# GTR9-8-06

Transmitted by the chairman of the IG GTR9-PH2

Informal document **GRSP-53-29**
(53rd GRSP, 13 – 17 May 2013,
agenda item 3 (a))

## GTR No. 9 – Draft proposal for Amendment 2

Note: The text reproduced below was prepared by the chairman of the informal working group on the global technical regulation No. 9 (Pedestrian safety)-Phase 2 proposing the use of a flexible pedestrian lower legform impactor in the global technical regulation No. 9 (pedestrian safety) - Phase 2. The modifications to the current text of gtr No. 9 on pedestrian safety are marked in bold for new or strikethrough for deleted characters. Text in square brackets is still under discussion and consideration of the informal group.

# I. Proposal

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## B. Text of the regulation

*Insert new paragraph 3.23., to read:*

"[**3.23** **Primary reference marks" means holes, surfaces, marks and identification signs on the vehicle body. The type and the position 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 3.22. These marks shall be selected such as to be able to easily check the vehicle front and rear ride heights and vehicle attitude.**

**If tThe primary reference marks are should be found to be within ± 25 mm of the design position in the vertical (Z) axis, ; then the vehicle is adjusted to the design position and all tests are conducted in this position. the The designThis position shall be considered to be the normal design ride height in this case. 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 3.23 to 3.31., renumber as paragraphs 3.24. to 3.32.*

*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 elongations 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 the application of the relaxation zone requirement in its domestic legislation if it decides that such a 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~~ **Flexible lower** ~~Lower~~ legform impactor:"

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

**The ~~overall~~ assembled length of the impactor shall be 928 ± 3 mm, having a required total mass of 13.2 ± 0.07 kg ~~including flesh~~. When**

**Kommentiert [TK1]:** Industry feels that the original tolerance of 1.4 kg in total, which represents about 10 % of the overall impactor mass, should be better controlled.

**Kommentiert [TK2R1]:** It needs to be noted that Industry has no common position on this: Some OICA members are okay with the text as it is, others feel that the tolerance is much too big as indicated above.

**fully assembled in the impactor, ~~t~~The measurable lengths of the femur~~, knee joint, and tibia~~ shall be 339 ± 2 mm, ~~of~~ the knee joint shall be 185 ± 1 mm~~,~~ and ~~of~~ the tibia shall be 404 ± 2 mm ~~respectively~~. The knee joint centre position shall be 94 ± 1 mm from the top of the knee joint at the vertical centre line of the knee.**

**Brackets, pulleys, protectors, connection parts, etc. attached to the impactor for the purposes of launching and/or protectionng 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 ± 5 mm, having a required test mass of 13.4 ± 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 the tibia main body ~~ies~~segments 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 13 (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 13 (a).**

~~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.~~

6.3.1.1.2. **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 13 (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 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 the tibia without the flesh and skin, including the connection parts to the knee joint, shall be 2.46 ± 0.012 kg and 2.64 ± 0.013 kg respectively. The mass of the knee joint without the flesh shall be 4.28 ± 0.021 kg. The ~~total~~ assembled mass of the femur, the knee joint and the tibia shall be 9.38 ± 0.047 kg.**

**The centres of gravity of the femur and the tibia without the flesh and skin, including the connection part to the knee joint, shall be 159 ± 8 mm and 202 ± 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 ± 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 ± 0.0016 kg m² and 0.0467 ± 0.0023 kgm² respectively. The moment of inertia of the**~~

**Kommentiert [TK3]:** In fact, adding the tolerances to the figure 12 would make it possible to delete this sentence.

**Kommentiert [TK4]:** Better: Add tolerances in figure 13 (a) and say "The cross sectional shape of the femur and the tibia main body segments shall be as defined in figure 13 (a)."

**Kommentiert [TK5]:** Better: Add tolerances in figure 13 (b) and say "The cross sectional shape of the knee joint shall be as defined in figure 13 (b)."

**Kommentiert [TK6]:** Again, it is felt that tolerances are much too big and should be reduced to 10 % of these values. In addition, the whole section is sufficiently described in figures 12 and 13 if the tolerances were added there.

**Kommentiert [TK7R6]:** Again, it needs to be noted that Industry has no common position on this: Some OICA members are okay with the tolerances as they are, others feel that they are much too big as indicated above.

**Kommentiert [TK8]:** The description here seems to be imperfect to describe a point in space. The tolerance needs to refer to a point that can be measured directly, e.g. 202 mm from the bottom of the tibia.

**Kommentiert [TK9]:** Can neither be checked nor be modified; this is part of the production of the legform and can be addressed by tightening the tolerances.

**Kommentiert [TK10R9]:** No common OICA position!

~~**knee joint about the X axis through the respective centre of gravity shall be 0.0180 ± 0.0009 kg m².**~~

~~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.~~

6.3.1.1.4. **For each test, the impactor (femur, knee joint~~,~~ and tibia) shall be covered by the flesh and skin composed of synthetic rubber sheets (R1, R2) and neoprene sheets (N1F, N2F, N1T, N2T, N3) as shown in Figure 14. The size of the sheets shall be within the requirements described in Figure 15. The sheets are required to have ~~a~~ compression characteristics as shown in Figure 15. The compression characteristics shall be checked using material from the same batch ~~of sheets~~ as the~~ose~~ sheets used for the impactor flesh and skin.~~ 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 ± 2 percent of the weight of the sheet used in the certification test.~~

6.3.1.1.5. **The complete ~~test~~ impactor components ~~or at least the flesh~~ shall be stored for at least four hours in a controlled storage area with a stabilized humidity of [35 ± 10 percent] and a stabilized temperature of 20 ± 2°C prior to impactor ~~removal for calibration~~verification. 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 ± 15 percent and a stabilized temperature of 20 ± 4°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 ± 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 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 ± 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**

**Kommentiert [SSB11]:** The long storage was required for the TRL leg impactor because of the Confor foam being sensitive to humidity. It was my understanding that the Flex Leg impactor is not as sensitive to humidity variation. If that is the case then the storage time should be reduced.

**Kommentiert [TK12]:** Unclear whether tis will be needed, to be discussed.

**Kommentiert [-13]:** as defined in 6.1.1

**measurement locations of each transducer are shown in Figure 16. The measurement locations shall be within ± 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**~~ **The Flexible lower legform impactor** ~~Lower legform cert~~ver~~ification~~.

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**~~ **verified using two certification tests as follows; first the certification should be conducted according to the inverse** ~~**type dynamic certification**~~ **verification test d**~~**pr**~~**escribed in paragraph 8.1.3.**~~. After the initial~~**second certification should be conducted** ~~**inverse type dynamic verification certification test, the c**~~**v**~~**ertified impactor shall be re-c**~~**v**~~**ertified according to the pendulum** ~~**type dynamic verification certification test d**~~**pr**~~**escribed in paragraph 8.1.2.** ~~**after**~~**After every 10 vehicle tests, with the exception,** ~~**– that every 3rd verification test shall be done according to the inverse type dynamic verification certification test will be repeated instead after every 30 vehicle tests**~~ **as prescribed in paragraph 8.1.3.**

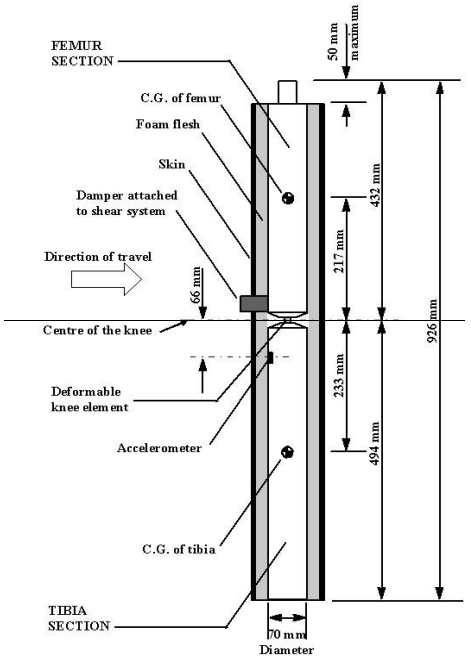
~~The certified impactor may be used for a maximum of 20 impacts before re-certification. With each test new plastically deformable knee elements should be used. The impactor shall also be re-certified if more than one year has elapsed since the previous certification, if any impactor transducer output,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

**Kommentiert [TK14]:** Not needed, part of impactor design.

**Kommentiert [TK15R14]:** However, also part of gtr9 phase 1.

**Kommentiert [TK16]:** Needs to be adapted according to the discussion on the [biofidelic] assessment interval.

*Delete Figures 12*, to read:




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

*Insert new Figures 12 to 16*, to read:

"

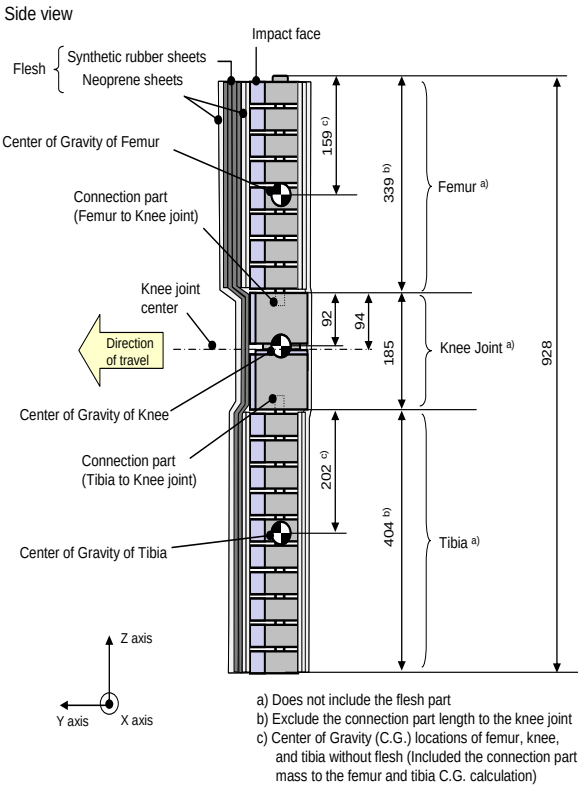



**Figure 12: Flexible lower legform impactor~~,~~ : nominal d~~D~~imensions and ~~C.G.~~centre of gravity locations of femur, knee joint and tibia (~~Side~~ side view)**

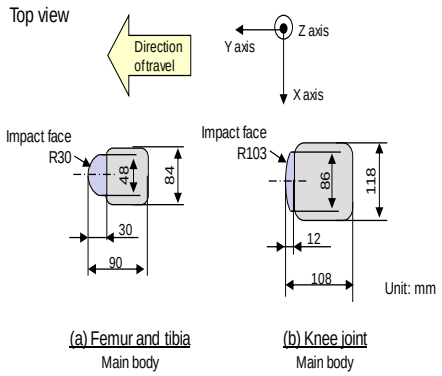



**Figure 13: ~~-~~ ~~f~~Flexible lower legform impactor; schematic plan views of femur, tibia~~,~~ and knee ~~dimensions (Top view)~~**

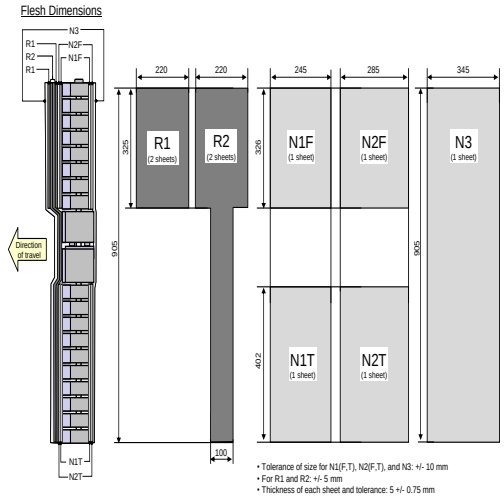
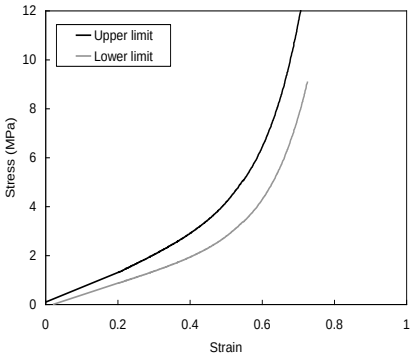
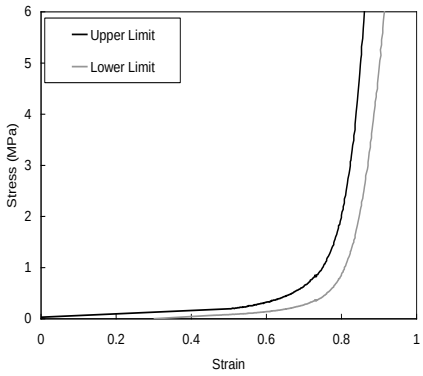



**Figure 14: Flexible lower legform impactor; flesh and skin dimensions**




**(a) Synthetic rubber sheets**




**(b) Neoprene sheets**

**Figure 15 Flexible lower legform impactor; flesh and skin compression characteristics**

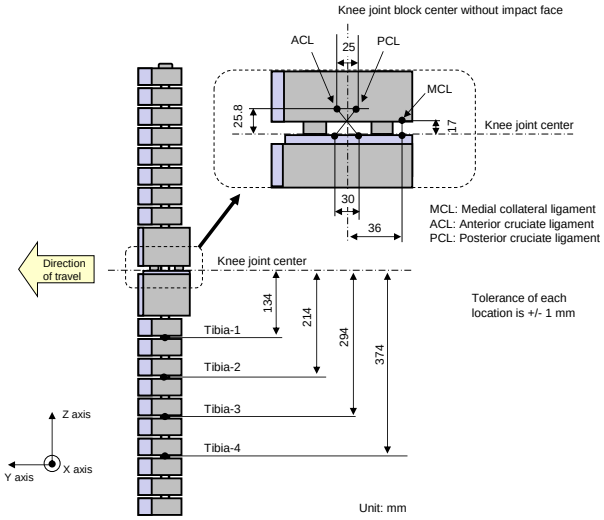



**Figure 16 : Flexible lower legform impactor; instrument locations**

"

*Paragraph 6.3.1.2.*, amend to read:

"…, foam covered at the impact side, and 350 ± 5 mm long (see Figure ~~13~~**17**)."

*Paragraph 6.3.1.2.9.1.*, amend to read:

"…in three positions, as shown in Figure ~~13~~**17**, 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 ~~13~~**17**)."

*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 ~~14~~**18**)

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 ~~14~~**18**) 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 ~~15~~**19**)

The adult … as shown in Figure ~~15~~**19**. 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 ~~15~~**19**) 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 ± 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 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 ± 2° at the time of first contact. The axis of the impactor shall be perpendicular to the horizontal plane with a tolerance of ± 2° in the lateral and longitudinal plane. The horizontal, longitudinal and lateral planes are orthogonal to each other (see Figure 16).~~

7.1.1.3. **The bottom of the impactor (without parts needed for the purposes of launching and/or protection) shall be ~~at~~ 75 mm above the ground reference plane at the time of the first contact with the bumper (see Figure 21), 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.**

**Kommentiert [TK17]:** It needs to be clarified that the bottom of the impactor does NOT consider the protective cap!

~~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 ± 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 the rebound of the impactor.**

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

~~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 ± 5° (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 ± 5° (see Figure 16).~~

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

7.1.1.3.4. During the 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 ± 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:

"

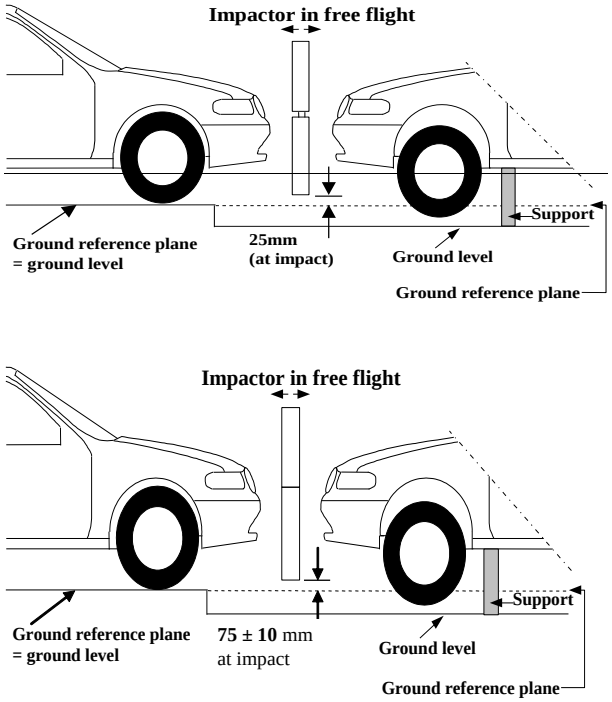



Figure ~~17~~ **21:** **Flexible lower legform impactor** ~~Lower legform~~ to bumper test~~s~~ for complete vehicle in normal ride attitude (left) and for cut-body mounted on supports (right) (see paragraph 7.1.1.3.) "

*Paragraphs 8.1. to 8.1.3.4.4.*, to read:

"8.1. **Flexible lower legform impactor** ~~Lower legform impactor~~ ~~c~~vert~~i~~fication

8.1.1. Static ~~c~~**vert~~i~~fication** tests

8.1.1.1. **The ~~femur and tibia~~femur and the tibia of the flexible lower legform impactor shall meet the requirements ~~respectively~~ specified in paragraph 8.1.1.2.~~.~~ when tested ~~as specified in~~according to 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~~ according to paragraph 8.1.1.5. The stabilized humidity of the impactor shall be [35 ± 10 percent] and the stabilized temperature of the impactor shall be 20° ± 2°C during the ~~c~~vert~~i~~fication 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.**

~~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 ± 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 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 the tibia of the impactor are loaded in bending in accordance with paragraph 8.1.1.4., the applied moment and the generated deflection at the centre of the ~~femur and tibia~~femur and the 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° of bending shall be 100 ± 7 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 the 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 23.**

**Kommentiert [TK18]:** It is unclear when the static verification is to be conducted. Is this needed in gtr No. 9 or can this be part of the disassembly/re-assembly procedure that can be covered in the owner's manual?

**Kommentiert [TK19R18]:** Some OICA members prefer to add this statement from the manual into the gtr. The static verification test is recommended to be conducted annually, after exceeding injury thresholds +10% or after maintenance and/or component exchange.

**Kommentiert [TK20]:** Unclear whether tis will be needed, to be discussed.

~~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 the 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~~ ± 2° 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~~femur and the tibia within ± 2° 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 + 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.~~

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~~ ± 2° 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 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 ± 2° 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~~ verification test~~s~~ **(pendulum test ~~type~~)**

8.1.2.1. The assembled **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~~according to ~~in~~ paragraph 8.1.2.4.

8.1.2.2. ~~C~~Vert~~i~~ification

8.1.2.2.1. **The test facility used for the certification test shall have a stabilized humidity of 35 ± 10 percent and a stabilized temperature of 20 ± 2 °C during ~~certification~~the test.**

~~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 ± 10 percent 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 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~~ verification and recorded in a ~~certification~~ verification report.**

~~The test facility used for the calibration test shall have a stabilized humidity of 40 ± 30 percent and a stabilized temperature of 20 ± 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~~ according to ~~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~~

**Kommentiert [-21]:**

Test lab conditions for certification:
Humidity: 35 +- 10%
Temperature: 20 +- 2° C

Test lab conditions for testing (6.1.1):
Humidity: 40 +- 30%
Temperature: 20 +- 4° C

**Kommentiert [TK22]:** Unclear whether tis will be needed, to be discussed.

~~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 the flesh and skin, shall be suspended from the** ~~**dynamic certification**~~ **test rig 15 ± 1° upward from the horizontal as shown in Figure 27. The impactor shall be released from the suspended position and** ~~**, whereupon the impactor**~~ **falls** ~~**s**~~ **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 ± 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 □ 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 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 ± 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 27.**

~~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 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.~~

**Kommentiert [TK23]:** Not needed, part of impactor design.

**Kommentiert [TK24R23]:** However, also part of gtr9 phase 1.

~~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~~ verification tests (inverse ~~type~~test)**

**8.1.3.1. The assembled 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~~ according to paragraph 8.1.3.4.**

**8.1.3.2. ~~C~~Ver~~t~~ification**

**8.1.3.2.1. The test facility used for the certification test shall have a stabilized humidity of [35 ± 15 percent] and a stabilized temperature of 20 ± 2 °C during ~~c~~ver~~t~~ification.**

**8.1.3.2.3. The temperature of the ~~c~~ver~~t~~ification area shall be measured at the time of ~~certification~~ verification and recorded in a ~~certification~~ verification report.**

**8.1.3.3. Requirements**

**8.1.3.3.1. When the flexible lower legform impactor is used for the test ~~specified in~~ according to 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 elongations 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 flexible lower legform impactor (with the flesh and skin) shall be ~~stationary suspended freely hanging~~hung vertically and freely suspended from a test rig as shown in Figure 28. It is then impacted by the upper edge of a linearly guided Aluminium honeycomb impactor, covered by a thin (less than 1 mm thickness) paper cloth, at an impact speed of 11~~,~~1 ± 0~~,~~2 m/s. The legform ~~is to~~shall achieve a free flight condition ~~be released from the test rig~~ within 10 ms after the time**

**Kommentiert [-25]:**

Test lab conditions for certification:
Humidity: 35 +- 10%
Temperature: 20 +- 2° C

Test lab conditions for testing (6.1.1):
Humidity: 40 +- 30%
Temperature: 20 +- 4° C

**Kommentiert [TK26]:** Unclear whether tis will be needed, to be discussed.

**Kommentiert [TK27]:** Should be moved to the respective figure (figure 28).

**of first contact of the honeycomb impactor ~~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 =~~ be 200 ± 5 mm wide, ~~w =~~ 160 ± 5 mm high and ~~d =~~ 60 ± 2 mm deep and shall have a crush strength of 75 psi ± 10 percent. ~~To ensure a consistent and good level of repeatability, t~~The honeycomb ~~should~~ shall have cell sizes of either ~~have a~~ 3/16 inch ~~cell size~~ or ~~a~~ 1/4 inch ~~cell size . The honeycomb should have~~and a density of 2.0 pcf ~~in combination with~~for ~~a~~ the 3/16 inch cell size or a density of 2.3 pcf ~~in combination with a~~for the 1/4 inch cell size.**

**8.1.3.4.3.** **The upper edge of the honeycomb face ~~is to~~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 ~~is to~~shall be in line with the knee joint centre line within a vertical tolerance of ~~0~~ ± 2 mm. ~~—~~The honeycomb shall not be deformed before the impact test.**

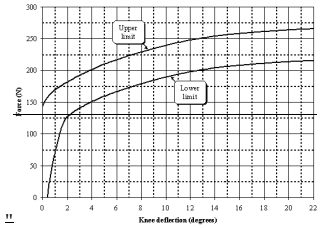
**8.1.3.4.4.** **At the time of the first contact, t~~T~~he flexible lower legform impactor pitch angle (rotation around Y-axis) and therefore the pitch angle of the velocity vector of the honeycomb impactor ~~(rotation around Y-axis) at the time of first contact~~ shall be within a tolerance of ~~0~~ ± 2° in relation to the lateral vertical plane. The flexible lower legform impactor roll angle (rotation around X-axis) 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~~ ± 2°in relation to the longitudinal vertical plane. The flexible lower legform impactor yaw angle (rotation around Z-axis) 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~~± 2°~~, to ensure a correct operation of the knee joint~~.**"

**Kommentiert [TK28]:** Does this need to be translated into metric sizes?

**Kommentiert [-29]:**
dimensions - inch
density – pcf
pressure - psi

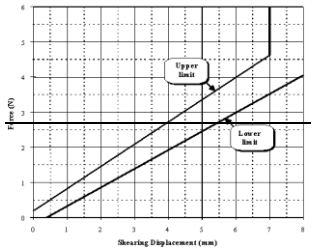
*Delete Figures 18 to Figure 21,* to read:

"

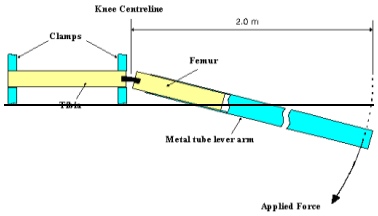



"

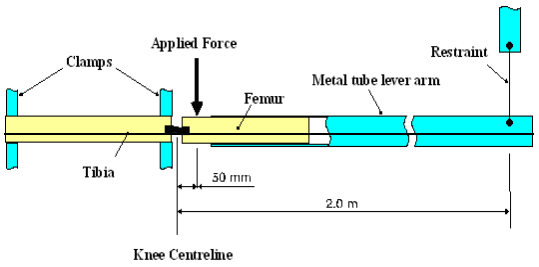
~~Figure 18: Force versus angle requirement in static lower legform impactor bending certification test (see paragraph 8.1.1.2.)~~



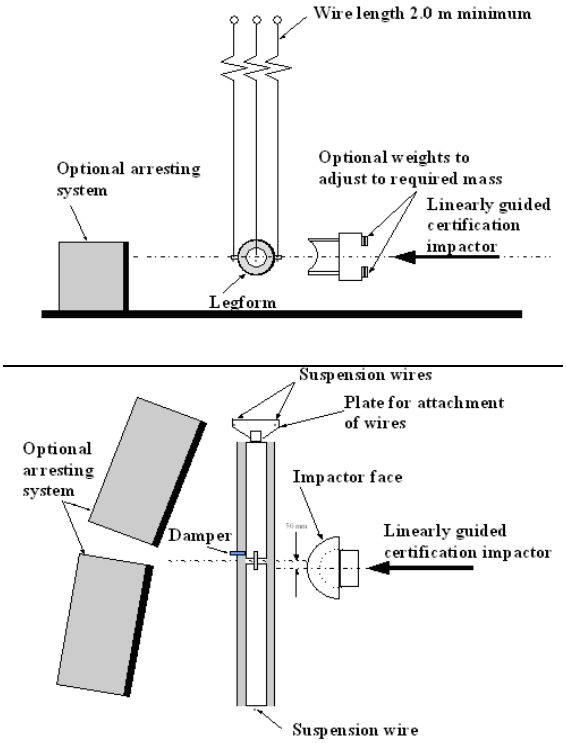

~~Figure 19: Force versus displacement requirement in static lower legform impactor shearing certification test (see paragraph 8.1.1.3.)~~




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



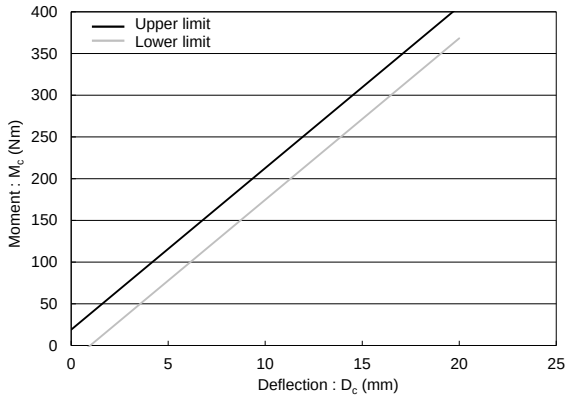

~~Figure 21: Top View of Test set-up for static lower legform impactor shearing certification test (see paragraph 8.1.1.5.)~~



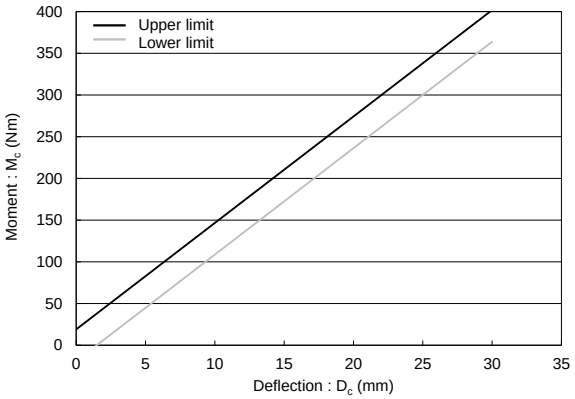

~~Figure 22: Test set-up for dynamic lower legform impactor certification test (side view top diagram, view from above bottom diagram) (see paragraph 8.1.2.4.1.)~~ "

*Insert new Figures 22 to 28.*, to read:

"



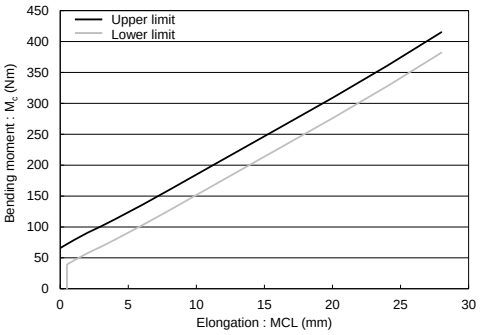

**(a) Femur bending corridor**



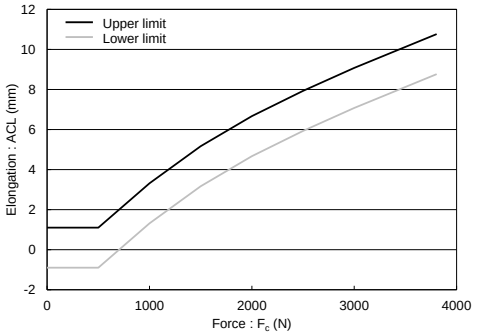

**(b) Tibia bending corridor**

**Figure 22: ~~Flexible lower legform impactor r~~Requirement corridors of the femur and the tibia in static ~~c~~verification tests**

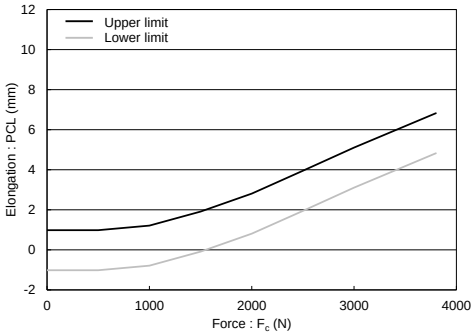
**(see paragraph 8.1.1.2.)**




(a) for MCL

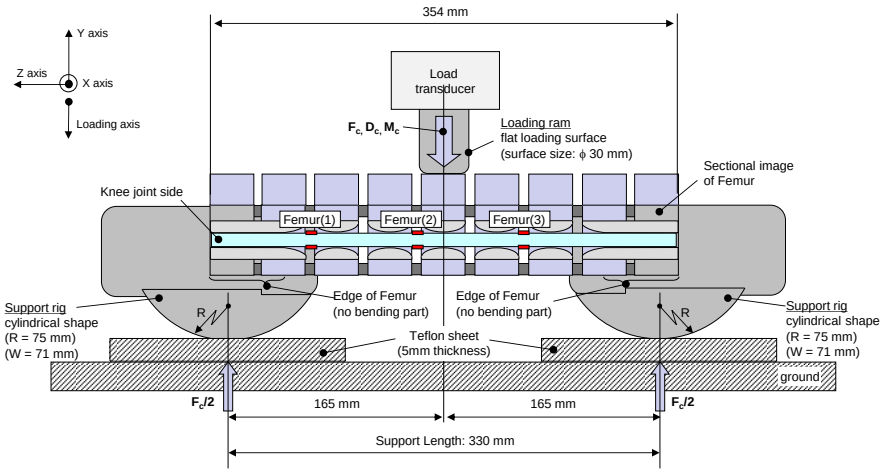



(b) for ACL




(c) for PCL

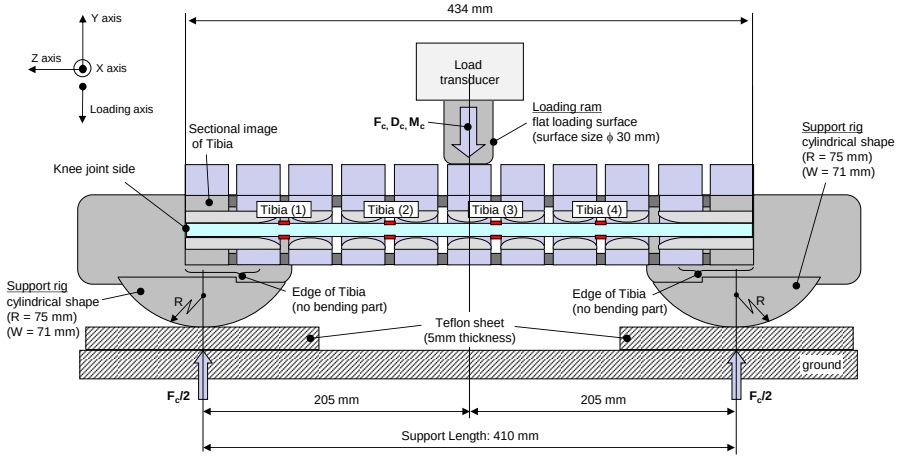
**Figure 23: ~~Flexible lower legform impactor r~~Requirement corridors for knee joint in static ~~e~~verification tests (see paragraph 8.1.1.3.)**




**$F_c$: 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**

**Figure 24: ~~Flexible lower legform impactor t~~Test set-up for femur in static ~~certification~~ verification tests**

**(see paragraph 8.1.1.4.)**




**$F_c$: 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**

**Figure 25: ~~Flexible lower legform impactor t~~Test set-up for tibia in static ~~certification~~ verification test**

**(see paragraph 8.1.1.4.)**

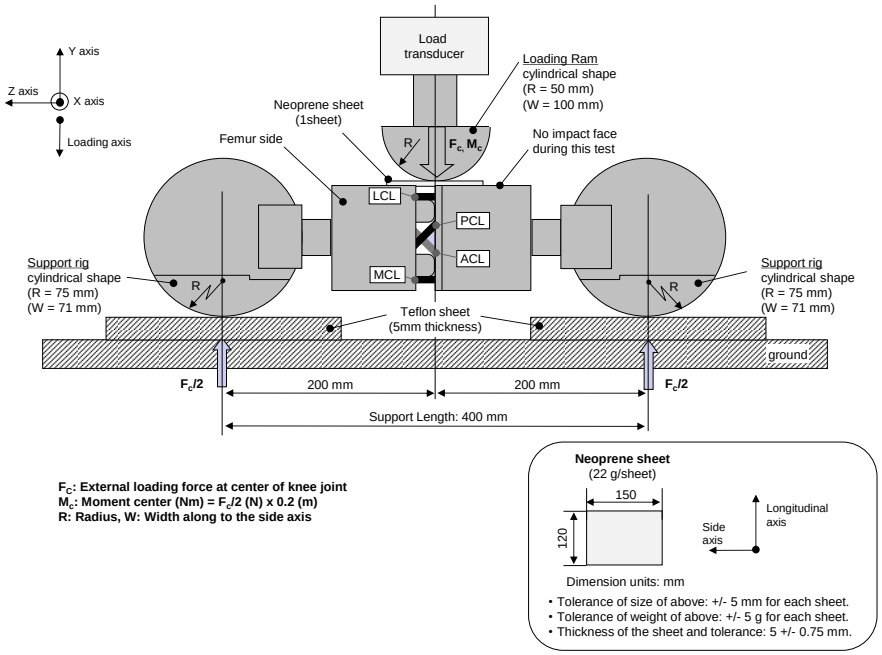



**Figure 26: ~~Flexible lower legform impactor t~~Test set-up for knee joint in static ~~c~~verification ~~t~~test (see paragraph 8.1.1.5.)**

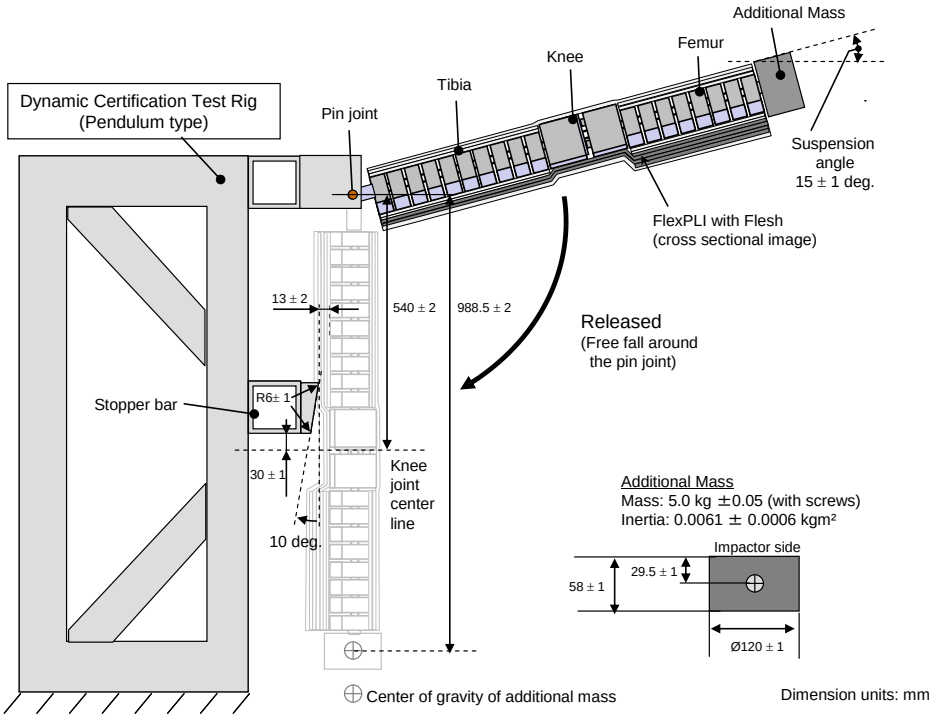



**Figure 27: ~~Flexible lower legform impactor t~~Test set-up for dynamic lower legform impactor ~~c~~verification test~~,~~ (pendulum test~~;ype~~ ~~(~~see paragraph 8.1.2.4.)

**Kommentiert [TK30]:** The drawing should say **test rig for pendulum test**.

**Kommentiert [TK31R30]:** Also, the impactor should be named “FlexPLI with flesh and skin”.

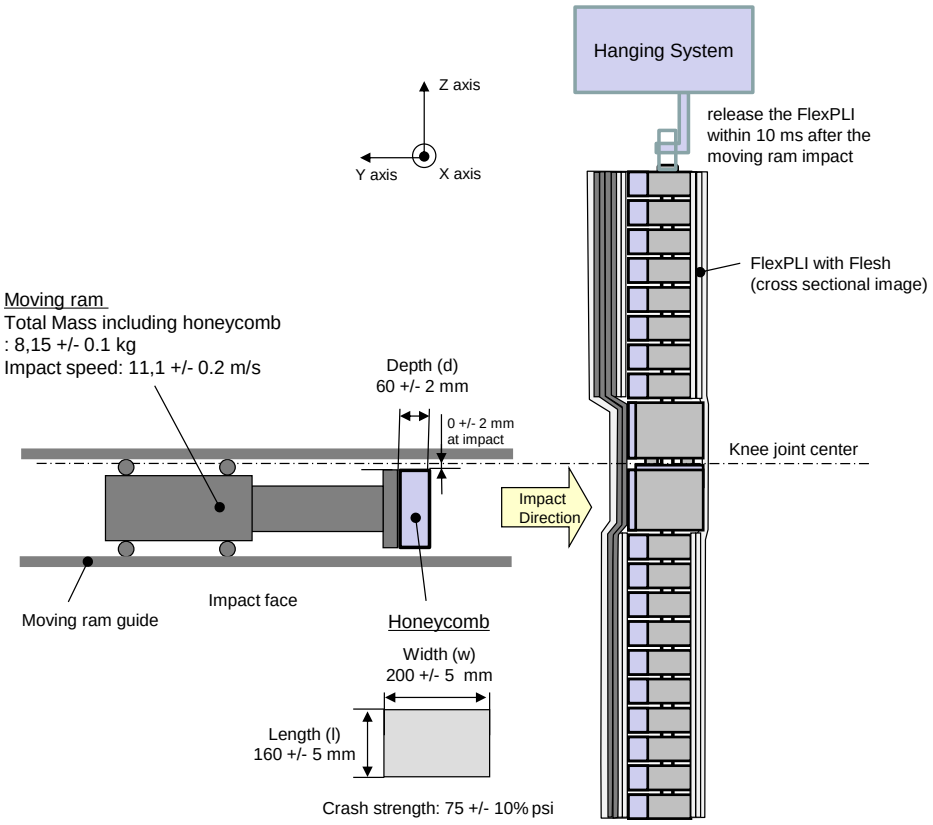



**Figure 28: ~~Flexible lower legform impactor t~~Test set-up for dynamic lower legform impactor ~~certification~~ verification test~~,~~ (inverse ~~type~~ test; (see paragraph 8.1.3.4.)**

"

**Kommentiert [TK32]:** The honeycomb cell should say wide and **high** and should mention the paper cover (max. 1 mm thick).

**Kommentiert [TK33R32]:** Also, the impactor should be named “FlexPLI with flesh and skin”.

*Paragraph 8.2.4.6.*, amend to read:

"… at a velocity of 7.1 ± 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 gtr on pedestrian protection (GTR No. 9)] .

### A. Statement of technical rationale and justification

tbd

### B. Text of the regulation

*Paragraph 3.23.:* [To cover tolerances in built-up, adjustment and alignment of a test vehicle in actual testing it recommended to include the concept of the primary reference marks, which is already defined in Part A of gtr9 also into in Part B of gtr9. The definitions shall give clear guidelines and definitions needed to be able to perform the approval test during the type approval of vehicles and verification testing for self-certification. The proposed definitions for test vehicles are already incorporated in applicable regulative language for pedestrian protection.]

*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).