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# Hybrid III Dummy Family Update - 10 Year Old and Large Male

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*This paper has not been screened for accuracy nor refereed by any body of scientific peers and should not be referenced in the open literature.*

## ABSTRACT

*This paper will highlight the design, development and features of the Hybrid III 95th Large Male and the Hybrid III 10 Year Old Child crash dummies. Both dummies have been developed by the co-operative efforts of Denton ATD, Inc., First Technology Safety Systems and R. A. Denton, Inc and other participants through the Society of Automotive Engineers (SAE). The main focus of the presentation will be to highlight each dummy including the history, design criteria, instrumentation capability, biofidelity corridors, injury reference values, and uses and applications.*

*The Hybrid III 10 year old fills the gap in the Hybrid III family between the 6 year old and the small adult female, and is designed to evaluate vehicle restraints with and without child booster seats, and passenger airbags with the occupant out of position. The dummy can be positioned in a "slouch" posture more typical of a real 10 year old sitting without a booster seat. The dummy also hosts several new load cells and innovative measurement capabilities. It is expected to be referenced in a future upgrade to the MVSS213 regulation.*

*The Hybrid III 95th Large Male was originally developed in the Center for Disease Control and Prevention/Ohio State University project. The SAE committee took the task on of updating the 95th to the Hybrid III Family level for instrumentation and measurement. The dummy design incorporates the latest features of the Hybrid family and new load cell and accelerometer locations. The dummy is expected to be included in the Part 572 regulations in 2003.*

## INTRODUCTION

In the mid 1980's the CDC awarded OSU a grant entitled "Development for Multisized Hybrid III Based Dummy Family". To support this effort, the HBSS (SAE committee) formed a task group to define the specifications for adult size small female and an adult size large male dummies having at least the same level of biofidelity and measurement capacity as the Hybrid III 50$^{th}$ percentile Male dummy.

Scaling techniques were used to define the new dummy designs and biofidelic responses. The key weight and dimensions needed for the dummies development were based on the UMTRI study (Schneider et al), which defines the anthropometry of a large male and a small female in seated driving positions. Mass and geometric scaling factors were calculated for various body segments. The scale factors were applied to the HIII 50$^{th}$ detail drawings thus insuring each dummy has similar design concepts as the 50$^{th}$ as well as corresponding body segments' densities. The scaling techniques were also applied to the biomechanical impact response of the 50$^{th}$ head, neck, chest and knees to give corresponding biomechanical responses for each dummy.

The first HIII 95$^{th}$ prototype was completed in 1989. Early experiences with the 95$^{th}$ raised many concerns about the pelvis design due to excessive dummy "submarining" experiences in sled tests. The pelvis design was not directly scaled from the HIII 50$^{th}$ but rather a new concept. In 1992 SAE opted to use the VIP 95$^{th}$ pelvis which had a taller iliac wing to prevent unrealistic submarining. The anthropometry of the VIP 95$^{th}$ was relatively close to a scaled HIII 50$^{th}$ pelvis.

In 1997, in response to serious injuries and fatalities attributed to airbag deployments, SAE, NHTSA and the dummy manufacturers began a major project to optimize the HIII family dummy design (3-year old, 6-year old, 5$^{th}$ female and 95$^{th}$ male). The focus of the project was to improve the measuring capabilities and biofidelity of the crash dummies to better evaluate neck and chest potential injury. The focus of our discussion is the HIII 95$^{th}$, however most of the design changes were similar in other dummy sizes as well.

Areas of improvement include:

- Noise isolation bushings in the neck and lumbar spine components
- Sternum and spine mounted accelerometers to measure sternum velocity for V*C calculation
- Upper rib guides to minimize vertical motion of ribs in airbag OOP deployments
- Redesign of the pelvis, femurs and abdomen to be a scaled version of the HIII 50$^{th}$
- ASIS load cells incorporated into the pelvic bone to measure seat belt loads
- Femur range of motion 45º minimum, bumper to prevent bone to bone contact
- Knee ball bearing sliders to replace the friction sliders
- Zippered lower leg for easy access to the tibia load cell
- 45º dorsiflexion ankle bumper

Prior to the development of the 10 year old dummy, the Hybrid III child dummies consisted of the 12 month old CRABI, the Hybrid III three year old and the Hybrid III six year old. The smallest adult HIII dummy was the 5$^{th}$ percentile small female, which has stature similar to a 50th percentile 12 year old adolescent. This left a gap in sizes between the 6 year old and 12 year old statures.

NHTSA recognized the need for a dummy child test device to evaluate occupant safety during the transitional stage of growth between being seated in a booster and transitioning to the three-point vehicle seat belt. The task to design such a dummy was taken on by the SAE Hybrid III Dummy Family Task Group in June of 2000.

Past studies (Klinich, et al) shows that the use of a booster seat versus a standard 3-point belt is transitional around the age of 10 years old. The study also showed that children who were too small to sit upright with their back and buttock against the seat back, would often slouch their pelvis forward in order for their knees to bend over the front of the seat cushion. This, in turn put this size of occupant at risk of the lap belt sliding up into the abdomen during a crash. Therefore, this slouch posture was an important feature to incorporate into the dummy.

The wish to expedite the development was taken into consideration during the conceptual phase of the design task. Two manufacturers agreed to work together by segmenting the dummy into two sections. Each manufacturer agreed to design a portion, then share the part drawings as well as 3D models for all castings and flesh pieces. These models were then used to produce the molds and ensure constancy between the manufacturers. Once the drawings and models were exchanged, each manufacturer produced a prototype for evaluation by the committee.

## DESIGN UPGRADES

### Hybrid III 95th Percentile Large Male

Prior to the redesign that took place in the year 2000, the Hybrid III 95th large male was used primarily to test seat belts integrity or as a ballast dummy. The desire to increase the measuring capabilities of the dummy resulted in the following design changes and upgrades.

The skull and head skin start with the same design as the Hybrid III 50$^{th}$ male dummy. The skull is the same casting, but is machined differently to allow the occipital condyle (OC joint) to be positioned lower relative to the center of gravity (CG) of the head than that of the Hybrid III 50$^{th}$ male. The total weight of the head can be controlled in two ways. The first is by ballast weights secured to the inside of the skull. The second way is by unique accelerometer mount designs that incorporate the correct weight to meet the overall mass and CG location. The head skin is the same design as the Hybrid III 50$^{th}$ but has a unique part number but is verified to a different corridor because of the assembly mass and CG location differences between the Hybrid III 50$^{th}$ and 95th.

The neck is constructed of four rubber pucks bonded to metal plates to make up the segmented neck. Each rubber puck has slits to allow for proper extension of the neck. The neck also has a center cable secured on one end by two jam nuts. The torque is specified to be 1.4 ± 0.2 N-m (12.0 ± 2 in-lb) to ensure it's test performance is constant. The torque setting should be checked regularly to ensure that the cable has not loosened during testing. The upgrade of the dummy includes the addition of an isolation bushing at the top and bottom of the cable to prevent metal to metal contact generating noise during a test. The upper and lower neck plates were modified to house these bushings properly.

The upper torso of the dummy has several features that make it a better design for today's applications. The updates integrate design improvements as well as increased measurement capabilities. Bumpers that were once mounted on the sternum were moved to the spine box to ensure contact with the ribs at more oblique angles of impact. Upper rib guides were added to prevent vertical movement of the ribs during testing. The upper rib guides attach to the spine box.

Mounting points were added for the three uni-axial accelerometers used together with the three accelerometers added to the sternum plate for V*C calculation.

The lower torso had the most extensive amount of redesign. The pelvis is the same as used in the VIP95th pelvis, but significant dimensional differences existed between the two manufacturers. Therefore a new pelvis flesh, pelvic bone, abdomen and femur designs were developed based on scaling of the Hybrid III 50$^{th}$ percentile male dummy. Upper and lower cable bushings were added to the two cables that run through the center of the lumbar spine to prevent noise during testing. These cables are tightened to the same torque specification as the neck using two jam nuts on the threaded end of the cables. Bumpers were added to the femur to eliminate the potential for hard contact between the femur bone and pelvis bone when the femur was rotated upward. The new femur design provides a 52° rotation at three abduction/adduction angles: seven degrees inboard, along the mid-sagittal plane, and seven degrees outboard. ASIS load cells were incorporated into the pelvis to measure lap belt loading to the dummy.

There were also improvements made to the legs of the dummy. Ball bearing slider knees were incorporated into the dummy as opposed to friction sliders to improve the performance. Bumpers were also added to the ankle assembly and the foot weight was increased to be a scaled weight of the 50$^{th}$ percentile male.

## Design Specifications

*Mass Measurements:* The segment assemblies and their masses should be checked with each new dummy or when parts are replaced in the dummy. The segment weights are listed in Table 1. Each segment contains specific parts of the dummy including fasteners and accelerometer mounts. For more complete details of each assembly, refer to the drawing package.

Table 1. HIII Large Male Segment Mass

| | **MASS** | |
|---|---|---|
| **ASSEMBLY** | **Lb** | **Kg** |
| Head | 10.90 ± 0.10 | 4.94 ± 0.05 |
| Neck | 3.70 ± 0.10 | 1.68 ± 0.05 |
| Upper Torso with Torso Jacket | 49.20 ± 0.80 | 22.32 ± 0.36 |
| Lower Torso (includes femurs and their lower lumbar adapting plate) | 66.80 ± 0.80 | 30.30 ± 0.36 |
| Upper Leg, Left<br>Upper Leg, Right | 18.10 ± 0.20<br>18.10 ± 0.20 | 8.21 ± 0.09<br>8.21 ± 0.09 |
| Lower Leg, Left<br>Lower Leg, Right | 12.68 ± 0.20<br>12.68 ± 0.20 | 5.75 ± 0.09<br>5.75 ± 0.09 |
| Upper Arm, Left<br>Upper Arm, Right | 6.20 ± 0.20<br>6.20 ± 0.20 | 2.81 ± 0.05<br>2.81 ± 0.05 |
| Lower Arm, Left<br>Lower Arm, Right | 4.55 ± 0.10<br>4.55 ± 0.10 | 2.06 ± 0.05<br>2.06 ± 0.05 |
| Hand, Left<br>Hand, Right | 1.25 ± 0.10<br>1.25 ± 0.10 | .57 ± 0.05<br>.57 ± 0.05 |
| Foot, Left<br>Foot, Right | 3.50 ± 0.15<br>3.50 ± 0.15 | 1.59 ± 0.07<br>1.59 ± 0.07 |
| Total Dummy Weight | 223.2 ± 3.60 | 101.24 ± 1.63 |

*External Dimensions:* The Hybrid III 95th Large Male dummy external dimensions are shown below. Each measurement is shown in Figure 1 and listed in Table 1.

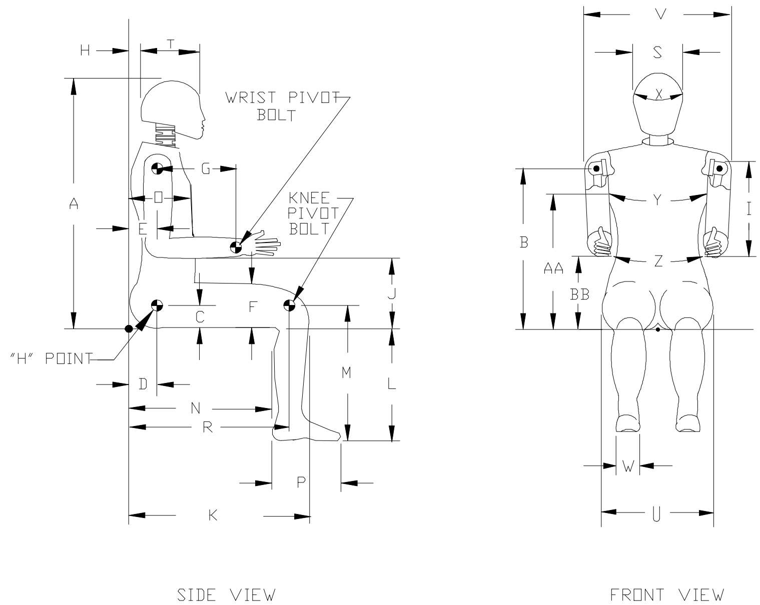



Figure 1: HIII Large Male External Dimensions

Table 1. HIII Large Male External Dimension Measurements

| TEST PARAMETER | DESIGNATION | in | mm |
|---|---|---|---|
| Total Sitting Height | (A) | 36.8 ± 0.3 | 934.7 ± 7.6 |
| Shoulder Pivot Height | (B) | 21.6 ± 0.3 | 548.6 ± 7.6 |
| H-Point Height (Ref.) | (C) | 4.2 ± 0.2 | 106.7 ± 5.1 |
| H-Point from Seat Back Ref.) | (D) | 5.6 ± 0.2 | 142.24 ± 5.1 |
| Shoulder Pivot from Back line | (E) | 4.5 ± 0.2 | 114.3 ± 5.1 |
| Thigh Clearance | (F) | 6.6 ± 0.3 | 167.6 ± 7.6 |
| Back of Elbow to Wrist Pivot | (G) | 12.3 ± 0.2 | 312.4 ± 5.1 |
| Skull Cap to Back line (Ref.) | (H) | 3.5 ± 0.1 | 88.9 ± 2.5 |
| Shoulder to Elbow Length | (I) | 14.0 ± 0.3 | 355.6 ± 7.6 |
| Elbow Rest Height | (J) | 8.5 ± 0.3 | 215.9 ± 7.6 |
| Buttock to Knee Length | (K) | 25.1 ± 0.5 | 637.5 ± 12.7 |
| Popliteal Height | (L) | 18.5 ± 0.5 | 469.9 ± 12.7 |
| Knee Pivot to Floor Height | (M) | 21.0 ± 0.5 | 533.4 ± 12.7 |
| Buttock Popliteal Length | (N) | 19.8 ± 0.5 | 502.9 ± 12.7 |
| Chest Depth (without jacket) | (O) | 9.7 ± 0.3 | 246.4 ± 7.6 |
| Foot Length | (P) | 10.2 ± 0.3 | 259.1 ± 7.6 |
| Buttock to Knee Pivot Length | (R) | 22.4 ± 0.5 | 569.0 ± 12.7 |
| Head Breadth | (S) | 6.1 ± .20 | 154.9 ± 5.1 |
| Head Depth | (T) | 7.7 ± .20 | 195.6 ± 5.1 |
| Hip Width at H-Point | (U) | 15.9 ± 0.3 | 403.9 ±7.6 |
| Shoulder Width | (V) | 18.7 ± 0.3 | 475.0 ± 7.6 |
| Foot Width | (W) | 3.9 ± 0.3 | 99.1 ± 7.6 |
| Head Circumference | (X) | 22.5 ± .20 | 571.5 ± 5.1 |
| Chest Circumference | (Y) | 44.7 ± 0.6 | 1135.4 ± 5.2 |
| Waist Circumference | (Z) | 39.5 ± 0.6 | 1003.3 ± 5.2 |
| Reference Location for Y | (AA) | 19.0 ± 0.1 | 482.6 ± 2.5 |
| Reference Location for (Z) | (BB) | 8.0 ± 0.1 | 279.4 ± 2.5 |

## Instrumentation Capabilities

Table 3 contains a list of available instrumentation for the Hybrid III 95$^{th}$ Large Male.

Table 2. HIII Large Male Available Instrumentation

| HYBRID III LARGE MALE DUMMY INSTRUMENTATON | | |
|---|---|---|
| **Location** | **Measurement** | **Number of Channels** |
| Head C.G. | Acceleration | 3 |
| Head | Angular Acceleration | 9 or 12 |
| Head | Angular Rate | 3 |
| Head-Neck Interface | Forces & Moments | 3 or 6 |
| Neck-Thorax Interface | Forces & Moments | 6 |
| Thorax C.G. | Acceleration | 3 |
| Thoracic Spine | Forces & Moments | 5 |
| Sternum | Acceleration | 6 |
| Sternum | Displacement | 1 |
| Lumbar Spine | Forces & Moments | 3 |
| Pelvis C.G. | Acceleration | 3 |
| Anterior Superior Iliac Spine | Load | 2 |
| Upper Femur | Forces & Moments | 6 each femur |
| Upper Femur | Force | 1 each femur |
| Lower Femur | Forces & Moments | 6 each femur |
| Lower Femur | Force | 1 each femur |
| Knee-Tibia | Displacement | 1 each knee |
| Knee-Clevis | Force | 2 each knee |
| Upper Tibia | Forces & Moments | 2 each leg |
| Upper Tibia | Forces & Moments | 3 each leg |
| Upper Tibia | Forces & Moments | 4 each leg |
| Upper Tibia | Forces & Moments | 5 each leg |
| Lower Tibia | Forces & Moments | 2 each leg |
| Lower Tibia | Forces & Moments | 3 each leg |
| Lower Tibia | Forces & Moments | 4 each leg |
| Lower Tibia | Forces & Moments | 5 each leg |

*Calibration Corridor:s* The calibration corridors include the head drop (Table 4), neck flexion (Table 5), neck extension (Table 6), thorax impact (Table 7), knee impact (Table 8) and knee slider impact (Table 9). The following sections will list the performance corridors for each test. For set-up information refer to the SAE User's Manual.

Table 4. HIII Large Male Head Drop Verification

| | |
|---|---|
| Temperature | 18.9 - 25.6 C |
| Humidity | 10.0 - 70.0 % |
| Peak Resultant | 220 - 265 G |
| Peak Lateral | -15.0 - 15.0 G |

Table 3. HIII Large Male Neck Flexion Verification

| **CORRIDORS** | | **LOWER** | **UPPER** | **UNITS** |
|---|---|---|---|---|
| Temperature | 20.6 – 22.2 C | 20.6 | 22.2 | C |
| Humidity | 40 ± 30 % RH | 10.0 | 70.0 | % RH |
| Velocity | 7.01 ± 0.12 m/s | 6.89 | 7.13 | m/s |
| Pendulum Pulse At 10 ms | 2.45 ± 0.25 m/s<br>(8.04±.82 ft/s) | 2.20<br>7.22 | 2.70<br>8.86 | m/s<br>ft/sec |
| Pendulum Pulse At 20 ms | 4.50 ± 0.50 m/s<br>(14.76 ± 1.64 ft/s) | 4.00<br>13.12 | 5.00<br>16.40 | m/s<br>ft/sec |
| Pendulum Pulse At 30 ms | 6.30 ± 0.60 m/s<br>(20.67 ± 1.97 ft/s) | 5.70<br>18.70 | 6.90<br>22.64 | m/s<br>ft/sec |
| D-Plane Rotation | 68 ± 7 deg | 61 | 75 | deg |
| Moment During Rotation Interval | 120 ± 10 Nm | 110 | 130 | Nm |
| Moment Decay to 10 Nm | 87 ± 10 ms | 77 | 97 | ms |

Table 4. HIII Large Male Neck Extension Performance Corridors

| **CORRIDORS** | | **LOWER** | **UPPER** | **Units** |
|---|---|---|---|---|
| Temperature | 20.6 – 22.2 C | 20.6 | 22.2 | C |
| Humidity | 40 ± 30 % RH | 10.0 | 70.0 | % RH |
| Velocity | 6.07 ± 0.12 m/s | 5.95 | 6.19 | m/s |
| Pendulum Pulse At 10 ms | 2.0 ± 0.2 m/s<br>(6.56 ± .66 ft/s) | 1.80<br>5.90 | 2.20<br>7.22 | m/s<br>ft/s |
| Pendulum Pulse At 20 ms | 3.8 ± 0.4 m/s<br>(12.47 ± 1.31 ft/s) | 3.40<br>11.15 | 4.20<br>13.78 | m/s<br>ft/s |
| Pendulum Pulse At 30 ms | 5.3 ± 0.5 m/s<br>(17.39 ± 1.64 ft/s) | 4.80<br>15.75 | 5.80<br>19.03 | m/s<br>ft/s |
| D-Plane Rotation | 89.5 ± 8.5 deg | 81 | 98 | Deg |
| Moment During Rotation Interval | 75 ± 9 Nm | 66 | 84 | Nm |
| Moment Decay to 10 Nm | 110 ± 10 ms | 100 | 120 | ms |

Table 5. HIII Large Male Thorax Impact Performance Corridors

| | |
|---|---|
| Temperature | 20.6 - 22.2 C |
| Humidity | 10.0 - 70.0 % |
| Velocity | 6.59 - 6.83 m/s<br>(21.62-22.41 ft/s) |
| Maximum Force in Displacement Corridor | 5.10 – 5.90 kN |
| Peak Chest Displacement | 66.0 - 76.0 mm |
| Internal Hysteresis | 69. - 85. % |

Table 6. HIII Large Male Knee Impact Performance Corridors

| | |
|---|---|
| Temperature | 18.9 – 25.6 C |
| Humidity | 10.0 - 70.0 % |
| Velocity | 2.07 - 2.13 m/s<br>(6.79 - 7.00 ft/s) |
| Knee Impact Force | 4.9 – 7.3 kN |

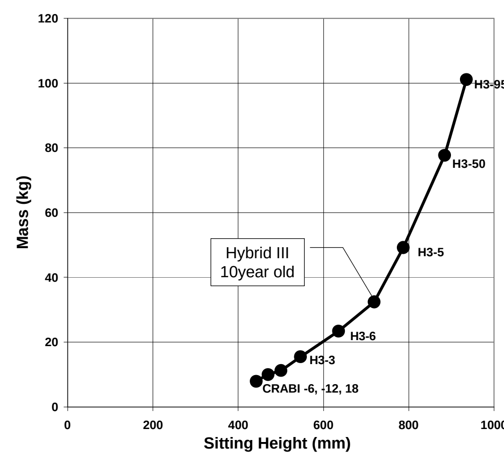
Table 7-HIII Large Male Knee Slider Performance Corridors

| | |
|---|---|
| Temperature | 18.9 - 25.6 C |
| Humidity | 10.0 - 70.0 % |
| Velocity | 2.70 - 2.80 m/s<br>(8.86 – 9.19 ft/s) |
| Peak Deflection | 15.0 - 18.3 mm |

## Hybrid III 10-Year Old Child

The Hybrid III 10-year old has been developed by generally scaling up and down from the HIII-6C and the HIII small female dummies. However the Hybrid III 10 year old design incorporates an adjustable lumbar spine which allows the dummy to be seated in a posture typical of a child that slides their hip forward to allow their knees to bend over the front of the seat cushion. With this feature it is not possible to do a direct scaling from the other dummies. Consequently, the anatomical joint centers were chosen to be the most important constant in the design of the dummy, and the individual components were scaled according to scale factors developed by Mertz et al for the SAE committee. Each scaled portion of the dummy was compared to actual anthropometry data to ensure that the relationship was consistent.

| Dummy | Mass kg | Sitting Ht. mm |
|---|---|---|
| Lg. Male | 101.1 | 935 |
| Mid Male | 77.7 | 884 |
| Sm. Fem. | 49.2 | 787 |
| 10-yr-old | 32.4 | 719 |
| 6-yr-old | 23.4 | 635 |
| 3-yr-old | 15.5 | 546 |
| 18-mo-old | 11.2 | 500 |
| 12-mo-old | 10.0 | 470 |
| 6-mo-old | 7.9 | 442 |




The anthropometry specifications of the 10 year old head are very similar in size and weight to the existing Hybrid III 5th female head. Therefore, the same design and test corridors were used for the 10 year old. The neck of the dummy has the same construction as the Hybrid III small female and is scaled down from that design. An early design requirement was for the lower neck load cell to be aligned with the center of the neck to avoid the need to translate the measured loads and moments. The lower neck has various mounting holes to allow the neck to be positioned at 0º, 8º, 16º and 23º. Markings on the spine box indicate the adjustment angle. The 0º setting is the position of the neck used when measuring the dummy's external dimensions. The 16º angle is marked with an "SP" for Standard Posture, and is the set up position for the verification testing.

The 23º angle is marked with an "SS" for Standard Slouch. These markings coincide with markings on the lumbar to achieve the Standard Position and Standard Slouch seating positions of the dummy.

The torso of the dummy is designed to accommodate several types of chest deflection measurement capabilities. A traditional Hybrid style rotary potentiometer arm and slider mechanism is the standard design for measuring chest deflection. Optionally, the rotary potentiometer can be replaced with two IR-Traccs (Rouhana et al) that can individually measure the motion of the top and bottom sternum plate (Figure 2). Rotary potentiometers record the lateral motion of the IR-Tracc. Accelerometers can be mounted on the sternum plate and spine box as an alternate method to measure sternum velocity. A two axis load cell in each shoulder measures the seat belt loads applied to the dummy.

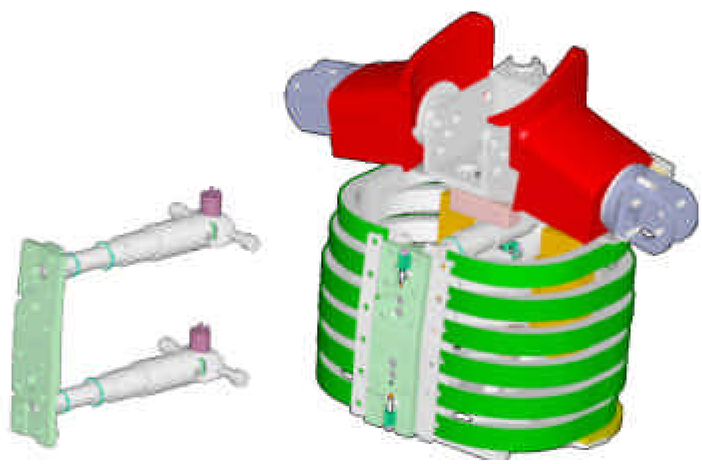


Figure 2: Optional IR-Tracc for Chest Deflection Measurement

The lower torso of the dummy is designed to allow for a slouched seating position (**Figure 3**).

Figure 3: HIII 10 Yo Child Lumbar Adjustment

When the lumbar is adjusted forward 12 degrees, the lumbar is in the standard position, as indicated with an "SP" on the lower lumbar bracket. This is the position of the lumbar for the external dimensions and verification test. The lumbar can be adjusted to a maximum of 24º. The lumbar cable is torqued to 0.9 ±0.02 Nm (8±2 in-lbs) for all testing.

*Instrumentation Capabilities:* Table 1 contains a list of available instrumentation for the Hybrid III 10 Year Old Child.

Table 8. HYBRID III 10 YO Child Available Instrumentation

| **HYBRID III 10 YEAR OLD DUMMY INSTRUMENTATON** | | |
|---|---|---|
| **Location** | **Measurement** | **Number of Channels** |
| Head C.G. | Acceleration | 3 |
| Head | Acceleration (tilt sensors) | 1 |
| Head-Neck Interface | Forces & Moments | 6 |
| Neck-Thorax Interface | Forces & Moments | 6 |
| Thorax C.G. | Acceleration | 3 |
| Thoracic Spine | Forces & Moments | 5 |
| Shoulder | Force | 2 |
| Sternum | Acceleration | 4 |
| Sternum | Displacement (IR TRACC) | 4 |
| Sternum | Displacement | 1 |
| Lumbar Spine | Forces & Moments | 3 |
| Pelvis C.G. | Acceleration | 3 |
| Anterior Superior Iliac Spine | Load | 2 |
| Upper Femur | Forces & Moments | 6 each femur |
| Upper Femur | Force | 1 each femur |
| Mid-shaft Tibia | Forces & Moments | 6 each femur |
| Mid-shaft Tibia | Force | 1 each femur |

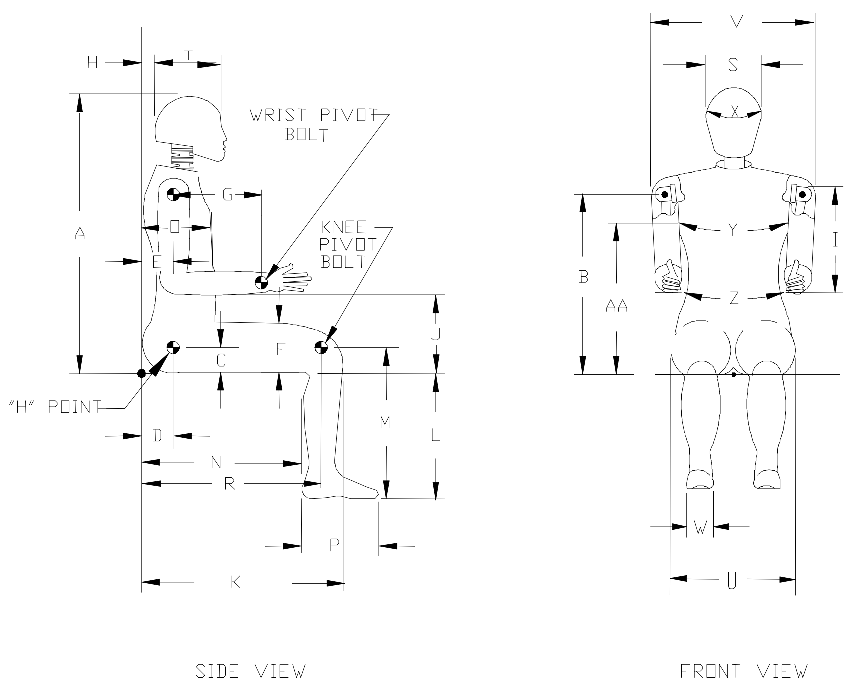



Figure 4: HIII 10 YO Child External Dimensions

Table 9. HIII 10 YO Child Target External Dimension Measurements

| TEST PARAMETER | DESIGNATION | in | mm |
|---|---|---|---|
| Total Sitting Height | (A) | 28.5 ± 0.50 | 723.9 ± 12.7 |
| Shoulder Pivot Height | (B) | 15.55 ± .30 | 395.0 ± 7.6 |
| H-Point Height (Ref.) | (C) | 3.31 ± 0.20 | 84.07 ± 5.1 |
| H-Point from Seat Back (Ref.) | (D) | 5.44 ± 0.20 | 138.2 ± 5.1 |
| Shoulder Pivot from Back line | (E) | 3.35 ± 0.20 | 85.1 ± 5.1 |
| Thigh Clearance | (F) | 4.25 ± 0.30 | 108.0 ± 7.6 |
| Back of Elbow to Wrist Pivot | (G) | 9.25 ± 0.30 | 235.0 ± 7.6 |
| Skull Cap to Back line (Ref.) | (H) | 1.90 ± 0.10 | 48.3 ± 2.5 |
| Shoulder to Elbow Length | (I) | 10.75 ± .30 | 273.1 ± 7.6 |
| Elbow Rest Height | (J) | 5.90 ± 0.40 | 149.9 ± 10.2 |
| Buttock to Knee Length | (K) | 18.65 ± .40 | 473.7 ± 10.2 |
| Popliteal Height | (L) | 13.40 ± .40 | 340.36 ± 10.2 |
| Knee Pivot to Floor Height | (M) | 14.80 ± .30 | 375.9 ± 7.6 |
| Buttock Popliteal Length | (N) | 14.50 ± .40 | 368.3 ± 10.2 |
| Chest Depth (without jacket) | (O) | 6.50 ± 0.30 | 165.1 ± 7.6 |
| Foot Length | (P) | 7.70 ± 0.30 | 195.6 ± 7.6 |
| Buttock to Knee Pivot Length | (R) | 16.50 ± .40 | 419.1 ± 10.2 |
| Head Breadth | (S) | 5.60 ± .20 | 142.2 ± 5.1 |
| Head Depth | (T) | 7.20 ± .20 | 182.9 ± 5.1 |
| Hip Width (maximum) | (U) | 10.40 ± .30 | 264.2 ± 7.6 |
| Shoulder Width (Bone to Bone) | (V) | 12.40 ± .30 | 315.0 ± 7.6 |
| Foot Width | (W) | 3.00 ± 0.30 | 76.2 ± 7.6 |
| Head Circumference | (X) | 21.20 ± .40 | 538.5 ± 10.2 |
| Chest Circumference | (Y) | 27.50 ± .50 | 698.5 ± 12.7 |
| Waist Circumference 0.5 inches below top rim of pelvis | (Z) | 28.00 ± .50 | 711.2 ± 12.7 |
| Reference Location for Chest Circumference (Ref.) | (AA) | 13.50 ± 0.20 | 342.9 ± 5.1 |

*Mass Measurements:* The segment assemblies and their masses should be checked with each new dummy or when parts are replaced in the dummy. The segment weights are listed in Table 10. Each segment contains specific parts of the dummy including fasteners and accelerometer mounts. For more complete details of each assembly, refer to the drawing package.

Table 10. HIII 10 Year Old Child Segment Mass

| ASSEMBLY | MASS | |
|---|---|---|
| | Lb | Kg |
| Head Assembly | 8.23 ± 0.10 | 3.73 ± 0.05 |
| Neck Assembly | 1.77 ± 0.10 | 0.80 ± 0.05 |
| Upper Torso Assembly with Torso Jacket | 17.94 ± 0.30 | 8.14 ± 0.14 |
| Lower Torso Assembly (includes femurs and lower lumbar adapting plate) | 19.21 ± 0.30 | 8.71 ± 0.14 |
| Upper Leg Assembly, Left<br>Upper Leg Assembly, Right | 5.90 ± 0.15<br>5.90 ± 0.15 | 2.68 ± 0.07<br>2.68 ± 0.07 |
| Lower Leg Assembly, Left<br>Lower Leg Assembly, Right | 4.92 ± 0.15<br>4.92 ± 0.15 | 2.23 ± 0.07<br>2.23 ± 0.07 |
| Upper Arm Assembly, Left<br>Upper Arm Assembly, Right | 1.78 ± 0.10<br>1.78 ± 0.10 | 0.81 ± 0.05<br>0.81 ± 0.05 |
| Lower Arm, Left<br>Lower Arm, Right | 1.35 ± 0.10<br>1.35 ± 0.10 | 0.61 ± 0.05<br>0.61 ± 0.05 |
| Hand Assembly, Left<br>Hand Assembly, Right | 0.38 ± .10<br>0.38 ± .10 | 0.17 ± 0.05<br>0.17 ± 0.05 |
| Foot Assembly, Left<br>Foot Assembly, Right | 0.90 ± 0.05<br>0.90 ± 0.05 | 0.41 ± 0.02<br>0.41 ± 0.02 |
| Total Dummy Weight | 77.61 ± 2.00 | 35.20 ± 0.91 |

*Calibration Corridors:* The calibration corridors include the head drop (Table 11), neck flexion (Table 12), neck extension (Table 13), thorax impact (Table 14), and the knee impact (Table 15). There is no knee slider test for the 10 year old since this feature was not incorporated into the design. The following sections list the verification corridors for each test. For set-up information refer to the SAE User's Manual.

Table 11. HIII 10 Year Old Child Head Drop Verification

| | |
|---|---|
| Temperature | 18.9 - 25.6 C |
| Humidity | 10.0 - 70.0 % |
| Peak Resultant | 250 – 300 G |
| Peak Lateral | -15.0 - 15.0 G |

Table 12. HIII 10 Year Old Child Neck Flexion Verification

| CORRIDORS | | LOWER | UPPER | UNITS |
|---|---|---|---|---|
| Temperature | 20.6 – 22.2 C | 20.6 | 22.2 | C |
| Humidity | 40 ± 30 % RH | 10.0 | 70.0 | % RH |
| Velocity | 6.1 ± 0.12 m/s | 5.98 | 6.22 | m/s |
| Pendulum Pulse At 10 ms | 1.64 ± 0.20 m/s<br>(6.04☟.66 ft/sec) | 1.64<br>5.38 | 2.04<br>6.69 | m/s<br>ft/sec |
| Pendulum Pulse At 20 ms | 3.54 ± 0.5 m/s<br>(11.64 ± 1.64 ft/sec) | 3.04<br>9.97 | 4.04<br>13.25 | m/s<br>ft/sec |
| Pendulum Pulse At 30 ms | 6.3 ± 0.6 m/s<br>(16.57 ± 1.97 ft/sec) | 4.45<br>14.60 | 5.65<br>18.53 | m/s<br>ft/sec |
| D-Plane Rotation | 81 ± 7 deg | 74 | 88 | deg |
| Moment During Rotation Interval | 58 ± 7 Nm | 51 | 65 | Nm |
| Moment Decay to 10 Nm | 95 ± 10 sec | 85 | 105 | ms |

Table 13. HIII 10 Year Old Child Neck Extension Verification

| CORRIDORS | | LOWER | UPPER | UNITS |
|---|---|---|---|---|
| Temperature | 20.6 – 22.2 C | 20.6 | 22.2 | C |
| Humidity | 40 ± 30 % RH | 10.0 | 70.0 | % RH |
| Velocity | 5.03 ± 0.12 m/s<br>(16.50 ± 0.40 ft/s) | 4.91<br>16.10 | 5.15<br>16.90 | m/s<br>ft/s |
| Pendulum Pulse At 10 ms | 1.69 ± 0.20 m/s<br>(5.55 ± .66 ft/s) | 1.49<br>4.89 | 1.89<br>6.20 | m/s<br>ft/s |
| Pendulum Pulse At 20 ms | 3.28 ± 0.40 m/s<br>(10.76 ± 1.31 ft/s) | 2.88<br>9.45 | 3.68<br>12.07 | m/s<br>ft/s |
| Pendulum Pulse At 30 ms | 4.70 ± 0.5 m/s<br>(15.42 ± 1.64 ft/s) | 4.20<br>13.78 | 5.20<br>17.06 | m/s<br>ft/s |
| D-Plane Rotation | 106.0 ± 7.5 deg | 98.5 | 113.5 | deg |
| Moment During Rotation Interval | -41 ± 6 Nm | -47 | -35 | Nm |
| Moment Decay to 10 Nm | 110 ± 10 sec | 100 | 120 | ms |

Table 14. HIII 10 Year Old Child Thorax Impact Verification

| | |
|---|---|
| Temperature | 20.6 - 22.2 C |
| Humidity | 10.0 - 70.0 % |
| Velocity | 5.88 - 6.12 m/s |
| Maximum Force in Displacement Corridor | 1.83 – 2.33 kN |
| Peak Chest Displacement | 39.0 – 47.0 mm |
| Internal Hysteresis | 69. - 85. % |

Table 15. HIII 10 Year Old Child Knee Impact Verification

| | |
|---|---|
| Temperature | 18.9 – 25.6 C |
| Humidity | 10.0 - 70.0 % |
| Velocity | 2.07 - 2.13 m/s |
| Knee Impact Force | 2.56 - 3.14 kN |

## HYBRID III 10 YEAR OLD INJURY ASSESSMENT REFERENCE VALUES

Recommended Injury Assessment Reference Values (IARVs) have been proposed by Mertz et al and are listed below (Table 16) for reference. The IARVs have been scaled from the limits established for the Hybrid III small female and HIII-6C. The limit prescribed for dummy response is such that if the IARV is not exceeded then the associated injury to that size and age of occupant will be unlikely to occur in the accident being simulated. Unlikely is defined as an Injury Risk = 5 %.

Table 16. HYBRID III 10 Year Old IARVs

| | |
|---|---|
| Head 15ms HIC | 740 |
| Thorax Sternal Compression | |
| Shoulder Belt Loading: | 37 mm |
| Distributed Loading: | 46 mm |
| Sternal Compression Rate: | 8.4 m/s |
| Spinal Acceleration: | 60 G |
| Femur Compression: | 4480 N |

## Upper Neck Loads

Combined Neck Moment & Axial Force , Nij

$$N_{ij} = \frac{M}{M_i} + \frac{F}{F_j} \leq 1.0$$

Table 127. Upper Neck IARV Intercepts

| | **OOP Intercepts** | **In-Position Intercepts** |
|---|---|---|
| $F_{tension}$ (N) | 3380 | 3735 |
| $F_{comp}$ (N) | 3380 | 3380 |
| $M_{flexion}$ (Nm) | 126 | 126 |
| $M_{ext}$ (Nm) | 50 | 56 |

Table 138. Upper Neck Peak Forces And Moments

| | **OOP IARV** | **In-Position IARV** |
|---|---|---|
| Tension (N) | 1800 | 2290 |
| Compression (N) | 2200 | 2200 |
| Flex. Moment (Nm) | 78 | 78 |
| Ext. Moment (Nm) | 32 | 40 |
| Lat. Moment (Nm) | 55 | 59 |
| Twist Moment (Nm) | 32 | 40 |

## CONCLUSION

The 95th Large Male and the 10-year old are the latest upgrades and additions to the Hybrid III family of dummies. A drawing package and user's manual for the Hybrid III $95^{th}$ Large Male and Hybrid III 10 Year Old Child have been developed under the guidance of the SAE Dummy Test Equipment Subcommittee.

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# DISCUSSION

PAPER: **Hybrid III Dummy Family Update - 10 Year Old and Large Male**

PRESENTER: ***Kristie Jarrett, DENTON ATD Inc.***
***Steve Moss, First Technology Safety Systems***

**Q**UESTION: *Guy Nushultz, Daimler/Chrysler*

Couple quick, mostly for clarification. It sounded like the way the 10 year-old was designed, it was taking into effect submarining as what was the primary focus of how the pelvis and lumbar structure was done. Does that affect any other use of the dummy change of response? And, that's a first question.

The second question is: You have the–The neck is straight as opposed to on an angle like it on the 5$^{th}$ and the 50$^{th}$. The neck comes straight up. The head doesn't seem to come forward as much. Did I get that correctly?

**A**NSWER: I'm not sure which slide you're looking at. The neck is adjustable at the base so that the slouch posture and the neck is preset. It is adjustable and then locked into place, depending on the initial set-up for the seating position of the dummy. The neck is adjustable. Which particular picture were you referring to?

**Q:** Well, you talked about–Actually, there was a discussion on the neck being aligned to take care of some loading at C-7.

**A:** Oh, yeah.

**Q:** That was it.

**A:** Yeah. The typical Hybrid III dummies: Because the joint for the clavicle shoulders is typically in this area right in here--the actual compliance joint?–which means that the neck load cell actually, is actually mounted rearwards and then there's an offset plate to get back to the c-7 location.

**Q:** Correct.

**A:** That's always had to have a translation applied to loads measured at that load cell to get back to the c-7 location.

**Q:** That's correct.

**A:** With this design here, we get out of having to do that translation.

**Q:** Is this–Is it more important to do that for the 10 year-old, or is it just an improvement in a design that you could map up to the 5$^{th}$ or the 50$^{th}$?

**A:** It's just, really, an ease of use function. It's anti-climatically more correct and gets you out of doing that translation which has been historically–

**Q:** So, it's something that you should probably move up to that 5$^{th}$ and that 50$^{th}$, then. Is that correct?

**A:** We would like to do that.

**Q:** That answers the questions. Okay. Thank you.

**Q:** *Pat, General Motors*
Just a couple questions on the 10 year-old. Because of the adjustable neck in the out-of-position settings, even though there's not a standard out-of-position, you know, static, static deployment, is there any recommendation for the particular neck angle? Or, are you looking into that?

**A:** Yeah. There's a standard position just for calibration, but there's not a seating procedures where to pre-set those for testing yet.

**Q:** And you said that that was ongoing. Do you know when they'll be some more information on that?

**A:** Not yet. I think that's the next work of the SAE Group we'd like to see some work on the seating procedures.

**Q:** Okay. And then on the 95$^{th}$ percentile: Did you do any work with the lower legs or with the foot? Was it the 50$^{th}$ percentile foot now? I can't remember. That was a rumor at one point in time.

**A:** It's a 45$^{o}$ foot. The foot was increased in weight so it's no longer identical to the 50$^{th}$ foot as it was before, and the bumper was adding in the ankle. I'm not sure if that answers your question.

**Q:** Geometrically, thought, the size, the length of the foot?

**A:** It's the same as the 50$^{th}$, but the weight is increased.

**Q:** Good. Thank you.