

**QUALIFICATION PROCEDURES
FOR PEDESTRIAN TEST DEVICES**

December 2019

Background

The qualification procedures contained in this document are pulled directly from the procedures outlined in ECE Regulation 127 (ECE/TRANS/WP.29/2014/38). The procedures for R127 were developed by the Global Technical Regulation (GTR) No. 9 technical working group, of which NHTSA was a participant. While the scope, requirements, and test fixtures are exactly as they are specified in R127, there are some additions and slight revisions based on test experience at the NHTSA Vehicle Research & Test Center (VRTC). These additions include number of vehicle impacts between tests, selection of one Flex lower legform test, and the use of the term “qualification” instead of “certification” to be consistent with NHTSA nomenclature. In sum, these procedures are provided to the public as research guidance to reflect how NHTSA currently qualifies pedestrian test tools for vehicle testing.

1. Flexible lower legform impactor

- 1.1. ECE Regulation 127 specifies three different qualification tests for the flexible lower legform impactor: (1) static, (2) dynamic inverse, and (3) dynamic pendulum. NHTSA has reviewed these procedures and determined that the dynamic pendulum test is the only test required before, during, and after vehicle testing. This test should be conducted every 10 vehicle impacts to assure that the impactor’s performance has not degraded or changed. It is recommended that the static tests be conducted on an annual basis to assure the legform is in working order. The dynamic inverse test is an optional test to conduct in addition to the static and dynamic pendulum tests.

1.1.1. Qualification requirements

- 1.1.1.1. The test facility used for the qualification test shall have a stabilized temperature of 20 ± 2 °C during the test.
- 1.1.1.2. The temperature of the qualification area shall be measured at the time of qualification and recorded in a qualification report.
- 1.1.1.3. When the flexible lower legform impactor is used for a test according to section 1.1.2, the absolute value of the maximum bending moment of the tibia at:
 - (a) Tibia-1 shall be $235 \text{ Nm} \leq 272 \text{ Nm}$;
 - (b) Tibia-2 shall be $187 \text{ Nm} \leq 219 \text{ Nm}$;
 - (c) Tibia-3 shall be $139 \text{ Nm} \leq 166 \text{ Nm}$;
 - (d) Tibia-4 shall be $90 \text{ Nm} \leq 111 \text{ Nm}$.

The absolute value of the maximum elongation of:

- (a) MCL shall be $20.5 \text{ mm} \leq 24.0 \text{ mm}$;
- (b) ACL shall be $8.0 \text{ mm} \leq 10.5 \text{ mm}$;
- (c) PCL shall be $3.5 \text{ mm} \leq 5.0 \text{ mm}$.

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

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

1.1.2. Test procedure

- 1.1.2.1. Before attaching the legform impactor to the dynamic certification test rig, the ballast mass is attached to the top of the femur. To do this, first remove the aluminum launch guide from the top of the femur. Then attach the ballast mass (dimensions shown in Figure 1) to the top of the femur using two M8 x 50 mm long cap head screws.
- 1.1.2.2. The flexible lower legform impactor, including the flesh and skin, shall be suspended from the dynamic certification test rig $15 \pm 1^\circ$ upward from the horizontal as shown in Figure 1. The impactor shall be released from the suspended position and fall freely against the pin joint of the test rig as shown in Figure 1.
- 1.1.2.3. The knee joint center of the impactor shall be $30 \pm 1 \text{ mm}$ below the bottom line of the stopper bar, and the tibia impact face without the flesh and skin shall be located $13 \pm 2 \text{ mm}$ from the front upper edge of the stopper bar when the impactor is hanging freely as shown in Figure 1.
- 1.1.2.4. If multiple tests are done, it is recommended that at least 30 minutes be allowed between tests.

2. Upper legform impactor

- 2.1. The qualified upper legform impactor may be used for a maximum of 20 vehicle impacts before re-qualification (this limit does not apply to propulsion or guidance components). The impactor shall also be re-qualified if more than one year has elapsed since the previous qualification or if any impactor transducer output, in any impact, has exceeded the specified channel amplitude class (CAC).

2.2. *Qualification requirements*

- 2.2.1. 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 certification. 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.
- 2.2.2. The test facility used for the qualification test shall have a stabilized humidity of 40 ± 30 per cent and a stabilized temperature of 20 ± 4 °C during qualification.
- 2.2.3. Each qualification test shall be completed within 30 minutes of when the foam for the impactor to be qualified is removed from the controlled storage area.
- 2.2.4. The relative humidity and temperature of the qualification area shall be measured at the time of qualification, and recorded in the qualification report.
- 2.2.5. When the impactor is propelled into a stationary cylindrical pendulum tube, the peak force measured in each load transducer shall be not less than 1.20 kN and not more than 1.55 kN and the difference between the peak forces measured in the top and bottom load transducers shall not be more than 0.10 kN. Also, the peak bending moment measured by the strain gauges shall not be less than 190 Nm and not more than 250 Nm on the center position and not less than 160 Nm and not more than 220 Nm for the outer positions. The difference between the upper and lower peak bending moments shall not be more than 20 Nm.
- For all these values, the readings used shall be from the initial impact with the pendulum tube and not from the arresting phase. Any system used to arrest the impactor or pendulum 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 channel amplitude class (CAC).
- 2.2.6. 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 10 kN for the force transducers and 1,000 Nm for the bending moment measurements.

2.3. *Test procedure*

- 2.3.1. The impactor shall be mounted to the propulsion and guidance system, by a torque limiting joint. The torque limiting joint shall be set so that the longitudinal axis of the front member is perpendicular to the axis of the guidance system, with a tolerance of $\pm 2^\circ$, with the joint friction torque set to 675 ± 25 Nm. The guidance system shall be fitted with low friction guides that allow the impactor to move only in the specified direction of impact, when in contact with the pendulum.
- 2.3.2. The impactor mass shall be adjusted to give a total mass of 12 ± 0.1 kg. This mass includes those propulsion and guidance components which are effectively part of the impactor during impact.
- 2.3.3. The center of gravity of those parts of the impactor which are effectively forward of the torque limiting joint, including the extra masses fitted, shall lie on the longitudinal centerline of the impactor, with a tolerance of ± 10 mm.
- 2.3.4. The impactor shall be qualified with previously unused foam. If multiple tests are done, it is recommended that at least 30 minutes be allowed between tests.
- 2.3.5. The impactor foam shall not be excessively handled or deformed before, during or after fitting.
- 2.3.6. The impactor with the front member vertical shall be propelled horizontally at a velocity of 7.1 ± 0.1 m/s into the stationary pendulum tube as shown in Figure 2.
- 2.3.7. The pendulum tube shall have a mass of 3 ± 0.03 kg, a wall thickness of 3 ± 0.15 mm and an outside diameter of 150 mm $+1$ mm/ -4 mm. Total pendulum tube length shall be 275 ± 25 mm. The pendulum tube shall be made from cold finished seamless steel (metal surface plating is permissible for protection from corrosion), with an outer surface finish of better than 2.0 micrometers. It shall be suspended on two wire ropes of 1.5 ± 0.2 mm diameter and of 2.0 m minimum length. The surface of the pendulum shall be clean and dry. The pendulum tube shall be positioned so that the longitudinal axis of the cylinder is perpendicular to the front member (i.e. level), with a tolerance of $\pm 2^\circ$, and to the direction of impactor motion, with a tolerance of $\pm 2^\circ$, and with the center of the pendulum tube aligned with the center of the impactor front member, with tolerances of ± 5 mm laterally and ± 5 mm vertically.

3. Child and adult headform

3.1. The qualified headform impactors may be used for a maximum of 20 impacts before re-qualification. The impactors shall be re-qualified if more than one year has elapsed since the previous qualification or if the transducer output, in any impact, has exceeded the specified channel amplitude class (CAC).

3.2. Qualification requirements

3.2.1. When the headform impactors are dropped from a height of 376 ± 1 mm in accordance with paragraph 3.3. below, the peak resultant acceleration measured by one triaxial (or three uniaxial) accelerometer (accelerometers) in the headform impactor shall be:

- (a) For the child headform impactor not less than 245 g and not more than 300 g;
- (b) For the adult headform impactor not less than 225 g and not more than 275 g.

The acceleration time curve shall be uni-modal.

3.2.2. The instrumentation response values channel frequency class (CFC) and CAC for each accelerometer shall be 1,000 and 500 g respectively as defined in ISO 6487:2002.

3.2.3. The headform impactors shall have a temperature of 20 ± 2 °C at the time of impact. The temperature tolerances 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.

3.3. Test procedure

3.3.1. The headform impactor shall be suspended from a drop rig as shown in Figure 3.

3.3.2. The headform impactor shall be dropped from the specified height by means that ensure instant release onto a rigidly supported flat horizontal steel plate, over 50 mm thick and over 300 x 300 mm square which has a clean dry surface and a surface finish of between 0.2 and 2.0 micrometers.

3.3.3. The headform impactor shall be dropped with the rear face of the impactor at a drop angle of 50 degrees for the child headform impactor and 65 degrees for the adult headform impactor with respect to the vertical as shown in Figure 3. The suspension of the headform impactor shall be such that it does not rotate during the fall.

- 3.3.4. The drop test shall be performed three times, with the headform impactor rotated 120° around its symmetrical axis after each test. All three tests need to fall within the required range specified in paragraph 3.2.1 for the headform to qualify for vehicle testing. A minimum recovery time of 30 minutes is required between tests.

Figure 1
Test set-up for the lower legform impactor qualification test

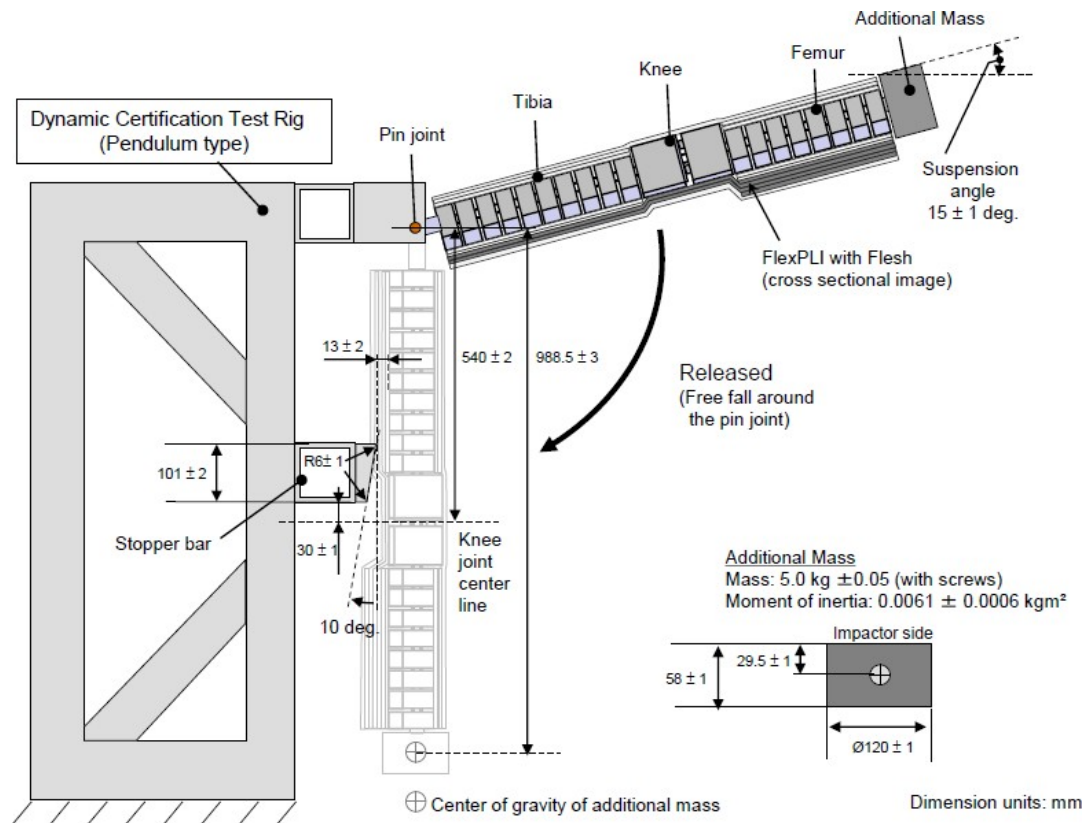


Figure 2
Test set-up for upper legform impactor qualification test

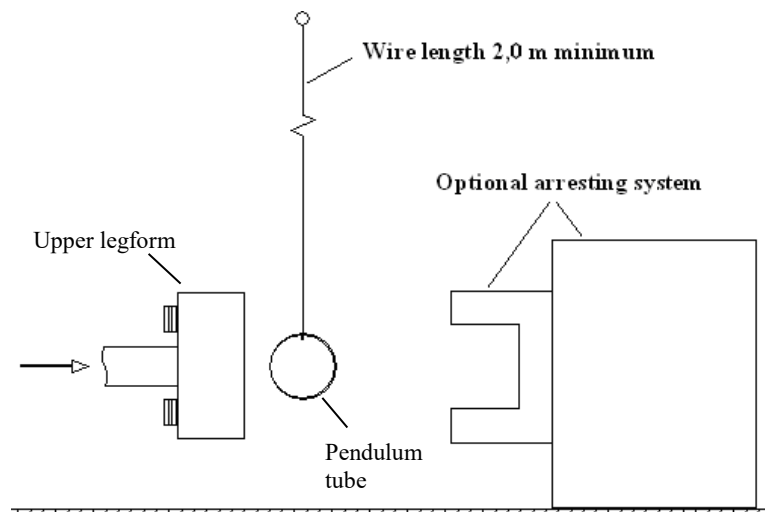


Figure 3
Test set-up for headform impactor qualification test

