

Snell M2000 vs. EC 22-05

Comparison Testing on Helmets
Certified to Either Standard

Testing Conducted by:

HPE

Farnham, Surrey

England

&

Snell Memorial Foundation

North Highlands, California

Paired Helmets

- All helmets were made by the same manufacturer
- Comparable EC 22-05 and Snell M2000 models were selected
- The helmets were paired, one EC 22-05 and one Snell M2000 sample to a pair.
- Within each pair, the samples were marked, conditioned and tested identically

That is...

- A Snell M2000 helmet and an EC 22-05 helmet both sized for the “J” headform, were conditioned hot and tested to Snell M2000 requirements with identical impacts at identical sites on the helmet.
- A similar pair of helmets was conditioned cold and tested to Snell M2000 requirements
- A similar pair was conditioned hot and tested to EC22-05 requirements
- A similar pair was conditioned cold and tested to EC22-05 requirements
- And we did the same thing for Snell and EC helmets fitting the “M” headform

Test Matrix

	Snell M2000 Type Tests	EC 22-05 Type Tests
Hot Condition	A Snell “J” Helmet & an EC“J” Helmet ----- A Snell “M” Helmet & an EC “M Helmet	A Snell “J” Helmet & an EC“J” Helmet ----- A Snell “M” Helmet & an EC “M Helmet
Cold Condition	A Snell “J” Helmet & an EC“J” Helmet ----- A Snell “M” Helmet & an EC “M Helmet	A Snell “J” Helmet & an EC“J” Helmet ----- A Snell “M” Helmet & an EC “M Helmet

Quick Summary of Results

- The Snell M2000 and EC 22-05 Standards are Incompatible
- For size XL and smaller, Snell M2000 qualified helmets will not satisfy HIC requirements in EC Testing
 - Snell would consider the responses as protective
- For size XL and smaller, EC 22-05 qualified helmets will not manage Snell impact energies in Snell testing
 - The responses would be considered hazardous by any standards

Headform Breakout

- “A” Headform – Snell 5.0 kg vs EC 3.1 kg
– 50 cm circumference, Size XXX-Small
- “E” Headform – Snell 5.0 kg vs EC 4.1 kg
– 54 cm circumference, Size X-Small
- “J” Headform – Snell 5.0 kg vs EC 4.7 kg
– 57 cm circumference, size Medium
- “M” Headform – Snell 5.0 kg vs EC 5.6 kg
– 60 cm circumference, size X-Large
- “O” Headform – Snell 5.0 kg vs EC 6.1 kg
– 62 cm circumference, size XXX-Large

Impact Gear Considerations

Snell M2000	EC 22-05	(EC 22-05 approximation)
<p>Drop mass 5.0 kg J & M Twin Wire Half Headform <i>**rotational components controlled and minimized</i></p>	<p>Drop Mass 4.7 kg J 5.6 kg M Guided Free Fall Full Headform</p>	<p>Drop Mass 4.7 kg J 5.6 kg M Twin Wire Half Headform <i>**rotational control may make this approximation more severe than actual test</i></p>

Impact Test Considerations

- Snell M2000 Flat & Hemi
 - Double Impact
 - 7.74 m/s, 6.63 m/s
 - 150 Joules, 110 Joules
- Snell M2000 Edge
 - Single Impact
 - 7.74 m/s
- No Kerbstone
- Test Criterion
 - Peak must not exceed 300g
- EC 22-05 Flat & Kerb
 - Single Impact
 - 7.5 m/s
 - (87 to 172 Joules depending on headform)
- No Hemisphere
- No Edge
- Test Criteria
 - HIC must not exceed 2400
 - Peak must not exceed 275g

Results

- 16 Helmets tested
 - On the M Headform
 - 2 pair in size XL to Snell (one pair hot & one cold)
 - 2 pair in size XL to EC 22-05 (as above)
 - On the J Headform
 - similarly
- 101 separate impacts, 70 sites

Note on Graphs

- Data presented in two formats:
 - Acceleration plotted versus time
 - Acceleration cross-plotted versus calculated displacement
 - Displacement versus time is calculated from the measured impact velocity and the acceleration time history
 - For Snell double impacts, the crossplots start the instant the tab clears the velocity gate

Results: 'J' EC Tests

- All the EC 22-05 Helmets meet EC 22-05 impact test requirements
- Snell Helmets
 - Failed HIC criteria for all flat impacts
 - 2888, 3233, 2571 and 2784 versus 2400
 - One Flat impact failed the Peak G limit
 - Measured 279 G versus a limit of 275 G

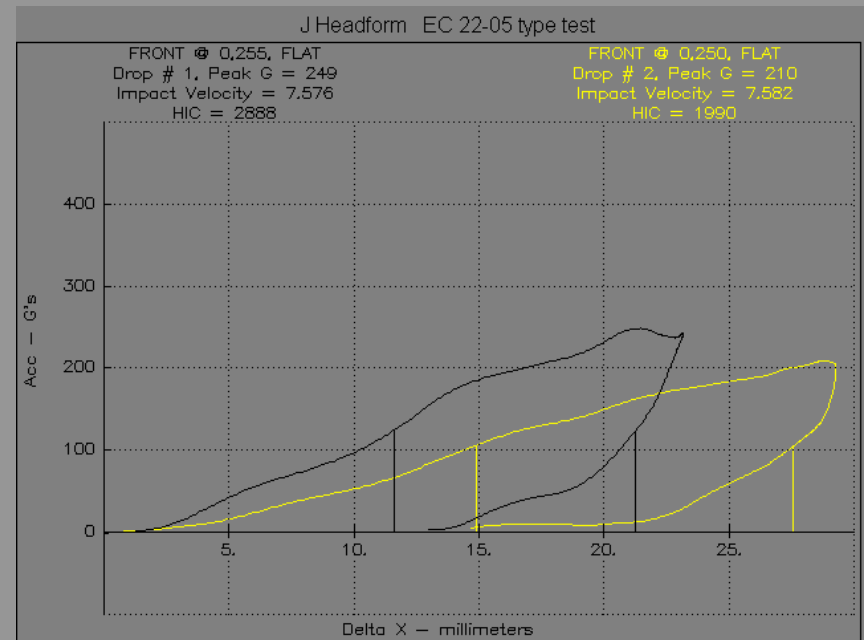
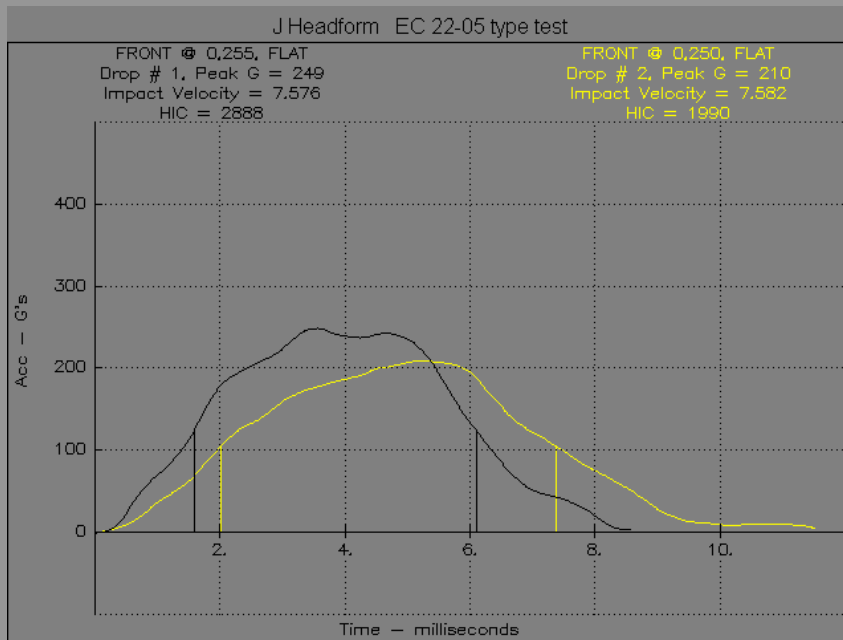
EC 22-05 Front Flat J Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



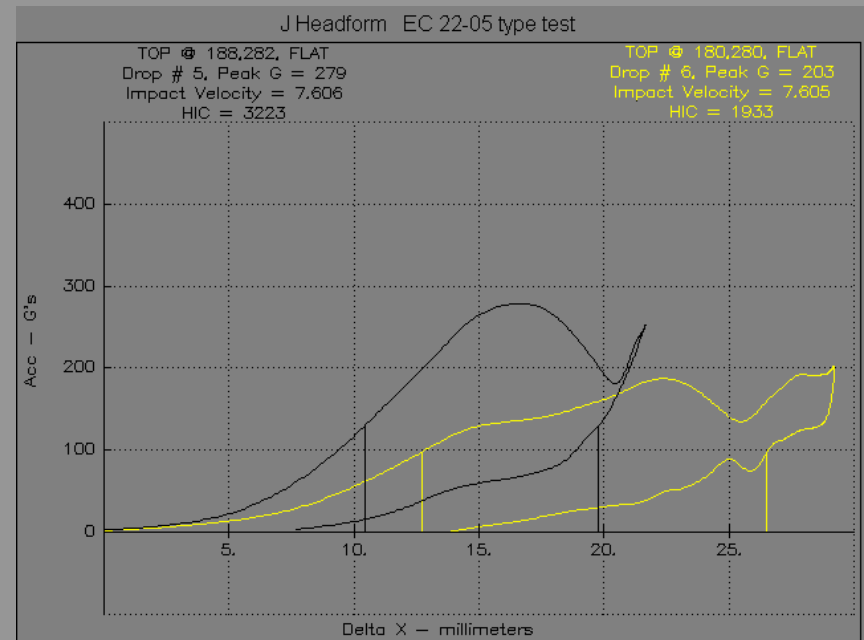
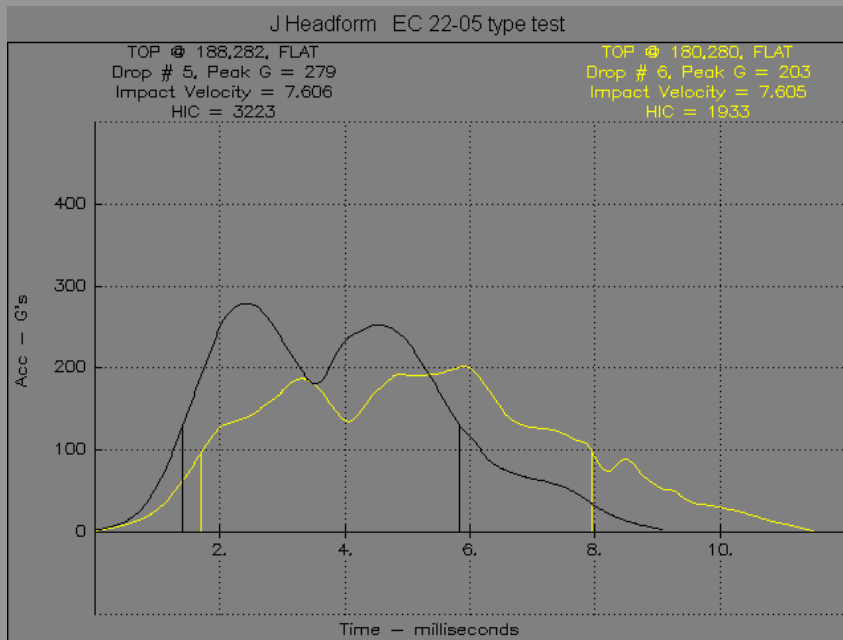
EC 22-05 Top Flat J Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



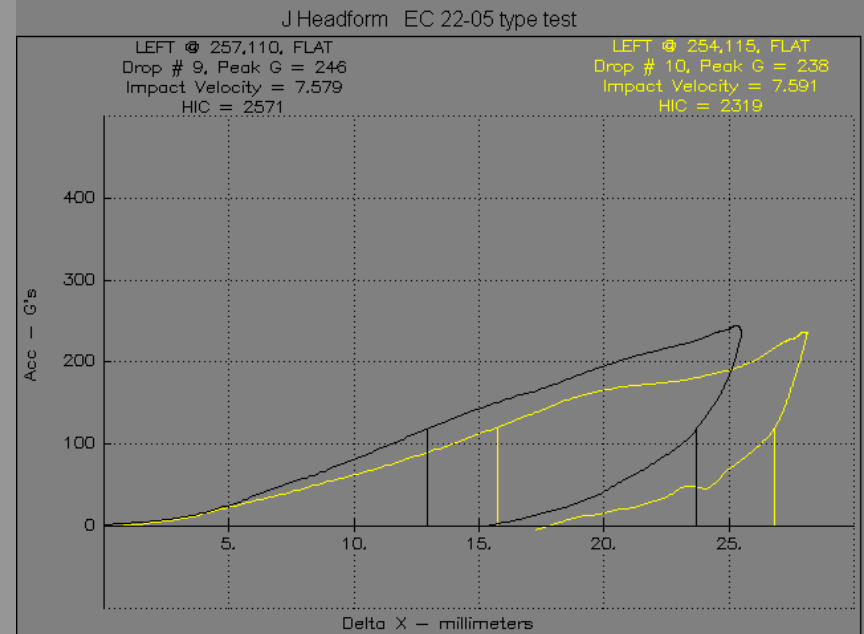
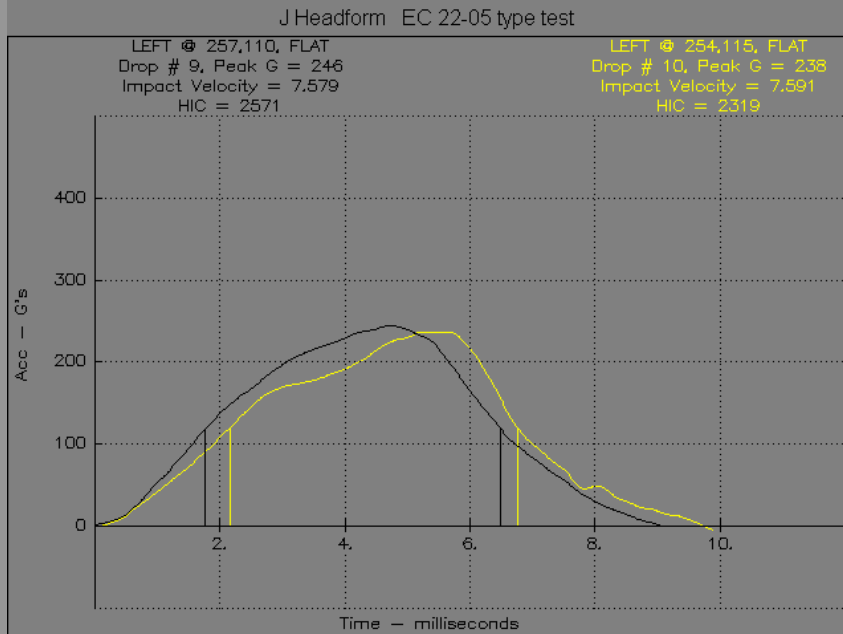
EC 22-05 Left Flat J Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



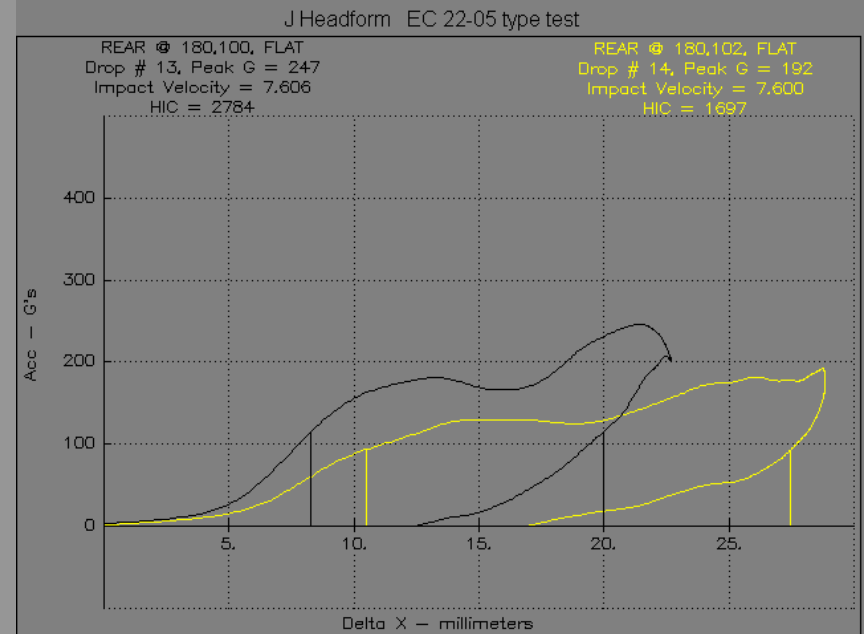
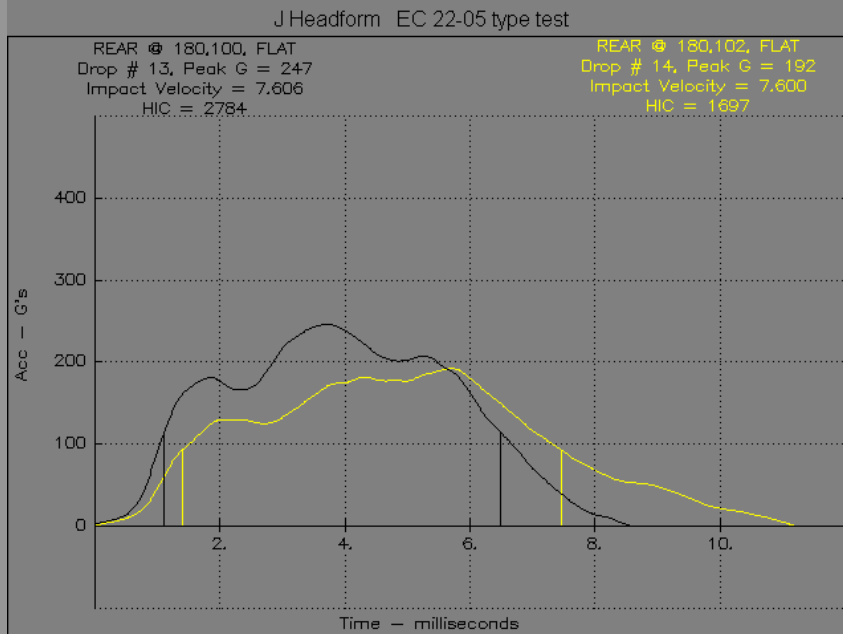
EC 22-05 Rear Flat J Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



Results: 'J' Snell M2000 Tests

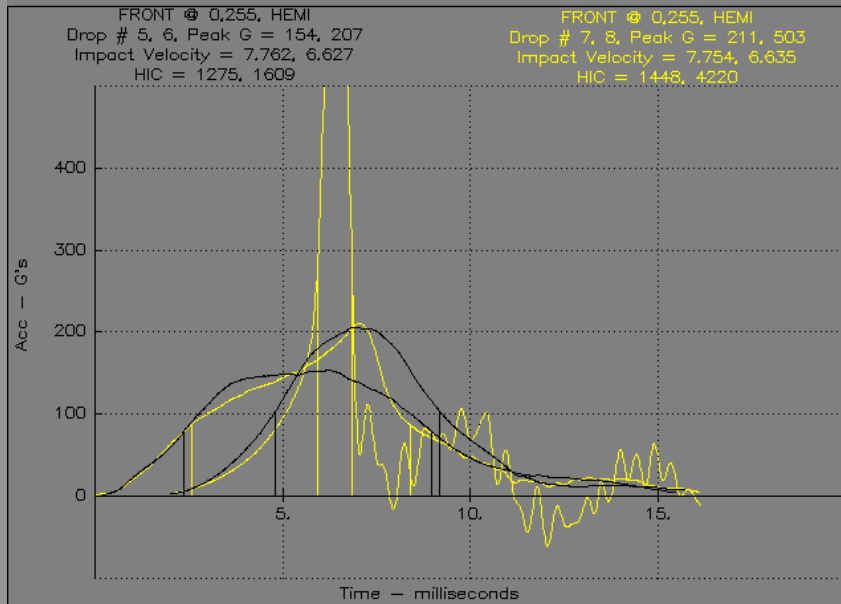
- All the Snell helmets meet M2000 impact test requirements
- The EC Helmets
 - Failed one edge anvil impact
 - Measured 410 G versus the 300 G criterion
 - Failed two hemi anvil impact series
 - 2nd front impact overload (~500 G)
 - 1st and 2nd Rear, 438 G and overload

Snell M2000 Front Hemi J Headform

Snell Helmet

EC 22-05 Helmet

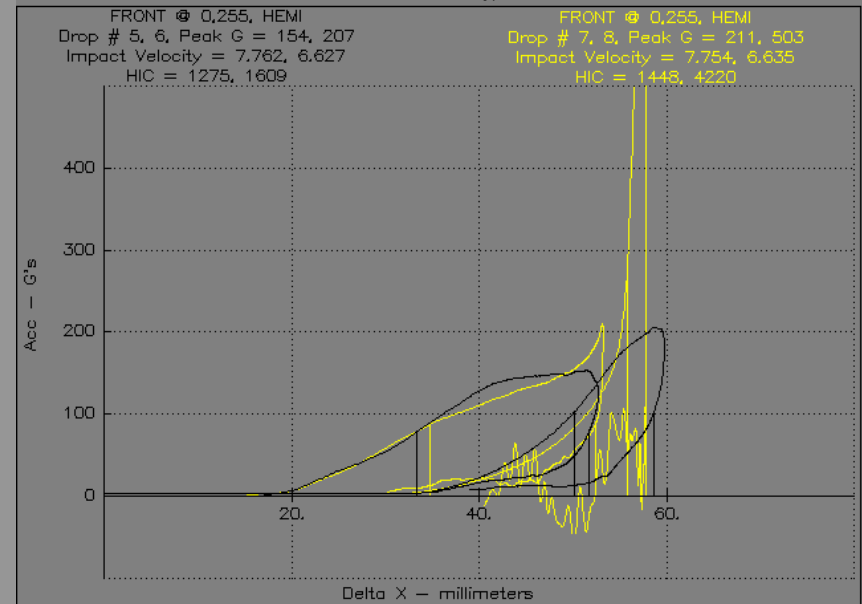
J Headform M2000 type test



Snell Helmet

EC 22-05 Helmet

J Headform M2000 type test

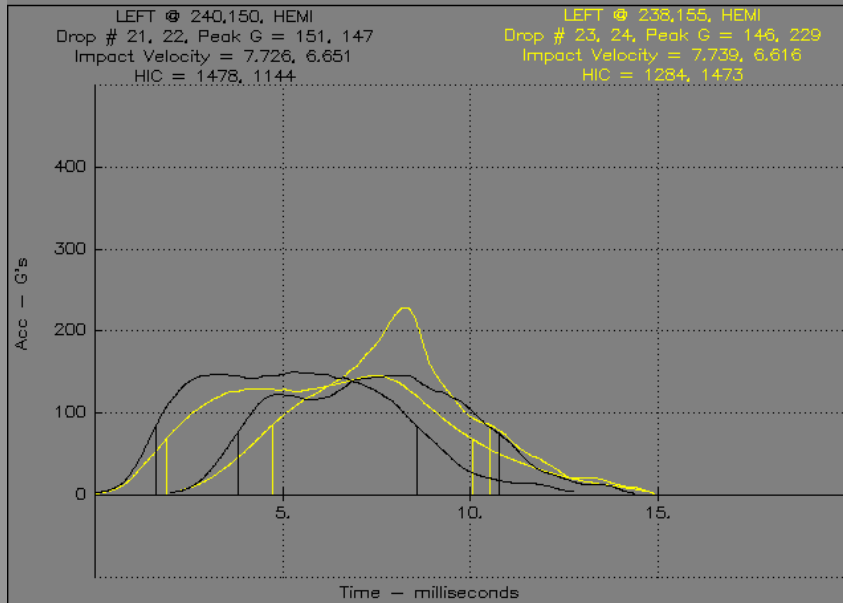


Snell M2000 Left Hemi J Headform

Snell Helmet

EC 22-05 Helmet

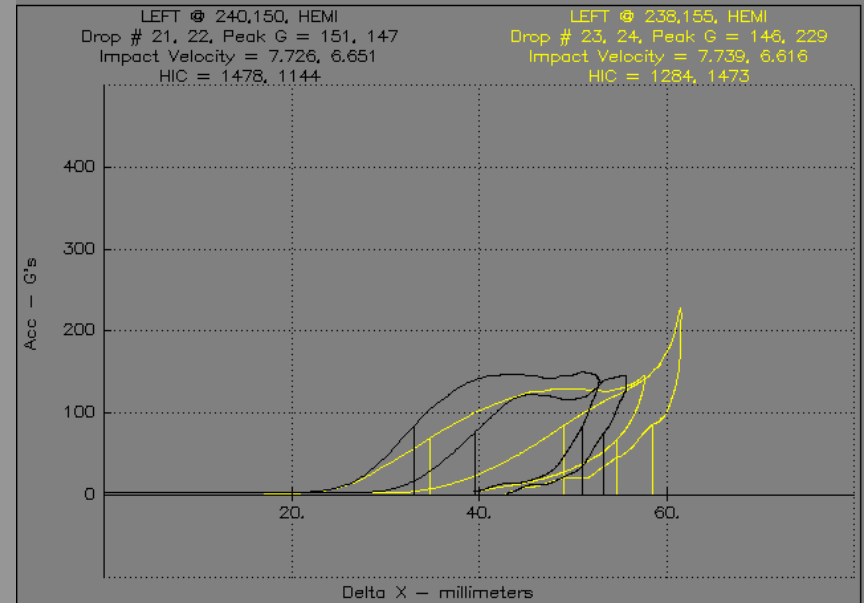
J Headform M2000 type test



Snell Helmet

EC 22-05 Helmet

J Headform M2000 type test



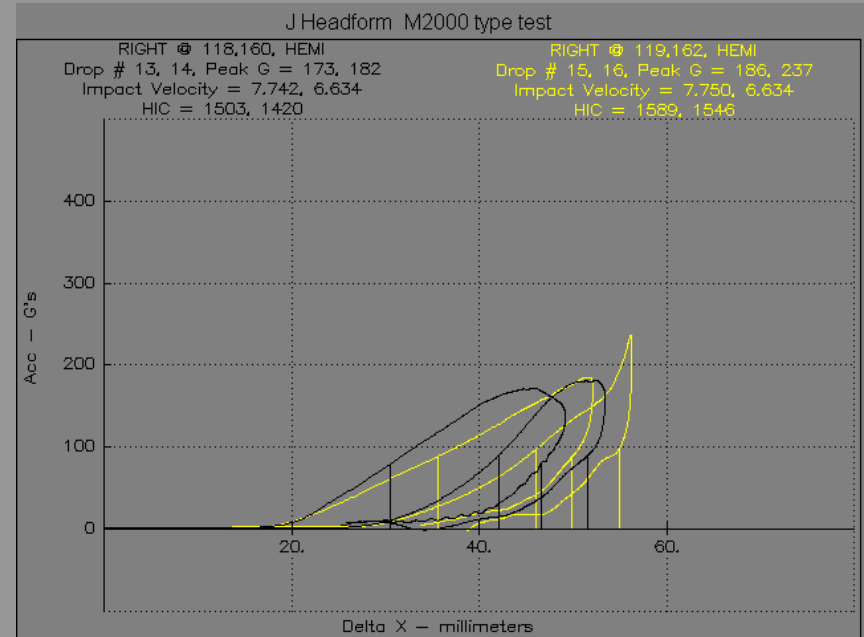
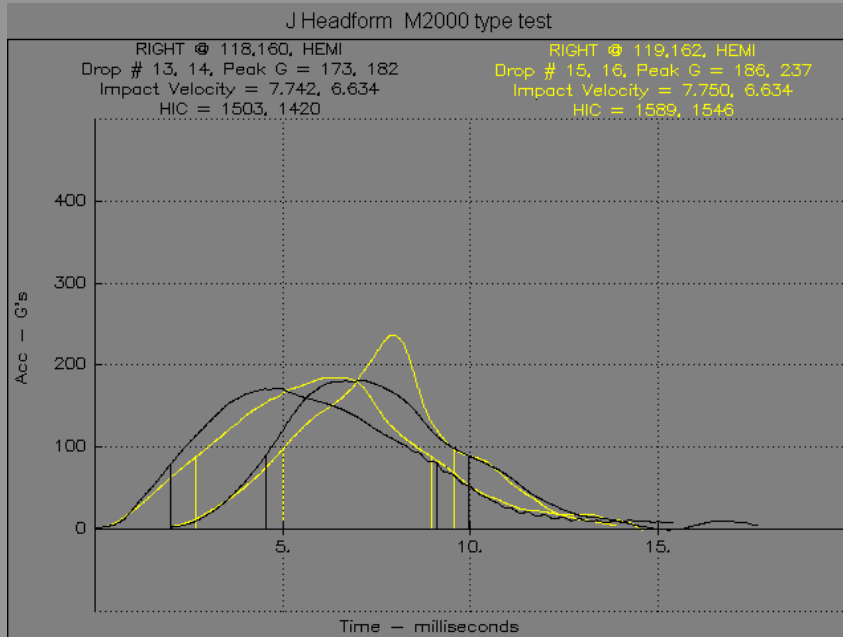
Snell M2000 Right Hemi J Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



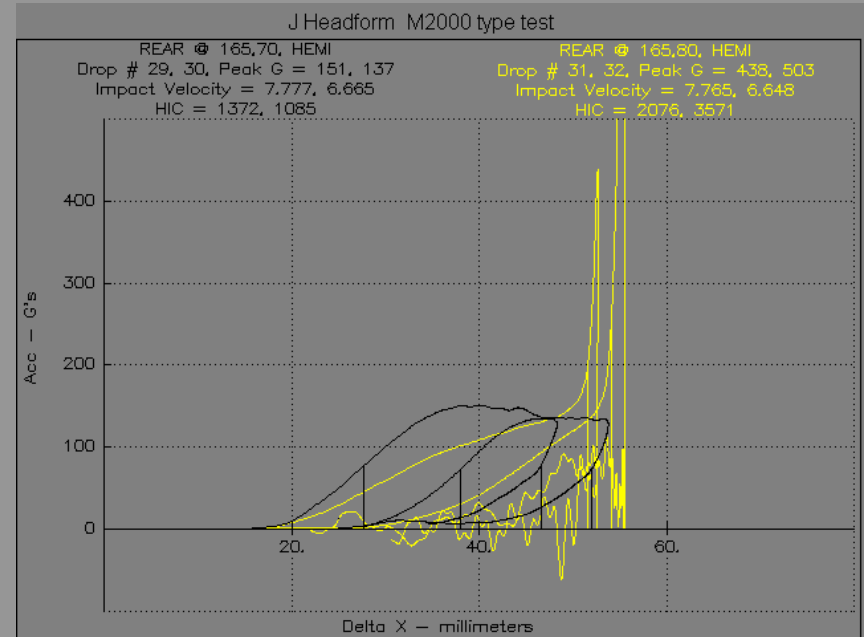
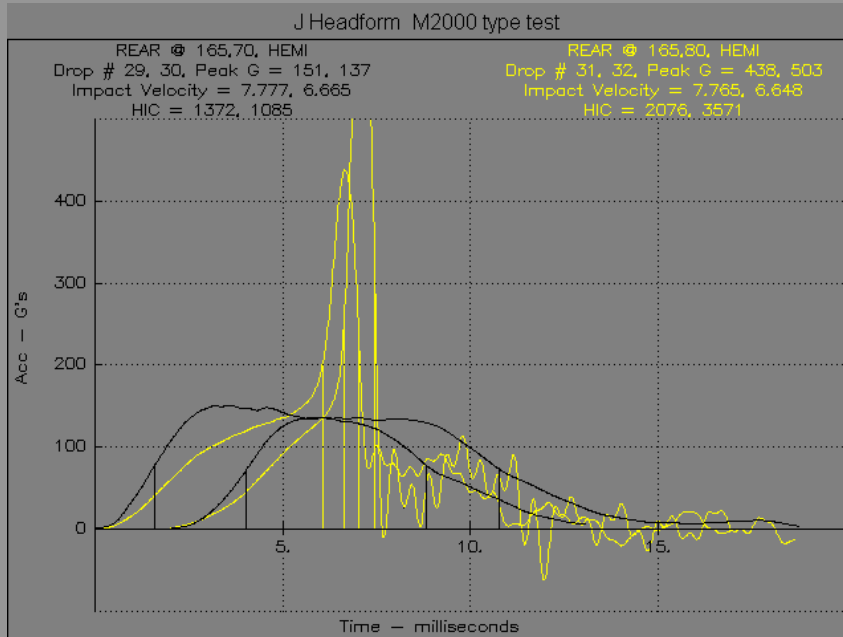
Snell M2000 Rear Hemi J Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



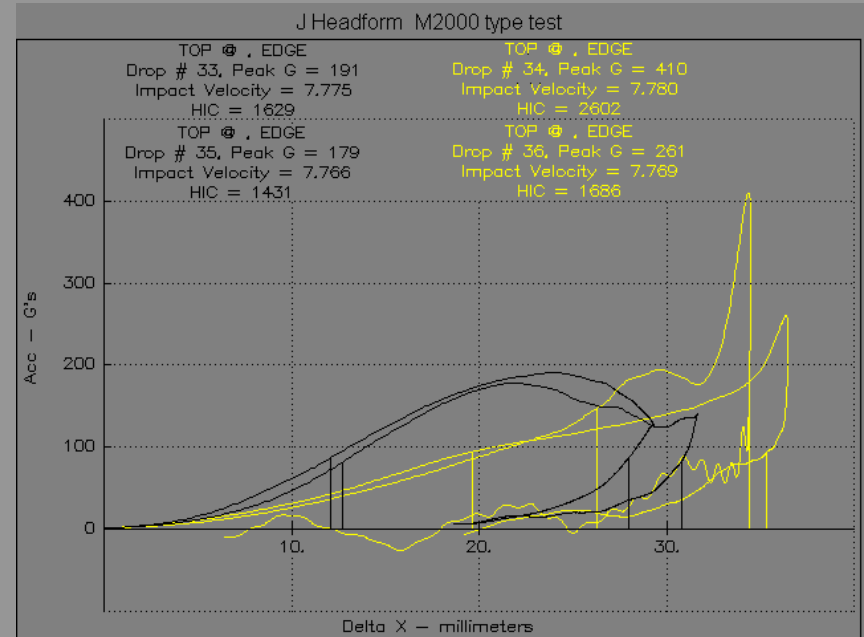
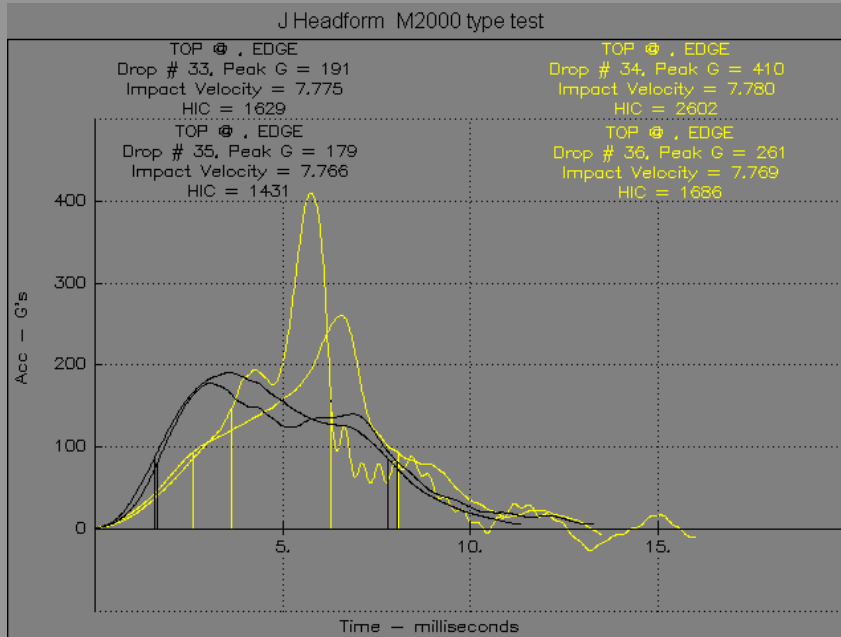
Snell M2000 Top Edge J Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



Results: 'M' EC Tests

- All Snell helmets and all EC helmets passed all the prescribed impacts.

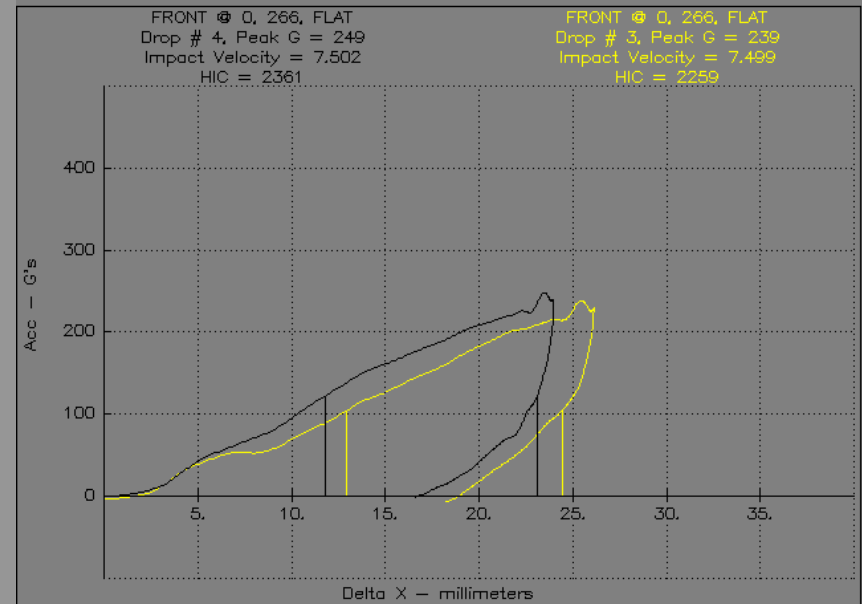
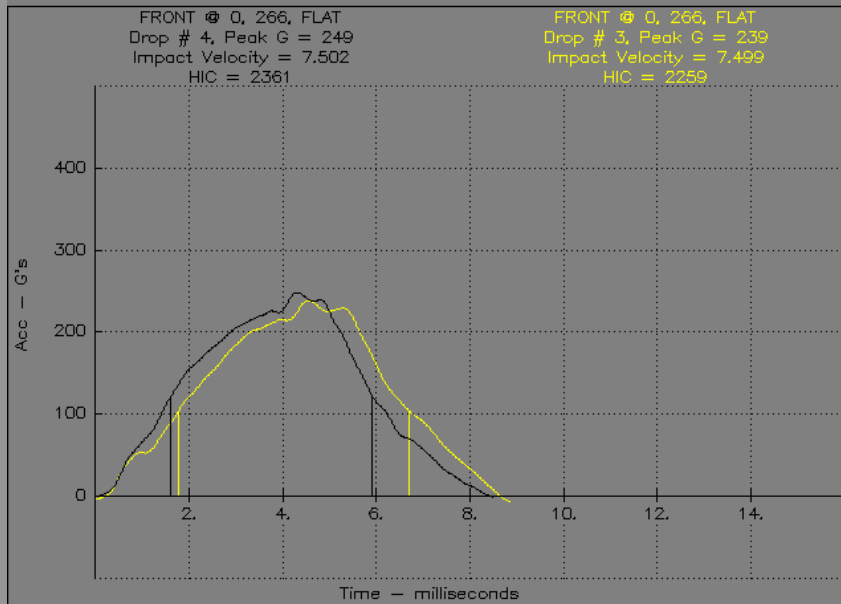
EC 22-05 Front Flat M Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

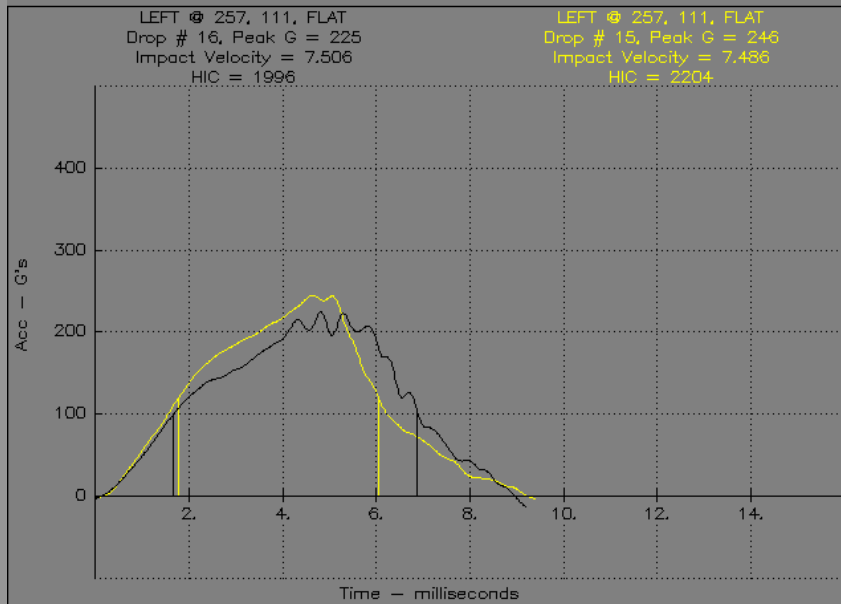
EC 22-05 Helmet



EC 22-05 Left Flat M Headform

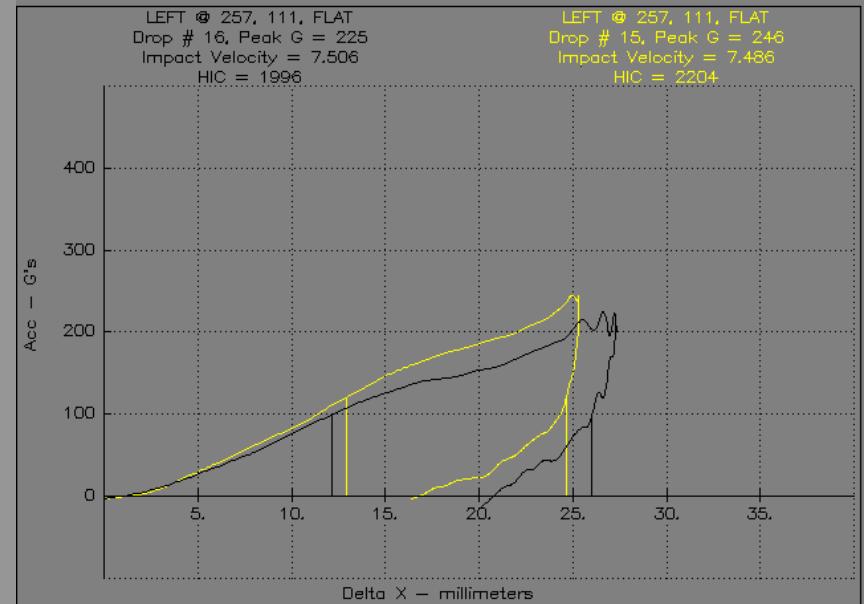
Snell Helmet

EC 22-05 Helmet



Snell Helmet

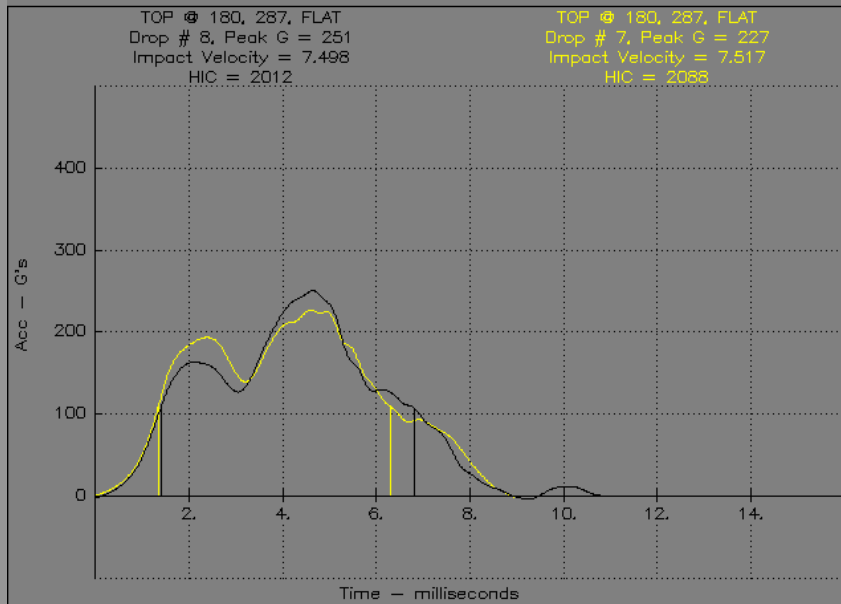
EC 22-05 Helmet



EC 22-05 Top Flat M Headform

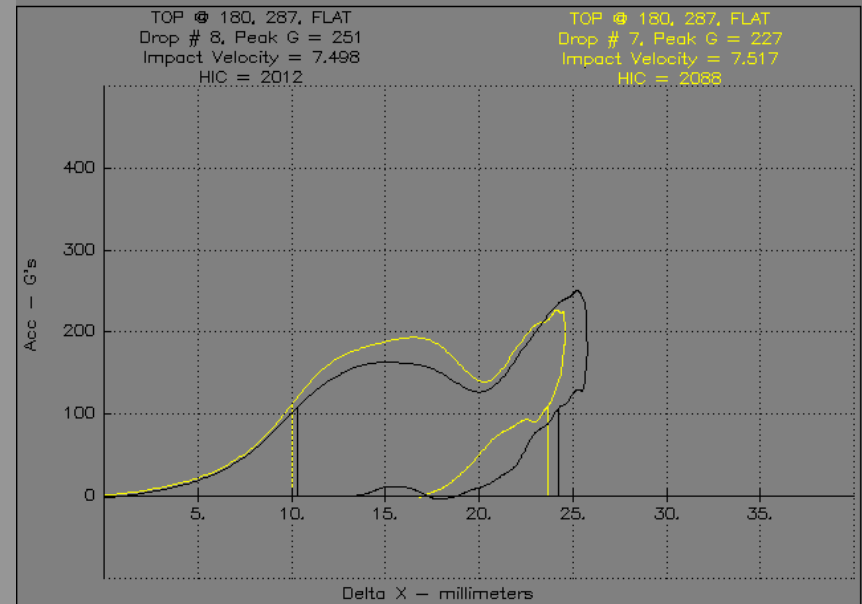
Snell Helmet

EC 22-05 Helmet



Snell Helmet

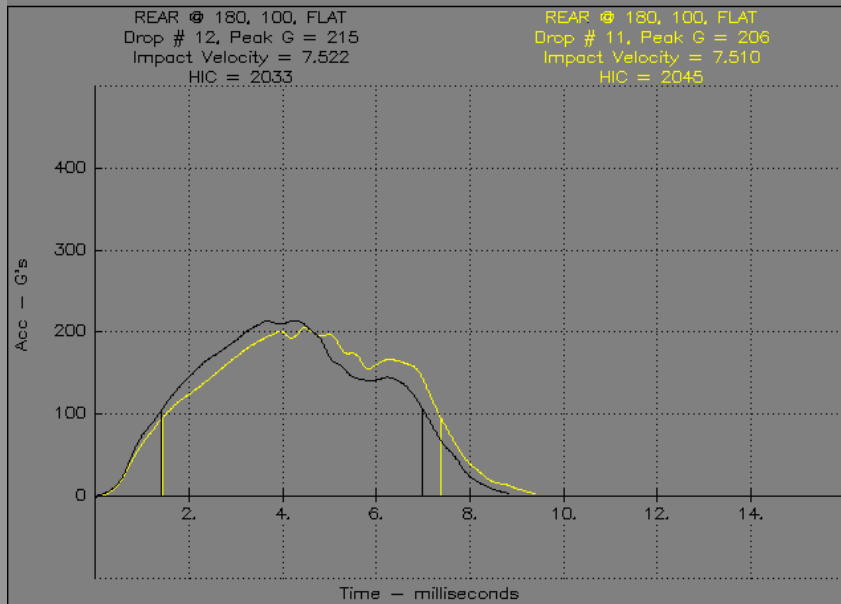
EC 22-05 Helmet



EC 22-05 Rear Flat M Headform

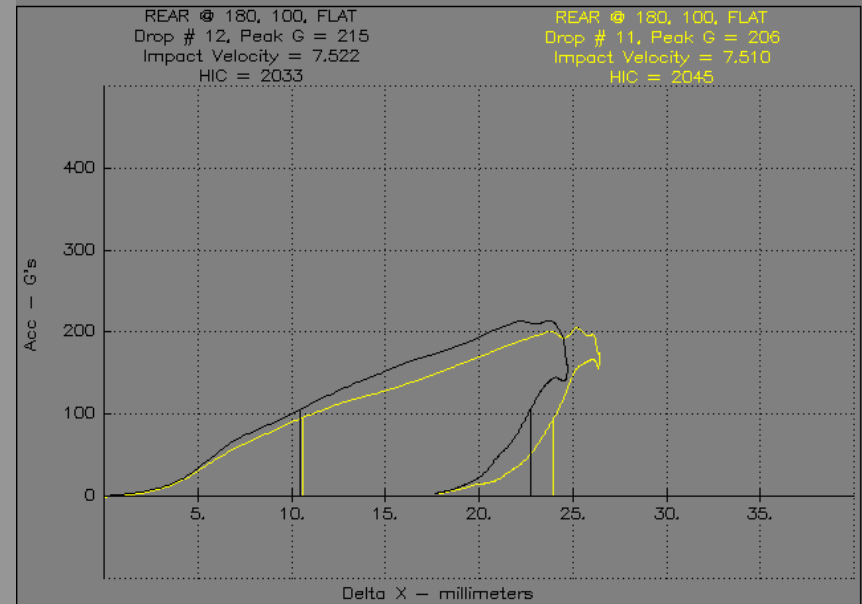
Snell Helmet

EC 22-05 Helmet



Snell Helmet

EC 22-05 Helmet



Results: 'M' Snell M2000 Tests

- All Snell Helmets and all EC Helmets passed all the Snell M2000 impacts
- BUT..
 - The Rear hemi impacts were performed 1 centimeter too low.. At the M2005 test line
 - The Snell helmet failed in the second of two impacts after managing the first
 - The EC helmet failed in the first impact

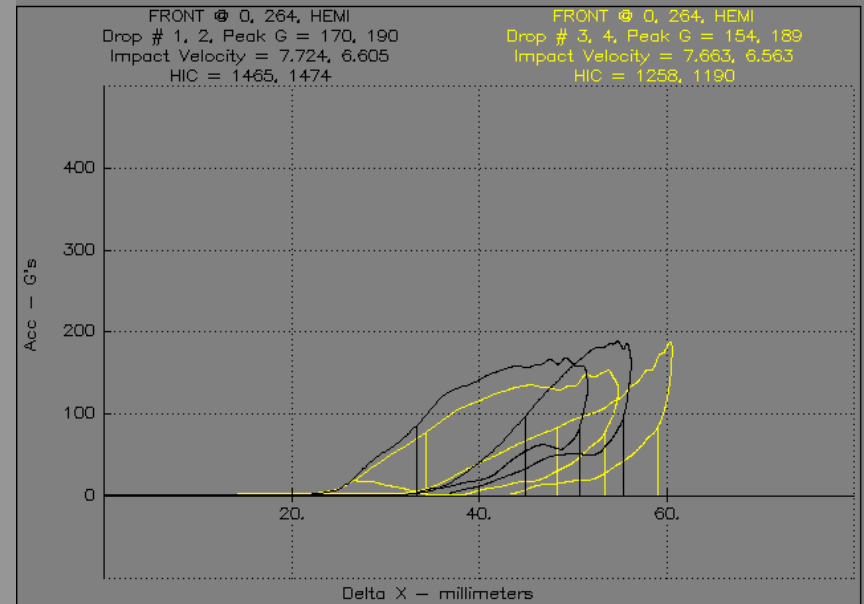
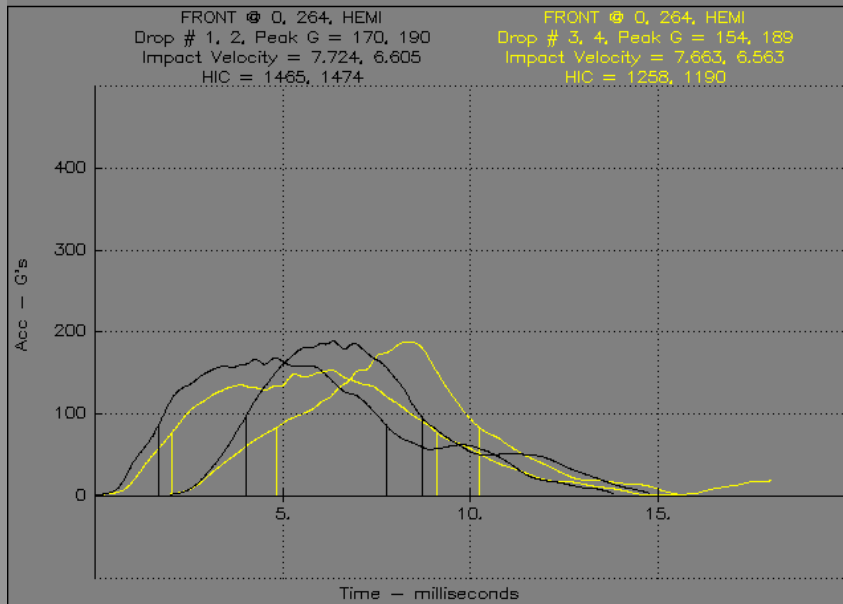
Snell M2000 Front Hemi M Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



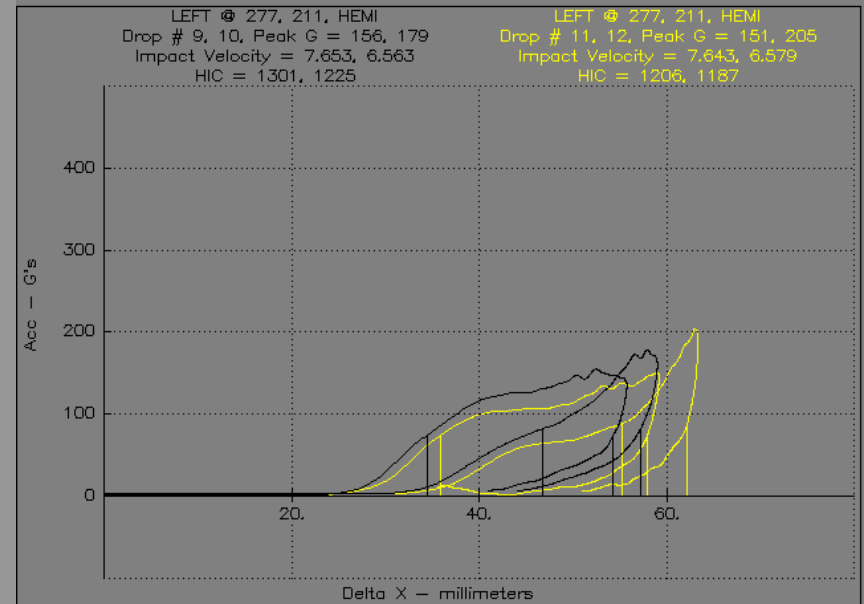
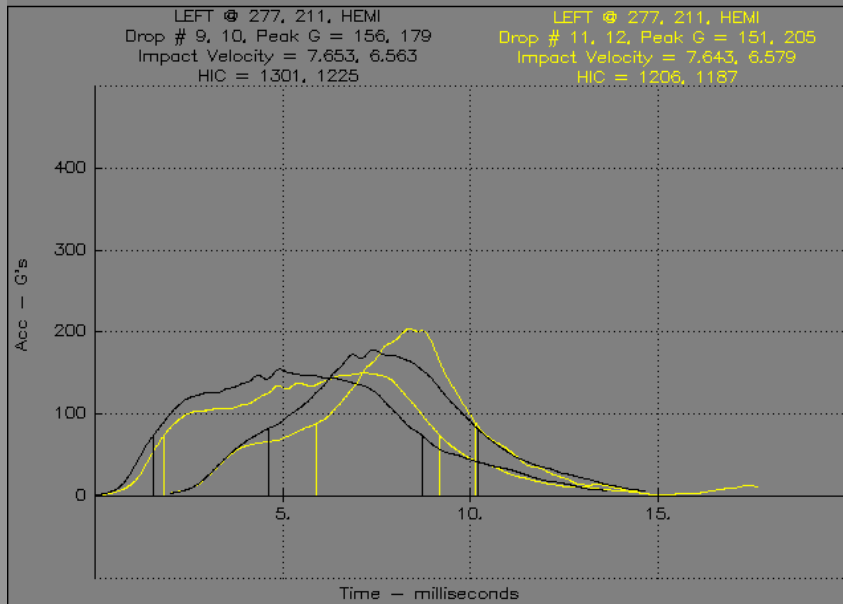
Snell M2000 Left Hemi M Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

EC 22-05 Helmet



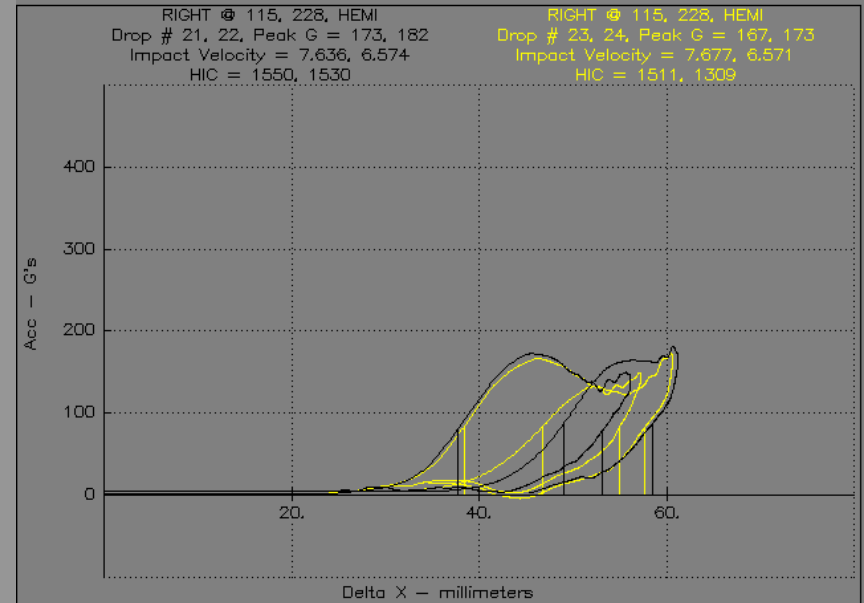
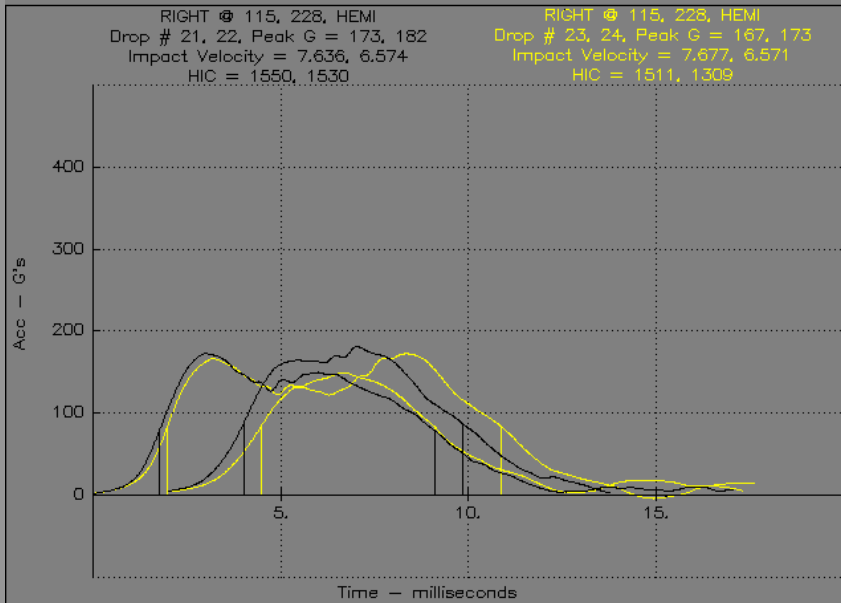
Snell M2000 Right Hemi M Headform

Snell Helmet

EC 22-05 Helmet

Snell Helmet

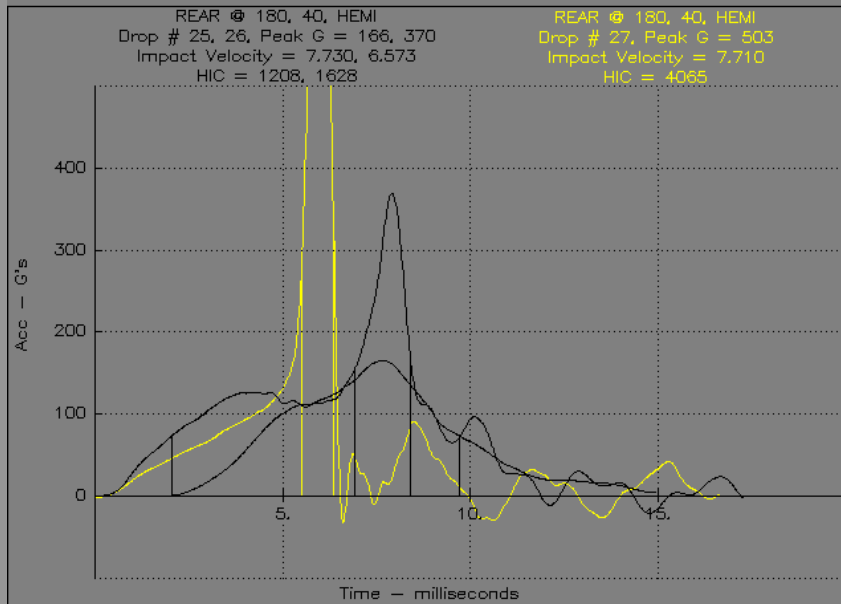
EC 22-05 Helmet



Snell M2000 Rear Hemi M Headform

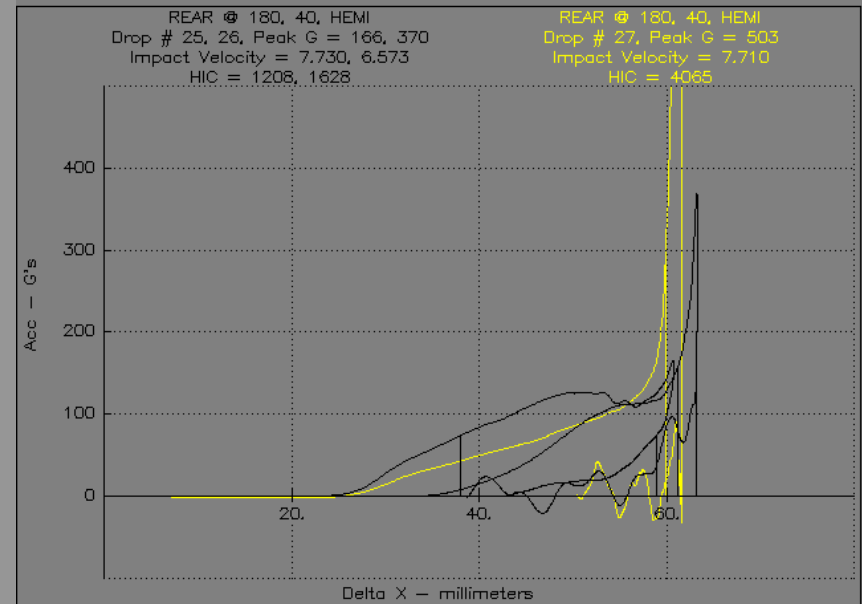
Snell Helmet

EC 22-05 Helmet



Snell Helmet

EC 22-05 Helmet

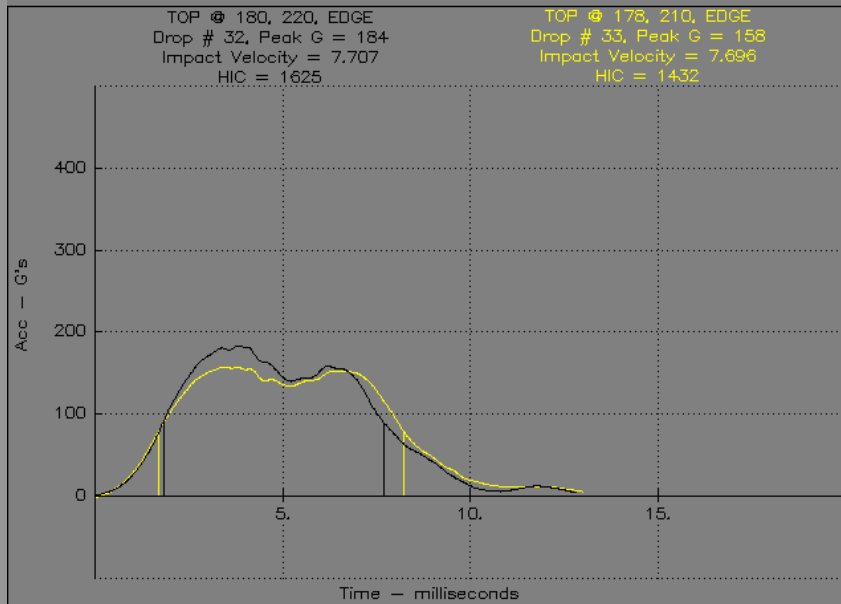


~1 cm. below test line... (an M2005 type impact)

Snell M2000 Top Edge M Headform

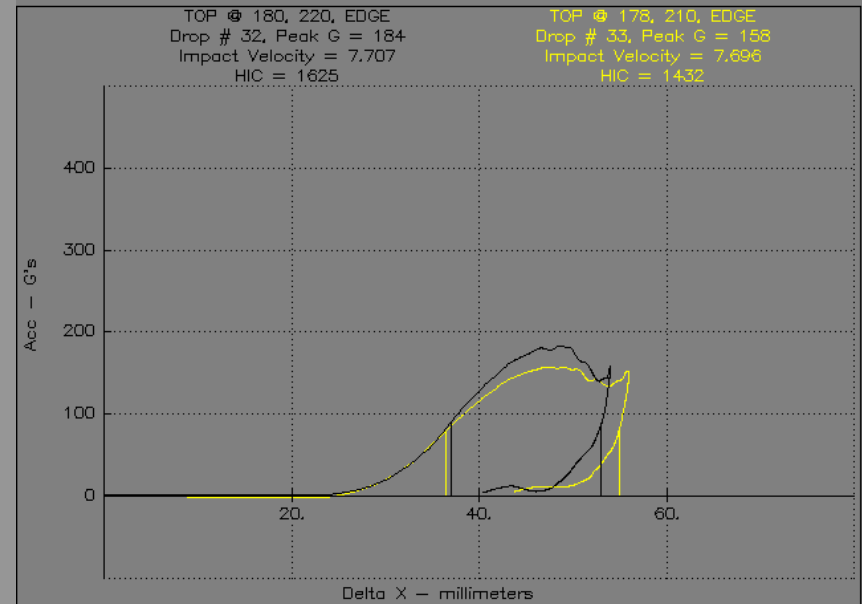
Snell Helmet

EC 22-05 Helmet



Snell Helmet

EC 22-05 Helmet



A, E and O Headforms

- Helmets fitting only two of five headforms have been evaluated... BUT
- It may be possible to draw some inferences for the A, E and O headforms based on the J and M results
- In general, the standards diverge even further as headform size decreases to the E and A sizes but, as with M, Snell/EC compatible helmets may be possible on the O headform.

The Critical Considerations

- Snell Impact energies, velocities and headform masses are constant across headforms
- EC velocities are constant but impact energy and mass increase with headform size – roughly with the cube of the headform circumference

Mass Effects

- Flat Impact –
 - Likely an inversely proportionate change in Peak G
 - If shock energy is the same, there may be an inverse square effect on HIC
 - If impact velocity is the same the effect on HIC is inverse and may be to the 1.5 power

Mass Effects

- Hemi & Kerbstone Impact –
 - If shock energy is the same, an inverse effect on Peak G
 - If Impact velocity is the same
 - Peak G may vary as the inverse square root
 - But if shock approaches the limits of the helmet... Peak G may suddenly go through the roof
 - HIC will remain well below Flat Anvil figures so long as shock is within capabilities

Snell M2000 Helmets in EC Testing

- 'A' Headform (size x-small) – failures expected
 - Peak G and HIC for Flat impact
- 'E' Headform (size small) – failures expected
 - Peak G and HIC for Flat (not so bad as 'A')
- 'J' Headform (size medium) – failures expected
 - Mostly Flat HIC (not so bad as 'E')
- 'M' Headform (size x-large) – Passes likely
- 'O' Headform (size xxx-large) – Passes likely
 - (kerbstone impacts are worth a look)

EC Helmets in Snell M2000 Testing

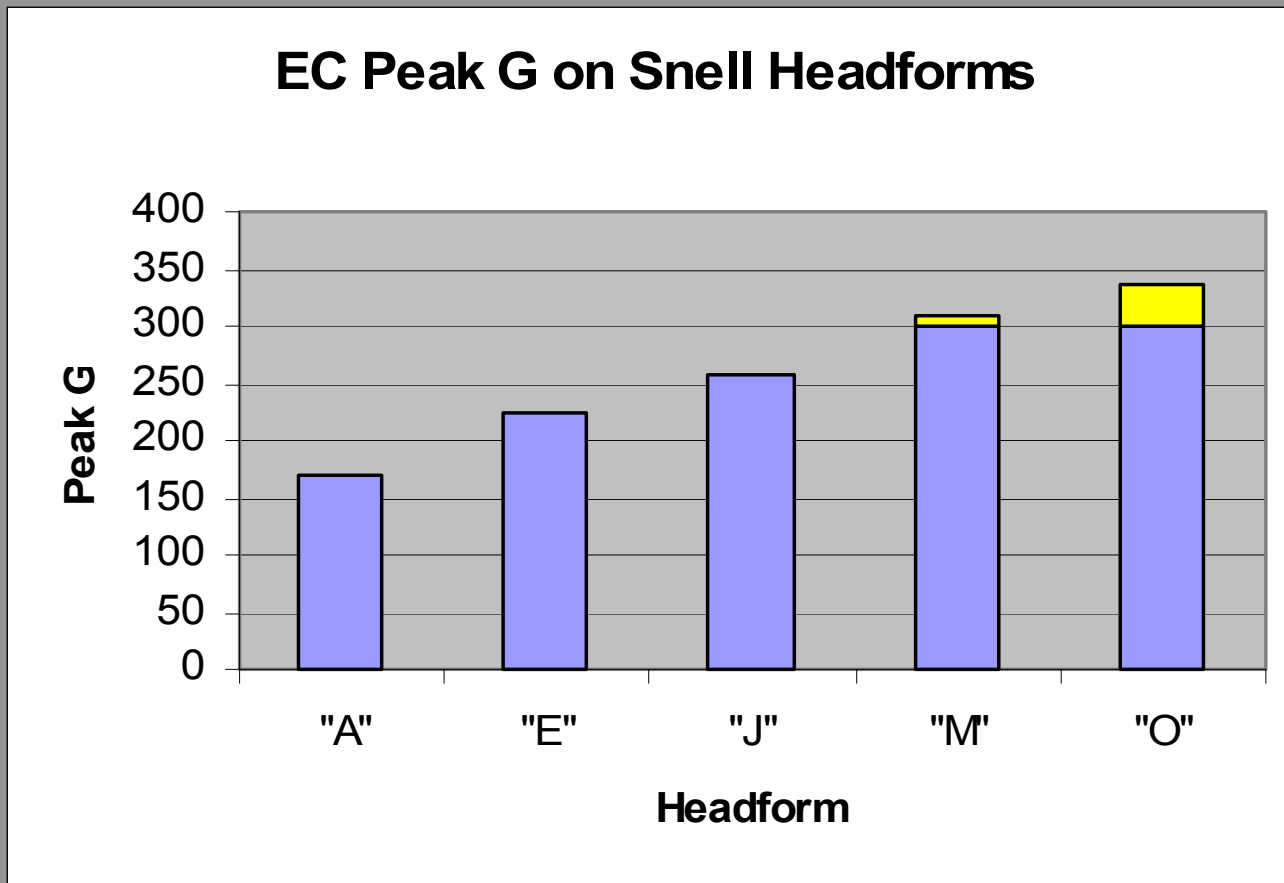
- 'A' Headform (size x-small) – failures expected
 - Catastrophic Hemi Anvil Results (worse than 'E')
- 'E' Headform (size small) – failures expected
 - Catastrophic Hemi Anvil Results (worse than 'J')
- 'J' Headform (size medium) – failures expected
 - Catastrophic Hemi Anvil Results
- 'M' Headform (size x-large) – Passes possible
- 'O' Headform (size xxx-large) – Passes likely
 - (But Flat Impacts may approach Snell 300 G limit)

Conclusions

- There is a conflict between Snell and EC 22-05 requirements for motorcycle helmets smaller than size X-Large
- XXX-Small through Large size Snell Helmets will not meet the EC HIC criterion in EC type testing
 - But helmet response would be deemed protective by Snell criteria
- XXX-Small through Large size EC Helmets will be overwhelmed in Snell testing
 - The helmet response would be deemed unprotective by any criteria

Mass Effects – Peak G

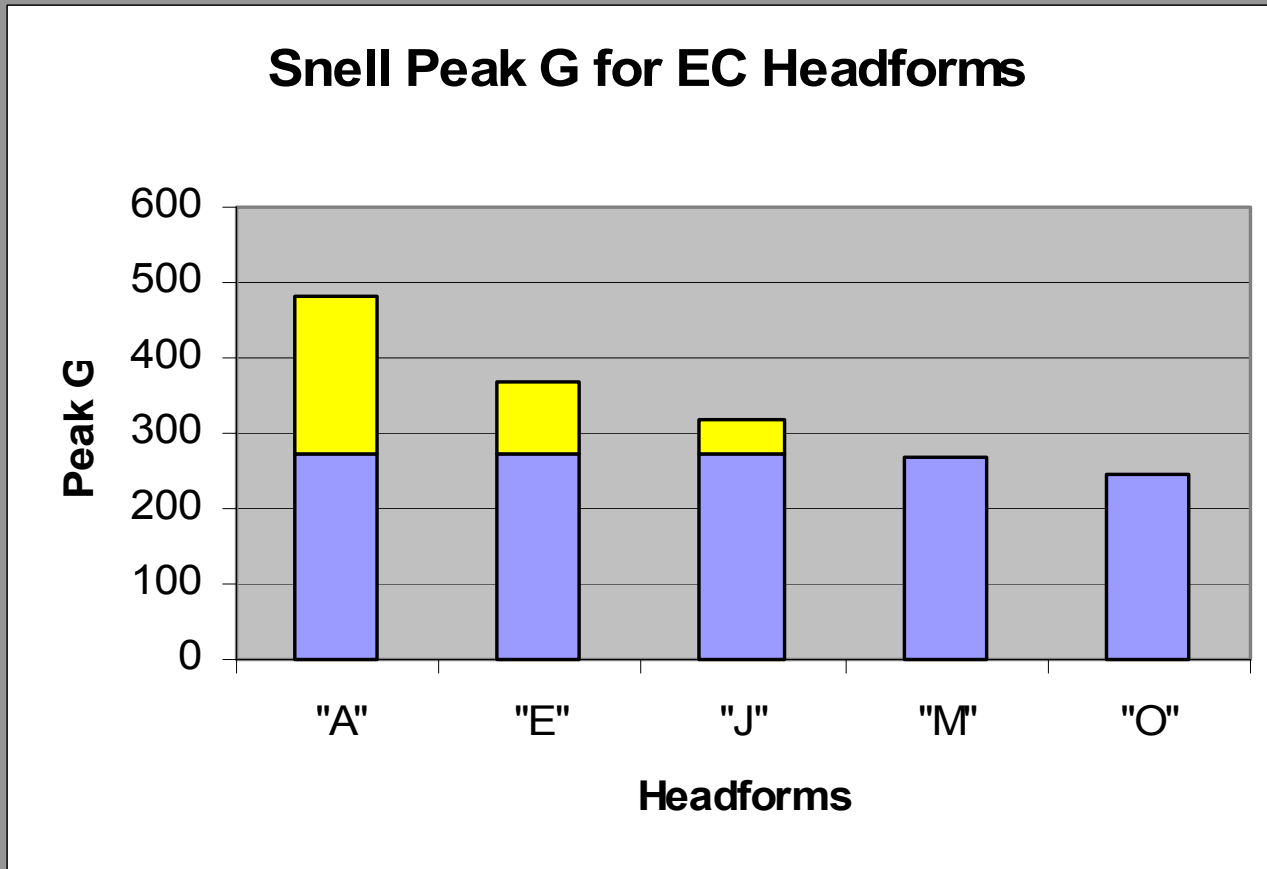
EC 275 G translated to Snell Headforms
Columns equal 275 g times mass ratios



Mass Effects – Peak G

Snell 300 G translated to EC Headforms

Columns equal 300 g times inverse mass ratio



Estimates of EC HIC values for Snell Helmets

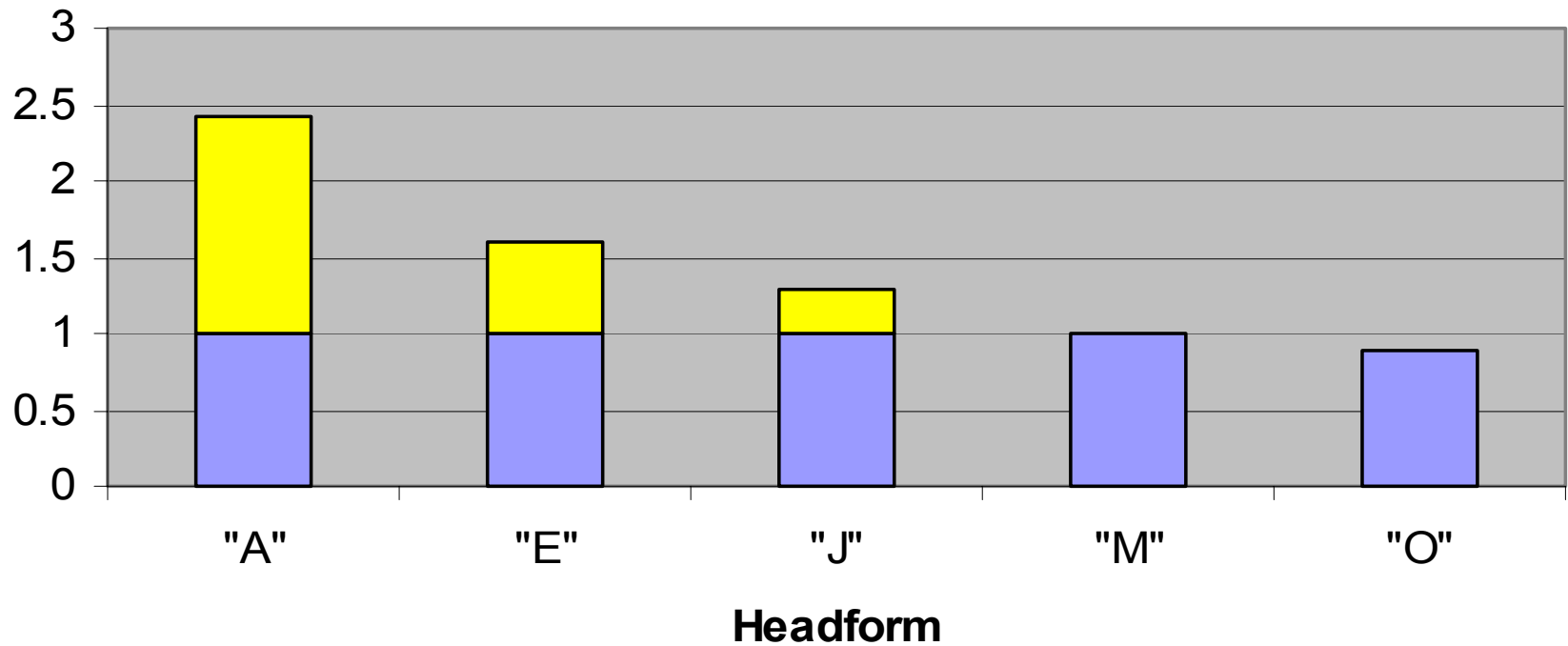
- Since Snell calls out 5.0 kg headform weights regardless of size,
 - Reasonably, similar values of HIC might be expected for comparable flat impacts on Snell helmets of any size.
- If so, the HIC responses of Snell helmets in EC testing might be expected to vary inversely with headform mass raised to the 1.5 power

Mass Effects

Expected Snell HIC in EC Testing

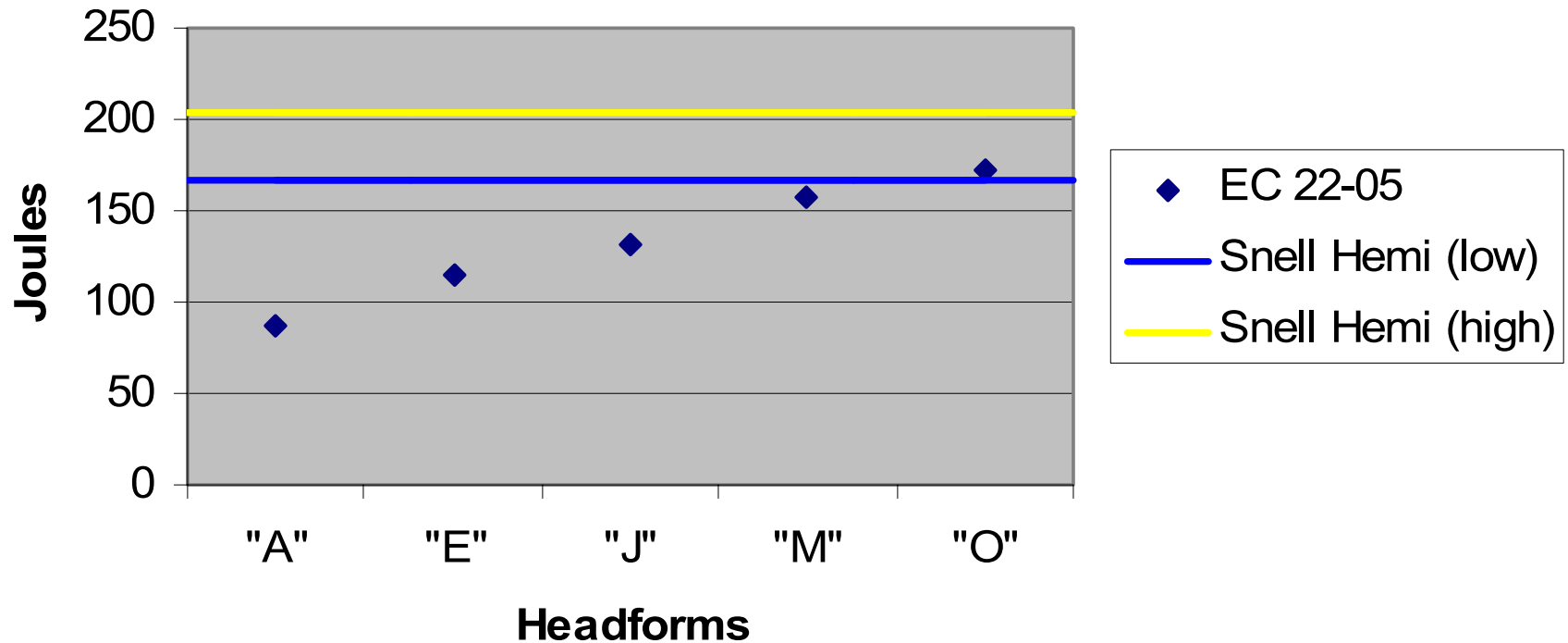
Taking the EC "M" headform response as a baseline

HIC - Multiples of "M" Result



Snell Hemi Energies vs EC

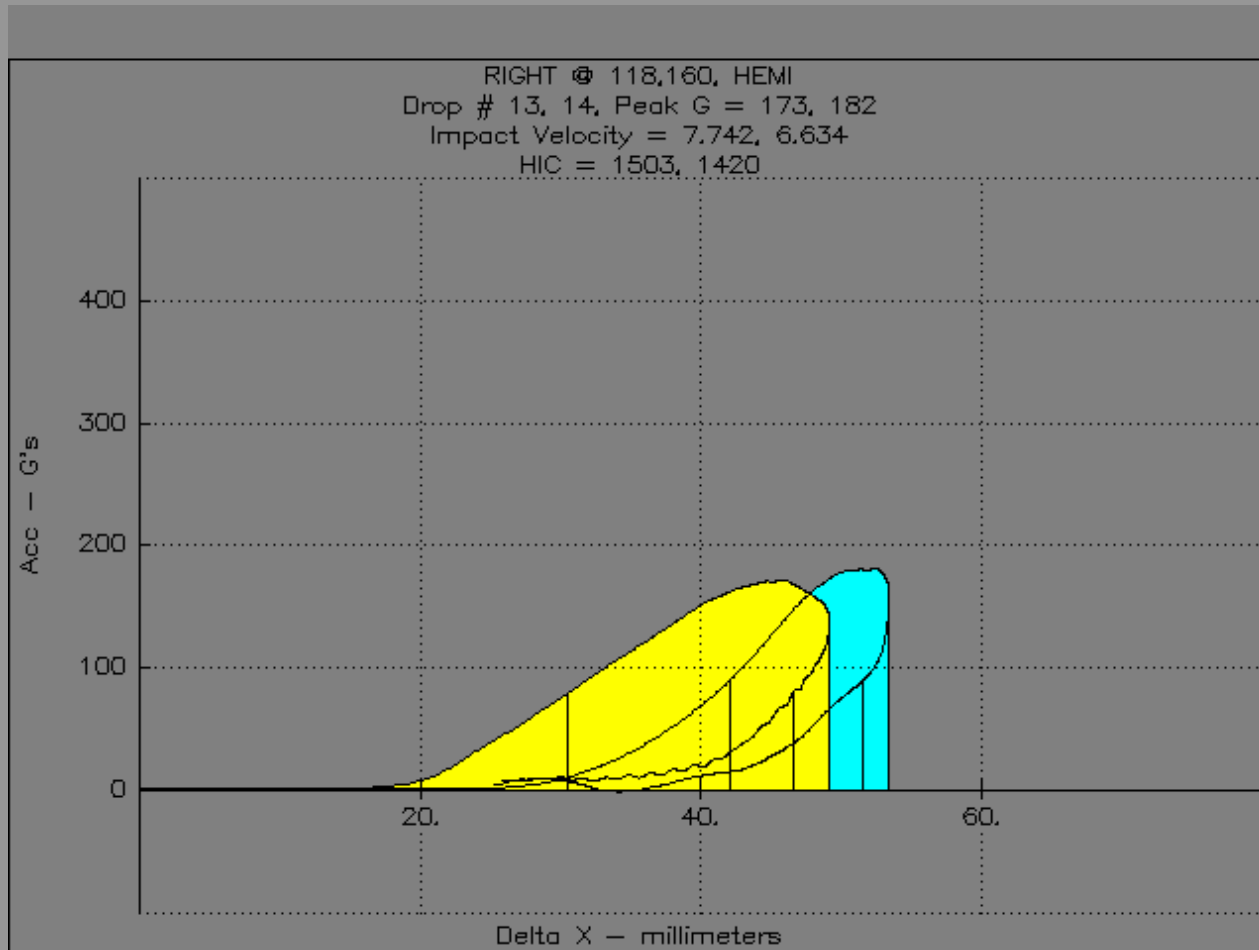
Energy Requirements



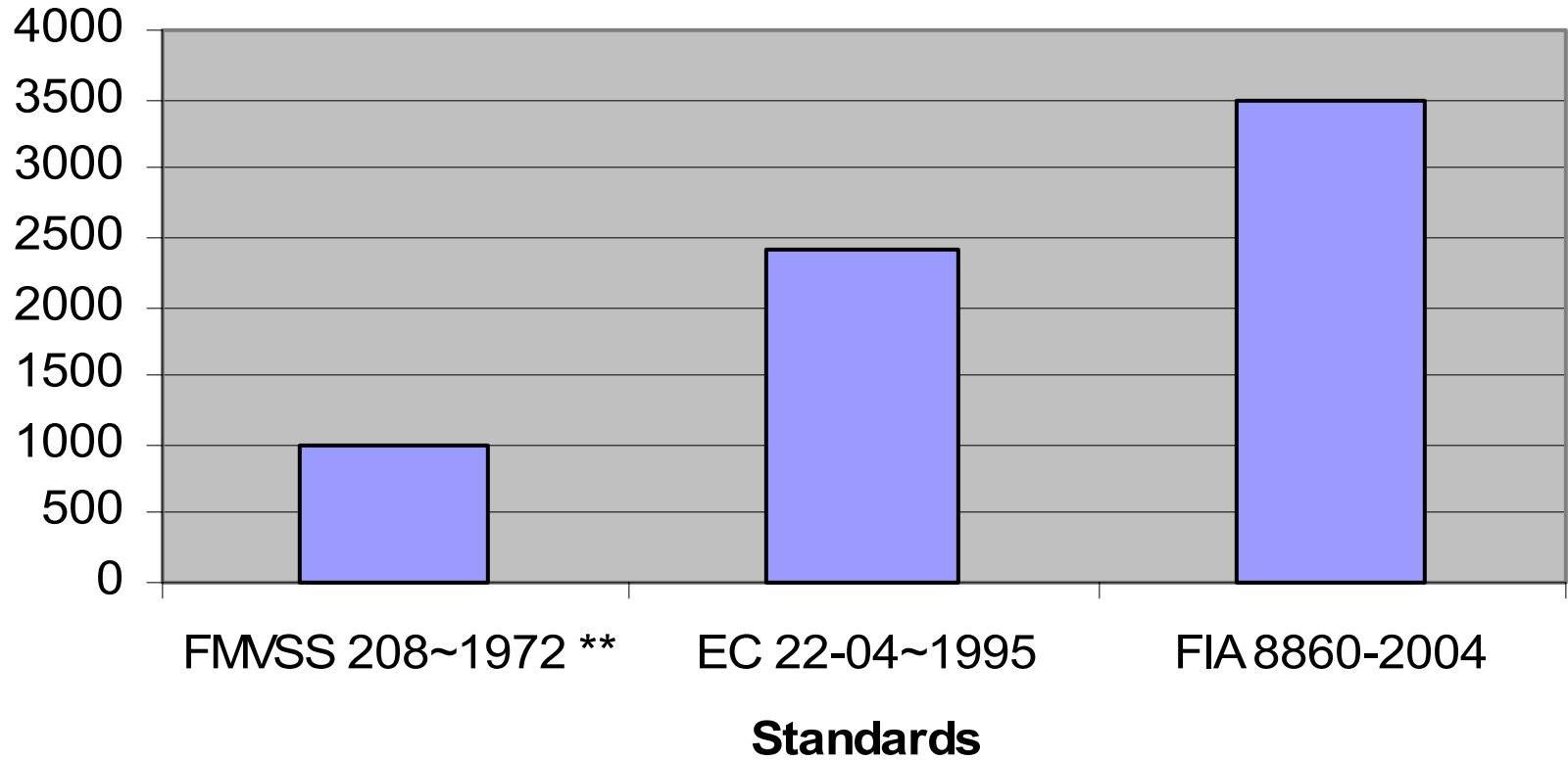
Snell Hemi Energy Estimate

- From RST data
- Energies from double impacts are not additive
- Estimates are based on the union of the areas from cross-plots of the loading portions of both impacts
- For 2500 plus hemi impacts the total energy averaged $185 \text{ joules} \pm 19 \text{ joules}$

Total Impact Energy Union of the Areas Under the Loading Portion of the Impacts



HIC Criteria

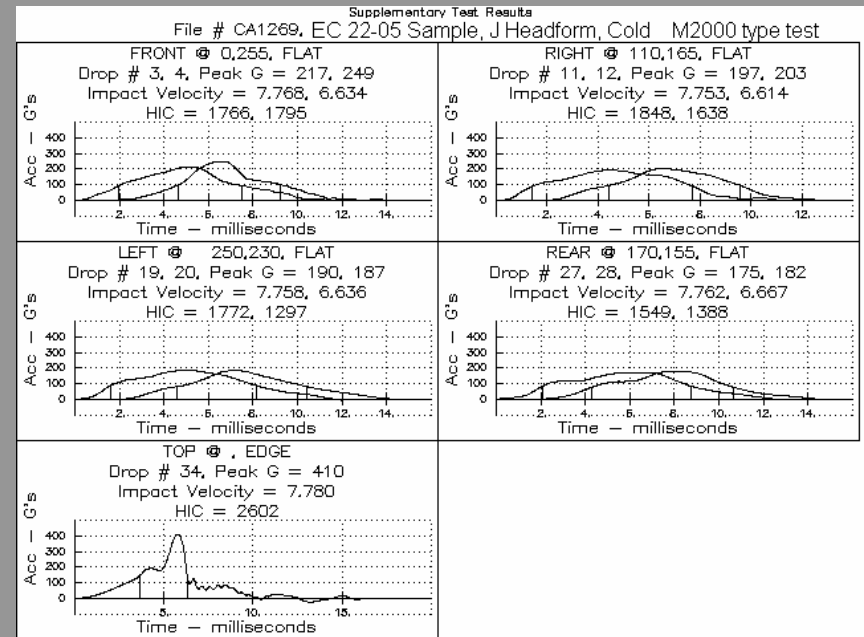
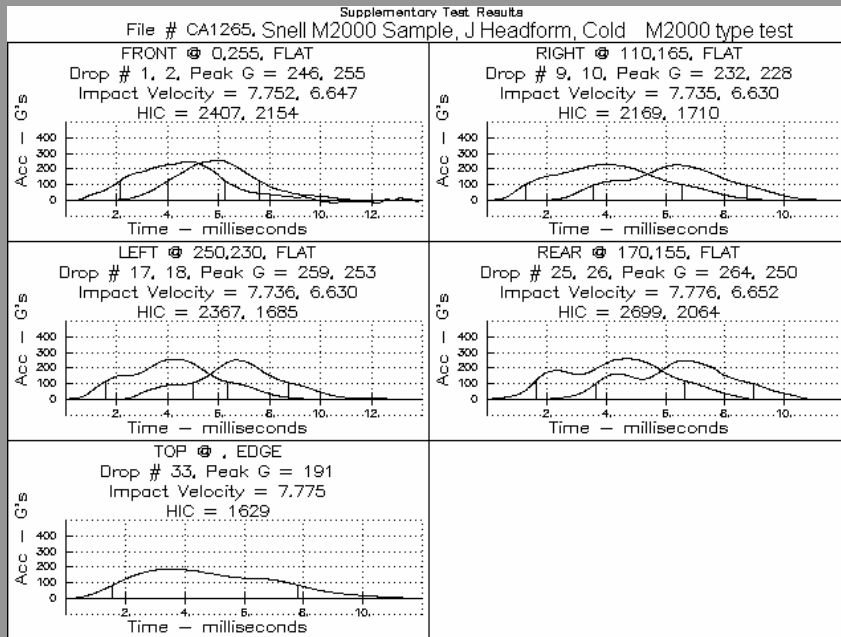


**Not a Helmet Standard – applies to vehicle cabins for bareheaded occupants

Snell M2000 Cold Results

J Headform

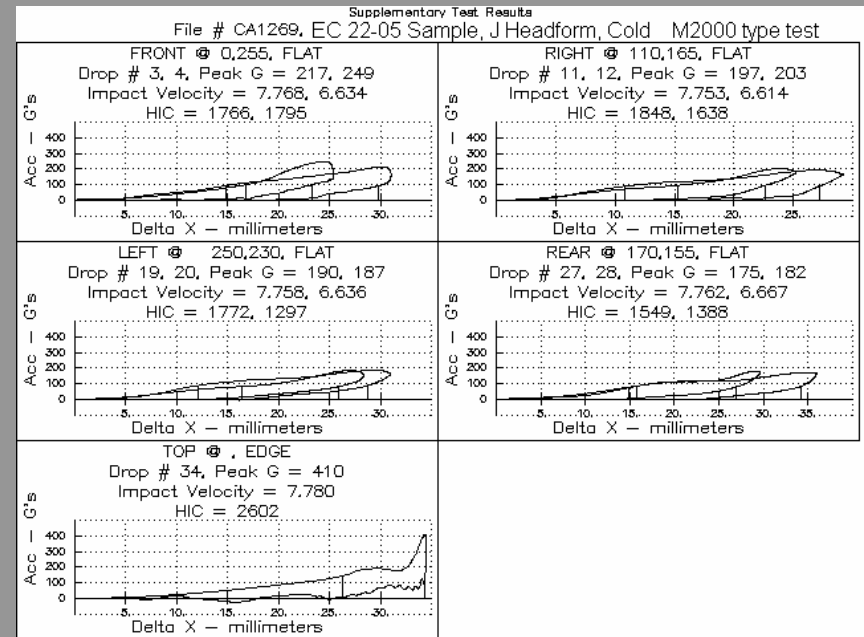
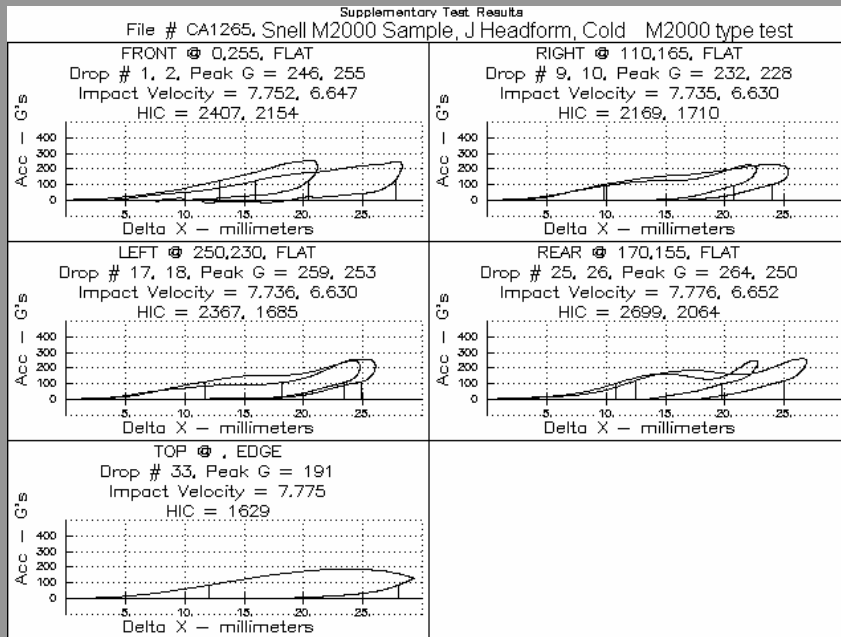
Time Domain



Snell M2000 Cold Results

J Headform

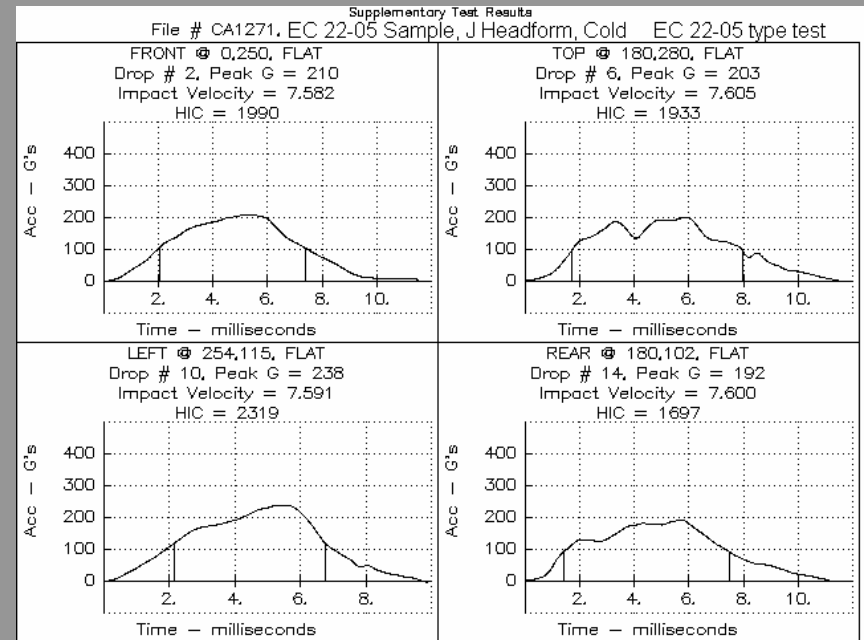
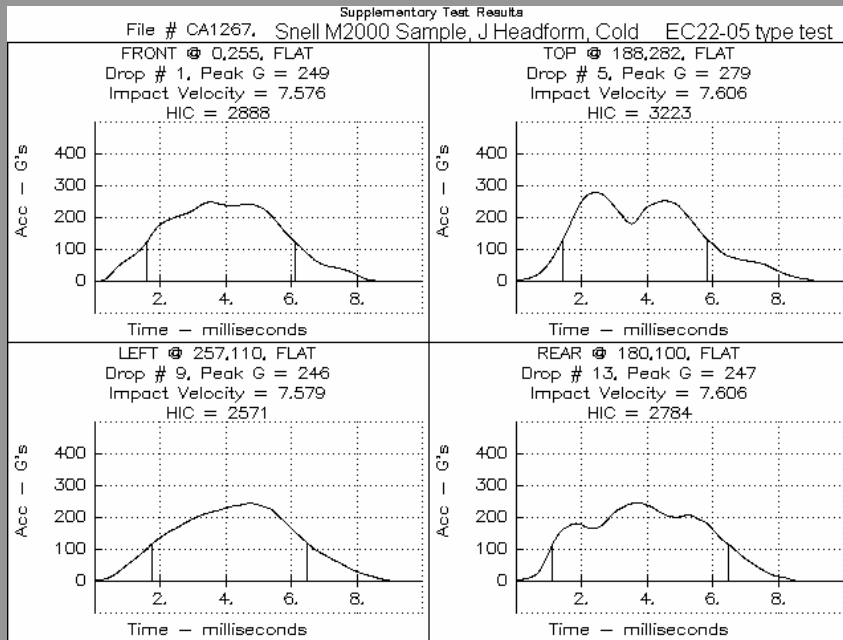
Displacement Domain



EC 22-05 Cold Results

J Headform

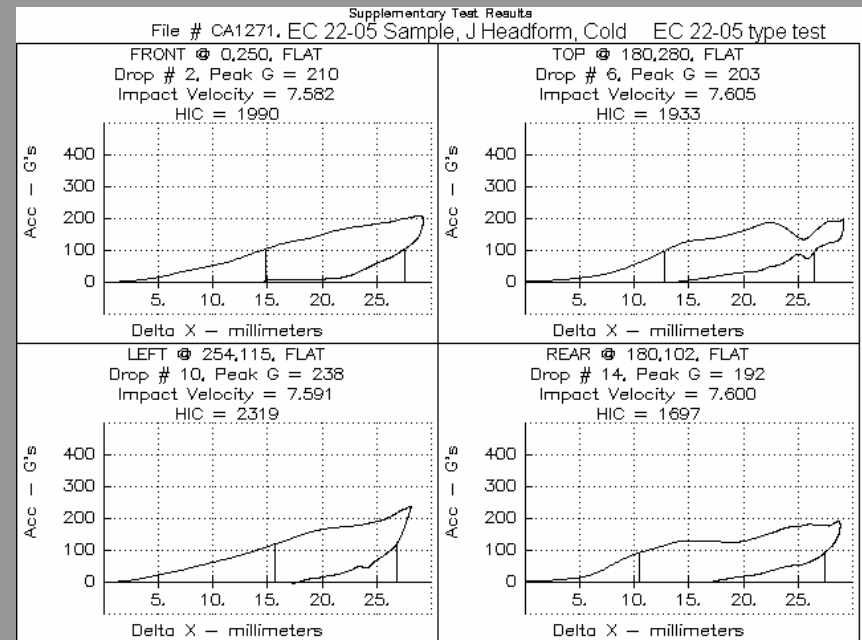
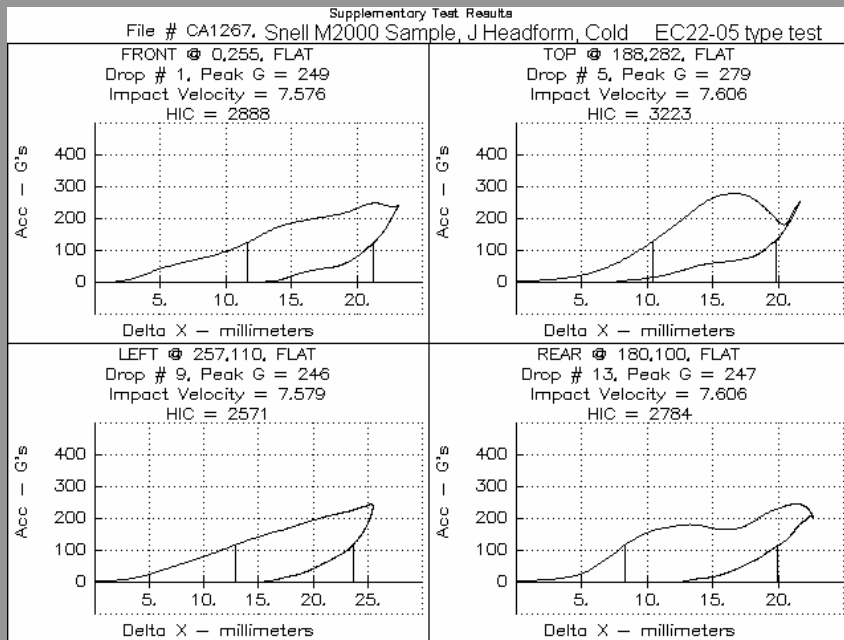
Time Domain



EC 22-05 Cold Results

J Headform

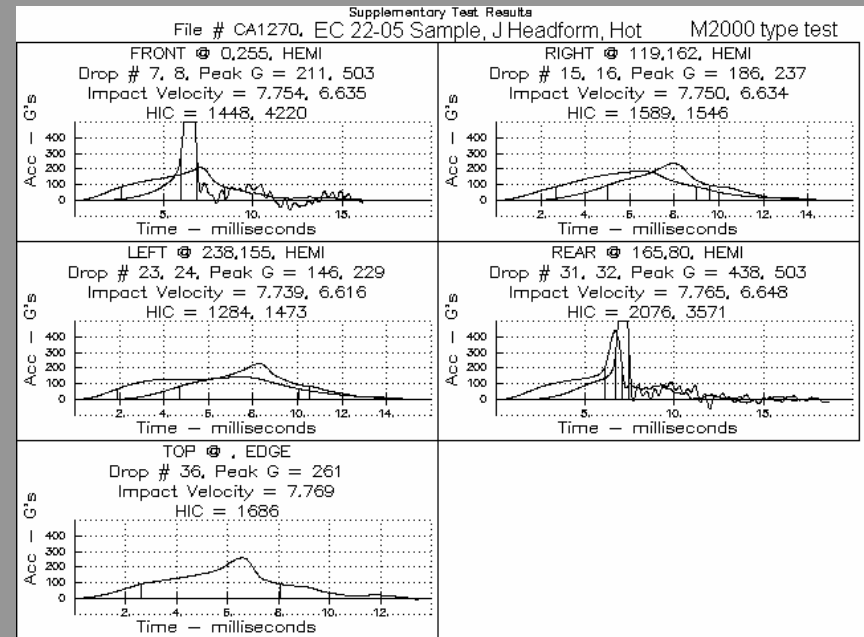
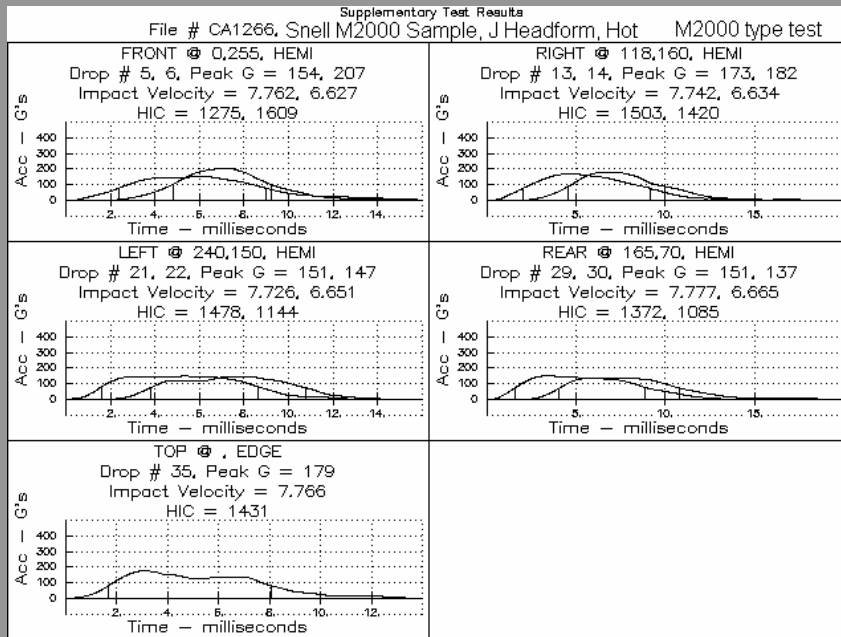
Displacement Domain



Snell M2000 Hot Results

J Headform

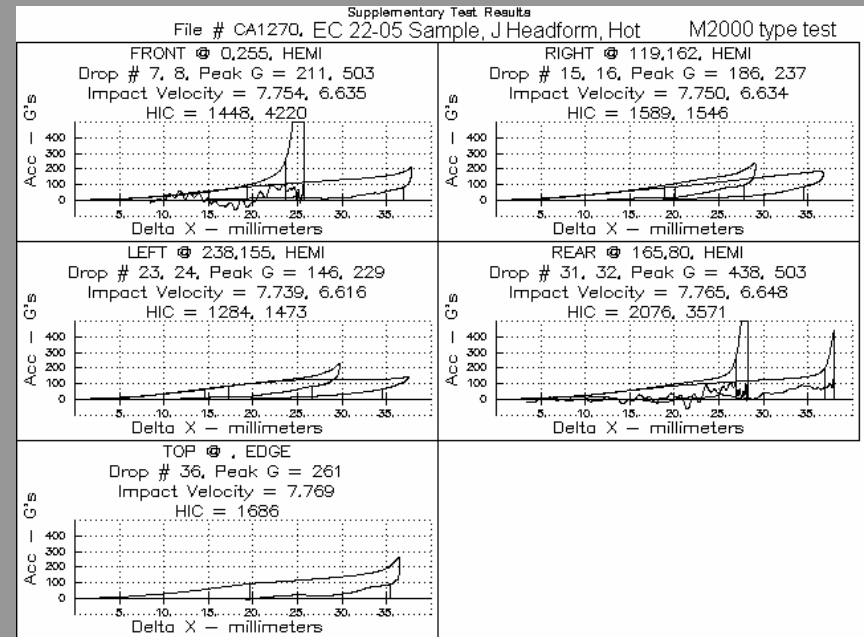
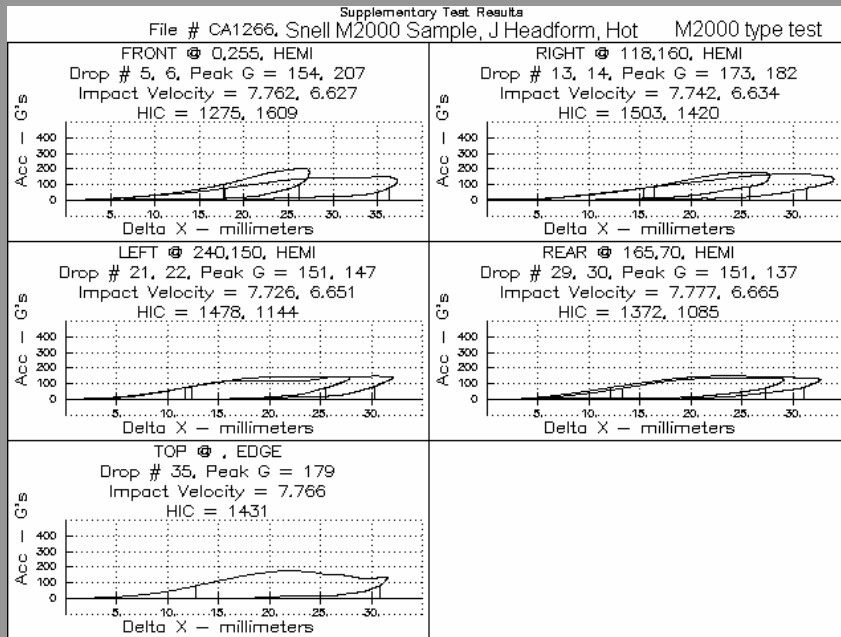
Time Domain



Snell M2000 Hot Results

J Headform

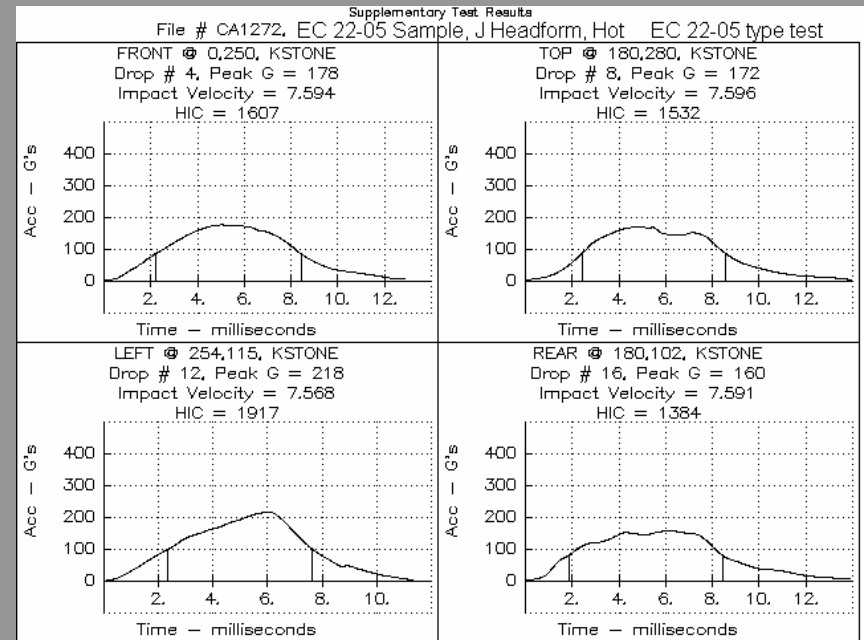
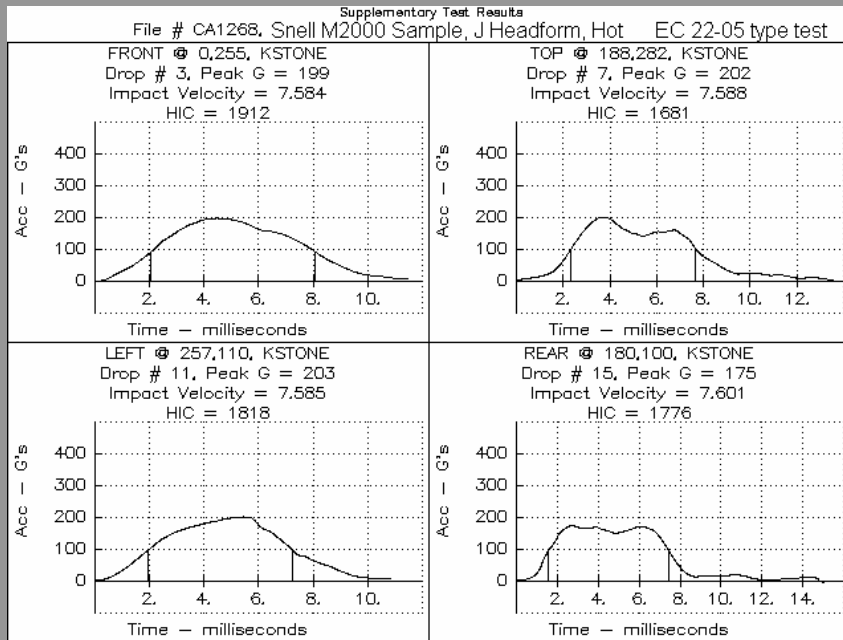
Displacement Domain



EC 22-05 Hot Results

J Headform

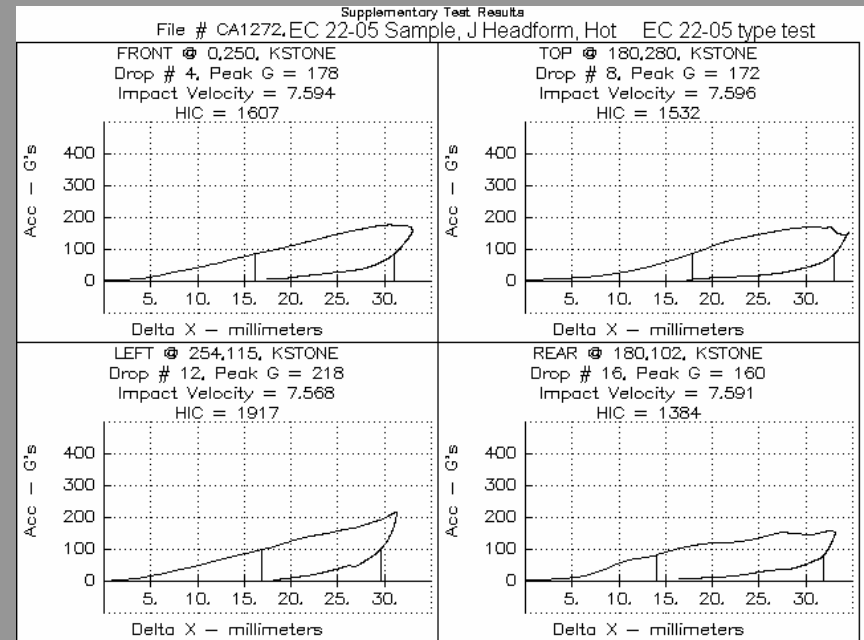
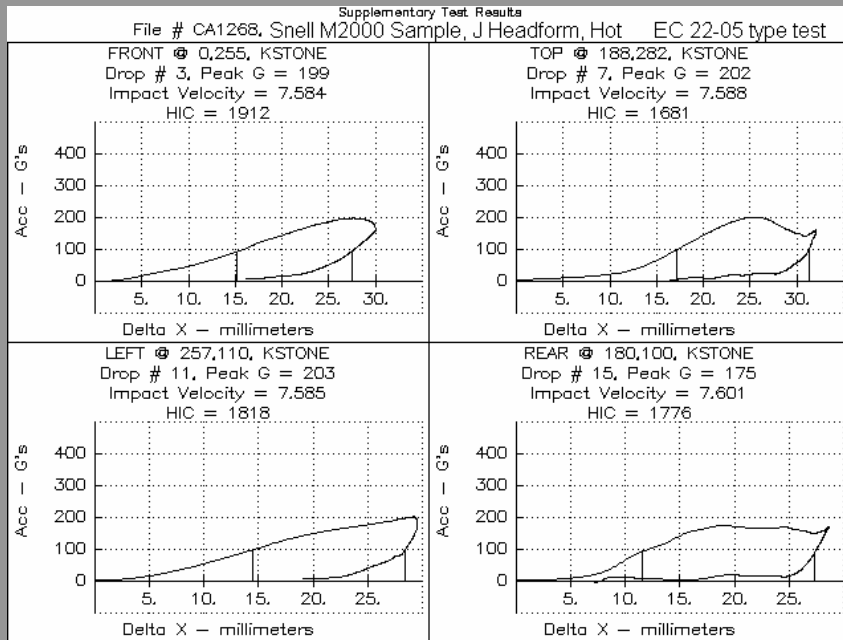
Time Domain



EC 22-05 Hot Results

J Headform

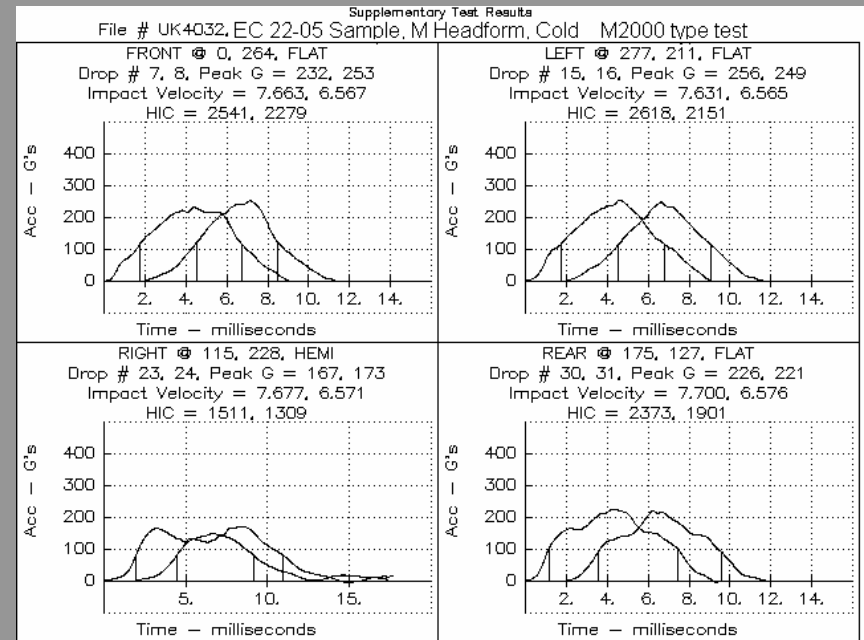
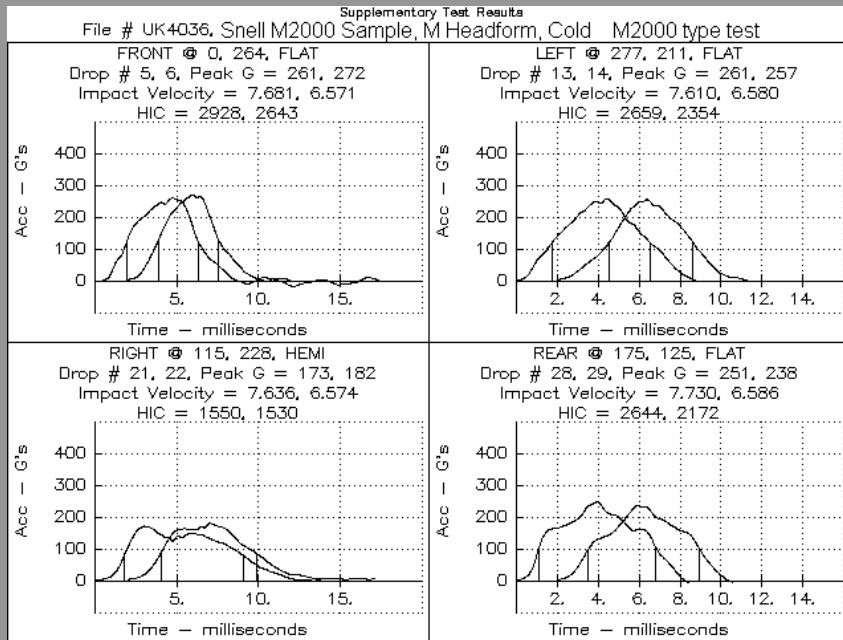
Displacement Domain



Snell M2000 Cold Results

M Headform

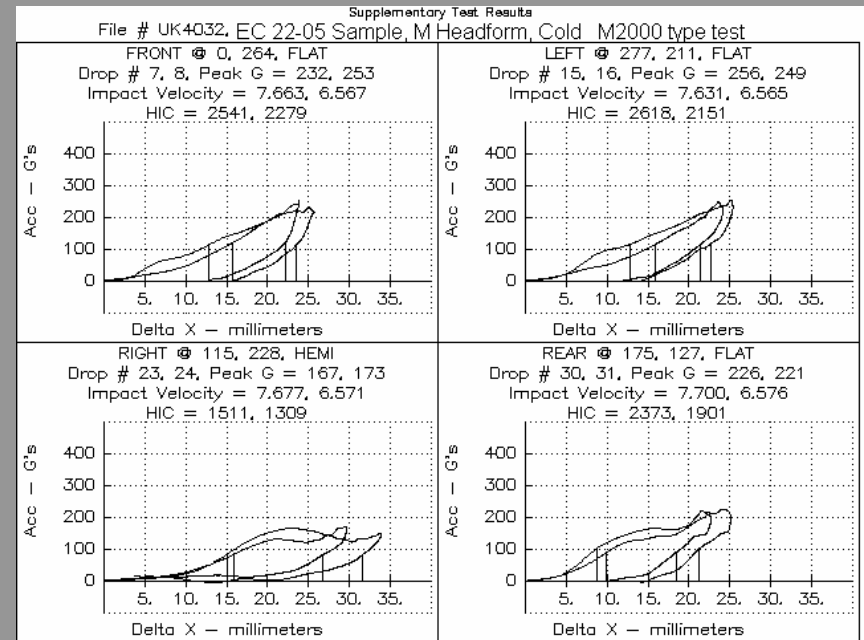
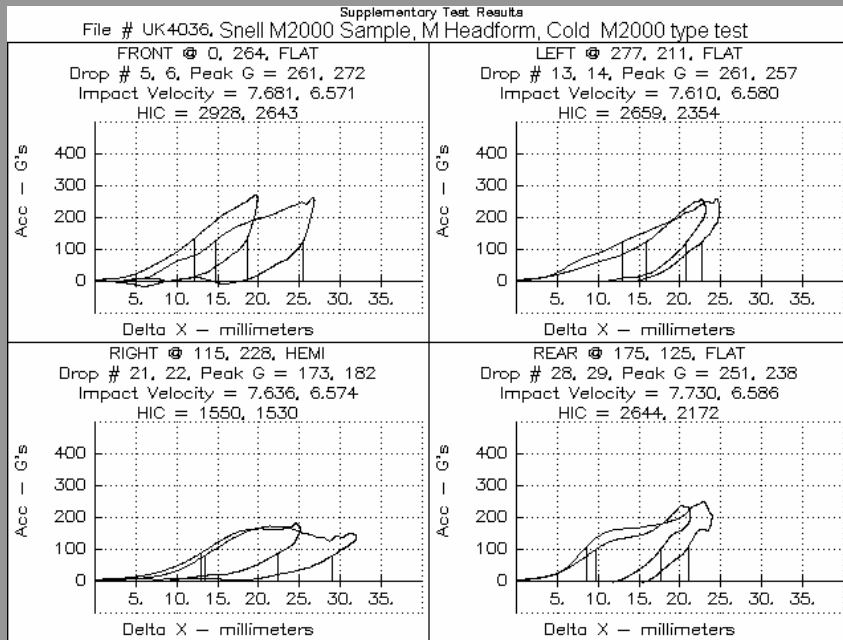
Time Domain



Snell M2000 Cold Results

M Headform

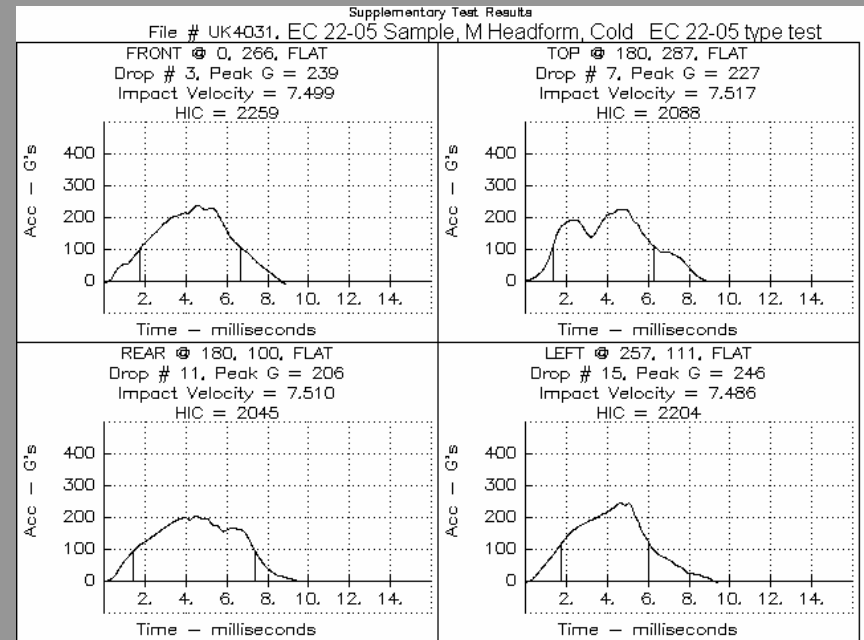
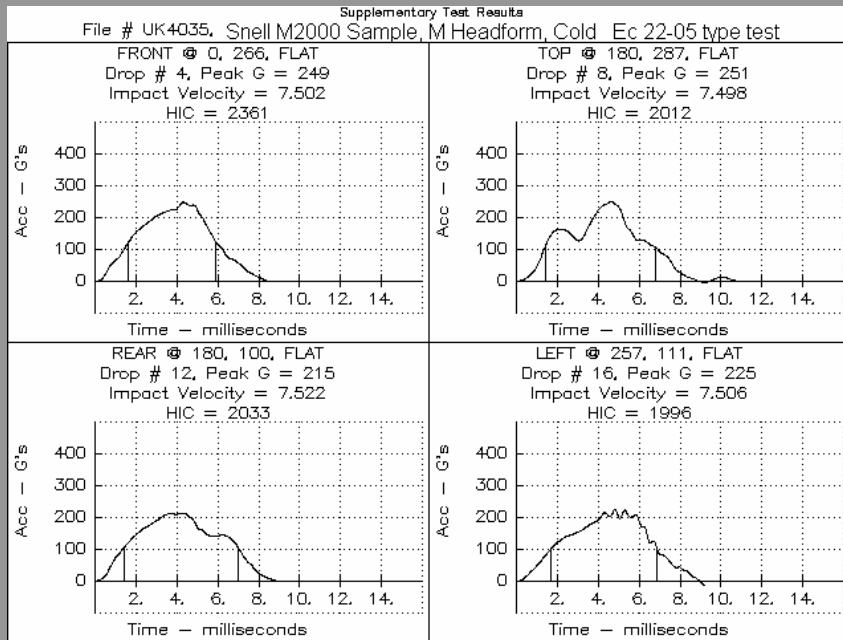
Displacement Domain



EC 22-05 Cold Results

M Headform

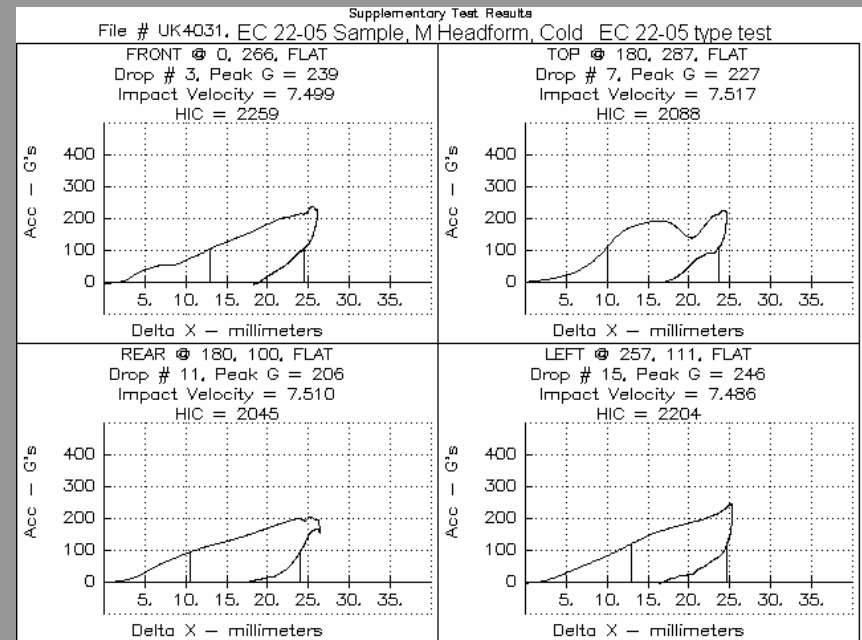
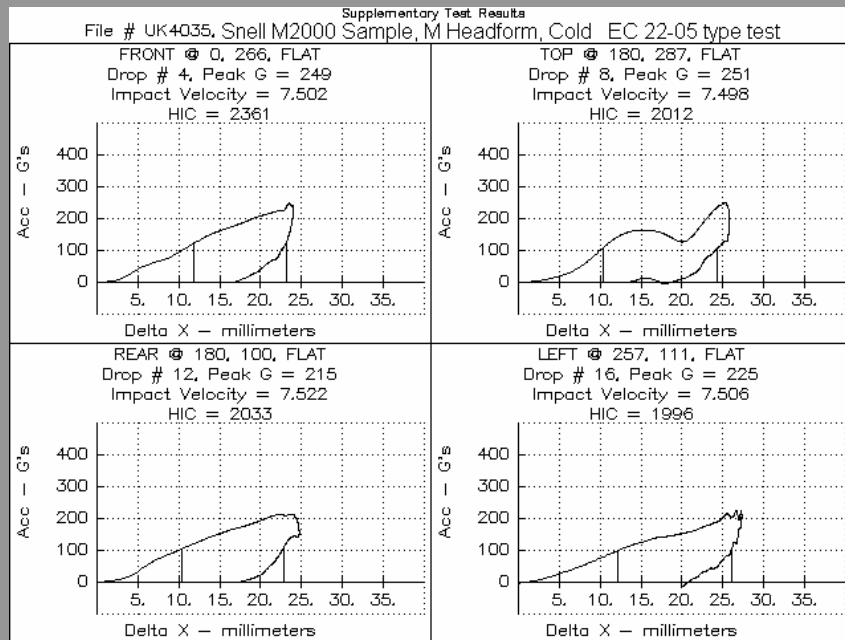
Time Domain



EC 22-05 Cold Results

M Headform

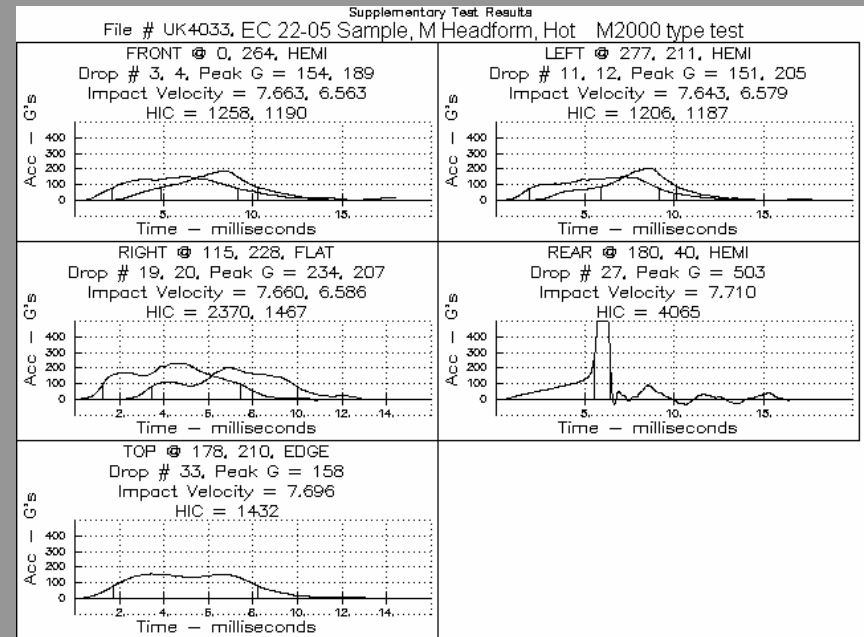
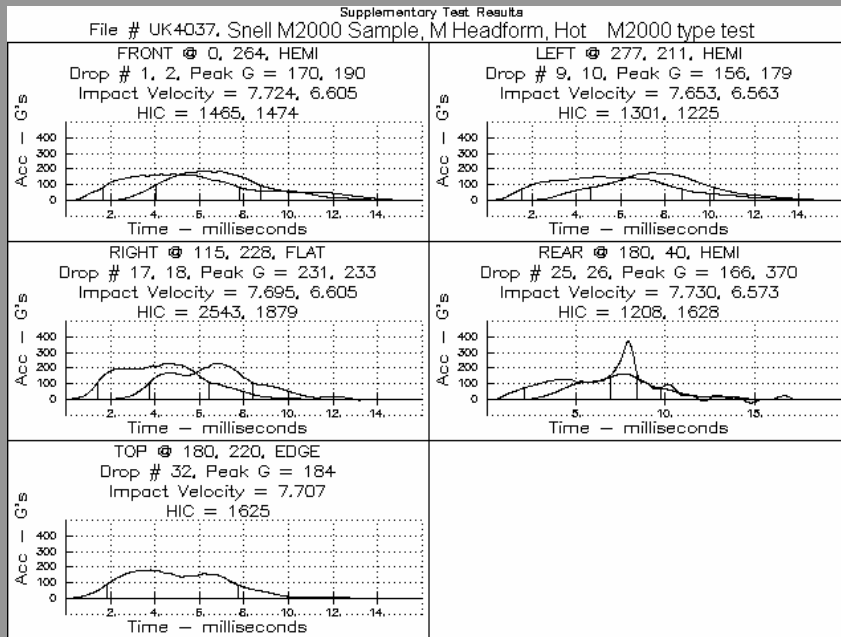
Displacement Domain



Snell M2000 Hot Results

M Headform

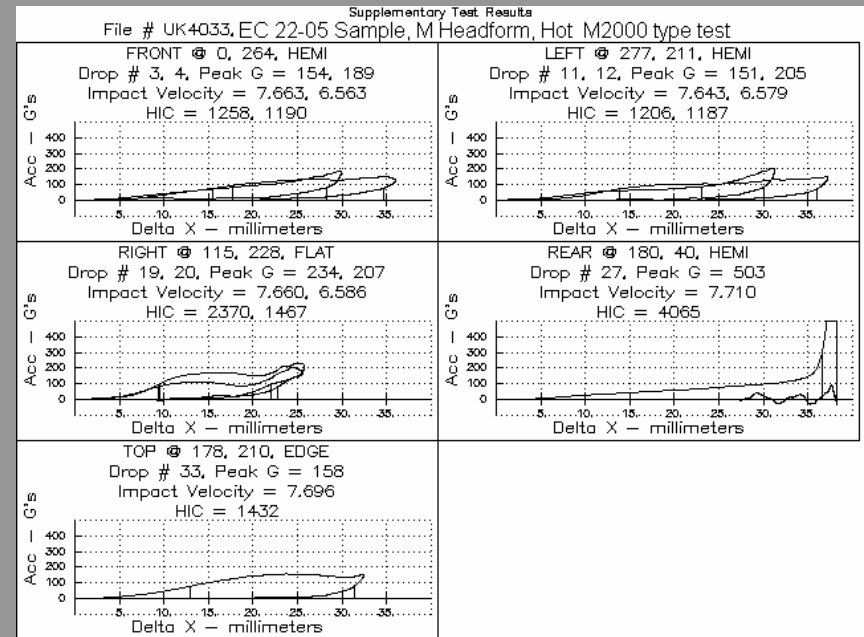
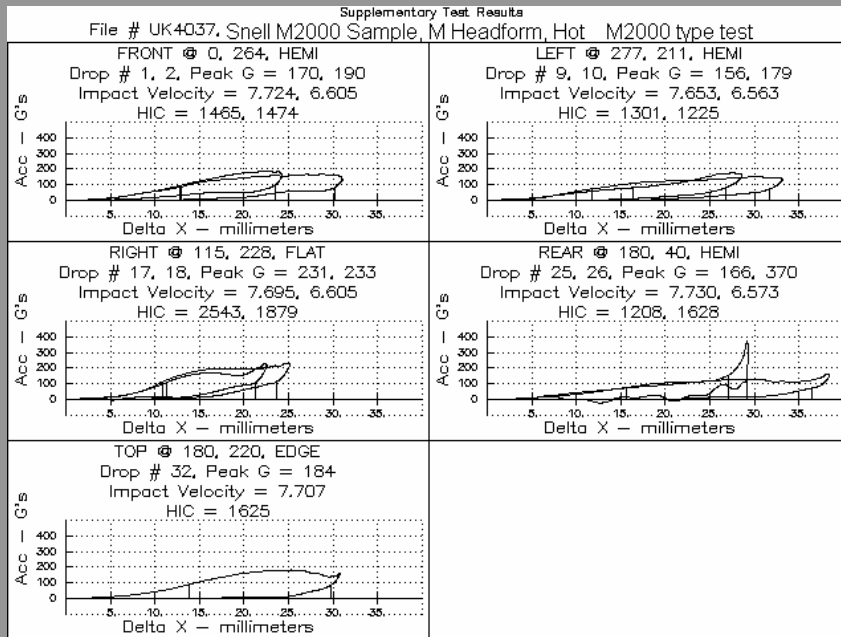
Time Domain



Snell M2000 Hot Results

M Headform

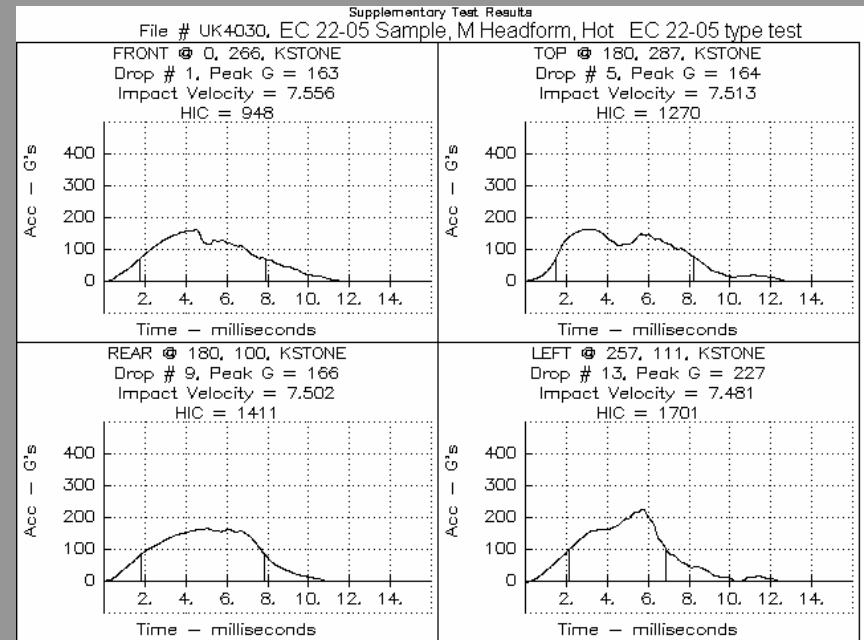
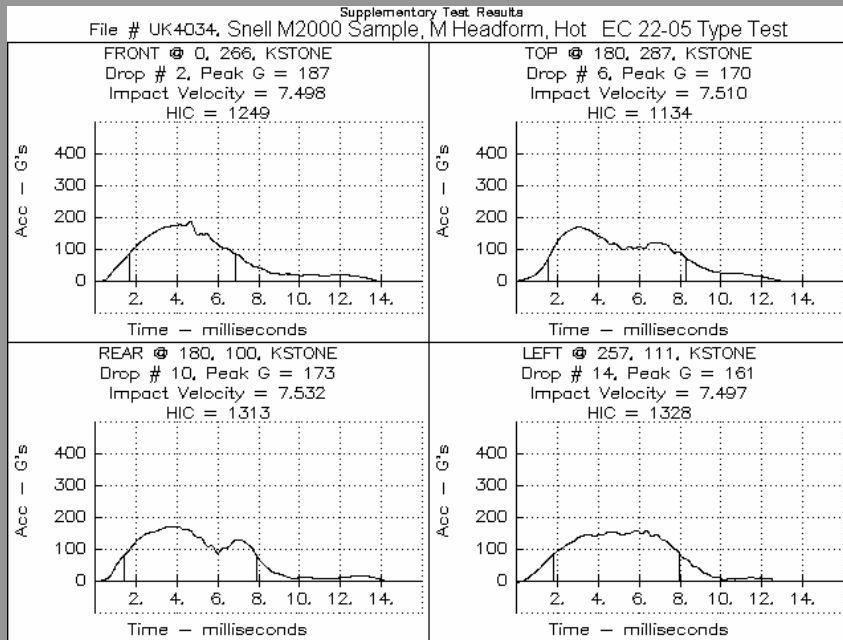
Displacement Domain



EC 22-05 Hot Results

M Headform

Time Domain



EC 22-05 Hot Results

M Headform

Displacement Domain

