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Item 18(b) of the provisional agenda
Regulation No. 127 (Pedestrian safety) - Proposal for the 01 series of amendments to Regulation No. 127

Proposal of 01 series of amendments to Regulation No. 127

Submitted by the experts from the informal working group on global technical regulation No. 9 Phase 2*

The text reproduced below was prepared by the experts from the informal working group on global technical regulation No. 9 Phase 2 (GTR9-PH2) proposing provisions on pedestrian protection of motor vehicles. The modifications to the text of the UN Regulation are marked in bold for new or strikethrough for deleted characters.

* 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.

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I. Proposal

List of contents, insert new paragraph 11, to read:

"11. **Transitional provisions**."

Insert new paragraph 2.2., to read:

"2.2. **"Assessment interval" (AI) of the flexible lower legform impactor is defined and limited by the time of first contact of the flexible lower legform impactor with the vehicle and the timing of the last zero crossing of all femur and tibia segments after their first local maximum subsequent to any marginal value of 15 Nm, within their particular common zero crossing phases. The AI is identical for all bone segments and knee ligaments. In the case that not all tibia [and] [or] femur bending moments having a zero crossing during the common zero crossing phase, the time history curves are shifted downwards until all bending moments are crossing zero. The downwards shift is to be applied for the determination of the AI only.**"

Paragraph 2.2. to 2.27., renumber as paragraphs 2.3. to 2.28.

Insert new paragraph 2.29., to read:

"2.29. **"Primary reference marks" means holes, surfaces, marks and identification signs on the vehicle body. The type of reference mark used and the vertical (Z) position of each mark relative to the ground shall be specified by the vehicle manufacturer according to the running conditions specified in paragraph 2.27. These marks shall be selected so as to be able to easily check the vehicle front and rear ride heights and vehicle attitude.**

If the primary reference marks are found to be within ± 25 mm of the design position in the vertical (Z) axis, then the design position shall be considered to be the normal ride height. If this condition is met, either the vehicle shall be adjusted to the design position, or all further measurements shall be adjusted, and tests performed, to simulate the vehicle being at the design position."

Paragraphs 2.28. to 2.40.(former), renumber as paragraphs 2.30. to 2.42.

Paragraph 5.1.1., amend to read:

"5.1.1. **Flexible** lower legform to bumper:

When tested in accordance with Annex 5, paragraph 1. (**Flexible** 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 170 g. 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 250 g.~~ **the absolute value of the maximum dynamic medial collateral ligament elongation at the knee shall not exceed [22 mm], and the maximum dynamic anterior cruciate ligament and posterior cruciate ligament elongation shall not exceed [13 mm]. The absolute value of dynamic bending moments at the tibia shall not exceed [340 Nm].** [**In addition, the manufacturer may**

nominate bumper test widths up to a maximum of 264 mm in total where the absolute value of 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.]

The **flexible** lower legform impactor shall be certified pursuant to Annex 6, paragraph 1."

Insert new paragraphs 11. to 11.4., to read:

"**[11. Transitional Provisions**

11.1 As from the official date of entry into force of the 01 series of amendments, no Contracting Party applying this UN Regulation shall refuse to grant or refuse to accept UN type approvals under this UN Regulation as amended by the 01 series of amendments.

11.2 As from [36] months after the date of entry into force of the 01 series of amendments, Contracting Parties applying this UN Regulation shall grant UN type approvals only if the vehicle type to be approved meets the requirements of this UN Regulation as amended by the 01 series of amendments.

11.3 Contracting Parties applying this UN Regulation shall not refuse to grant extensions of UN type approvals for existing vehicle types which have been granted according to the preceding series of amendments to this UN Regulation.

11.4 Even after the date of entry into force of the 01 series of amendments to this UN Regulation, UN type approvals to the preceding series of amendments to the UN Regulation shall remain valid. Contracting Parties applying this UN Regulation shall continue to accept them.]"

Annex 4,

Paragraphs 1. to 1.4., amend to read:

"1. **Flexible** ~~L~~lower legform impactor

1.1. ~~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 ± 5 mm, having a required test mass of 13.4 ± 0.2 kg (see Figure 1). Dimensions of the various parts are detailed in Figure 1.~~

The flexible lower legform impactor shall consist of flesh and skin, flexible long bone segments (representing femur and tibia), and a knee joint as shown in Figure 1. The assembled impactor shall have a total mass of 13.2 ± [0.7 kg]. The dimensions of the fully assembled impactor shall be as defined in Figure 1.

Brackets, pulleys, **protectors, connection parts,** etc. attached to the impactor for the purpose**s** of launching ~~it~~ [and][or] **protection~~,~~** may extend **beyond** the dimensions **and tolerances** shown in Figure 1 **and Figures 2 (a) and (b)**.

1.2. ~~The diameter of the femur and tibia shall be 70 ± 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.~~ **The cross-sectional shape of the femur main body segments, the tibia main body segments and their impact faces shall be as defined in Figure 2(a).**

1.3. ~~The knee joint shall be fitted with deformable knee elements from the same batch as those used in the certification tests.~~ **The cross-sectional shape of the knee joint and its impact face shall be as defined in Figure 2 (b).**

1.4. ~~The total masses of the femur and tibia shall be 8.6 ± 0.1 kg and 4.8 ± 0.1 kg respectively, and the total mass of the impactor shall be 13.4 ± 0.2 kg. The centre of gravity of the femur and tibia shall be 217 ± 10 mm and 233 ± 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 ± 0.010 kgm² and 0.120 ± 0.010 kgm² respectively.~~ **The masses of the femur and the tibia without the flesh and skin, including the connection parts to the knee joint, shall be 2.46 [± 0.12] kg and 2.64 [± 0.13] kg respectively. The mass of the knee joint without the flesh and skin shall be 4.28 [± 0.21] kg. The assembled mass of the femur, the knee joint and the tibia without the flesh and skin shall be 9.38 ± 0.46 kg.**

The centres of gravity of the femur and tibia without the flesh and skin, including the connection parts to the knee joint, shall be as defined in Figure 1 . The centre of gravity of the knee joint shall be as defined in Figure 1.

The moment of inertia of the femur and the tibia without the flesh and skin, including the connection parts inserted to the knee joint, about the X-axis through the respective centre of gravity shall be 0.0325 ± 0.0016 kgm² and 0.0467 ± 0.0023 kgm² respectively. The moment of inertia of the knee joint about the X-axis through the respective centre of gravity shall be 0.0180 ± 0.0009 kgm²."

Paragraphs 2.1. to 2.4., amend to read:

"2.1. ~~An uniaxial accelerometer shall be mounted on the non impacted side of the tibia, 66 ± 5 mm below the knee joint centre, with its sensitive axis in the direction of impact~~**Four transducers shall be installed in the tibia to measure bending moments at the locations within the tibia. Three transducers shall be installed in the femur to measure bending moments applied to the femur. The sensing locations of each of the transducers are as defined in Figure 2. The measurement axis of each transducer shall be the X-axis of the impactor**.

2.2. ~~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~~**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 3. The measurement locations shall be within ± 4 mm along the X-axis from the knee joint centre**.

2.3. ~~Transducers shall be fitted to measure knee bending angle and knee shearing displacement~~ **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 and femur bending moments. This does not require that the impactor itself be able to physically elongate or bend until these values**.

2.4. ~~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 500 g for the acceleration. This does not require that the impactor itself be able to physically bend and shear to these angles and displacements~~ **The determination of all flexible lower legform impactor peak tibia bending moments and ligament elongations shall be limited to the assessment interval (AI) as defined in paragraph 2.2.**"

Figure 1 (former), shall be deleted

Insert new Figures 1 to 3, to read:

"Figure 1

Flexible lower legform impactor

Dimensions and centre of gravitiy locations of femur, knee joint and tibia (Side view)

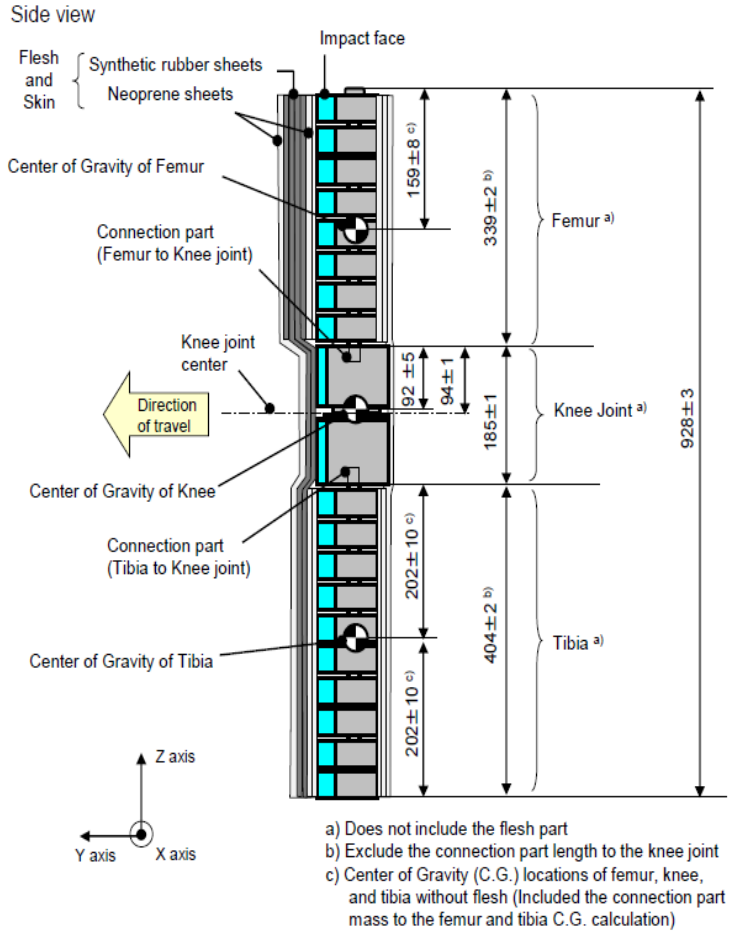

Figure 2

Flexible lower legform impactor schematic plan views of femur, tibia, and knee dimensions (top view)

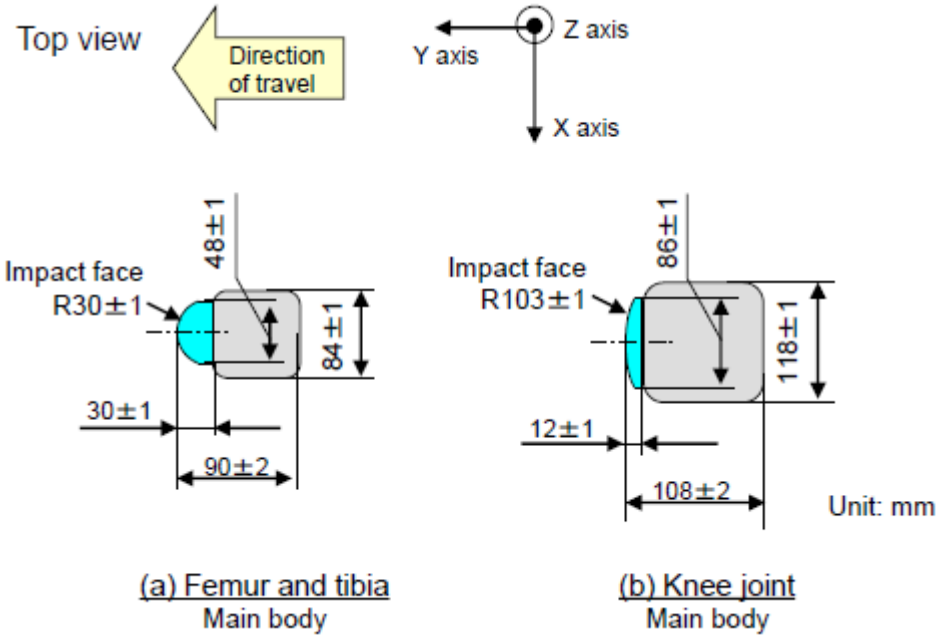

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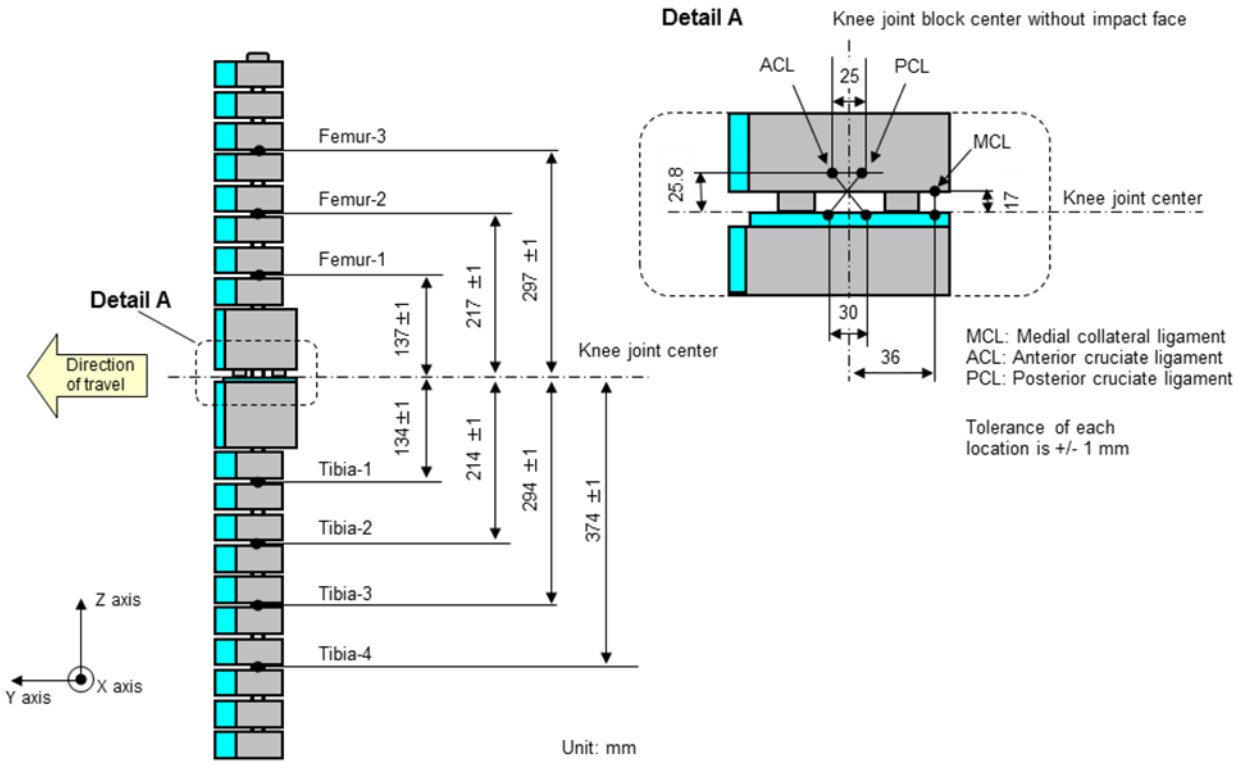
Figure 3
Flexible lower legform impactor instrument locations



"

Paragraph 3.1., amend to read:

"3.1. … and 350 ± 5 mm long (see Figure **4**)."

Paragraph 4.1., amend to read:

"4.1. … positions, as shown in Figure **4**, each using …."

Paragraph 4.2., amend to read:

"4.2. … side of the centre line (see Figure **4**)."

Figure 2. (former), renumber as Figure 4.

Paragraph 5.1., amend to read:

"5.1. … Child headform impactor (see Figure **5**)."

Paragraph 5.2.2., amend to read:

"5.2.2. … perpendicular to the mounting face A (see Figure **5**) and its seismic mass …"

Figure 3. (former), renumber as Figure 5.

Paragraph 5.3., amend to read:

"5.3. … Adult headform impactor (see Figure **6**)."

Paragraph 5.3.1., amend to read:

"5.3.1. The adult…as shown in Figure **6**…"

Figure 4. (former), renumber as Figure 6.

Paragraph 5.4.2., amend to read:

"5.4.2. If three … face A (see Figure **6**)."

Annex 5,

Paragraphs 1. to 1.2., amend to read:

"1. **Flexible** ~~L~~lower legform impactor

1.1. 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 ±2 per cent of the weight of the sheet used in the certification test.~~ **(femur, knee joint and tibia) shall be covered by flesh and skin composed of synthetic rubber sheets (R1, R2) and neoprene sheets (N1F, N2F, N1T, N2T, N3) as shown in Figure 1. The size of the sheets shall be within the requirements described in Figure 1. The sheets are required to have compression characteristics as shown in Figure 2. The compression characteristics shall be checked using material from the same batch as the sheets used for the impactor flesh and skin.**

1.2. All impactor components ~~The test impactor or at least the foam flesh~~ shall be stored ~~during a period of~~ **for** ~~at least four hours~~ **a sufficient period of time** in a controlled storage area with ~~a stabilized humidity of 35 ± 15 per cent and~~ a stabilized temperature of 20 ± **4** °C prior to impactor removal for test**ing**. After removal from the storage the impactor shall not be subjected to conditions other than those pertaining in the test area **as defined in Annex 3, paragraph 1.1**."

Paragraphs 1.6. to 1.9., amend to read:

"1.6. The direction of the impact velocity vector shall be in the horizontal plane and parallel to the longitudinal vertical plane of the vehicle. The tolerance for the direction of the velocity vector in the horizontal plane and in the longitudinal plane shall be ±2° at the time of first contact. The axis of the impactor shall be perpendicular to the horizontal plane with a **roll and pitch angle** tolerance of ±2° in the lateral and longitudinal plane. The horizontal, longitudinal and lateral planes are orthogonal to each other (see Figure ~~1~~3).

1.7. The bottom of the impactor **(without parts needed for the purposes of launching and/or protection)** shall be at ~~25~~ **75** mm above ground reference plane at the time of first contact with the bumper (see Figure ~~2~~4), with a ±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.

1.8. 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~~ **any** means that can be shown to ~~give the same result~~ **meet the requirements of the test**.

1.9. 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 ±5° (see Figure ~~1~~3)."

Insert new paragraphs 1.13. to 1.14., to read:

"**1.13. The tibia bending moments shall not exceed +/- 15 Nm within an evaluation interval of 30 ms immediately prior to impact.**

1.14. The offset compensation shall be done with the flexible lower legform impactor in resting position prior to the test/acceleration phase."

Insert new Figures 1 and 2, to read:

"Figure 1

Flexible lower legform impactor: Flesh and skin dimensions

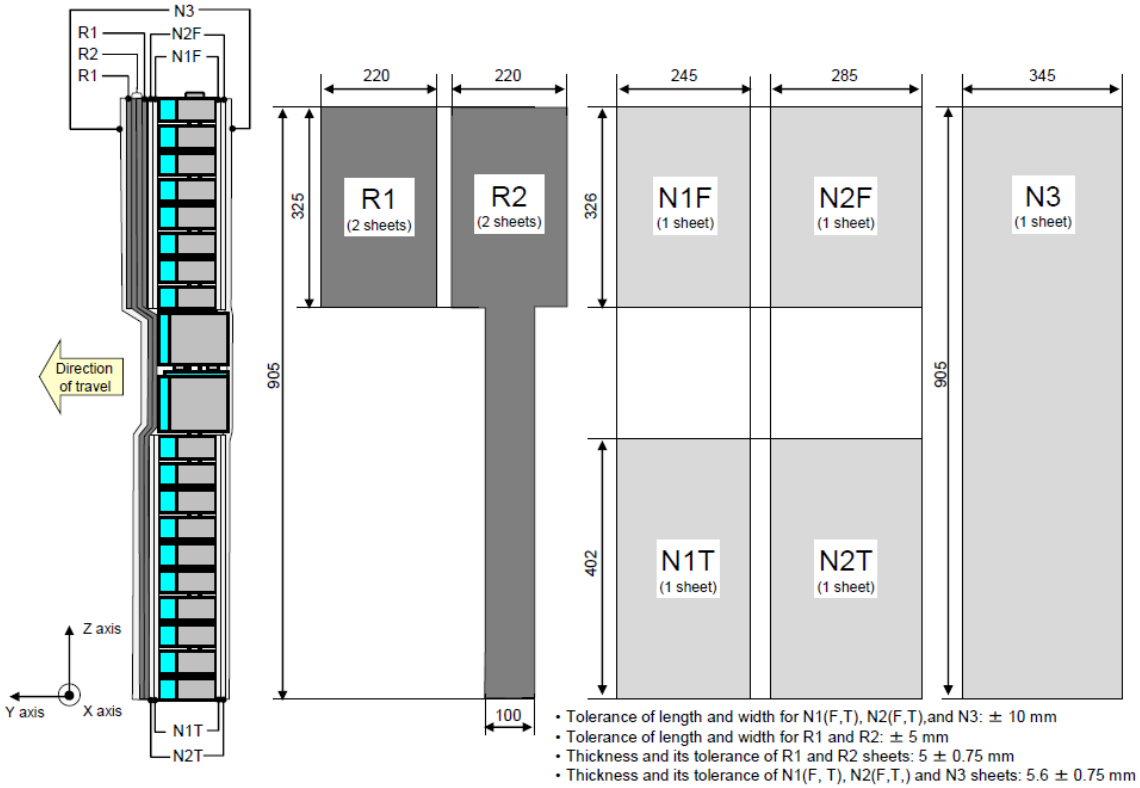
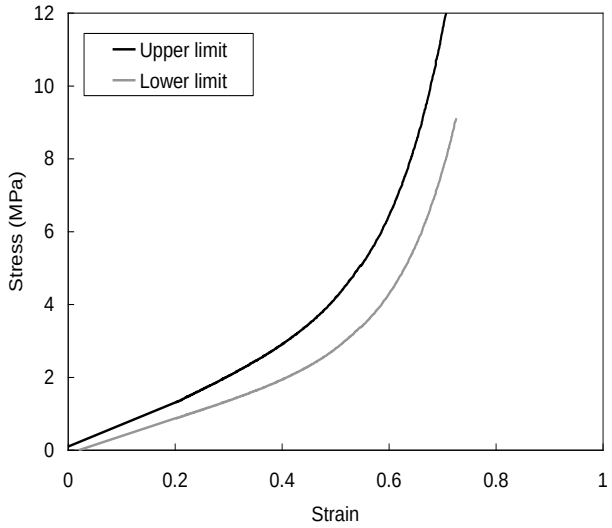


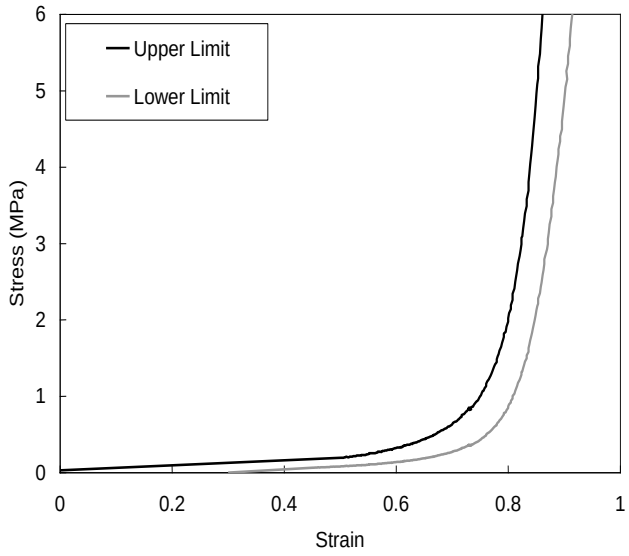
Figure 2

Flexible lower legform impactor: Flesh and skin compression characteristics

(a) Synthetic rubber sheets



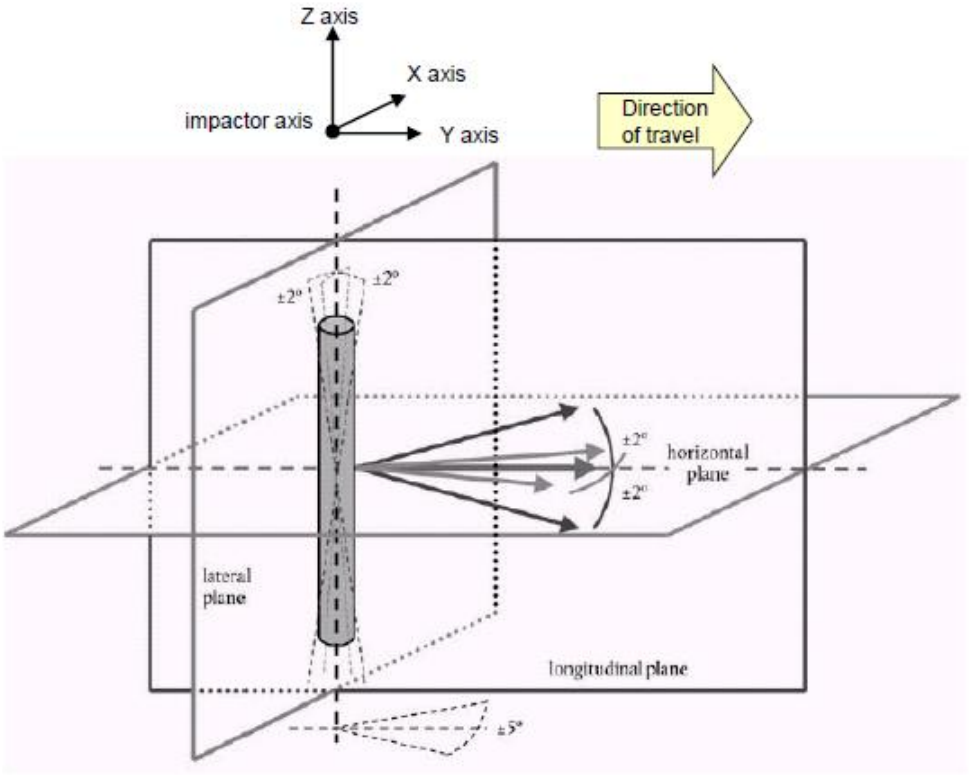
(b) [Neoprene sheets]



"

Figure 1(former), renumber as Figure 3 and amend to read:

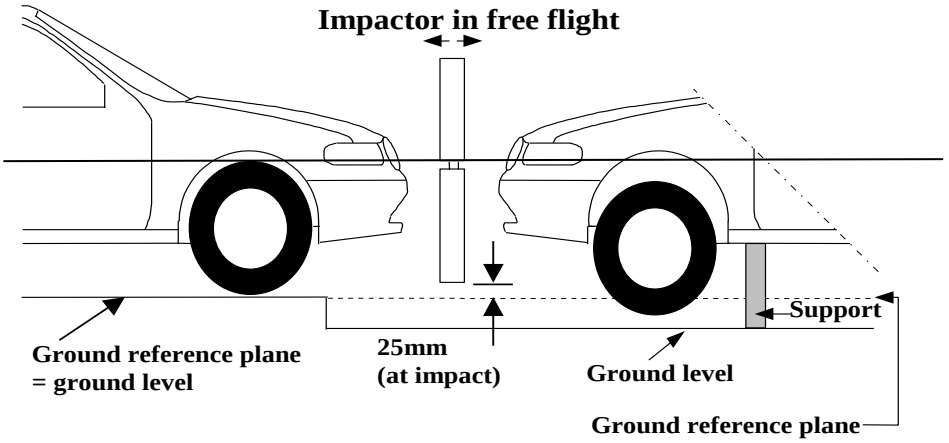
"Figure ~~1~~3
Tolerances of angles for the **flexible** lower legform impactor at the time of the first impact

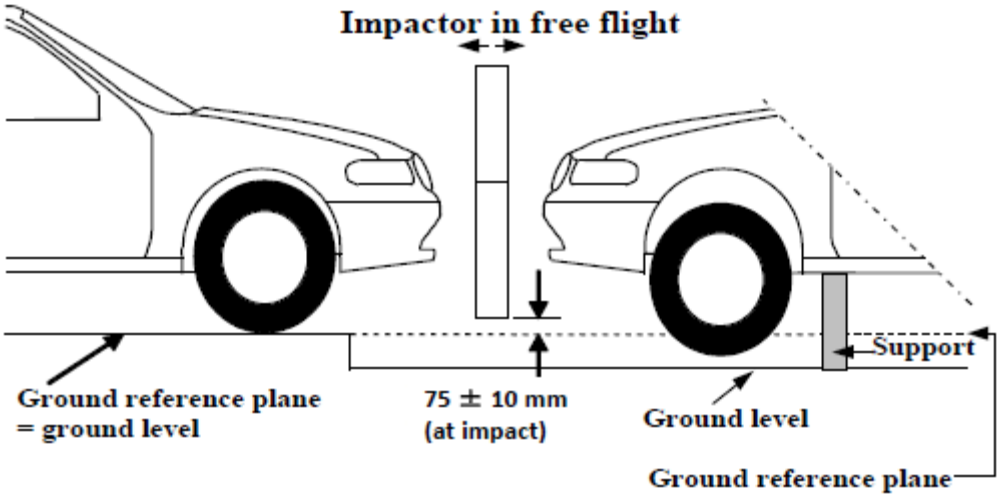


"

Figure 2 (former), renumber as Figure 4 and amend to read:

"Figure ~~2~~ **4**
Flexible lower legform **impactor** to bumper tests for complete vehicle in normal ride attitude (left) and for cut-body mounted on supports (right)





"

Paragraph 3.4.1., amend to read:

"3.4.1. … (see Figure **5**)."

Figure 3 (former), renumber as Figure 5.

Annex 6

Paragraphs 1. to 1.3.1.2., amend to read:

"1. **Flexible ~~L~~l**ower legform impactor certification

1.1. **The impactor shall be certified using two certification tests as follows: First, the certification shall be conducted according to the inverse certification (IC) test procedure prescribed in paragraph 1.4. of this Annex before starting a vehicle test series. Second, after a maximum of 10 vehicle tests, certification should be conducted according to the pendulum certification (PC) test procedure prescribed in paragraph 1.3. of this Annex. Ongoing certification testing then shall constitute the sequence IC – PC – PC – IC – PC – PC – etc. with a maximum of 10 tests between each certification.**

In addition, the impactor shall be certified according to the procedures prescribed in paragraph 1.2. below at least once a year.

~~The certified impactor may be used for a maximum of 20 impacts before re-certification. With each test new plastically deformable knee elements shall 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.~~

1.2. Static **certification** tests

1.2.1. **The femur and the tibia of the flexible lower legform impactor shall meet the requirements specified in paragraph 1.2.2. of this Annex when tested according to paragraph 1.2.4. of this Annex. The knee joint of the lower legform impactor shall meet the requirements specified in paragraph 1.2.3. of this Annex when tested according to paragraph 1.2.5 of this Annex. The stabilized temperature of the impactor during the certification tests shall be 20 ± 2°C.**

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

~~For both tests specified in paragraphs 1.2.2. and 1.2.3. below, the impactor shall have the intended orientation about its longitudinal axis, for the correct operation of its knee joint, with a tolerance of ±2°.~~

~~The stabilized temperature of the impactor during certification shall be 20° ± 2 °C.~~

~~The CAC response values, as defined in ISO 6487:2002 shall be 50° for the knee bending angle and 500 N for the applied force when the impactor is loaded in bending in accordance with paragraph 1.2.4., 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 1.2.5. 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.~~

1.2.2. **When the femur and the tibia of the impactor are loaded in bending in accordance with paragraph 1.2.4., the applied moment and the generated deflection at the centre of the femur and the tibia (M_c and D_c) shall be within the corridors shown in Figure 1.**

~~When the impactor is loaded in bending in accordance with paragraph 1.2.4. below, the applied force/bending angle response shall be within the limits shown in Figure 1. Also, the energy taken to generate 15.0° of bending shall be 100 ± 7 J.~~

1.2.3. **When the knee joint of the impactor is loaded in bending in accordance with paragraph 1.2.5 of this Annex, the MCL, ACL, and PCL elongations and applied bending moment or the force at the centre of the knee joint (M_c or F_c) shall be within the corridors shown in Figure 2.**

~~When the impactor is loaded in shearing in accordance with paragraph 1.2.5. below, the applied force/shearing displacement response shall be within the limits shown in Figure 2.~~

1.2.4. **The edges of the femur and tibia, not bending parts, shall be mounted to the support rig firmly as shown in Figure 3 and Figure 4. The Y-axis of the impactor shall be parallel to the loading axis within 180 ± 2° tolerance. To obtain repeatable loading, low friction Polytetrafluoroethylene (PTFE) plastic pads are used under each support (see Figure 3 and Figure 4).**

The centre of the loading force shall be applied at the centre of the femur and the tibia within ± 2mm tolerance along the Z-axis. The force shall be increased so as to maintain a deflection rate between 10 and 100 mm/minute until the bending moment at the centre part (M_c) of the femur or tibia reaches 380 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 3. The rotational axis of the 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 ± 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°/s until the angle of deflection of the knee is in excess of 22º. 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 ± 0.01 m.~~

1.2.5. **The ends of the knee joint shall be mounted to the support rig firmly as shown in Figure 5. The Y-axis of the impactor shall be parallel to the loading axis within ± 2° tolerance. To obtain repeatable loading, low friction Polytetrafluoroethylene (PTFE) plastic pads are used under each support (see Figure 5). 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 3 (b) of Annex 4 shall be**

removed. The neoprene sheet used in this test shall have compression characteristics as shown in Figure 2 (b) of Annex 5.

The centre of the loading force shall be applied at the knee joint center within ± 2mm tolerance along the Z-axis (see Figure 5). The external load shall be increased so as to maintain a deflection 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 4.~~

~~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 at a rate 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.~~

1.3. Dynamic **certification** tests **(pendulum test)**

1.3.1. ~~Calibration~~**Certification**

1.3.1.1. **The test facility used for the certification test shall have a stabilized temperature of 20 ± 2 °C during the test.**

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

1.3.1.2. **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 ± 30 per cent and a stabilized temperature of 20 ± 4 °C during calibration.~~"

Paragraphs 1.3.1.3. and 1.3.1.4., shall be deleted

Paragraphs 1.3.2. to 1.3.3.2., amend to read:

"1.3.2. Requirements

1.3.2.1. **When the flexible lower legform impactor is used for a test according to paragraph 1.3.3, the absolute value of the maximum bending moment of the tibia at:**

(a) tibia-1 shall be 235 Nm ≤ 272 Nm;

(b) tibia-2 shall be 187 Nm ≤ 219 Nm;

(c) tibia-3 shall be 139 Nm ≤ 166 Nm;

(d) tibia-4 shall be 90 Nm ≤ 111 Nm.

The absolute value of the maximum elongation of:

(a) MCL shall be 20.5 ≤ 24.0 mm;

(b) ACL shall be 8.0 mm ≤ 10.5 mm;

(c) PCL shall be 3.5 mm ≤ 5.0 mm.

For all these values for the maximum bending moment and the maximum elongation, the readings used shall be from the initial impact timing to 200 ms after the impact timing.

~~When the impactor is impacted by a linearly guided certification impactor, as specified in paragraph 1.3.3., the maximum upper tibia acceleration shall be not less than 120 g and not more than 250 g. 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.~~

1.3.2.2. **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.**

~~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 500 g for the acceleration. This does not require that the impactor itself be able to physically bend and shear to these angles and displacements.~~

1.3.3. Test procedure

1.3.3.1. **The flexible lower legform impactor, including the flesh and skin, shall be suspended from the dynamic certification test rig 15 ± 1° upward from the horizontal as shown in Figure 6. The impactor shall be released from the suspended position and fall freely against the pin joint of the test rig as shown in Figure 6.**

~~The impactor, including foam covering and skin, shall be suspended horizontally by three wire ropes of 1.5 ± 0.2 mm diameter and of 2000 mm minimum length, as shown in Figure 5. It shall be suspended with its longitudinal axis horizontal, with a tolerance of ±0.5°, and perpendicular to the direction of the certification impactor motion, with a tolerance of ±2°. The impactor shall have the intended orientation about its longitudinal axis, for the correct operation of its knee joint, with a tolerance of ±2°. The impactor must meet the requirements of paragraph 1.1., with the attachment bracket(s) for the wire ropes fitted.~~

1.3.3.2. **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 without the flesh and skin shall be located 13 ± 2 mm from the front upper edge of the stopper bar when the impactor is hanging freely as shown in Figure 6.**

~~The certification impactor shall have a mass of 9.0 ± 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 6. 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.~~"

Paragraphs 1.3.3.3. to 1.3.3.5., shall be deleted

Insert new paragraphs 1.4. to 1.4.3.4., to read:

"**1.4. Dynamic certification tests (inverse test)**

1.4.1. Certification

1.4.1.1. The test facility used for the certification test shall have a stabilized temperature of 20 ± 2 °C during the test.

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

1.4.2. Requirements

1.4.2.1. When the flexible lower legform impactor is used for the test according to paragraph 1.4.3 of this Annex, the absolute value of the maximum bending moment of the tibia:

(a) tibia-1 shall be 230 Nm ≤ 272 Nm;

(b) tibia-2 shall be 210 Nm ≤ 252 Nm;

(c) tibia-3 shall be 166 Nm ≤ 192 Nm;

(d) tibia-4 shall be 93 Nm ≤ 108 Nm.

The absolute value of the maximum elongation of:

(a) MCL shall be 17.0 ≤ 21.0 mm;

(b) ACL shall be 8.0 mm ≤ 10.0 mm;

(c) PCL shall be 4.0 mm ≤ 6.0 mm.

For all these values for the maximum bending moment and the maximum elongation, the readings used shall be from the initial impact timing to 50 ms after the impact timing.

1.4.2.2. 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.

1.4.3. Test procedure

1.4.3.1. The assembled flexible lower legform impactor (with the flesh and skin) shall be hung vertically and freely suspended from a test rig as shown in Figure 7. It is then impacted by the upper edge of a linearly guided aluminium honeycomb impactor, covered by a thin paper cloth with a maximum thickness of 1 mm, at an impact speed of 11.1 ± 0.2 m/s. The

legform shall achieve a free flight condition within 10 ms after the time of first contact of the honeycomb impactor.

1.4.3.2. **The honeycomb of 5052 alloy, which is attached in front of the moving ram, shall be 200 ± 5 mm wide, 160 ± 5 mm high and 60 ± 2 mm deep and shall have a crush strength of 75 pound per square inch (psi) ± 10 per cent. The honeycomb should have cell sizes of either 3/16 inch or ¼ inch and a density of 2.0 pound per cubic foot (pcf) for the 3/16 inch cell size or a density of 2.3 pcf for the ¼ inch cell size.**

1.4.3.3. **The upper edge of the honeycomb face shall be in line with the rigid plate of the linearly guided impactor. At the time of first contact, the upper edge of the honeycomb shall be in line with the knee joint centre line within a vertical tolerance of ± 2 mm.**

The honeycomb shall not be deformed before the impact test.

1.4.3.4. **At the time of the first contact, the flexible lower legform impactor pitch angle (rotation around the Y-axis) and therefore the pitch angle of the velocity vector of the honeycomb impactor shall be within a tolerance of ± 2° in relation to the lateral vertical plane. The flexible lower legform impactor roll angle (rotation around the X-axis) and therefore the roll angle of the honeycomb impactor shall be within a tolerance of ± 2° in relation to the longitudinal vertical plane. The flexible lower legform impactor yaw angle (rotation around the Z-axis) and therefore the yaw angle of the velocity vector of the honeycomb impactor shall be within a tolerance of ± 2°.**"

Paragraph 2.4.6., amend to read:

"2.4.6. The impactor … at a velocity of 7.1 ± 0.1 m/s into the stationary pendulum as shown in Figure ~~7~~**8**."

Paragraph 3.3.1., amend to read:

"3.3.1. The headform…impactor shall be suspended from a drop rig as shown in Figure ~~8~~**9**."

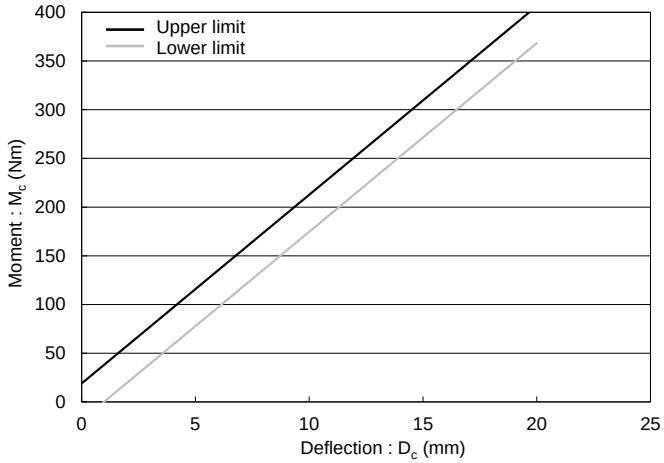
Paragraph 3.3.3., amend to read:

"3.3.3. The headform… respect to the vertical as shown in Figure **9**. The suspension of the …"

Insert new Figures 1 to 7, to read:

"Figure 1
Flexible lower legform impactor: Requirement corridors of the femur and the tibia in the static certification test (see paragraph 1.2.2. of this Annex)

(a) Femur bending corridor



(b) Tibia bending corridor

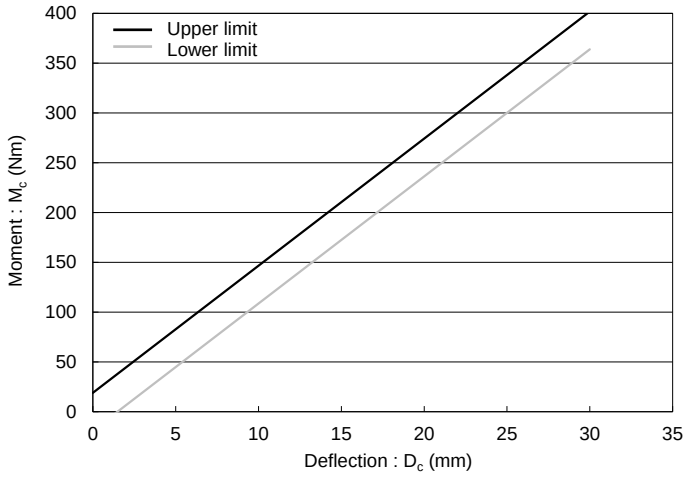
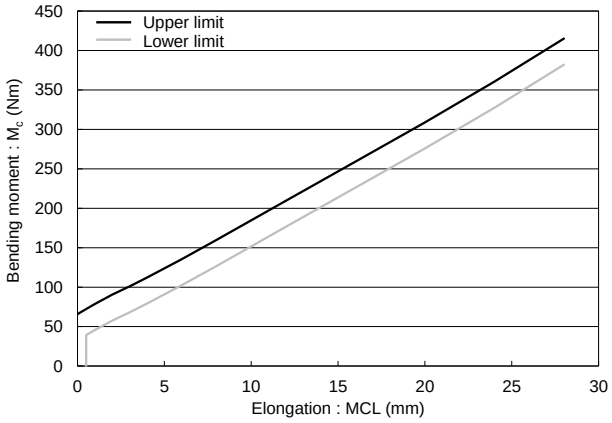
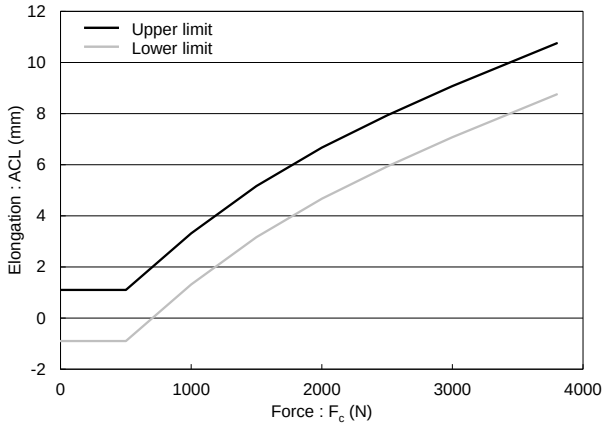


Figure 2

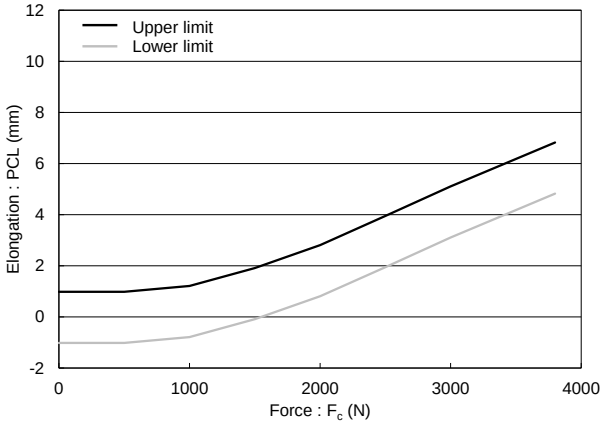
Flexible lower legform impactor: Requirement corridors for the knee joint in the static certification test (see paragraph 1.2.3. of this Annex)



(a) for MCL



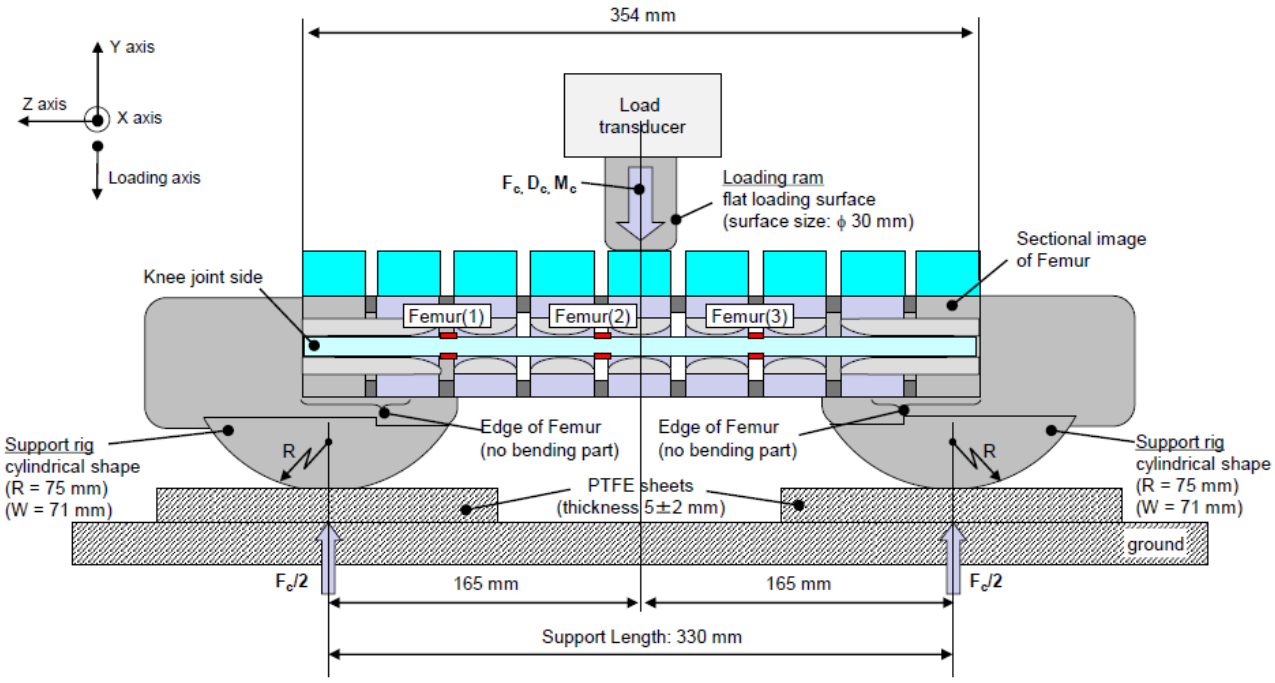
(b) for ACL



(c) for PCL

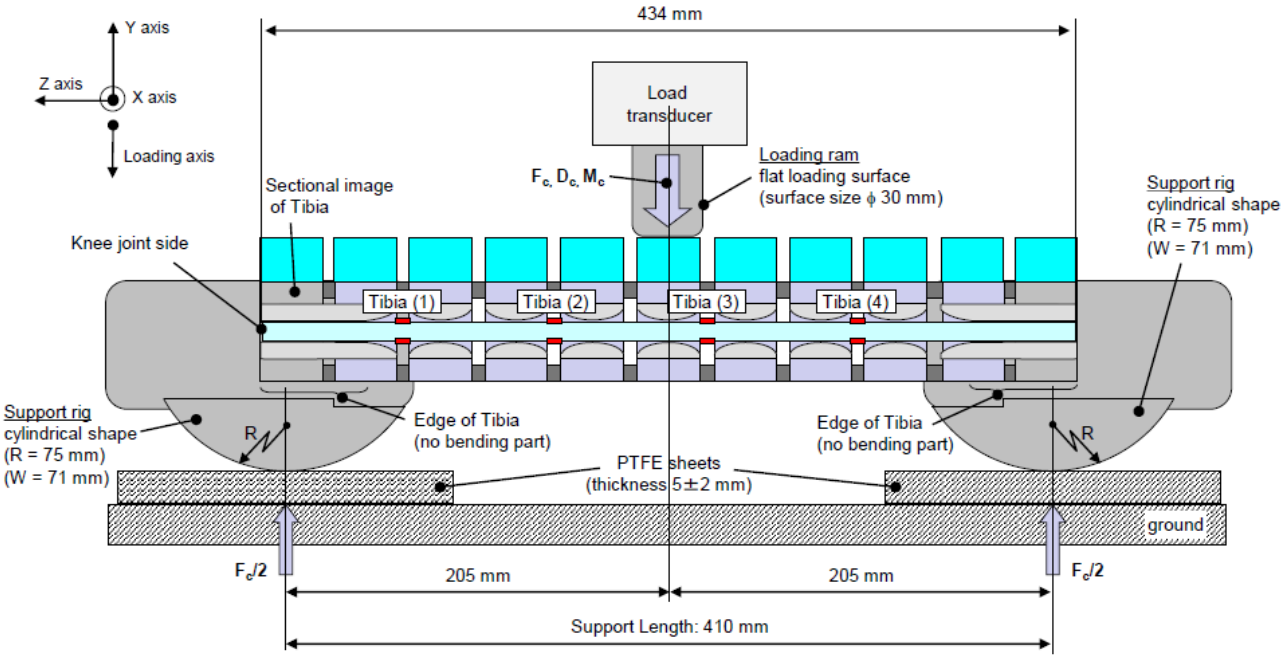
Figure 3

Flexible lower legform: Impactor test set-up for the femur in the static certification test (see paragraph 1.2.4. of this Annex)



F_c: External loading force at center of the femur
D_c: Deflection at center of the femur
M_c: Moment Center (Nm) = $F_c/2$ (N) x 0.165 (m)
R: Radius, W: Width along to the side axis
Tolerances for all dimensions above: ± 2 mm

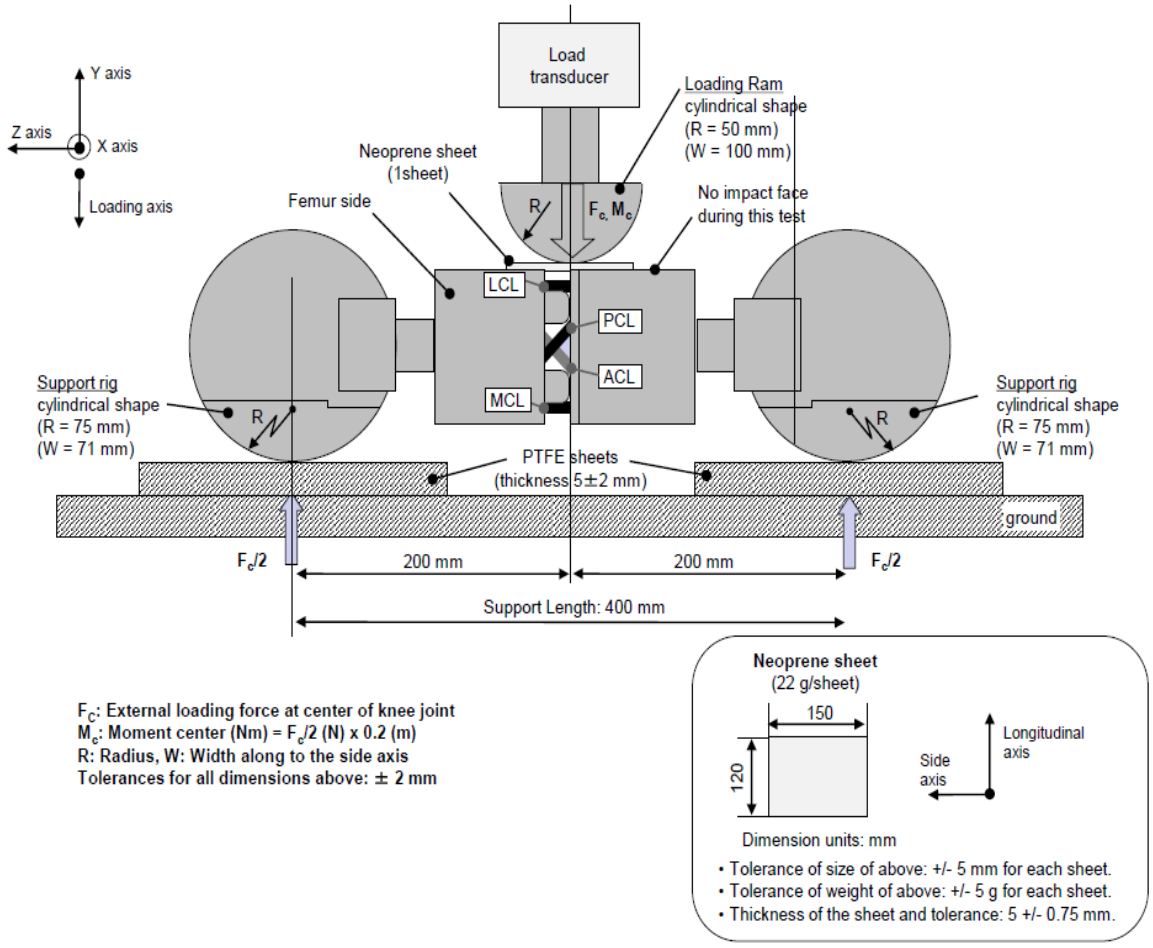
Figure 4:
Flexible lower legform impactor: Test set-up for the tibia in the static certification test (see paragraph 1.2.4. of this Annex)



F_c: External loading force at center of the tibia
D_c: Deflection at center of the tibia
M_c: Moment Center (Nm) = F_C/2 (N) x 0.205 (m)
R: Radius, W: Width along to the side axis
Tolerances for all dimensions above: ± 2 mm

Figure 5

Flexible lower legform impactor: Test set-up for the knee joint in the static certification test (see paragraph 1.2.5.)



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
Tolerances for all dimensions above: ± 2 mm

Figure 6

Flexible lower legform impactor: Test set-up for the dynamic lower legform impactor certification test (pendulum test, see paragraph 1.3.3.1.)

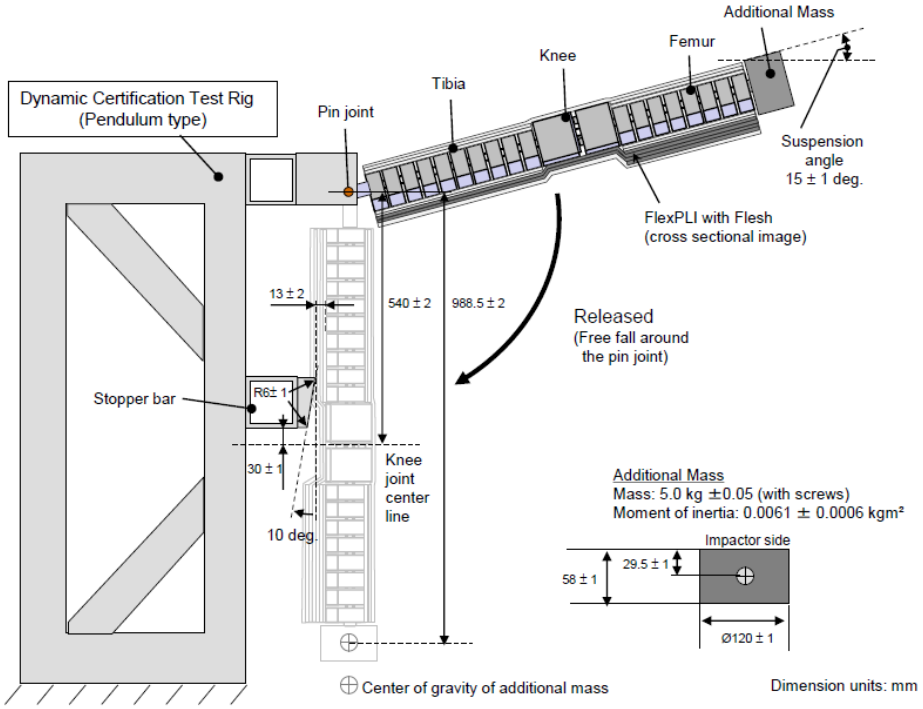
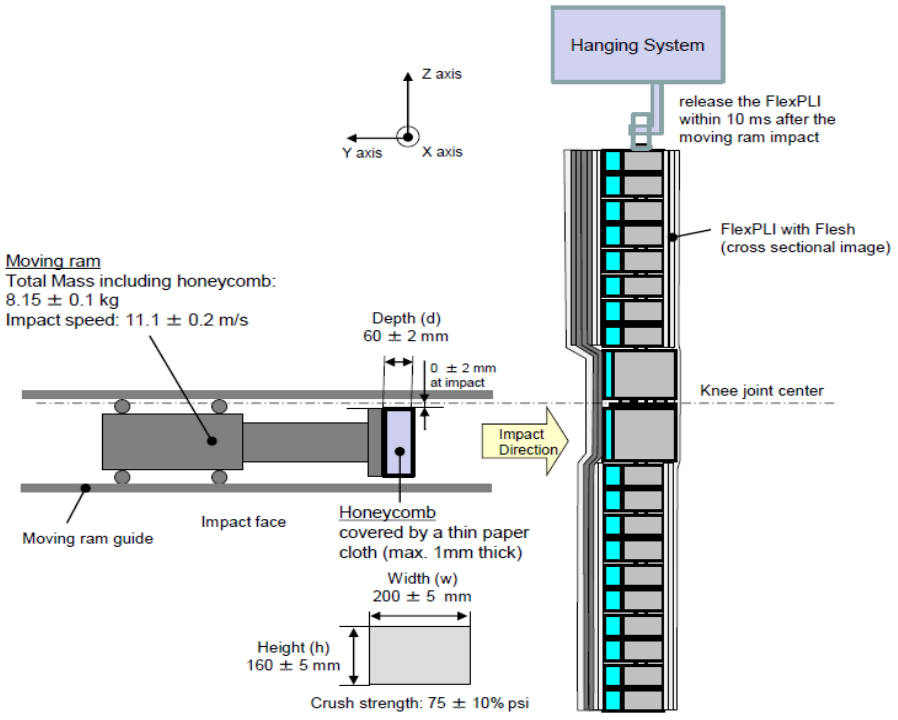


Figure 7

Flexible lower legform impactor: Test set-up for the dynamic lower legform impactor certification test (inverse test, see paragraph 8.1.3.4.)



"

Figures 1 to 6 (former), shall be deleted.

Figures 7 to 8 (former), renumber as Figures 8 to 9.

II. Justification

Submitted in as an informal document.