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October 19, 2020

James Clayton Owens, Acting Administrator
National Highway Traffic Safety Administration
Docket Management Facility, M-30
U.S. Department of Transportation
1200 New Jersey Avenue S.E.
West Building Ground Floor, Room W12-140
Washington, DC 20590-0001

Subject: NHTSA NPRM HIII 5F Request for Comments
Docket No. NHTSA-2019-0023

Humanetics Innovative Solutions appreciates the opportunity to provide additional supplemental information regarding NHTSA's Notice of Proposed Rulemaking (NPRM) announced December 26, 2019 to update the Hybrid III 5th Female ATD chest jacket specifications.

We are the proud supplier of the world's most sophisticated crash test dummies. We are an industry partner that relentlessly brings advanced technologies to market, raising the bar on vehicle safety standards and ultimately saving lives.

The supplemental information herein is complimentary to the comments provided by Humanetics to the original NPRM closing February 20, 2020 and August 3, 2020 (italicized).

Hybrid III 5th Percentile Female ATD (HIII-5F) Item 3 comments from 2/20/2020 & 8/3/2020:
(Note: All data, keys and templates for the measurements were provided 8/3/2020)

Summarized

3. *NPRM Page 14: Our proposed additional specifications for the jacket's contour adds breadth, depth, and circumference dimensions at different section levels of the jacket on the main assembly drawing of the dummy (880105-000, Rev. J, Sheet 5).*

   Humanetics cannot support the enhanced physical dimensional check of the jacket as proposed. Humanetics welcomes the efforts of NHTSA to further define the jacket geometry to ensure no barriers are in place for new suppliers. However, after further investigation, we have determined that the additional dimensional checks cannot realistically be met using the procedural updates provided, both on and off the ATD.

   A study was conducted comparing measurements taken as prescribed in the NPRM and with the chest jacket mounted on a mandrel. The Gage R&R for measuring the completely assembled ATD on the bench as shown on the external dimension procedure had poor to bad results. The measurement system had Total Gage R&R values ranging between 33% and 201%. Typically, the Total Gage R&R should be equal to or less than 30% of the study variation or %Tolerance depending on which is more significant. Repeatability was also shown to be a significant source of variability. The range of repeatability values fluctuated between 31.97 to as high as 184.58 percent of tolerance.

   Beyond repeatability, there were also a large amount of technician to technician differences as indicated by the reproducibility numbers ranging as high as 135% of tolerance. This shows that different technicians, even in the same lab with one set of equipment and common procedures were unable to get the same average measurements.

   The jacket only measurements as prescribed were also concerning, having all 5 jackets evaluated failing 4 or more measurements. An improvement to the measurement process and/or change in corridors is needed if this update is implemented. However, we strongly advise removing the additional measurements from the external dimension portion of the top-level drawing, 880105-000. If we implement the changes proposed in the NPRM the pass yield to the chest jackets is going to be very small, approaching near 0%.

Continuation of comments providing data as of 10/2/2020:
(Note: All data, keys and templates for the measurements are in the attachments)

The use of the mandrel can serve as a precision tool to constrain the jacket and provide a more repeatable setup. The mandrel was designed to be a representation of the design geometry of the torso portion of the dummy. With the jacket constrained to the mandrel, users are then able to focus on the jacket and gather measurements with a higher level of certainty than if measuring the jacket while on the ATD, especially when using a FARO or CMM.

The improved mandrel design provides locating pins at the access holes to assist in orienting the jacket. The removeable arm feature provides added structure for the jacket to rest upon, while doubling to accommodate the arm opening measurements once removed. The mandrel also tapers to the current SAE jacket modifications made subsequent of the original designs from Denton and FTSS, ensuring the appropriate fit.

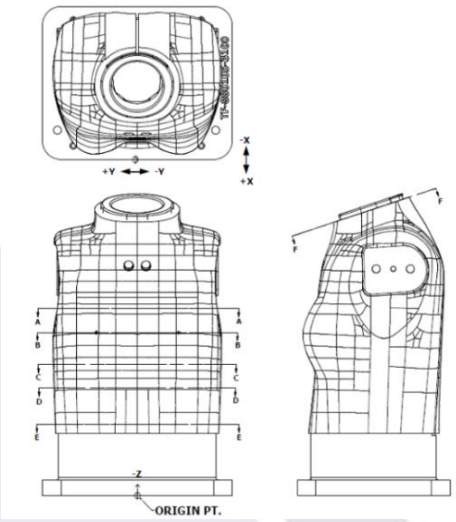
Reference surfaces were implemented to establish a coordinate system; a compliment to the FARO used to capture measurements. The mandrel keeps the jacket conformed to the design shape as if on an ideal dummy and provides support of the flexible vinyl to allow the best repeatability of measurements possible.

External Measurements on Mandrel:

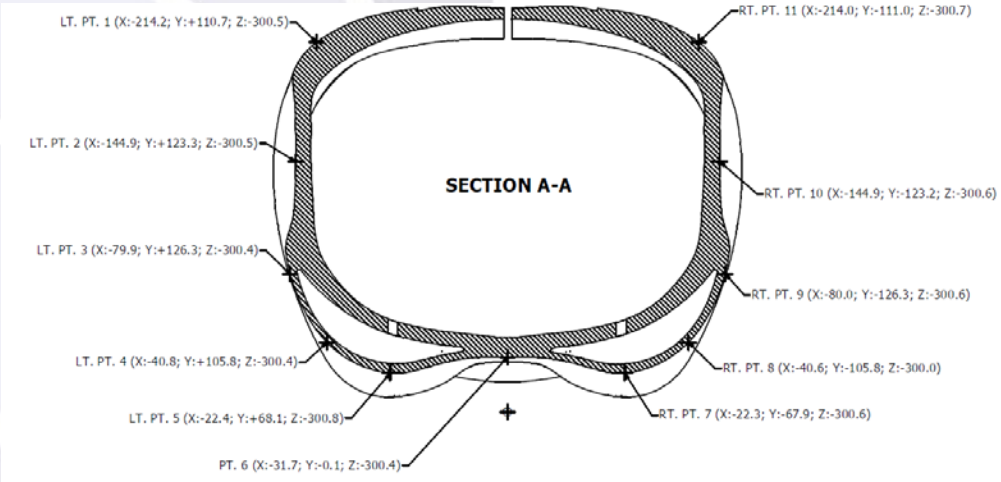
Humanetics developed a method to measure the critical features to define the shape of the jacket to check the design against the drawing design intent. To do this, 3D measurements were taken at points along cross sections as well as other areas which were used to define the overall shape of the jacket. All 3D points are taken from the 3D CAD model of the jacket referenced to the origin of the mandrel. This set of 3D measurements allows the shape of the jacket to be checked against the original design intent of the jacket.

This method of checking the jacket was evaluated by taking measurements conducted by two technicians and (10) jackets of varying vintages. A large number of measurements were taken per jacket using the FARO. Using the mandrel to establish the coordinate system, points were established to capture the critical 3D theoretical nominal geometry.

We established multiple points around the jacket to capture the 3D shape in the critical areas defining the placement and geometry of key features. The section spacing correlate to the original spacing of the sections provided but are tied back to the mandrel coordinate system; not the h-point. Moving these measurements to the component drawing, ensures goodness of the jacket geometry and would be applicable to all new jackets including spares. The mandrel measurements were captured using a FARO and illustrate the deviation from the 3D point which is on the surface of the jacket design model. (as shown is schematic provided below)



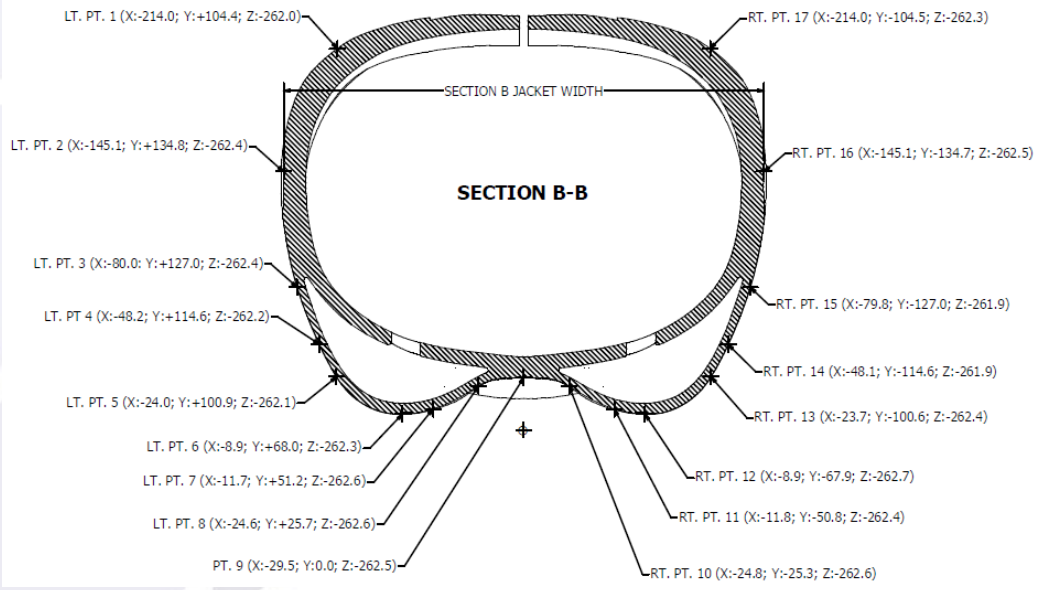
Once set up, the technicians were able to complete the measurements in approximately 30 mins per jacket. Measurements were repeated for each series of jackets a total of 4 times; exceptions noted.



		SECTION A POINT LOCATION 1	SECTION A POINT LOCATION 1	SECTION A POINT LOCATION 1	SECTION A POINT LOCATION 2	SECTION A POINT LOCATION 2	SECTION A POINT LOCATION 2	SECTION A POINT LOCATION 3	SECTION A POINT LOCATION 3	SECTION A POINT LOCATION 3	SECTION A POINT LOCATION 4	SECTION A POINT LOCATION 4	SECTION A POINT LOCATION 4
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
ALL	Max	-213.2	111.8	-300.3	-144.9	128.9	-300.5	-79.4	128.3	-300.3	-38.3	108.7	-299.6
	Nominal	-214.2	110.7	-300.5	-144.9	123.3	-300.5	-79.9	126.3	-300.4	-40.8	105.8	-300.4
	Min	-215.2	110.7	-300.6	-144.9	125.0	-302.3	-80.8	124.9	-300.5	-42.3	104.6	-301.7
	Average	-214.5	111.2	-300.4	-144.9	126.5	-301.5	-80.0	126.1	-300.4	-40.5	106.5	-300.6
	Standard Deviation (all jackets and operators)	0.362	0.237	0.056	0.009	0.801	0.310	0.241	0.765	0.026	0.840	0.853	0.434
	4 *Standard Deviation	1.449	0.948	0.224	0.034	3.203	1.239	0.963	3.061	0.103	3.359	3.413	1.737
	Repeatability (pooled std dev)	0.306	0.196	0.047	0.007	0.697	0.272	0.160	0.446	0.017	0.523	0.530	0.270
	4 * Repeatability	1.223	0.784	0.189	0.030	2.789	1.087	0.641	1.783	0.069	2.091	2.120	1.081
	Upper Tolerance	-206.904	118.808	-292.831	-137.302	134.124	-293.935	-72.438	133.681	-292.815	-32.858	114.112	-292.982
	Lower Tolerance	-222.104	103.608	-308.031	-152.502	118.924	-309.135	-87.638	118.481	-308.015	-48.058	98.912	-308.182
	4*Repeatability % of Tolerance	8.05%	5.16%	1.25%	0.20%	18.35%	7.15%	4.22%	11.73%	0.45%	13.76%	13.95%	7.11%

		SECTION A POINT LOCATION 5	SECTION A POINT LOCATION 5	SECTION A POINT LOCATION 5	SECTION A POINT LOCATION 6	Midsagittal SECTION A POINT LOCATION 6	SECTION A POINT LOCATION 6	SECTION A POINT LOCATION 7	SECTION A POINT LOCATION 7	SECTION A POINT LOCATION 7	SECTION A POINT LOCATION 8	SECTION A POINT LOCATION 8	SECTION A POINT LOCATION 8
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
ALL	Max	-15.8	70.1	-301.8	-24.5	1.8	-300.9	-15.5	-66.4	-302.3	-37.0	-106.4	-300.4
	Nominal	-22.4	68.1	-300.8	-31.7	-0.1	-300.4	-22.3	-67.9	-300.6	-40.6	-105.8	-300.0
	Min	-20.5	68.4	-304.4	-26.2	0.2	-301.0	-19.3	-68.1	-304.4	-39.8	-109.3	-301.9
	Average	-17.6	68.7	-303.4	-25.5	0.4	-301.0	-17.4	-67.9	-303.4	-38.3	-107.9	-301.2
	Standard Deviation (all jackets and operators)	1.061	0.245	0.587	0.528	0.248	0.051	0.802	0.251	0.443	0.665	0.709	0.346
	4 *Standard Deviation	4.243	0.980	2.350	2.113	0.993	0.204	3.208	1.005	1.771	2.661	2.838	1.385
	Repeatability (pooled std dev)	0.588	0.230	0.326	0.198	0.238	0.019	0.482	0.236	0.266	0.433	0.460	0.225
	4 * Repeatability	2.354	0.921	1.303	0.791	0.953	0.076	1.928	0.944	1.064	1.731	1.838	0.901
	Upper Tolerance	-9.990	76.325	-295.812	-17.884	7.965	-293.354	-9.807	-60.288	-295.753	-30.725	-100.302	-293.587
	Lower Tolerance	-25.190	61.125	-311.012	-33.084	-7.235	-308.554	-25.007	-75.488	-310.953	-45.925	-115.502	-308.787
	4*Repeatability % of Tolerance	15.48%	6.06%	8.58%	5.20%	6.27%	0.50%	12.68%	6.21%	7.00%	11.39%	12.09%	5.93%

		SECTION A POINT LOCATION 9	SECTION A POINT LOCATION 9	SECTION A POINT LOCATION 9	SECTION A POINT LOCATION 10	SECTION A POINT LOCATION 10	SECTION A POINT LOCATION 10	SECTION A POINT LOCATION 11	SECTION A POINT LOCATION 11	SECTION A POINT LOCATION 11
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
ALL	Max	-78.7	-127.0	-300.6	-145.0	-126.1	-301.7	-214.2	-110.9	-300.1
	Nominal	-80.0	-126.3	-300.6	-144.9	-123.2	-300.6	-214.0	-111.0	-300.7
	Min	-79.7	-129.5	-300.7	-145.0	-128.9	-302.9	-217.4	-112.8	-300.6
	Average	-79.4	-128.3	-300.7	-145.0	-127.4	-302.1	-215.4	-111.7	-300.4
	Standard Deviation (all jackets and operators)	0.176	0.516	0.019	0.008	0.733	0.279	0.584	0.367	0.095
	4 *Standard Deviation	0.705	2.062	0.075	0.031	2.932	1.114	2.335	1.469	0.382
	Repeatability (pooled std dev)	0.152	0.393	0.016	0.007	0.579	0.239	0.460	0.266	0.075
	4 * Repeatability	0.607	1.572	0.064	0.027	2.315	0.957	1.842	1.065	0.301
	Upper Tolerance	-71.770	-120.676	-293.066	-137.374	-119.811	-294.531	-207.767	-104.108	-292.823
	Lower Tolerance	-86.970	-135.876	-308.266	-152.574	-135.011	-309.731	-222.967	-119.308	-308.023
	4*Repeatability % of Tolerance	3.99%	10.34%	0.42%	0.18%	15.23%	6.30%	12.12%	7.01%	1.98%



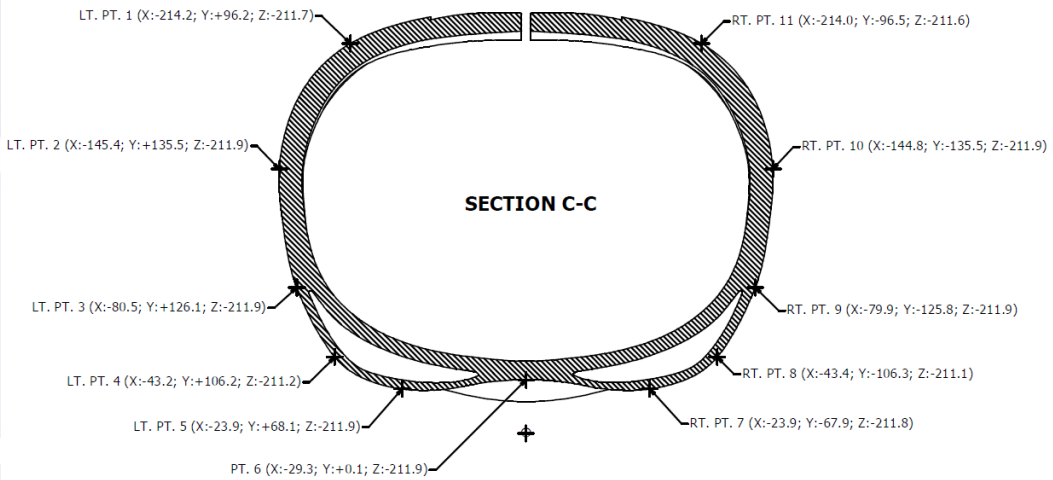
		SECTION B POINT LOCATION 1	SECTION B POINT LOCATION 1	SECTION B POINT LOCATION 1	SECTION B POINT LOCATION 2	SECTION B POINT LOCATION 2	SECTION B POINT LOCATION 2	SECTION B POINT LOCATION 3	SECTION B POINT LOCATION 3	SECTION B POINT LOCATION 3	SECTION B POINT LOCATION 4	SECTION B POINT LOCATION 4	SECTION B POINT LOCATION 4
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
	Max	-213.2	105.6	-261.9	-145.0	140.2	-262.0	-79.4	129.3	-262.3	-46.9	117.5	-262.2
	Nominal	-214.0	104.4	-262.0	-145.1	134.8	-262.4	-80.0	127.0	-262.4	-48.2	114.6	-262.2
	Min	-214.9	104.4	-262.1	-145.1	134.9	-263.5	-80.9	126.0	-262.4	-50.4	110.2	-262.2
	Average	-214.2	104.9	-262.0	-145.0	136.4	-262.7	-80.1	127.1	-262.4	-48.5	114.2	-262.2
	Standard Deviation (all jackets and operators)	0.322	0.230	0.037	0.013	0.887	0.210	0.256	0.754	0.014	0.706	1.474	0.014
ALL	4 *Standard Deviation	1.288	0.921	0.147	0.050	3.549	0.840	1.023	3.016	0.057	2.824	5.896	0.055
	Repeatability (pooled std dev)	0.253	0.185	0.029	0.011	0.776	0.185	0.167	0.439	0.009	0.617	1.277	0.012
	4 * Repeatability	1.014	0.742	0.115	0.044	3.103	0.741	0.667	1.756	0.037	2.469	5.107	0.048
	Upper Tolerance	-206.616	112.454	-254.418	-137.434	144.031	-255.073	-72.498	134.673	-254.778	-40.897	121.839	-254.599
	Lower Tolerance	-221.816	97.254	-269.618	-152.634	128.831	-270.273	-87.698	119.473	-269.978	-56.097	106.639	-269.799
	4*Repeatability % of Tolerance	6.67%	4.88%	0.76%	0.29%	20.42%	4.88%	4.39%	11.55%	0.24%	16.24%	33.60%	0.32%

		SECTION B POINT LOCATION 5	SECTION B POINT LOCATION 5	SECTION B POINT LOCATION 5	SECTION B POINT LOCATION 6	SECTION B POINT LOCATION 6	SECTION B POINT LOCATION 6	SECTION B POINT LOCATION 7	SECTION B POINT LOCATION 7	SECTION B POINT LOCATION 7	SECTION B POINT LOCATION 8	SECTION B POINT LOCATION 8	SECTION B POINT LOCATION 8
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
	Max	-22.4	103.1	-262.0	-3.1	69.8	-263.0	-4.4	51.7	-262.9	-16.4	24.0	-262.9
	Nominal	-24.0	100.9	-262.1	-8.9	68.0	-262.3	-11.7	51.2	-262.6	-24.6	25.7	-262.6
	Min	-25.2	99.9	-262.2	-7.8	68.1	-263.5	-9.4	49.3	-263.4	-21.2	21.1	-263.4
	Average	-23.7	101.5	-262.1	-5.2	68.2	-263.2	-6.7	50.0	-263.2	-18.9	22.7	-263.2
	Standard Deviation (all jackets and operators)	0.711	0.820	0.041	1.181	0.264	0.129	1.149	0.459	0.125	1.039	0.629	0.104
ALL	4 *Standard Deviation	2.842	3.279	0.163	4.724	1.055	0.514	4.594	1.835	0.500	4.157	2.514	0.416
	Repeatability (pooled std dev)	0.464	0.521	0.027	0.790	0.253	0.086	0.689	0.336	0.075	0.658	0.412	0.066
	4 * Repeatability	1.858	2.085	0.107	3.161	1.014	0.344	2.757	1.342	0.300	2.631	1.647	0.263
	Upper Tolerance	-16.128	109.134	-254.496	2.392	75.844	-255.639	0.941	57.589	-255.587	-11.311	30.253	-255.555
	Lower Tolerance	-31.328	93.934	-269.696	-12.808	60.644	-270.839	-14.259	42.389	-270.787	-26.511	15.053	-270.755
	4*Repeatability % of Tolerance	12.22%	13.72%	0.70%	20.79%	6.67%	2.26%	18.14%	8.83%	1.98%	17.31%	10.84%	1.73%

		Midsagittal SECTION B POINT LOCATION 9	Midsagittal SECTION B POINT LOCATION 9	Midsagittal SECTION B POINT LOCATION 9	SECTION B POINT LOCATION 10	SECTION B POINT LOCATION 10	SECTION B POINT LOCATION 10	SECTION B POINT LOCATION 11	SECTION B POINT LOCATION 11	SECTION B POINT LOCATION 11	SECTION B POINT LOCATION 12	SECTION B POINT LOCATION 12	SECTION B POINT LOCATION 12
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
	Max	-23.3	1.8	-262.6	-18.8	-21.7	-262.7	-6.1	-48.5	-262.6	-3.2	-66.0	-262.9
	Nominal	-29.5	0.0	-262.5	-24.8	-25.3	-262.6	-11.8	-50.8	-262.4	-8.9	-67.9	-262.7
	Min	-25.6	0.2	-262.6	-23.1	-24.0	-263.1	-10.3	-50.0	-263.1	-7.7	-67.6	-263.3
	Average	-24.5	0.3	-262.6	-21.5	-23.1	-262.9	-8.3	-49.4	-262.8	-5.5	-67.5	-263.1
	Standard Deviation (all jackets and operators)	0.672	0.248	0.013	0.906	0.503	0.085	1.014	0.339	0.111	1.062	0.246	0.098
ALL	4 *Standard Deviation	2.690	0.994	0.053	3.624	2.013	0.340	4.056	1.356	0.443	4.247	0.983	0.394
	Repeatability (pooled std dev)	0.254	0.238	0.005	0.663	0.423	0.062	0.826	0.331	0.090	0.678	0.240	0.063
	4 * Repeatability	1.017	0.953	0.020	2.651	1.693	0.249	3.304	1.324	0.361	2.713	0.959	0.252
	Upper Tolerance	-16.905	7.926	-254.988	-13.858	-15.513	-255.270	-0.725	-41.779	-255.220	2.066	-59.898	-255.454
	Lower Tolerance	-32.105	-7.274	-270.188	-29.058	-30.713	-270.470	-15.925	-56.979	-270.420	-13.134	-75.098	-270.654
	4*Repeatability % of Tolerance	6.69%	6.27%	0.13%	17.44%	11.14%	1.64%	21.74%	8.71%	2.37%	17.85%	6.31%	1.66%

		SECTION B POINT LOCATION 13	SECTION B POINT LOCATION 13	SECTION B POINT LOCATION 13	SECTION B POINT LOCATION 14	SECTION B POINT LOCATION 14	SECTION B POINT LOCATION 14	SECTION B POINT LOCATION 15	SECTION B POINT LOCATION 15	SECTION B POINT LOCATION 15	SECTION B POINT LOCATION 16	SECTION B POINT LOCATION 16	SECTION B POINT LOCATION 16
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
	Max	-20.0	-101.5	-261.4	-45.6	-114.4	-261.9	-78.3	-128.0	-262.6	-144.9	-136.7	-262.9
	Nominal	-23.7	-100.6	-262.4	-48.1	-114.6	-261.9	-79.8	-127.0	-261.9	-145.1	-134.7	-262.5
	Min	-22.7	-104.7	-261.6	-48.0	-119.7	-262.0	-79.4	-130.4	-262.7	-145.0	-140.0	-263.7
	Average	-21.4	-103.0	-261.5	-46.9	-116.7	-261.9	-79.0	-129.0	-262.7	-145.0	-137.6	-263.1
	Standard Deviation (all jackets and operators)	0.671	0.751	0.035	0.493	0.989	0.012	0.194	0.496	0.011	0.015	0.692	0.172
ALL	4 *Standard Deviation	2.686	3.002	0.142	1.970	3.956	0.049	0.777	1.984	0.042	0.059	2.767	0.690
	Repeatability (pooled std dev)	0.418	0.451	0.022	0.439	0.871	0.011	0.181	0.426	0.010	0.014	0.651	0.169
	4 * Repeatability	1.672	1.806	0.088	1.755	3.486	0.044	0.724	1.705	0.039	0.058	2.602	0.674
	Upper Tolerance	-13.806	-95.426	-253.913	-39.303	-109.144	-254.326	-71.428	-121.429	-255.056	-137.395	-129.976	-255.535
	Lower Tolerance	-29.006	-110.626	-269.113	-54.503	-124.344	-269.526	-86.628	-136.629	-270.256	-152.595	-145.176	-270.735
	4*Repeatability % of Tolerance	11.00%	11.88%	0.58%	11.55%	22.93%	0.29%	4.76%	11.22%	0.26%	0.38%	17.12%	4.43%

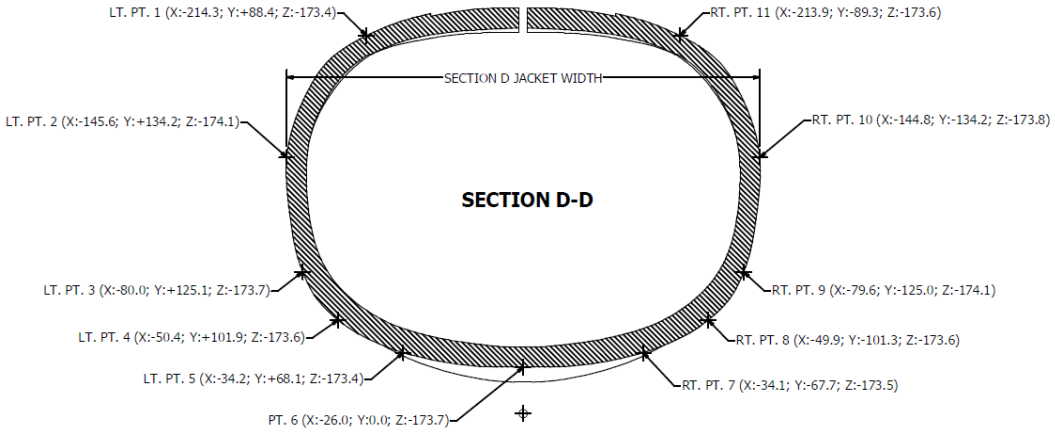
		SECTION B POINT LOCATION 17	SECTION B POINT LOCATION 17	SECTION B POINT LOCATION 17	SECTION B JACKET WIDTH
		X Distance	Y Distance	Z Distance	Y Distance
ALL	Max	-213.6	-103.9	-262.0	277.0
	Nominal	-214.0	-104.5	-262.3	267.0
	Min	-216.6	-105.8	-262.4	272.1
	Average	-215.1	-105.0	-262.2	274.0
	Standard Deviation (all jackets and operators)	0.576	0.390	0.066	1.074
	4 *Standard Deviation	2.306	1.561	0.264	4.295
	Repeatability (pooled std dev)	0.493	0.333	0.056	0.812
	4 * Repeatability	1.973	1.334	0.226	3.249
	Upper Tolerance	-207.490	-97.434	-254.605	281.607
	Lower Tolerance	-222.690	-112.634	-269.805	266.407
	4*Repeatability % of Tolerance	12.98%	8.77%	1.49%	21.37%



		SECTION C POINT LOCATION 1	SECTION C POINT LOCATION 1	SECTION C POINT LOCATION 1	SECTION C POINT LOCATION 2	SECTION C POINT LOCATION 2	SECTION C POINT LOCATION 2	SECTION C POINT LOCATION 3	SECTION C POINT LOCATION 3	SECTION C POINT LOCATION 3	SECTION C POINT LOCATION 4	SECTION C POINT LOCATION 4	SECTION C POINT LOCATION 4
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
ALL	Max	-213.2	97.5	-211.6	-145.2	138.9	-211.8	-79.3	129.4	-211.8	-41.7	108.5	-210.5
	Nominal	-214.2	96.2	-211.7	-145.4	135.5	-211.9	-80.5	126.1	-211.9	-43.2	106.2	-211.2
	Min	-214.9	96.1	-211.8	-145.5	134.5	-211.9	-81.4	125.3	-211.9	-44.9	104.7	-212.1
	Average	-214.2	96.6	-211.7	-145.4	135.9	-211.9	-80.4	126.5	-211.9	-43.5	106.2	-211.4
	Standard Deviation (all jackets and operators)	0.346	0.228	0.035	0.045	0.761	0.020	0.317	0.761	0.004	0.734	0.882	0.356
	4 *Standard Deviation	1.383	0.911	0.142	0.181	3.045	0.079	1.270	3.042	0.016	2.934	3.527	1.422
	Repeatability (pooled std dev)	0.257	0.159	0.026	0.040	0.652	0.017	0.206	0.422	0.003	0.383	0.424	0.186
	4 * Repeatability	1.027	0.637	0.105	0.160	2.609	0.070	0.824	1.688	0.010	1.533	1.697	0.743
	Upper Tolerance	-206.585	104.179	-204.062	-137.778	143.473	-204.268	-72.813	134.068	-204.255	-35.928	113.753	-203.769
	Lower Tolerance	-221.785	88.979	-219.262	-152.978	128.273	-219.468	-88.013	118.868	-219.455	-51.128	98.553	-218.969
	4*Repeatability % of Tolerance	6.75%	4.19%	0.69%	1.05%	17.17%	0.46%	5.42%	11.11%	0.07%	10.09%	11.16%	4.89%

		SECTION C POINT LOCATION 5	SECTION C POINT LOCATION 5	SECTION C POINT LOCATION 5	Midsagittal SECTION C POINT LOCATION 6	Midsagittal SECTION C POINT LOCATION 6	Midsagittal SECTION C POINT LOCATION 6	SECTION C POINT LOCATION 7	SECTION C POINT LOCATION 7	SECTION C POINT LOCATION 7	SECTION C POINT LOCATION 8	SECTION C POINT LOCATION 8	SECTION C POINT LOCATION 8
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
	Max	-20.0	69.7	-209.7	-23.8	1.9	-211.9	-21.0	-66.0	-210.2	-41.1	-106.1	-210.0
	Nominal	-23.9	68.1	-211.9	-29.3	0.1	-211.9	-23.9	-67.9	-211.8	-43.4	-106.3	-211.1
	Min	-25.9	68.2	-213.0	-27.3	0.3	-212.0	-26.1	-68.0	-213.0	-43.5	-109.2	-211.1
	Average	-23.5	68.5	-211.6	-25.9	0.4	-212.0	-23.6	-67.6	-211.6	-42.5	-107.2	-210.7
	Standard Deviation (all jackets and operators)	1.349	0.259	0.741	0.914	0.249	0.021	1.233	0.304	0.674	0.649	0.817	0.312
ALL	4 *Standard Deviation	5.397	1.035	2.962	3.655	0.995	0.083	4.930	1.217	2.695	2.597	3.269	1.249
	Repeatability (pooled std dev)	0.711	0.238	0.390	0.449	0.238	0.010	0.512	0.242	0.280	0.348	0.367	0.167
	4 * Repeatability	2.843	0.953	1.560	1.796	0.953	0.041	2.048	0.968	1.120	1.393	1.468	0.670
	Upper Tolerance	-15.888	76.101	-204.041	-18.288	8.034	-204.354	-16.002	-59.989	-204.036	-34.889	-99.646	-203.079
	Lower Tolerance	-31.088	60.901	-219.241	-33.488	-7.166	-219.554	-31.202	-75.189	-219.236	-50.089	-114.846	-218.279
	4*Repeatability % of Tolerance	18.70%	6.27%	10.26%	11.82%	6.27%	0.27%	13.48%	6.37%	7.37%	9.16%	9.66%	4.41%

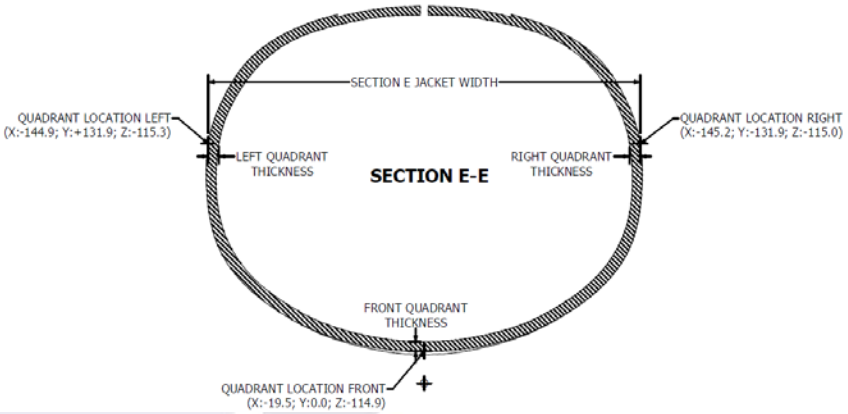
		SECTION C POINT LOCATION 9	SECTION C POINT LOCATION 9	SECTION C POINT LOCATION 9	SECTION C POINT LOCATION 10	SECTION C POINT LOCATION 10	SECTION C POINT LOCATION 10	SECTION C POINT LOCATION 11	SECTION C POINT LOCATION 11	SECTION C POINT LOCATION 11
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
	Max	-78.2	-126.9	-211.9	-144.9	-136.9	-211.8	-213.4	-95.8	-211.1
	Nominal	-79.9	-125.8	-211.9	-144.8	-135.5	-211.9	-214.0	-96.5	-211.6
	Min	-79.4	-130.1	-211.9	-145.0	-139.7	-211.9	-218.9	-99.1	-211.7
	Average	-79.1	-127.6	-211.9	-144.9	-137.5	-211.8	-214.9	-96.7	-211.5
	Standard Deviation (all jackets and operators)	0.287	0.669	0.004	0.033	0.631	0.017	0.948	0.570	0.098
ALL	4 *Standard Deviation	1.150	2.677	0.015	0.134	2.522	0.068	3.792	2.280	0.390
	Repeatability (pooled std dev)	0.219	0.433	0.003	0.031	0.565	0.016	0.754	0.543	0.078
	4 * Repeatability	0.877	1.732	0.012	0.126	2.260	0.063	3.017	2.170	0.310
	Upper Tolerance	-71.478	-120.012	-204.298	-137.279	-129.876	-204.248	-207.282	-89.081	-203.914
	Lower Tolerance	-86.678	-135.212	-219.498	-152.479	-145.076	-219.448	-222.482	-104.281	-219.114
	4*Repeatability % of Tolerance	5.77%	11.40%	0.08%	0.83%	14.87%	0.42%	19.85%	14.28%	2.04%



		SECTION D POINT LOCATION 1	SECTION D POINT LOCATION 1	SECTION D POINT LOCATION 1	SECTION D POINT LOCATION 2	SECTION D POINT LOCATION 2	SECTION D POINT LOCATION 2	SECTION D POINT LOCATION 3	SECTION D POINT LOCATION 3	SECTION D POINT LOCATION 3	SECTION D POINT LOCATION 4	SECTION D POINT LOCATION 4	SECTION D POINT LOCATION 4
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
	Max	-213.6	90.1	-173.1	-145.3	135.8	-174.0	-79.0	128.0	-173.6	-47.3	104.5	-173.5
	Nominal	-214.3	88.4	-173.4	-145.6	134.2	-174.1	-80.0	125.1	-173.7	-50.4	101.9	-173.6
	Min	-217.3	88.4	-173.4	-145.8	133.0	-174.2	-81.1	124.2	-173.7	-51.9	101.8	-173.7
	Average	-214.5	88.9	-173.3	-145.6	134.0	-174.1	-80.1	125.3	-173.7	-50.1	102.5	-173.6
	Standard Deviation (all jackets and operators)	0.787	0.427	0.083	0.061	0.483	0.028	0.301	0.679	0.013	0.793	0.553	0.035
ALL	4 *Standard Deviation	3.148	1.707	0.331	0.244	1.931	0.112	1.204	2.717	0.051	3.171	2.211	0.141
	Repeatability (pooled std dev)	0.399	0.231	0.042	0.063	0.500	0.029	0.223	0.445	0.010	0.358	0.251	0.016
	4 * Repeatability	1.595	0.922	0.168	0.251	2.002	0.115	0.891	1.781	0.038	1.433	1.003	0.064
	Upper Tolerance	-206.949	96.487	-165.738	-137.974	141.615	-166.467	-72.504	132.861	-166.089	-42.464	110.055	-166.007
	Lower Tolerance	-222.149	81.287	-180.938	-153.174	126.415	-181.667	-87.704	117.661	-181.289	-57.664	94.855	-181.207
	4*Repeatability % of Tolerance	10.49%	6.07%	1.10%	1.65%	13.17%	0.76%	5.86%	11.72%	0.25%	9.43%	6.60%	0.42%

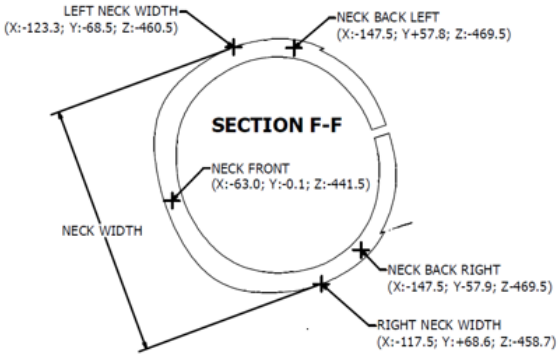
		SECTION D POINT LOCATION 5	SECTION D POINT LOCATION 5	SECTION D POINT LOCATION 5	Midsagittal SECTION D POINT LOCATION 6	Midsagittal SECTION D POINT LOCATION 6	Midsagittal SECTION D POINT LOCATION 6	SECTION D POINT LOCATION 7	SECTION D POINT LOCATION 7	SECTION D POINT LOCATION 7	SECTION D POINT LOCATION 8	SECTION D POINT LOCATION 8	SECTION D POINT LOCATION 8
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
ALL	Max	-31.1	69.6	-173.3	-21.1	4.1	-173.8	-30.0	-66.3	-173.4	-45.7	-100.9	-173.4
	Nominal	-34.2	68.1	-173.4	-26.0	0.0	-173.7	-34.1	-67.7	-173.5	-49.9	-101.3	-173.6
	Min	-35.2	68.2	-173.5	-25.2	2.5	-174.3	-34.2	-68.6	-173.5	-49.8	-104.1	-173.6
	Average	-33.5	68.6	-173.4	-24.1	2.7	-173.9	-33.0	-67.7	-173.5	-48.8	-101.8	-173.6
	Standard Deviation (all jackets and operators)	1.045	0.343	0.037	1.000	0.248	0.113	0.964	0.360	0.034	0.813	0.591	0.033
	4 *Standard Deviation	4.179	1.373	0.149	3.999	0.992	0.451	3.856	1.440	0.135	3.252	2.365	0.131
	Repeatability (pooled std dev)	0.329	0.223	0.012	0.518	0.238	0.058	0.499	0.220	0.018	0.501	0.302	0.020
	4 * Repeatability	1.318	0.893	0.047	2.073	0.954	0.234	1.997	0.880	0.070	2.005	1.209	0.081
	Upper Tolerance	-25.879	76.204	-165.800	-16.473	10.267	-166.335	-25.390	-60.129	-165.885	-41.172	-94.226	-165.956
	Lower Tolerance	-41.079	61.004	-181.000	-31.673	-4.933	-181.535	-40.590	-75.329	-181.085	-56.372	-109.426	-181.156
	4*Repeatability % of Tolerance	8.67%	5.87%	0.31%	13.64%	6.27%	1.54%	13.14%	5.79%	0.46%	13.19%	7.95%	0.53%

		SECTION D POINT LOCATION 9	SECTION D POINT LOCATION 9	SECTION D POINT LOCATION 9	SECTION D POINT LOCATION 10	SECTION D POINT LOCATION 10	SECTION D POINT LOCATION 10	SECTION D POINT LOCATION 11	SECTION D POINT LOCATION 11	SECTION D POINT LOCATION 11	SECTION D JACKET WIDTH
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	Y Distance
ALL	Max	-77.9	-125.3	-174.0	-144.9	-134.9	-173.6	-213.7	-88.6	-172.9	272.2
	Nominal	-79.6	-125.0	-174.1	-144.8	-134.2	-173.8	-213.9	-89.3	-173.6	265.0
	Min	-79.4	-128.9	-174.1	-145.2	-138.2	-173.8	-220.3	-92.3	-173.6	268.7
	Average	-78.9	-126.4	-174.0	-145.0	-136.0	-173.7	-215.0	-89.6	-173.4	270.1
	Standard Deviation (all jackets and operators)	0.322	0.715	0.014	0.074	0.769	0.038	1.499	0.770	0.159	0.866
	4 *Standard Deviation	1.287	2.861	0.055	0.295	3.076	0.151	5.995	3.078	0.634	3.464
	Repeatability (pooled std dev)	0.242	0.481	0.010	0.058	0.538	0.030	1.240	0.632	0.131	0.624
	4 * Repeatability	0.967	1.922	0.041	0.232	2.150	0.119	4.958	2.530	0.525	2.496
	Upper Tolerance	-71.328	-118.759	-166.440	-137.366	-128.438	-166.119	-207.414	-81.995	-165.841	277.653
	Lower Tolerance	-86.528	-133.959	-181.640	-152.566	-143.638	-181.319	-222.614	-97.195	-181.041	262.453
	4*Repeatability % of Tolerance	6.36%	12.65%	0.27%	1.52%	14.15%	0.78%	32.62%	16.64%	3.45%	16.42%

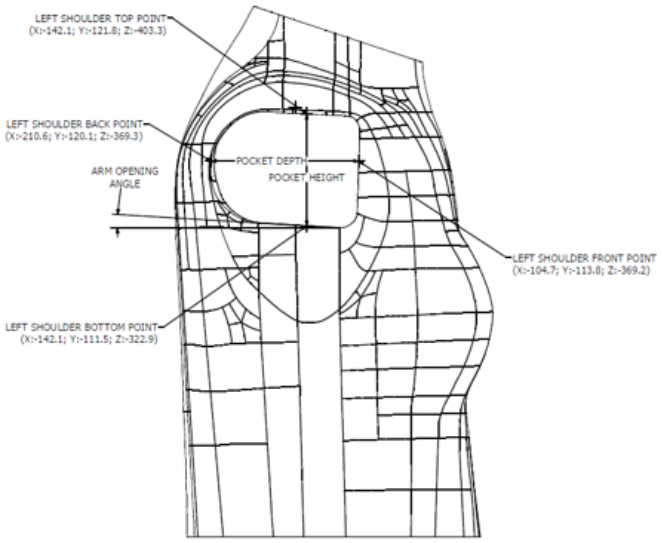


		SECTION E QUADRANT LOCATION RIGHT SIDE	SECTION E QUADRANT LOCATION RIGHT SIDE	SECTION E QUADRANT LOCATION RIGHT SIDE	SECTION E QUADRANT LOCATION FRONT	SECTION E QUADRANT LOCATION FRONT	SECTION E QUADRANT LOCATION FRONT	SECTION E QUADRANT LOCATION LEFT SIDE	SECTION E QUADRANT LOCATION LEFT SIDE	SECTION E QUADRANT LOCATION LEFT SIDE
		X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance	X Distance	Y Distance	Z Distance
ALL	Max	-144.5	132.0	-114.9	-19.2	3.0	-114.8	-144.9	-132.6	-114.9
	Nominal	-145.2	130.7	-115.0	-19.5	1.2	-114.9	-144.9	-133.1	-115.3
	Min	-145.3	127.9	-115.3	-20.8	1.4	-115.0	-145.7	-137.7	-115.3
	Average	-145.0	130.0	-115.0	-19.9	1.6	-114.9	-145.2	-134.7	-115.2
	Standard Deviation (all jackets and operators)	0.166	0.954	0.078	0.384	0.249	0.048	0.254	1.605	0.121
	4 *Standard Deviation	0.662	3.816	0.314	1.538	0.997	0.193	1.015	6.422	0.483
	Repeatability (pooled std dev)	0.144	0.843	0.068	0.232	0.239	0.029	0.145	0.824	0.069
	4 * Repeatability	0.578	3.372	0.274	0.927	0.954	0.116	0.582	3.295	0.277
	Upper Tolerance	-137.436	137.588	-107.439	-12.343	9.157	-107.261	-137.590	-127.127	-107.562
	Lower Tolerance	-152.636	122.388	-122.639	-27.543	-6.043	-122.461	-152.790	-142.327	-122.762
	4*Repeatability % of Tolerance	3.80%	22.18%	1.80%	6.10%	6.28%	0.76%	3.83%	21.68%	1.82%

		SECTION E JACKET WIDTH	SECTION E RIGHT QUADRANT THICKNESS	SECTION E LEFT QUADRANT THICKNESS	SECTION E FRONT QUADRANT THICKNESS
		Y Distance			
ALL	Max	267.1	4.9	4.8	4.9
	Nominal	261.4	6.0	6.0	6.0
	Min	259.4	4.6	4.5	4.5
	Average	262.5	4.7	4.7	4.7
	Standard Deviation (all jackets and operators)	2.182	0.076	0.103	0.100
	4 *Standard Deviation	8.729	0.306	0.413	0.402
	Repeatability (pooled std dev)	1.302	0.030	0.026	0.027
	4 * Repeatability	5.207	0.119	0.103	0.109
	Upper Tolerance	270.057	5.696	5.657	5.668
	Lower Tolerance	254.857	3.696	3.657	3.668
	4*Repeatability % of Tolerance	34.26%	5.95%	5.16%	5.45%

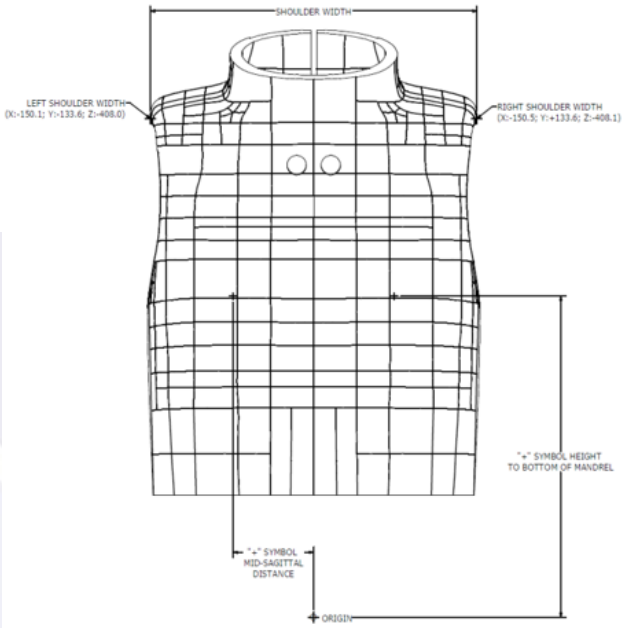


		SECTION F NECK BACK RIGHT HT FROM BTM OF MANDREL	SECTION F NECK FRONT HT FROM BTM OF MANDREL	SECTION F NECK BACK LEFT HT FROM BTM OF MANDREL	NECK WIDTH
		Z Distance	Z Distance	Z Distance	Y Distance
ALL	Max	469.6	444.3	469.9	136.7
	Nominal	469.6	441.5	469.5	137.1
	Min	463.9	435.6	463.9	133.7
	Average	467.4	440.7	467.7	135.6
	Standard Deviation (all jackets and operators)	1.254	1.859	1.057	0.594
	4 *Standard Deviation	5.016	7.437	4.230	2.376
	Repeatability (pooled std dev)	0.506	0.699	0.703	0.509
	4 * Repeatability	2.024	2.797	2.814	2.037
	Upper Tolerance	474.985	448.334	475.342	143.202
	Lower Tolerance	459.785	433.134	460.142	128.002
	4*Repeatability % of Tolerance	13.31%	18.40%	18.51%	13.40%

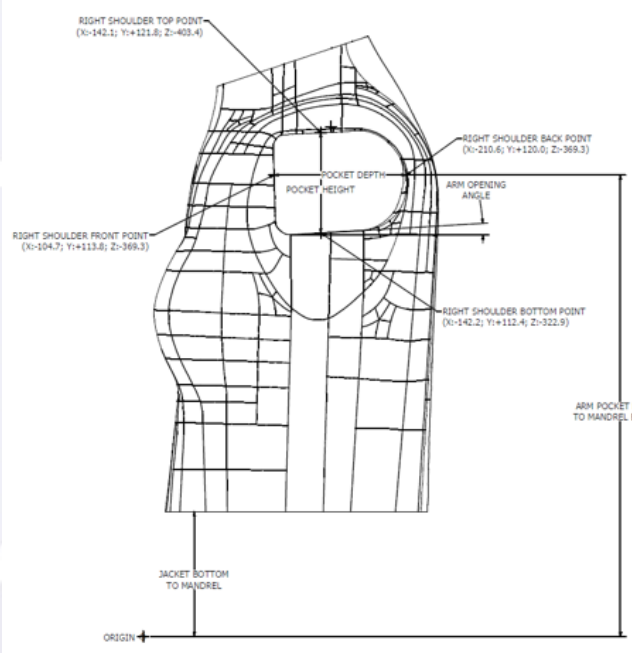


		LEFT SHOULDER POCKET HT	LEFT SHOULDER POCKET DEPTH	LEFT SHOULDER OPENING ANGLE
		Z Distance	X Distance	Z/X Angle
ALL	Max	80.0	112.2	4.8
	Nominal	80.4	105.9	4.0
	Min	72.1	102.6	2.4
	Average	77.6	109.5	3.5
	Standard Deviation (all jackets and operators)	1.917	1.713	0.625
	4 *Standard Deviation	7.667	6.854	2.502
	Repeatability (pooled std dev)	1.263	1.717	0.433
	4 * Repeatability	5.052	6.867	1.733
	Upper Tolerance	85.184	117.150	4.478
	Lower Tolerance	69.984	101.950	2.478
	4*Repeatability % of Tolerance	33.24%	45.18%	86.64%

ORIGIN



		SHOULDER WIDTH	RIGHT + HT FROM BTM OF MANDREL	RIGHT + MIDSAGITAL DIS	LEFT + HT FROM BTM OF MANDREL	LEFT + MIDSAGITAL DIS
		Y Distance	Z Distance	Y Distance	Z Distance	Y Distance
ALL	Max	272.2	264.9	66.4	265.7	65.7
	Nominal	267.2	262.2	65.6	262.2	65.6
	Min	265.5	262.8	65.1	263.4	64.2
	Average	268.7	263.8	65.7	264.3	65.1
	Standard Deviation (all jackets and operators)	1.365	0.487	0.3	0.590	0.3
	4 *Standard Deviation	5.460	1.950	1.2	2.360	1.2
	Repeatability (pooled std dev)	0.857	0.304	0.285	0.344	0.290
	4 * Repeatability	3.427	1.216	1.140	1.377	1.159
	Upper Tolerance	276.286	271.429	73.306	271.910	72.666
	Lower Tolerance	261.086	256.229	58.106	256.710	57.466
	4*Repeatability % of Tolerance	22.54%	8.00%	7.50%	9.06%	7.62%



		RIGHT SHOULDER POCKET HT	RIGHT SHOULDER POCKET DEPTH	RIGHT SHOULDER OPENING ANGLE	RIGHT ARM POCKET HT TO MANDREL BOTTOM	LEFT ARM POCKET HT TO MANDREL BOTTOM	JACKET BOTTOM TO MANDREL BOTTOM
		Z Distance	X Distance	Z/X Angle	Z Distance	Z Distance	Z Distance
ALL	Max	80.1	112.9	4.9	371.4	370.5	111.2
	Nominal	80.4	105.9	4.0	369.3	369.2	100.0
	Min	73.5	109.9	2.9	368.2	368.9	101.7
	Average	77.4	111.4	3.8	368.9	369.7	107.3
	Standard Deviation (all jackets and operators)	1.332	0.687	0.486	0.610	0.423	2.837
	4 *Standard Deviation	5.328	2.747	1.945	2.442	1.690	11.350
	Repeatability (pooled std dev)	0.835	0.473	0.381	0.564	0.362	1.053
	4 * Repeatability	3.339	1.893	1.523	2.256	1.448	4.211
	Upper Tolerance	84.974	118.983	4.772	376.534	377.328	114.859
	Lower Tolerance	69.774	103.783	2.772	361.334	362.128	99.659
	4*Repeatability % of Tolerance	21.97%	12.45%	76.17%	14.84%	9.53%	27.70%

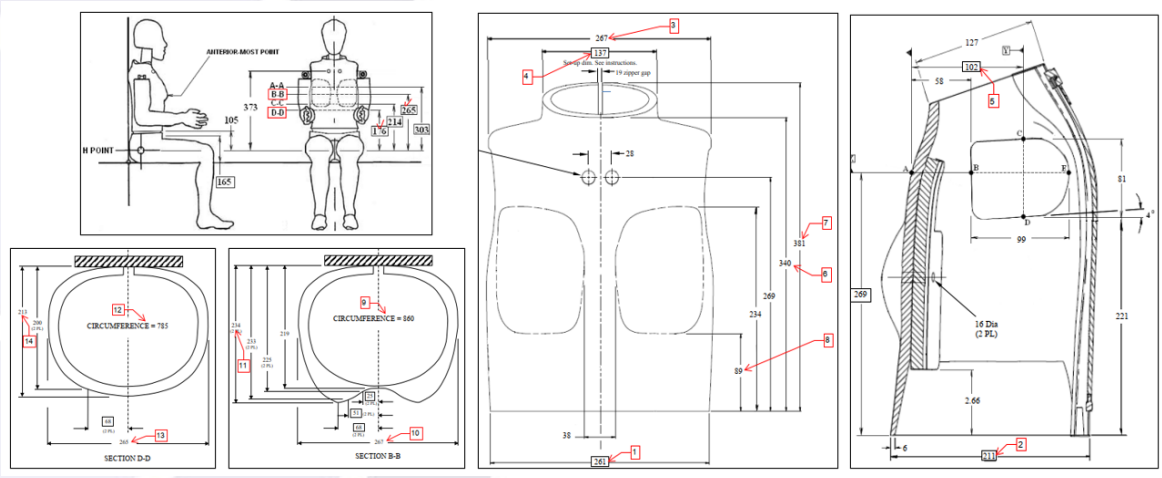
All tolerances are based on the average of the measured jackets +/- 7.6 mm, except for angles which are +/-1°. This centers the tolerances around a population of jackets. If NHTSA measures their jackets, the values of the population can be updated if desirable.

We were able to see a marked improvement in repeatability of measured values while using the mandrel. Most points pass the acceptance criteria of repeatability <=30% of tolerance with acceptable to marginal values based on the corridors provided.

We suggest updates be limited to the jacket drawing, 880105-355-H, to define a component level method of checking new jackets to the design intent. Current jacket dimensions should be made reference, and this method should be used on new jackets to check the shape. This will ensure the component is manufactured with the intended geometry and measured on the ideal fixture, the mandrel, alleviating any stack-up concerns. This method could be used by any jacket manufacturer as well as by customers to check new jackets to verify they meet the correct shape.

Round Robin using the mandrel:

Humanetics participated in a round robin with two other labs, at Ford and GM. We agreed to take a specified number of measurements both on the mandrel and on-ATD. The same mandrel and procedures were used by each participant and is provided in the attachments.



The results were favorable to the use of the mandrel; marked by more repeatable and reproducible data and noted by technicians for the ease of use. The mandrel allows for proper jacket alignment. Whereas some issues were noted with the on-dummy setups. For example, the jacket was tilted relative to the design position by the orientation of the dummy.

Comparison of Data using different collection methods:

We noted that when taking equivalent measurements, the FARO resulted in equal or better results when compared to the caliper method at the critical sections. For this reason, we suggest manufacturers use a FARO or equivalent to ensure increased precision. The manual / caliper measurement method is acceptable to marginal for basic annual inspections.

	Width Section B-B		
	Mean	Repeatability (pooled std dev)	%ofTol
Average on Mandrel (Calipers) (-MC)	273.2	1.13	29.54
Average on Mandrel (Faro) (-MF)	273.9	0.81	21.32
Average on Table (Faro) (-TF)	*	*	*
Average on ATD (Calipers) (-AC)	267.0	1.78	46.69

	Width Section D-D		
	Mean	Repeatability (pooled std dev)	%ofTol
Average on Mandrel (Calipers) (-MC)	267.3	1.26	33.13
Average on Mandrel (Faro) (-MF)	270.0	0.62	16.38
Average on Table (Faro) (-TF)	*	*	*
Average on ATD (Calipers) (-AC)	262.2	2.65	69.49

	Width bottom		
	Mean	Repeatability (pooled std dev)	%ofTol
Average on Mandrel (Calipers) (-MC)	262.3	1.31	34.46
Average on Mandrel (Faro) (-MF)	262.3	1.29	33.82
Average on Table (Faro) (-TF)	*	*	*
Average on ATD (Calipers) (-AC)	256.4	4.24	111.19

	Width shoulders		
	Mean	Repeatability (pooled std dev)	%ofTol
Average on Mandrel (Calipers) (-MC)	267.8	1.86	48.71
Average on Mandrel (Faro) (-MF)	268.5	0.86	22.49
Average on Table (Faro) (-TF)	270.3	2.45	64.23
Average on ATD (Calipers) (-AC)	264.4	1.24	32.43

	Width Section B-B	Tolerances (±0.3"/7.62mm)
Nominal	266.954	
Upper Tolerance	274.574	7.6
Lower Tolerance	259.334	-7.6

Width Section D-D	Tolerances (±0.3"/7.62mm)
264.922	
272.542	7.6
257.302	-7.6

Width shoulders	Tolerances (±0.3"/7.62mm)
266.7	
274.32	7.6
259.08	-7.6

Width bottom	Tolerances (±0.3"/7.62mm)
261.62	
269.24	7.6
254	-7.6

	Width neck		
	Mean	Repeatability (pooled std dev)	%ofTol
Average on Mandrel (Calipers) (-MC)	136.5	1.03	27.15
Average on Mandrel (Faro) (-MF)	135.6	0.52	13.76
Average on Table (Faro) (-TF)	*	*	*
Average on ATD (Calipers) (-AC)	129.2	1.88	49.38

	Bottom of Jacket To Top,FrontSide,Midline (Mandrel)		
	Mean	Repeatability (pooled std dev)	%ofTol
Average on Mandrel (Calipers) (-MC)	333.6	1.51	39.60
Average on Mandrel (Faro) (-MF)	333.1	0.79	20.69
Average on Table (Faro) (-TF)	335.7	2.78	72.86
Average on ATD (Calipers) (-AC)	334.3	1.53	40.15

	Bottom of Jacket ToXmarks/B-B,Left Side (Mandrel)		
	Mean	Repeatability (pooled std dev)	%ofTol
Average on Mandrel (Calipers) (-MC)	158.8	1.10	28.94
Average on Mandrel (Faro) (-MF)	156.8	1.05	27.45
Average on Table (Faro) (-TF)	161.5	0.63	16.48
Average on ATD (Calipers) (-AC)	159.5	1.21	31.75

	Bottom of Jacket to Xmarks/B-B,Right Side (Mandrel)		
	Mean	Repeatability (pooled std dev)	%ofTol
Average on Mandrel (Calipers) (-MC)	158.4	1.37	35.83
Average on Mandrel (Faro) (-MF)	156.4	0.95	24.85
Average on Table (Faro) (-TF)	162.0	1.26	33.13
Average on ATD (Calipers) (-AC)	159.6	1.40	36.70

	Width neck	Tolerances (±0.3"/7.62mm)
Nominal	137.16	
Upper Tolerance	144.78	7.6
Lower Tolerance	129.54	-7.6

Bottom of Jacket To Top,FrontSide,Midline (Mandrel)	Tolerances (±0.3"/7.62mm)
340.36	
347.98	7.6
332.74	-7.6

"+"Loc	Tolerances (+1%/-4%)
162.5	
170.12	7.6
154.88	-7.6

"+"Loc	Tolerances (+1%/-4%)
162.5	
170.12	7.6
154.88	-7.6

Annual Inspection Recommendation:

We propose that jackets go through an annual subset of parameters to be included as an inspection check in the Procedures for Assembly, Disassembly, and Inspection (PADI). The inspection of the eight parameters shown in the table below will check for aging shrinkage of the jacket over time. This assessment can be done using various instruments, such as FARO, calipers, height gages, etc. We suggest that jackets failing the checks provided are noted as out of tolerance and taken out of service at the user's discretion.

Proposal for Jacket Check
Width jacket bottom
Width at shoulders
Width at neck
Jacket height (bottom of jacket to most anterior point at neck)
Jacket height (bottom of jacket to symbols left side)
Jacket height (bottom of jacket to symbols right side)
Width at section b-b (at height of symbols)
Width at section d-d

Lessons learned:

There are some things to consider avoiding while measuring the chest jacket. We advise to stay away from the zipper area of the jacket, as this leads to problems with variability. The zipper tabs, both at the top and bottom of the jacket, distort the shape. Also, we noted that over time, the cable routing may deform the shape of the rear jacket.

The technicians did note having difficulty performing measurements with the FARO at the arm opening due to the double curvature design of the flesh. For this reason, we suggest that to check the arm opening length and height, the positions for making the measurements, top/bottom or front/back, be marked using the FARO to find the location and a pencil to mark the jacket. The height and length of the arm opening can then be measured using a caliper. This is the easiest way to overcome the double curvature of the jacket in this area. We were unable to evaluate this method due to time constraints, but it should be a reasonable approach.

Summary:

Humanetics recommends replacing the current jacket only checks in the NPRM with the measurement of critical overall dimensions and surface deviation points on the mandrel using a FARO or equivalent CMM measurement system. All current dimensions on the jacket drawing

should be made reference, and the drawing should point to the measurement procedure for checking the design and shape of new jackets.

Humanetics recommends an annual check of jackets by users with a measurement of 8 critical dimensions on the mandrel. This measurement can be done using a FARO, equivalent CMM, or manual measurements tools like calipers and height gages. These 8 critical measurements will check for shrinkage that could occur over time as a jacket ages. Based on these measurements the user will be alerted that a jacket may have changed too much, and they can consider whether it is still appropriate to use.

Humanetics has included with these submission comments a Microsoft Excel workbook containing all data and calculations for data shown in these comments.

3D CAD information for the mandrel is available. Humanetics was unable to upload the CAD file due to restrictions on file type for NPRM submissions. However, Humanetics is willing to provide NHTSA with the 3D CAD file to upload to the NPRM for evaluation. If it is included in the final rule, it can be made available as public domain along with the other NHTSA documentation. The 3D CAD could be used by anyone to create a physical mandrel by utilizing common manufacturing technologies. A physical mandrel can be provided to NHTSA for evaluation purposes upon request. If there are any additional questions, or NHTSA requires further information regarding this submission, do not hesitate to contact us. Thank you.

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