

5th% Hybrid III Chest Jacket Study

Ford, GM, and HIS

Test Setup:

- Three SAE Harmonized Chest Jackets
 - Ford – New
 - GM & HIS – In use
 - Jackets were measured by each member at their respective labs
- One HIS mandrel
 - Mandrel reflects the updated version that will be proposed by HIS except for the shoulder/arm area but this should not affect the dimensions taken
 - Mandrel was used by each member at their respective labs
- Five 5th% Hybrid IIIs (5H3s) (Ford – 1 cabled, GM – 2 cabled & 1 iDAS, HIS – 1 cabled)
 - 5H3s all passed dynamic certification
- Five operators (Ford – 2, GM – 2, HIS – 1)
- Two measurement methods (Ford, GM & HIS – manual measurements, HIS – Faro arm measurements)
 - Faro arm measurements were only taken on the mandrel and fewer dimensions were measured

Matrix:

Lab	Technician	Method	Jacket	Mandrel	n	ATD 1	n	ATD 2	n	ATD 3	n
Ford	F1	Manual	Ford	HIS-M1	3	F-369	3				
			GM	HIS-M1	3	F-369	3				
			HIS	HIS-M1	3	F-369	3				
	F2	Manual	Ford	HIS-M1	3	F-369	3				
			GM	HIS-M1	3	F-369	3				
			HIS	HIS-M1	3	F-369	3				
GM	G1	Manual	Ford	HIS-M1	3	G-6	3	G-27	3	G-29 (iDAS)	1
			GM	HIS-M1	3	G-6	3	G-27	3	G-29 (iDAS)	1
			HIS	HIS-M1	3	G-6	3	G-27	3	G-29 (iDAS)	1
	G2	Manual	Ford	HIS-M1	3	G-6	3	G-27	1	G-29 (iDAS)	1
			GM	HIS-M1	3	G-6	3	G-27	1	G-29 (iDAS)	1
			HIS	HIS-M1	3	G-6	3	G-27	1	G-29 (iDAS)	1
HIS	H1	Manual	Ford	HIS-M1	3	CAE	3				
			GM	HIS-M1	3	CAE	3				
			HIS	HIS-M1	3	CAE	3				
		Faro Arm	Ford	HIS-M1	3						
			GM*	HIS-M1	3						
			HIS*	HIS-M1	3						

* Two out of three measurements of the width of the neck (4) provided. The third measurement was at a wrong location and deleted.

Common Dimensions: On-ATD and On-Mandrel

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|---|--|
| <p>1. W_{bottom}^* – Width at bottom of jacket
261.6 mm, range: 251.2 - 264.2mm (10.3", range: 10.2 - 10.4")</p> <p>2. D_{bottom}^* – Depth at bottom of jacket
210.8 mm, range: 202.4 – 212.9 mm (8.3", range: 8.0 -8.4")</p> <p>3. $W_{\text{shoulders}}^*$ – Width at the top of shoulders
266.7 mm, range: 256.0 – 269.4 mm (10.5", range 10.1 – 10.6")</p> <p>4. W_{neck}^* – Width at top of neck
137.2 mm, range: 131.7 - 138.5 mm (5.4", range: 5.2 – 5.5")</p> <p>5. D_{neck}^{**} (skin to zipper) – Depth of neck, front edge of skin to rear edge of zipper, parallel to the neck opening
127 mm, range: 121.9 – 128.3 mm (5.0", range: 4.8 – 5.1")</p> <p>6. Bottom of Jacket to Top, Front Side, Midline*
340.4 mm, range: 326.7 – 343.8 mm (13.4", range: 12.9 – 13.5")</p> <p>7. Bottom of Jacket to Top, Back Side, Midline*
381 mm, range: 365.8 – 384.8 mm (15", range: 14.4 – 15.2")</p> <p>8. Bottom of Jacket to Xmarks, B-B, Left Side – appx. 265 mm above H-point and 68 mm laterally from midline*
162.6 mm, range: 156.1 – 164.2 mm (6.4", range: 6.1 – 6.5")</p> | <p>9. Bottom of Jacket to Xmarks, B-B, Right Side - appx. 265 mm above H-point and 68 mm laterally from midline*
162.6 mm , range: 156.1 – 164.2 mm (6.4", range: 6.1 -6.5")</p> <p>12. H-Point to Xmarks, B-B, Left Side (ATD only)
264.2 mm (10.4")</p> <p>13. H-Point to Xmarks, B-B, Right Side (ATD only)
264.2 mm (10.4")</p> <p>14. $C_{\text{B-B}}$ at Xmarks† – Circumference at crossmarks (\approx 265 mm above H-point)
860.0 mm, range: 855.0 – 865.0 mm (33.86", range: 33.7 – 34.1")</p> <p>15. $W_{\text{B-B}}$ at Xmarks‡ – Width at crossmarks (\approx 265 mm above H-point)
267.0 mm, range: 259.3 – 274.6 mm (10.51", range: 10.2 – 10.8")</p> <p>16. $D_{\text{B-B}}$ at Xmarks‡ – Depth at crossmarks (\approx 265 mm above H-point)
233.9 mm, range: 226.3 – 241.6 mm (9.21", range: 8.9 – 9.5")</p> <p>17. $C_{\text{D-D}}^{\ddagger}$ - Circumference at D-D (176 mm up from H-point)
786.9 mm, range: 779.3 – 794.5 mm (30.98", range: 30.7 – 31.3")</p> <p>18. $W_{\text{D-D}}^{\ddagger}$ – Width at D-D (176 mm up from H-point)
264.9 mm, 257.3 – 272.5 7.6 mm (10.43", range: 10.1 – 10.7")</p> <p>19. $D_{\text{D-D}}^{\ddagger}$ – Depth at D-D (176 mm up from H-point)
214.9 mm, range: 207.3 – 222.5 mm (8.46", range: 8.2 – 8.8")</p> |
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*NHTSA, Engineering Change Proposal, Revision K, Hybrid III 5th Percentile Female Test Dummy, Part 572, Subpart O, p. 17, Note 3: Tolerance +1%/-4% , 11/2019

**NHTSA, Measurement Procedure: Chest Jacket Dimensions, Hybrid III 5th % Female Test Dummy, p. 4 Fig. 2, nominal dimension; Tolerances from NHTSA, Eng. Change Prop., Rev. K, Hybrid III 5th % Female Test Dummy, Part 572, Subpart O, p. 17, Note 3: Tolerance +1%/-4% , 11/2019

†NHTSA, Engineering Change Proposal, Revision K, Hybrid III 5th Percentile Female Test Dummy, Part 572, Subpart O, p. 36, Change 3 2nd Table, 11/2019

‡ NHTSA, Engineering Change Proposal, Revision K, Hybrid III 5th Percentile Female Test Dummy, Part 572, Subpart O, p. 27, Note 5, 11/2019

Unique Dimensions: On-ATD or On-Mandrel

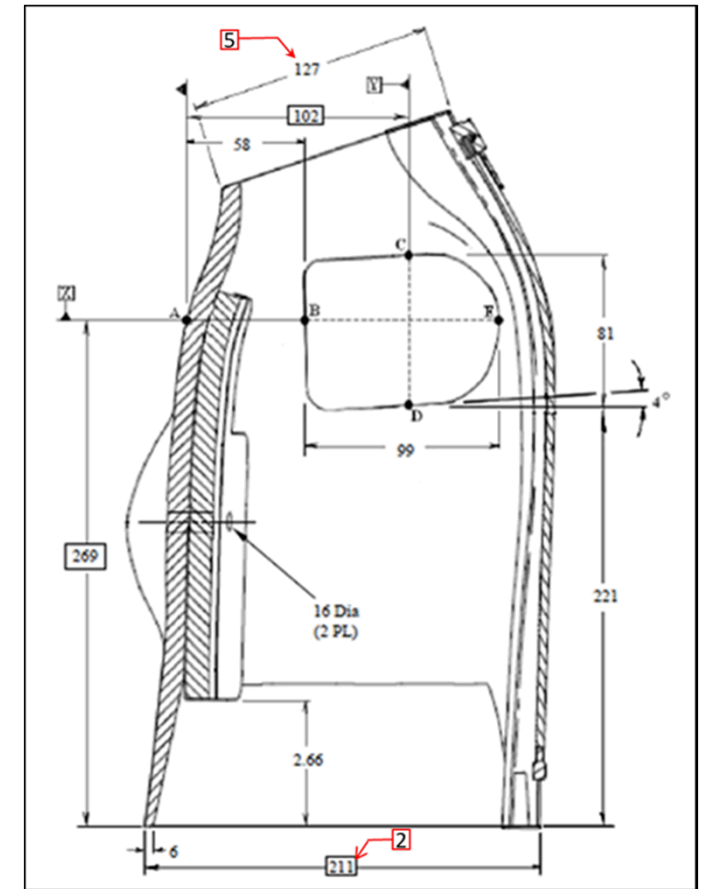
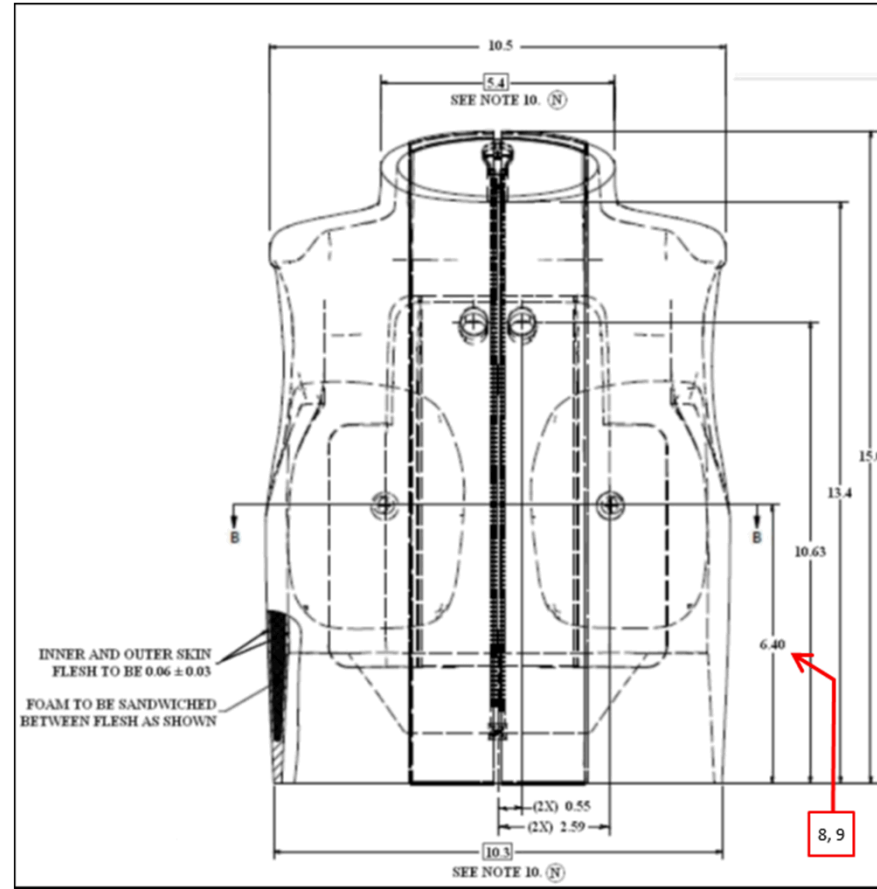
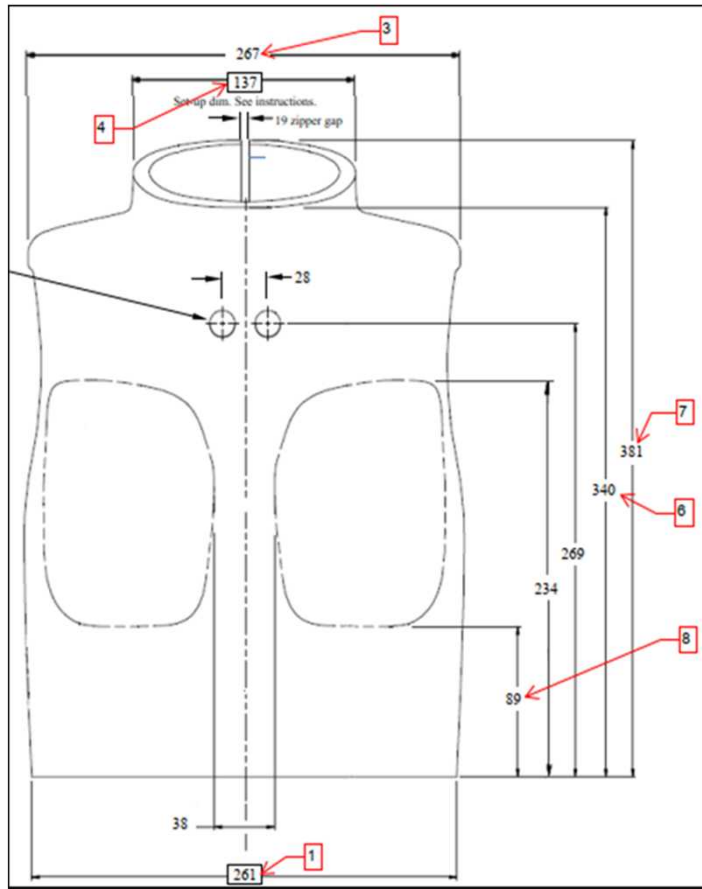
On-ATD only:

- 10. H-Point to Top, FrontSide, Midline
- 11. H-Point to Top, BackSide, Midline
- 20. Bottom of Jacket to Table (Ford only)
Ford ATD measurement: Bottom of Jacket to Table the ATD was seated on; distances are not equivalent go mandrel measurement

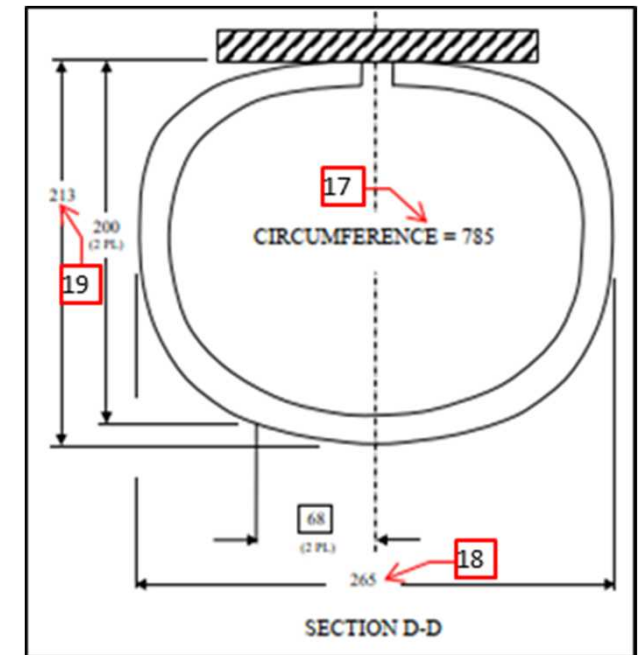
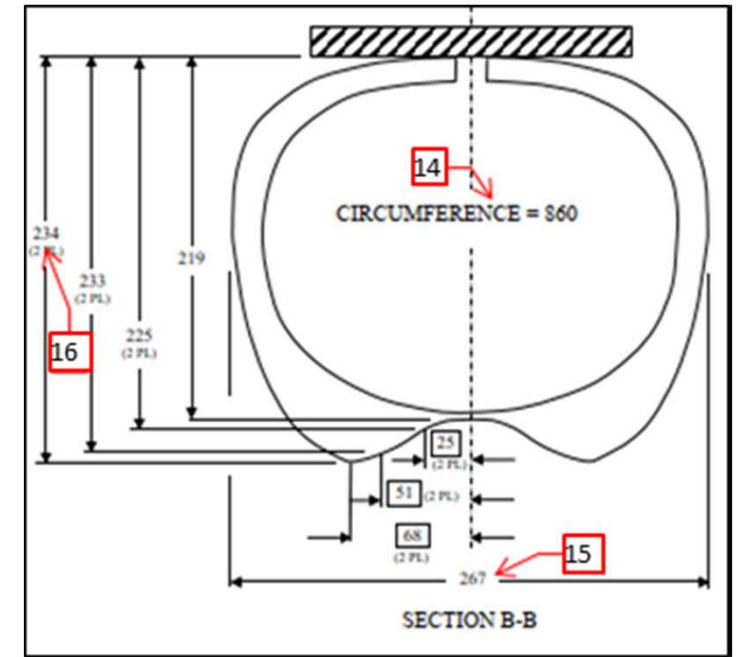
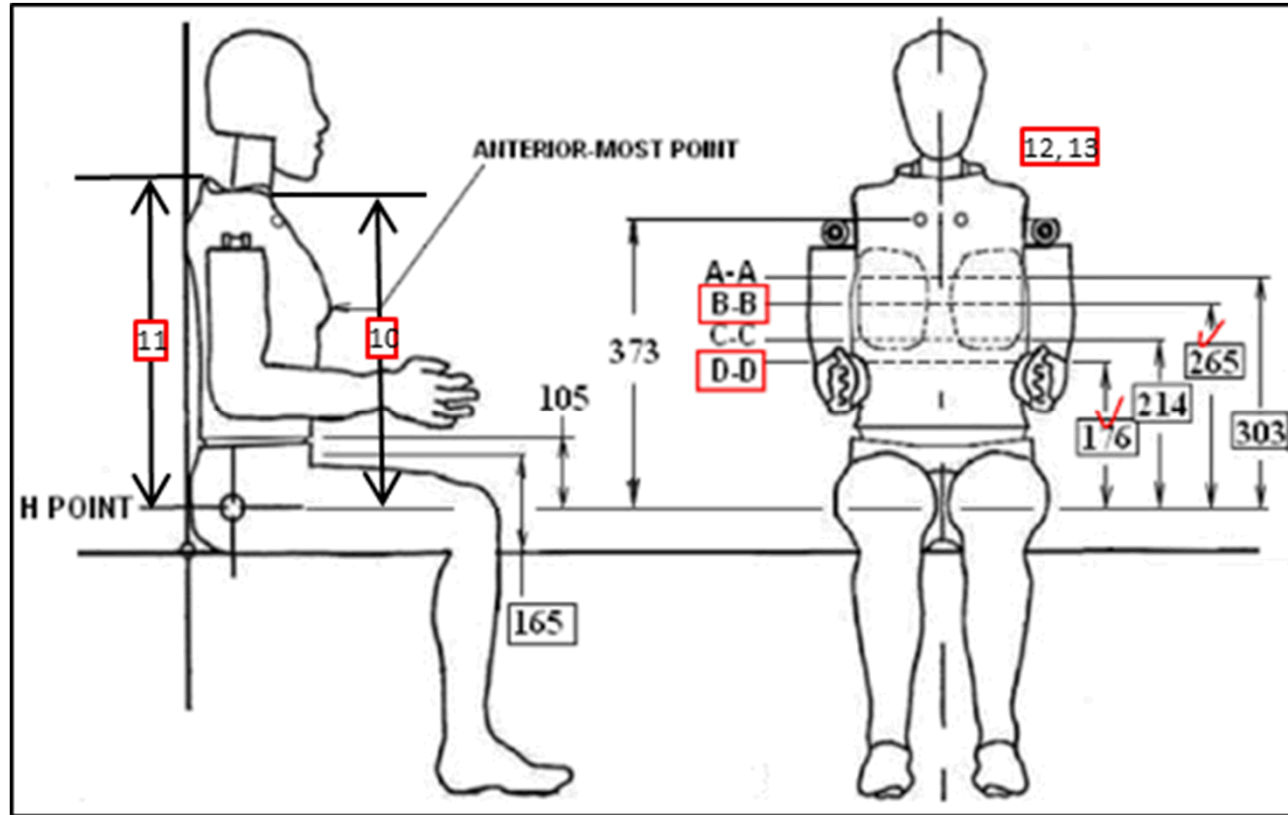
On-Mandrel only:

- 20. Bottom of Jacket to Table
Ford ATD measurement: Bottom of Jacket to Table the mandrel was on

Figures of Dimensions:



Figures of Dimensions:



Overall: Combined on mandrel and on ATD measurements

					MEASUREMENTS (in mm)																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Setup	OnVsOff	ATD SN	Jacket SN	Mandrel SN	W _{bottom}	D _{bottom}	W _{shoulders}	W _{neck}	D _{neck} (skin to zipper)	Bottom of Jacket to Top,FrontSide, Midline	Bottom of Jacket to Top,BackSide, Midline	Bottom of Jacket to ToXmarks/B-B,Left Side	Bottom of Jacket to Xmarks/B-B,Right Side	H-Point to Top,FrontSide, Midline (ATD only)	H-Point to Top,BackSide, Midline (ATD only)	H-Point to Xmarks/B-B,Left Side (ATD only)	H-Point to Xmarks/B-B,Right Side (ATD only)	C _{B-B} at X-marks	W _{B-B}	D _{B-B}	C _{D-D} [†]	W _{D-D} [†]	D _{D-D} [†]	Bottom of Jacket to Table
On Mandrel and ATD: Ford, HIS & GM ATDs 6, 27, 29																								
GM Jacket				Average	259.70	222.19	266.75	130.61	142.06	334.62	374.64	159.60	159.20	446.33	485.57	277.57	276.67	862.94	270.02	237.28				
				SD (sample)	3.90	7.49	2.45	5.36	3.46	1.73	2.00	1.57	1.57	10.42	8.65	11.59	12.08	4.52	3.47	3.34				
				CV	1.50%	3.37%	0.92%	4.11%	2.44%	0.52%	0.53%	0.98%	0.99%	2.33%	1.78%	4.18%	4.37%	0.52%	1.29%	1.41%				
Ford Jacket				Average	256.30	218.69	265.51	133.74	139.92	334.60	377.64	159.26	159.26	447.90	492.52	278.10	277.52	859.19	270.15	234.75				
				SD (sample)	6.27	8.66	2.35	3.14	3.89	1.58	2.11	1.53	1.59	9.48	11.40	10.29	10.41	5.57	3.28	3.72				
				CV	2.45%	3.96%	0.88%	2.35%	2.78%	0.47%	0.56%	0.96%	1.00%	2.12%	2.32%	3.70%	3.75%	0.65%	1.21%	1.59%				
HIS Jacket				Average	257.94	219.28	265.34	133.04	137.33	331.58	375.19	158.09	157.99	447.33	494.38	278.86	279.10	860.14	270.39	233.83				
				SD (sample)	5.93	10.69	2.50	3.44	3.50	1.82	1.89	1.44	1.98	6.76	7.06	9.69	9.47	4.10	3.34	3.92				
				CV	2.30%	4.87%	0.94%	2.58%	2.55%	0.55%	0.50%	0.91%	1.26%	1.51%	1.43%	3.47%	3.39%	0.48%	1.23%	1.68%				
All				Average	257.98	220.06	265.87	132.47	139.77	333.60	375.82	158.98	158.82	447.19	490.83	278.17	277.76	860.76	270.19	235.29				
				SD (sample)	5.60	9.09	2.49	4.27	4.08	2.22	2.38	1.63	1.81	8.90	9.84	10.39	10.58	4.99	3.34	3.92				
				CV	2.17%	4.13%	0.94%	3.23%	2.92%	0.67%	0.63%	1.03%	1.14%	1.99%	2.00%	3.74%	3.81%	0.58%	1.24%	1.66%				

- GM Jacket: Three average responses exceeded tolerances (D_{bottom}, W_{neck}, D_{neck}); four responses had a CV > 3% (D_{bottom}, W_{neck}, H-point to X-marks, both left and right sides)
- Ford Jacket: Two average responses exceeded tolerances (D_{bottom}, D_{neck}); three responses had a CV > 3% (D_{bottom}, H-point to X-marks, both left and right sides)
- HIS Jacket: Two average responses exceeded tolerances (D_{bottom}, D_{neck}); three responses had a CV > 3% (D_{bottom}, H-point to X-marks, both left and right sides)
- All Jackets: Two average responses exceeded tolerances (D_{bottom}, D_{neck}); four responses had a CV > 3% (D_{bottom}, W_{neck}, H-point to X-marks, both left and right sides)

Overall: On mandrel vs. on 5H3s

		MEASUREMENTS (in mm)																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Setup	Mandrel SN	W _{bottom}	D _{bottom}	W _{shoulders}	W _{neck}	D _{neck} (skin to zipper)	Bottom of Jacket To Top,FrontSide, Midline	Bottom of Jacket to Top,BackSide, Midline	Bottom of Jacket To Xmarks/B-,Left Side	Bottom of Jacket to Xmarks/B-,Right Side	H-Point To Top,FrontSide, Midline (ATD only)	H-Point to Top,BackSide, Midline (ATD only)	H-Point to Xmarks/B-,Left Side (ATD only)	H-Point to Xmarks/B-,Right Side (ATD only)	C _{B-B} at X-marks	W _{B-B}	D _{B-B}	C _{D-D} [†]	W _{D-D} [†]	D _{D-D} [†]	Bottom of Jacket to Table
On Mandrel: All (manual + Faro) measurements																					
GM Jacket	Average	262.30	215.47	268.95	136.31	139.20	334.11	375.40	158.85	158.32	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	861.00	273.31	234.73	789.27	267.44	217.13	108.20
	SD (sample)	1.53	4.26	1.41	1.42	2.81	1.82	0.99	1.30	1.27	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	5.36	1.01	1.58	4.32	1.40	4.47	6.89
	CV	0.58%	1.98%	0.52%	1.04%	2.02%	0.55%	0.26%	0.82%	0.80%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.62%	0.37%	0.67%	0.55%	0.52%	2.06%	6.37%
Ford Jacket	Average	261.60	211.67	267.16	136.59	139.60	334.13	379.53	158.57	158.45	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	857.07	273.11	230.93	785.00	267.96	210.80	105.93
	SD (sample)	1.44	2.99	1.98	0.87	2.72	1.88	1.06	1.79	1.87	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	6.08	1.35	1.33	4.84	1.32	1.97	4.85
	CV	0.55%	1.41%	0.74%	0.63%	1.95%	0.56%	0.28%	1.13%	1.18%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.71%	0.50%	0.58%	0.62%	0.49%	0.94%	4.58%
HIS Jacket	Average	262.37	210.87	267.30	136.09	136.60	331.10	376.27	157.48	156.99	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	857.67	273.41	230.40	782.60	267.73	208.60	107.33
	SD (sample)	1.02	1.96	1.80	0.96	3.40	1.99	1.03	1.80	2.05	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	3.89	0.60	0.91	6.07	1.68	1.72	4.95
	CV	0.39%	0.93%	0.68%	0.70%	2.49%	0.60%	0.27%	1.14%	1.30%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.45%	0.22%	0.40%	0.78%	0.63%	0.83%	4.61%
All	Average	262.09	212.67	267.80	136.34	138.47	333.11	377.07	158.30	157.92	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	858.58	273.28	232.02	785.62	267.71	212.18	107.16
	SD (sample)	1.37	3.74	1.90	1.10	3.22	2.36	2.06	1.72	1.85	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	5.36	1.02	2.33	5.73	1.46	4.68	5.59
	CV	0.52%	1.76%	0.71%	0.81%	2.32%	0.71%	0.55%	1.09%	1.17%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.62%	0.37%	1.00%	0.73%	0.55%	2.21%	5.22%
On ATD: Ford, HIS & GM ATDs 6, 27, 29																					
GM Jacket	Average	257.48	227.00	264.86	126.00	144.10	335.05	374.10	160.24	159.95	446.33	485.57	277.57	276.67	864.33	267.19	239.10				206.33
	SD (sample)	3.96	5.22	1.28	1.26	2.23	1.56	2.36	1.51	1.43	10.42	8.65	11.59	12.08	3.29	1.97	3.08				8.02
	CV	1.54%	2.30%	0.48%	1.00%	1.55%	0.47%	0.63%	0.94%	0.89%	2.33%	1.78%	4.18%	4.37%	0.38%	0.74%	1.29%				3.88%
Ford Jacket	Average	251.76	223.71	264.10	131.29	140.14	335.00	376.29	159.86	159.95	447.90	492.52	278.10	277.52	860.71	267.62	237.48				205.33
	SD (sample)	5.11	7.84	1.61	2.10	4.60	1.18	1.55	0.96	0.86	9.48	11.40	10.29	10.41	4.77	2.06	2.06				9.71
	CV	2.03%	3.51%	0.61%	1.60%	3.28%	0.35%	0.41%	0.60%	0.54%	2.12%	2.32%	3.70%	3.75%	0.55%	0.77%	0.87%				4.73%
HIS Jacket	Average	254.14	225.29	263.67	130.57	137.86	332.00	374.43	158.62	158.86	447.33	494.38	278.86	279.10	861.90	267.81	236.29				207.89
	SD (sample)	5.76	10.31	1.65	2.62	3.55	1.58	2.01	0.74	1.49	6.76	7.06	9.69	9.47	3.32	2.38	3.33				8.43
	CV	2.26%	4.57%	0.63%	2.01%	2.58%	0.48%	0.54%	0.47%	0.94%	1.51%	1.43%	3.47%	3.39%	0.38%	0.89%	1.41%				4.06%
All	Average	254.46	225.33	264.21	129.29	140.70	334.02	374.94	159.57	159.59	447.19	490.83	278.17	277.76	862.32	267.54	237.62				206.52
	SD (sample)	5.45	8.04	1.58	3.12	4.39	2.03	2.20	1.30	1.38	8.90	9.84	10.39	10.58	4.08	2.12	3.06				8.47
	CV	2.14%	3.57%	0.60%	2.41%	3.12%	0.61%	0.59%	0.82%	0.86%	1.99%	2.00%	3.74%	3.81%	0.47%	0.79%	1.29%				4.10%

Overall: On mandrel vs. on 5H3s (cont.)

- GM Jacket:
 - On mandrel, two average responses exceeded tolerances (Dbottom, Dneck); one response had a CV > 3% (Bottom of Jacket to Table).
 - On 5H3, three average responses exceeded tolerances (Dbottom, Wneck, Dneck); three responses had a CV > 3% (H-Point to X-marks, both sides, Bottom of Jacket to Table). The maximum CV was 4.37%, H-Point to X-marks, right side.
- Ford Jacket:
 - On mandrel, one average response exceeded tolerances (Dneck); one response had a CV > 3% (Bottom of Jacket to Table).
 - On 5H3s, three average responses exceeded tolerances (Dbottom, Wneck, Dneck); five responses had a CV > 3% (Dbottom, Dneck, H-Point to X-marks, both sides, Bottom of Jacket to Table). The maximum CV was 3.75%, H-Point to X-marks, right side, excluding the Bottom of Jacket to Table response.
- HIS Jacket:
 - On mandrel, one average response exceeded tolerances (Dneck); one response had a CV > 3% (Bottom of Jacket to Table).
 - On 5H3s, three average responses exceeded tolerances (Dbottom, Wneck, Dneck); four responses had a CV > 3% (Dbottom, H-Point to X-marks, both sides, Bottom of Jacket to Table). The maximum CV was 4.57%, Dbottom.
- All Jackets:
 - On mandrel, one average response exceeded tolerances (Dneck); one response had a CV > 3% (Bottom of Jacket to Table).
 - On 5H3s, three average responses exceeded tolerances (Dbottom, Wneck, Dneck); five responses had a CV > 3% (Dbottom, Dneck, H-Point to X-marks, both sides, Bottom of Jacket to Table). The maximum CV was 3.81%, H-Point to X-marks, right side, excluding the Bottom of Jacket to Table response.
 - Note: The Bottom of Jacket to Table response was not considered when choosing the response with the maximum CV since this is not a NHTSA specified response. Additionally, on the 5H3s, Ford was the only lab to measure this parameter.

GM Lab: Cabled (G-6, G-27) vs iDAS (G-29) 5H3s

		MEASUREMENTS (in mm)																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Setup	Mandrel SN	W _{bottom}	D _{bottom}	W _{shoulders}	W _{neck}	D _{neck} (skin to zipper)	Bottom of Jacket To Top,FrontSide, Midline	Bottom of Jacket to Top,BackSide, Midline	Bottom of Jacket To Xmarks/B- B,Left Side	Bottom of Jacket to Xmarks/B- B,Right Side	H-Point To Top,FrontSide, Midline (ATD only)	H-Point to Top,BackSide, Midline (ATD only)	H-Point To Xmarks/B- B,Left Side (ATD only)	H-Point to Xmarks/B- B,Right Side (ATD only)	C _{B-B} at X-marks	W _{B-B}	D _{B-B}	C _{D-D} [†]	W _{D-D} [†]	D _{D-D} [†]
ATDs 6 & 27																				
GM Jacket	Average	255.80	230.30	264.60	125.90	144.50	334.90	375.30	161.10	160.50	439.60	479.10	274.10	272.50	865.50	268.80	237.10	796.70	263.10	227.50
	SD (sample)	2.30	4.55	1.43	1.29	1.58	1.52	1.06	1.52	1.72	5.23	7.26	4.04	4.17	3.41	1.23	2.81	4.08	1.45	2.17
	CV	0.90%	1.97%	0.54%	1.02%	1.09%	0.46%	0.28%	0.95%	1.07%	1.19%	1.52%	1.47%	1.53%	0.39%	0.46%	1.18%	0.51%	0.55%	0.96%
Ford Jacket	Average	247.90	228.80	264.30	132.40	140.30	334.60	376.50	159.70	159.90	443.50	485.20	277.00	275.80	863.60	268.50	237.80	795.33	263.11	225.00
	SD (sample)	1.45	5.29	1.70	2.22	5.56	1.07	1.65	0.82	0.88	7.32	11.21	3.23	3.16	4.65	1.43	2.74	2.78	4.04	2.06
	CV	0.58%	2.31%	0.64%	1.68%	3.96%	0.32%	0.44%	0.52%	0.55%	1.65%	2.31%	1.17%	1.14%	0.54%	0.53%	1.15%	0.35%	1.54%	0.92%
HIS Jacket	Average	250.80	229.40	264.60	132.70	138.00	331.90	375.20	158.80	159.30	445.00	490.60	277.40	277.60	863.30	269.30	238.20	796.67	260.44	223.78
	SD (sample)	4.57	4.65	1.07	1.16	2.79	1.20	1.87	0.63	1.95	4.69	7.89	6.40	6.28	3.56	2.00	2.94	2.50	3.36	2.44
	CV	1.82%	2.03%	0.41%	0.87%	2.02%	0.36%	0.50%	0.40%	1.22%	1.05%	1.61%	2.31%	2.26%	0.41%	0.74%	1.23%	0.31%	1.29%	1.09%
All	Average	251.50	229.50	264.50	130.33	140.93	333.80	375.67	159.87	159.90	442.70	484.97	276.17	275.30	864.13	268.87	237.70	796.25	262.25	225.50
	SD (sample)	4.45	4.71	1.38	3.56	4.50	1.85	1.63	1.41	1.60	6.11	9.88	4.82	5.03	3.90	1.57	2.77	3.18	3.24	2.67
	CV	1.77%	2.05%	0.52%	2.73%	3.19%	0.55%	0.43%	0.88%	1.00%	1.38%	2.04%	1.75%	1.83%	0.45%	0.58%	1.16%	0.40%	1.24%	1.19%
ATD 29 (iDAS)																				
GM Jacket	Average	250.50	230.50	265.00	124.50	147.00	335.00	368.50	160.50	160.00	437.50	484.50	261.50	260.00	865.50	266.00	243.50	797.50	259.50	225.00
	SD (sample)	2.12	3.54	0.00	0.71	2.83	1.41	0.71	0.71	1.41	2.12	2.12	0.71	1.41	0.71	1.41	2.12	2.12	2.12	1.41
	CV	0.85%	1.53%	0.00%	0.57%	1.92%	0.42%	0.19%	0.44%	0.88%	0.48%	0.44%	0.27%	0.54%	0.08%	0.53%	0.87%	0.27%	0.82%	0.63%
Ford Jacket	Average	248.50	227.00	262.00	130.00	139.50	335.50	375.50	161.50	161.00	439.00	488.50	261.00	260.50	863.50	266.00	239.00	794.00	259.50	223.50
	SD (sample)	4.95	5.66	0.00	1.41	9.19	0.71	0.71	0.71	0.00	0.00	4.95	5.66	6.36	2.12	1.41	0.00	7.07	0.71	2.12
	CV	1.99%	2.49%	0.00%	1.09%	6.59%	0.21%	0.19%	0.44%	0.00%	0.00%	1.01%	2.17%	2.44%	0.25%	0.53%	0.00%	0.89%	0.27%	0.95%
HIS Jacket	Average	252.50	240.00	261.00	127.00	144.50	332.50	372.50	159.00	159.00	440.00	492.00	267.00	267.00	860.50	266.00	234.50	787.50	260.00	221.50
	SD (sample)	0.71	21.21	1.41	0.00	3.54	0.71	2.12	0.00	0.00	0.00	2.83	0.00	0.00	0.71	1.41	2.12	3.54	0.00	2.12
	CV	0.28%	8.84%	0.54%	0.00%	2.45%	0.21%	0.57%	0.00%	0.00%	0.00%	0.57%	0.00%	0.00%	0.08%	0.53%	0.90%	0.45%	0.00%	0.96%
All	Average	250.50	232.50	262.67	127.17	143.67	334.33	372.17	160.33	160.00	438.83	488.33	263.17	262.50	863.17	266.00	239.00	793.00	259.67	223.33
	SD (sample)	3.02	11.62	1.97	2.56	5.72	1.63	3.31	1.21	1.10	1.47	4.32	3.92	4.55	2.48	1.10	4.24	5.83	1.03	2.16
	CV	1.20%	5.00%	0.75%	2.02%	3.98%	0.49%	0.89%	0.76%	0.68%	0.34%	0.88%	1.49%	1.73%	0.29%	0.41%	1.78%	0.74%	0.40%	0.97%

GM Lab: Cabled (G-6, G-27) vs iDAS (G-29) 5H3s (cont.)

- GM Jacket:
 - With cabled 5H3s, four average responses exceeded tolerances (D_{bottom}, W_{neck}, D_{neck}, C_{B-B} at X-marks); no responses had a CV > 3%.
 - With iDAS 5H3, six average responses exceeded tolerances (W_{bottom}, D_{bottom}, W_{neck}, D_{neck}, C_{B-B} at X-marks, D_{B-B}); no responses had a CV > 3%.
- Ford Jacket:
 - With cabled 5H3s, three average responses exceeded tolerances (W_{bottom}, D_{bottom}, D_{neck}); one response had a CV > 3% (D_{neck}).
 - With iDAS 5H3, four average responses exceeded tolerances (W_{bottom}, D_{bottom}, W_{neck}, D_{neck}); one response had a CV > 3% (D_{neck} – 6.59%).
- HIS Jacket:
 - With cabled 5H3s, three average responses exceeded tolerances (W_{bottom}, D_{bottom}, D_{neck}); no responses had a CV > 3%.
 - With iDAS 5H3, three average responses exceeded tolerances (W_{bottom}, D_{bottom}, W_{neck}, D_{neck}); one response had a CV > 3% (D_{bottom} – 8.84%).
- All Jackets:
 - With cabled 5H3s, three average responses exceeded tolerances (D_{bottom}, W_{neck}, D_{neck}); one response had a CV > 3% (D_{neck} – 3.19%).
 - With iDAS 5H3, four average responses exceeded tolerances (W_{bottom}, D_{bottom}, W_{neck}, D_{neck}); two responses had a CV > 3% (D_{bottom}, D_{neck}). The maximum CV was 5.00%, D_{bottom}.

HIS Lab: On mandrel measurements, manual vs. Faro arm

		MEASUREMENTS (in mm)							
		1	3	4	6	8	9	15	18
Setup	Mandrel SN	W _{bottom}	W _{shoulders}	W _{neck}	Bottom of Jacket To Top,FrontSide, Midline	Bottom of Jacket To Xmarks/B-,Left Side	Bottom of Jacket to Xmarks/B-,Right Side	W _{B-B}	W _{D-D}
On Mandrel									
Manual Measurements (Did NOT use Faro arm)									
GM Jacket	Average	262.33	271.00	134.67	332.00	158.33	158.00	272.67	267.33
	SD (sample)	0.58	2.00	0.58	0.00	0.58	0.00	1.15	0.58
	CV	0.22%	0.74%	0.43%	0.00%	0.36%	0.00%	0.42%	0.22%
Ford Jacket	Average	263.33	269.67	135.67	332.67	158.33	157.67	273.33	267.67
	SD (sample)	1.15	1.53	0.58	0.58	0.58	1.53	0.58	0.58
	CV	0.44%	0.57%	0.43%	0.17%	0.36%	0.97%	0.21%	0.22%
HIS Jacket	Average	262.67	269.33	135.00	329.67	157.67	155.33	273.33	267.33
	SD (sample)	0.58	1.53	1.00	0.58	0.58	0.58	0.58	0.58
	CV	0.22%	0.57%	0.74%	0.18%	0.37%	0.37%	0.21%	0.22%
All	Average	262.78	270.00	135.11	331.44	158.11	157.00	273.11	267.44
	SD (sample)	0.83	1.66	0.78	1.42	0.60	1.50	0.78	0.53
	CV	0.32%	0.61%	0.58%	0.43%	0.38%	0.96%	0.29%	0.20%

		MEASUREMENTS (in mm)							
		1	3	4	6	8	9	15	18
Setup	Mandrel SN	W _{bottom}	W _{shoulders}	W _{neck}	Bottom of Jacket To Top,FrontSide, Midline	Bottom of Jacket To Xmarks/B-,Left Side	Bottom of Jacket to Xmarks/B-,Right Side	W _{B-B}	W _{D-D}
On Mandrel									
Faro Arm Measurements									
GM Jacket	Average	261.12	268.69	134.17	332.35	157.45	156.94	273.54	269.61
	SD (sample)	0.75	0.82	0.59	1.93	1.74	1.58	0.16	0.22
	CV	0.29%	0.30%	0.44%	0.58%	1.11%	1.01%	0.06%	0.08%
Ford Jacket	Average	259.96	267.62	135.89	331.10	155.39	155.39	273.33	269.78
	SD (sample)	0.52	0.60	0.18	0.18	0.20	0.56	0.19	0.13
	CV	0.20%	0.22%	0.13%	0.06%	0.13%	0.36%	0.07%	0.05%
HIS Jacket	Average	261.58	266.48	135.24	327.91	154.54	154.25	273.79	269.74
	SD (sample)	0.93	1.61	0.77	0.19	1.85	1.79	0.41	0.43
	CV	0.35%	0.61%	0.57%	0.06%	1.20%	1.16%	0.15%	0.16%
All	Average	260.89	267.60	135.21	330.45	155.79	155.53	273.56	269.71
	SD (sample)	0.97	1.35	0.87	2.21	1.82	1.70	0.31	0.26
	CV	0.37%	0.51%	0.65%	0.67%	1.17%	1.09%	0.11%	0.10%

- GM Jacket: With manual measurements, one average response exceeded tolerances (Wshoulders); with faro arm, no average response exceeded tolerances. No responses had a CV > 3%.
- Ford Jacket: With manual measurements, one average response exceeded tolerances (Wshoulders); with faro arm, two average responses exceeded tolerances (Bottom of Jacket to X-marks, both sides). No responses had a CV > 3%.
- HIS Jacket: With manual measurements, one average response exceeded tolerances (Bottom of Jacket to X-Marks, right side); with faro arm, two average responses exceeded tolerances (Bottom of Jacket to X-marks, both sides). No responses had a CV > 3%.
- All Jackets: With manual measurements, one average response exceeded tolerances (Wshoulders); with faro arm, two average responses exceeded tolerances (Bottom of Jacket to X-marks, both sides). No responses had a CV > 3%.

Observations:

- Tolerances:

- Two average responses (D_{bottom} and D_{neck}) frequently exceeded the specified tolerances regardless if measured on mandrel or on 5H3.
 - As HIS pointed out, the zipper may be affecting measurements.
 - Agree with HIS's recommendation that the zipper should be avoided.
- Two other parameters (W_{bottom} and $W_{\text{shoulders}}$) exceeded tolerances; however, this usually occurred when measured on a 5H3 and in one specific lab.

- Repeatability & Reproducibility:

- For the same situation (lab, technician, jacket, structure), repeatability was good with almost all the CVs $< 3\%$ regardless of the underlying structure or measurement method.
- Reproducibility on the mandrel (various labs, technicians, jackets) was better than on the 5H3s. However, it should be noted that only one mandrel was evaluated and five different ATDs were used.
 - The type of 5H3, cabled vs. iDAS, appeared to have an effect however, only one iDAS 5H3 was evaluated.

- Usability:

- Using the mandrel was found to be easier than the ATDs by all labs.

Recommendations:

- Overall, agree with the HIS recommendations:
 - Upon production, the jacket should be certified by its manufacturer on the mandrel and using a 3D measurement system such as a Faro arm.
 - The measurement parameters recommended by HIS should be used as well as the tolerances (± 7.6 mm or $\pm 1.0^\circ$ as appropriate).
 - A yearly inspection should be performed measuring a subset of parameters as specified by HIS.
 - This inspection may be conducted either on a 5H3 or a mandrel using a 3D measurement system or manual measurements with tools (calipers, tape measures, etc.).
 - The user of the ATD should use these results, in combination with the dynamic certification results, to decide whether or not to change the jacket.
 - This annual dimensional inspection has less priority than the dynamic certification tests and should be a guide only, and not a certification requirement.