lower jaw. The entire dynamic test apparatus hangs freely on the retention system. The entire mass of the support assembly, including the 4-kg (8.8-lb) drop weight, shall be 11 kg $\pm$ 0.5 kg (24.2 lb $\pm$ 1.1 lb).

(b) Test procedure. (1) Place the helmet on the appropriate size headform on the test device according to the HPI. Fasten the strap of the retention system under the stirrup.

(2) Mark the pre-test position of the retention system, with the entire dynamic test apparatus hanging freely on the retention system.

(3) Raise the 4-kg (8.8-lb) drop weight to a height of 0.6 m (2 ft) from the stop anvil and release it, so that it impacts the stop anvil.

(4) Record the maximum elongation of the retention system during the impact. A marker system or a displacement transducer, as shown in Figure 8, are two methods of measuring the elongation.

## §1203.17 Impact attenuation test.

(a) Test instruments and equipment. (1) Measurement of impact attenuation. Impact attenuation is determined by measuring the acceleration of the test headform during impact. Acceleration is measured with a uniaxial accelerometer that is capable of withstanding a shock of at least 1000 g. The helmet is secured onto the headform and dropped in a guided free fall, using a monorail test apparatus (see Figure 9), onto an anvil fixed to a rigid base. The base shall consist of a solid mass of at least 135 kg (298 lb), the upper surface of which shall consist of a steel plate at least 12 mm (0.47 in.) thick and having a surface area of at least 0.10 m<sup>2</sup> (1.08 ft<sup>2</sup>).

(2) Accelerometer. A uniaxial accelerometer is mounted at the center of gravity of the test headform, with the sensitive axis aligned within 5 degrees of vertical when the test headform is in the impact position. The acceleration data channel and filtering shall comply with SAE Recommended Practice J211 OCT88, Instrumentation for Impact Tests, Requirements for Channel Class 1000.

(3) Headform and drop assembly centers of gravity. The center of gravity of the test headform is located at the center of the mounting ball on the support assembly and lies within an inverted cone with its axis vertical, and forming a 10 degree included angle with the vertex at the point of impact. The location of the center of gravity of the drop assembly (combined test headform and support assembly) must meet FMVSS 218 S7.1.8. The center of gravity of the drop assembly lies within the rectangular volume bounded by x =

-6.4 mm (-0.25 in.), x = 21.6 mm (0.85 mm)in), y = 6.4 mm (0.25 in.), and y = -6.4mm (-0.25 in), with the origin located at the center of gravity of the test headform. The rectangular volume has no boundary along the z-axis. The x-yz axes are mutually perpendicular and have positive or negative designations in accordance with the right-hand rule. The origin of the coordinate axes is located at the center of the mounting ball on the support assembly. The x-yz axes of the test headform assembly on monorail impact-test equipment are oriented as follows: From the origin, the x-axis is horizontal with its positive direction going toward and passing through the vertical centerline of the monorail. The positive z-axis is downward. The y-axis also is horizontal, and its direction is decided by the z- and x-axes, using the righthand rule. See Figure 10 for an overhead view of the x-y boundary of the location of the center of gravity.

(4) Drop assembly. The center of gravity of the headform shall be at the center of the mounting ball.

(i) Mass of the drop assembly for testing helmets for adults and children 5 years of age and older. The combined mass of the instrumented test headform and support assembly (excluding the test helmet) for the impact test shall be  $5.0 \pm 0.1$  kg (11.00  $\pm 0.22$  lb).

(ii) Mass of the drop assembly for testing helmets for children under 5 years. The combined mass of the instrumented test headform (ISO A or ISO E) and support assembly (excluding the test helmet) for the impact test shall be  $3.9 \pm 0.1$  kg (8.60  $\pm 0.22$  lb).

(5) Impact anvils. Impact tests shall be performed against the three different anvils described below. All of the anvils shall be constructed of steel and shall be solid (i.e., without internal cavities).

(i) Flat Anvil. The flat anvil shall have a flat surface area with an impact face having a minimum diameter of 125 mm (4.92 in.) and shall be at least 24 mm (0.94 in.) thick (see Figure 11).

(ii) Hemispherical anvil. The hemispherical anvil shall have an impact surface with a radius of  $48 \pm 1$ mm (1.89 ±0.04 in.). The profile of the impact surface shall be one half the surface of a sphere (see Figure 12).

(iii) Curbstone anvil. The curbstone anvil shall have two flat faces making an angle of 105 degrees and meeting along a striking edge with a radius of 15 mm  $\pm 0.5$  mm (0.59  $\pm 0.02$  in.). The height of the curbstone anvil shall not be less than 50 mm (1.97 in.), and the length shall not be less than 200 mm (7.87 in.) (see Figure 13).

(b) Test Procedure. (1) Instrument system check. The impact-attenuation

test instrumentation shall be checked before and after each series of tests (at least at the beginning and end of each test day) by dropping an impactor with a spherical impact surface onto an elastomeric test medium (MEP). The impactor shall be dropped onto the MEP at a specified impact velocity  $(\pm 2\%)$  of a central value) that is representative of helmet testing drop heights. Before conducting a series of drops, the center vertical axis of the accelerometer (see § 1203.17(a)(2)) shall be aligned with the geometric center of the MEP pad. Six impacts, at intervals of  $75 \pm 15$  seconds, shall be performed at the beginning and end of the day. The first three impacts at the beginning and end of the day shall be considered warm-up drops and shall be discarded from the series. The test parameters selected at each laboratory shall produce impact accelerations shown to be repeatable within  $\pm 2\%$  of a central value.

(2) Impact sites. Each of helmets 1 through 4 (one helmet for each conditioning environment) shall impact at four different sites, one impact on the flat anvil, one impact on the hemispherical anvil, one impact on the curbstone anvil, and one impact on an anvil chosen at the discretion of the test personnel.<sup>4</sup> The center of any impact may be on or anywhere above the test line, provided it is at least 120 mm (4.72 in), measured on the surface of the helmet, from any prior impact center. Rivets and other mechanical fasteners, vents, and any other helmet feature within the test region are valid test sites.

(3) Impact velocity. The helmet shall be dropped onto the flat anvil from a theoretical drop height of 2 meters (6.56 ft) to achieve an impact velocity of 6.2 m/s  $\pm 3\%$  (20.34 ft/s  $\pm 3\%$ ). The helmet shall be dropped onto the hemispherical and curbstone anvils from a theoretical drop height of 1.2 meters (3.94 ft) to achieve an impact velocity of 4.8 m/s  $\pm 3\%$  (15.75 ft/s  $\pm 3\%$ ). The impact velocity shall be measured during the last 40 mm (1.57 in) of free-fall for each test.

(4) Helmet position. Prior to each test, the helmet shall be positioned on the test headform in accordance with the HPI. The helmet shall be secured so that it does not shift position prior to impact. The helmet retention system shall be secured in a manner that does not interfere with free-fall or impact.

<sup>&</sup>lt;sup>4</sup>The intent of this requirement is that the fourth impact will be on the anvil likely to result in the highest g-value. In the absence of an indication why another anvil would be more stringent, this fourth impact should be made with the anvil that produced the highest g-value in the previous three impacts.