Proposal
TEG-075	BASSt_Flex_Inverse_Dynamic_Calibration_Proposal
TEG-076	JAMA_Proposal_MCL_Threshod_Value
TEG-077	JAMA_Proposal_Tibia_Threshod_Value
TEG-078	BASSt_Proposal_ACL-PCL-MCL_Threshod_Value
TEG-079	JAMA_Proposal_Flex-GTR-prot_Evaluation_Schedule
TEG-080	J-MLIT proposal for the Flex-TEG working schedule
TEG-081	JAMA_Flesh_Sensitivity_TRL_Flex
TEG-082	BASSt_Flesh_Sensitivity_TRL



<i>Number of working paper</i>	<i>Title of Flex TEG document</i>
TEG-083	Draft Minutes of the 7th Flex-TEG Meeting
TEG-083-Rev1	Finalized_Minutes_7th_Flex-TEG_Meeting
TEG-084	JAMA_Proposal_Tibia_Injury_Criteria
TEG-085	Draft_Agenda_8th_Flex-TEG_Meeting
TEG-085-Rev1	Finalized_Agenda_8th_Flex-TEG_Meeting
TEG-086	Draft_Status_Report_Action_Items
TEG-086-Rev1	Finalized_Status_Report_Action_Items
TEG-087	JAMA-JARI_L-R_Symetric_Bumper_Corner_Test_0903011
TEG-088	JAMA_Flex-GTR-proto_Round_Robin_Test
TEG-089	BASt_BGS_Flex_Test_Report
TEG-090	ACEA_Summary
TEG-091	Opel_Report
TEG-092	FTSS_Proposal
TEG-093	JAMA-JARI_Study_for_Inverse_Test_090517
TEG-094	BASt_Tentative_Corridor_Inverse_Test
TEG-095	JAMA_Investigation_Human_MCL_Injury_Criteria
TEG-096	Correlation_Flex-GTR-proto_and_Human_Lower_Limb_Output
TEG-097	JAMA_Proposal_Flex-GTR-proto_Tibia_MCL_Threshold
TEG-098	BASt_Proposal_Flex-GTR-proto_Tibia_Threshold
TEG-099	Evaluation_Test_Schedule_Flex-GTR-proto
TEG-100	DRAFT_Minutes_8th_Flex-TEG_Meeting_090812
TEG-100-Rev.1	Final: 8th Flex-TEG Minutes
TEG-101	DRAFT: 9th Flex-TEG Agenda
TEG-101-Rev.1	Final: 9th Flex-TEG Agenda
TEG-102	Review of Dynamic Calibration Corridor Making Method
TEG-103	DRAFT: Status of Action Items
TEG-103-Rev.1	Final: Status of Action Items
TEG-104	Pushing surface Information for Flex-GTR-prototype for Flex-GTR-prototype
TEG-105	JAMA Round Robin Test Results Flex-GTR-prototype (SN03)
TEG-106	ACEA Comments, 9th TEG meeting

<i>Number of working paper</i>	<i>Title of Flex TEG document</i>
TEG-107	9th Flex-TEG Meeting Discussion Results of day 1
TEG-108	Refinement of (tentative) Certification Corridors for the Dynamic Full Assembly (Inverse) Certification Test Procedure
TEG-109	DRAFT: 9th Flex-TEG Minutes
TEG-109-Rev.1	Final: 9th Flex-TEG Minutes
TEG-110	DRAFT: 10th Flex-TEG Agenda
TEG-110-Rev.1	Final: 10th Flex-TEG Agenda
TEG-111	DRAFT: Status of Action Items
TEG-111-Rev.1	Final: Status of Action Items
TEG-112	Flex-GTR Testing, NHTSA
TEG-113	KATRI Round Robin Tests Using the Flex-GTR-Prototype (SN03)
TEG-114	ACEA Comments, 10th Flex-TEG Meeting
TEG-115	Influence of Test Parameter Variations on The Flex GTR Joint Project of ACEA and BAST
TEG-116	Impact Parameter Tolerances for Inverse Certification Test and Vehicle Testing, BAST
TEG-117	Minor updates and pusher plate discussion for Flex Pli GTR, FTSS
TEG-118	General Status from FLEX Pli GTR Model Consortium, FTSS
TEG-119	Finalization of Impact and Assessment Conditions for Inverse Certification Test, BAST
TEG-120	Requirement Corridor (BAST-Method) for Pendulum Type (Type 3) Dynamic Calibration Test Method, JAMA-JARI
TEG-121	Flex-GTR Flesh Dimensions and Mass Tolerance, JAMA-JARI with FTSS communications
TEG-122	Flex-GTR (Mass, COG, Inertia) Tolerances , JAMA-JARI with FTSS communications
TEG-123	SLICE Updates for FLEX-GTR, DTS
TEG-124	DRAFT Minutes 10th Flex-PLI Technical Evaluation Group (Flex-TEG) Meeting
TEG-124-Rev.1	Finalized Minutes 10th Flex-PLI Technical Evaluation Group (Flex-TEG) Meeting
TEG-125	Draft Agenda 11th Flex-PLI Technical Evaluation Group (Flex-TEG) Meeting

<i>Number of working paper</i>	<i>Title of Flex TEG document</i>
TEG-125-Rev.1	<b>Finalized Agenda 11th Flex-PLI Technical Evaluation Group (Flex-TEG) Meeting</b>
TEG-126	<b>Status Report on Action Items at 11th Flex-TEG meeting</b>
TEG-127	<b>Technical Background Information Document for the UN-ECE GRSP explaining the Derivation of Threshold Values and Impactor Certification methods for the FlexPLI version GTR agreed by the FlexPLI-TEG at their 9th Meeting</b>
TEG-128	<b>ACEA; Injury values : impact vs rebound</b>
TEG-129	<b>ACEA Comments</b>
TEG-130	<b>BASt; Flex-GTR: Proposal for ACL/PCL injury threshold</b>
TEG-131	<b>TEG Agreement on the Tibia and ACL Issues (Finalized)</b>
TEG-132	<b>FTSS; Flex PLI Catch Rope and Bracket Proposal</b>
TEG-133	<b>FTSS; 400 Nm Tibia Gage Loading Results</b>
TEG-134	<b>FTSS; FLEX PLI GTR Model development status</b>

**A list of working papers used by the IG GTR9-PH2 group is available on the UNECE WP.29 website:**

**<https://www2.unece.org/wiki/pages/viewpage.action?pageId=3178637>**

<i>Number of working paper</i>	<i>Title of IG GTR9-PH2 document</i>
<b>GTR9-C-01</b>	<b>Agenda for the constitutional meeting of the Informal Group on Pedestrian Safety Phase 2 (IG PS2)</b>
<b>GTR9-C-01-Rev.1</b>	<b>Final agenda of the Constitutional Meeting of the Informal Group on GTR No 9 - Phase 2 (IG GTR9-PH2) (Revised)</b>
<b>GTR9-C-02</b>	<b>Draft minutes of the Constitutional Meeting of the IG GTR9-PH2</b>
<b>GTR9-C-02 - Rev.1</b>	<b>Draft minutes of the Constitutional Meeting of the IG GTR9-PH2 (Revised)</b>
<b>GTR9-C-03</b>	<b>Draft Terms of Reference for the Informal Group on Pedestrian Safety Phase 2 (IG PS2)</b>
<b>...</b>	<b>This table will be finalized at the timing of the IG GTR9-PH2 work is completed.</b>

## B. Text of the regulation

Paragraph 5.1.1., amend to read:

"5.1.1. When tested in accordance with paragraph 7.1.1. (lower legform to bumper), the maximum dynamic medial collateral ligament elongation at the knee shall not exceed 22 mm, and the dynamic bending moments at the tibia shall not exceed 340 Nm. The maximum dynamic anterior cruciate ligament and posterior cruciate ligament elongation shall not exceed 13 mm. In addition, the manufacturer may nominate bumper test widths up to a maximum of 264 mm in total where the tibia bending moment shall not exceed 380 Nm. A Contracting Party may restrict application of the relaxation zone requirement in its domestic legislation if it decides that such restriction is appropriate.

~~When tested in accordance with paragraph 7.1.1. (lower legform to bumper), 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."~~

Paragraph 6.3.1.1., amend to read:

"6.3.1.1. **Flexible lower** ~~Lower~~ legform impactor:"

The **Flexible lower legform impactor** shall consist of flesh, flexible long bone segments (representing femur and tibia), and a knee joint as shown in Figure 12.

The overall length of the impactor shall be  $928 \pm 3$  mm, having a required mass of  $13.2 \pm 0.7$  kg including flesh. The length of the femur, knee joint, and tibia shall be  $339 \pm 2$  mm,  $185 \pm 1$  mm, and  $404 \pm 2$  mm respectively. The knee joint centre position shall be  $94 \pm 1$  mm from the top of the knee joint.

Brackets, pulleys, protectors, connection parts, etc. attached to the impactor for the purpose of launching and/or protecting may extend beyond the dimensions shown in Figure 12 and Figure 13.

~~The lower legform impactor shall consist of two foam covered rigid segments, representing femur (upper leg) and tibia (lower leg), joined by a deformable, simulated knee joint. The overall length of the impactor shall be  $926 \pm 5$  mm, having a required test mass of  $13.4 \pm 0.2$  kg (see Figure 12).~~

~~Brackets, pulleys, etc. attached to the impactor for the purpose of launching it, may extend the dimensions shown in Figure 12.~~

6.3.1.1.1. The cross-sectional shape perpendicular to the Z-axis of the femur and tibia main bodies shall be  $90 \pm 2$  mm in width along the Y-axis, and  $84 \pm 1$  mm in width along the X-axis as shown in Figure 13 (a). The impact face shall be  $30 \pm 1$  mm in radius,  $30 \pm 1$  mm in width along the Y-axis, and  $48 \pm 1$  mm in width along the X-axis as shown in Figure 13 (a).

~~The diameter of the femur and tibia shall be  $70 \pm 1$  mm and both shall be covered by foam flesh and skin. The foam flesh shall be 25 mm thick foam type CF 45 or equivalent. The skin shall be made of neoprene foam, faced with 0.5 mm thick nylon cloth on both sides, with an overall thickness of 6 mm.~~

- 6.3.1.1.2. **The cross-sectional shape perpendicular to the Z-axis of the knee joint shall be  $108 \pm 2$  mm in width along the Y-axis, and  $118 \pm 1$  mm in width along the X-axis as shown in Figure 13 (b). The impact face shall be  $103 \pm 1$  mm in radius,  $12 \pm 1$  mm in width along the Y-axis, and  $86 \pm 1$  mm in width along the X axis as shown in Figure 13 (b).**

~~The knee joint shall be fitted with deformable knee elements from the same batch as those used in the certification tests.~~

- 6.3.1.1.3. **The masses of the femur and tibia without flesh, including the connection part to the knee joint, shall be  $2.46 \pm 0.12$  kg and  $2.64 \pm 0.13$  kg respectively. The mass of the knee joint without flesh shall be  $4.28 \pm 0.21$  kg. The total mass of the femur, knee joint and tibia shall be  $9.38 \pm 0.47$  kg.**

**The centre of gravity of the femur and tibia without flesh, including the connection part to the knee joint, shall be  $159 \pm 8$  mm and  $202 \pm 10$  mm respectively from the top, but not including the connection part to the knee joint, of each part as shown in Figure 12. The centre of gravity of the knee shall be  $92 \pm 5$  mm from the top of the knee joint as shown in Figure 12.**

**The moment of inertia of the femur and tibia without flesh, including the connection part inserted to the knee joint, about the X-axis through the respective centre of gravity shall be  $0.0325 \pm 0.0016$  kg m<sup>2</sup> and  $0.0467 \pm 0.0023$  kgm<sup>2</sup> respectively. The moment of inertia of the knee joint about the X axis through the respective centre of gravity shall be  $0.0180 \pm 0.0009$  kg m<sup>2</sup>.**

~~The total masses of the femur and tibia shall be  $8.6 \pm 0.1$  kg and  $4.8 \pm 0.1$  kg respectively, and the total mass of the impactor shall be  $13.4 \pm 0.2$  kg. The centre of gravity of the femur and tibia shall be  $217 \pm 10$  mm and  $233 \pm 10$  mm from the centre of the knee respectively. The moment of inertia of the femur and tibia, about a horizontal axis through the respective centre of gravity and perpendicular to the direction of impact, shall be  $0.127 \pm 0.010$  kgm<sup>2</sup> and  $0.120 \pm 0.010$  kgm<sup>2</sup> respectively.~~

- 6.3.1.1.4. **For each test, the impactor (femur, knee joint, and tibia) shall be covered by flesh composed of synthetic rubber sheets (R1, R2) and neoprene sheets (N1F, N2F, N1T, N2T, N3) as shown in Figure 14. The sheets are required to have a compression characteristic as shown in Figure 15. The compression characteristic shall be checked using the same batch of sheets as those used for the impactor flesh. The size of the sheets shall be within the requirements described in Figure 15.**

~~For each test the impactor shall be fitted with new foam flesh cut from one of up to four consecutive sheets of foam type CF 45 flesh material or equivalent, produced from the same batch of manufacture (cut from one block or 'bun' of foam), provided that foam from one of these sheets was used in the dynamic certification test and the individual weights of these sheets are within  $\pm 2$  percent of the weight of the sheet used in the certification test.~~

- 6.3.1.1.5. **The test impactor or at least the flesh shall be stored for at least four hours in a controlled storage area with a stabilized temperature of  $20 \pm 2^\circ\text{C}$  prior to impactor removal for calibration. After removal from the storage, the impactor shall not be subjected to conditions other than those pertaining in the test area.**

~~The test impactor or at least the foam flesh shall be stored during a period of at least four hours in a controlled storage area with a stabilized humidity of 35 percent  $\pm$  15 percent and a stabilized temperature of  $20 \pm 4^\circ\text{C}$  prior to impactor removal for calibration. After removal from the storage the impactor shall not be subjected to conditions other than those pertaining in the test area.~~

- 6.3.1.1.6. Lower legform instrumentation

- 6.3.1.1.6.1. **Four transducers shall be installed in the tibia to measure bending moments applied to the tibia. The sensing locations of each of the transducers are as follows: tibia-1:  $134 \pm 1$  mm, tibia-2:  $214 \pm 1$  mm, tibia-3:  $294 \pm 1$  mm and tibia-4:  $374 \pm 1$  mm below the knee joint centre respectively as shown in Figure 16. The measurement axis of each transducer shall be the X-axis of the impactor.**

~~A uniaxial accelerometer shall be mounted on the non impacted side of the tibia,  $66 \pm 5$  mm below the knee joint centre, with its sensitive axis in the direction of impact.~~

- 6.3.1.1.6.2. **Three transducers shall be installed in the knee joint to measure elongations of the medial collateral ligament (MCL), anterior cruciate ligament (ACL), and posterior cruciate ligament (PCL). The measurement locations of each transducer are shown in Figure 16. The measurement locations shall be within  $\pm 4$  mm along the X-axis from the knee joint centre.**

~~A damper shall be fitted to the shear displacement system and may be mounted at any point on the rear face of the impactor or internally. The damper properties shall be such that the impactor meets both the static and dynamic shear displacement requirements and prevents excessive vibrations of the shear displacement system.~~

- 6.3.1.1.6.3. **The instrumentation response value channel frequency class (CFC), as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 400 Nm for the tibia bending moments. This does not require that the impactor itself be able to physically elongate or bend until these values.**

~~Transducers shall be fitted to measure knee bending angle and knee shearing displacement.~~

- 6.3.1.1.6.4. **The measurements for the **Flexible lower legform impactor** shall be taken only for the major impact with the vehicle prior to the rebound phase. All maxima occurring during or after the rebound phase shall be ignored. For example, the zero crossing after the maximum of the MCL elongation or of the tibia bending moments shall be considered as the end of the major impact with the vehicle.**

~~The instrumentation response value channel frequency class (CFC), as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC~~

~~response values, as defined in ISO 6487:2002, shall be 50° for the knee bending angle, 10 mm for the shearing displacement and 500g for the acceleration. This does not require that the impactor itself be able to physically bend and shear to these angles and displacements.~~

- 6.3.1.1.7. **Flexible lower legform impactor** ~~Lower legform certification~~
- 6.3.1.1.7.1. The **Flexible lower legform impactor** ~~lower legform~~ shall meet the performance requirements specified in paragraph 8.
- 6.3.1.1.7.2. **The impactor shall be certified according to the inverse type dynamic certification test described in paragraph 8.1.3. After the initial inverse type dynamic certification test, the certified impactor shall be re-certified according to the pendulum type dynamic certification test described in paragraph 8.1.2. after every 10 vehicle tests, except that the inverse type dynamic certification test will be repeated instead after every 30 vehicle tests.**

~~The certified impactor may be used for a maximum of 20 impacts before re-certification. With each test new plastically deformable knee elements should be used. The impactor shall also be re-certified if more than one year has elapsed since the previous certification, if any impactor transducer output, in any impact, has exceeded the specified CAC or has reached the mechanical limits of the leg impactor deformation capability."~~

Delete Figures 12, to read:

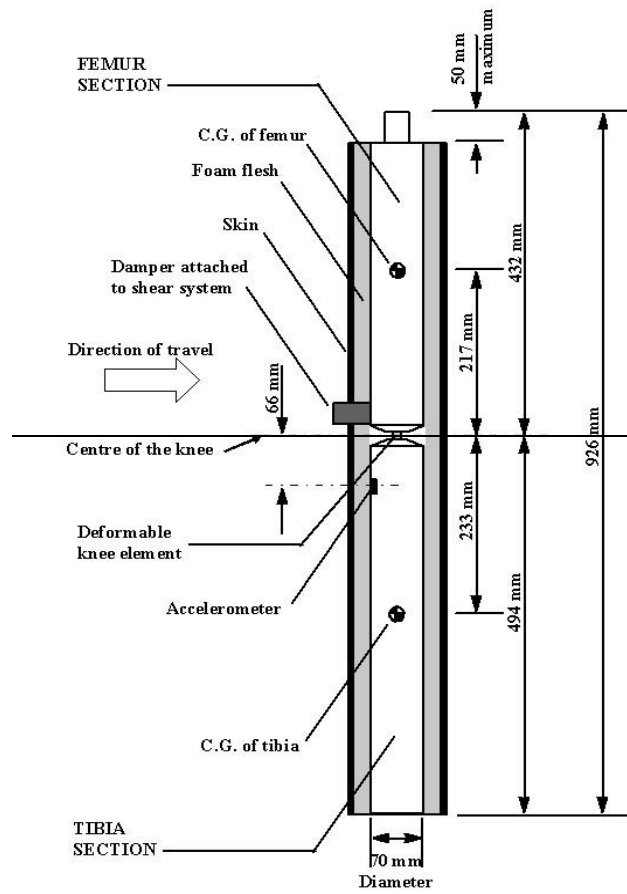
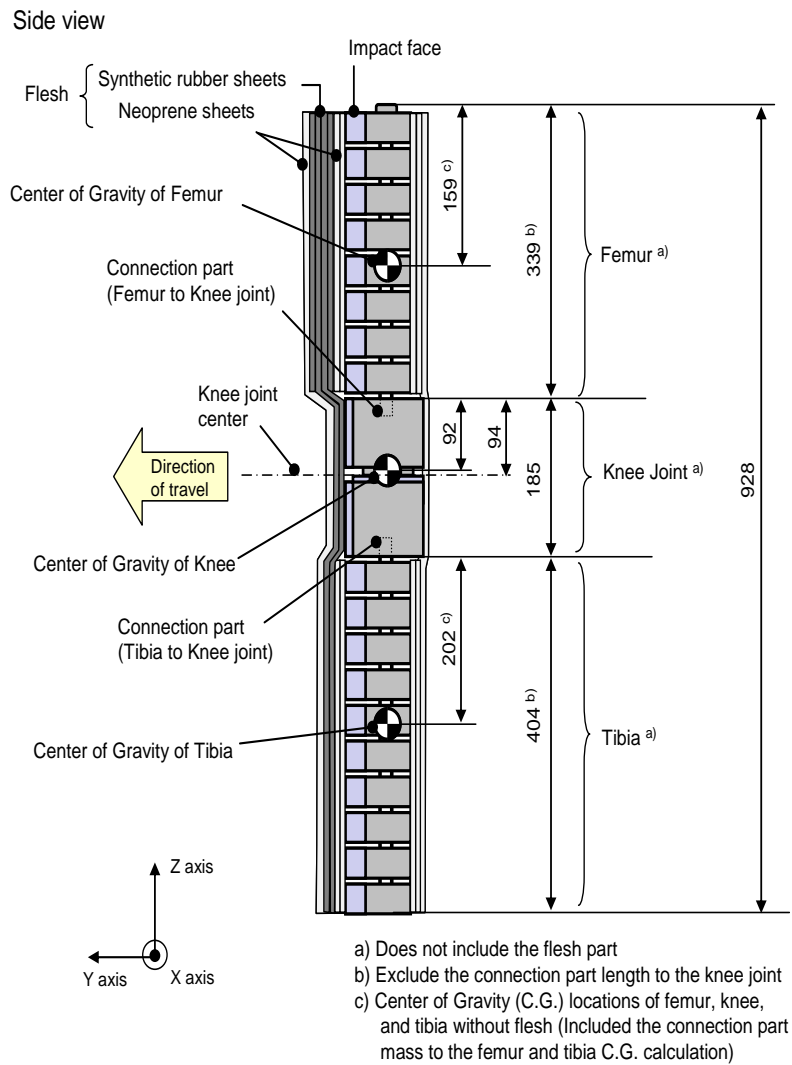


Figure 12: Lower legform impactor (see paragraph 6.3.1.1.)



Insert new Figures 12 to 16, to read:

"



**Figure 12 Flexible lower legform impactor; Dimensions and C.G. locations of femur, knee joint and tibia (Side view)**

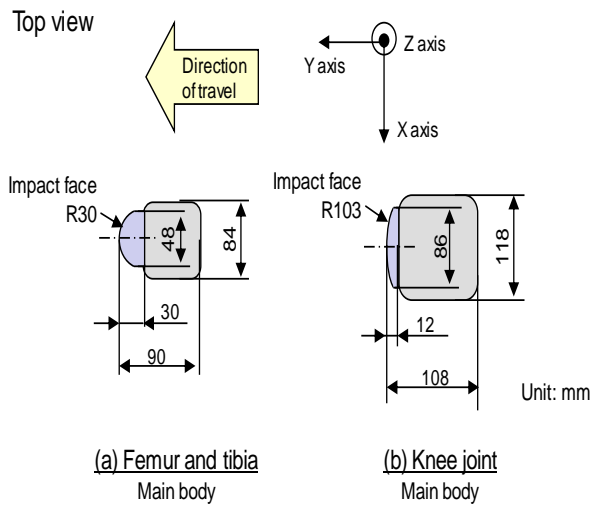


Figure 13 Flexible lower legform impactor; femur, tibia, and knee dimensions (Top view)

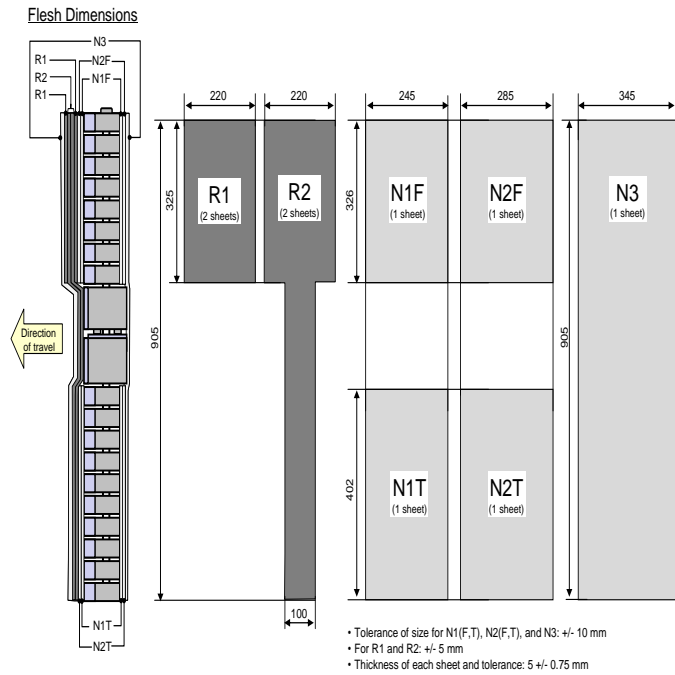
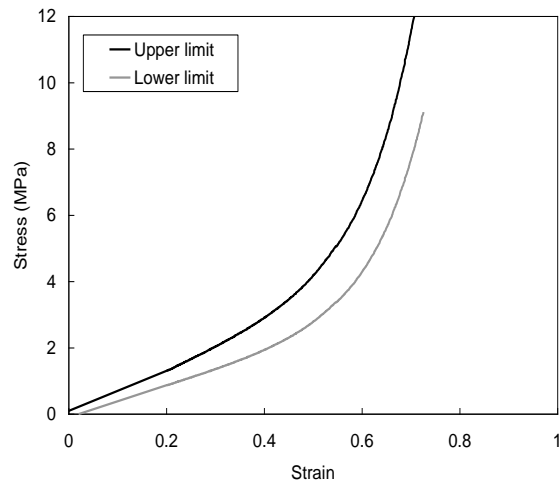
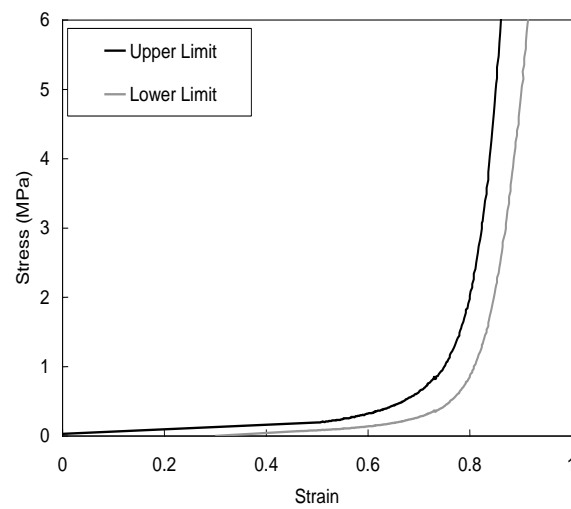


Figure 14 Flexible lower legform impactor; flesh dimensions

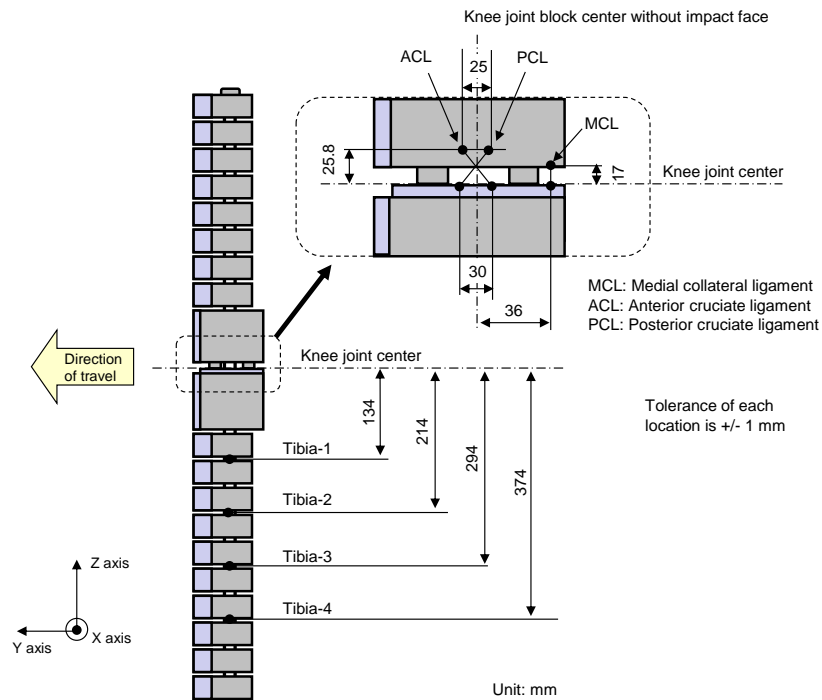


(a) Synthetic rubber sheets



(b) Neoprene sheets

Figure 15 Flexible lower legform impactor; flesh compression characteristics



**Figure 16 Flexible lower legform impactor; instrument locations**

Paragraph 6.3.1.2., amend to read:

"..., foam covered at the impact side, and  $350 \pm 5$  mm long (see Figure ~~1317~~)." "

Paragraph 6.3.1.2.9.1., amend to read:

"...in three positions, as shown in Figure ~~1317~~, each using a separate channel. ...." "

Paragraph 6.3.1.2.9.2., amend to read:

"...at positions 50 mm either side of the centre line (see Figure ~~1317~~)." "

Title of Figure 13(former), renumber as Figure 17.

Paragraph 6.3.2.1., amend to read:

"6.3.2.1. Child headform impactor (see Figure ~~1418~~)

The child....."

Paragraph 6.3.2.1.1., amend to read:

"6.3.2.1.1. ... axis perpendicular to the mounting face A (see Figure ~~1418~~) and ..."

Figure 14 (former), renumber as Figure 18.

Paragraph 6.3.2.2., amend to read:

"6.3.2.2. Adult headform impactor (see Figure ~~1519~~)

The adult ... as shown in Figure ~~1519~~. The mass ..."

Figure 15 (former), renumber as Figure 19.

Paragraph 6.3.2.2.1., amend to read:

"6.3.2.2.1. ... axis perpendicular to the mounting face A (see Figure 1519) and ..."

Figure 16 (former), renumber as Figure 20.

Paragraphs 7.1.1. to 7.1.1.4., amend to read:

"7.1.1. **Flexible lower legform impactor** ~~Lower legform~~ 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.

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

7.1.1.2. **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  $\pm 2^\circ$  at the time of first contact. The axis of the impactor shall be perpendicular to the horizontal plane, with a roll and pitch angle tolerance of  $\pm 2^\circ$  in the lateral and longitudinal plane. The horizontal, longitudinal and lateral planes are orthogonal to each other (see Figure 20).**

~~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  $\pm 2^\circ$  at the time of first contact. The axis of the impactor shall be perpendicular to the horizontal plane with a tolerance of  $\pm 2^\circ$  in the lateral and longitudinal plane. The horizontal, longitudinal and lateral planes are orthogonal to each other (see Figure 16).~~

7.1.1.3. **The bottom of the impactor shall be at 75 mm above ground reference plane at the time of first contact with the bumper (see Figure 21), with a  $\pm 10$  mm tolerance. 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.**

~~The bottom of the impactor shall be at 25 mm above ground reference plane at the time of first contact with the bumper (see Figure 17), with a  $\pm 10$  mm tolerance. 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.~~

7.1.1.3.1. **The lower legform impactor for the bumper tests shall be in 'free flight' at the moment of impact. The impactor shall be released to free flight at such a distance from the vehicle that the test results are not influenced by contact of the impactor with the propulsion system during rebound of the impactor.**

**The impactor may be propelled by any means that can be shown to meet the requirements.**

~~The lower legform impactor for the bumper tests shall be in 'free flight' at the moment of impact. The impactor shall be released to free flight at such a distance from the vehicle that the test results are not influenced by contact of the impactor with the propulsion system during rebound of the impactor.~~

~~The impactor may be propelled by an air, spring or hydraulic gun, or by other means that can be shown to give the same result.~~

- 7.1.1.3.2. **At the time of first contact the impactor shall have the intended orientation about its vertical axis, for the correct operation of its knee joint, with a yaw angle tolerance of  $\pm 5^\circ$  (see Figure 20).**

~~At the time of first contact the impactor shall have the intended orientation about its vertical axis, for the correct operation of its knee joint, with a tolerance of  $\pm 5^\circ$  (see Figure 16).~~

- 7.1.1.3.3. At the time of first contact the centre line of the impactor shall be within a  $\pm 10$  mm tolerance of the selected impact location.

- 7.1.1.3.4. During contact between the impactor and the vehicle, the impactor shall not contact the ground or any object which is not part of the vehicle.

- 7.1.1.4. The impact velocity of the impactor when striking the bumper shall be  $11.1 \pm 0.2$  m/s. The effect of gravity shall be taken into account when the impact velocity is obtained from measurements taken before the time of first contact."

Figures 17(former), renumber as Figure 21 and amend to read:

"

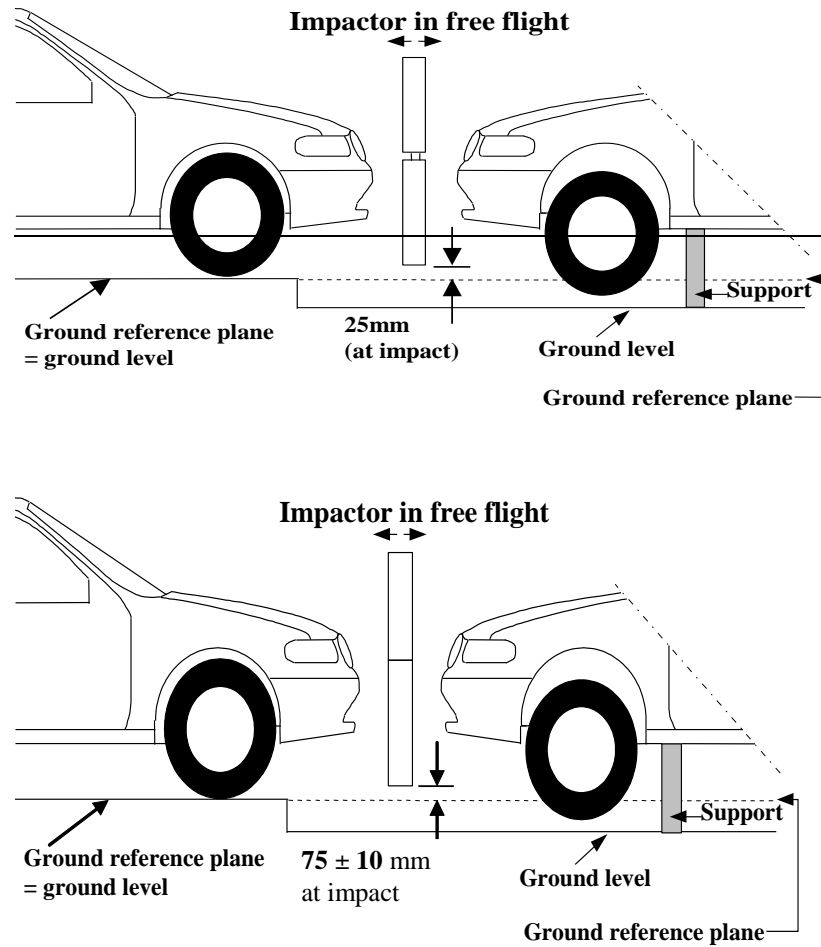


Figure 21 **Flexible lower legform impactor** Lower legform to bumper tests for complete vehicle in normal ride attitude (left) and for cut-body mounted on supports (right) (see paragraph 7.1.1.3.) "

Paragraphs 8.1. to 8.1.3.4.4., to read:

"8.1. **Flexible lower legform impactor** ~~Lower legform impactor~~ certification

8.1.1. Static certification tests

8.1.1.1. The femur and tibia of the **Flexible lower legform impactor** shall meet the requirements respectively specified in paragraph 8.1.1.2. when tested as specified in paragraph 8.1.1.4. The knee joint of the lower legform impactor shall meet the requirements specified in paragraph 8.1.1.3. when tested as specified in paragraph 8.1.1.5. The stabilized temperature of the impactor during the certification tests shall be  $20^{\circ} \pm 2^{\circ}\text{C}$ .

The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 4 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.

~~The lower legform impactor shall meet the requirements specified in paragraph 8.1.1.2. when tested as specified in paragraph 8.1.1.4. and the requirements specified in paragraph 8.1.1.3. when tested as specified in paragraph 8.1.1.5.~~

~~For both tests the impactor shall have the intended orientation about its longitudinal axis, for the correct operation of its knee joint, with a tolerance of  $\pm 2^{\circ}$ .~~

~~The stabilized temperature of the impactor during certification shall be  $20^{\circ} \pm 2^{\circ}\text{C}$ .~~

~~The CAC response values, as defined in ISO 6487:2002 shall be  $50^{\circ}$  for the knee bending angle and 500 N for the applied force when the impactor is loaded in bending in accordance with paragraph 8.1.1.4., and 10 mm for the shearing displacement and 10 kN for the applied force when the impactor is loaded in shearing in accordance with paragraph 8.1.1.5. For both 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.~~

8.1.1.2. When the femur and tibia of the impactor are loaded in bending in accordance with paragraph 8.1.1.4., the applied moment and generated deflection at the centre of the femur and tibia ( $M_c$  and  $D_c$ ) shall be within the corridors shown in Figure 22.

~~When the impactor is loaded in bending in accordance with paragraph 8.1.1.4., the applied force/bending angle response shall be within the limits shown in Figure 18. Also, the energy taken to generate  $15.0^{\circ}$  of bending shall be  $100 \pm 7\text{J}$ .~~

8.1.1.3. When the knee joint of the impactor is loaded in bending in accordance with paragraph 8.1.1.5., the MCL, ACL, and PCL elongations and applied bending moment or force at the centre of the knee joint ( $M_c$  or  $F_c$ ) shall be within the corridors shown in Figure 23.

~~When the impactor is loaded in shearing in accordance with paragraph 8.1.1.5., the applied force/shearing displacement response shall be within the limits shown in Figure 19.~~



- 8.1.1.4. **The edges of the femur and tibia, not bending parts, shall be mounted to the support rig firmly as shown in Figure 24 and Figure 25. The Y-axis of the impactor shall be parallel to the loading axis within  $180 \pm 2^\circ$  tolerance. In order to avoid friction errors, roller plates shall be set underneath the support rigs.**

**The centre of the loading force shall be applied at the centre of the femur and tibia within  $\pm 2^\circ$  tolerance along the Z-axis. The force shall be increased at a rate between 10 and 100 mm/minute until the bending moment at the centre part ( $M_c$ ) of the femur or tibia reaches 400 Nm.**

~~The impactor, without foam covering and skin, shall be mounted with the tibia firmly clamped to a fixed horizontal surface and a metal tube connected firmly to the femur, as shown in Figure 20. The rotational axis of impactor knee joint shall be vertical. To avoid friction errors, no support shall be provided to the femur section or the metal tube. The bending moment applied at the centre of the knee joint, due to the mass of the metal tube and other components (excluding the legform itself), shall not exceed 25 Nm.~~

~~A horizontal normal force shall be applied to the metal tube at a distance of  $2.0 \pm 0.01$  m from the centre of the knee joint and the resulting angle of knee deflection shall be recorded. The load shall be increased at a rate between 1.0 and  $10^\circ/s$  until the angle of deflection of the knee is in excess of  $22^\circ$ . Brief excursions from these limits due, for instance, to the use of a hand pump shall be permitted.~~

~~The energy is calculated by integrating the force with respect to the bending angle in radians, and multiplying by the lever length of  $2.0 \pm 0.01$  m.~~

- 8.1.1.5. **The edges of the knee joint, not bending parts, shall be mounted to the support rig firmly as shown in Figure 26. The Y-axis of the impactor shall be parallel to the loading axis within  $180 \pm 2^\circ$ . In order to avoid friction errors, roller plates shall be set underneath the support rigs. To avoid impactor damage, a neoprene sheet shall be set underneath the loading ram and the impactor face of the knee joint which is described in the Figure 13 shall be removed. The neoprene sheet used in this test shall have compression characteristics as shown in Figure 15.**

**The centre of the loading force shall be applied at the centre of the knee joint within  $\pm 2^\circ$  tolerance along the Z-axis. The external load shall be increased at a rate between 10 and 100 mm/minute until the bending moment at the centre part of the knee joint ( $M_c$ ) reaches 400 Nm.**

~~The impactor, without foam covering and skin, shall be mounted with the tibia firmly clamped to a fixed horizontal surface and a metal tube connected firmly to the femur and restrained at 2.0 m from the centre of the knee joint, as shown in Figure 21.~~

~~A horizontal normal force shall be applied to the femur at a distance of 50 mm from the centre of the knee joint and the resulting knee shearing displacement shall be recorded. The load shall be increased between 0.1 and 20 mm/s until the shearing displacement of the knee is in excess of 7.0 mm or the load is in excess of 6.0 kN. Brief excursions from these limits due, for instance, to the use of a hand pump shall be permitted.~~

- 8.1.2. **Dynamic certification tests (pendulum type)**

8.1.2.1. The **Flexible lower legform impactor** lower legform impactor (femur, knee joint and tibia are connected/assembled firmly) shall meet the requirements specified in paragraph 8.1.2.3. when tested as specified in paragraph 8.1.2.4.

8.1.2.2. Certification

8.1.2.2.1. **The test facility used for the certification test shall have a stabilized temperature of  $20 \pm 2$  °C during certification.**

~~The foam flesh for the test impactor shall be stored during a period of at least four hours in a controlled storage area with a stabilized humidity of  $35 \pm 10$  percent and a stabilized temperature of  $20 \pm 2$ °C prior to impactor removal for calibration. The test impactor itself shall have a temperature of  $20 \pm 2$ °C at the time of impact. The temperature tolerances for the test impactor shall apply at a relative humidity of  $40 \pm 30$  percent after a soak period of at least four hours prior to their application in a test.~~

8.1.2.2.2. **The temperature of the certification area shall be measured at the time of certification and recorded in a certification report.**

~~The test facility used for the calibration test shall have a stabilized humidity of  $40 \pm 30$  percent and a stabilized temperature of  $20 \pm 4$ °C during calibration.~~

~~8.1.2.2.3. Each calibration shall be completed within two hours of when the impactor to be calibrated is removed from the controlled storage area.~~

~~8.1.2.2.4. Relative humidity and temperature of the calibration area shall be measured at the time of calibration and recorded in a calibration report.~~

8.1.2.3. Requirements

8.1.2.3.1. **When the **Flexible lower legform impactor** is used for a test as specified in paragraph 8.1.2.4., the maximum bending moment of the tibia at tibia-1 shall be not more than 272 Nm and not less than 235 Nm, the maximum bending moment at tibia-2 shall be not more than 219 Nm and not less than 187 Nm, the maximum bending moment at tibia-3 shall be not more than 166 Nm and not less than 139 Nm, and the maximum bending moment at tibia-4 shall be not more than 111 Nm and not less than 90 Nm. The maximum elongation of MCL shall be not more than 24.0 mm and not less than 20.5 mm, the maximum elongation of ACL shall be not more than 10.5 mm and not less than 8.0 mm, and the maximum elongation of PCL shall be not more than 5.0 mm and not less than 3.5 mm.**

**For all these values, the readings used shall be from the initial impact timing to 250 ms after the impact timing.**

~~When the impactor is impacted by a linearly guided certification impactor, as specified in paragraph 8.1.2.4., the maximum upper tibia acceleration shall be not less than 120g and not more than 250g. The maximum bending angle shall be not less than 6.2° and not more than 8.2°. The maximum shearing displacement shall be not less than 3.5 mm and not more than 6.0 mm.~~

~~For all these values, the readings used shall be from the initial impact with the certification impactor and not from the arresting phase. Any system used~~

~~to arrest the impactor or certification impactor shall be so arranged that the arresting phase does not overlap in time with the initial impact. The arresting system shall not cause the transducer outputs to exceed the specified CAC.~~

- 8.1.2.3.2. **The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 400 Nm for the tibia bending moments. This does not require that the impactor itself be able to physically elongate and bend to these values.]**

~~The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 50° for the knee bending angle, 10 mm for the shearing displacement and 500g for the acceleration. This does not require that the impactor itself be able to physically bend and shear to these angles and displacements.~~

- 8.1.2.4. Test procedure

- 8.1.2.4.1. **The Flexible lower legform impactor, including flesh, shall be suspended from the dynamic certification test rig  $15 \pm 1^\circ$  upward from the horizontal as shown in Figure 27. The impactor shall be released from the suspended position, whereupon the impactor falls freely against the pin joint of the test rig as shown in Figure 27.**

~~The impactor, including foam covering and skin, shall be suspended horizontally by three wire ropes of  $1.5 \pm 0.2$  mm diameter and of 2000 mm minimum length, as shown in Figure 22. It shall be suspended with its longitudinal axis horizontal, with a tolerance of  $\square 0.5^\circ$ , and perpendicular to the direction of the certification impactor motion, with a tolerance of  $\square 2^\circ$ . The impactor shall have the intended orientation about its longitudinal axis, for the correct operation of its knee joint, with a tolerance of  $\pm 2^\circ$ . The impactor must meet the requirements of paragraph 6.3.1.1., with the attachment bracket(s) for the wire ropes fitted.~~

- 8.1.2.4.2. **The knee joint centre of the impactor shall be  $30 \pm 1$  mm below the bottom line of the stopper bar, and the tibia impact face without flesh shall be located  $13 \pm 2$  mm from the front upper edge of the stopper bar when the impactor is hanging freely as shown in Figure 27.**

~~The certification impactor shall have a mass of  $9.0 \square 0.05$  kg, this mass includes those propulsion and guidance components which are effectively part of the impactor during impact. The dimensions of the face of the certification impactor shall be as specified in Figure 23. The face of the certification impactor shall be made of aluminium, with an outer surface finish of better than 2.0 micrometers.~~

~~The guidance system shall be fitted with low friction guides, insensitive to off axis loading, that allow the impactor to move only in the specified direction of impact, when in contact with the vehicle. The guides shall prevent motion in other directions including rotation about any axis.~~

- ~~8.1.2.4.3. The impactor shall be certified with previously unused foam.~~

- ~~8.1.2.4.4. The impactor foam shall not be excessively handled or deformed before, during or after fitting.~~

~~8.1.2.4.5. The certification impactor shall be propelled horizontally at a velocity of 7.5 ± 0.1 m/s into the stationary impactor as shown in Figure 23. The certification impactor shall be positioned so that its centreline aligns with a position on the tibia centreline of 50 mm from the centre of the knee, with tolerances of ± 3 mm laterally and ± 3 mm vertically.~~

### 8.1.3. Dynamic certification tests (inverse type)

8.1.3.1. The **Flexible lower legform impactor** with flesh (femur, knee joint, and tibia are connected/assembled firmly) shall meet the requirements specified in paragraph 8.1.3.3. when tested as specified in paragraph 8.1.3.4.

#### 8.1.3.2. Certification

8.1.3.2.1. The test facility used for the certification test shall have a stabilized temperature of  $20 \pm 2$  °C during certification.

8.1.3.2.3. The temperature of the certification area shall be measured at the time of certification and recorded in a certification report.

#### 8.1.3.3. Requirements

8.1.3.3.1. When the lower legform impactor is used for the test specified in paragraph 8.1.3.4., the maximum bending moment of the tibia at tibia-1 shall be not more than 272 Nm and not less than 230 Nm, the maximum bending moment at tibia-2 shall be not more than 252 Nm and not less than 210 Nm, the maximum bending moment at tibia-3 shall be not more than 192 Nm and not less than 166 Nm, and the maximum bending moment at tibia-4 shall be not more than 108 Nm and not less than 93 Nm. The maximum elongation of the MCL shall be not more than 21.0 mm and not less than 17.0 mm, that of the ACL shall be not more than 10.0 mm and not less than 8.0 mm, and that of the PCL shall be not more than 6.0 mm and not less than 4.0 mm.

For all these values, the readings used shall be from the initial impact timing to 50 ms after the impact timing.

8.1.3.3.2. The instrumentation response value CFC, as defined in ISO 6487:2002, shall be 180 for all transducers. The CAC response values, as defined in ISO 6487:2002, shall be 30 mm for the knee ligament elongations and 400 Nm for the tibia bending moments. This does not require that the impactor itself be able to physically elongate and bend to these values.

#### 8.1.3.4. Test procedure

8.1.3.4.1. The fully assembled lower legform impactor (with flesh and skin) shall be stationary suspended vertically from a test rig as shown in Figure 28. It is then impacted by the upper edge of a linearly guided Al honeycomb impactor, covered by a thin (less than 1 mm thickness) paper cloth, at an impact speed of  $11,1 \pm 0,2$  m/s. The legform is to be released from the test rig within 10 ms after the time of first contact to ensure a free flight condition.

8.1.3.4.2. The honeycomb of 5052 alloy, which is attached in front of the moving ram, shall have a crush strength of 75 psi ± 10 per cent and dimensions of  $l = 200 \pm 5$  mm,  $w = 160 \pm 5$  mm and  $d = 60 \pm 2$  mm. To ensure a consistent and good level of repeatability, the honeycomb should either have a 3/16 inch cell size or a 1/4 inch cell size. The honeycomb should

have a density of 2.0 pcf in combination with a 3/16 inch cell size or a density of 2.3 pcf in combination with a 1/4 inch cell size.

- 8.1.3.4.3.** The upper edge of the honeycomb face is to be in line with the rigid plate of the linearly guided impactor. At the time of first contact, the upper edge of the honeycomb is to be in line with the knee joint centre line within a vertical tolerance of  $0 \pm 2$  mm. The honeycomb shall not be deformed before the impact test.
- 8.1.3.4.4.** The lower legform impactor pitch angle and therefore the pitch angle of the velocity vector of the honeycomb impactor (rotation around Y-axis) at the time of first contact shall be within a tolerance of  $0 \pm 2^\circ$  in relation to the lateral vertical plane. The lower legform impactor roll angle and therefore the roll angle of the honeycomb impactor (rotation around X-axis) at the time of first contact shall be within a tolerance of  $0 \pm 2^\circ$  in relation to the longitudinal vertical plane. The lower legform impactor yaw angle and therefore the yaw angle of the velocity vector of the honeycomb impactor (rotation around Z-axis) at the time of first contact shall be within a tolerance of  $0 \pm 2^\circ$ , to ensure a correct operation of the knee joint."

Delete Figures 18 to Figure 21, to read:

"

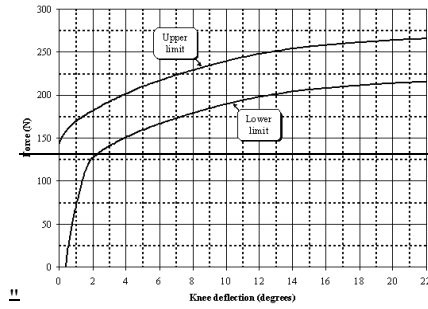


Figure 18: Force versus angle requirement in static lower legform impactor bending certification test (see paragraph 8.1.1.2.)

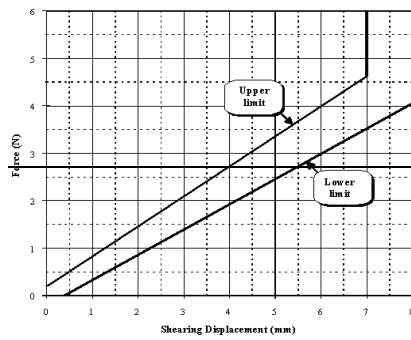


Figure 19: Force versus displacement requirement in static lower legform impactor shearing certification test (see paragraph 8.1.1.3.)

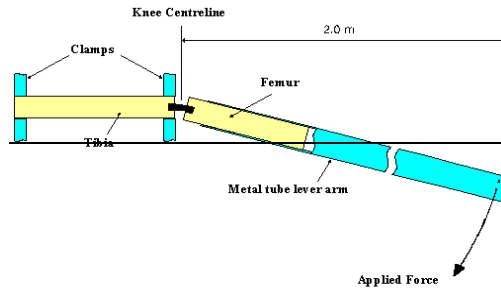


Figure 20: Top View of Test set up for static lower legform impactor bending certification test (see paragraph 8.1.1.4.)

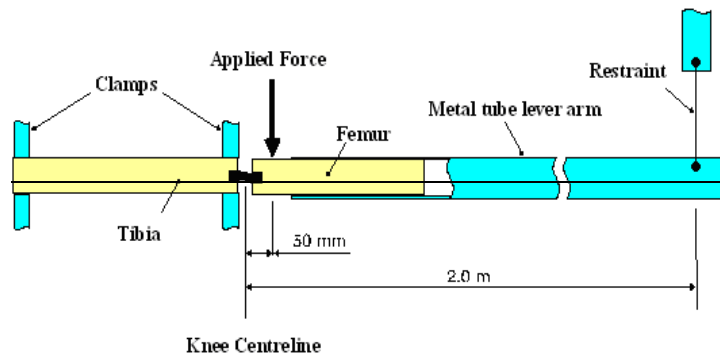


Figure 21: Top View of Test set up for static lower legform impactor shearing certification test (see paragraph 8.1.1.5.)

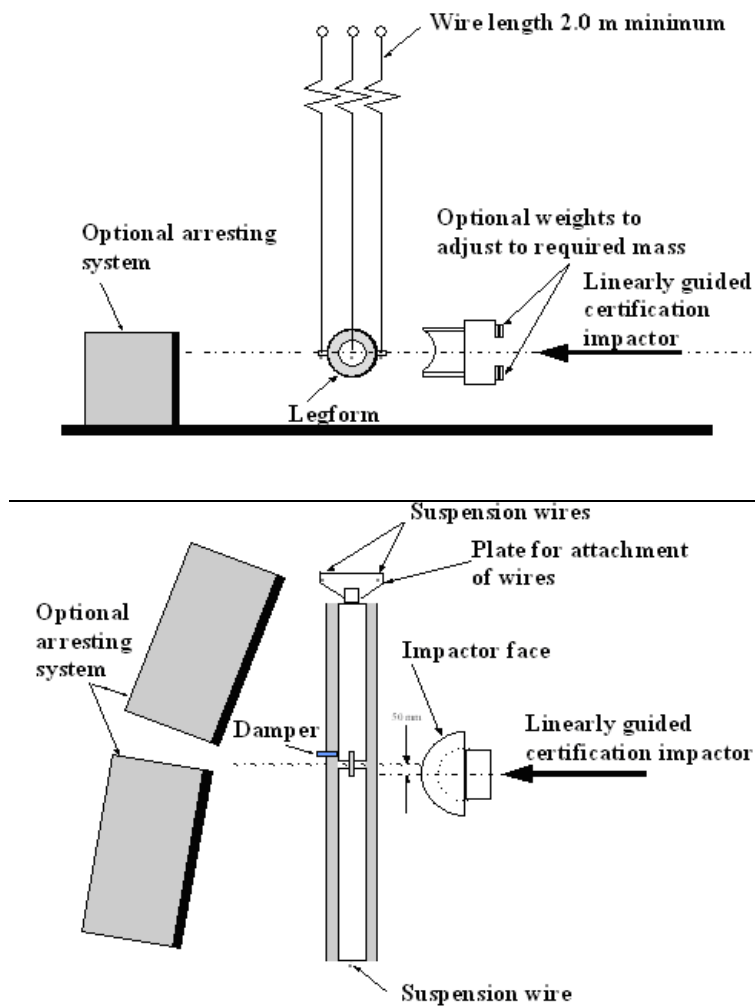
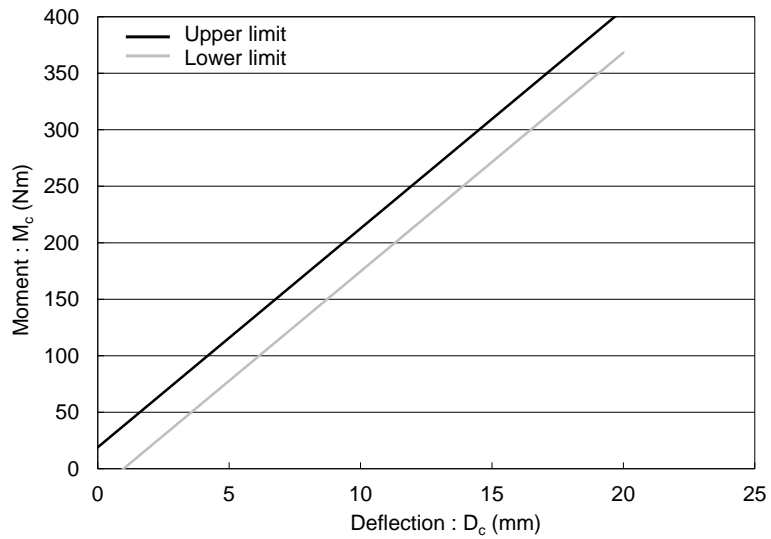


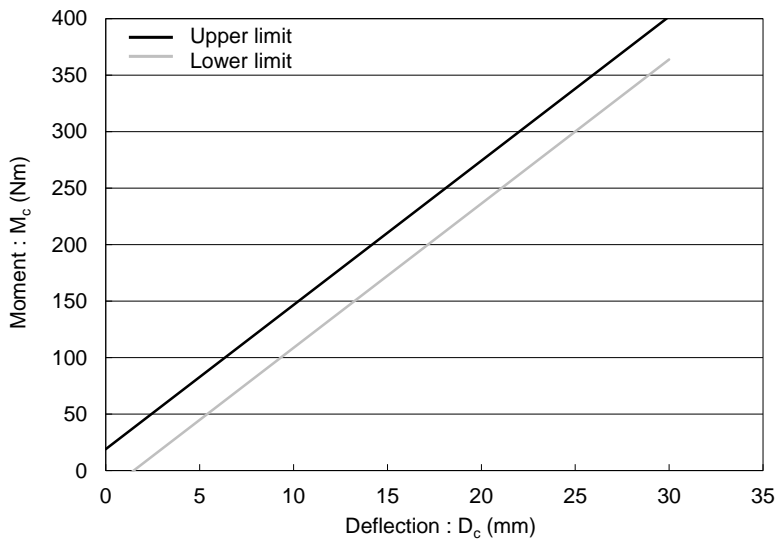
Figure 22: Test set up for dynamic lower legform impactor certification test (side view top diagram, view from above bottom diagram) (see paragraph 8.1.2.4.1.)"

Insert new Figures 22 to 28., to read:

"



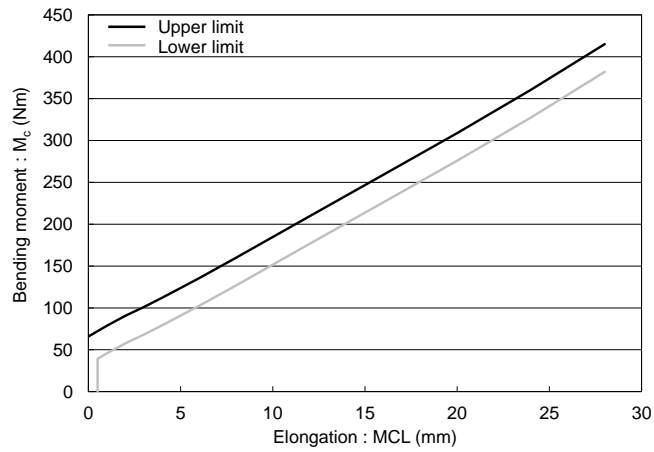
(a) Femur bending corridor



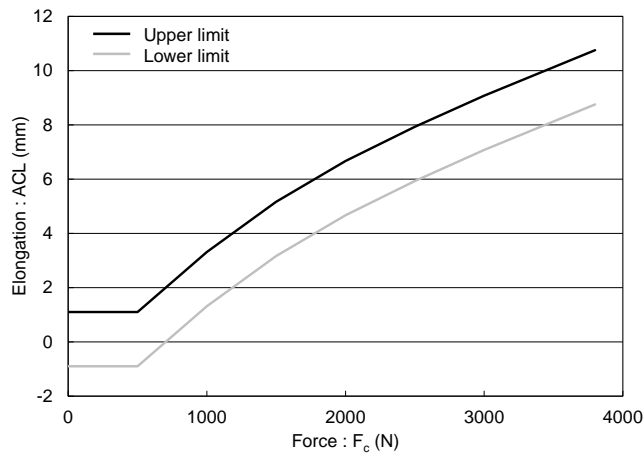
(b) Tibia bending corridor

Figure 22 Flexible lower legform impactor requirement corridor of femur and tibia in static certification test (see paragraph 8.1.1.2.)

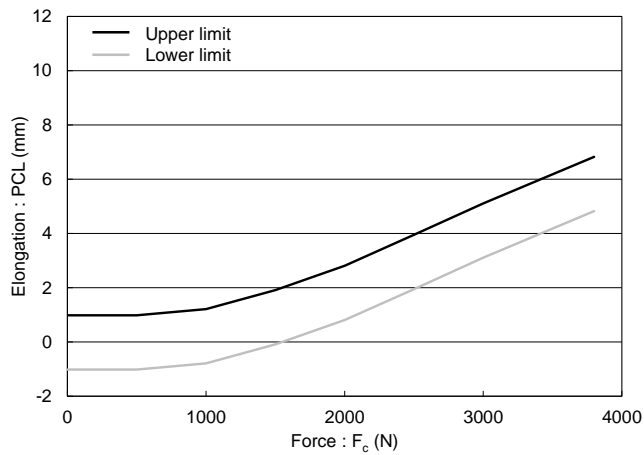




(a) for MCL

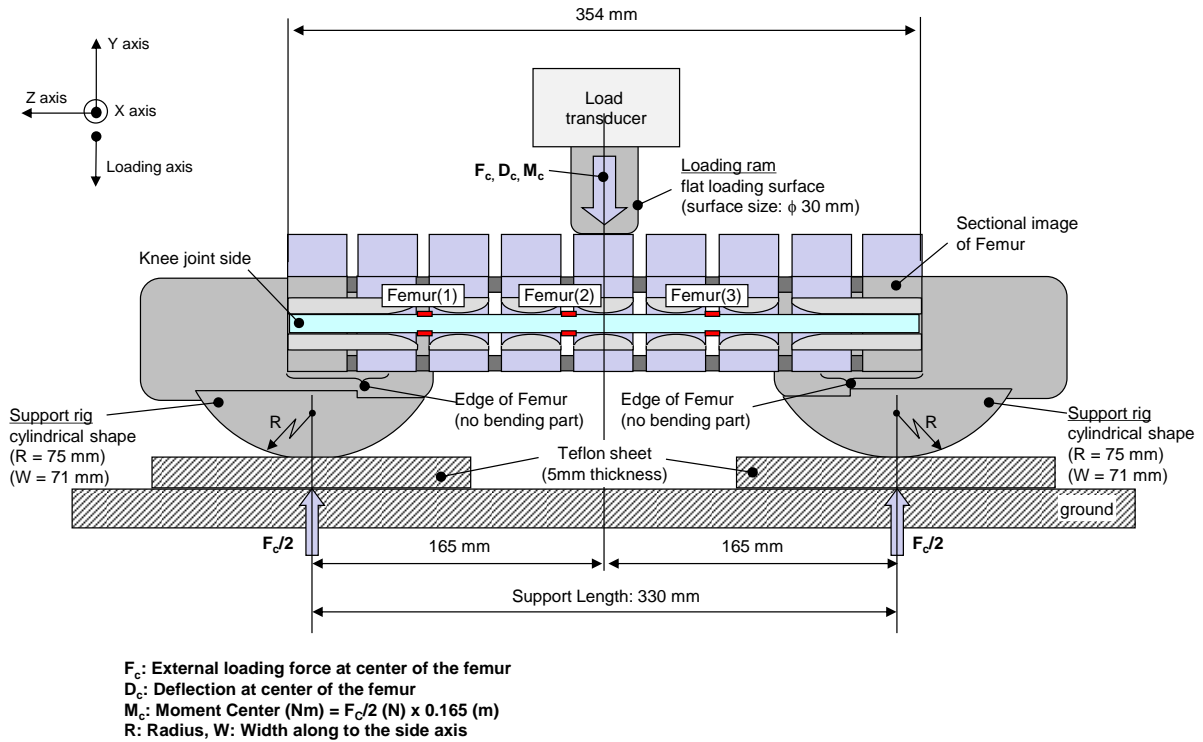


(b) for ACL



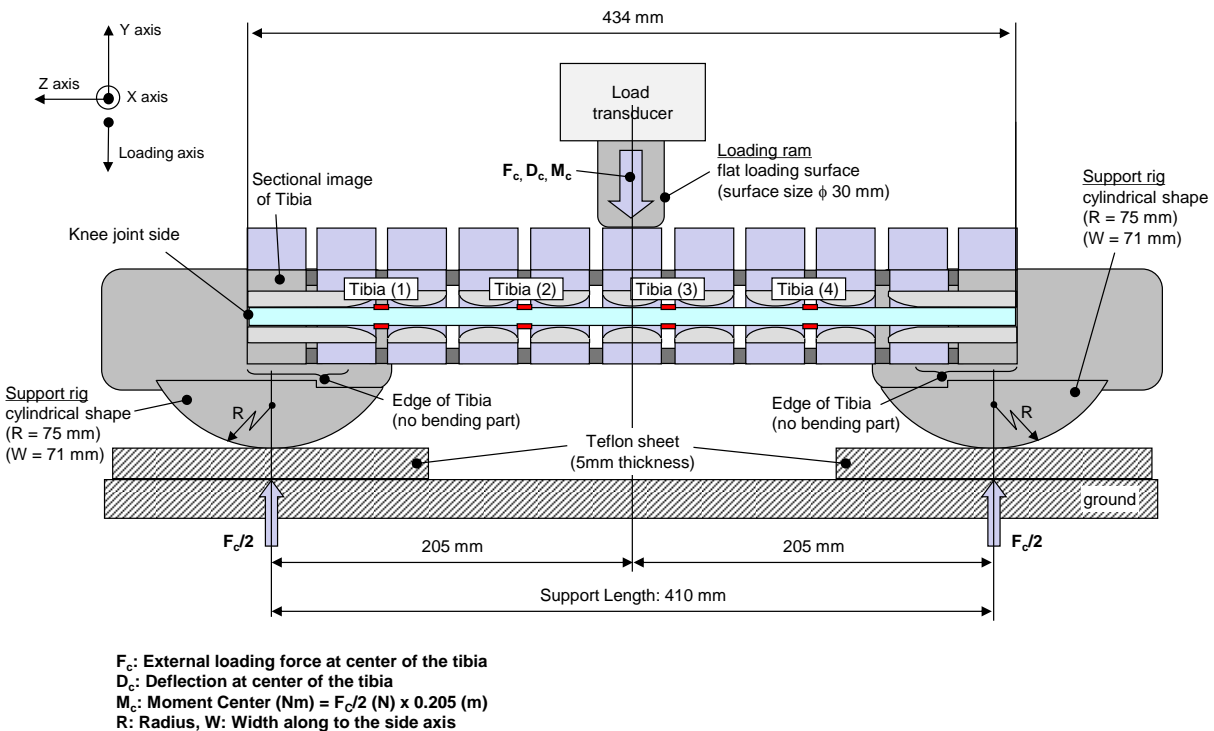
(c) for PCL

**Figure 23 Flexible lower legform impactor requirement corridors for knee joint in static certification test (see paragraph 8.1.1.3.)**



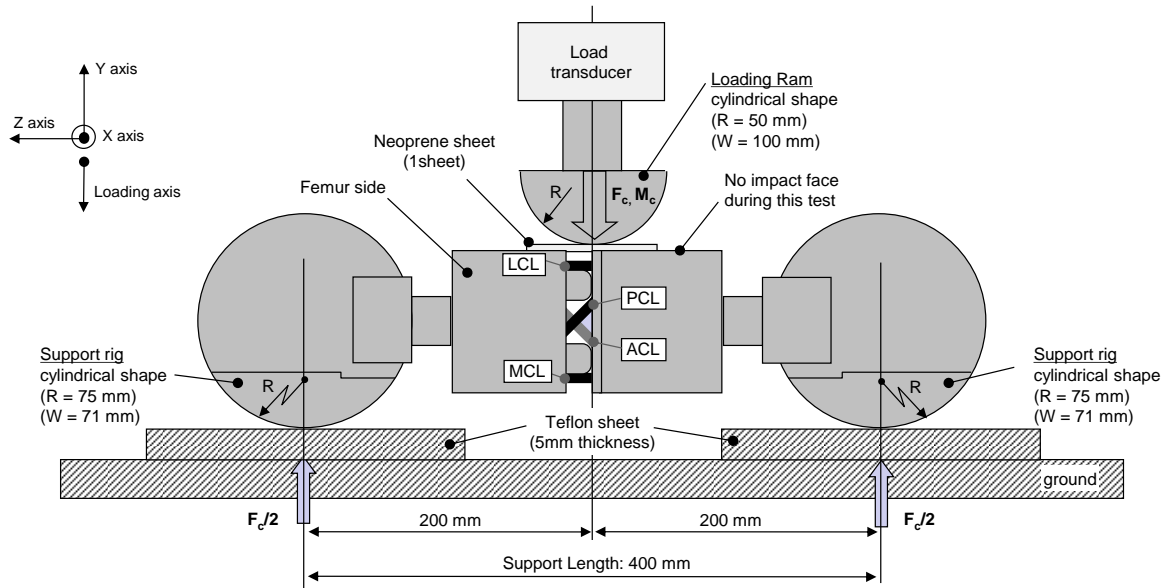
**Figure 24 Flexible lower legform impactor test set-up for femur in static certification tests**

(see paragraph 8.1.1.4.)

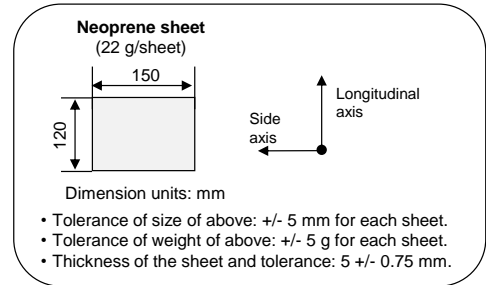


**Figure 25 Flexible lower legform impactor test set-up for tibia in static certification test**  
(see paragraph 8.1.1.4.)



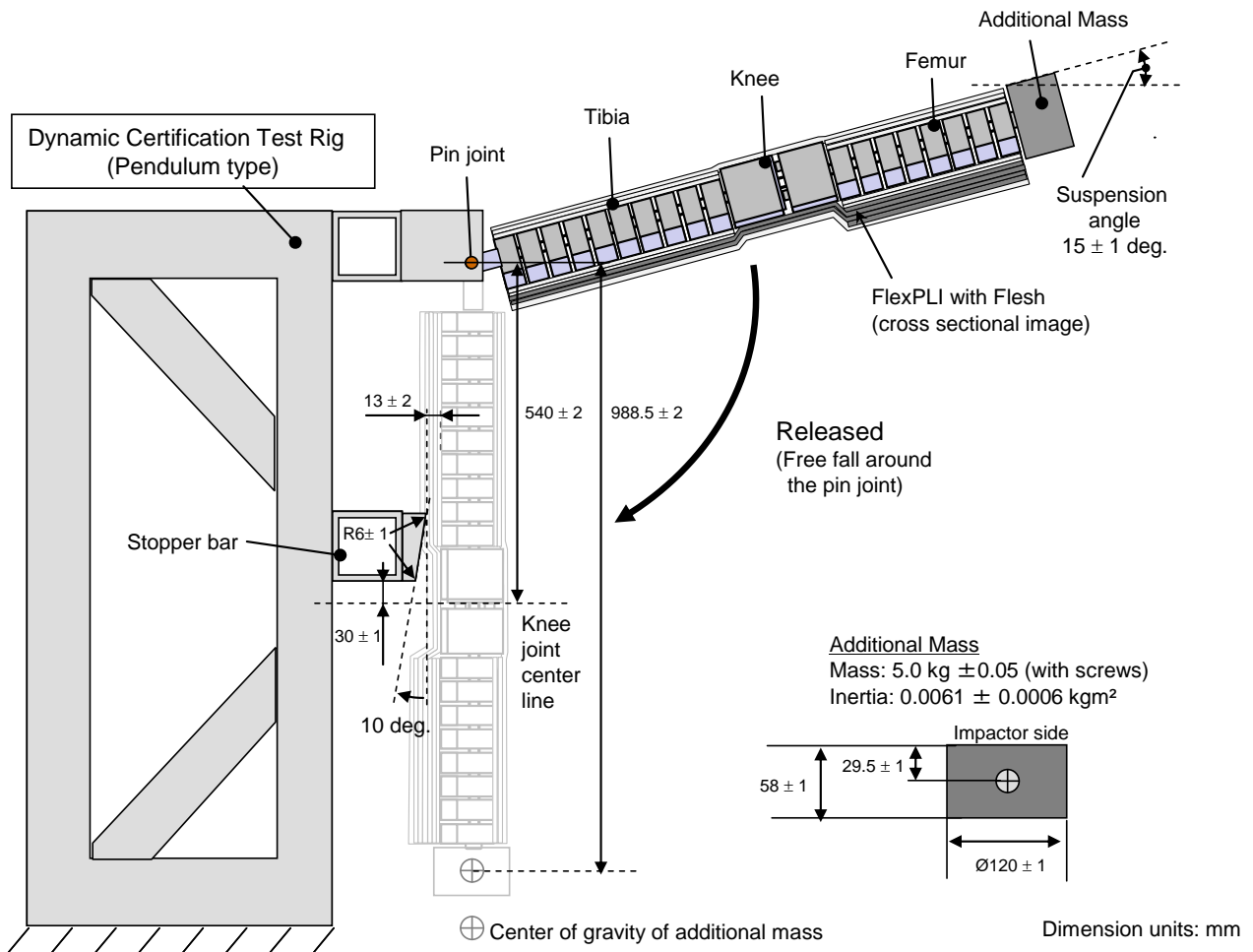


$F_c$ : External loading force at center of knee joint  
 $M_c$ : Moment center (Nm) =  $F_c/2$  (N) x 0.2 (m)  
 R: Radius, W: Width along to the side axis



**Figure 26 Flexible lower legform impactor test set-up for knee joint in static certification test**

(see paragraph 8.1.1.5.)



**Figure 27 Flexible lower legform impactor test set-up for dynamic lower legform impactor certification test, pendulum type (see paragraph 8.1.2.4.)**

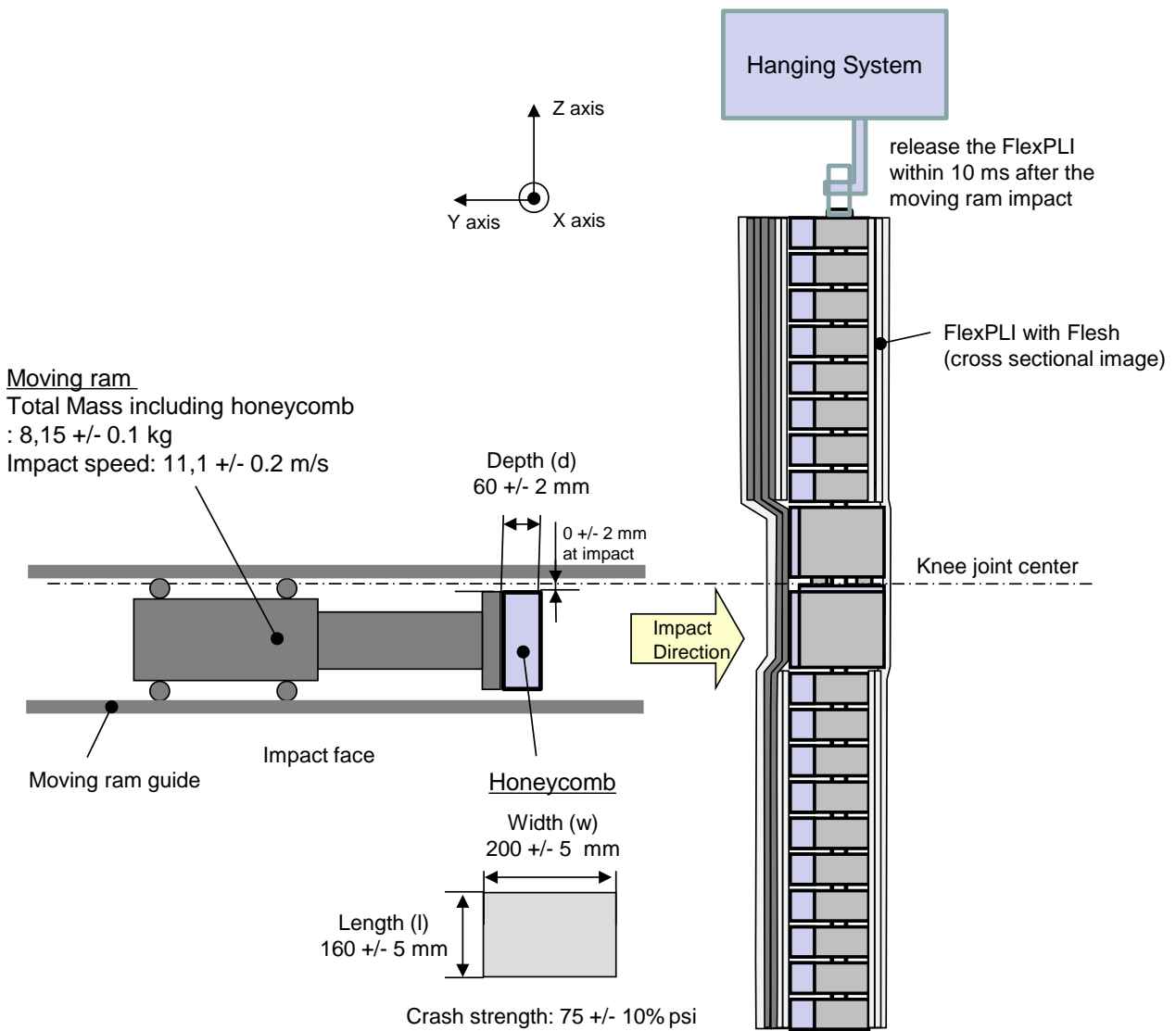


Figure 28 Flexible lower legform impactor test set-up for dynamic lower legform impactor certification test, inverse type (see paragraph 8.1.3.4.)

"

*Paragraph 8.2.4.6.*, amend to read:

"... at a velocity of  $7.1 \pm 0.1$  m/s into the stationary pendulum as shown in Figure ~~24~~**29**."

*Paragraph 8.3.3.1.*, renumber as paragraph 8.4.3.1. and amend to read:

"...impactor shall be suspended from a drop rig as shown in Figure ~~25~~**30**."

*Paragraph 8.3.3.3.*, amend to read:

"... impactor with respect to the vertical as shown in Figure ~~25~~**39**. The suspension of ..."

*Figures 23 to Figure 25 (former)*, renumber as Figures 29 to Figures 31.

## II. Justification

Based on the results of the TEG as well as IG GTR9 PH2 activities, the IG GTR9 PH2 proposes the above-mentioned draft amendments to the gr on pedestrian protection (GTR No. 9).

### A. Statement of technical rationale and justification

*Paragraph 64:* new text are added to introduce **Flexible lower legform impactor** (editorial).

*Paragraphs 102:* new text are added to introduce **Flexible lower legform impactor** (technical).

*Paragraph 106:* new text are added to introduce **Flexible lower legform impactor** (editorial).

*Paragraphs 110, 111, 112, 113:* new text are added to introduce **Flexible lower legform impactor** (technical).

*Paragraph 114:* clarification (editorial).

*Paragraphs 115:* new text are added to introduce **Flexible lower legform impactor** (technical).

*Insert a new section 10:* new text to introduce the **Flexible lower legform impactor** to each Contracting Party smoothly.

*Section 10 (former):* renumbering and new text are added to introduce **Flexible lower legform impactor** (editorial).

### B. Text of the regulation

*Insert a new Paragraph 3.30.:* new definitions were inserted to introduce the **Flexible lower legform impactor** (editorial)

*Paragraph 5.1.1.:* replaced by **Flexible lower legform impactor** requirements.

*Paragraph 6.3.1.1. to 6.3.1.1.7.2:* replaced by **Flexible lower legform impactor** requirements.

*Delete Figures 12 :* delete figure for **EEVC lower legform impactor**.

*Insert new Figures 12 to 16 :* insert figures for **Flexible lower legform impactor**.

*Paragraph 6.3.1.2. to 6.3.2.2.1 and Figure 15 (former):* renumbering (editorial).

*Figure 16 (former):* renumbering (editorial).

*Paragraph 7.1.1. to 7.1.1.4.:* replaced by **Flexible lower legform impactor** requirements.



*Figure 17 (former):* renumbering and replaced by **Flexible lower legform impactor** requirements.

*Paragraph 8.1. to 8.1.3.4.4.:* replaced by **Flexible lower legform impactor** requirements.

*Delete Figures 18 to Figure 21 :* delete figure for **EEVC lower legform impactor**.

*Insert new Figures 22 to 28 :* insert figures for **Flexible lower legform impactor**.

*Paragraph 8.2.4.6. to 8.3.3.3:* renumbering (editorial).

*Figure 23 to Figure 25 (former):* renumbering (editorial).