Some Snell testing requires more than 3.5 meters of drop height. FIA 8860-2010 impact testing requires almost 4.6 meters of drop and their dynamic crush test demands half a meter more than that. And by the time allowances are made for the necessary hardware at either end of the drop, testing to the exact letter of the standard may be all but impossible. However, for many kinds of helmets, a simple workaround may yield useful results without architectural modifications to the laboratory. That is, it may be possible to approximate a 3.5 meter impact test with a 3.0 meter drop facility.

The technique calls for performing drops at energies equal to those implied in the test standard. The technicians will increase the mass of the head form and associated hardware and decrease the impact velocities correspondingly until they achieve an impact velocity they can achieve reliably with their test gear.

If the test standard calls for a mass of M_S and an impact velocity of V_S but V_0 is the maximum velocity achievable with the current gear, the technicians may choose to increase the mass according to:

$$M_T \geq M_S \left(\frac{V_S}{V_0}\right)^2$$

Then:

$$V_T = V_S \sqrt{\frac{M_S}{M_T}} \leq V_0$$

Where V_T and M_T are the impact velocity and drop mass to be used in the actual testing. It should be noted that the masses in these equations are those of the head forms and directly attached hardware but not that of the helmet being tested.

Test interpretation also requires some arithmetic. The increased drop mass implies that the head form decelerations must be scaled up to approximate the results corresponding to a test according to the standard and the decreased impact velocity implies that the observed durations must be scaled down. The scale factors are:

$$A_S \cong A_T \frac{M_T}{M_S}$$

and

$$t_S \cong t_T \sqrt{\frac{M_S}{M_T}}$$

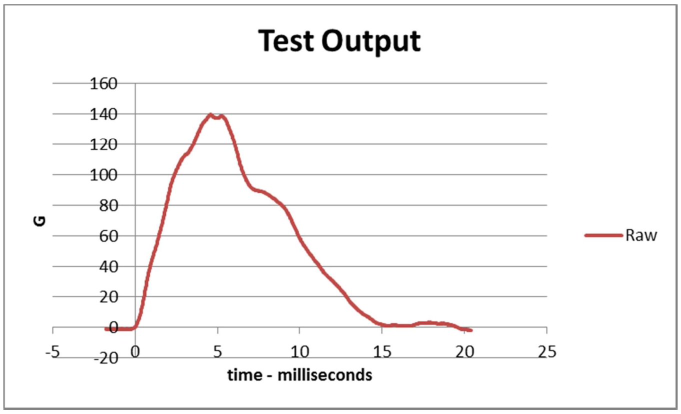
Where A_T and t_T are the acceleration and time coordinates of the helmet response observed in the test while A_S and t_S are values which might reasonably be expected in a test according to the standard.

An Example

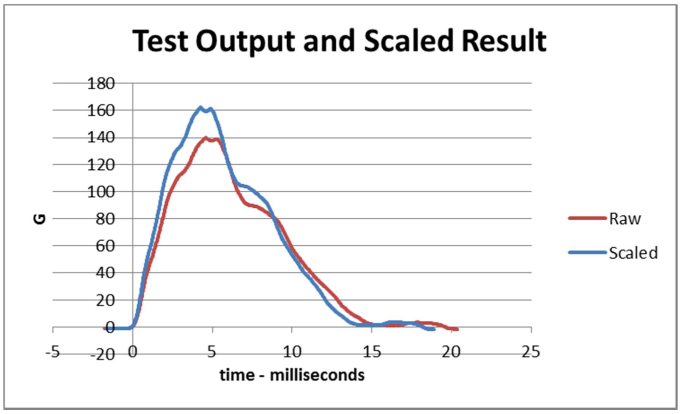
A test standard calls for testing at 8.0 meters per second using a drop mass of 5.6 kg but the laboratory cannot drop at velocities greater than 7.5 meters per second.

The first equation calls for a drop mass greater than 6.3716 kg. The technician sorts through his available hardware and opts for a drop mass of 6.5 kg. Now the second equation calls for an impact velocity of about 7.43 meters per second. The technician is now ready to test with the heavier drop mass and the reduced impact velocity but he still must scale his results appropriately.

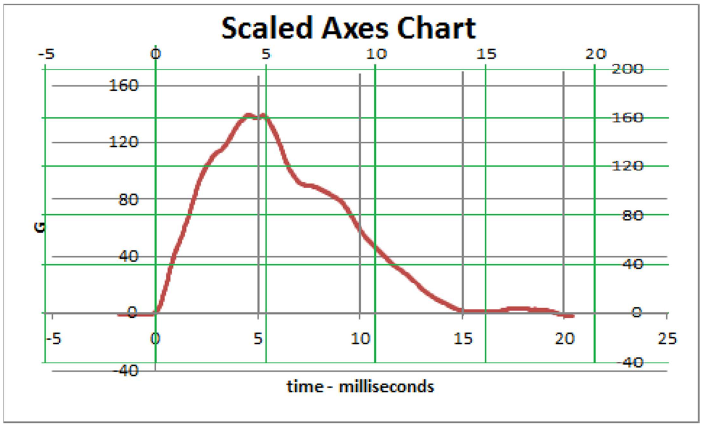
If the impact yields a chart like the following:



applying the appropriate scale factors to the time and G components of each point will yield:



Another possibility, though, is to apply the scale factors to a second set of axes on the same chart:



The axes at the bottom and left and the gray grid lines apply to the raw data as collected from the test. The axes at the top and right and the green grid are scaled and apply to the raw data as an approximation of the results which might be obtained if the drop mass and impact velocity had been 5.6 kg and 8.0 m/sec as called out in the standard.

Caveats

The validity of this procedure depends on the helmet response being mostly strain related and having little or no dependence on strain rate. But the response of EPS in compression does have some strain rate dependence and so does the impact response of many shells.

In the example, the strain rate in the physical test is likely within 10% of that of the ideal test described in the standard so, for most current crash helmet configurations, the result should be a reasonable approximation of the ideal test. However, it is best to set drop masses and impact velocities as close to the values specified as possible; and to work with all deliberate speed toward setting up a facility with all the necessary drop height so that testing can be done by the book.