



## **Humanetics Innovative Solutions, Inc.**

The Brand Harmonization of the Hybrid III 5<sup>th</sup> Small Female Crash Test Dummy  
880105-000



The ATD Harmonization Task Group  
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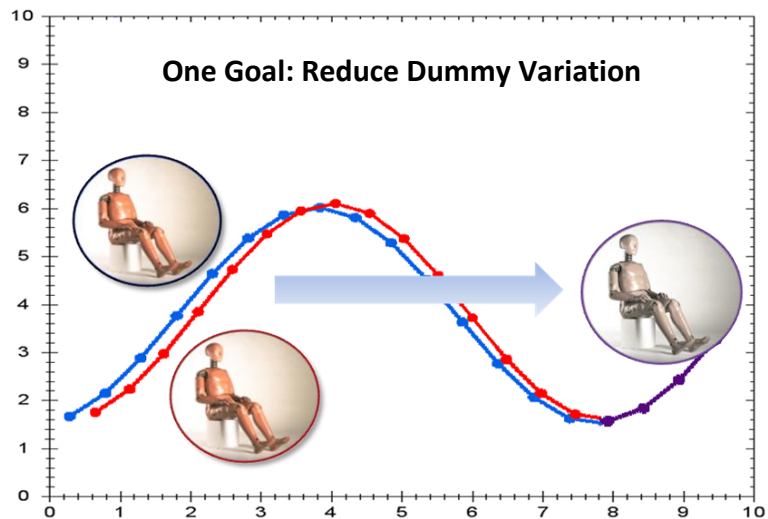
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## An Introduction to Crash Test Dummy Harmonization

Crash test dummies, known in technical jargon as Anthropomorphic Test Devices (ATDs), have been the center of attention for a worldwide community of scientists, engineers, and technicians focused on harmonizing two brands of dummies into test devices that will narrow performance variability and help reduce crash test to crash test variation.

In April of 2010, the two leading manufacturers of ATDs, *First Technologies Safety Systems Inc.* (FTSS) and *Denton ATD Inc.* became subsidiaries of *Humanetics Innovative Solutions Inc.* For almost two decades these two companies produced many of the most common dummies in regulation today. Utilizing federalized drawing packages, each organization manufactured their own translation of the Part 572 specifications of the same ATDs. By nature, these specifications have allowed for some differences in the production of these various test dummies-differences the global community would like to see minimized or eliminated entirely.



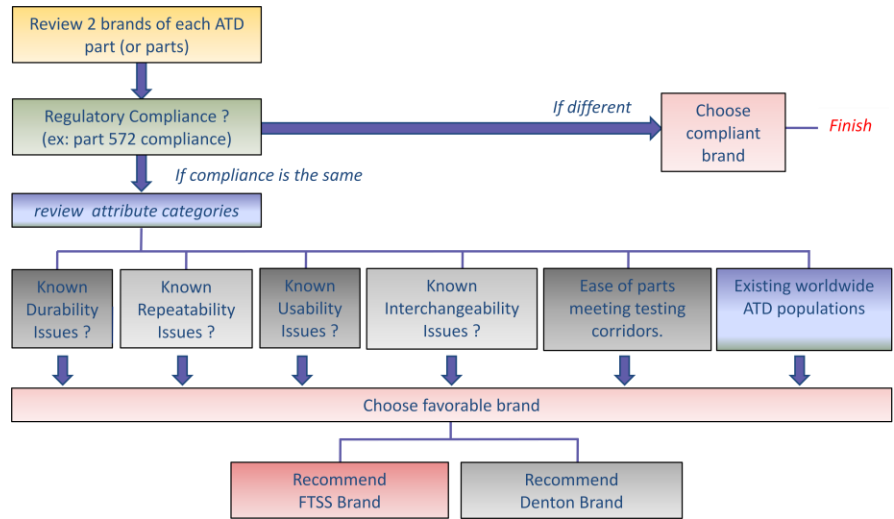
The first organizational meeting was held in November of 2010 to create a global harmonization working group. This initial meeting brought together worldwide members from the Partnership for Dummy Technology and Biomechanics (PDB), the European Auto Manufacturers Association (ACEA), the Occupant Safety Research Partnership (OSRP), the Japan Auto Manufacturers Association (JAMA), Hyundai, and GESAC, as well as regulators and insurance bodies such as the European New Car Assessment Program (EuroNCAP), the National Highway Traffic Safety Administration (NHTSA), Transport Canada, and the Insurance Institute for Highway Safety (IIHS). With these organizations in support of the harmonization strategy, the new committee was able to shape the process in use throughout the year.

The goal of this group was to make technical recommendations towards the consolidation of current brands of ATDs and ATD parts. The intention of the group was not to advocate a particular ATD manufacturer, but rather make technical recommendations regarding harmonizing brands within a manufacturer. No NHTSA documentation changes were recommended. Recommendations were based on adherence to the current drawing packages.

The benefits to the auto industry are to reduce dummy to dummy and crash test to crash test variations for both those who manufacture vehicles as well as those who evaluate them. The harmonized ATDs do not create a third band of variability since they are based on components already found within the current mix of brands in the field. No statistically known performance differences are known. Since the task group is not changing regulations, labs that are currently testing vehicles to regulatory requirements could likely do so with their existing dummies. When the life cycles of the dummy parts are depleted, they could be replaced with harmonized parts.

**The Harmonization Process**

During 2011, almost thirty voting and non-voting members of the Harmonization Task Group have consistently met on a monthly basis to review the individual dummy components with Humanetics. These ongoing monthly harmonization meetings have successfully produced recommendations for consolidated ATDs for the most common dummies in use and regulation today.



Selected ATDs were reviewed from head to toe and the similarities and differences of each brand are discussed. Humanetics provided the design and manufacturing history of the dummies as well as engineering knowledge generated from the multiple brand versions. Members in attendance also provided feedback from their own experiences with each brand. Body segment attributes of design, manufacturing, testing, durability and general interchangeability were shared and examined. A wide variety of characteristics including component shape, conformance to specified drawing packages, performance history, worldwide populations, and molding capabilities were carefully considered.

Before adjourning the meetings, voting members cast their votes for the component brand of choice. The task group then provided their final recommendations to Humanetics, but did not offer legal or regulatory advice or solicitation.

**Vinyl Material Harmonization**

The technical reviews of the Hybrid III family of ATDs have also produced a harmonized vinyl and foam material that incorporates the best practices and features of the Denton and FTSS brands. The common vinyl material utilizes a light brown pigment that sets it apart from the flesh hues of the current Hybrid III family. The chemical and material composition has been optimized for the best performance while still meeting the requirements outlined in regulations.



The general vinyl flesh formulations of each ATD brand are very similar; both the Denton and FTSS material use the same resins, plasticizers, and stabilizers that are merely mixed slightly different. Currently, both brands of raw vinyl are manufactured by the same vendor using individual color pigments. The major control verification is durometer (hardness) based on the drawing specifications.

Since pink flesh tones can be challenging to color match and keep consistent, the European brown color utilized on the EuroSID-2 was a natural choice to help distinguish harmonized parts from many of the current Denton and FTSS versions. Some of the many benefits of the brown pigment include a reduction in vinyl trimming during manufacture with fewer surface imperfections on the final product. The new color will also be photo friendly with a hue that's not too light or too dark to capture under high speed filming conditions.

The two brand's process variations have yielded different surface finishes and 'feel' from their respective flesh. The final step of vinyl surface polish is distinctive for each brand. The FTSS version uses acetone for exterior conditioning once the parts have been trimmed and any imperfections sanded out. Acetone produces a slightly dull, matte surface finish. The Denton brand uses methyl ethyl ketone (MEK) to condition the surface, which produces a relatively shiny finish. Whether using acetone or MEK, one method does not have a protective advantage over the other. From a commercial standpoint, acetone is easier to handle during production and is more environmentally acceptable relative to MEK, making it the recommended choice of the Harmonization group.

The harmonized vinyl characteristics:

- FTSS brand 52 durometer vinyl
- European brown color
- Acetone processed surface finish

### Foamed Vinyl Part Sealing

The foam pour holes in vinyl parts typically leave noticeable holes that have historically been patched for both brands. Generally the European manufactured parts (ex. EuroSID) have left the pour holes open. Sealing has drawbacks from a ventilation aspect; foam curing sometimes produces slight shriveling in sealed parts.

The committee agreed that any part with noticeable pour holes when the dummy is fully assembled; i.e. chest jackets and pelvis assemblies will be sealed. Abdomens will be sealed as a general rule for all dummy types. Other body parts that have hidden pour holes on the assembled dummy will not require patches.



*Leg flesh with exposed pour holes*



*Nickel plated spine box*

### Surface Coatings and Finishes

The recommendations of the Harmonization Task Group state that surface finishes and coatings should be consistent across all models of ATDs. These include a single type of nickel coating for steel, the anodizing of aluminum, and the treatment of casted metal surfaces.

Nickel plating is a superior coating that ensures parts do not rust through normal usage and has been in use on the Denton brand for many years with great success. Although black oxide appears on older drawing specifications, it provides very little rust protection. White rust can occur within minutes when exposed to standard salt spray tests and red rust can occur within 10 hours of exposure. Nickel plating will withstand 48 hours in a standard salt

spray test without the appearance of white rust and will withstand a salt spray for 300 hours before the appearance of red rust.

Anodizing is an oxidation process that increases corrosion and wear resistance on machined aluminum. Dyes can be used to create varied shades of colors. Typically, the FTSS brand utilized a red color and the Denton brand anodized with a blue shade. Colors hues can drift from batch to batch, sometimes making it challenging to produce consistent results over time. Humanetics is currently using a clear, colorless anodizing for all machined aluminum parts and will incorporate this process into all harmonized aluminum product as well.



*Clear anodized aluminum neck bracket*

Tumble finishing for metals is the process of smoothing, cleaning, deburring and polishing rough surfaces. Within Humanetics this technique is mainly used on casted metal surfaces such as aluminum skulls and clavicle components. Originally used on the Denton brand, tumbling is being incorporated throughout the harmonized product line to reduce this type of surface variation.



*Tumbled aluminum surface*

*Non-tumbled aluminum surface*

**The Hybrid III 5<sup>th</sup> Small Female**

The Task Group’s recommendation for the harmonized HIII 5<sup>th</sup> Small Female consists of the following brand based components:

<i>DN = Denton Brand FTSS = FT Brand</i>	Head	Neck	Upper Torso	Lower Torso	Legs & Feet	Arms & Hand	Comments
<b>HIII 5<sup>th</sup> Small Female*</b>	DN	DN	FTSS	FTSS	FTSS	FTSS	<i>Harmonized Jacket, DN Ball Sliders, &amp; Lower Leg Cavity, DN Hands</i>
<i>*Harmonized Vinyl for all HYIII Family and CAPPs brand shoes.</i>							

**Head Assembly**

The Harmonization Task group analyzed head skin dimensions for three separate versions for the small female produced from the FTSS mold, the current Denton mold, and a brand new Denton mold that had not officially been put into production service. Width and length measurements were the same across the three versions, but thickness and weight showed minor variations.



The new Denton head skin mold (vs. the current Denton mold) produces a skin thickness in the forehead region within the drawing specification. The current Denton head skin was casted in 1999 from the VRTC ‘Golden Shell’ dummy which is no longer available.

According to the drawing measurements, the new Denton brand head skin mold is the closest of the three versions to the specifications. No 3D shapes are available. This new head skin mold is unchanged in all other Denton brand size and shape characteristics and only revises the forehead thickness. Since the only true specification available for the head skin is the drawing, which the new mold conforms to the closest, the task group chose this version to use on the harmonized head assembly.



The analysis of the casted skull components and machined parts within the head assembly proved comparable between brands. There are no issues with neck shield engagements between brands.

The task group’s consensus was to use the Denton brand head assembly for the harmonized small female dummy. The thickness and weight of each brand of head skin showed minor differences; therefore users should check the weight and CG of the head assembly when replacing head skins or skulls with harmonized parts.

## Neck Assembly

Both brand necks use 70-80 durometer butyl rubber and both are shipped with the nodding blocks used to certify the neck. No preference on the rubber neck was voiced by members of the reviewing task group. Both rubber neck brands meet and pass the design specifications adequately, so the decision was to keep the neck brand the same as the head brand.

## Upper Torso

The main difference in the brands of the upper torso portion of the small female are found in the chest jacket and rib set combinations. Each brand's current chest jacket has enough difference in geometry and construction to require the ribs to be tuned to the specific jacket being used.

## Chest Jacket

Today, when using the standard FTSS or Denton brand jacket, the rib damping material must be produced with different thicknesses to match the brand of jacket being used. Each brand's damping material thickness tuning corridor is wide enough to cause jacket interchangeability issues.



*Denton and FTSS brand chest jackets*

The FTSS and Denton versions of the small female jackets are different interpretations of the specifications and vary mainly in the construction and placement of the breasts. To alleviate this variable, SAE organized a joint effort in 2009 between FTSS and Denton to create a jacket with one common geometry and breast location for both brands. The material and stiffness specs were not part of this original harmonization, but jacket stiffness is now called out in an SAE J document as a durometer measurement. The harmonized jacket shape was created purely from the federalized drawings and is the closest to those specifications.



*Harmonized chest jacket design*

Unfortunately, at the time of the task group's evaluation of the small female, NHTSA had yet to adopt the harmonized version of the chest jacket because of ongoing validation with the torso flexion requirement. Pending the outcome of NHTSA's tests, slight changes to the 2009 harmonized design may be required.

NHTSA currently asks manufacturers which small female jacket they use in testing their vehicles. This practice will continue even after NHTSA incorporates the new jacket into regular testing. NHTSA rules do not favor any particular manufacturer of jackets or dummies.

Some of the design advantages to the 2009 harmonized jacket include:

- Meets the drawing specs better
- Shoulder engagement is better, more consistent
- New molds



- Mandrel tool to check jacket size and shrinkage
- Shoulder belt engagement is better
- New foam pad drawing with corrections
- Molded on breasts (as opposed to fused on separately)



*Mandrel used for inspecting the fit of the 2009 harmonized chest jacket*

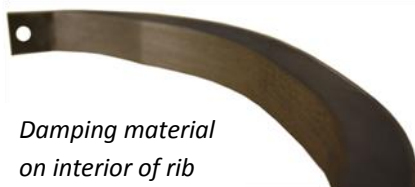
Fundamentally, the group agreed that the harmonized jacket should be the recommended component for the harmonized small female because it is the best choice; the closest to the drawing package. NHTSA plans to begin using the new jacket as soon as it is commercially available and anticipates its use throughout the industry. The rib damping material thickness and tuning will have to be worked through as new jackets are acquired by users and the harmonized components are phased in.

The task group agreed that since the automotive cycle for design and testing can span multiple years, Humanetics should continue producing multiple versions of the jacket for a time period after the harmonized dummy is fully available. NHTSA typically gives multiple year phase-in periods, so even if the jacket was incorporated today, the multiple brand versions will need to be available for a few years to come.

The group's consensus was to use only the harmonized jacket on all new small female dummies. The FTSS and Denton brand versions of the jackets will be offered as spare parts.

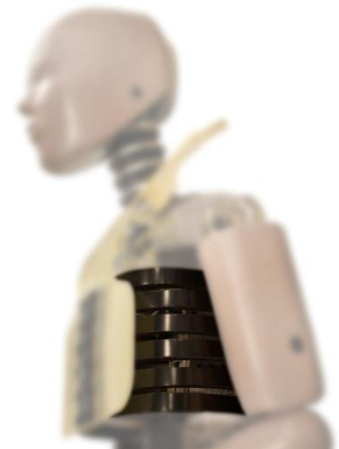
## Ribs

The current rib damping material thickness is tuned to each brand's thorax impact performance based on the chest jacket used. The interchangeability varies from brand to brand, so certification and adjustments may be necessary when switching jackets. The FTSS and Denton brands use the same rib damping material from the same manufacturer.



*Damping material on interior of rib*

When replacing either brand jacket with a new Harmonized version, the ribs should be evaluated and tuned if necessary.



## Lower Torso

The molded pelvis assemblies in the lower torso are noticeably different between the FTSS and Denton brands. The pelvis bones vary in the tuberosity shape (bottom set of 'wings') and their respective locations in front or behind of the H-point location. The FTSS bone dates back to 1988 and is a scaled version of the 50<sup>th</sup> male pelvis with the wings cut down. In 1995 the Denton version was created from both the NHTSA drawings and a dummy provided by NHTSA for examination. Neither brand of pelvis bone completely



matches the drawing, but the drawing itself is inadequate to determine the exact shapes. The difference in the bottom shape of the pelvis bone brought up questions concerning its affect on dummy submarining and whether the two different pelvis assemblies could rotate differently during testing.



*FTSS and Denton raw pelvis bone castings showing differences in shape*

Both lower torsos meet weight and CG requirements, but there have been different iliac load cell openings in the past and the individual weights of the molded pelvis differ for each brand. Both brand pelvises' now have the molded triangular shape in front for the iliac wing load cells.

The FTSS brand upper femurs are slightly heavier, resulting in a lighter molded pelvis weight which creates interchangeability issues when combining with Denton brand parts. The FTSS molded pelvis alone is slightly under the weight spec, relying on the heavier femurs to make up the difference in the full lower torso assembly weight.

The abdomen brands have slightly different shapes, especially around the pocket and stepped area. The drawing is deficient in giving enough information for the correct shape and specification for the step location. No appreciable differences in the lumbar were observed between brands.

The FTSS brand Lower Torso assembly was recommended by the Task Group for the harmonized small female dummy.

### **Arm and Hand Assemblies**

A few differences in arm components were noticed when analyzing the two brands of arm assemblies.

The size and shape of the hands vary between brands. The Denton hand is solid vinyl while the FTSS brand is foam filled. This difference had produced some debate on the durability and pliability of fingers with foam filling. The group also questioned whether hand construction could cause variances in the arm positioning and differences in the chest g's depending on the placement of each hand. The drawing shows a solid vinyl hand.



The task group's evaluation of the arm assemblies also showed that the foam fill around the wrist of the 5<sup>th</sup> lower arm has similar brand differences as those seen



*FTSS and Denton hands showing differences in size and shape*

in the HIII 50<sup>th</sup>. The FTSS foam stops at a set point down the lower arm while the Denton brand has foam throughout the entire vinyl molding. Neither version exactly matches the drawing at the molded wrist area, but all arm pieces are interchangeable between brands.

The FTSS brand arms using the Denton brand hand were recommended by the task group for the harmonized small female dummy. No interchangeable issues are known to exist.

### Leg Assemblies



The lower leg assemblies were discussed. Some users prefer the lower leg cavity of the Denton version flesh for ease of use. All other parts were shown to be equal. The group agreed that the optional ball sliders (the standard female has friction sliders) should follow the design preference of the 50<sup>th</sup>, which had been identified previously as the Denton brand.

A key deciding factor that was also considered in the decision making: the same small female leg assemblies used on the 5<sup>th</sup> are also used on the SIDII, which has already been harmonized to the FTSS brand version.

The FTSS brand legs using the Denton brand lower leg cavity and optional ball sliders were recommended by the task group for the harmonized small female dummy.

### Shoe Brand for the HIII Adult Family

The Denton and FTSS brands both meet the drawing specifications of MIL-S-21711E. They both have rubber soles, removable insoles, and conform to the 7 ½ W small female sizing. The FTSS CAPPS version is recommended.



### Phase-in

The majority of both brands of ATD components are already interchangeable and will have no effect on use. Currently, these types of parts may only be identifiable by their metal surface coating or the shade of the vinyl flesh. The major discussion points have included the head, pelvis, and the chest jacket components.

The Harmonization Task Group emphasizes to individual labs and companies that there is no need to replace all ATDs and ATD parts immediately. A user may choose to replace parts only as typically needed, but do so with the harmonized versions. Some groups such as NHTSA, IIHS, and others expressed that they would prefer to start ordering harmonized parts as soon as possible. Therefore, Humanetics has begun to harmonize Hybrid III components and will provide Technical Bulletins as each part is ready for sale.

Once brand specific components are depleted from stock, current orders will be fulfilled with harmonized versions. New components available for sale will be completely based upon the harmonization decisions recommended by the Task Group.

-End-