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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 - flexible legform impactor

Proposal to develop amendments to global technical regulation No. 9 (pedestrian safety)

Submitted by the expert from Japan */

The text reproduced below was prepared by the expert from Japan in order to propose the use of the Flexible Pedestrian Legform Impactor (FlexPLI) and the rigid lower legform impactor designed by the Transport Research Laboratory (TRL) as lower leg form test tool. It is based on a document without symbol (informal document No. GRSP-45-09) distributed during the forty-fifth session of the Working Party on Passive Safety (GRSP). The modifications to the current text of the global technical regulation (gtr) on Pedestrian protection (gtr No.9) are marked in bold or strikethrough characters.

*/ In accordance with the programme of work of the Inland Transport Committee for 2006-2010 (ECE/TRANS/166/Add.1, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance performance of vehicles with respect to passive safety. The present document is submitted in conformity with that mandate.

A. PROPOSAL

STATEMENT OF TECHNICAL RATIONALE AND JUSTIFICATION

Paragraph 64., amend to read:

"64... in the United Kingdom, **and then called as EEVC WG17 pedestrian lower legform impactor**. 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 **EEVC WG17 pedestrian 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. the TEG will also consider a transitional period during which the FlexPLI and the rigid lower legform impactor can be used as alternatives. **Several years have passed since then, and the TEG finalised their technical evaluation on the FlexPLI by a majority of the its members in 2009. Therefore, this gtr also includes the FlexPLI requirements as well as the EEVC WG17 pedestrian lower legform impactor requirements.**"

Paragraph 102., amend to read:

"102... 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 EEVC WG17 pedestrian lower legform impactor but also to the case of using the FlexPLI**"

Paragraph 106., amend to read:

"106... 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 have passed, and the TEG finalised their technical evaluation on the FlexPLI by a majority of its members in 2009. Therefore, this gtr also includes the FlexPLI requirements as well as the EEVC WG17 pedestrian lower legform impactor requirements.**"

Paragraph 110., amend to read:

"110... For these reasons, a bending limit of 19° **for the EEVC WG17 pedestrian 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 at [22] mm based on the agreement of the TEG from a biomechanical point of view (based on BASt correlation study and Japan Automobile Manufacturers Association (JAMA) biomechanical study).**"

Paragraph 111., amend to read:

"111. With regard to knee shearing limits, the informal group selected a limit of 6 mm **for the EEVC WG 17 pedestrian 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 [(1) 13 mm only for monitoring purposes or nothing because the percentage of isolated ACL/PCL damage in car-pedestrian accidents is very small (3 per cent). Besides only two biomechanical data are available for the ACL/PCL threshold values (JAMA and ACEA opinion), or (2) 13 mm as mandatory threshold value because the current gtr 9 sets shearing displacement requirement for the EEVC WG17 pedestrian legform impactor and because of existing though limited biomechanical data (BASt opinion)].**"

Paragraph 112., amend to read:

"112... 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 WG17 pedestrian lower legform impactor**. **As for the FlexPLI, the limit of tibia bending moment is set at [340] Nm based on the agreement of the TEG from a biomechanical point of view (based on BASt and JAMA biomechanical studies).**"

Paragraph 113., amend to read:

"113. ...at the following limits:

For EEVC WG 17 pedestrian lower legform impactor

- Maximum lateral knee bending angle $\leq 19.0^\circ$;
- Maximum lateral knee shearing displacement ≤ 6.0 mm;
- Maximum lateral tibia acceleration ≤ 170 g.

For FlexPLI

- Maximum MCL elongation $\leq [22]$ mm;**
- Maximum Tibia bending moment $\leq [340]$ Nm;**

Maximum ACL and PCL elongation \leq [13 mm only for monitoring purposes or nothing or mandatory]. "

Paragraph 114., amend to read:

"114... These values **for EEVC WG17 pedestrian lower legform impactor** are identical to those under consideration by the EC in its review of the Phase 2 requirements of the European directive. "

Paragraph 115., amend to read:

"115... 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 WG 17 pedestrian 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, the TEG proposed to allow manufacturers, if necessary, based on TEG technical feasibility study results, to nominate bumper test widths up to 264 mm in total where the tibia bending moment of the FlexPLI shall not exceed TBD Nm]."**

Introduce a new section 10., to read:

"10. METHOD OF INTRODUCING THE FLEX-PLI

133. As for the introduction of the new lower legform impactor FlexPLI by each Contracting Party, the TEG provided the following recommendations:

- (a) Effective date of the amendment [x] to the original version entry into force for each Contracting Party: from the date when this gtr is adopted by WP.29.**
- (b) The TEG also proposed that the period for using alternative impactors of EEVC WG 17 pedestrian lower legform impactor or FlexPLI should end [20XX] [[XX] months after the date of entry into force] "**

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

"4011. APPENDIX – REFERENCE DOCUMENTS USED BY THE WORKING GROUP

...	
INF GR/PS/188	Draft meeting minutes of the 10th meeting
INF GR/PS/189	Attendance list 10th meeting

A list of working papers used by the FlexTEG group is listed and available on the UNECE WP.29 website

(http://www.unece.org/trans/main/wp29/wp29wgs/wp29grsp/pedestrian_FlexPLI.html).

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

Number of working paper	Title of FlexTEG document
	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
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

Number of working paper	Title of FlexTEG document
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
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-07 ^e -Rev1	MESSRING Suggest ISO MME corde Flex
TEG-074	FTSS Flex Pendulum Dynamic Calbraiton Proposal
TEG-075	BASSt Flex Inverce Dynamic Calbration 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
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

Number of working paper	Title of FlexTEG document
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 Prposale Flex-GTR-proto Tibia Threshold
TEG-099	Evaluation Test Schedule Flex-GTR-proto
TEG-100	DRAFT Minutes 8th Flex-TEG Meeting 090812

TEXT OF THE REGULATION

Paragraph 4.1.1., amend to read:

"4.1.1. Lower legform to bumper:

To verify compliance with the performance requirements as specified in paragraph 5.1.1., both the test impactor specified in paragraph 6.3.1.1. and the test procedures specified in paragraph 7.1.1. **for the EEVC WG17 pedestrian lower legform impactor, or both the test impactor specified in paragraph 6.3.1.2. and the test procedures specified in paragraph 7.1.2. for the FlexPLI,** shall be used respectively."

Paragraph 4.1.2., amend to read:

"4.1.2. Upper legform to bumper:

To verify compliance with the performance requirements as specified in paragraph 5.1.2., both the test impactor specified in paragraph 6.3.1.-23. and the test procedures specified in paragraph 7.1.-23. shall be used."

Insert a new paragraph 5.1.1., to read:

"5.1.1. **When tested in accordance with paragraph 7.1.1. (EEVC WG17 pedestrian 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."

Paragraph 5.1.1. (former), renumber as paragraph 5.1.1.1. and amend to read:

"**5.1.1.1.** When tested in accordance with paragraph 7.1.1. (~~lower legform to bumper~~), the maximum dynamic knee bending"

Insert a new paragraph 5.1.1.2., to read:

"**5.1.1.2.** When tested in accordance with paragraph 7.1.2., 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 be monitored with a reference value of 13 mm or nothing or mandatory with a reference value of 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 of the FlexPLI shall not exceed TBD Nm]."

Paragraph 5.1.2., amend to read:

"5.1.2. When tested in accordance with paragraph 7.1.23. (upper legform to bumper), the instantaneous sum of the impact forces with respect to time shall not exceed 7.5 kN and the bending moment on the test impactor shall not exceed 510 Nm."

Title of paragraph 6.3.1.1., amend to read:

"6.3.1.1. **EEVC WG17 pedestrian** ~~Lower legform impactor:~~"

Title of Figure 12., amend to read:

"Figure 12: **EEVC WG17 pedestrian** ~~Lower legform impactor~~ (see paragraph 6.3.1.1.)"

Insert new paragraphs 6.3.1.2. to 6.3.1.2.7.2., to read:

"**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 $[13.4] \pm 0.4$ 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.

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 13.

- 6.3.1.2.1. The cross-sectional shape perpendicular to the Z axis of the femur and tibia main bodies shall be 90 ± 2 mm in width along the Y axis, and 84 ± 1 mm in width along the X axis as shown in Figure 14 (a). The impact face shall be 30 ± 1 mm in radius, 30 ± 1 mm in width along the Y axis, and 48 ± 1 mm in width along the X axis as shown in Figure 14 (a).
- 6.3.1.2.2. The cross-sectional shape perpendicular to the Z axis of the knee joint shall be 108 ± 2 mm in width along the Y axis, and 118 ± 1 mm in width along the X axis as shown in Figure 14 (b). The impact face shall be 103 ± 1 mm in radius, 12 ± 1 mm in width along the Y axis, and 86 ± 1 mm in width along the X axis as shown in Figure 14 (b).
- 6.3.1.2.3. The masses of the femur and tibia without flesh, including the connection part to the knee joint, shall be 2.47 ± 0.05 kg and 2.67 ± 0.05 kg respectively. The mass of the knee joint without flesh shall be 4.34 ± 0.1 kg. The total mass of the femur, knee joint, and tibia shall be 9.48 ± 0.2 kg.

The centre of gravity of the femur and tibia without flesh, including the connection part to the knee joint, shall be $[158] \pm 3$ mm and $[204] \pm 3$ mm respectively from the top, but not including the connection part to the knee joint, of each part as shown in Figure 13. The centre of gravity of the knee joint shall be $[92] \pm 3$ mm from the top of the knee joint as shown in Figure 13.

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 0.0331 ± 0.002 kgm² and 0.04685 ± 0.002 kgm² respectively. The moment of inertia of the knee joint about the X axis through the respective centre of gravity shall be 0.01818 ± 0.0015 kgm².

- 6.3.1.2.4. 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 15. The sheets are required to have a compression characteristic as shown in Figure 16. The compression characteristic shall be checked using the same batch of sheets as those used for the impactor flesh. The size and weight of the sheets shall be within the requirements described in Figure 16.
- 6.3.1.2.5. The test impactor or at least the flesh shall be stored for at least four hours in a controlled storage area with a stabilised 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.

6.3.1.2.6. Lower legform instrumentation

6.3.1.2.6.1. 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 ± 1 mm, tibia-2: 214 ± 1 mm, tibia-3: 294 ± 1 mm, and tibia-4: 374 ± 1 mm below the knee joint centre respectively as shown in Figure 17. The measurement axis of each transducer shall be the X axis of the impactor.

6.3.1.2.6.2. 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 17. The measurement locations shall be within ± 3 mm along the X axis from the knee joint centre.

6.3.1.2.6.3. 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 350 Nm for the tibia bending moments. This does not require that the impactor itself be able to physically elongate or bend until these values.

6.3.1.2.7. Lower legform certification

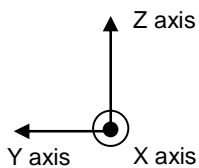
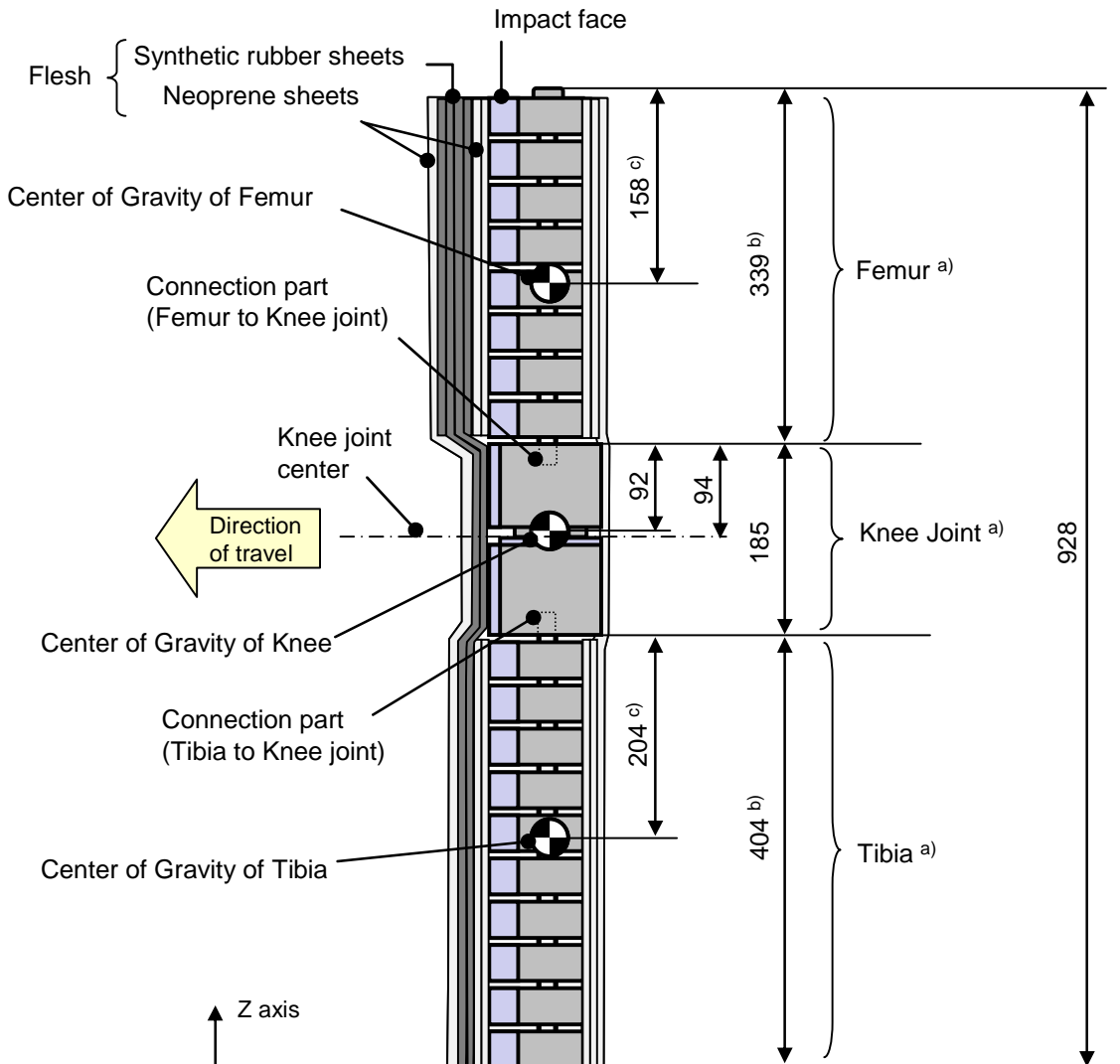
6.3.1.2.7.1. The lower legform impactor shall meet the performance requirements specified in paragraph 8.

6.3.1.2.7.2. The impactor has to be certified according to the inverse type dynamic certification test described in 8.1.2.3. in advance of to start the homologation test series. The certified impactor shall be certified according to the pendulum type dynamic certification test described in 8.1.2.2 after every 10 car tests*, as well as inverse type dynamic certification test after every 30 car tests (*no need to perform pendulum type dynamic certification test after every 30 car tests). The impactor shall be re-certified by these dynamic tests if more than one year has elapsed since the previous dynamic certification tests, if any impactor transducer output has exceeded the specified CAC. If the impactor fails the dynamic certification tests, it shall be re-certified by using the static calibration test described in 8.1.2.1. in order to identify the parts that shall be changed to new ones."

Insert new Figures 13 to 17., to read:

"

Side view



- a) Does not include the flesh part
- b) Exclude the connection part length to the knee joint
- c) Center of Gravity (C.G.) locations of femur, knee, and tibia without flesh (Included the connection part mass to the femur and tibia C.G. calculation)

Figure 13: Flex-PLI; Dimensions and C.G. locations of femur, knee joint, and tibia (Side view)

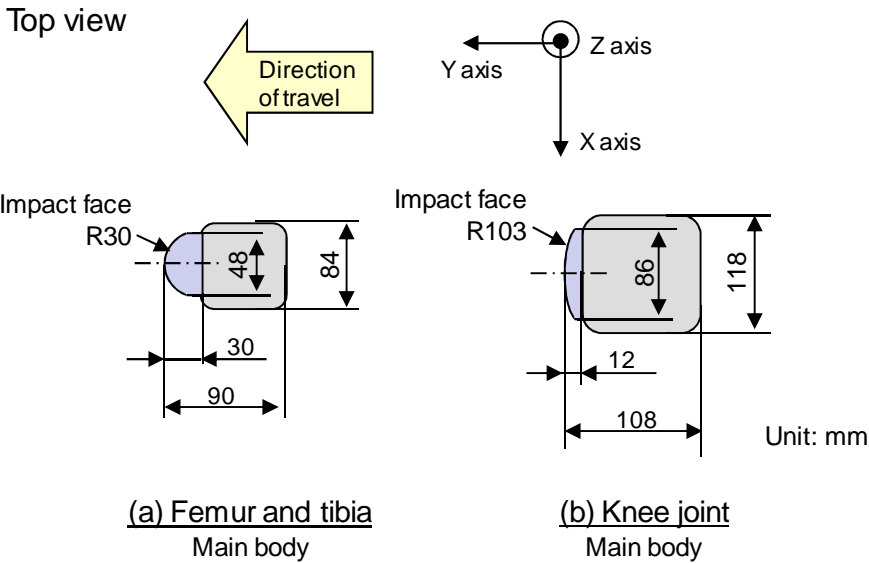


Figure 14: Flex-PLI; femur, tibia, and knee dimensions (Top view)

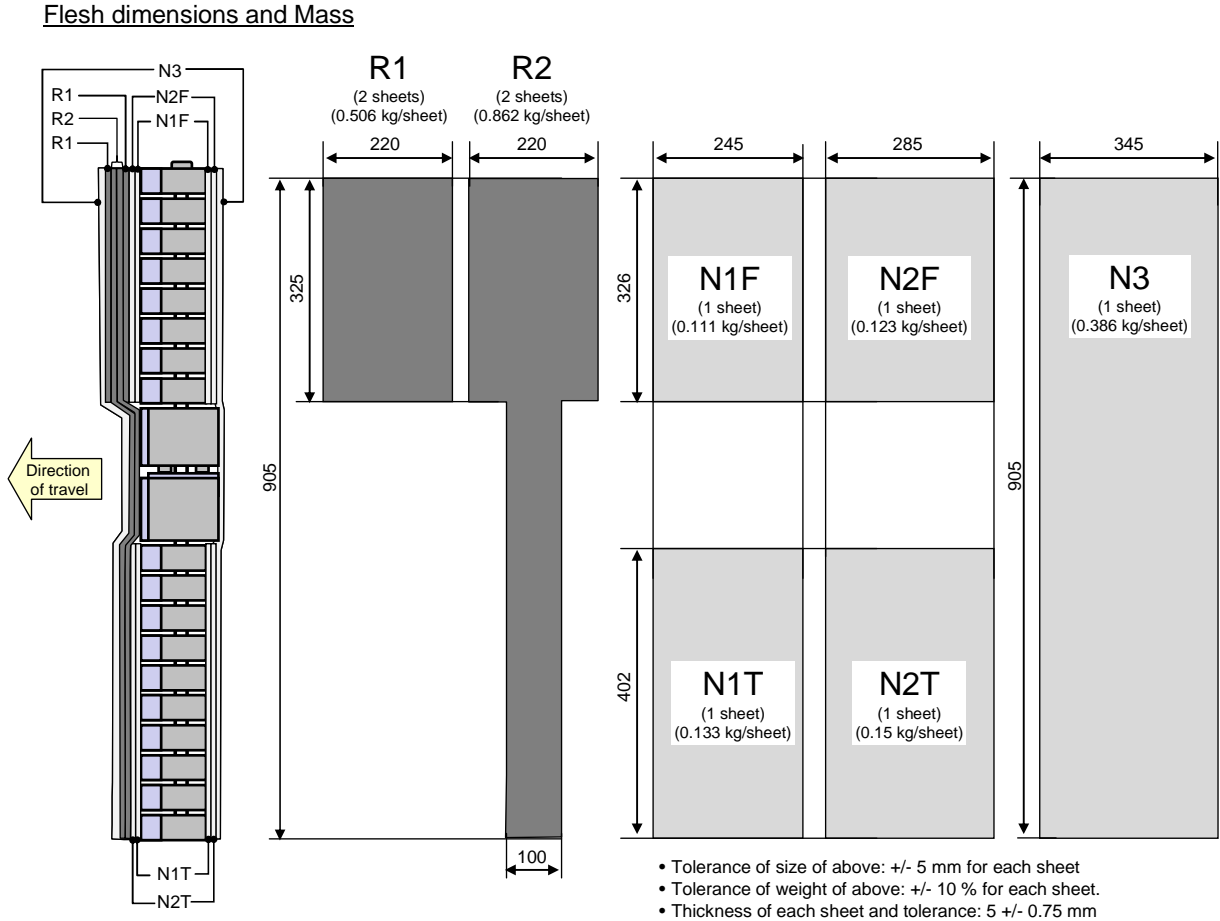
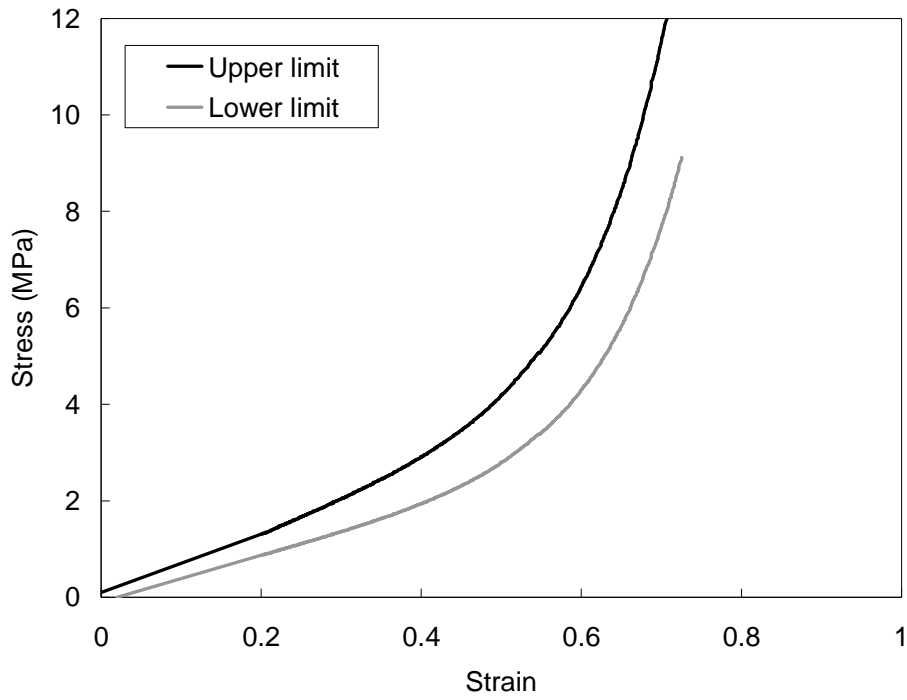
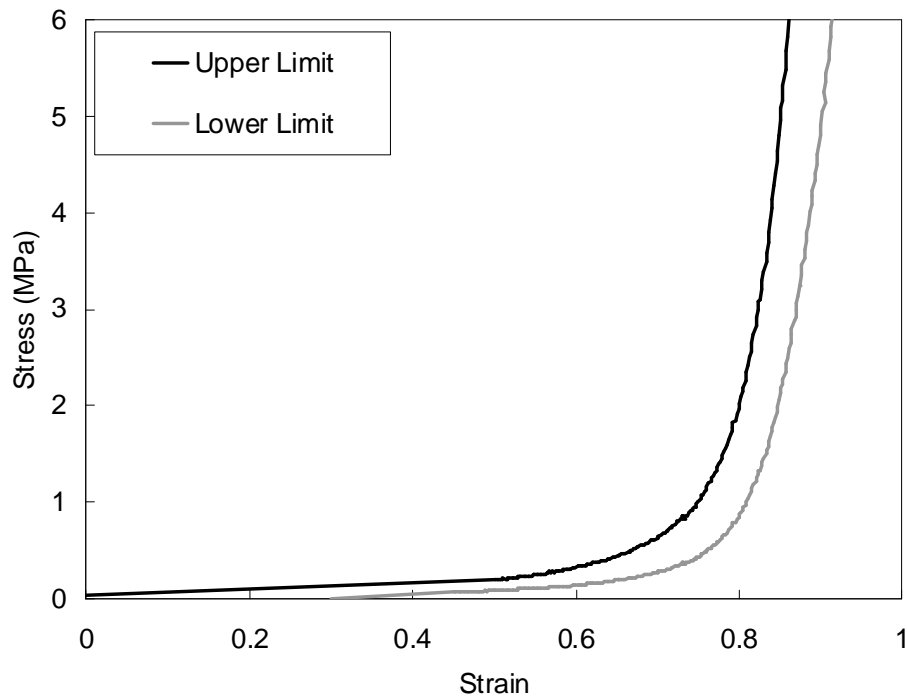


Figure 15: Flex-PLI; flesh dimensions and mass



(a) Synthetic rubber sheets



(b) Neoprene sheets

Figure 16: Flex-PLI; flesh compression characteristics

Instruments locations

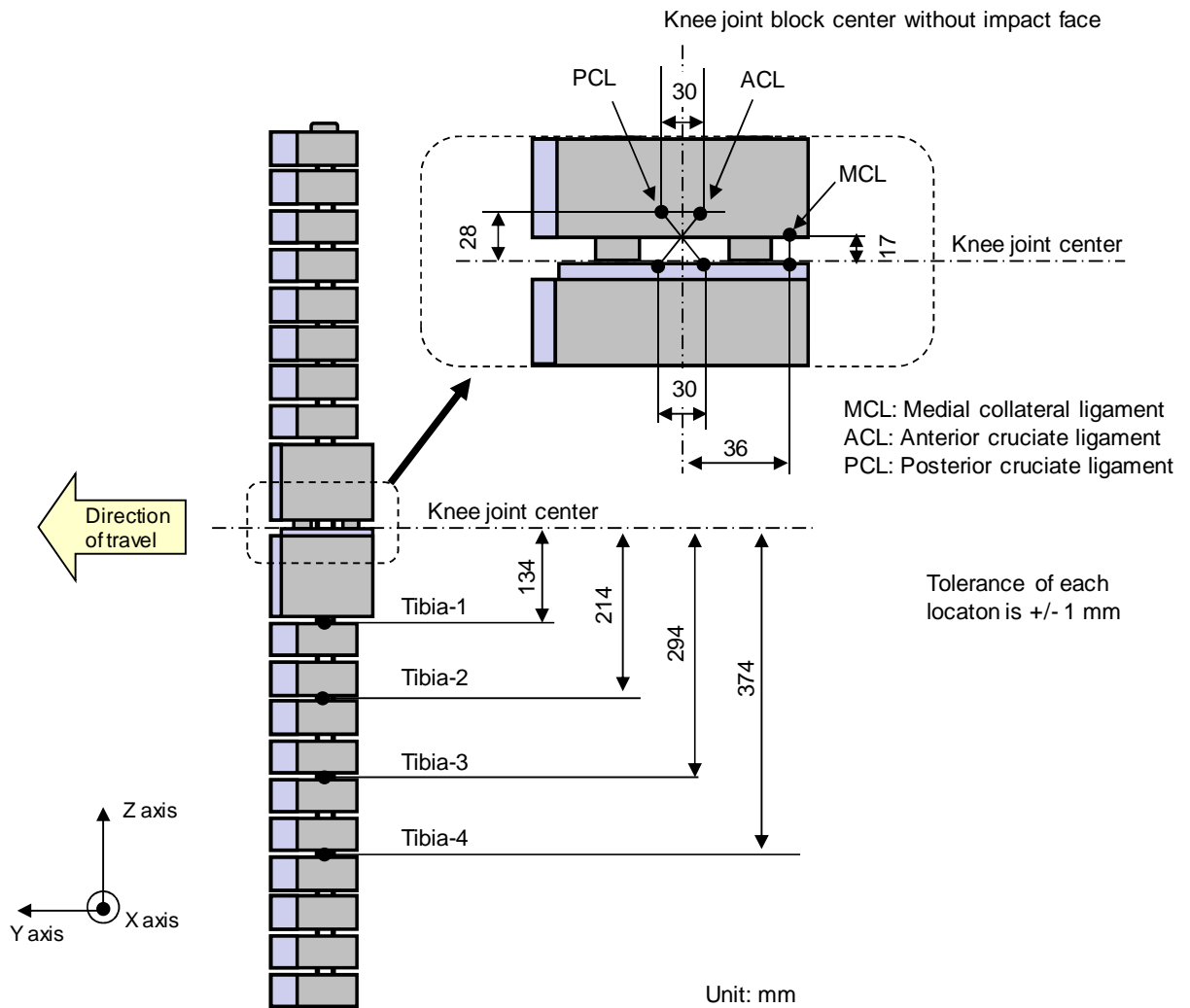


Figure 17: Flex-PLI; instrument locations "

Paragraph 6.3.1.2. (former), renumber as paragraph 6.3.1.3. and amend to read:

"**6.3.1.3.** ..., foam covered at the impact side, and 350 ± 5 mm long (see Figure 138)."

Paragraphs 6.3.1.2.1. to 6.3.1.2.9. (former), renumber as paragraphs 6.3.1.3.1. to 6.3.1.3.9.

Paragraph 6.3.1.2.9.1. (former), renumber as paragraph 6.3.1.3.9.1. and amend to read:

"**6.3.1.3.9.1.** ...in three positions, as shown in Figure 138, each using a separate channel."

Paragraph 6.3.1.2.9.2. (former), renumber as paragraph 6.3.1.3.9.2. and amend to read:

"**6.3.1.3.9.2.** ...at positions 50 mm either side of the centre line (see Figure 138)."

Paragraph 6.3.1.2.9.3. to 6.3.1.2.10.2. (former), renumber as paragraphs 6.3.1.3.9.3. to 6.3.1.3.10.2.

Title of Figure 13, amend to read:

"Figure 13: Upper legform impactor (see paragraph 6.3.1.~~23~~.)"

Paragraph 6.3.2.1., amend to read:

"6.3.2.1. Child headform impactor (see Figure ~~1419~~)

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 ~~1419~~) and ..."

Figure 14 (former), renumber as Figure 19.

Paragraph 6.3.2.2., amend to read:

"6.3.2.2. Adult headform impactor (see Figure ~~1520~~)

The adult....."

Figure 15 (former), renumber as Figure 20.

Paragraph 6.3.2.2.1., amend to read:

"6.3.2.2.1. ... axis perpendicular to the mounting face A (see Figure ~~1520~~) and ..."

Paragraph 7.1.1., amend to read:

"7.1.1. **EEVC WG 17 pedestrian** Lower legform to bumper test procedure:

...."

Paragraph 7.1.1.2., amend to read:

"7.1.1.2. ... and lateral planes are orthogonal to each other (see Figure ~~1621~~)."

Paragraph 7.1.1.3., amend to read:

"7.1.1.3. ... at the time of first contact with the bumper (see Figure ~~1722~~), ..."

Paragraph 7.1.1.3.2., amend to read:

"7.1.1.3.2. ...its knee joint, with a tolerance of $\pm 5^\circ$ (see Figure 4621)."

Figures 16 to 17 (former), renumber as Figures 21 to 22.

Insert new paragraphs 7.1.2. to 7.1.2.4., to read:

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 $\pm [2]^\circ$ 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 23).

7.1.2.3. 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 24), 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.

7.1.2.3.1. 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 an air, spring or hydraulic gun, or by other means that can be shown to give the same result.

7.1.2.3.2. 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 tolerance of $\pm 5^\circ$ (see Figure 23).

7.1.2.3.3. At the time of first contact the centre line of the impactor shall be within a ± 10 mm tolerance to the selected impact location.

7.1.2.3.4. 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.

7.1.2.4. The impact velocity of the impactor when striking the bumper shall be 11.1 ± 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. "

Insert new Figures 23 and 24., to read:

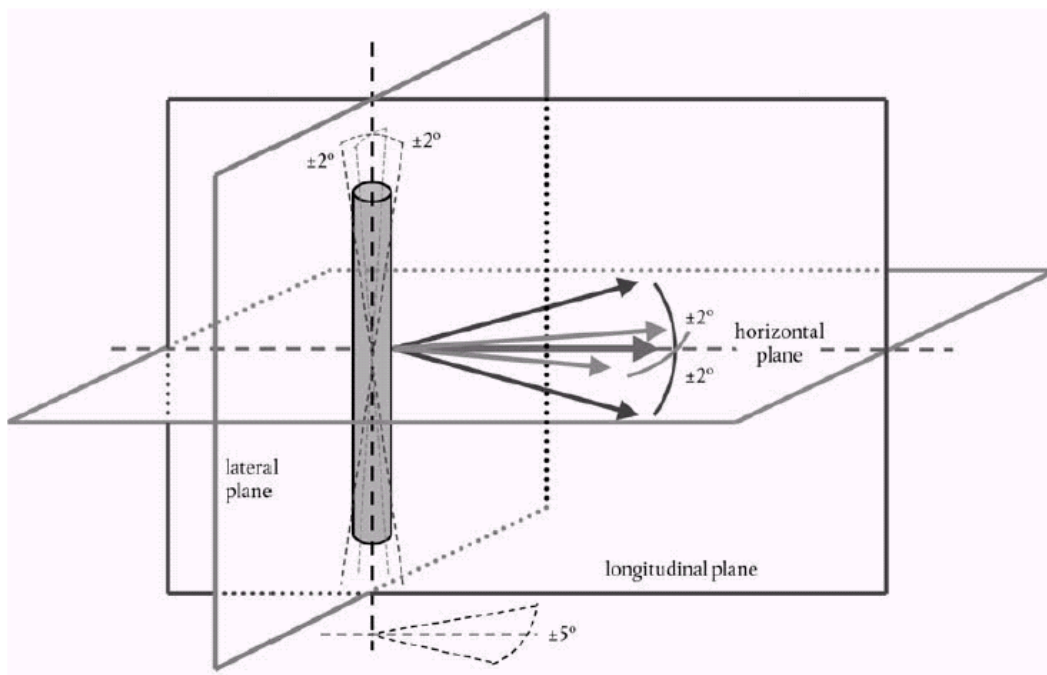


Figure 23: Tolerances of angles for the lower legform impactor at the time of the first impact (see paragraphs 7.1.2.2. and 7.1.2.3.2.)

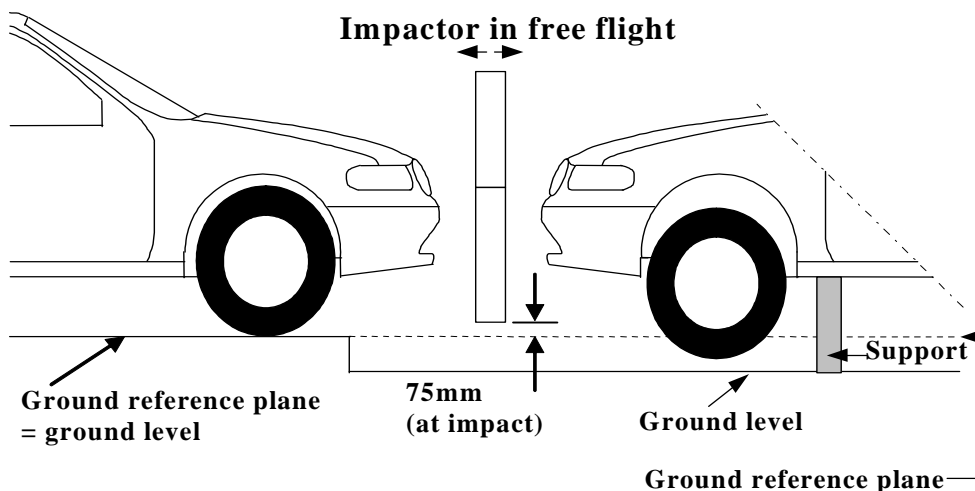


Figure 24: Flex-PLI to bumper tests for complete vehicle in normal ride attitude (left) and for cut-body mounted on supports (right) (see paragraph 7.1.2.3.) "

Paragraphs 7.1.2. to 7.1.2.3. (former), renumber as paragraphs 7.1.3. to 7.1.3.3.

Paragraph 8., amend to read:

"8.

The requirements for the lower legform impactor are specified in paragraph 8.1. **or 8.2.**, the upper legform impactor requirements are specified in paragraph ~~8.28.3.~~ and the adult and child headform impactors requirements are specified in paragraph ~~8.38.4.~~"

Paragraph 8.1., amend to read:

"8.1. **EEVC WG 17 pedestrian Lower legform impactor certification**"

Paragraph 8.1.1.2., amend to read:

"8.1.1.2. ... shall be within the limits shown in Figure ~~1825.~~ Also, the energy ..."

Paragraph 8.1.1.3., amend to read:

"8.1.1.3. ...shall be within the limits shown in Figure ~~1926.~~"

Paragraph 8.1.1.4., amend to read:

"8.1.1.4. ... firmly to the femur, as shown in Figure ~~2027.~~ The rotational axis ..."

Paragraph 8.1.1.5., amend to read:

"8.1.1.5. ... from the centre of the knee joint, as shown in Figure ~~2128~~. ..."

Paragraph 8.1.2.4.1., amend to read:

"8.1.2.4.1. ...of 2000 mm minimum length, as shown in Figure ~~2229~~. It shall be ..."

Paragraph 8.1.2.4.2., amend to read:

"8.1.2.4.2. ...the certification impactor shall be as specified in Figure ~~2330~~. The face of ..."

Paragraph 8.1.2.4.5., amend (renumber) to read:

"8.1.2.4.5 ...the stationary impactor as shown in Figure ~~2330~~. The certification impactor ..."

Insert new paragraphs 8.2. to 8.2.3.4.4., to read:

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 $20^{\circ} \pm 2^{\circ}\text{C}$.

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

8.2.1.2. When the femur and tibia of the impactor are loaded in bending in accordance with paragraph 8.2.1.4., 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 31.

8.2.1.3. When the knee joint of the impactor is loaded in bending in accordance with paragraph 8.2.1.5., 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 32.

8.2.1.4. The edges of the femur and tibia, not bending parts, shall be mounted to the support rig firmly as shown in Figure 33. 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. To avoid impactor damage, a neoprene sheet shall be set underneath the loading ram. The neoprene sheet used in this test shall have compression characteristics as shown in Figure 16.

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 [340] Nm.

8.2.1.5. The edges of the knee joint, not bending parts, shall be mounted to the support rig firmly as shown in Figure 35. 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 14 shall be removed. The neoprene sheet used in this test shall have compression characteristics as shown in Figure 16.

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 300 Nm.

8.2.2. Dynamic certification tests (pendulum type)

8.2.2.1. The lower legform impactor (femur, knee joint, and tibia are connected/assembled firmly) shall meet the requirements specified in paragraph 8.2.2.3. when tested as specified in paragraph 8.2.2.4.

8.2.2.2. Certification

8.2.2.2.1. The test facility used for the certification test shall have a stabilised temperature of $20 \pm 4^\circ\text{C}$ during certification.

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

8.2.2.3. Requirements

8.2.2.3.1. When the lower legform impactor is used for a test as specified in paragraph 8.2.2.4., the maximum bending moment of the tibia at tibia-1 shall

be not more than [267] Nm and not less than [240] Nm, the maximum bending moment at tibia-2 shall be not more than [220] Nm and not less than [197] Nm, the maximum bending moment at tibia-3 shall be not more than [173] Nm and not less than [153] Nm, and the maximum bending moment at tibia-4 shall be not more than [108] Nm and not less than [95] Nm. The maximum elongation of MCL shall be not more than [25] mm and not less than [23] mm, the maximum elongation of ACL shall be not more than [11] mm and not less than [9.7] mm, and the maximum elongation of PCL shall be not more than [5.6] mm and not less than [3] mm.

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

8.2.2.3.2. 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 350 Nm for the tibia bending moments. This does not require that the impactor itself be able to physically elongate and bend to these values.

8.2.2.4. Test procedure

8.2.2.4.1. The impactor, excluding flesh, shall be suspended from the dynamic certification test rig $15 \pm 1^\circ$ upward from the horizontal as shown in Figure 36. 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 36.

8.2.2.4.2. The knee joint centre of the impactor shall be 30 ± 1 mm below the bottom line of the stopper bar, and the tibia impact face shall be located 13 ± 1 mm from the front upper edge of the stopper bar when the stopper block is removed from the stopper bar and then hung from the impactor without any contact (see Figure 36).

8.2.3. Dynamic certification tests (inverse type)

8.2.3.1. The lower legform impactor with flesh (femur, knee joint, and tibia are connected/assembled firmly) shall meet the requirements specified in paragraph 8.2.3.3. when tested as specified in paragraph 8.2.3.4.

8.2.3.2. Certification

8.2.3.2.1. The test facility used for the certification test shall have a stabilised temperature of $20 \pm 4^\circ\text{C}$ during certification.

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

8.2.3.3. Requirements

8.2.3.3.1. When the lower legform impactor is used for the test specified in paragraph 8.2.3.4., the maximum bending moment of the tibia at tibia-1 shall be not more than [278] Nm and not less than [235] Nm, the maximum bending moment at tibia-2 shall be not more than [269] Nm and not less than [223] Nm, the maximum bending moment at tibia-3 shall be not more than [220] Nm and not less than [176] Nm, and the maximum bending moment at tibia-4 shall be not more than [120] Nm and not less than [102] Nm. The maximum elongation of the MCL shall be not more than [22.8] mm and not less than [18.1] mm, that of the ACL shall be not more than [12] mm and not less than [9] mm, and that of the PCL shall be not more than [6.5] mm and not less than [4.5] mm.

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

8.2.3.3.2. 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 350 Nm for the tibia bending moments. This does not require that the impactor itself be able to physically elongate and bend to these values.

8.2.3.4. Test procedure

8.2.3.4.1. The impactor covered by flesh shall be hung vertically as shown in Figure 37. The impactor shall be impacted by a moving ram of 8.1 ± 0.1 kg mass, at an impact speed of 11.1 ± 0.2 m/s. The impactor shall be released from the hanging system within 5 ms after the moving ram impacts the impactor.

8.2.3.4.2. The honeycomb, which is attached in front of the moving ram, shall have a crash strength of [75 (-0/+10per cent)] psi, and it shall have the dimensions shown in Figure 38.

8.2.3.4.3. The honeycomb, to be covered by a thin paper cloth, shall be set in front of the moving ram with its top line matching the knee joint centre line within a tolerance of 0 [± 3] mm along the vertical axis at the impact timing. The top line of the impact face of the moving ram also shall match the knee joint centre line within a tolerance of 0 [± 3] mm along the vertical axis at the impact timing.

The honeycomb shall not be excessively handled or deformed before the impact test.

8.2.3.4.4. The impact direction of the moving ram shall be parallel to the horizontal axis with a tolerance of $\pm [2]^\circ$."

Paragraph 8.2. (former), renumber as paragraph 8.3.

Paragraph 8.2.1. (former), renumber as 8.3.1. and amend to read:

"**8.3.1.** ... specified in paragraph 8.~~23~~.3. when tested as specified in paragraph 8.~~23~~.4."

Paragraphs 8.2.2. to 8.2.4.5. (former), renumber as paragraphs 8.3.2. to 8.3.4.5.

Paragraph 8.2.4.6. (former), renumber as paragraph 8.3.4.6. and amend to read:

"**8.3.4.6.** ... at a velocity of 7.1 ± 0.1 m/s into the stationary pendulum as shown in Figure ~~24~~**38**."

Paragraphs 8.2.4.7. to 8.3.1. (former), renumber as paragraphs 8.3.4.7. to 8.4.1.

Paragraph 8.3.1.1. (former), renumber as paragraph 8.4.1.1. and amend to read:

"**8.4.1.1.** ... specified in paragraph 8.~~34~~.2. when tested as specified in paragraph 8.~~34~~.3."

Paragraphs 8.3.2. to 8.3.3. (former), renumber as paragraphs 8.4.2. to 8.4.3.

Paragraph 8.3.3.1. (former), renumber as paragraph 8.4.3.1. and amend to read:

"**8.4.3.1.** ...impactor shall be suspended from a drop rig as shown in Figure ~~25~~**39**."

Paragraph 8.3.3.2. (former), renumber as paragraph 8.4.3.2.

Paragraph 8.3.3.3. (former), renumber as paragraph 8.4.3.3. and amend to read:

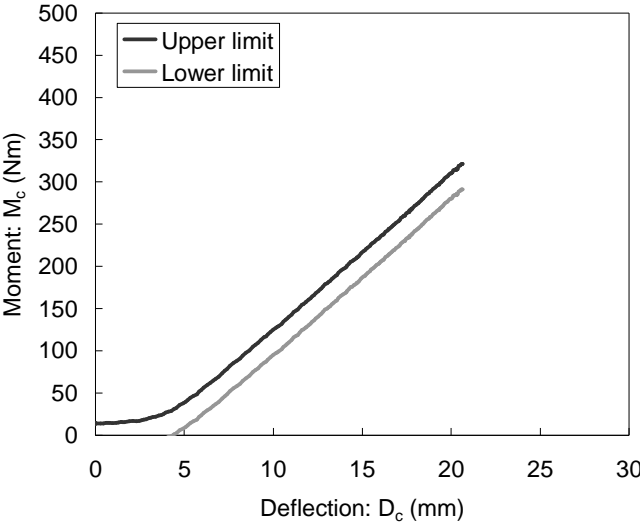
"**8.4.3.3.** ... impactor with respect to the vertical as shown in Figure ~~25~~**37**. The suspension of ..."

Paragraph 8.3.3.4. (former), renumber as paragraph 8.4.3.4.

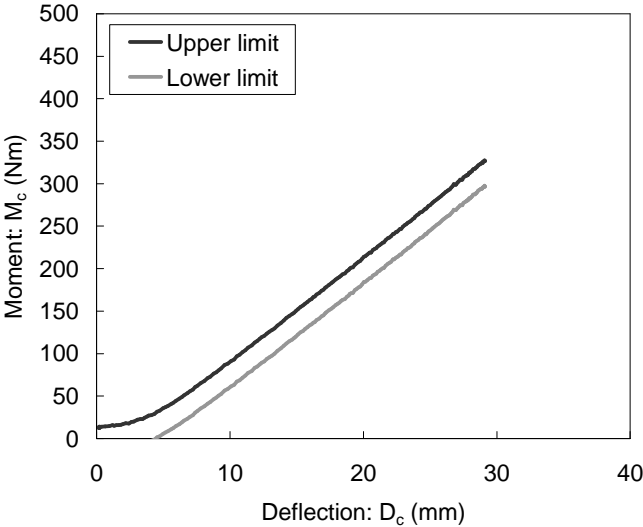
Figures 18 to 23 (former), renumber as Figures 25 to 30.

Insert new Figures 31 to 38., to read:

"

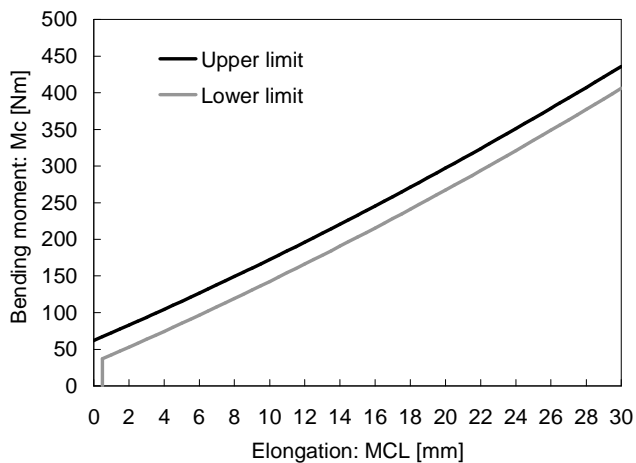


(a) Femur bending corridor

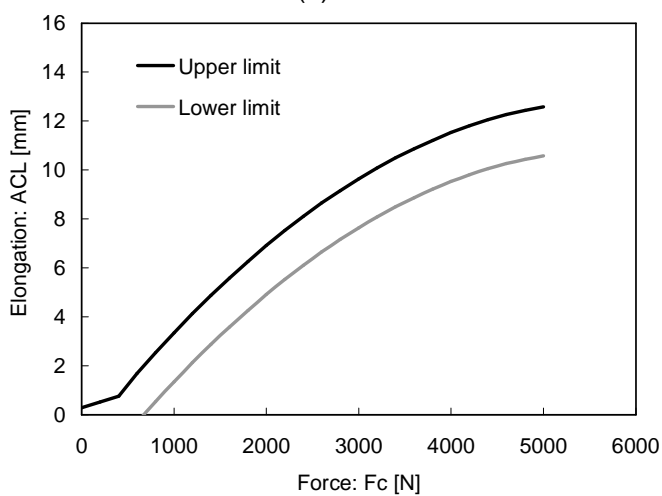


(b) Tibia bending corridor

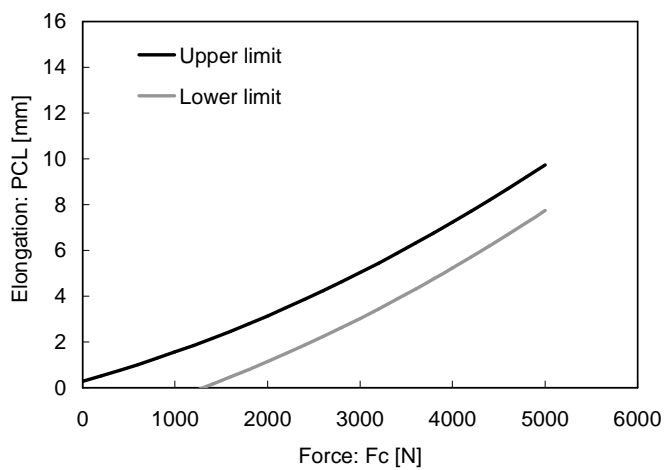
Figure 31: Requirement corridor of femur and tibia in static certification test (see paragraph 8.2.1.2.)



(a) for MCL



(b) for ACL



(c) for PCL

Figure 32: Requirement corridors for knee joint in static certification test (see paragraph 8.2.1.3.)

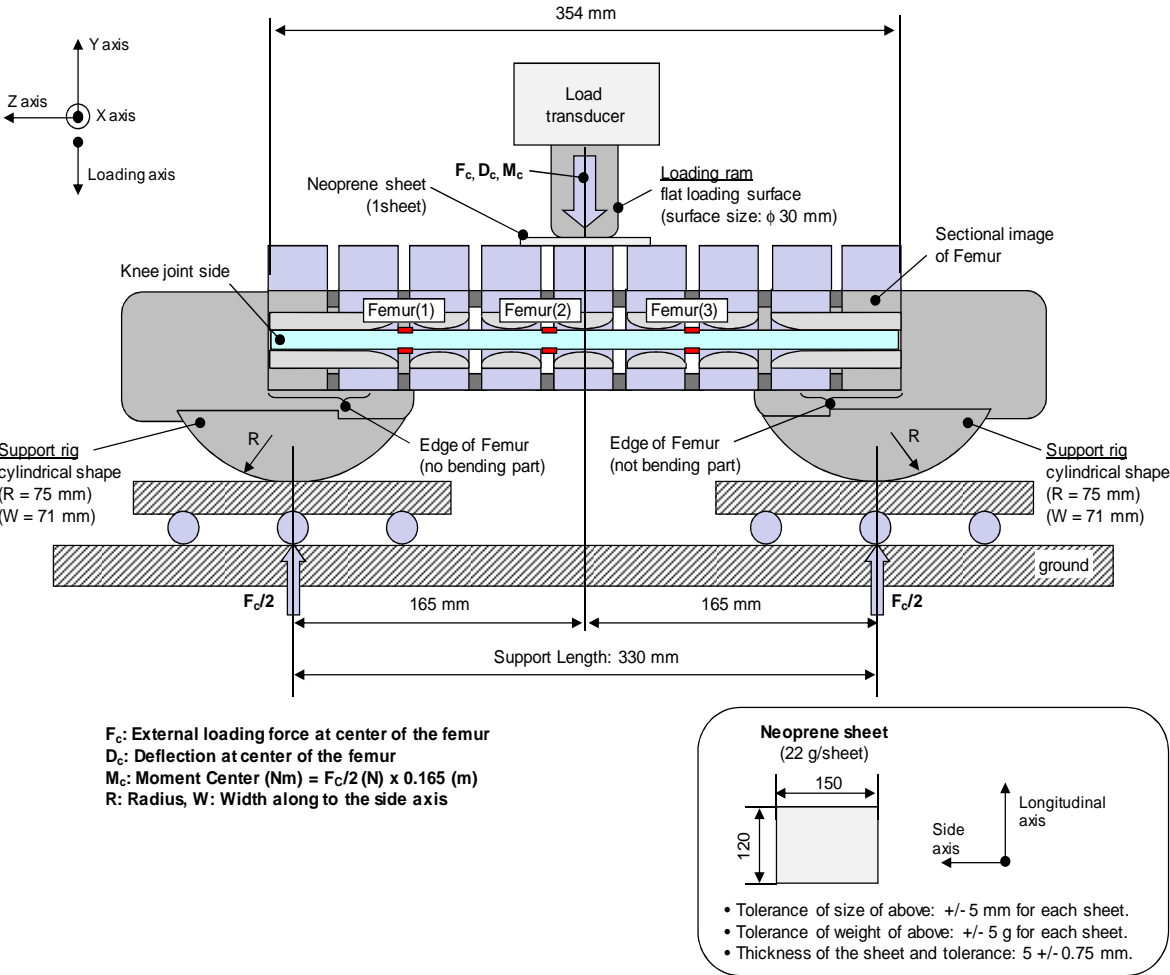


Figure 33: Test set-up for femur in static certification tests (see paragraph 8.2.1.4.)

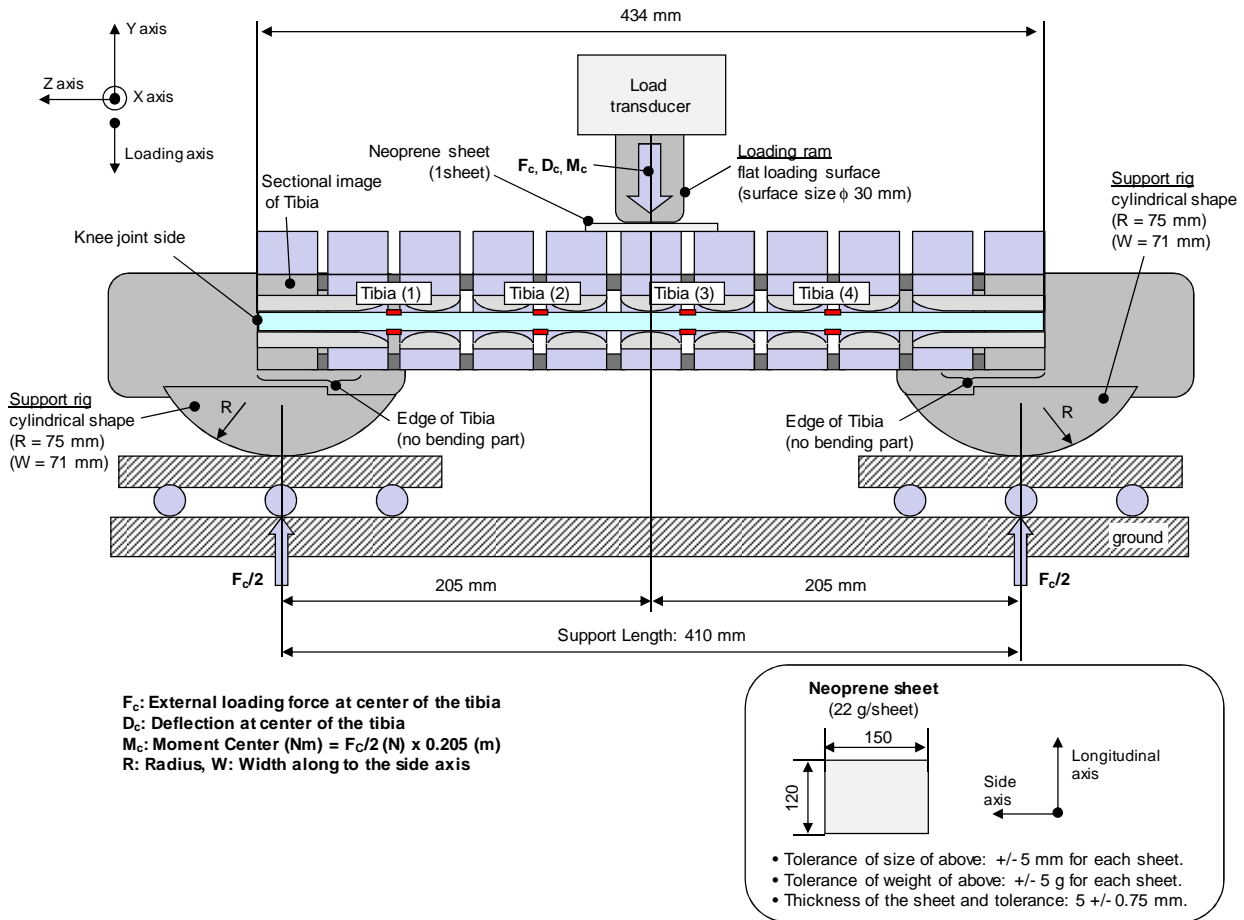


Figure 34: Test set-up for tibia in static certification tests
(see paragraph 8.2.1.4.)

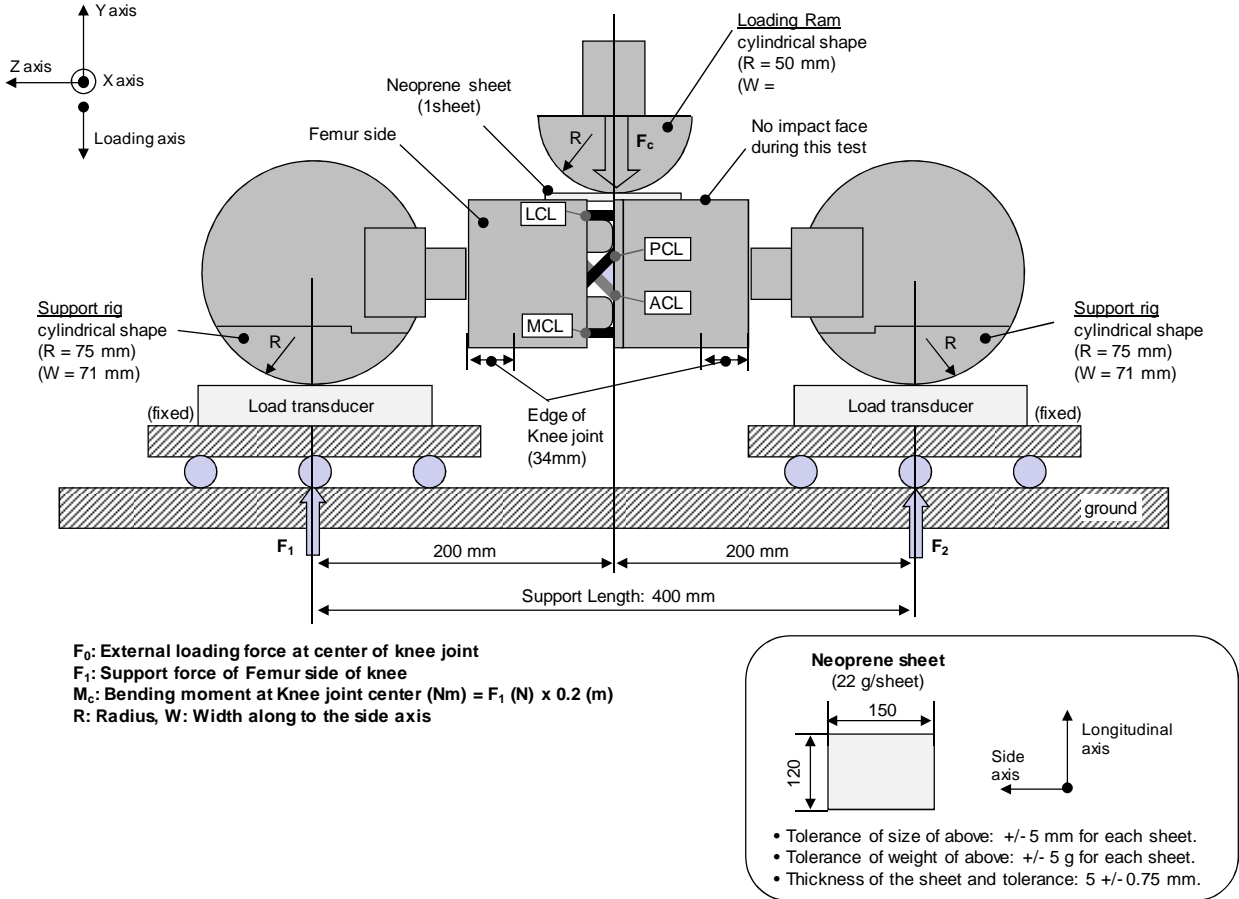


Figure 35: Test set-up for knee joint in static certification test (see paragraph 8.2.1.5.)

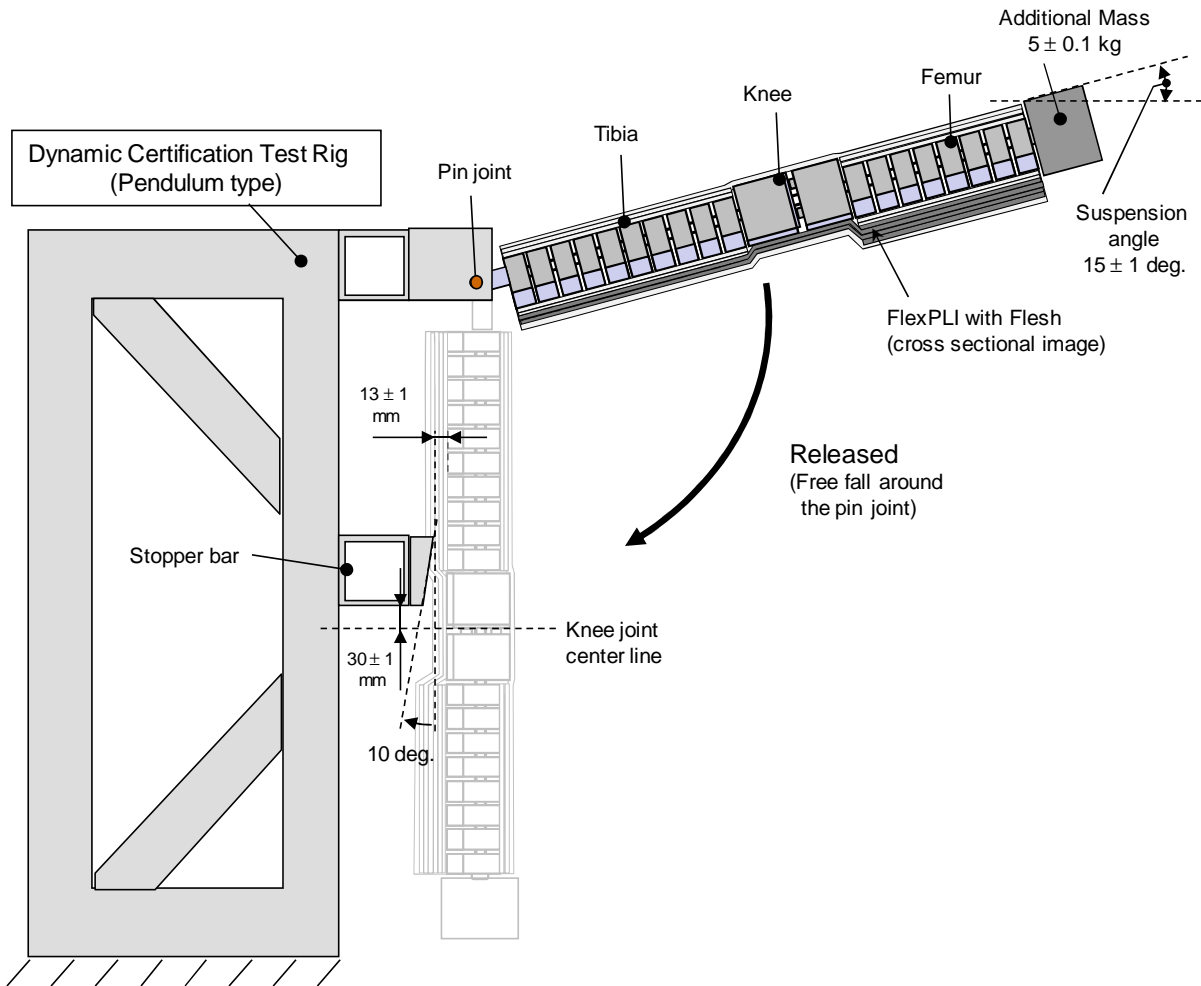


Figure 36: Test set-up for dynamic lower legform impactor certification test, Pendulum type (see paragraph 8.2.2.4.)

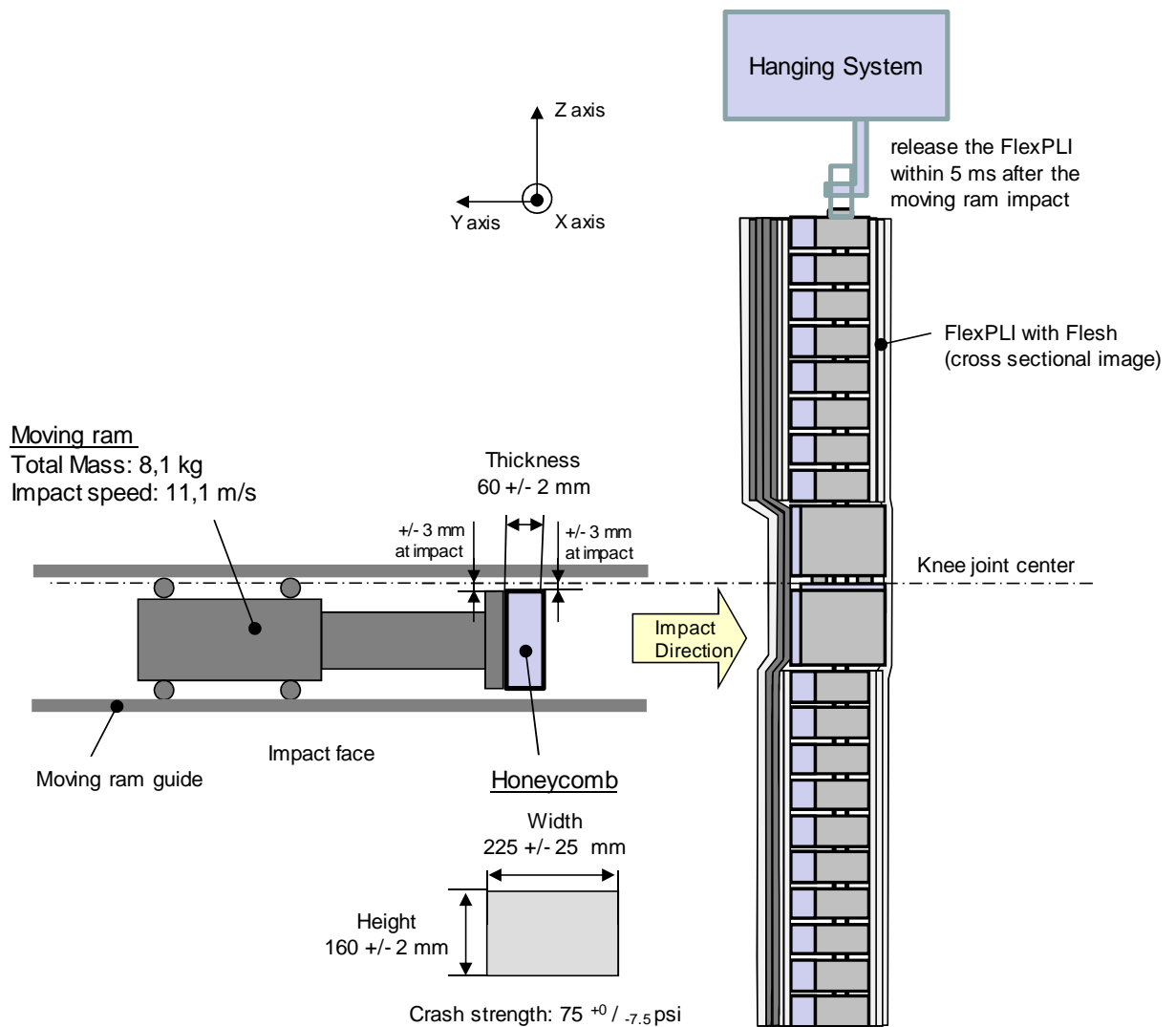


Figure 37: Test set-up for dynamic lower legform impactor certification test, Inverse type (see paragraph 8.2.3.4.)

Figures 24 and 25 (former), renumber as Figures 38 and 39.

B. JUSTIFICATION

Based on the results of the TEG activities up to now, the expert from Japan proposes the above mentioned draft amendments to the gtr on pedestrian protection (gtr No. 9) following the responsibility of the TEG chairmanship.

STATEMENT OF TECHNICAL RATIONALE AND JUSTIFICATION

Paragraph 64: new text to introduce the TEG activities so far.

Paragraphs 102, 110, 111, 112, 113, 115: new text regarding the Flexible Pedestrian Legform Impactor (FlexPLI).

Paragraph 106: new text to introduce the TEG activities so far.

Paragraph 114: clarification on the EEVC WG17 pedestrian lower legform impactor

Title of Section 10: new text on the FlexPLI.

Inserted a new paragraph 133.: new text to introduce the FlexPLI to each Contracting Party smoothly.

Section 10 (former): renumbering (Editorial).

TEXT OF THE REGULATION

Paragraph 4.1.1: clarification on the EEVC WG17 pedestrian lower legform impactor as well as to the FlexPLI.

Paragraph 4.1.2: renumbering (editorial).

Paragraph 5.1.1: guidance for the alternative use of the EEVC WG17 pedestrian lower legform and FlexPLI during an alternative period.

Paragraph 5.1.1.2.: new text on the FlexPLI.

Title of Paragraph 6.3.1.1.: clarification (editorial).

Title of Figure 12: clarification (editorial).

New paragraphs 6.3.1.2. to 6.3.1.2.7.2.: new paragraphs regarding the FlexPLI.

New Figures 13 to 17: new figures regarding the Flex-PLI.

Paragraph 6.3.1.2. (former): renumbering (editorial).

Paragraph 6.3.1.2.9.1. (former): renumbering (editorial).

Paragraph B. 6.3.1.2.9.2. (former): renumbering (editorial).

Title of Figure 13: renumbering (editorial).

Title of Paragraph B. 6.3.2.1.: renumbering (editorial).

Paragraph B. 6.3.2.1.1.: renumbering (editorial).

Figure 14 (former): renumbering (editorial).

Title of paragraph 6.3.2.2.: renumbering (editorial).

Figure 15 (former): renumbering (editorial).

Paragraph 6.3.2.2.1.: renumbering (editorial).

Title of paragraph 7.1.1.: clarification (editorial).

Paragraph 7.1.1.2.: renumbering (editorial).

Paragraph 7.1.1.3.: renumbering (editorial).

Paragraph 7.1.1.3.2.: renumbering (editorial).

Figure 16 to 17 (former): renumbering (editorial).

New paragraphs 7.1.2. to 7.1.2.4.: new paragraphs regarding to the Flex-PLI.

Figures 23 to 24: new figures regarding the Flex-PLI.

Paragraph 7.1.2. to 7.1.2.3. (former): renumbering (editorial).

Paragraph 8.: renumbering (editorial) and alternative use of the EEVC WG17 pedestrian legform impactor and FlexPLI during an alternative period.

Title of Paragraph B. 8.1: clarification (editorial).

Paragraph B. 8.1.1.2.: renumbering (editorial).

Paragraph B. 8.1.1.3.: renumbering (editorial).

Paragraph B. 8.1.1.4.: renumbering (editorial).

Paragraph B. 8.1.1.5.: renumbering (editorial).

Paragraph B. 8.1.2.4.1.: renumbering (editorial).

Paragraph B. 8.1.2.4.2.: renumbering (editorial).

Paragraph B. 8.1.2.4.5.: renumbering (editorial).

New paragraphs. 8.2. to 8.2.3.4.4: new paragraphs regarding the FlexPLI.

Paragraph 8.2. to 8.2.4.7. (former): renumbering (editorial).

Paragraph 8.2.1 (former): renumbering (editorial).

Paragraph 8.2.4.6. (former): renumbering (editorial).

Paragraph 8.3. to 8.3.3.4. (former): renumbering (editorial).

Paragraph 8.3.1.1. (former): renumbering (editorial).

Paragraph 8.3.3.1. (former): renumbering (editorial).

Paragraph 8.3.3.3. (former): renumbering (editorial).

Figure 18 to 23 (former): new figures regarding the FlexPLI.
