Crew Systems Bulletin

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Number: EZFC-CSB-16-001

Date: 28 Nov 2016

Subject: USAF Revision of MIL-HDBK-516C section 9.1.1Escape system safety compatibility criteria standard; supporting data and legacy criteria.

References:

Parr, Jeffrey, “A Method to Develop Neck Injury Criteria to Aid Design and Test of Escape Systems Incorporating Helmet Mounted Displays,” AFIT/DS/ENV/14-01.

Rowson, Steven and Duma, Stefan, “Brain Injury Prediction: Assessing the Combined Probability of Concussion Using Linear and Rotational Head Acceleration,” Annals of Biomedical Engineering, Vol. 41, No.5, May 2013.

Gennarelli, Thomas & Wodzin, Elaine, editors, “Abbreviated Injury Scale 2005, Updated 2008,” Association for the Advancement of Automotive Medicine, Oct 2008.

Joint Service Specification Guide, 2010-11, Crew Systems Emergency Egress Handbook, 30 Oct 1998.

Joint Service Specification Guide, 2010-12, Deployable Aerodynamic Decelerator Handbook, 30 Oct 1998.

Background:

Airworthiness change notice 516CN-5 implements updates to the Air Force standard for airworthiness criteria in section 9.1.1 of MIL-HDBK-516. In order to accommodate the format of MIL-HDBK-516 and associated templates much of the supporting data for the new criteria could not be included directly in the document. Consequently it is being presented in this bulletin, below, in section 1. In addition, there was a desire to present legacy criteria for instances where minor modifications may be made to legacy systems, which do not justify the

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necessity to meet the new criteria. This legacy data is also presented below in section 2. Appendix A of this document has also been added to provide some context and rationale for the new criteria; as a means of documenting the intent of the update. Appendix B is intended to present guidance for standard methods of collecting and processing data from escape system tests. Appendix C includes guidance for minimum seat and manikin instrumentation for ejection seat tests. Appendix D provides information on acceptable manikin configurations for USAF ejection seat tests.

1. Direct supporting data for change notice 516CN-5, MIL-HDBK-516 revision of Air Force section 9.1.1 Escape system safety compatibility, current airworthiness standard.

1.1 Dynamic Response Index Z axis (DRI/DRZ) Calculation: The DRI is representative of the maximum dynamic compression of the vertebral column of the human body. In physical terms, the human body is described mathematically in terms of an analogous, lumped parameter mechanical model consisting of a mass, spring, and damper. DRI was originally developed for catapult phase only; given the acceleration vector is parallel to the spinal column; within 5^{o} of the z-axis. DRI terms have also been developed for the x-axis (DRX) and y-axis (DRY) which can be combined with the original z-axis term (DRZ) to describe acceleration effects on the human body from all axes after the ejection seat has separated from the aircraft (see Multi-axis Dynamic Response Criterion (MDRC) below). The compression of the human body along an axis i is captured by the following second order differential equation:

$$\ddot{\delta}_i(t) + 2\zeta_i\omega_{n_i}\dot{\delta}_i(t) + (\omega_{n_i})^2\delta_i(t) = A_i(t)$$

Where

$\delta_i(t)$ Displacement of the occupant's body with respect to the critical point

$\dot{\delta}_i(t)$ Occupant's relative velocity with respect to the critical point

$\ddot{\delta}_i(t)$ Occupant's acceleration in an inertial frame

ζ_i Damping coefficient ratio of the dynamic system

ω_{n_i} Undamped natural frequency of the dynamic system

$A_i(t)$ Measured acceleration along the pertinent axis of the seat at the critical point

Note. For DRZ and MDRC calculations, measured gz accelerations shall include 1 'g' for gravity.

Critical Point definition: Prior to seat/occupant separation, MDRC and DR are calculated from seat accelerations acting into the *Critical Point*. The coordinate system and the dimensions that define the location of the *Critical Point* are given in figure 1.1. Since placement of an accelerometer at the Critical Point is not practical, the seat sensors shall be arranged as follows: the primary seat sensor array consisting of a triaxial accelerometer shall be located on the seat pan and as near to the base of the occupant's spine as possible so that the Z-axis of the sensor(s) is parallel to the seat back tangent plane. The z-axis acceleration shall be used to calculate the DRZ. An additional triaxial accelerometer with the Z-axis of the sensor(s) parallel to the seat back tangent plane shall be mounted on the centerline of the seat back, approximately 46.2 cm (18.2") up from the lower seat reference point. The X and Y accelerations from this accelerometer shall be used to calculate the DRX and DRY, respectively. After seat/occupant separation, MDRC and DR are calculated from lumbar z axis accelerations acting into the base of the spine with the z axis aligned along the spine and with x and y axis chest accelerations as shown in figure 1.2.

The estimated natural frequency and damping ratio for the Air Force flying population along each axis direction is given in table 1.1 based on axis orientation as shown in figure 1.2.

Axis	Direction	ω_n (rad/s)	ζ
$-X$	Eyeballs Out	60.8	0.04
$+X$	Eyeballs In	62.8	0.2
$-Y$	Eyeballs Left	58.0	0.09
$+Y$	Eyeballs Right	58.0	0.09
$-Z$	Eyeballs Up	47.1	0.24
$+Z$	Eyeballs Down	52.9	0.224

Table 1.1 Natural Frequency and Damping Ratio Coefficients.

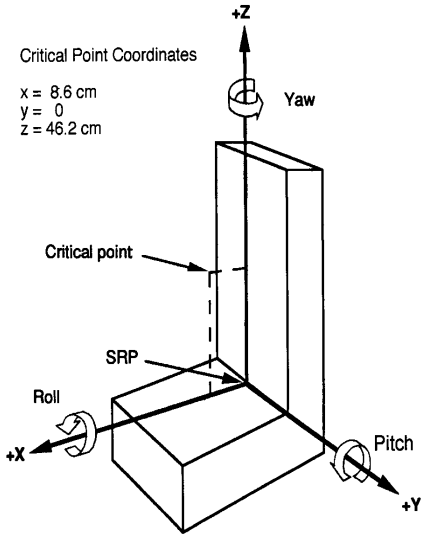


Figure 1.1 Seat coordinate system with critical point.

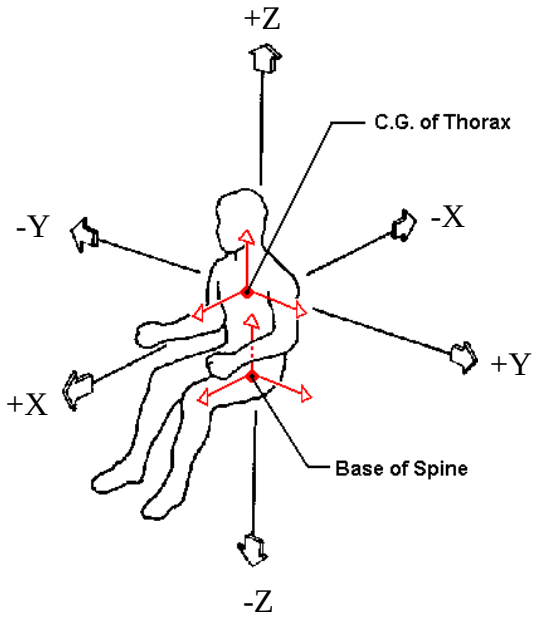


Figure 1.2 Human coordinate system with lumbar and chest acceleration positions.

The dynamic response for each axis is calculated as follows; where g is the acceleration due to gravity:

$$DR_i(t) = \frac{(\omega_{n_i})^2 \delta_i(t)}{g}$$

At the maximum deflection, the DRI is defined as:

$$DRI_i = \frac{(\omega_{n_i})^2 \delta_i^{max}}{g}$$

1.2 Multi-axis Dynamic Response Criterion (MDRC) calculation: MDRC is defined as:

$$MDRC(t) = \sqrt{\left(\frac{DR_x(t)}{DR_x^{lim}}\right)^2 + \left(\frac{DR_y(t)}{DR_y^{lim}}\right)^2 + \left(\frac{DR_z(t)}{DR_z^{lim}}\right)^2}$$

$DR_{x,y,z}(t)$ The dynamic response values computed for each x-, y-, and z-axis component of the acceleration time history (see section 1.1 above for calculation method).

$DR_{x,y,z}^{lim}$ The limit value of the dynamic response for each axis direction; as shown in table 1.2.

Axis Direction	Limits (5% Injury Risk)
- X Eyeballs Out	$DR_x^{lim} = 35$
+X Eyeballs In	$DR_x^{lim} = 40$
- Y Eyeballs Left	$DR_y^{lim} = 17$
+Y Eyeballs right	$DR_y^{lim} = 17$
- Z Eyeballs Up	$DR_z^{lim} = 16.5$
+Z Eyeballs Down	$DR_z^{lim} = 18$

Table 1.2 MDRC Dynamic Response Limits per axis.

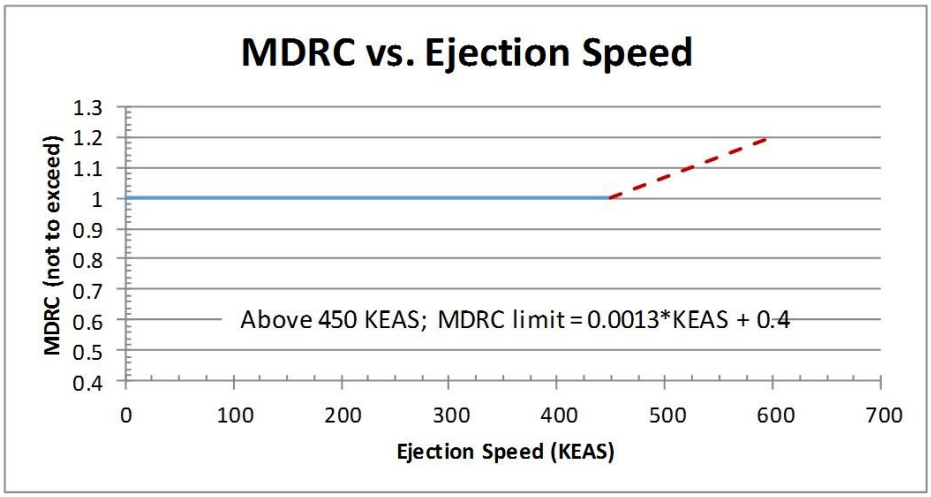


Figure 1.3 Maximum allowable MDRC value vs. Ejection Speed.

The MDRC shall be below 1 for speeds up to and including 450 KEAS. While not part of the MIL-HDBK-516 standard as a design goal for speeds in excess of 450 KEAS every effort should be made to maintain the MDRC below the line shown in Figure 1.3

1.3 Probability of concussion calculation: The probability of concussion is defined as:

$$P_{concussion} = \frac{1}{1 + e^{-(-10.2+0.0433a+0.000873\alpha-0.00000092a\alpha)}}$$

Where 'a' is the observed peak linear acceleration and 'α' is the observed peak rotational acceleration as a function of time. Figure 1.4 shows probability of concussion plotted against 'a' and 'α'.

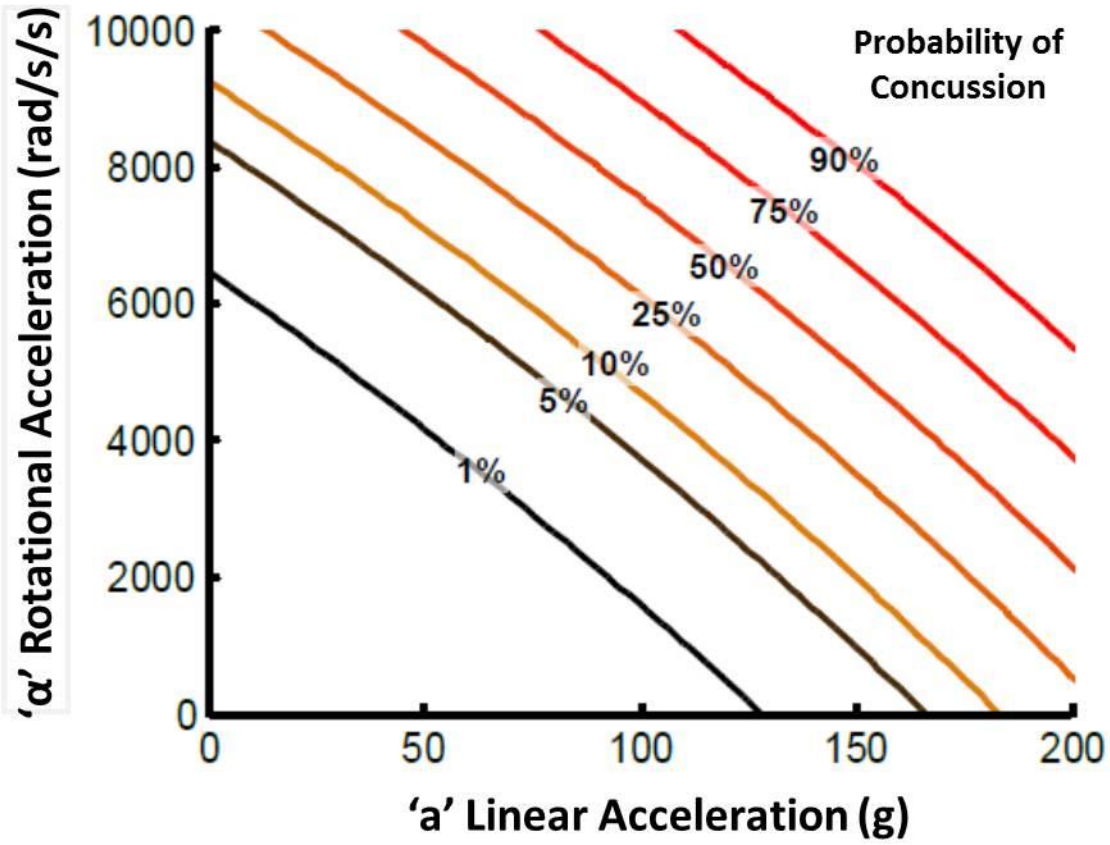


Figure 1.4 Probability of Concussion vs. Rotational and Linear Acceleration.

1.4 Neck injury calculations: Neck injury criteria are based on the Multi-Axial Neck Injury Criteria (MANIC) and the Neck Moment Index about the x axis (NMIx). MANIC and NMIx are defined below with individual critical values as shown in table 1.3. The probability of AIS 2 or greater injury corresponding to the MANIC and NMIx values is shown in figure 1.5.

MANIC (identified as MANIC (Gy) by Parr) is defined as:

$$MANIC = \sqrt{\left(\frac{F_X}{F_{Xcrit}}\right)^2 + \left(\frac{F_Y}{F_{Ycrit}}\right)^2 + \left(\frac{F_Z}{F_{Zcrit}}\right)^2 + \left(\frac{M_Y}{M_{Ycrit}}\right)^2 + \left(\frac{M_Z}{M_{Zcrit}}\right)^2}$$

NMI_X is defined as:

$$NMI_x = \frac{M_x}{M_{xcrit}}$$

Where:
Fx = observed x direction shear loading
Fxcrit = critical intercept value for x direction shear loading
Fy = observed y direction shear loading
Fycrit = critical intercept value for y direction shear loading
Fz = observed axial loading (+*Fz* = tension, -*Fz* = compression)
Fzcrit = critical intercept value for axial loading (different for tension/compression)
Mx = observed moment about the anatomical x axis (side bending)
Mxcrit = critical intercept value for side bending
My = observed moment about the anatomical y axis (sagittal plane anterior/posterior bending, +*My* = flexion, -*My* = extension)
Mycrit = critical intercept value for sagittal plane moments (different for flexion/extension)
Mz = observed moment about the anatomical z axis (neck twisting)
Mzcrit = critical intercept value for neck twisting

Manikin Neck Size	Manikin Mass	Human Mass	Component	Force		Component	Moment	
	(lbs)	(lbs)		(lbs)	(N)		(in-lbs)	(N-m)
Small Female Hybrid III (for 103-135 pound manikin)	103	<114	F_{xcrit}	405	1802	M_{xcrit}	593	67
			F_{ycrit}			$-M_{ycrit}$ (extens)		
			$-F_{zcrit}$ (comp)	872	3880	M_{zcrit}		
			$+F_{zcrit}$ (tens)	964	4287	$+M_{ycrit}$ (flex)	1372	155
	125	114-130.5	F_{xcrit}	496	2206	M_{xcrit}	845	95
			F_{ycrit}			$-M_{ycrit}$ (extens)		
			$-F_{zcrit}$ (comp)	1099	4889	M_{zcrit}		
			$+F_{zcrit}$ (tens)	1214	5400	$+M_{ycrit}$ (flex)	1939	219
	136	130.5-143	F_{xcrit}	522	2322	M_{xcrit}	912	103
			F_{ycrit}			$-M_{ycrit}$ (extens)		
Mid Male Hybrid III (for 136-199 pound manikin)			$-F_{zcrit}$ (comp)	1157	5147	M_{zcrit}		
			$+F_{zcrit}$ (tens)	1278	5685	$+M_{ycrit}$ (flex)	2094	237
	150	143-161	F_{xcrit}	561	2495	M_{xcrit}	1016	115
			F_{ycrit}			$-M_{ycrit}$ (extens)		
			$-F_{zcrit}$ (comp)	1243	5529	M_{zcrit}		
			$+F_{zcrit}$ (tens)	1373	6107	$+M_{ycrit}$ (flex)	2333	264
	172	161-186	F_{xcrit}	625	2780	M_{xcrit}	1195	135
			F_{ycrit}			$-M_{ycrit}$ (extens)		
			$-F_{zcrit}$ (comp)	1385	6160	M_{zcrit}		
			$+F_{zcrit}$ (tens)	1530	6806	$+M_{ycrit}$ (flex)	2744	310
	200	186-210	F_{xcrit}	683	3038	M_{xcrit}	1364	154
			F_{ycrit}			$-M_{ycrit}$ (extens)		
			$-F_{zcrit}$ (comp)	1513	6730	M_{zcrit}		
			$+F_{zcrit}$ (tens)	1671	7433	$+M_{ycrit}$ (flex)	3133	354
Large Male Hybrid III (for 200-245 pound manikin)	220	210-232.5	F_{xcrit}	777	3456	M_{xcrit}	1584	179
			F_{ycrit}			$-M_{ycrit}$ (extens)		
			$-F_{zcrit}$ (comp)	1673	7440	M_{zcrit}		
			$+F_{zcrit}$ (tens)	1847	8216	$+M_{ycrit}$ (flex)	3673	415
	245	232.5+	F_{xcrit}	836	3719	M_{xcrit}	1850	209
			F_{ycrit}			$-M_{ycrit}$ (extens)		
			$-F_{zcrit}$ (comp)	1853	8243	M_{zcrit}		
			$+F_{zcrit}$ (tens)	2047	9106	$+M_{ycrit}$ (flex)	4248	480

Table 1.3. MANIC and NMI_X upper neck critical values based on body mass.

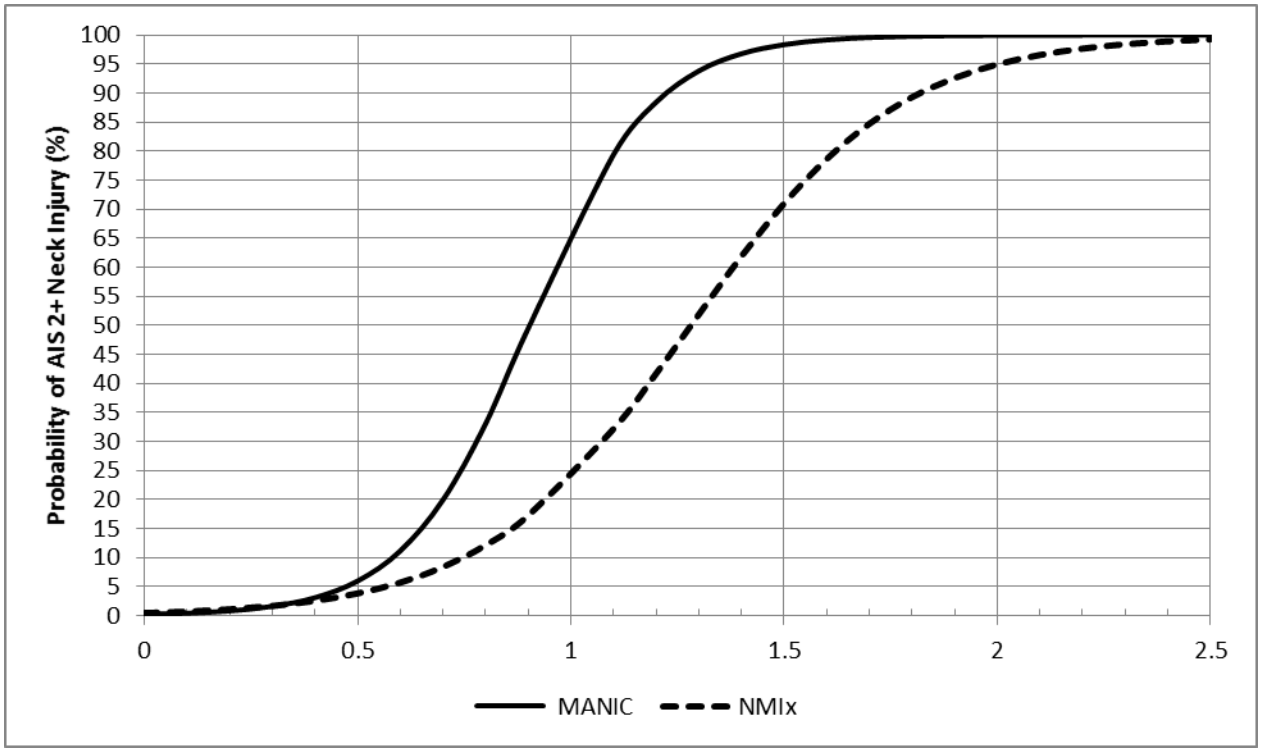


Figure 1.5 Probability of neck injury vs. MANIC and NMI_X values.

As plotted above in figure 1.5, the probability of AIS 2+ injury based on the MANIC value is defined by:

$$P(AIS \geq 2) = \frac{1}{1 + e^{6.185 - 6.85 * MANIC}}$$

As plotted above in figure 1.5, the probability of AIS 2+ injury based on the Neck Moment Index about the x-axis (NMI_X) value is defined by:

$$P(AIS \geq 2) = \frac{1}{1 + e^{5.2545 - 4.1 * NMIx}}$$

1.5 Stability and Center of Gravity Envelope.

1.5.1 Pitch Stability for escape systems that will be used where the head supported mass and center of gravity location is outside the range for the

standard head listed in table 1.5A while wearing the appropriate sized HGU-55P helmet, high speed visor, combat edge kit, appropriate sized MBU-20P oxygen mask, 3 inches of O2 hose and communications cord. Seat stability will be maintained to align the neutral axis direction of the aerodynamic deceleration parallel to the main rocket thrust line at low speeds (where rocket thrust is the predominant force and drogues may not be deployed long enough to be effective) or the eyeballs-out (eyeballs-in for backward facing seats) direction at higher speeds (where free-stream velocity is the predominant force); and limit excursions about the neutral axis to +/- 20^{O} in the pitch plane and positively damped at all ejection speeds from seat aircraft separation through sustainer rocket burn out. Positively damped means any oscillations caused by the excursions are bounded and eventually return to zero.

Manikin Head	Weight (lbs)	Cgx (inches)	Cgy (Inches)
SF-74A	7.4	0.71	2.33
SF-81	8.1	0.71	1.96
Small Adam	8.4	0.29	1.92
Large ADAM	8.8	0.22	1.91
LM-110	11.0	0.74	1.84

Table 1.5A. Manikin Head weights and Gg location relative to the Occipital Condyle

1.5.2 Yaw stability. Limit excursions +/- 20^{o} in the yaw plane and positively damped at speeds above 250 KEAS. Positively damped means any oscillations caused by the excursions are bounded and eventually return to zero.

1.5.3 Historical data and analysis has shown that controlling the CG envelope is critical to meeting the injury and stability criteria. As a design goal the CG envelope shown in Figure 1.6B illustrates the tolerance about the Center of Gravity (CG) positions for the combined seat/aircrew combination.

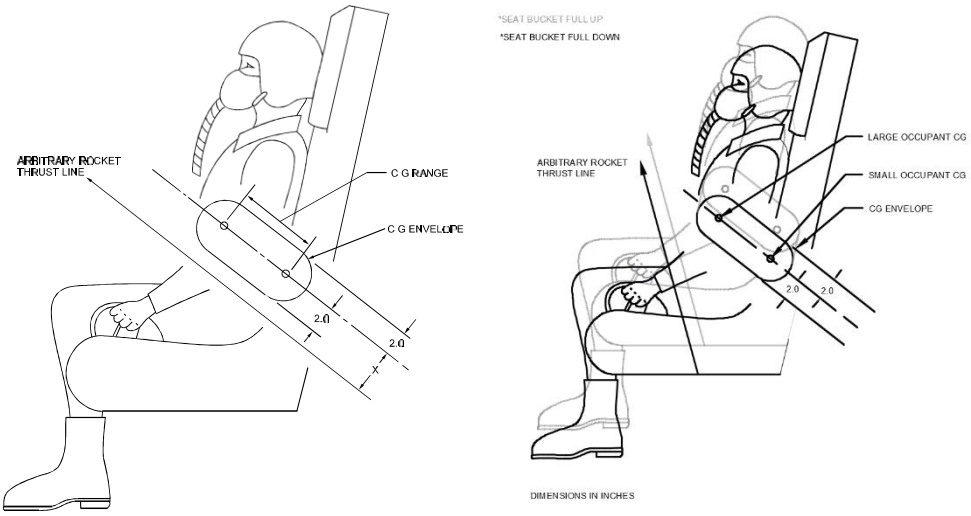


Figure 1.6b CG Envelope for one piece seat and movable seat bucket.

1.5.4 Parachute Deployment. The ejection seat-aircrew combination should rotate beyond 90 degrees aft from parachute deployment through parachute opening shock. This ensures that the aircrew is in optimal alignment for the opening shock.

2. Legacy airworthiness criteria for MIL-HDBK-516 section 9.1.1 Escape system safety compatibility standard.

For legacy in-flight escape systems that are not receiving a major upgrade or replacement, legacy requirements will apply per table 2.1.

Parameter	Class A: Pre-1970 aircraft & seats	Class B: 1970-2000 aircraft & seats	Class C: aircraft & seats from 2000-release of this bulletin
Catapult Accelerations	Paragraphs 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5	Paragraphs 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5	Paragraphs 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5
Free-flight/drogue phase accelerations	Paragraph 2.2.1	Paragraph 2.2.2	Paragraph 2.2.3
Head accelerations	Paragraph 2.3	Paragraph 2.3	Paragraph 2.3
Parachute accelerations	Paragraph 2.4	Paragraph 2.4	Paragraph 2.4
Parachute descent rate	Paragraph 2.5.1	Paragraph 2.5.1	Paragraph 2.5.2
Stability	Paragraph 2.6.1	Paragraph 2.6.2	Paragraph 2.6.2

Limb Flail	Paragraph 2.7.1	Paragraph 2.7.1	Paragraph 2.7.1
Neck Injury	Paragraph 2.8.1	Paragraph 2.8.2	Paragraph 2.8.3
Escape Capability	Paragraph 2.9.1	Paragraph 2.9.2	Paragraph 2.9.2

Table 1. Legacy system requirements matrix.

2.1 Accelerations: Catapult phase.

2.1.1 The acceleration imposed on the seat occupant in the $+G_Z$ direction (parallel to the spinal column) by the ejection catapult should be limited in terms of Dynamic Response Index Z axis (DRZ) values for the z-axis, DRZ, calculated according to the method described below. The following DRI_z limits are for specific catapult pre-ignition temperature and ejected weight representing the ejection seat, personal equipment, and human body weight representative of the crew member population anthropometric range. In addition the following limits are based on a configuration which includes the head rest not more than one inch in front of the seat back tangent line, the seat back tangent line no more than 5^o offset from the catapult thrust vector, and standard USAF torso harness with a chest strap and lap belt restraint (or equivalent restraint as determined by 711^{th} HPW).

2.1.2 For Class A, B and C systems ensure the mean seat pan acceleration time history generated in system level ejection sled or in-flight tests at test ambient conditions, does not yield a DRZ value in excess of 18.

2.1.3 For Class A, B and C systems ensure the mean seat pan acceleration time history generated in controlled component testing at a pre-ignition temperature of 70 °F does not yield a DRZ value in excess of 18.0 (5% risk of Abbreviated Injury Scale (AIS) 2 injury) with an allowable standard deviation of 1.0.

2.1.4 For Class A, B and C systems ensure the mean seat pan acceleration time history generated in controlled component testing at a pre-ignition temperature of 165 °F does not yield a DRZ value in excess of 22.0 with an allowable standard deviation of 1.0.

2.1.5 For systems that are inconsistent with the above configuration i.e. head rest more than one inch forward of back tangent line, seat back tangent line more than 5^o offset from catapult thrust vector and other harness systems, the DRZ values for all pre-ignition temperatures are reduced by 2 in order to compensate for the differences.

See section 1.1 for DRI Calculation method.

2.2 Accelerations: Free-flight and drogue phase (seat/aircraft separation to seat/aircrew separation). The MDRC is a method used to evaluate injury risk due to accelerations in all axis during the free-flight/drogue-flight phase of an ejection. See section 1.2 for MDRC calculation.

2.2.1 For Class A systems, MDRC is not applicable.

2.2.2 For Class B systems, all accelerations shall be limited to meet a MDRC value not to exceed 1.0 (5% risk of AIS 2 injury) up to 350 KEAS and may increase linearly, over 350 KEAS, not to exceed 2.0 at 600 KEAS (see figure 2.1).

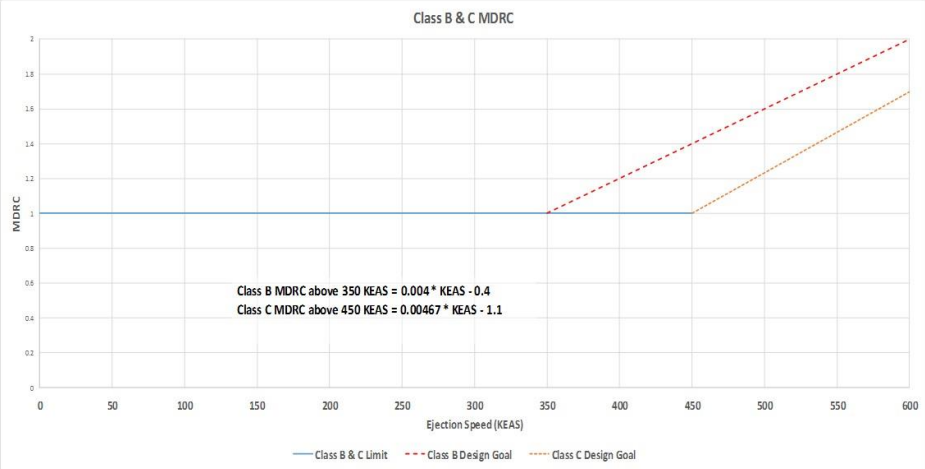


Figure 2.1 Maximum allowable MDRC value vs. Ejection Speed.

2.2.3 For legacy Class C systems, MDRC limit of 1.0 is applicable up to 450 KEAS and may increase linearly, over 450 KEAS, not to exceed 1.7 at 600 KEAS (see figure 2.1).

2.3. Accelerations: Head Injury, all phases. For Class A, B, and C systems head acceleration criteria will be in accordance with the program contractual requirements.

2.4. Accelerations: Recovery parachute deployment/inflation phase. For all Cases A, B and C, the maximum resultant deceleration/stabilization recovery parachute deployment and inflation loads experienced by the aircrew during escape do not exceed the following maximum resultant chest accelerations.

No more than 15 G (vector sum) if the direction of force applied to the body is random and unpredictable as in a typical manual bailout or crew mounted parachute system.

No more than 25 G (vector sum) if the system is controlled so the force is applied while the body is in an optimum position (inertial resultant in +z to –x direction or “eyeballs out” to “eyeballs down.”)

2.5. Descent rate: Recovery parachute descent/steady state phase.

2.5.1 For legacy Class A and B systems average recovery parachute descent rates do not exceed vertical velocity of 25 ft/sec for 300 pound suspended weight at standard day SL conditions.

2.5.2 For legacy Class C systems average recovery parachute descent rates do not exceed vertical velocity of 24 ft/sec for 337 pounds suspended weight at standard day SL conditions.

2.6. Stability: Free-flight and drogue phase (seat/aircraft separation to seat/aircrew separation).

2.6.1 Seat stability criteria are not applicable to Class A systems

2.6.2 For Class B and C systems, seat stability will be maintained to align the neutral axis direction of the aerodynamic deceleration parallel to the main rocket thrust line at low speeds (where rocket thrust is the predominant force and drogues may not be deployed long enough to be effective) or the eyeballs-out (eyeballs-in for backward facing seats) direction at higher speeds (where free-stream velocity is the predominant force); and limit excursions about the neutral axis to +/- 20^{O} in the pitch plane and be positively damped at all ejection speeds and +/- 20^{o} in the yaw plane at speeds above 250 KEAS.

2.7. Limb Flail: Windblast, free-flight and drogue phases (seat immersion into airflow to seat/aircrew separation).

2.7.1 Aircraft capable of speeds above 300 KEAS must incorporate limb restraints (arm & leg) to prevent limb flail. Legacy data indicates probability of flail injuries increases with airspeed and is approximately 5% probability at 300 KEAS. Leg restraints should prevent movement of the legs laterally beyond the sides of the seat. Arm restraints should prevent movement of arms rearward beyond the seat back tangent line. For class A, B & C systems this criteria is

only applicable to those systems which incorporated limb restraints prior to any modification.

2.8. Neck injury criteria: all phases. The neck injury criteria detailed below apply through all phases of the ejection with and without helmet mounted displays such as night vision goggles or joint helmet mounted cueing system.

2.8.1 Neck injury criteria are not applicable to Class A systems.

2.8.2 The following neck injury criteria apply to Class B systems.

The neck injury criteria, Nij, calculated from the following equation

$$N_{ij} = \frac{F_z}{F_{\text{int}}} + \frac{M_y}{M_{\text{int}}}$$

should not exceed 1.0 for all time during the escape sequence where F_z is the axial load, F_{int} is the critical intercept load, M_y is the flexion/extension bending moment, and M_{int} is the critical intercept moment. The critical intercepts are as given in table 2.2 below.

Manikin	Tension (Lb)	Compression (Lb)	Flexion (in - Lb)	Extension (in - Lb)
Small Female	755	755	1370	550
Mid-sized Male	1000	1000	2740	1105
Large Male	1220	1220	3670	1470

Table 2.2 Critical intercept values for Nij calculation.

2.8.3 For Class C systems the following neck injury criteria apply up to 450 KEAS. Above 450 KEAS the Large Male Hybrid III Type Manikin limits apply to all manikins and weight ranges.

The maximum acceptable neck tension (lifting force) limits measured at the occipital condyles (C0-C1, upper neck) and cervical vertebrae (C7-T1, lower neck) are defined in table 2.3 (use linear interpolation for intermediate values in force and time duration). These limits represent the maximum allowable load that can be sustained for a given duration.

Small Female Hybrid III Type Manikin (103 to 118 lbs)		Mid-Size Male Hybrid III Type Manikin		Large Male Hybrid III Type Manikin (200 to 245 lbs)	
Duration (ms)	**Tension at C0-C1 & C7-T1 (lbs)**	**Duration (ms)**	**Tension at C0-C1 & C7-T1 (lbs)**	**Duration (ms)**	**Tension at C0-C1 & C7-T1 (lbs)**
5	414	5	618	5	761
31	414	35	618	37	761
40	200	45	320	48	450
80	200	80	320	80	450

Table 2.3 Class C Neck Tension Force and Duration Limits for a Given Occupant Size.

Neck Compression and Shear Force Limits

The maximum acceptable cervical compression and shear force limits are defined in table 2.4 (use linear interpolation for intermediate values in force and time duration).

Small Female Hybrid III Type Manikin (103 to 118 lbs)		Mid-Size Male Hybrid III Type Manikin		Large Male Hybrid III Type Manikin (200 to 245 lbs)	
Duration (ms)	**Compression at C0-C1 & C7-T1 (lbs)**	**Duration (ms)**	**Compression at C0-C1 & C7-T1 (lbs)**	**Duration (ms)**	**Compression at C0-C1 & C7-T1 (lbs)**
5	519	5	790	5	979
27	200	30	320	32	450
80	200	80	320	80	450
Duration (ms)	**Resultant Shear at C0-C1 (lbs)**	**Duration (ms)**	**Resultant Shear at C0-C1 (lbs)**	**Duration (ms)**	**Resultant Shear at C0-C1 (lbs)**
5	405	5	625	5	777
20	225	25	337	28	414
29	225	35	337	39	414
37	165	45	247	50	304
80	165	80	247	80	304
Duration (ms)	**Resultant Shear at C7-T1 (lbs)**	**Duration (ms)**	**Resultant Shear at C7-T1 (lbs)**	**Duration (ms)**	**Resultant Shear at C7-T1 (lbs)**
5	810	5	1250	5	1554
20	450	25	674	28	828
29	450	35	674	39	828
37	330	45	494	50	608
80	330	80	494	80	608

Table 2.4 Class C Neck Compression and Shear Force Limits for a Given Occupant Size.

Combined Neck Moment and Load Limits

The maximum combined-cervical-force-and-moment limit, expressed as Neck Injury Criteria (N_{ij}), is 0.5, as measured at the occipital condyles (C0-C1). The maximum N_{ij} as measured at the cervical vertebrae (C7-T1) is 1.5. N_{ij} is not applied for pure tension or compression. N_{ij} is calculated from the following equation:

$$N_{ij} = \frac{F_z}{F_{\text{int}}} + \frac{M_y}{M_{\text{int}}}$$

where:

F_z is the axial tension/compression load.

F_{int} is the critical intercept load (defined in table 2.5).

M_y is the flexion/extension bending moment.

M_{int} is the critical intercept moment (defined in table 2.8)

Force or Moment	Small Female Hybrid III Type Manikin (103 to 118 lbs) intercept load or moment	Mid-Size Male Hybrid III Type Manikin intercept load or moment	Large Male Hybrid III Type Manikin (200 to 245 lbs) intercept load or moment
Tension (lb) ($+F_z$)	964	1530	1847
Compression (lb) ($-F_z$)	872	1385	1673
Flexion (in-lb) (+My)	1372	2744	3673
Extension (in-lb) (-My)	593	1195	1584

Table 2.5 Class C Critical Intercept Values for N_{ij} Calculation at C0-C1 and C7-T1 for a Given Occupant Size.

Neck X and Z Moment Limits

To evaluate neck lateral bending (M_x) and rotation (M_z), the Neck Moment Index (NMI) will be calculated. The maximum allowable NMI_x, is 0.5, as measured at the occipital condyles (C0-C1) and 1.5 as measured at the cervical vertebrae (C7-T1). The maximum allowable NMI_z, is 0.5, as measured at the occipital condyles (C0-C1) and 1.0 as measured at the cervical vertebrae (C7-T1). NMI is calculated using the following equation:

$$NMI_i = \frac{M_i}{M_{iLIM}}$$

where:

NMI_i is NMI_x or NMI_z

M_i is M_x or M_z

M_{iLIM} is the M_x or M_z limit (defined in Table 2.6)

Moment	Small Female Hybrid III Type Manikin (103 to 118 lbs) limit	Mid-Size Male Hybrid III Type Manikin limit	Large Male Hybrid III Type Manikin (200 to 245 lbs) limit
Lateral Bending (in-lb) (+/- Mx)	593	1195	1584
Rotation (in-lb) (+/- Mz)	593	1195	1584

Table 2.6. Class C Values for NMI Calculation at C0-C1 and C7-T1 for a Given Occupant Size.

2.9 Escape Capability.

2.9.1 For Class A systems, escape capability criteria will be in accordance with the program contractual requirements.

2.9.2 For Class B and C systems, ejection seat systems will have the capability for zero altitude (in level flight) up to the absolute ceiling of the aircraft and from zero airspeed to maximum velocity of the aircraft or 600 KEAS whichever is less (for an open ejection seat). This applies to the full combined CG envelope of the seat and occupant combination; to include a +/- 2 inch tolerance about each individual CG for the full range of specified aircrew population (see figure 1.5). That is, each CG position must include a two inch sphere around it to define the entire CG range.

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Coordination

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Appendix A

Background information on 2016 MIL-HDBK-516 revision of Air Force section 9.1.1 Escape system safety compatibility standard.

The following is provided to document the intent of the USAF update to section 9.1.1 of MIL-HDBK-516, change notice 516CN-5.

Congress has recently provided direction on reducing ejection seat injury risk for the full range of aircrew population. A July 2014 Congressional letter to the Secretary and Chief of Staff of the Air Force stated that new and old ejection seats should meet a 5% chance of injury. In the National Defense Authorization Act (NDAA) for Fiscal Year 2015 congress tasked the DoD IG to evaluate aircraft ejection seat safety when using advanced helmet sensors. The DoD IG recommended that MIL-HDBK-516 be updated to ensure that a 5% risk of major injury was the standard for airworthiness. In response to the Congressional letter and DoD IG the USAF has reviewed the operational ejection data that showed the standard USAF ejection seat was achieving less than 2% spinal injury rate that is lower than the 5% rate required by the 1967 MIL-SPEC that drove the development of the ACES II ejection seat. The USAF has identified recently published research that establishes a new head and neck criterion that can be used to establish a 5% chance of an Abbreviated Injury Scale (AIS) 2 neck injury. (The AIS was developed by what is now the Association for the Advancement of Automotive Medicine to fill the need for a standardized system for classifying type and severity of injuries resulting from vehicular crashes. The AIS was adopted as the standard for crash investigation teams funded by the US Department of Transportation as well as many academic and industry research organizations in the US and internationally. It therefore provides a widely accepted standard of injury classification with which to correlate with injury probabilities.)

The changes to section 9.1.1 of MIL-HDBK-516 are intended to implement the Congressional request and the findings of the DoD IG for new systems and upgrades to the greatest extent allowed by current technology. The proposed criteria establish a 5% or less (in the case of spinal injury) probability of AIS 2 injury for each major phase of an ejection event.

The injury criteria used by the USAF to determine the airworthiness for escape systems has not been updated since MIL-HDBK-516 was initially issued. The criteria as identified were established in 1967 and reflected the requirement for a 5% chance of a major, comparable to AIS 2, spinal injury or other injury caused by seat accelerations. In the late 1990's the government expanded the aircrew population to include females and larger males and established head and neck load requirements to account for the use of helmet mounted displays. These changes are intended to account for these newer requirements as well as the Congressional and DoD IG guidance.

Existing escape system performance and injury criteria have not always been applied correctly. In recent years some criteria have been utilized without all the specific conditions and/constraints under which they were developed and should be applied. In other cases, criteria have been developed without a way to correlate to injury probability. In addition, particularly with respect to neck injury, multiple criteria have been developed which are difficult to interpret and potentially conflicting. This bulletin seeks to correct some of these issues while attempting to meet the Congressional intent noted above.

Dynamic Response Index (DRI) has been in existence for many years; however in more recent applications, the specific conditions for applying the DRI have not always been carried forth. The DRI was developed around a specific seating geometry of headrest position and direction of applied load relative to the seat back as well as traditional USAF seat restraint harness geometry. In order to apply the DRI correctly these constraints must be present in the system. If not, then extensive testing and/or operational data is required in order to show that DRI can be applied to other system configurations. Without this addition data the DRI limit must be reduced to account for non-standard configurations. In addition, while the DRI was designed to reflect a five percent injury risk (as also currently required by Congress) USAF experience over the past 38 years with the ACES II ejection seat have shown that a 2% spinal injury risk due to catapult acceleration has been achieved and this favorable level of performance should be maintained in USAF aircraft for the future.

Multi-axis Dynamic Response Criterion (MDRC) is defined with three different risk levels for a major or incapacitating injury (AIS2). When using the low risk limiting values a MDRC of 1 has been correlated to 0.5% chance of injury. When using the moderate risk limiting values a MDRC of 1 has been correlated to 5.0% chance of injury. When using the high risk limiting values a MDRC of 1 has been correlated to 50% chance of injury. Due to the difficultly in the past of meeting this requirement up through the desired 600 KEAS envelope of an open ejection seat, it has only been applied up to 450 KEAS. There has been no guidance above 450 KEAS; however, based on empirical data and analysis of MDRC with different risk level limits an attempt has been made to provide guidance for limits above 450 KEAS. This may not provide a five percent injury risk above 450 KEAS but at least provides some boundaries at the higher speeds.

Recent research on head injury has noted the importance of rotational acceleration of the brain in addition to linear accelerations typically associated with brain injury. This combined linear and rotational acceleration criteria as related to concussion injury is provided as guidance for head acceleration limits.

Little new information is available on acceleration injury due to parachute opening shock loads. For typical ejection seat testing, instrumented manikins are generally used which allows for an MDRC to be measured based on manikin mounted instrumentation rather than seat mounted. For these applications

MDRC based on manikin mounted instrumentation is being used to account for accelerations during the seat/aircrew separation and parachute opening phase. For applications using torso manikins or test vehicles where a fully instrumented manikin is not used and no data exists to determine the MDRC, previously established and coordinated requirements are being used. In addition, in order to help reduce Parachute Landing Fall (PLF) injuries, lower vertical descent rates are being provided, which are based on achievable limits from recent military emergency parachute developments.

Ejection seat instability is a leading cause of injurious accelerations and complications in proper seat operation which may lead to other injuries. Previous USAF requirements for seat stability are being brought forth as guidance for better seat performance.

The original USAF ACES ejection seat utilized limb restraints but these were later removed for weight savings for the final ACES II seat design. Unfortunately this lack of limb restraint has resulted in numerous serious and some fatal injuries in USAF ACES II equipped aircraft. Improvements in technology now allow for other limb restraint options with less impact on weight and aircrew movement. Guidance is included for requiring limb restraints on open ejection seats at higher speeds based on legacy limb flail injury data.

Multiple neck injury criteria have been developed in the last 20 years to address ejection injury risk with occupants wearing helmet mounted devices. Some criteria consider duration of applied loads and some only discreet limits. Most do not provide for a continuum of injury probability. In order to reduce the number of criteria and provide more information on injury probability recent research on Multi-Axial Neck Injury Criteria (MANIC) is being utilized for neck injury risk. While there is some lack of data to support utilizing the full MANIC term as defined by Parr; the Neck Moment Index about the x-axis is being used to supplement this.

Appendix B

Guidance on Escape System Test Data Acquisition, and Reduction

TBD

Appendix C.

Minimum Instrumentation List

Electronic Data

Ch Sym	Channel Description	Dynamic Sled Test
HLAX	Head Acceleration X	R
HLAY	Head Acceleration Y	R
HLAZ	Head Acceleration Z	R
UNFX	Upper Head/Neck Force X	R
UNFY	Upper Head/Neck Force Y	R
UNFZ	Upper Head/Neck Force Z	R
UNMX	Upper Head/Neck Moment X	R
UNMY	Upper Head/Neck Moment Y	R
UNMZ	Upper Head/Neck Moment Z	R
HAAY	Head Angular Accel Y	R
LNFX	Lower Head/Neck Force X	O
LNFY	Lower Head/Neck Force Y	O
LNFZ	Lower Head/Neck Force Z	O
LNMX	Lower Head/Neck Moment X	O
LNMY	Lower Head/Neck Moment Y	O
LNMZ	Lower Head/Neck Moment Z	O
CLAX	Chest Acceleration X	X
CLAY	Chest Acceleration Y	X
CLAZ	Chest Acceleration Z	X
CARX	Chest Angular Rate About X	X
CARY	Chest Angular Rate About Y	X
CARZ	Chest Angular Rate About Z	X
LLAX	Lumbar Acceleration X	R
LLAY	Lumbar Acceleration Y	R
LLAZ	Lumbar Acceleration Z	R
LFX	Lumbar Force X	R
LFY	Lumbar Force Y	R
LFZ	Lumbar Force Z	R
LMX	Lumbar Moment X	R
LMY	Lumbar Moment Y	R
LMZ	Lumbar Moment Z	R
SBLAX	Seat Back Linear Acceleration X (-Y)	R
SBLAY	Seat Back Linear Acceleration Y (X)	R
SBLAZ	Seat Back Linear Acceleration Z (-Z)	R
SBARX	Seat Back Angular Rate X	O

SBARY	Seat Back Angular Rate Y	O
SBARZ	Seat Back Angular Rate Z	O
SPLAX	Seat Pan Linear Acceleration X (-Y)	R
SPLAY	Seat Pan Linear Acceleration Y (X)	R
SPLAZ	Seat Pan Linear Acceleration Z (-Z)	R
SARX	Seat Pan Angular Rate X	R
SARY	Seat Pan Angular Rate Y	R
SARZ	Seat Pan Angular Rate Z	R

R= Required

O=Optional

Appendix D

USAF Acceptable Manikin Configurations

Appendix D-1 Lightest Occupant in Service (LOIS) 103 lbs

Appendix D-2 Case 2 Short Torso Light (Case 2STL) 136 lbs

Appendix D-3 Case 2 Short Torso (Case 2ST) 150 lbs

Appendix D-4 Large Anthropometric Research Device (LARD, Case 6) 245 lbs

Appendix D-5 5% Male Aerospace

Appendix D-6 Manikin Trousers

Appendix D-1

LOIS (Lightest Occupant In Service) Manikin May 2016
Model: 240-000

This document describes the anthropometry and configuration of the LOIS manikin.

Background

In 1994 congress declared that the JPATS (Joint Primary Aircraft Training Systems) would accommodate 95% of the female population which translates to a 58 inch standing height and a 31 inch sitting height minimum. 6 Case sizes were introduced and shortly after Case 7 was added.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
	Small	Medium Build Short Limbs	Medium Build Long Limbs	Tall Sitting Height Short Limbs	Overall Large	Longest Limbs	Overall Small
Thumb Tip Reach	27.0	27.6	33.9	29.7	35.6	36.0	26.1
Buttock-Knee Length	21.3	21.3	26.5	22.7	27.4	27.9	20.8
Knee-Height Sitting	18.7	19.1	23.3	20.6	24.7	24.8	18.1
Sitting Height	32.8	35.5	34.9	38.5	40.0	38.0	31.0
Eye Height Sitting	28.0	30.7	30.2	33.4	35.0	32.9	26.8
Shoulder Height Sitting	20.6	22.7	22.6	25.2	26.9	25.0	19.5
Shoulder Breath Range	14.7-18.1	16.4-20.6	16.2-21.2	16.8-21.7	16.9-22.6	16.8-22.5	14.2-18.0
Chest Depth Range	7.4-10.9	6.9-10.6	7.2-11.3	7.1-11.0	7.3-12.1	7.4-12.2	7.2-10.2
Thigh Circumference Range	18.5-25.0	17.1-25.0	20.2-27.6	17.6-26.3	18.6-29.2	19.1-29.7	17.8-25.2

Manikin Development

First Technology Safety Systems, of Plymouth Michigan was given the task to develop a small female manikin to meet the Case 1 specifications. They started with their 5% female Hybrid III automotive dummy, used their pedestrian pelvis, and lengthened the segments to meet the Case 1 specifications. The chest box was changed to house an EME data acquisition system (DAS) along with battery packs. To improve strength, some material changes were incorporated. In the pelvic region, a straight spine was used in conjunction with a femur load cell for the ability to obtain 6 channels of data. The manikin total weight was to be 116 pounds including 11 pounds of instrumentation. The instrumentation portion consisted of a DAS, battery packs, instrumentation itself, and wiring. Shortly after this manikin was produced, it was determined that a smaller one was needed. Case 7 was then added listing these smaller specifications. To keep cost low, limb lengths remained the same but bone material was changed to aluminum for weight reduction. This manikin was given the name of Lightest Occupant In Service (LOIS), with a total weight of 103 pounds with instrumentation.

Manikin Evolvement Changes

A different chest box (the universal chest box) was introduced to house more DAS sizes. A second universal chest box came about by changing its material from steel to aluminum. Two more head sizes; the JSF-SF74 and the JSF-SF81 were developed to take the place of the original head. The neck was changed to the standard Hybrid III which uses bushings. The aluminum block at the top of the neck (nodding joint) started to use bushings instead of washers. Knee stops were improved. The lower arm increased material, in the elbow area, as well as a better weld for strength.



LOIS Manikin

Anthropometry

The table below gives the anthropometry measurements with the two different heads mounted.

LOIS Anthropometry Measurements – in inches	
Stature (With a JSF-SF81H Head)	60.7
Head Length (With a JSF-SF81H Head)	7.52
Head Breath (With a JSF-SF81H Head)	6.09
Head Circumference (With a JSF-SF81H Head)	21.73
Sitting Height (With a JSF-SF81H Head)	32.7
Eye Height Sitting (With a JSF-SF81H Head)	27.5
Stature (With a JSF-SF74A Head)	60.4
Head Length (JSF-SF74A Head)	7.32
Head Breath (JSF-SF74A Head)	5.51
Head Circumference (JSF-SF74A Head)	21.25
Sitting Height (With a JSF-SF74A Head)	32.4
Eye Height Sitting (With a JSF-SF74A Head)	27.8
Thumb Tip Reach	27.2
Shoulder Breath	15.0
Chest Depth	9.7
Chest Breath	10.1
Chest Circumference	34.1
Waist Circumference	31.0
Hip Breath	11.6
Thigh Circumference	17.4
Buttock-Knee Length	21.0
Knee-Height Sitting	18.7
Foot Length	8.9
Shoulder Height Sitting	21.6

A LOIS manikin without instrumentation normally has a weight of 95 pounds. Fully instrumented tests sometimes give a weight variance of 103 +5/- 0 pounds.

Heads

The original head, which was developed for the 5% VIP dummy, is no longer used. The two head sizes that are used with the LOIS manikin are the JSF-SF74 and the JSF-SF81. The JSF-SF74 head was developed using the CEASAR data base. The shape was a scanned human having one side mirrored so data points would be consistent from side to side. The head assembly has an average weight of 8.1 pounds. It originally weighed 7.4 pounds, but had a volume and weight increase, thus the final version has a part number of JSF-SF74A.

HEAD DESCRIPTION

JSF- SF74A

Production or MFG. Part Number: 241-100HX

Average Weight ~ 8.1 Pounds

Average durometer shore "A " reading ~ 57

-- New mold developed for JSF --

Normally used with – LOIS manikin



Flight Equipment Required :

Medium – Helmet LW HGU-55/P (CE MOD)

Medium – Zeta Liners

S / N – Oxygen Mask – MBU- 20/P

Head Size :

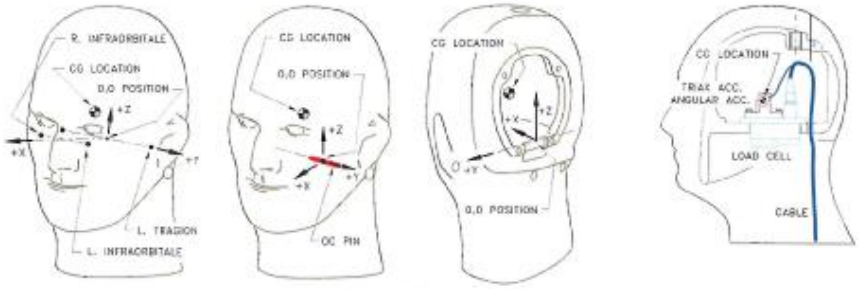
Breath - 5.51 Length - 7.32

Circumference - 21.25

Neck Size :

Normally used with a 5% female Hybrid III & bushings

Part No: FTSS & Denton ~ 880105-255



Average Measurements

Landmarks	X (cm)	Y (cm)	Z (cm)	X (in.)	Y (in.)	Z (in.)
CG Anatomical Location	00	00	00	00	00	00
CG Head/Neck Joint Location	00	00	00	00	00	00
CG Manufacturer Location	00	00	00	00	00	00
CG Head/Neck Joint subtracting 1/2 load cell and OC Pin	00	00	00	.72	00	1.93

Components used when measured:



The second head used is the JSF-SF81 head which was developed using the CEASAR data base. The shape was a scanned human having one side mirrored so data points would be consistent from side to side. The head assembly has an average weight of 8.1 pounds. Through the development process, a harder version was needed which concluded with the part number being JSF-SF81H.

HEAD DESCRIPTION

JSF- SF81H

Production or MFG. Part Number: 200-100HX

Average Weight ~ 8.1 Pounds

Average durometer shore "A " reading ~ 57

-- New mold developed for JSF –

Normally used with – LOIS manikin



Flight Equipment Required :

Medium – Helmet LW HGU-55/P (CE MOD)

Medium – Zeta Liners

S / N – Oxygen Mask – MBU- 20/P

Head Size :

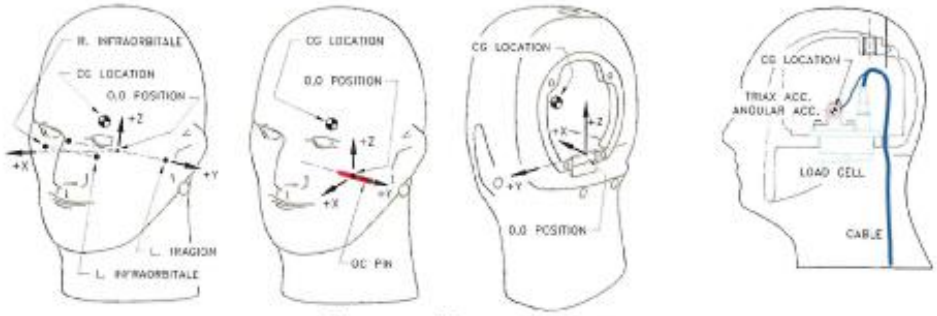
Breath - 6.09 Length - 7.52

Circumference - 21.73

Neck Size :

Normally used with a 5% female Hybrid III & bushings

Part No: FTSS & Denton ~ 880105-255



Average Measurements

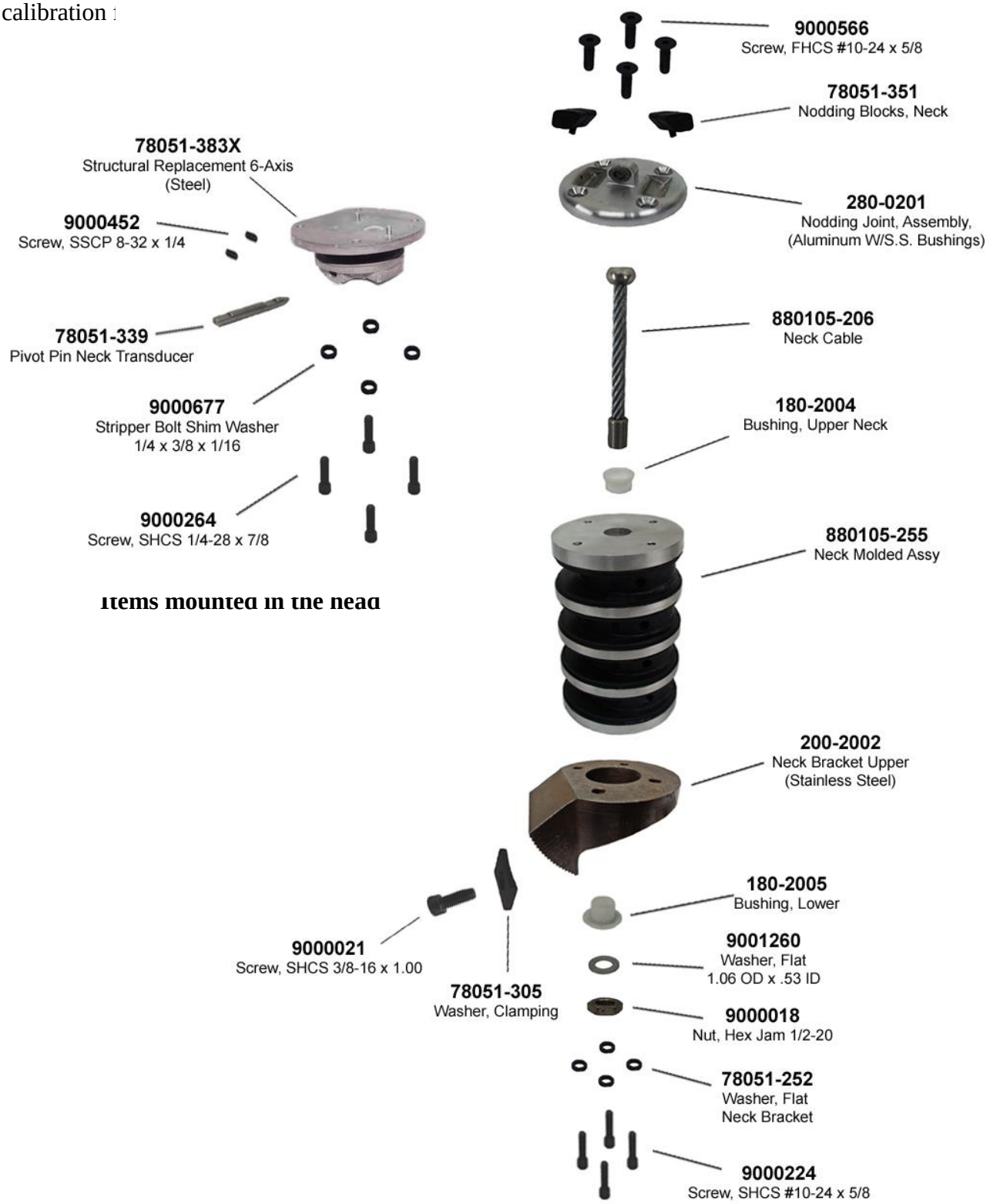
Landmarks	X (cm)	Y (cm)	Z (cm)	X (in.)	Y (in.)	Z (in.)
CG Anatomical Location	.24	0.08	1.81	0.10	0.03	0.71
CG Head/Neck Joint Location	1.67	-0.03	4.73	0.62	-0.02	1.87
CG Manufacturer Location	5.41	0.03	3.53	2.13	0.01	1.39
CG Head/Neck Joint subtracting 1/2 load cell and OC Pin	1.69	-0.07	5.12	0.66	-0.02	2.01

Components used when measured:



Neck Assembly

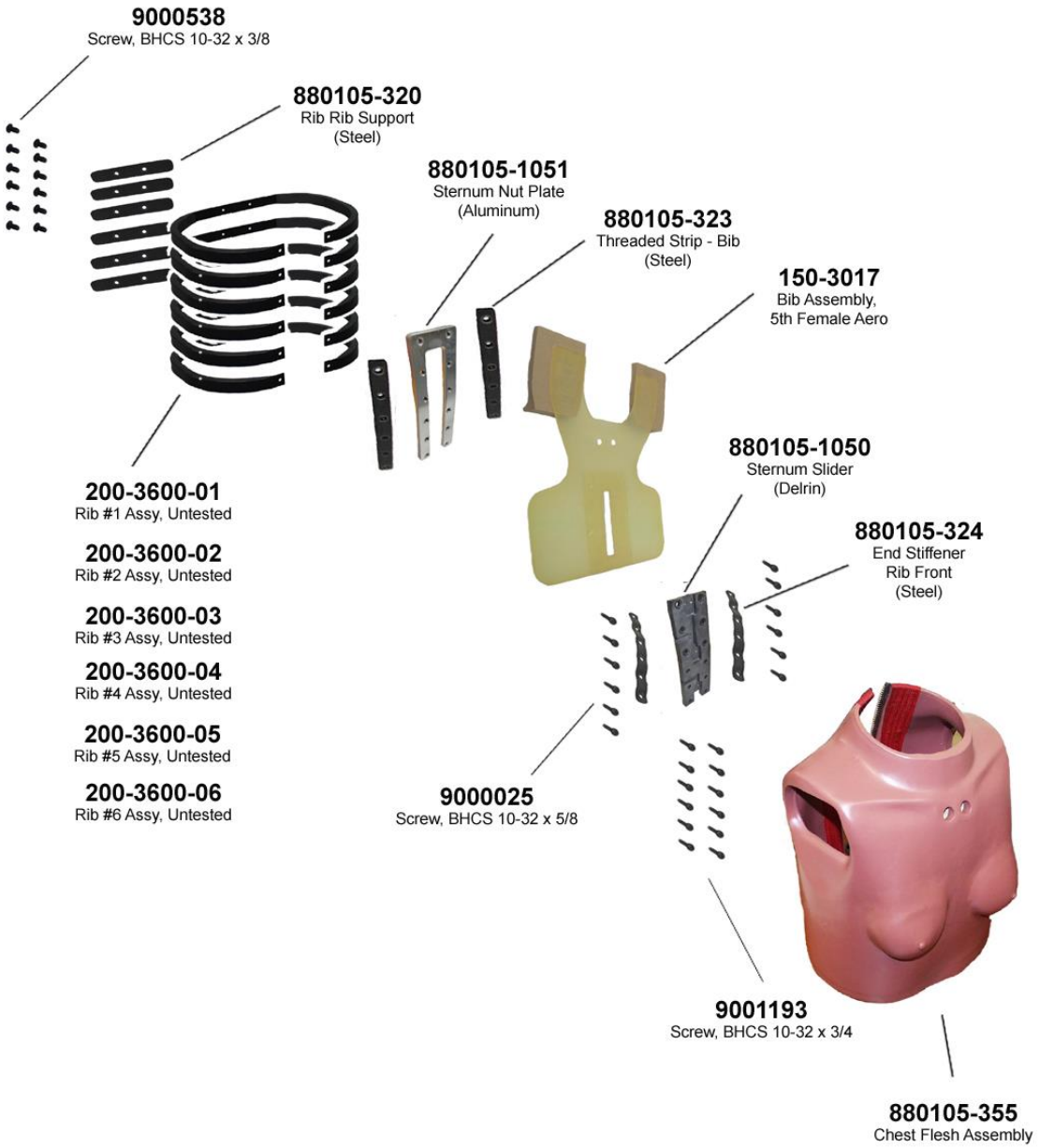
The neck used today is the same one used on the 5% female Hybrid III automotive crash test dummy (PN: 880105-225). The original LOIS neck (PN: 880105-202) is acceptable to use. Part numbers 880105-225 is to be used with neck bushings. Necks are in calibration



Items mounted in the head

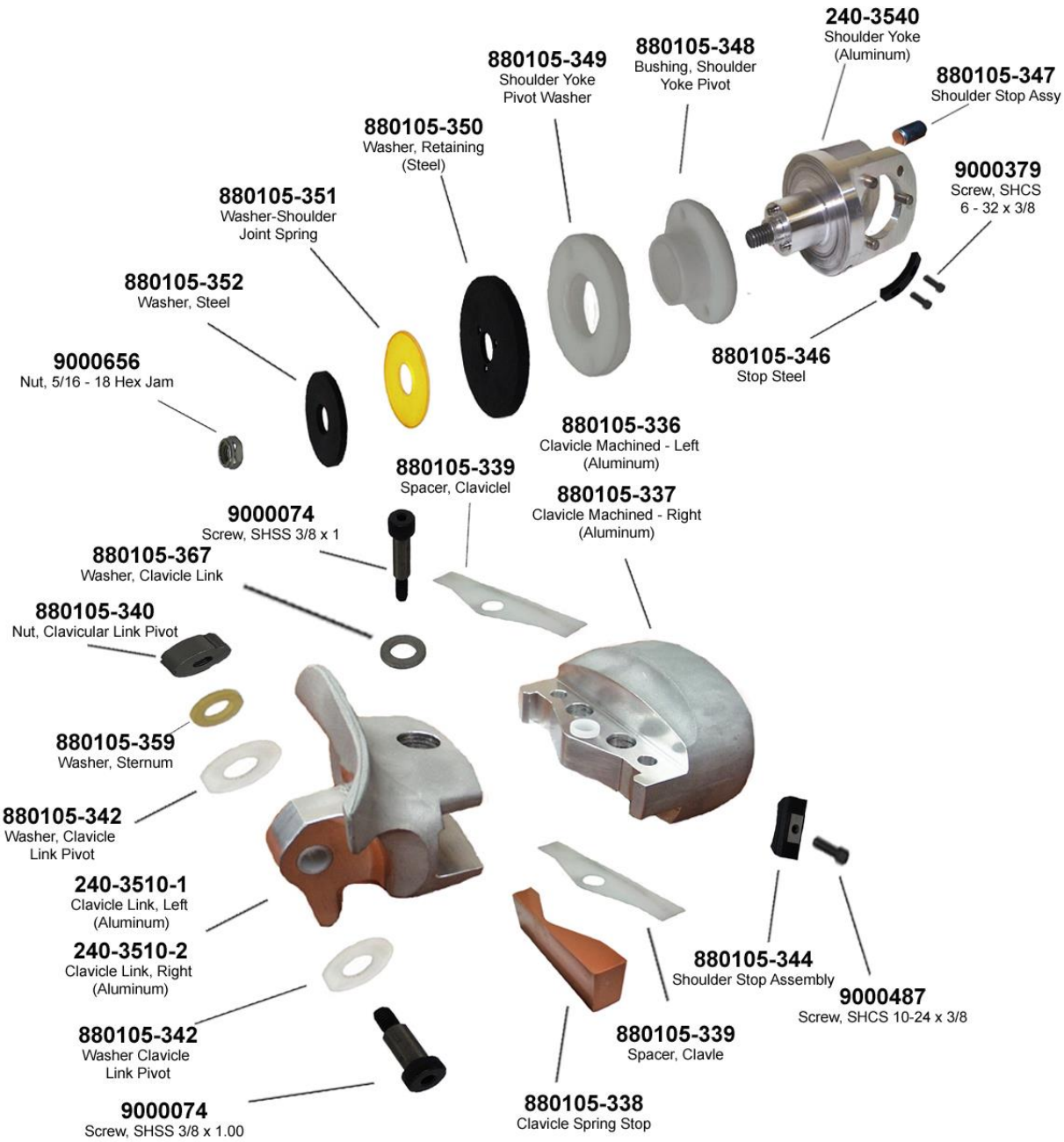
Chest Components

The chest was originally set up with a chest potentiometer for measuring chest deflection, but was removed because there was not a need. The chest flesh is different from the 5% female automotive Hybrid III by the zipper starting at the bottom, which allows better access to added instrumentation.



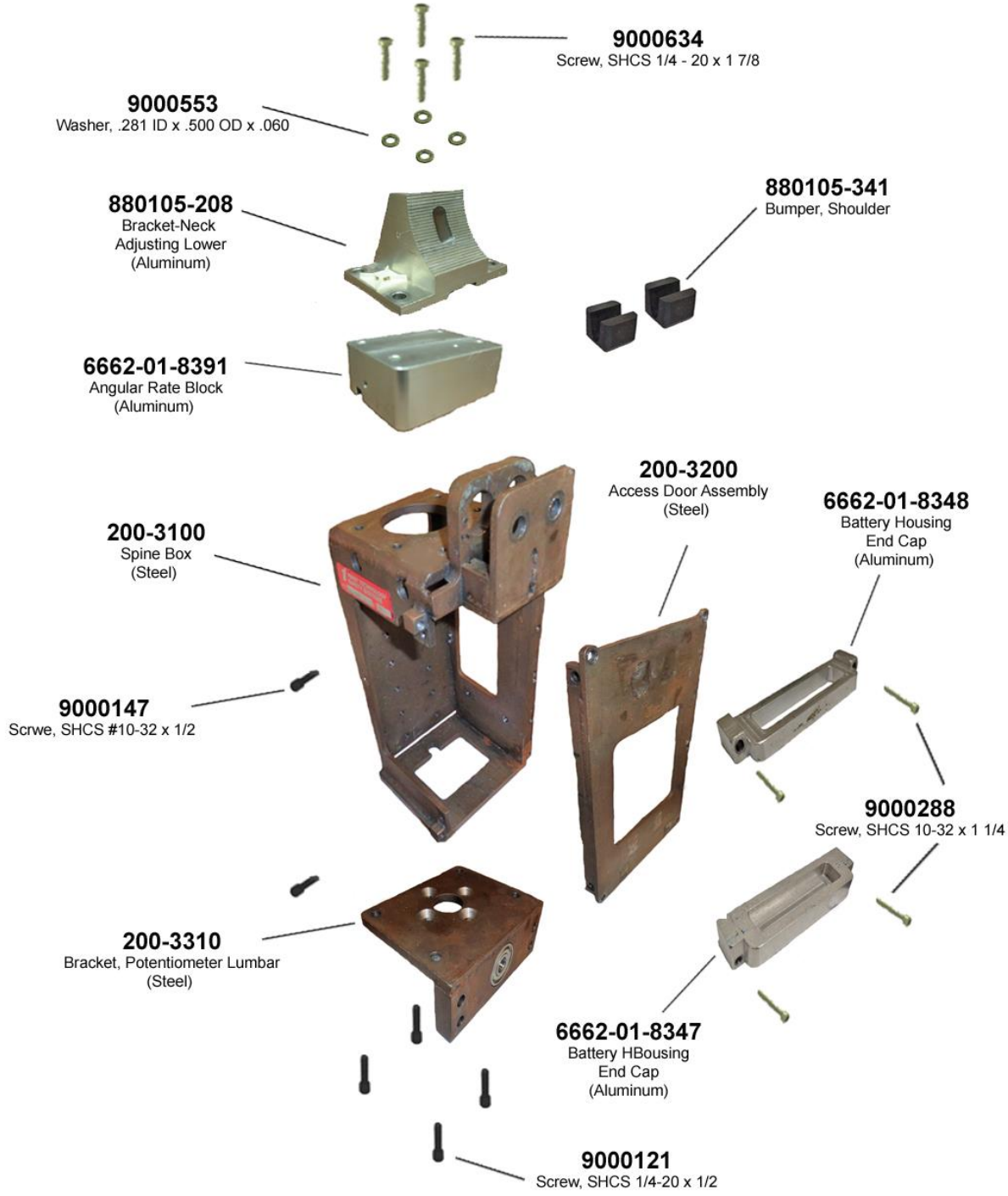
Shoulder Components

The shoulder design is the same as the 5% female Hybrid III automotive dummy. The clavicle links have been modified by allowing clearance for the universal chest box. Shoulder yoke material is aluminum as compared to steel on the automotive dummy. Shoulder extensions will be described later.

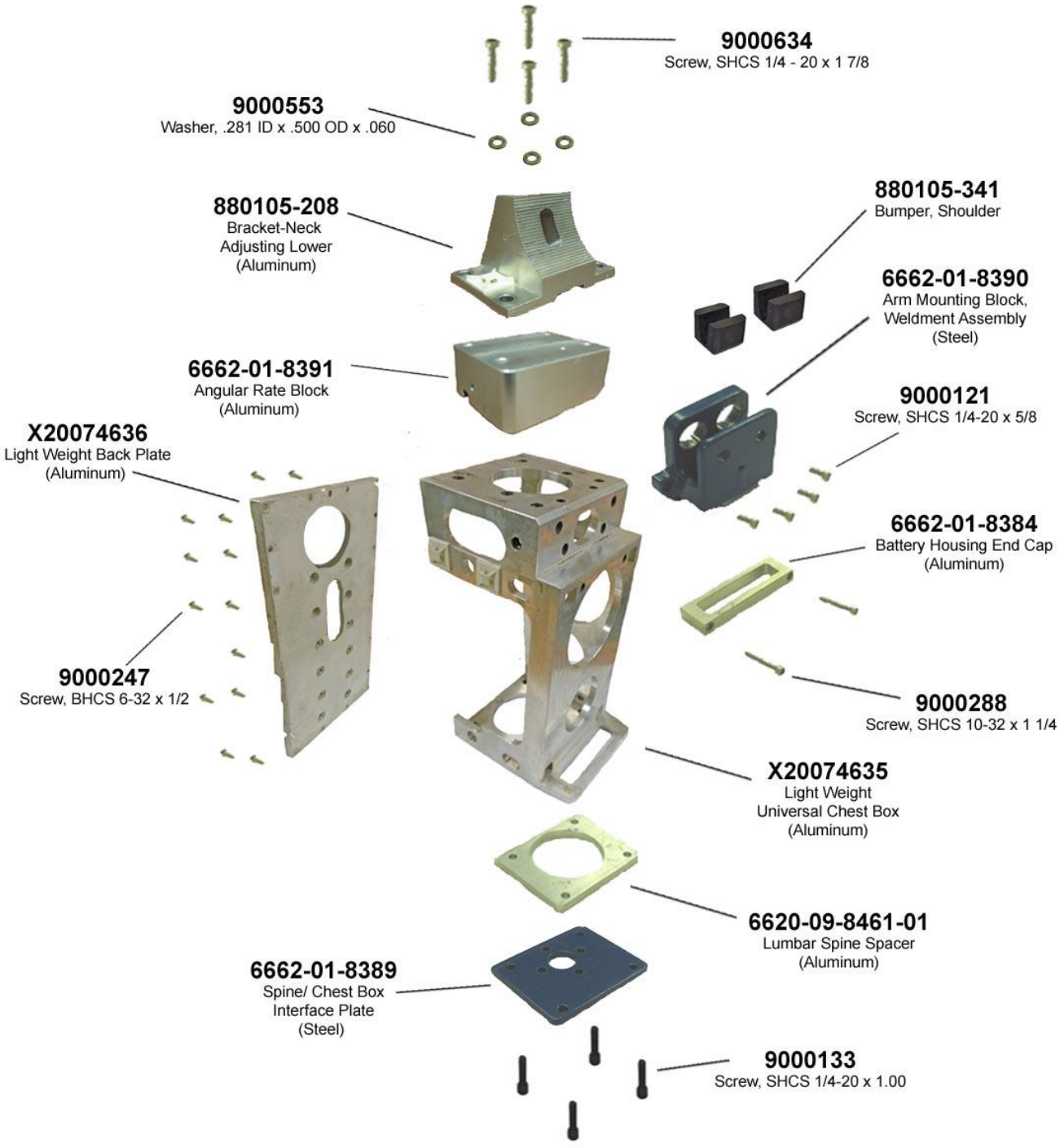


Chest Box Components

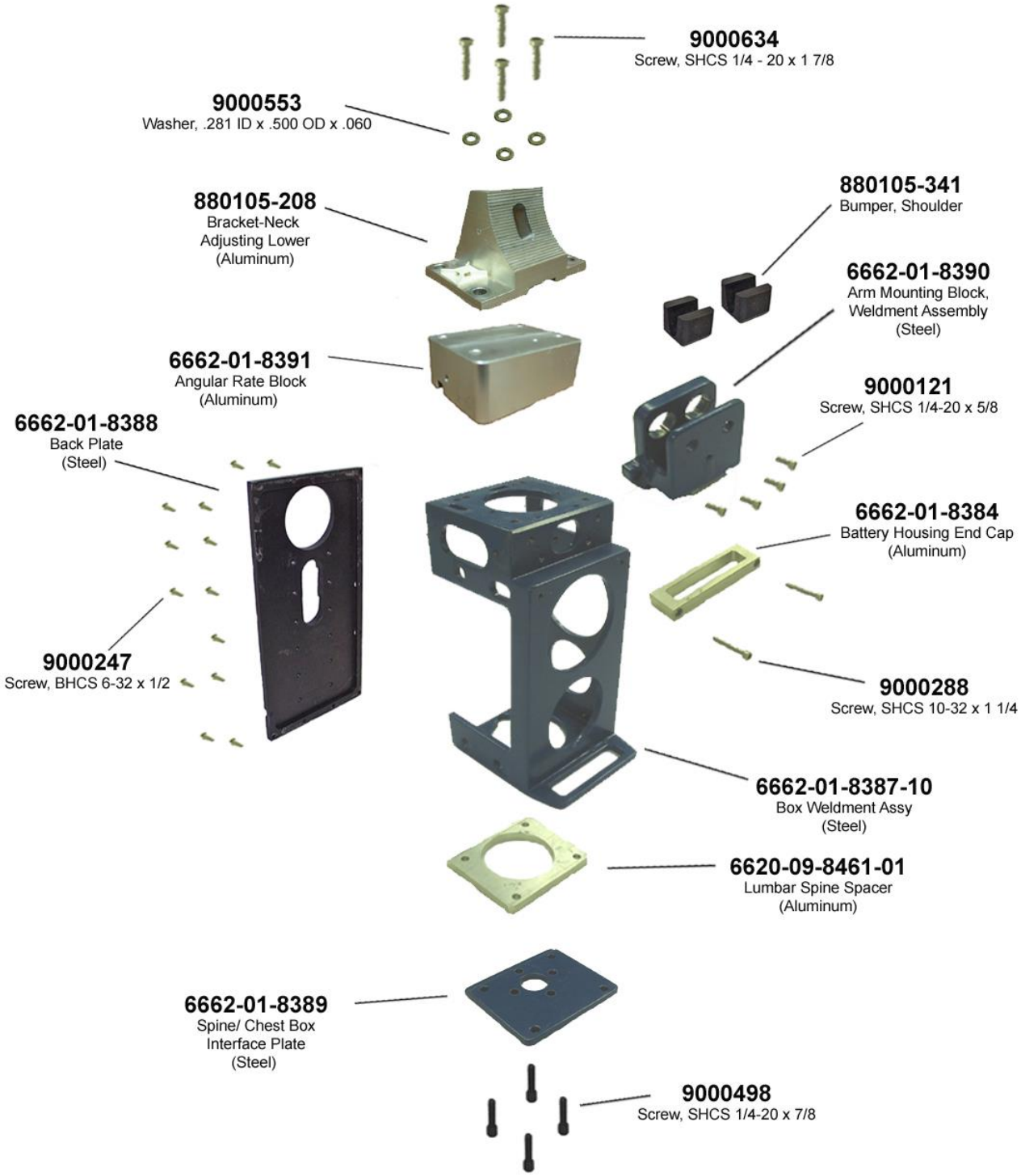
There are three chest box designs; the original in steel and two universal chest box types. The early universal box was made from steel and a new version is made of aluminum. Any one of the three boxes can be used. A lighter weight is obtained by using the aluminum one.



Original Steel Chest Box



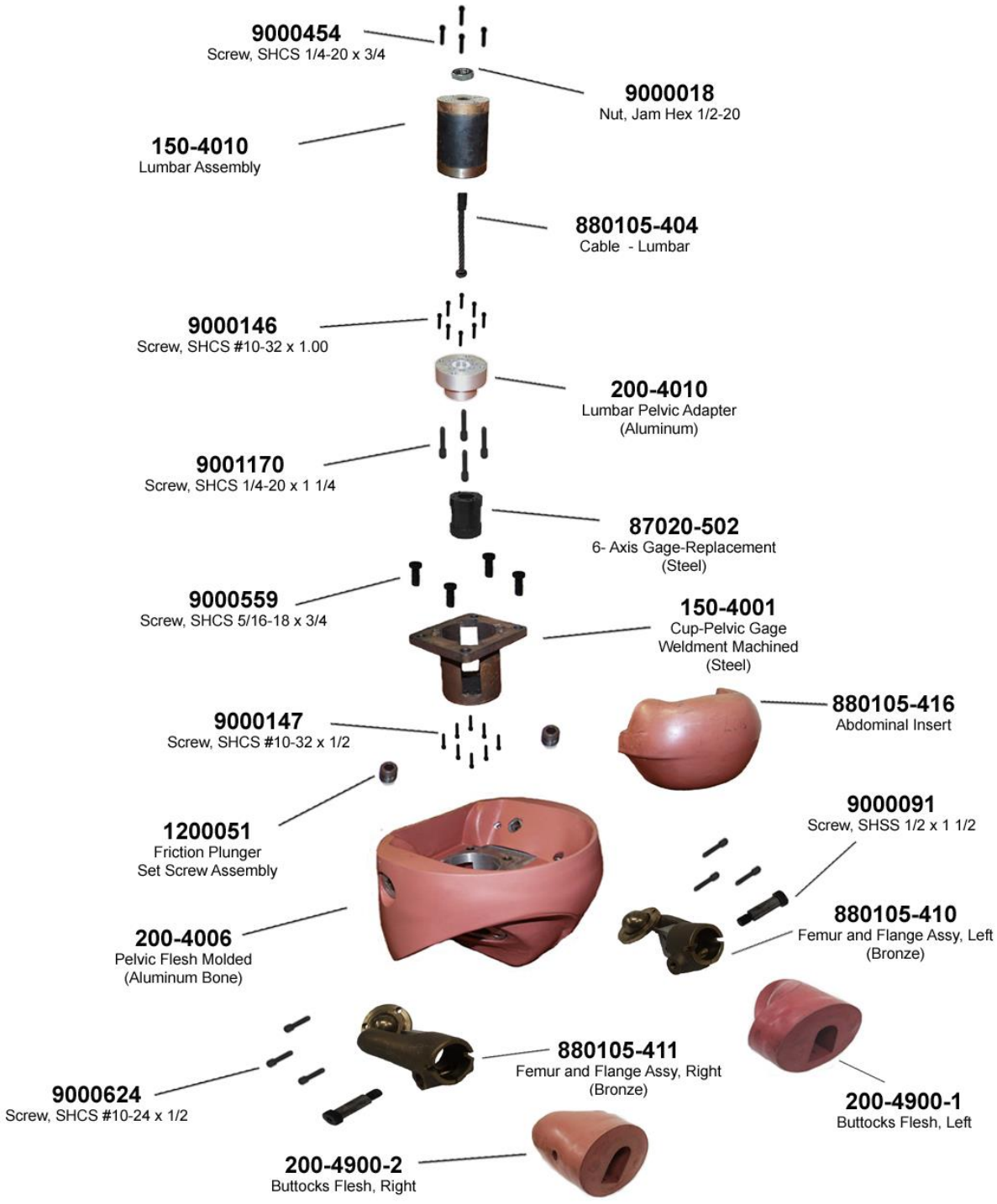
Aluminum Universal Chest Box



Steel Universal Chest Box

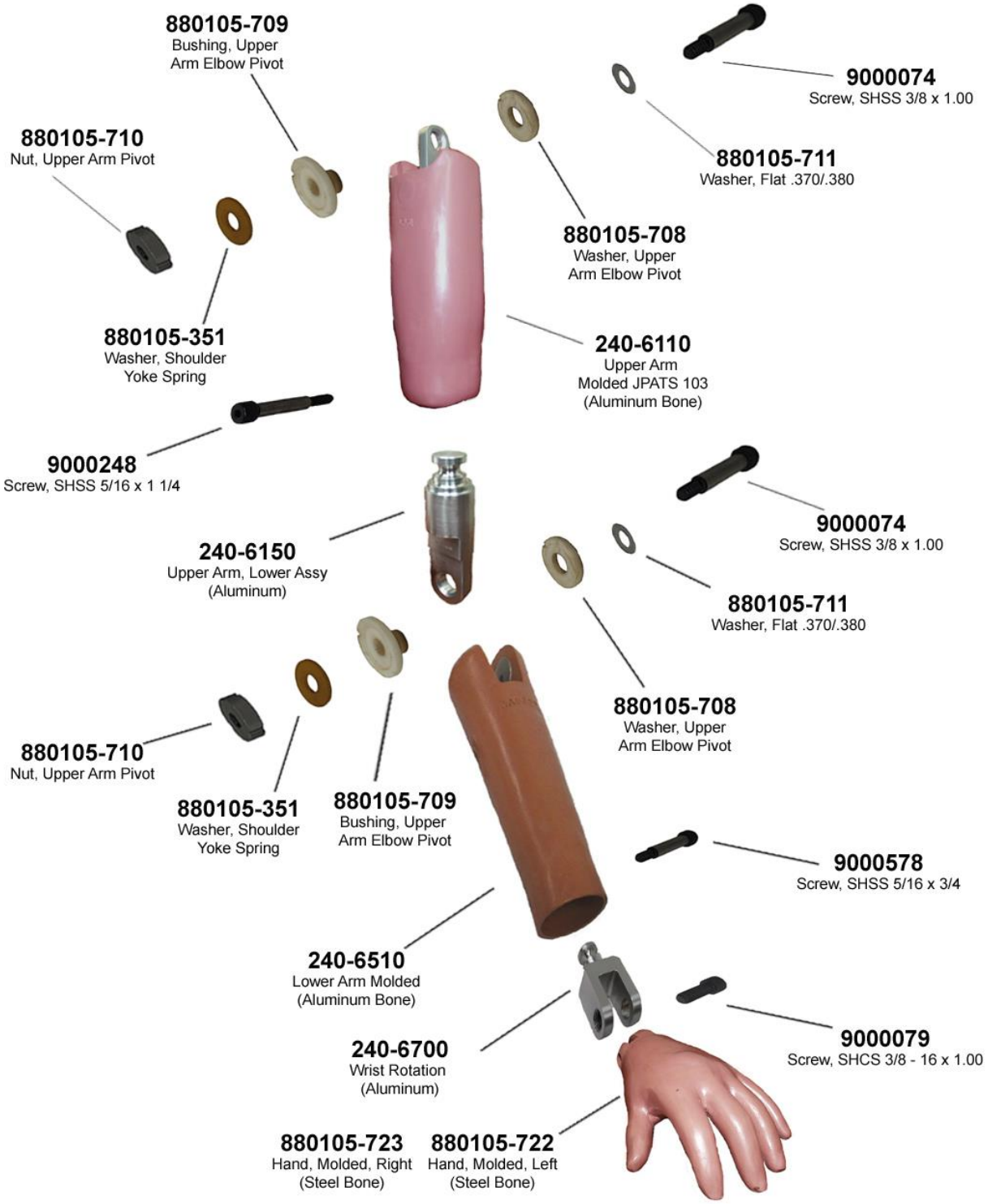
Lower Torso Pelvis

The pelvis is a pedestrian design for standing along with a straight spine.



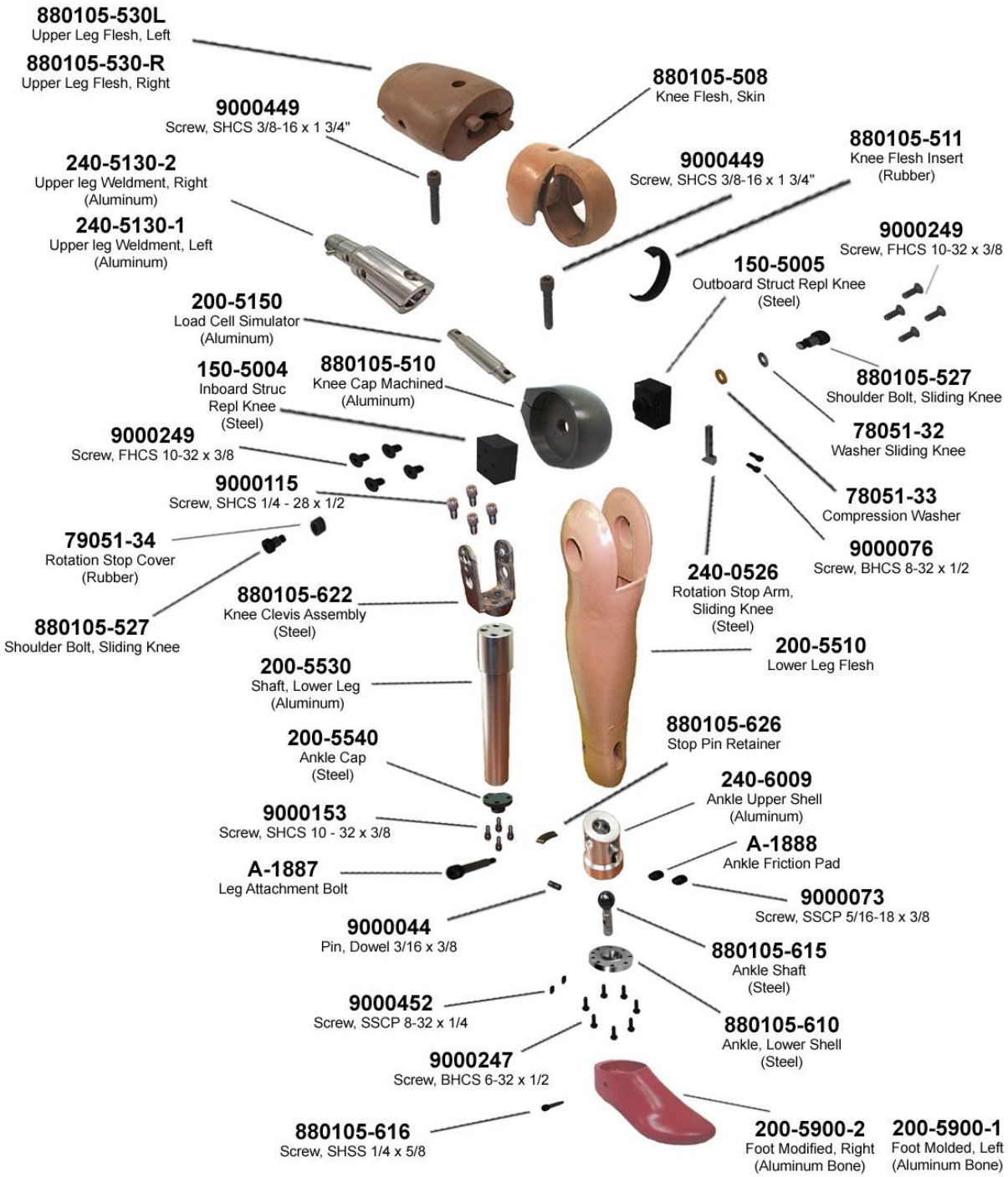
Arm Assembly

The arms are the same design as the 5% female automotive Hybrid III. The bones have been changed to aluminum and the upper and lower segments have been lengthened to meet the JPATS Case 1 specifications.



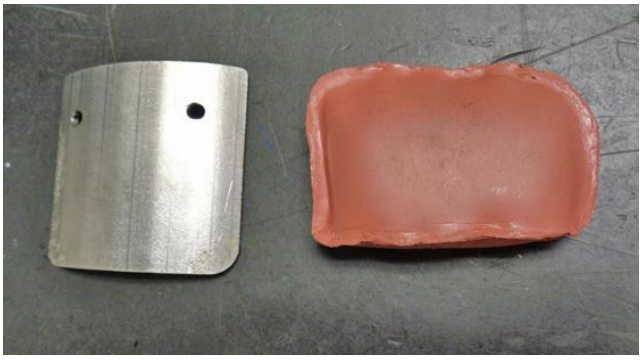
Leg Assembly

The legs are basically the same design as the 5% female automotive Hybrid III. Some of the bone material was changed to aluminum and the upper and lower leg segments have been lengthened to meet the JPATS Case 1 specifications.



Shoulder Extensions

Shoulder extensions are sometimes used as part of the manikin buildup and are added to the nude weight. The general idea is to lengthen the chest jacket covering the normally exposed shoulder. There are no specific guide lines for shoulder extensions but sometimes they are made from 1/8 thick aluminum plates that are bent in the shape of the clavicle and bolted in pace to the clavicles. A foam type pad, sometimes made of skin covered or tape covered, is either Velcro or taped in place to fill the area between the aluminum extension and the chest jacket. On an average, both sides add about 3/4 pounds.







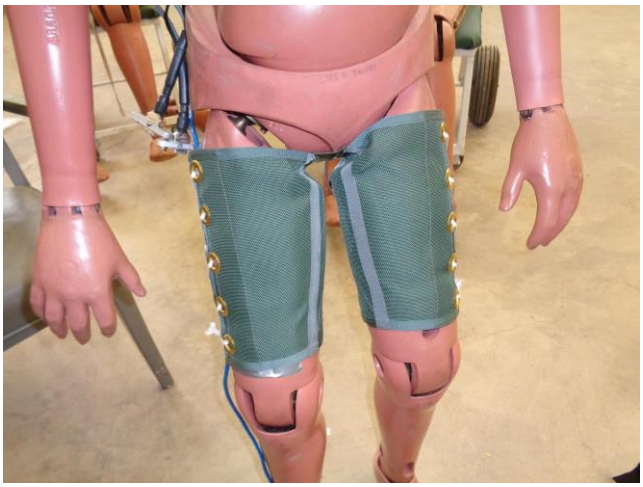




Chaps

Chaps are sometimes used as part of the manikin buildup and are added to the nude weight. Chaps can be made from materials, sown together. They are generally laced in place on the upper legs to somewhat close off the opening between the upper legs and the pelvis in hopes of keeping the harness from sliding into this gap. On an average this adds about 1 1/4 pounds.





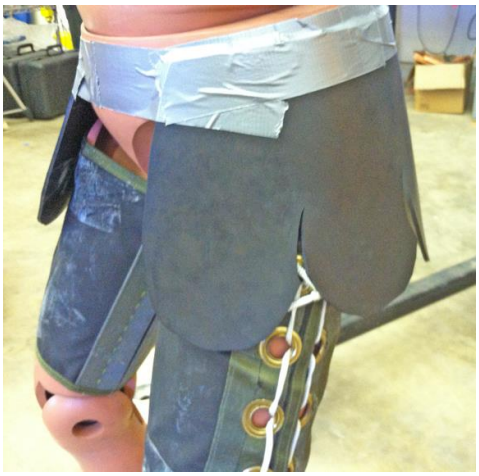


Skirts

Skirts are sometimes used as part of the manikin buildup and are added to the nude weight. Skirts can be 1/8 thick rubber or manikin bib material. They are generally duck tapped in place, on the pelvis, to somewhat close off the opening between the upper legs and the pelvis in hopes of keeping the harness from sliding into this gap. There is no specific place on the pelvis for location. On an average, both add about 1 1/2 pounds.



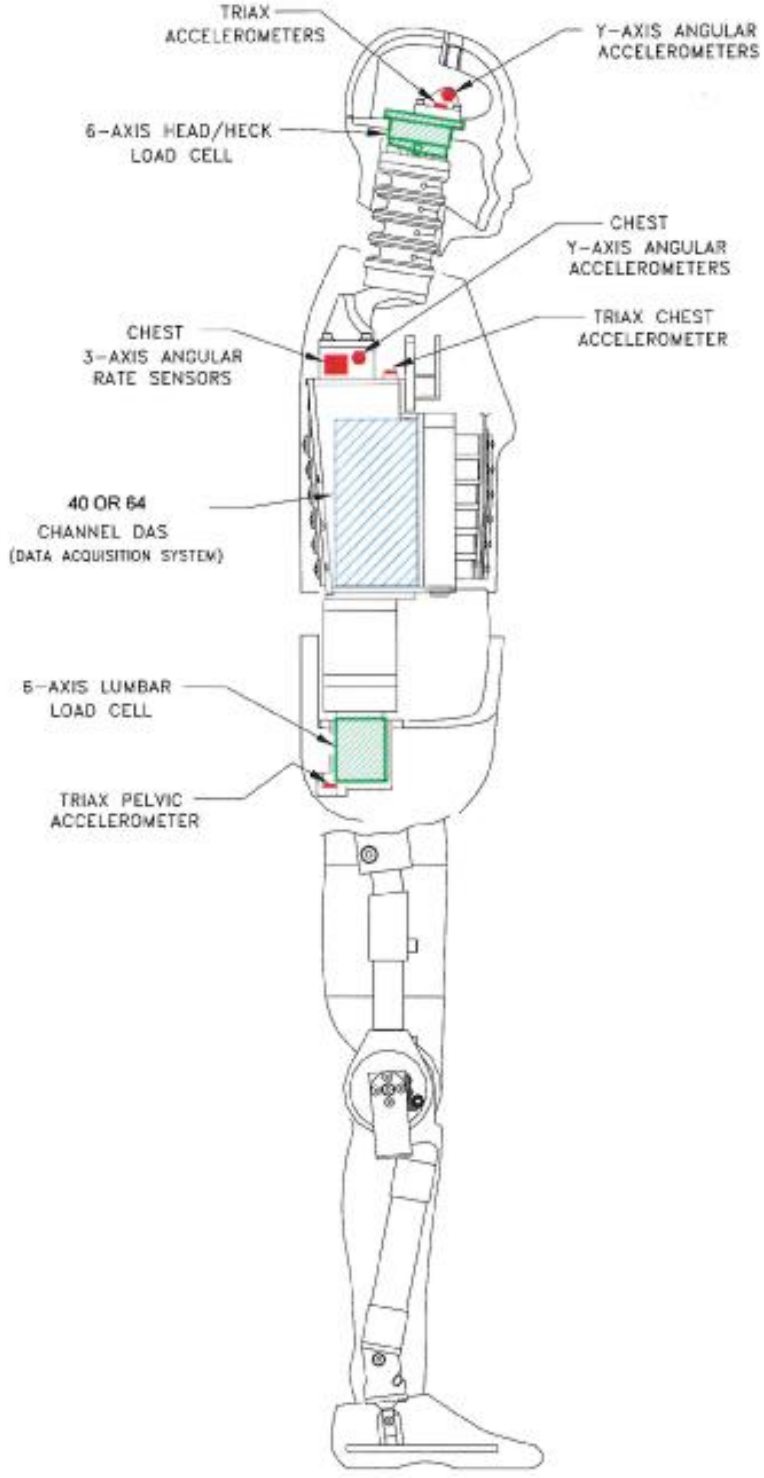






Instrumentation

Shown below is a general location and instrumentation that can be used with the LOIS manikin.



Appendix D-2
CASE 2STL (CASE 2 Short Torso Lightweight) May 2016

This document describes the anthropometry and configuration of the CASE 2STL manikin.

Background

In 1994 congress declared that the JPATS (Joint Primary Aircraft Training Systems) would accommodate 95% of the female population which translates to a 58 inch standing height and a 31 inch sitting height minimum. 6 Case sizes were introduced. This size manikin was brought about because of a needed lighter version of the manikin Martin-Baker used in the Mk16E seat testing.

	Case 1 Small	Case 2 Medium Build Short Limbs	Case 3 Medium Build Long Limbs	Case 4 Tall Sitting Height Short Limbs	Case 5 Overall Large	Case 6 Longest Limbs	Case 7 Overall Small
Thumb Tip Reach	27.0	27.6	33.9	29.7	35.6	36.0	26.1
Buttock-Knee Length	21.3	21.3	26.5	22.7	27.4	27.9	20.8
Knee-Height Sitting	18.7	19.1	23.3	20.6	24.7	24.8	18.1
Sitting Height	32.8	35.5	34.9	38.5	40.0	38.0	31.0
Eye Height Sitting	28.0	30.7	30.2	33.4	35.0	32.9	26.8
Shoulder Height Sitting	20.6	22.7	22.6	25.2	26.9	25.0	19.5
Shoulder Breath Range	14.7-18.1	16.4-20.6	16.2-21.2	16.8-21.7	16.9-22.6	16.8-22.5	14.2-18.0
Chest Depth Range	7.4-10.9	6.9-10.6	7.2-11.3	7.1-11.0	7.3-12.1	7.4-12.2	7.2-10.2
Thigh Circumference Range	18.5-25.0	17.1-25.0	20.2-27.6	17.6-26.3	18.6-29.2	19.1-29.7	17.8-25.2

Manikin Development

Humanoids Systems, of Carson, California developed the 5th percentile male aerospace manikin having an un-instrumented weight of 146 pounds. To achieve the specified weight, some material was changed to aluminum. The chest box was changed to house an EME data acquisition system (DAS) along with battery packs. The manikin total weight was to be 136 pounds including 11 pounds of instrumentation. The instrumentation portion consisted of a DAS, battery packs, instrumentation itself, and wiring. Also in the nude weight, chaps, skirts and shoulder extensions were to be added.

Manikin Evolvement Changes

Through testing and evaluation, this document describes the components for this CASE 2 STL manikin.



CASE 2 STL Manikin

Anthropometry

The table below gives the anthropometry measurements.

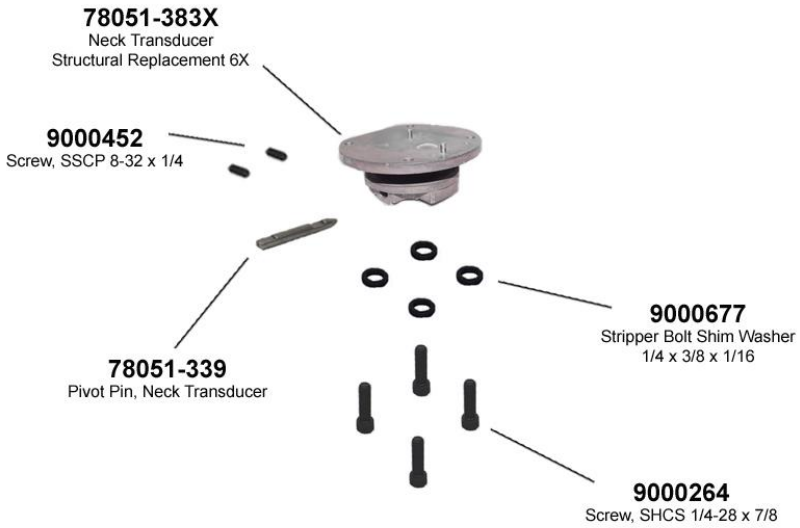
CASE 2STL Anthropometry Measurements – in inches	
Stature	66
Head Length	8.0
Head Breath	6.0
Head Circumference	23.1
Sitting Height	34.9
Eye Height Sitting	30.4
Thumb Tip Reach	27.4
Shoulder Breath	18.8
Chest Depth	9.8
Chest Breath	11.7
Chest Circumference	37.2
Waist Circumference	33
Hip Breath	14.7
Thigh Circumference	20.2
Buttock-Knee Length	22.6
Knee-Height Sitting	21.0
Foot Length	10.2

A CASE 2STL manikin without instrumentation normally has a weight of 122 pounds. Fully instrumented tests could have a weight variance of 136 +/- 3 pounds.

Head

The head is an ADAM type with a total weight of 10.4 pounds having a CG location of 1.9 inches in the Z-axis and 0.5 inches in the X-axis. This weight was established by adding the total weight of the head, a Denton 1716 load cell, pin, and head instrumentation package having 12" cable length. The instrumentation package consisted of a JSF-LM 110 mounting block, Entran EGV3 triax accelerometer, and an Endevco 7302B angular accelerometer. To establish the head's total weight, .66 pounds was subtracted, which equals the lower part of the load cell, ending with the noted 10.4 pounds. Ears were glued on the head (the ADAM mold does not have ears).

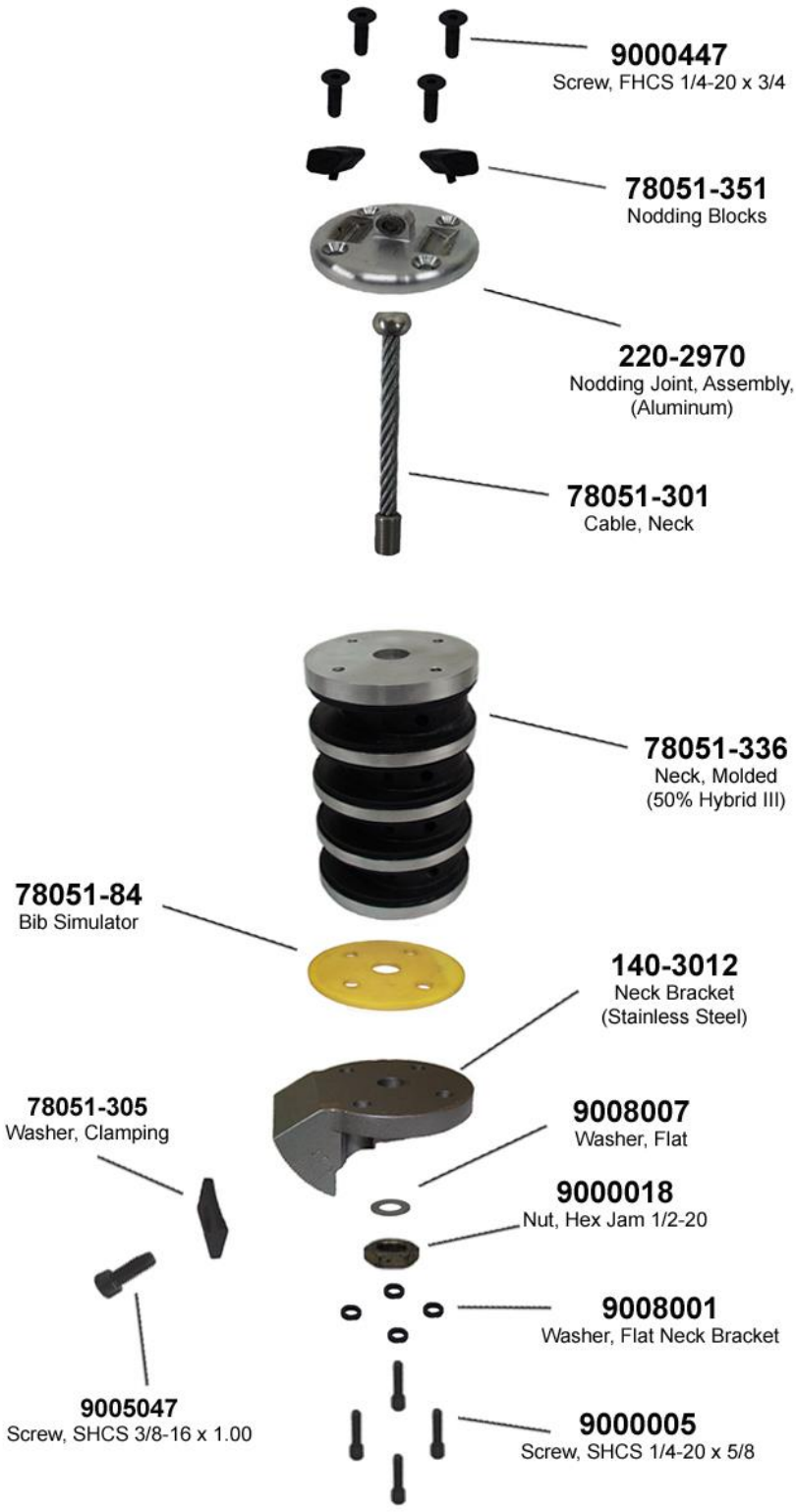




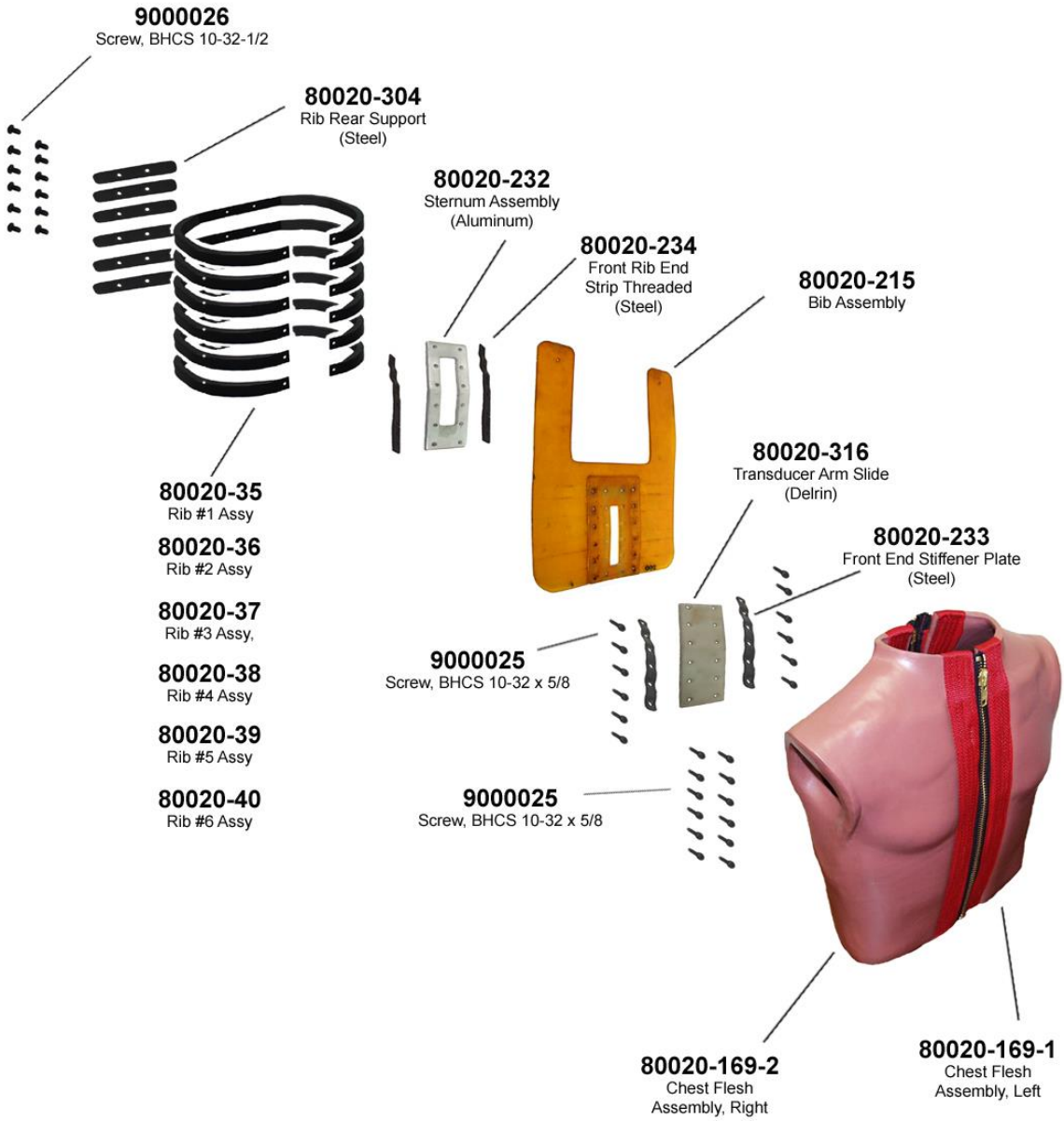
Items mounted in the head

Neck Assembly

The neck used is the same one used on the 50% Hybrid III automotive crash test dummy (PN: 78051-336). Necks are in calibration for a year.

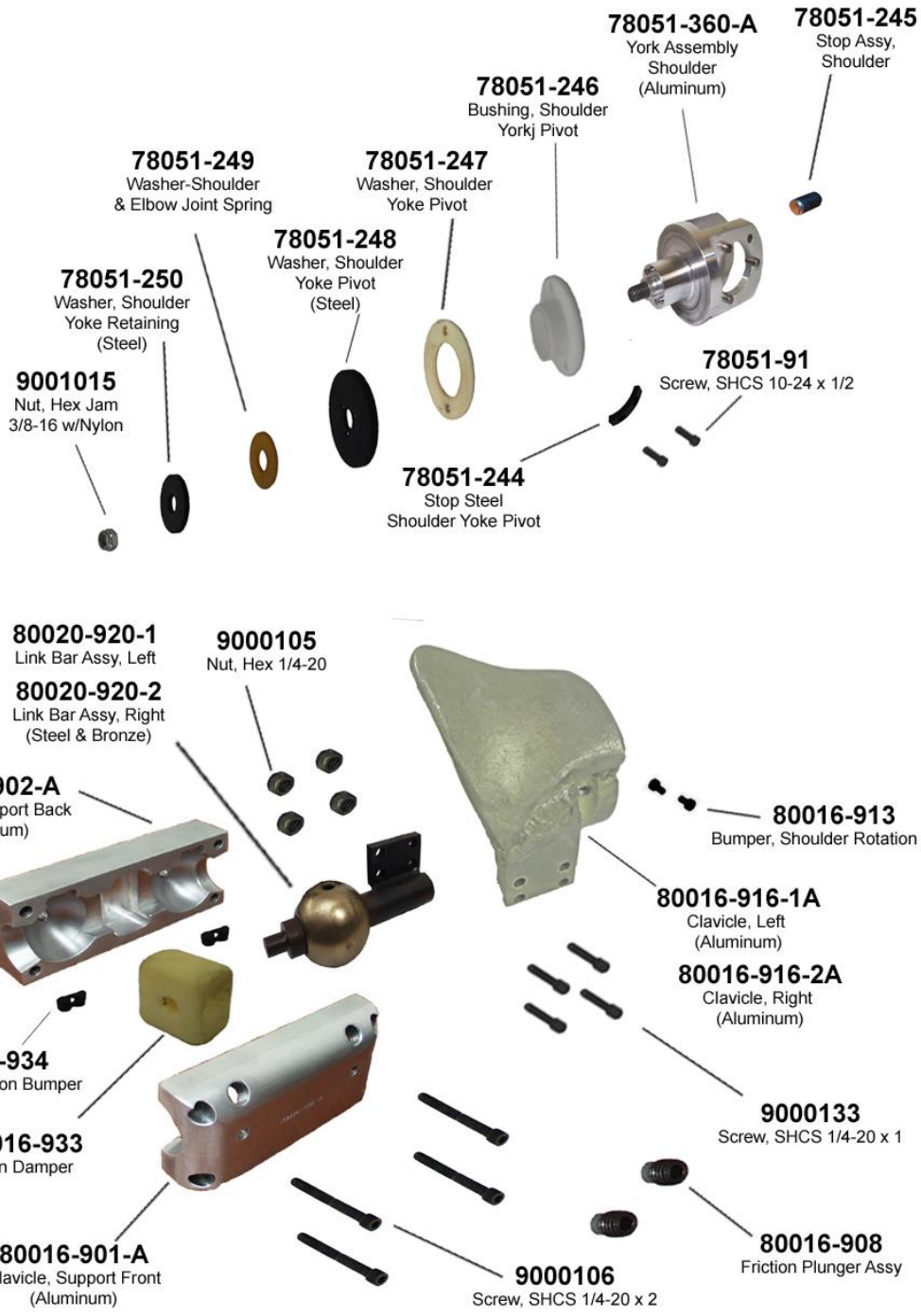


Chest Components

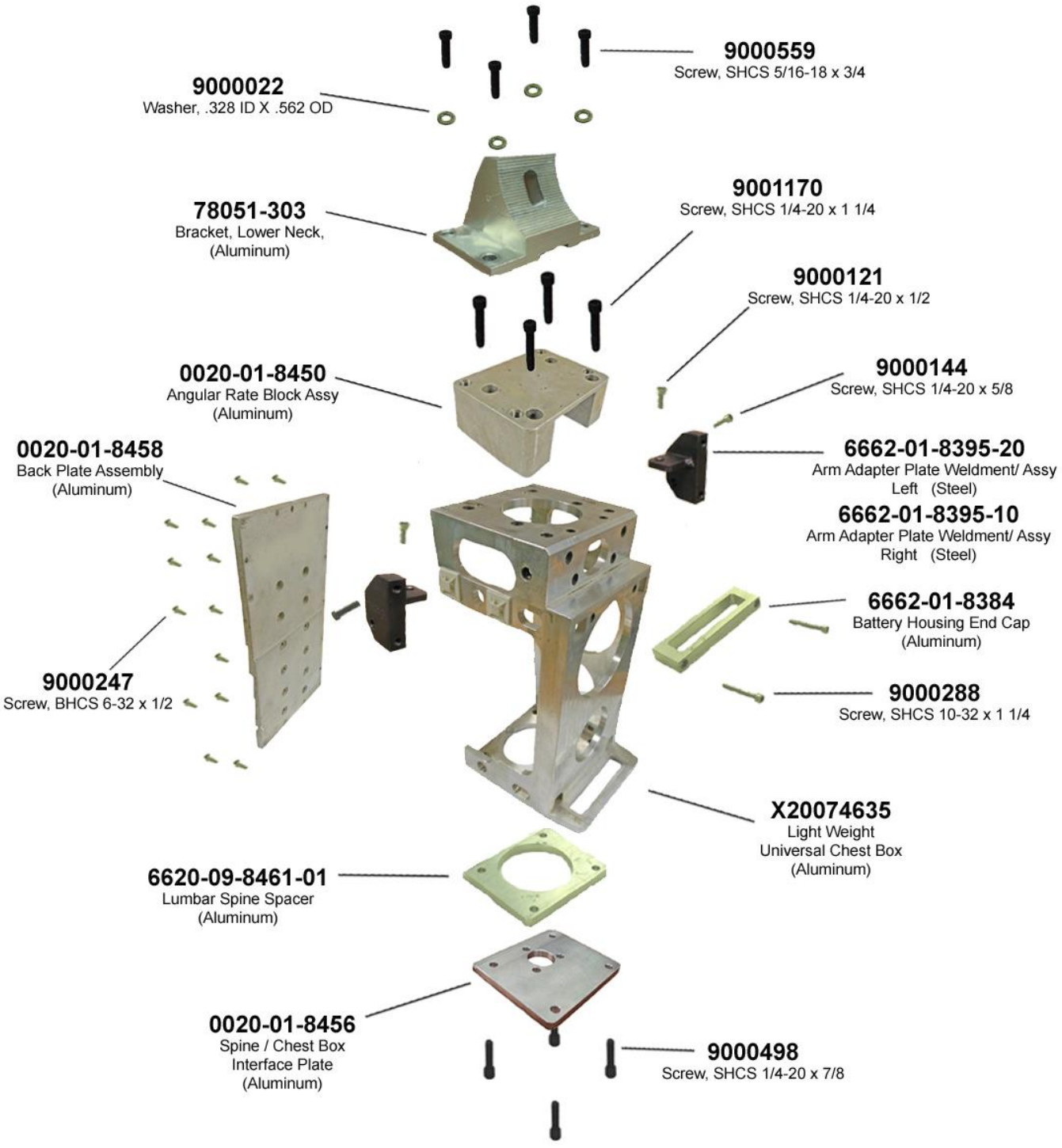


Shoulder Components

The shoulder design is the same as the 5% male aerospace dummy. Materials of some components have been changed to aluminum for weight requirements. Shoulder extensions will be described later.

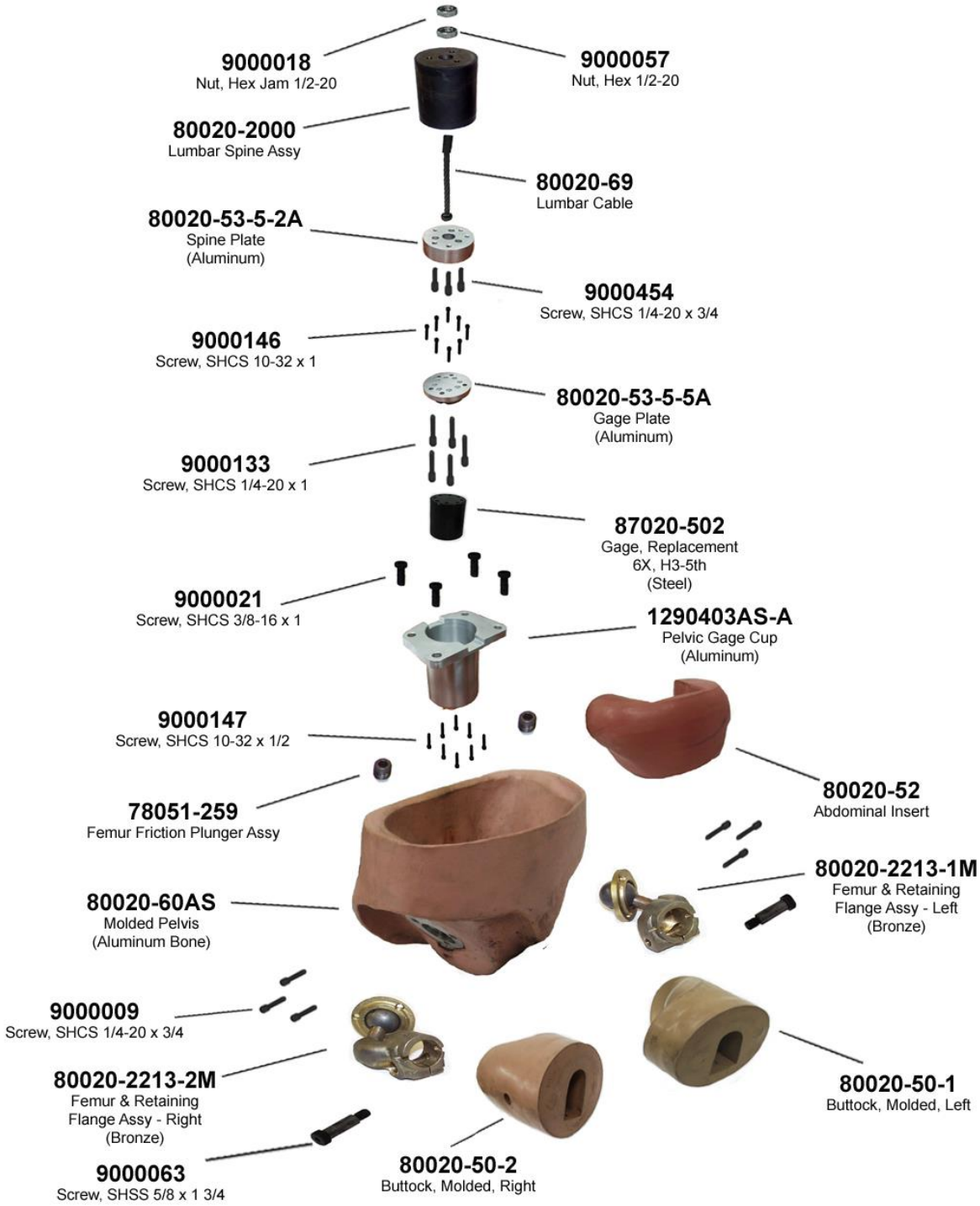


Chest Box Components

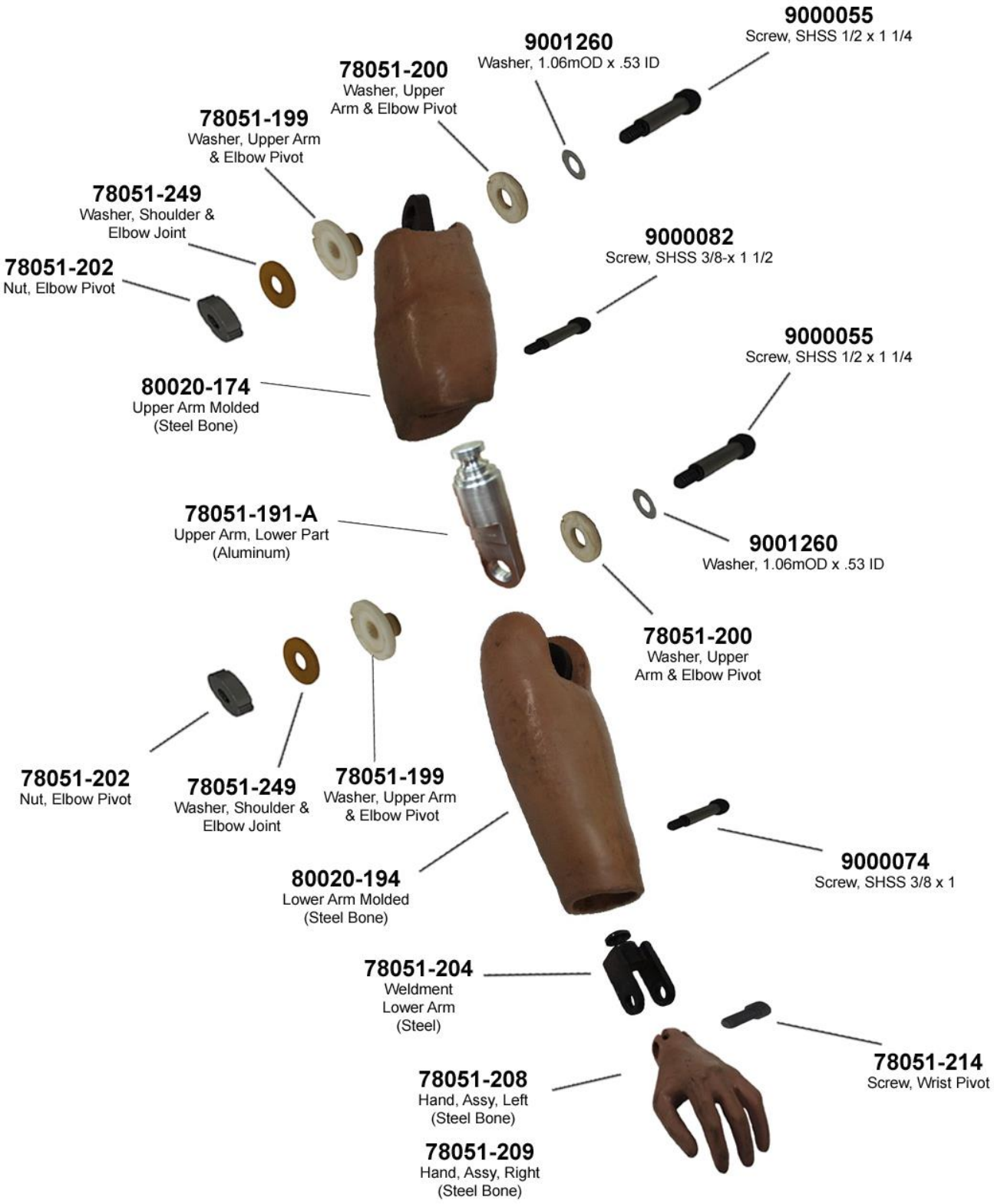


Lower Torso Pelvis

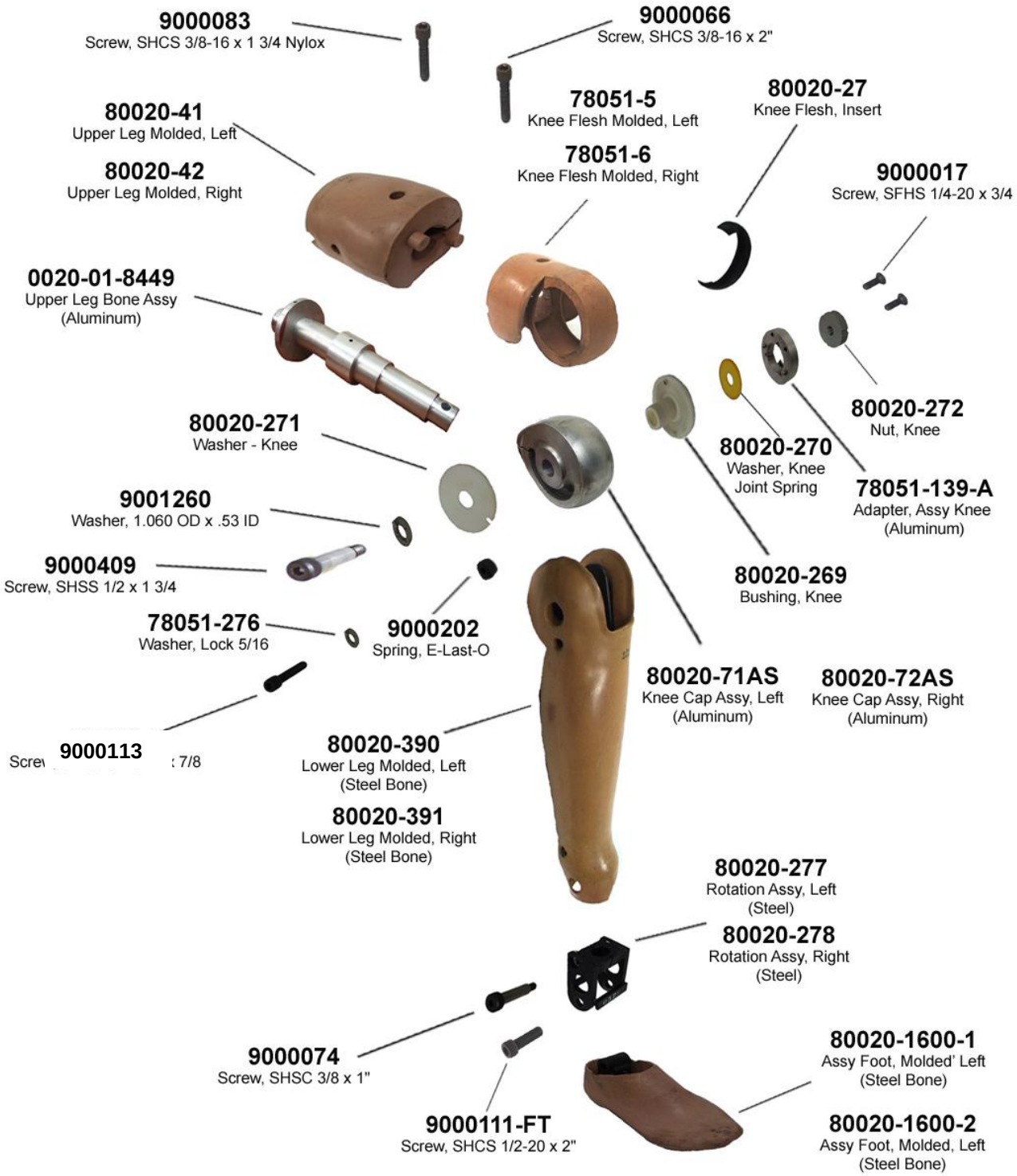
The pelvis is a pedestrian design for standing along with a straight spine.



Arm Assembly

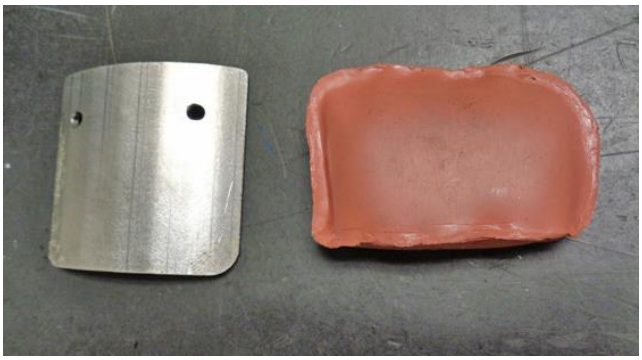


Leg Assembly



Shoulder Extensions

Shoulder extensions are sometimes used as part of the manikin buildup and are added to the nude weight. The general idea is to lengthen the chest jacket covering the normally exposed shoulder. There are no specific guide lines for shoulder extensions but normally they are made from 1/8 thick aluminum plates that are bent in the shape of the clavicle and bolted in pace to the clavicles. A foam type pad, either skin covered or tape covered, is either Velcro or taped in place to fill the area between the aluminum extension and the chest jacket. On an average, both sides add about 3/4 pounds.







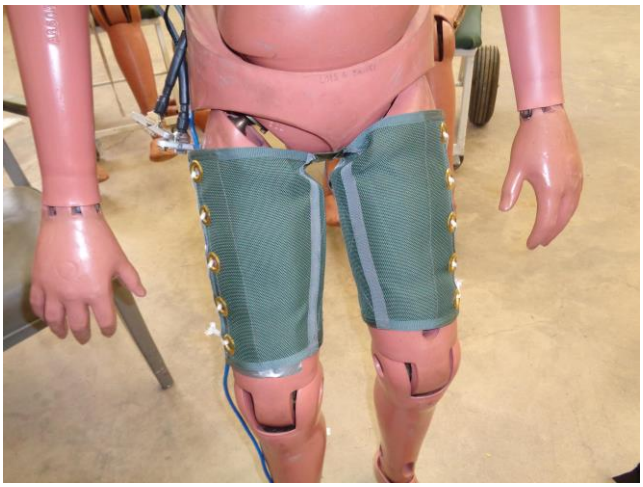




Chaps

Chaps are sometimes used as part of the manikin buildup and are added to the nude weight. Chaps are made from materials, sown together. They are generally laced in place on the upper legs to somewhat close off the opening between the upper legs and the pelvis in hopes of keeping the harness from sliding into this gap. On an average this adds about 1 1/4 pounds.





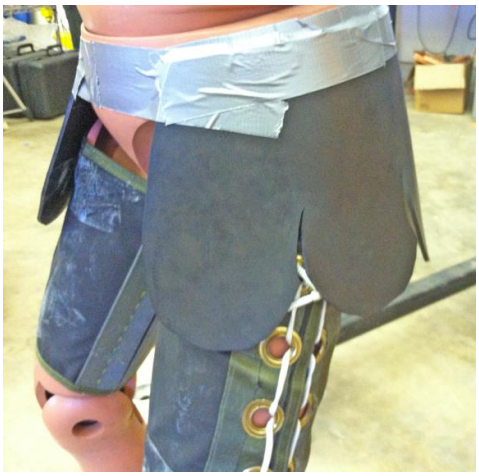


Skirts

Skirts are sometimes used as part of the manikin buildup and are added to the nude weight. Skirts are 1/8 thick rubber or manikin bib material. They are generally duck tapped in place on the pelvis to somewhat close off the opening between the upper legs and the pelvis in hopes of keeping the harness from sliding into this gap. There is no specific place on the pelvis for location. On an average, both add about 1 1/2 pounds.



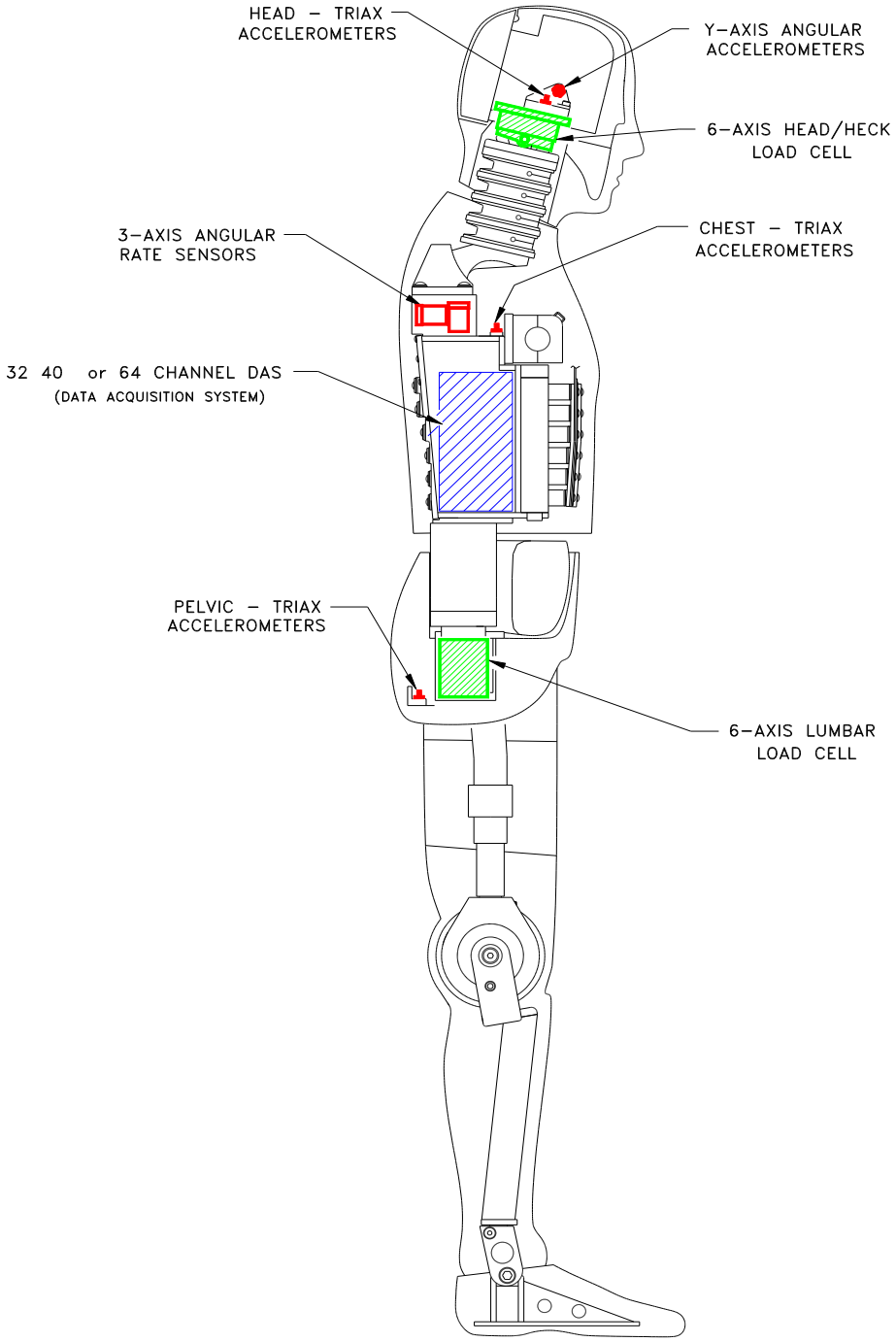






Instrumentation

Shown below is a general location and instrumentation that can be used with the Case 2 STL manikin.



5% MALE INSTRUMENTATION LOCATIONS

Appendix D-3

CASE 2ST (CASE 2 Short Torso) May 2016

This document describes the anthropometry and configuration of the CASE 2ST manikin.

Background

In 1994 congress declared that the JPATS (Joint Primary Aircraft Training Systems) would accommodate 95% of the female population which translates to a 58 inch standing height and a 31 inch sitting height minimum. 6 Case sizes were introduced. This size manikin was brought about because of a needed lighter version of the manikin Martin-Baker used in the Mk16E seat testing.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
	Small	Medium Build Short Limbs	Medium Build Long Limbs	Tall Sitting Height Short Limbs	Overall Large	Longest Limbs	Overall Small
Thumb Tip Reach	27.0	27.6	33.9	29.7	35.6	36.0	26.1
Buttock-Knee Length	21.3	21.3	26.5	22.7	27.4	27.9	20.8
Knee-Height Sitting	18.7	19.1	23.3	20.6	24.7	24.8	18.1
Sitting Height	32.8	35.5	34.9	38.5	40.0	38.0	31.0
Eye Height Sitting	28.0	30.7	30.2	33.4	35.0	32.9	26.8
Shoulder Height Sitting	20.6	22.7	22.6	25.2	26.9	25.0	19.5
Shoulder Breath Range	14.7-18.1	16.4-20.6	16.2-21.2	16.8-21.7	16.9-22.6	16.8-22.5	14.2-18.0
Chest Depth Range	7.4-10.9	6.9-10.6	7.2-11.3	7.1-11.0	7.3-12.1	7.4-12.2	7.2-10.2
Thigh Circumference Range	18.5-25.0	17.1-25.0	20.2-27.6	17.6-26.3	18.6-29.2	19.1-29.7	17.8-25.2

Manikin Development

Humanoids Systems, of Carson, California developed the 5th percentile male aerospace manikin having an un-instrumented weight of 146 pounds. To achieve the specified weight, some material was changed to aluminum. The chest box was changed to house an EME data acquisition system (DAS) along with battery packs. The manikin total weight was to be 147 pounds including 11 pounds of instrumentation. The instrumentation portion consisted of a DAS, battery packs, instrumentation itself, and wiring. Also in the nude weight, chaps, skirts and shoulder extensions were to be added.

Manikin Evolvement Changes

Through testing and evaluation, this document describes the components for this CASE 2ST manikin.



CASE 2ST Manikin

Anthropometry

The table below gives the anthropometry measurements.

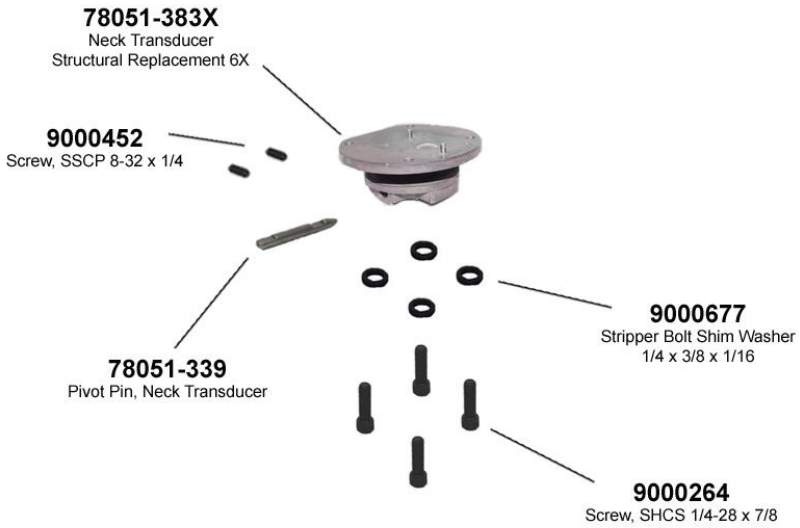
CASE 2ST Anthropometry Measurements – in inches	
Stature	66
Head Length	8.0
Head Breath	6.0
Head Circumference	23.1
Sitting Height	34.9
Eye Height Sitting	30.4
Thumb Tip Reach	27.4
Shoulder Breath	18.8
Chest Depth	9.8
Chest Breath	11.7
Chest Circumference	37.2
Waist Circumference	33
Hip Breath	14.7
Thigh Circumference	20.2
Buttock-Knee Length	22.6
Knee-Height Sitting	21.0
Foot Length	10.2

A CASE 2ST manikin without instrumentation normally has a weight of 133 pounds. Fully instrumented tests could have a weight variance of 147 +/- 3 pounds.

Head

The head is an ADAM type with a total weight of 10.4 pounds having a CG location of 1.9 inches in the Z-axis and 0.5 inches in the X-axis. This weight was established by adding the total weight of the head, a Denton 1716 load cell, pin, and head instrumentation package having 12" cable length. The instrumentation package consisted of a JSF-LM 110 mounting block, Entran EGV3 triax accelerometer, and an Endevco 7302B angular accelerometer. To establish the head's total weight, .66 pounds was subtracted, which equals the lower part of the load cell, ending with the noted 10.4 pounds. Ears were glued on the head (the ADAM mold does not have ears).





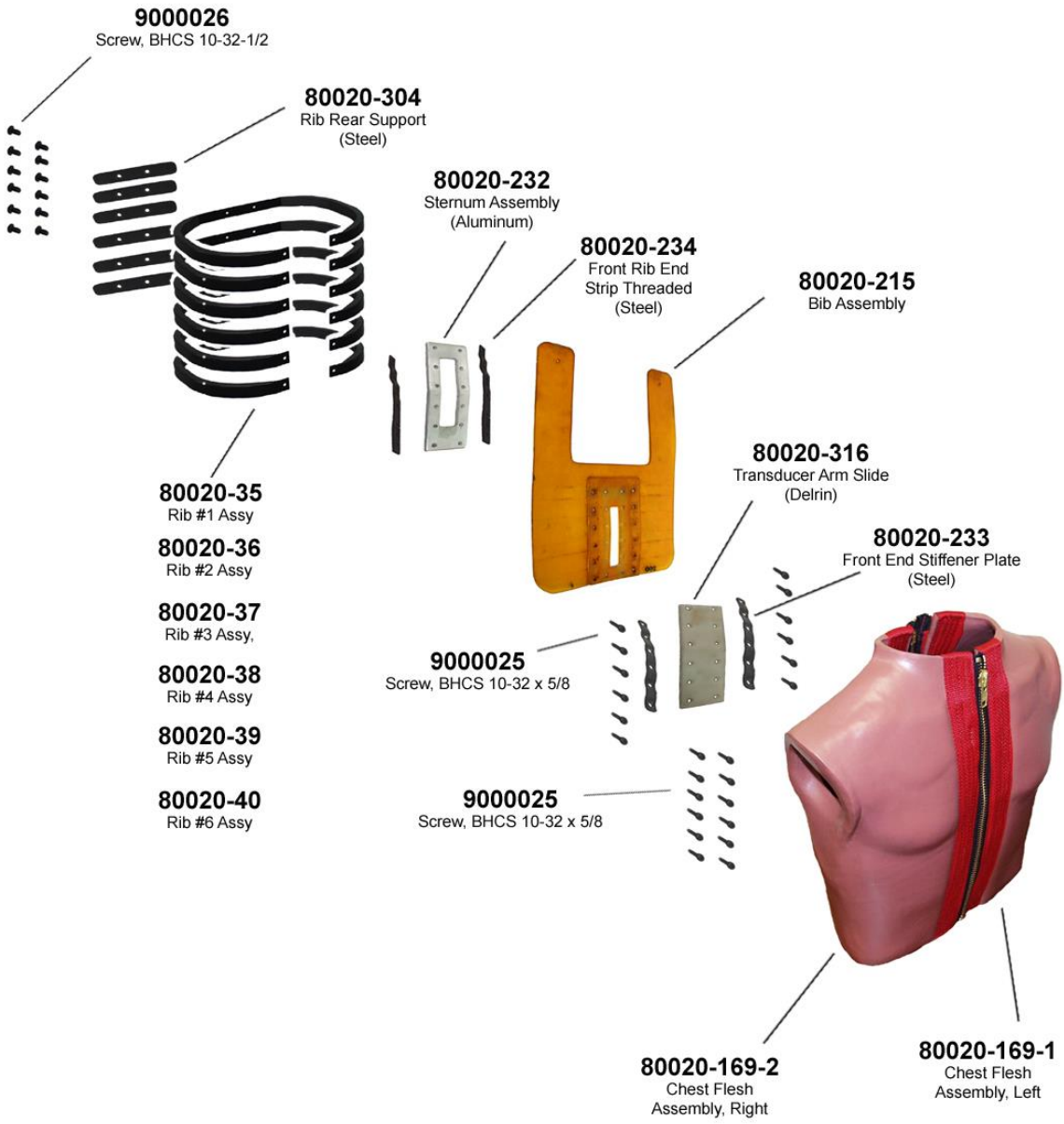
Items mounted in the head

Neck Assembly

The neck used is the same one used on the 50% Hybrid III automotive crash test dummy (PN: 78051-336). Necks are in calibration for a year.

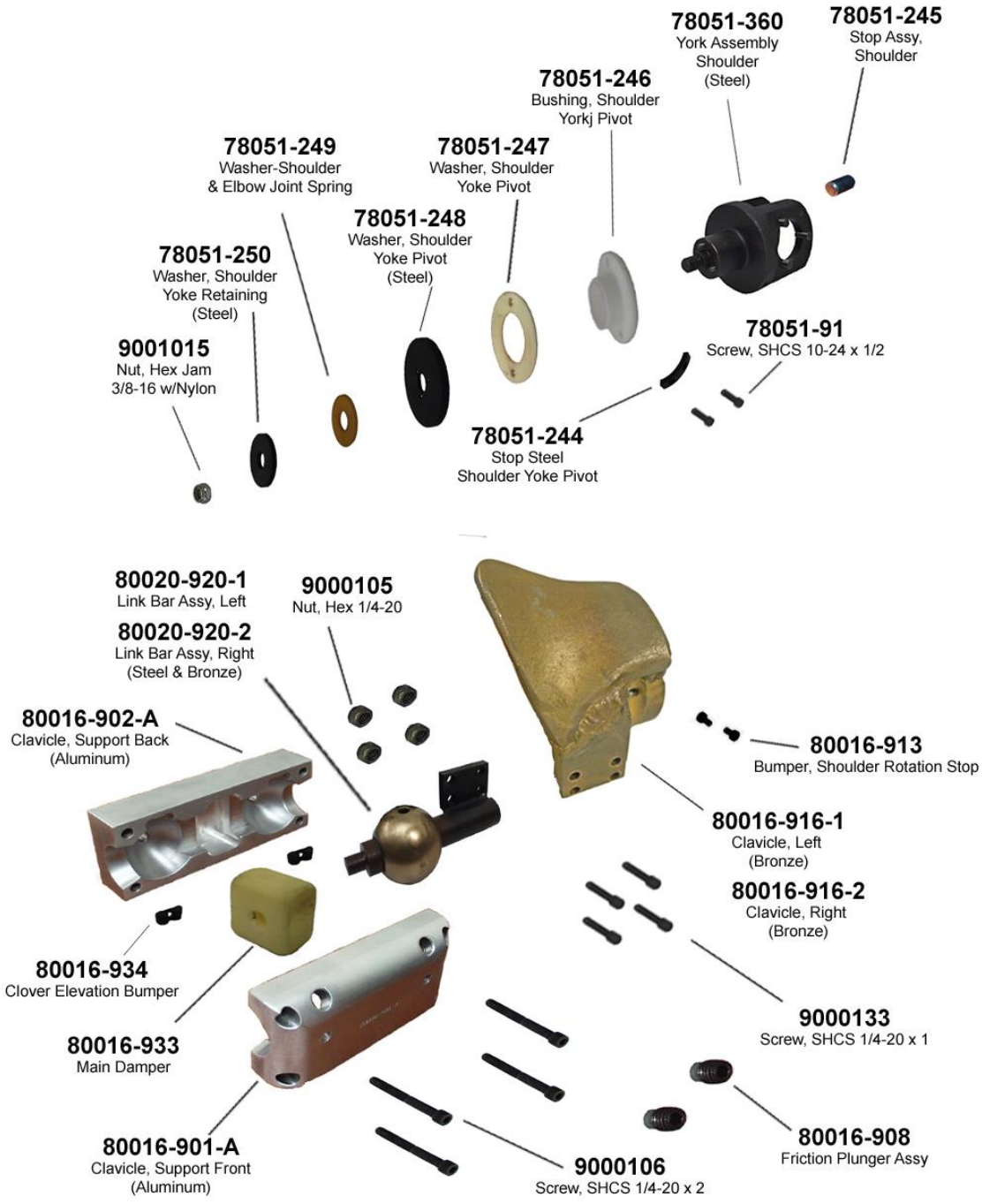


Chest Components

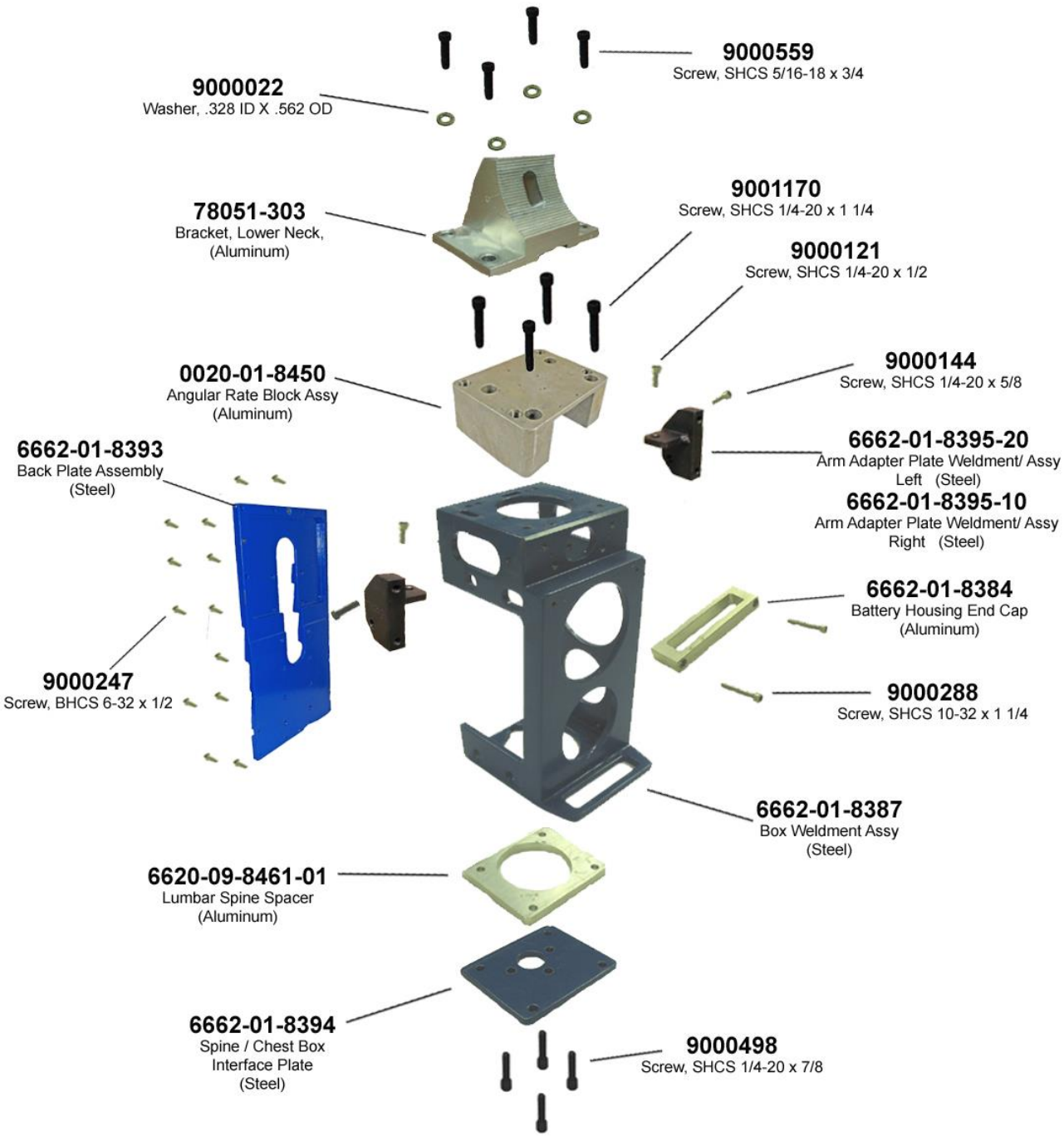


Shoulder Components

The shoulder design is the same as the 5% male aerospace dummy. Materials of some components have been changed to aluminum for weight requirements. Shoulder extensions will be described later.

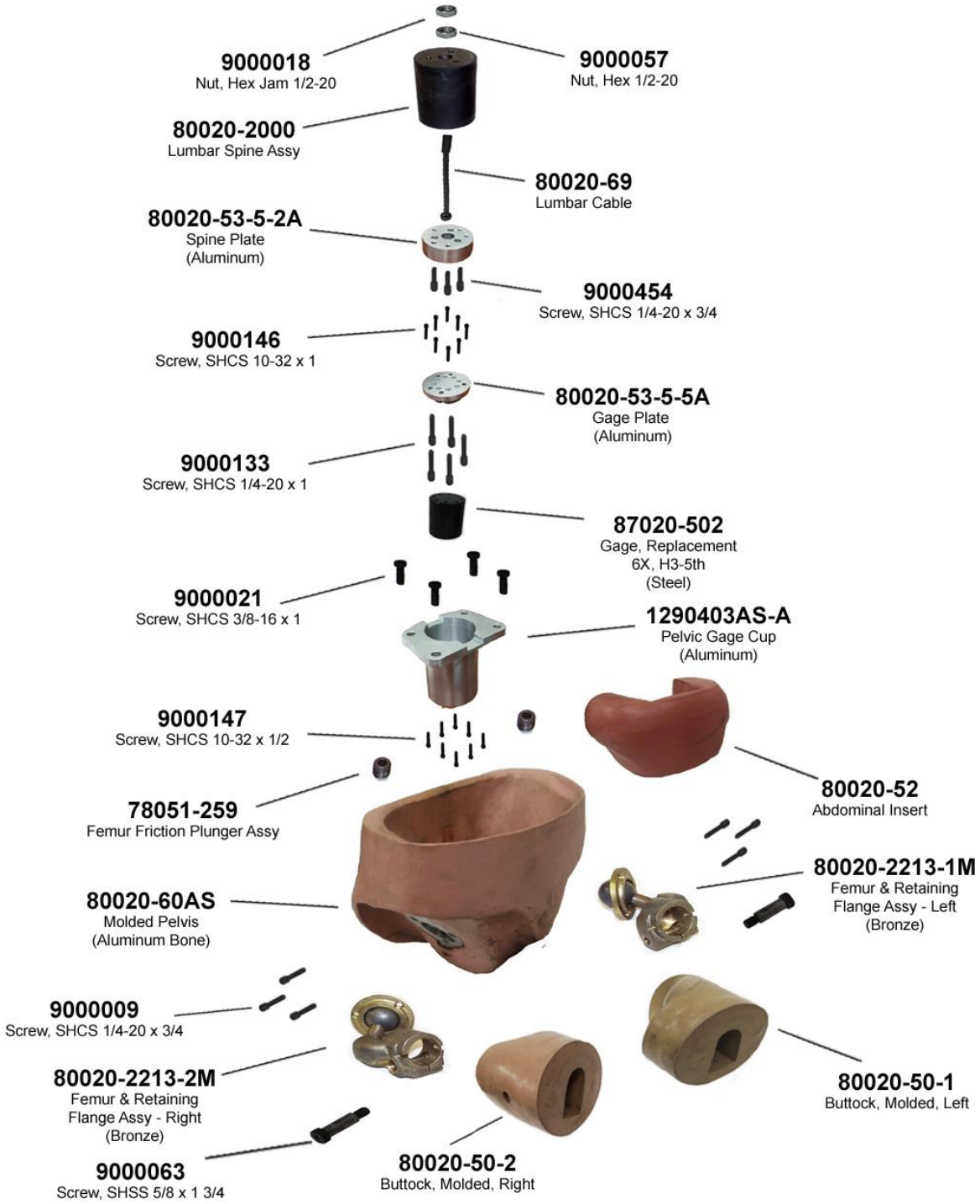


Chest Box Components

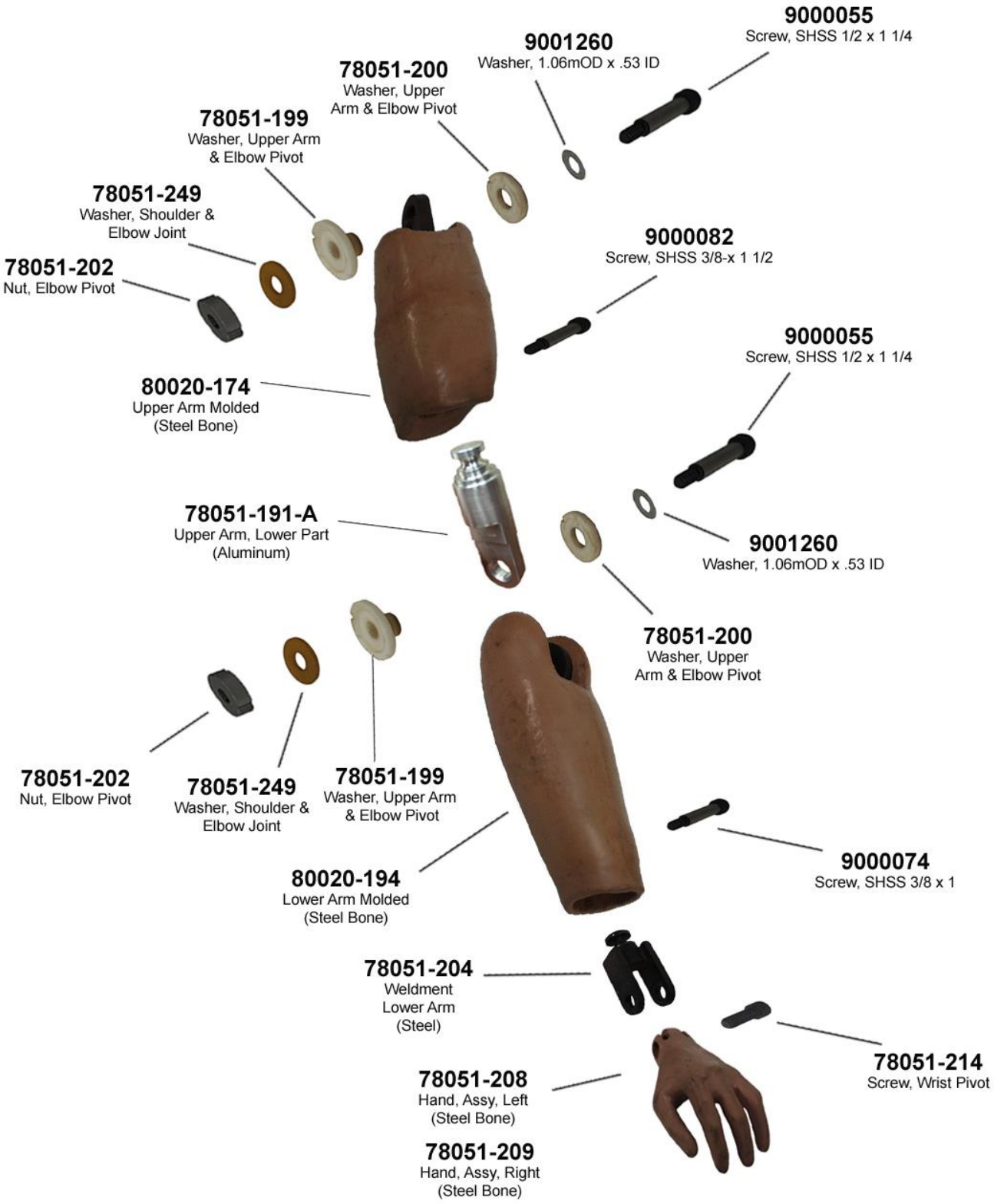


Lower Torso Pelvis

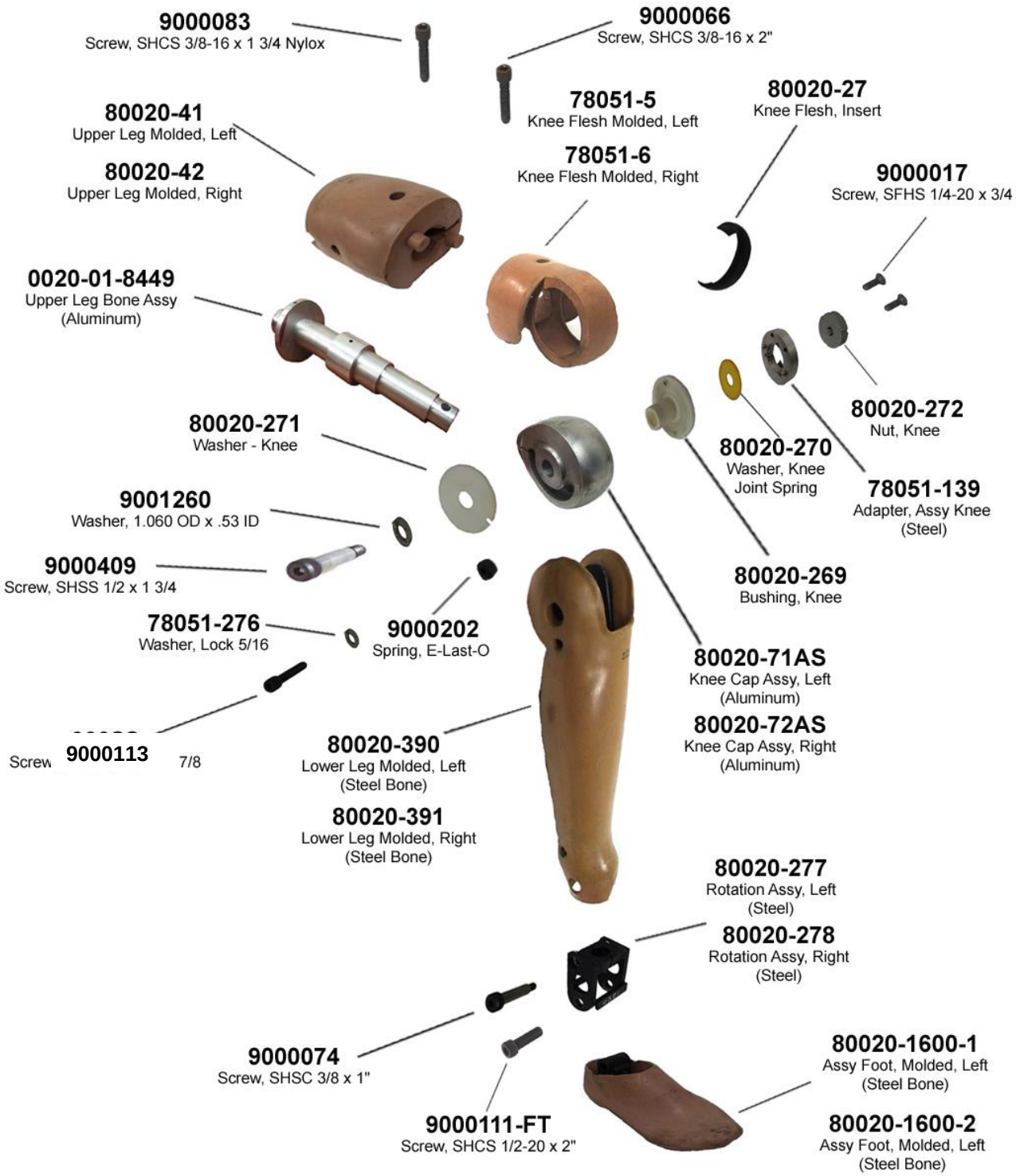
The pelvis is a pedestrian design for standing along with a straight spine.



Arm Assembly

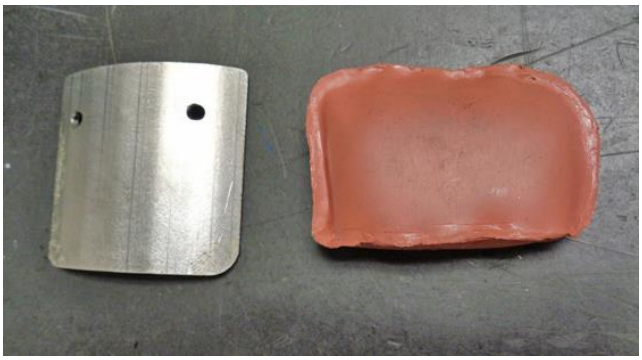


Leg Assembly



Shoulder Extensions

Shoulder extensions are sometimes used as part of the manikin buildup and are added to the nude weight. The general idea is to lengthen the chest jacket covering the normally exposed shoulder. There are no specific guide lines for shoulder extensions but normally they are made from 1/8 thick aluminum plates that are bent in the shape of the clavicle and bolted in pace to the clavicles. A foam type pad, either skin covered or tape covered, is either Velcro or taped in place to fill the area between the aluminum extension and the chest jacket. On an average, both sides add about 3/4 pounds.







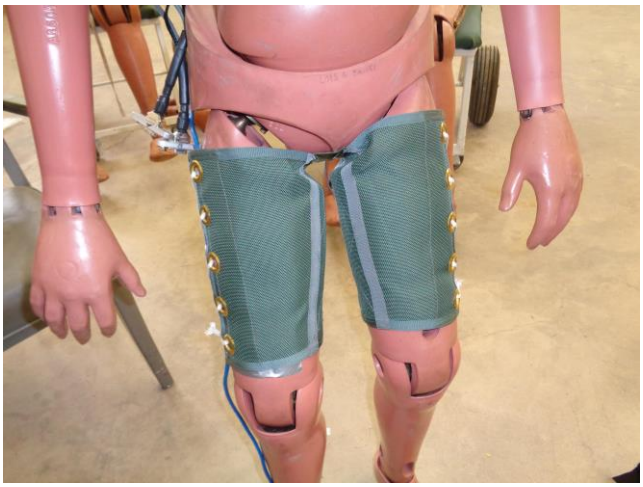


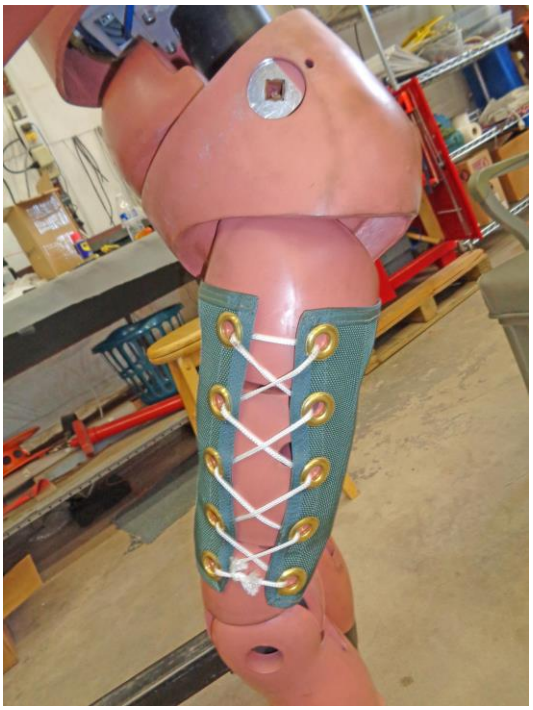


Chaps

Chaps are sometimes used as part of the manikin buildup and are added to the nude weight. Chaps are made from materials, sown together. They are generally laced in place on the upper legs to somewhat close off the opening between the upper legs and the pelvis in hopes of keeping the harness from sliding into this gap. On an average this adds about 1 1/4 pounds.





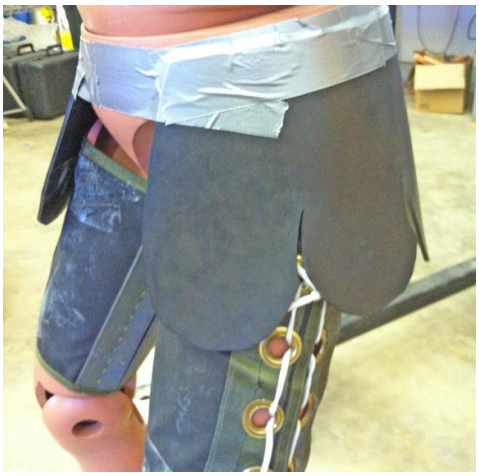


Skirts

Skirts are sometimes used as part of the manikin buildup and are added to the nude weight. Skirts are 1/8 thick rubber or manikin bib material. They are generally duck tapped in place on the pelvis to somewhat close off the opening between the upper legs and the pelvis in hopes of keeping the harness from sliding into this gap. There is no specific place on the pelvis for location. On an average, both add about 1 1/2 pounds.



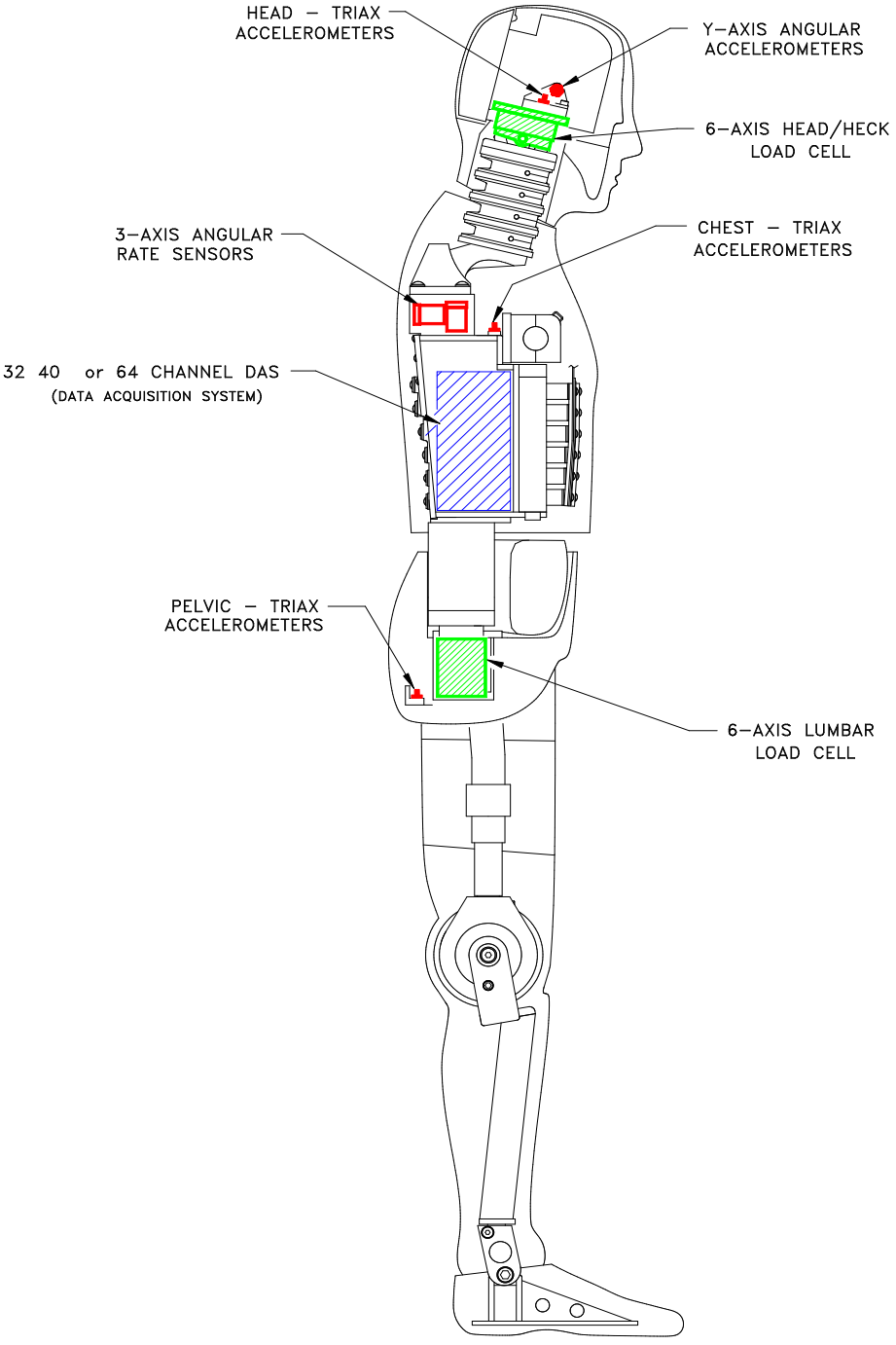






Instrumentation

Shown below is a general location and instrumentation that can be used with the Case 2 ST manikin.



5% MALE INSTRUMENTATION LOCATIONS

Appendix D-4
LARD (Large Anthropomorphic Research Dummy) / CASE 6
May 2016 Model: 190-0000

This document describes the anthropometry and configuration of the LARD manikin.

Background

In 1994 congress declared that the JPATS (Joint Primary Aircraft Training Systems) would accommodate 95% of the female population which translates to a 58 inch standing height and a 31 inch sitting height minimum. 6 case sizes were introduced and the Case 6 – longest limbs, was chosen for development of a manikin. After being in use the acronym LARD (Largest Anthropomorphic Research Dummy) was given to this manikin.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
	Small	Medium Build Short Limbs	Medium Build Long Limbs	Tall Sitting Height Short Limbs	Overall Large	Longest Limbs
Thumb Tip Reach	27.0	27.6	33.9	29.7	35.6	36.0
Buttock-Knee Length	21.3	21.3	26.5	22.7	27.4	27.9
Knee-Height Sitting	18.7	19.1	23.3	20.6	24.7	24.8
Sitting Height	32.8	35.5	34.9	38.5	40.0	38.0
Eye Height Sitting	28.0	30.7	30.2	33.4	35.0	32.9
Shoulder Height Sitting	20.6	22.7	22.6	25.2	26.9	25.0
Shoulder Breath Range	14.7-18.1	16.4-20.6	16.2-21.2	16.8-21.7	16.9-22.6	16.8-22.5
Chest Depth Range	7.4-10.9	6.9-10.6	7.2-11.3	7.1-11.0	7.3-12.1	7.4-12.2
Thigh Circumference Range	18.5-25.0	17.1-25.0	20.2-27.6	17.6-26.3	18.6-29.2	19.1-29.7

Manikin Development

First Technology Safety Systems, of Plymouth Michigan was given the task to develop this manikin. They started with their 95% Hybrid III dummy, used their pedestrian pelvis and lengthened the segments to meet the Case 6 specifications. The chest box was changed to house an EME data acquisition system (DAS) along with battery packs. To improve strength, some material changes were incorporated. In the pelvic region, a straight spine was used and a femur load cell for the ability to obtain 6 channels of data. The manikin total weight was to be 245 pounds with the addition of 11 pounds of instrumentation. This instrumentation consisted of a DAS, battery packs, instrumentation itself, and wiring.

Manikin Evolvement Changes

Some components were changed to better represent a human at this size. This involved a shift of weight in the legs by using smaller feet, changing the knee material from bronze to aluminum and adding weight to the end of the upper leg bone at the femur location. Also a one piece upper leg skin was incorporated for better harness support. A different

chest box (the universal chest box) was introduced to house more DAS sizes. Feet were changed, once more, to provide better ankle rotation. Another head size (JSF-LM110) was introduced which represented a larger head volume size than the original head. The neck was changed to the standard Hybrid III which uses bushings. The aluminum block at the top of the neck (nodding joint) started to use bushings instead of washers. Knee stops were improved.



LARD Manikin

Anthropometry

The table below gives the anthropometry measurements with the two different heads mounted.

LARD Anthropometry Measurements – in inches	
Stature (With a Large JPATS Head)	74.6
Head Length (Large JPATS Head)	7.7
Head Breath (Large JPATS Head)	6.0
Head Circumference (LARGE JPATS Head)	23.1
Sitting Height (With a Large JPATS Head)	38.0
Eye Height Sitting (With a Large JPATS Head)	33.2
Stature (With a JSF-LM110H Head)	75.8
Head Length (JSF-LM110H Head)	8.2
Head Breath (JSF-LM110H Head)	6.5
Head Circumference (JSF-LM110H Head)	24.0
Sitting Height (With a JSF-LM110H Head)	39.1
Eye Height Sitting (With a JSF-LM110H Head)	34.4
Thumb Tip Reach	36.1
Shoulder Breath	19.9
Chest Depth	11.5
Chest Breath	13.4
Chest Circumference	44.7
Waist Circumference	41.7
Hip Breath	17.7
Thigh Circumference	25.2
Buttock-Knee Length	27.8
Knee-Height Sitting	24.2
Foot Length	10.3
Shoulder Height Sitting	24.6

A LARD manikin without instrumentation normally has a weight of 233 pounds. Fully instrumented tests sometimes give a weight variance of 245 +/- 3 pounds.

Heads

Two head sizes are used. The large JPATS head was produced with the original manikin. It is what is known as an ADAM type head because this mold was first used with the Advanced Dynamic Anthropomorphic Manikin (ADAM). The mold is a Hybrid II with the addition of ears after the molding process. The head assembly has an average weight of 10.8 pounds.

HEAD DESCRIPTION

Large JPATS

Production or MFG. Part Number: 190-1000-X

Average Weight ~ 10.8 Pounds

Average durometer shore "A " reading ~ 64

– Hybrid II mold with attached ears–

Normally used with – Large JPATS manikin



Flight Equipment Required :

Large – Helmet LW HGU-55/P (CE MOD)

Large – Zeta Liners

M / N – Oxygen Mask – MBU- 20/P

Head Size :

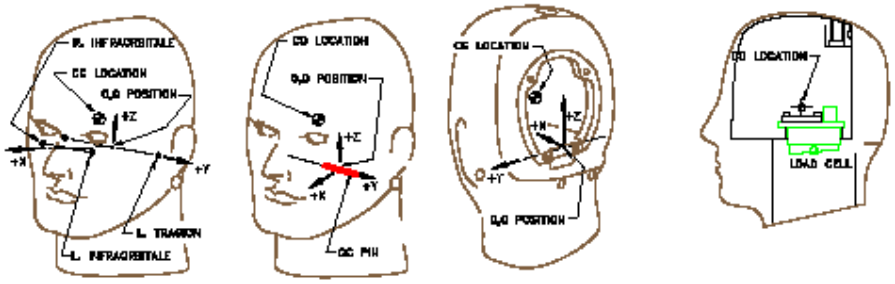
Breath - 6.0 In. Length - 8.00 In.

Circumference - 23.1 In.

Neck Size :

Normally used with a 95% Hybrid III & bushings

Part No: FTSS & Denton ~ 880995-1260



Average Measurements

Landmarks	X (cm)	Y (cm)	Z (cm)	X (in.)	Y (in.)	Z (in.)
CG Anatomical Location	-0.99	0.30	1.70	-0.39	.11	.67
CG Head/Neck Joint Location	.57	-0.30	4.41	.22	-0.11	1.74
CG Manufacturer Location	5.59	-0.21	3.00	2.20	.08	1.18

Components



GT Nov. 2014

The second head used is the JSF-LM110 head which was developed using the CEASAR data base. The shape was a scanned human having one side mirrored so data points would be consistent from side to side. The head assembly has an average weight of 11.0 pounds. Through the development process a harder version was produced which resulted in the full number being JSF-LM110H.

HEAD DESCRIPTION

JSF- LM110H

Production or MFG. Part Number: 190-100HX

Average Weight ~ 11.03 Pounds

Average durometer shore "A " reading ~ 53

– New mold developed for JSF –

Normally used with – Large JPATS manikin



Flight Equipment Required :

X - Large – Helmet LW HGU-55/P (CE MOD)

X - Large – Zeta Liners

L / W – Oxygen Mask – MBU- 20/P

Head Size :

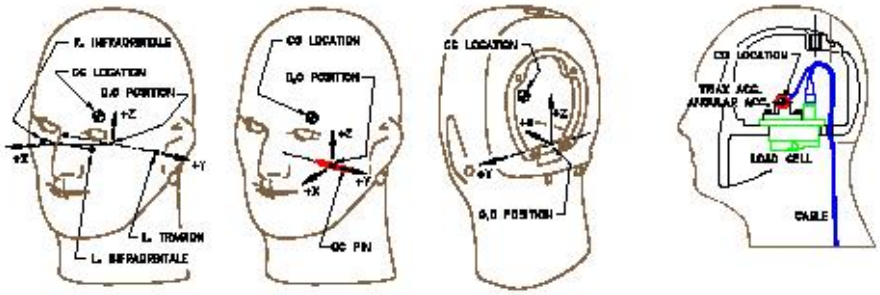
Breath - 6.50 Length - 8.23

Circumference - 24.00

Neck Size :

Normally used with a 95% Hybrid III & bushings

Part No: FTSS & Denton ~ 880995-1260



Average Measurements

Landmarks	X (cm)	Y (cm)	Z (cm)	X (in.)	Y (in.)	Z (in.)
CG Anatomical Location	-0.30	0.38	1.03	-0.13	0.15	0.53
CG Head/Neck Joint Location	1.91	0.11	4.98	0.70	-0.08	1.97
CG Manufacturer Location	6.30	0.19	3.73	2.50	-0.07	1.47
CG Head/Neck Joint subtracting 1/2 load cell and OC Pin	1.88	-0.10	5.28	0.74	-0.04	2.08

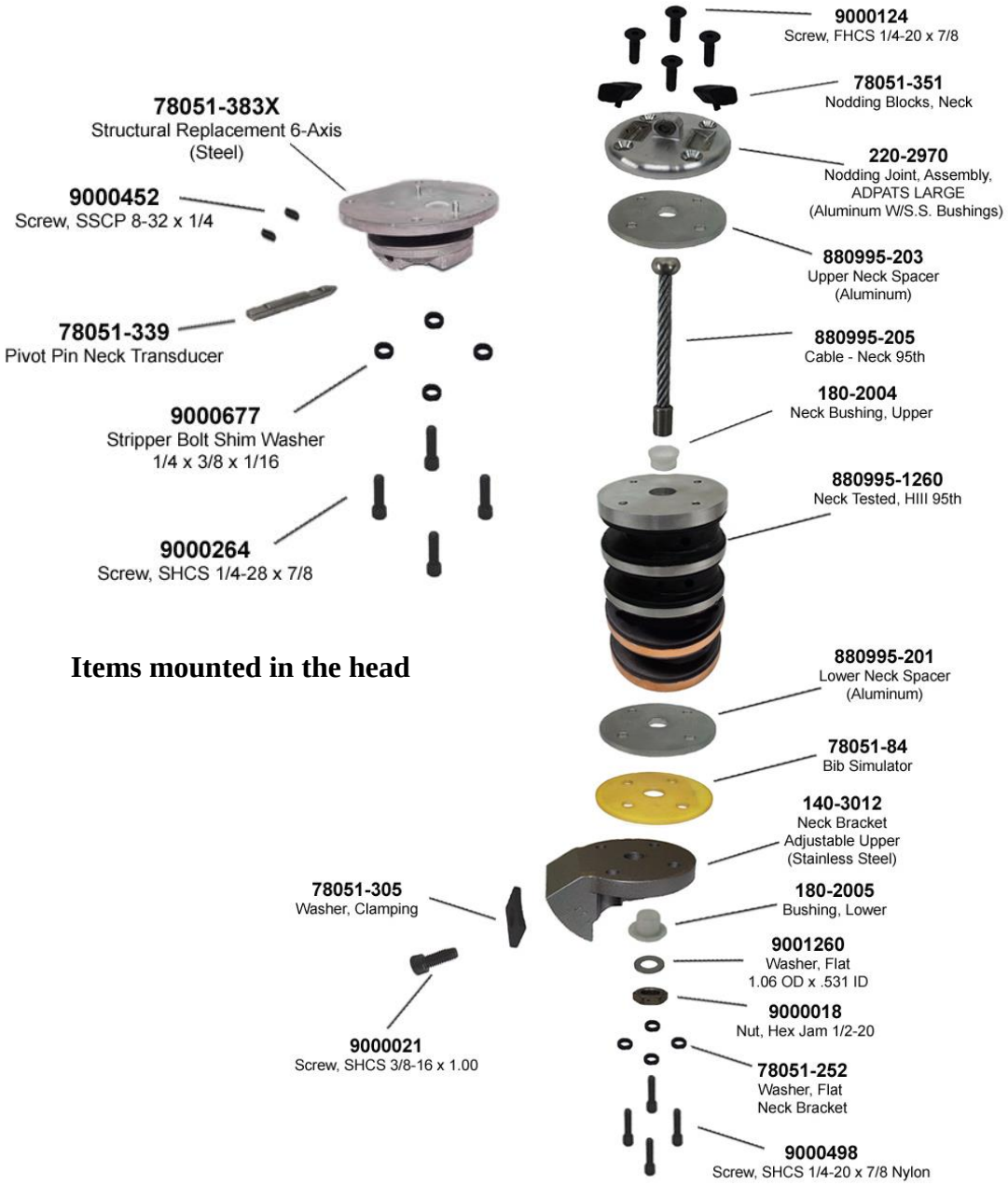
Components used when measured:



GT Nov. 2010

Neck Assembly

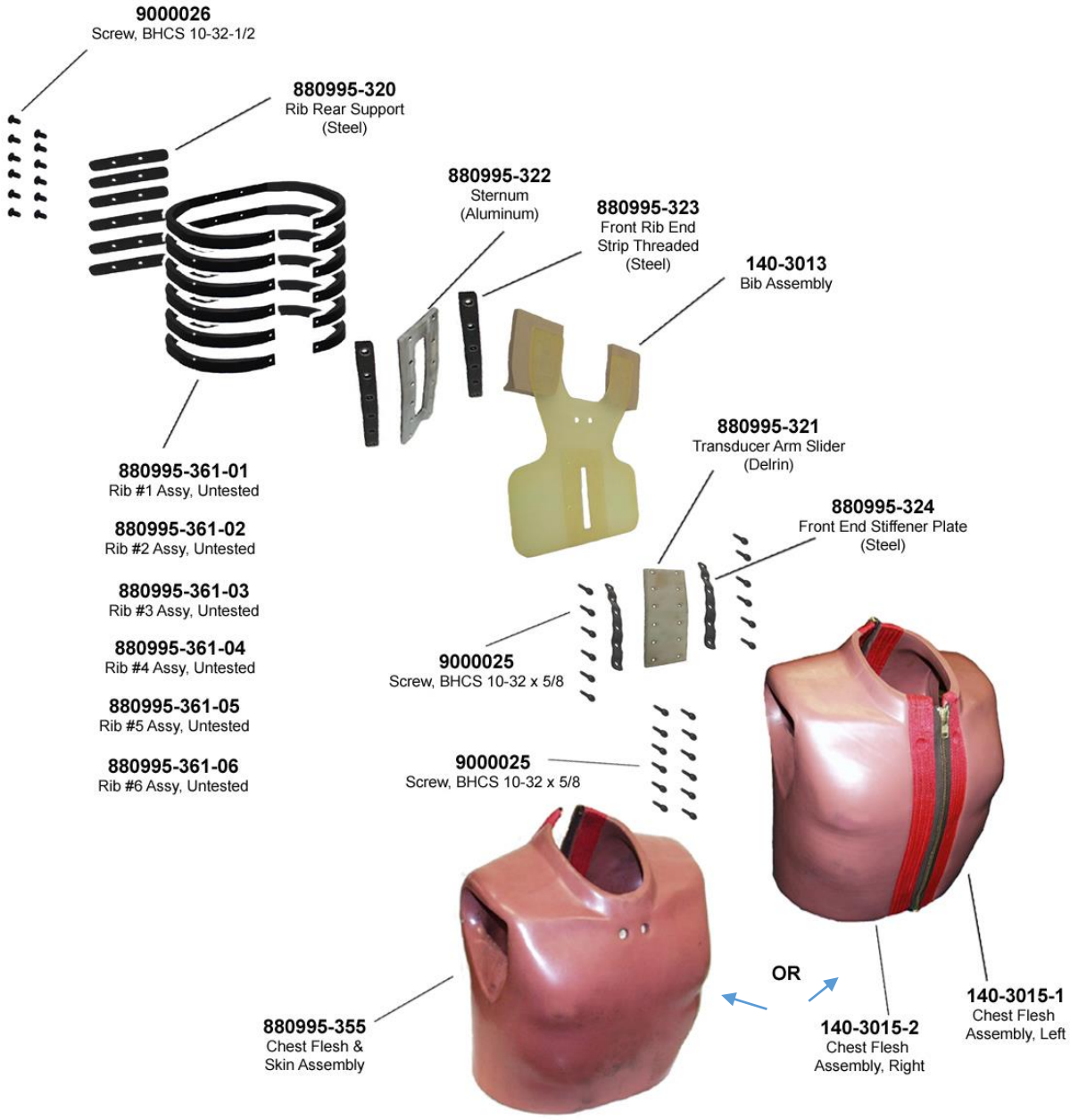
The neck used today is the same one used on the 95% Hybrid III automotive crash test dummy (PN: 880995-1260). The original LARD neck (PN: 880995-204) and a newer version (PN: 190-2001) are acceptable. The lower two aluminum rings are painted a gold color to distinguish between a 50th and 95th neck. Part numbers 880995-1260 and 190-2001 are to be used with neck bushings. To accept the lower bushing, the adjustable upper neck bracket may need to have the hole diameter increased. Necks are in calibration for a year.



Items mounted in the head

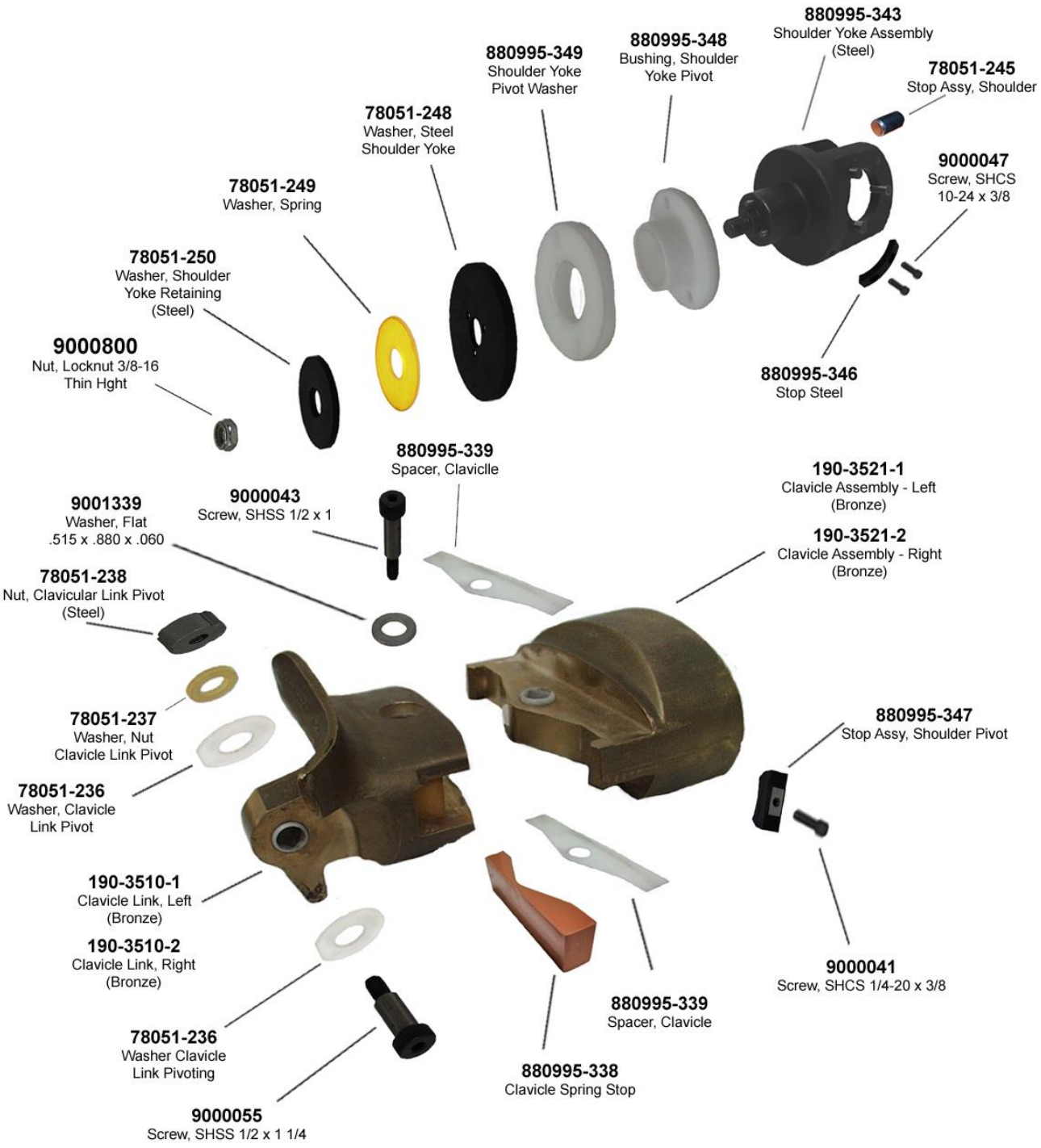
Chest Components

The chest was originally set up with a chest potentiometer for measuring chest deflection, but was removed because there was not a need. The one or two piece chest flesh can be used.



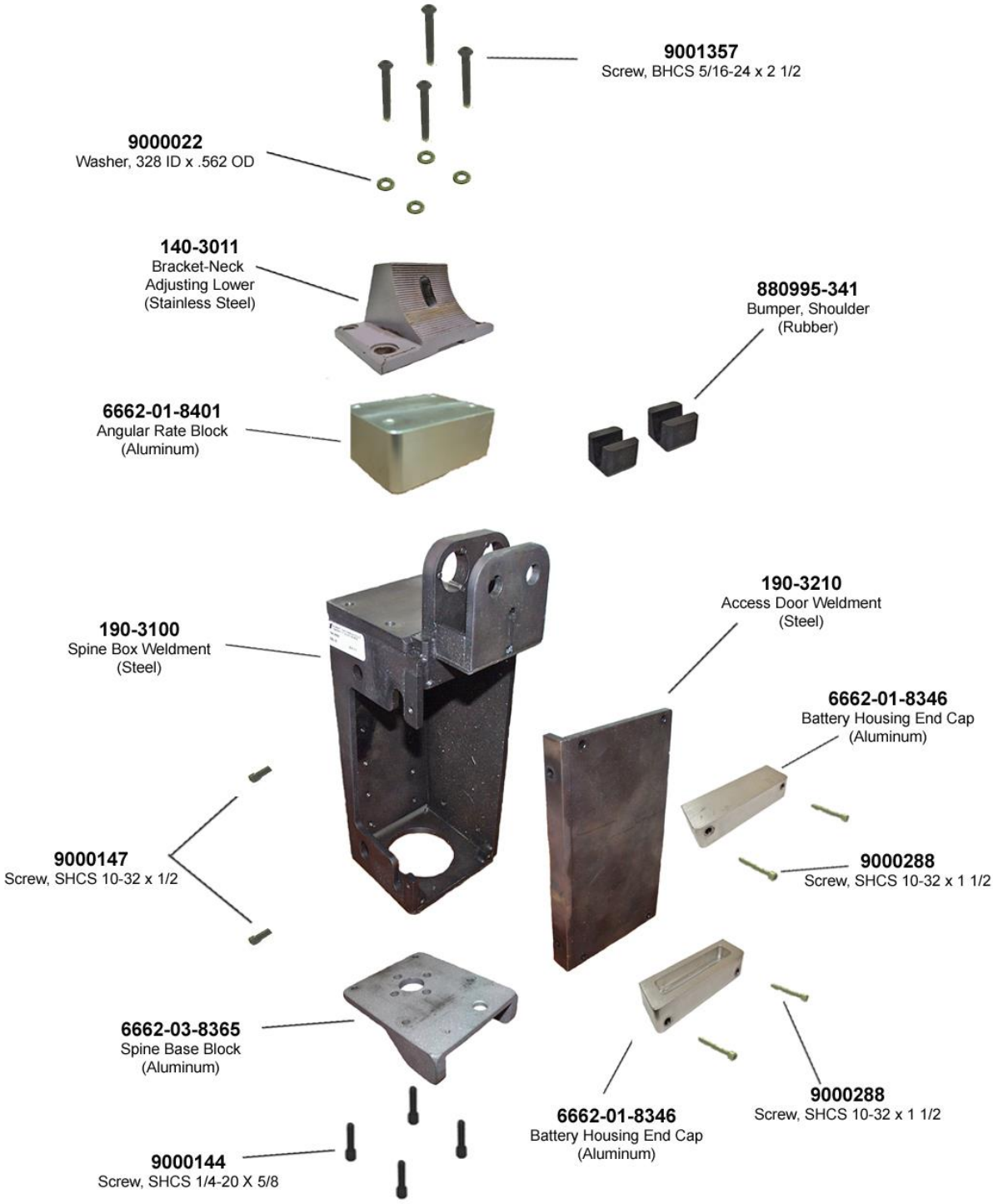
Shoulder Components

The shoulder design is the same as the 95% Hybrid III automotive dummy. The clavicle and clavicle link had a material change from aluminum to bronze for LARD. Shoulder extensions will be described later.

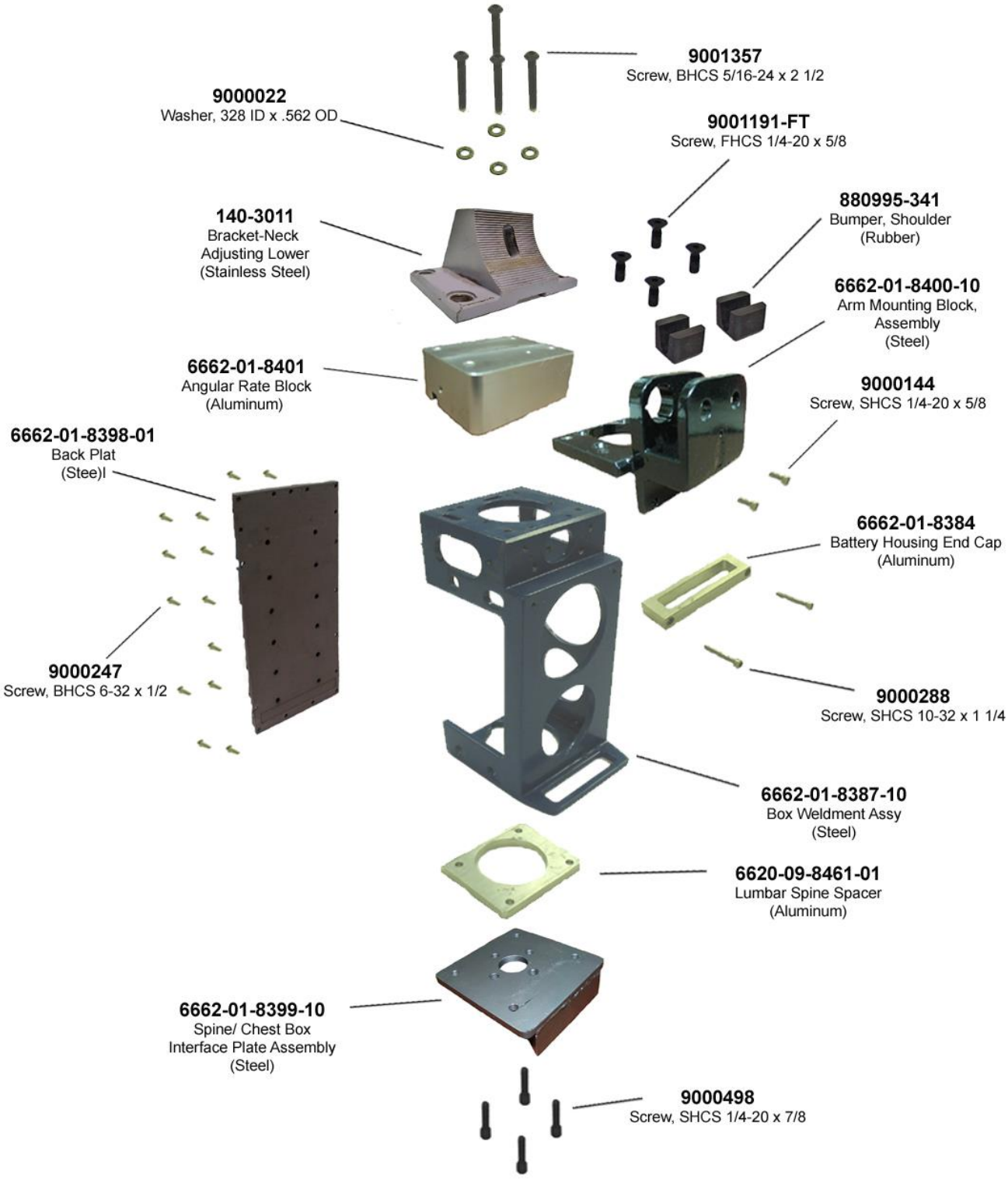


Chest Box Components

There are two chest box designs; the original and the universal chest box.



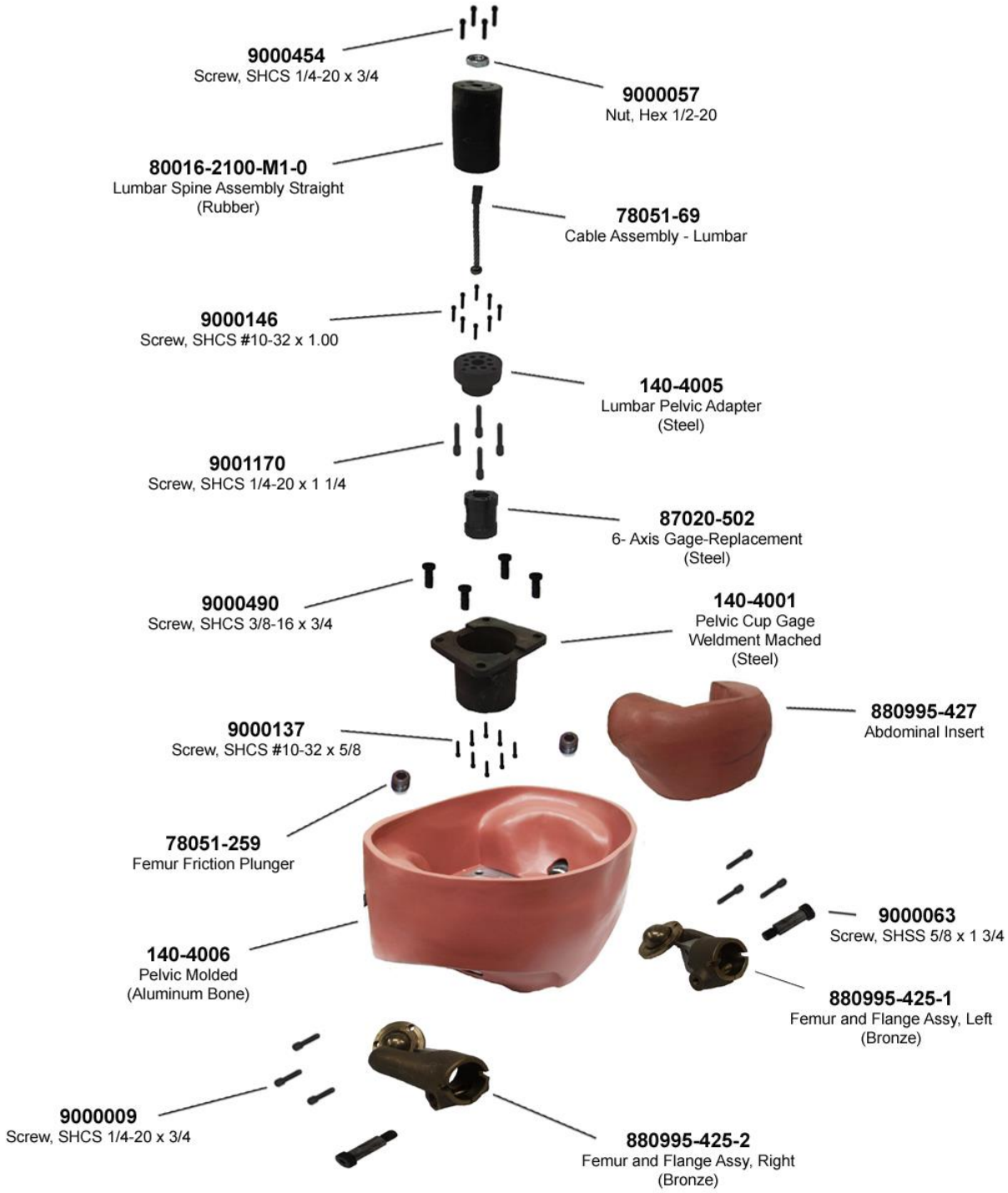
Original Chest Box



Universal Chest Box

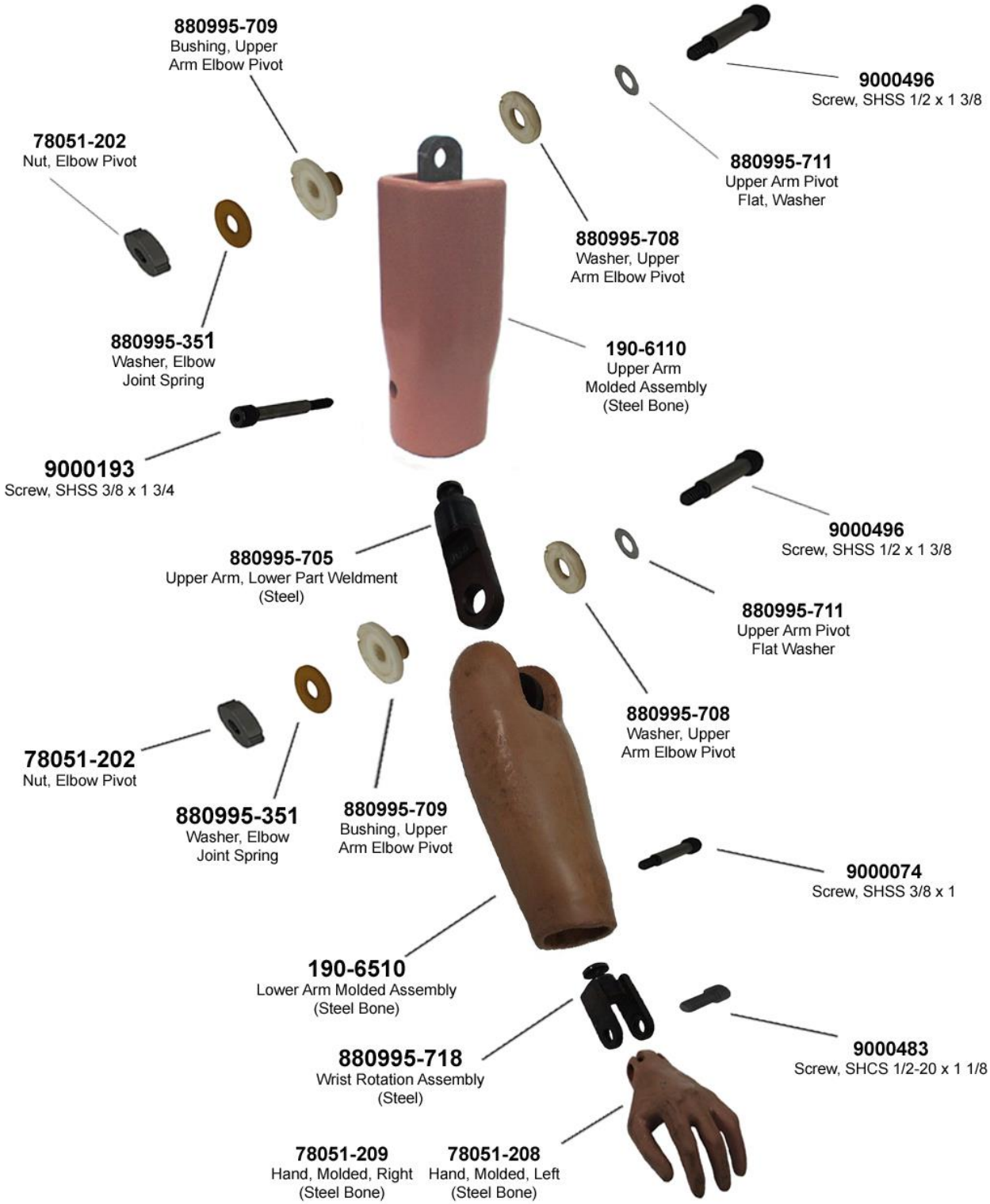
Lower Torso Pelvis

The pelvis is a pedestrian design for standing along with a straight spine. The femur bones saw a change from led wrapings to a tungstine block bolted to the inside for the addition of weight. It was then updated by shifting this weight to the back portion of the lower leg.



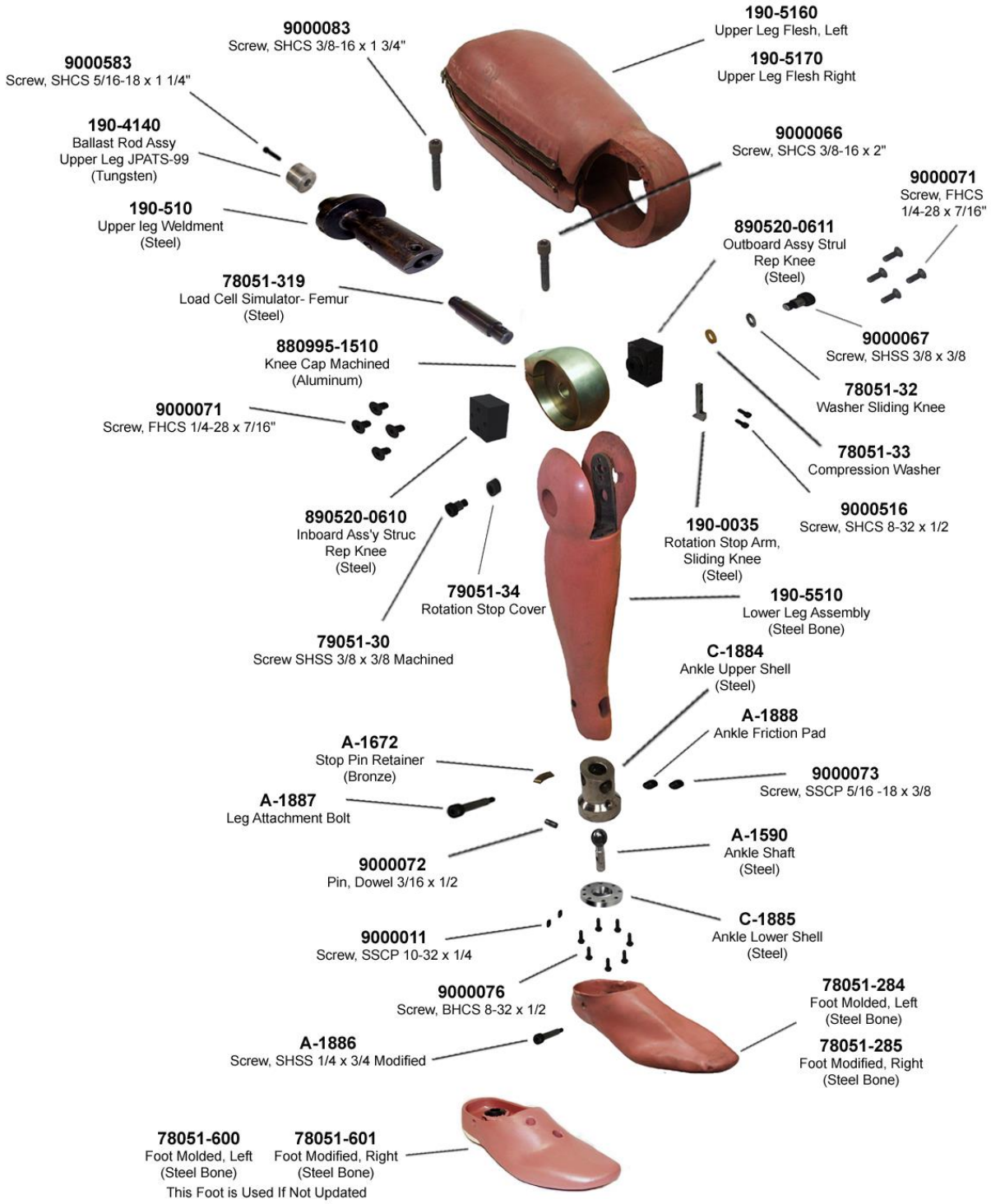
Arm Assembly

The arms are the same design as the 95% Hybrid III. The upper and lower arm segments have been lengthened to meet the JPATS specifications.



Leg Assembly

The legs are the same design as the 95% Hybrid III. The upper and lower leg segments have been lengthened to meet the JPATS specifications. Since the initial design, they have gone through several changes.



Shoulder Extensions

Shoulder extensions are sometimes used as part of the manikin buildup and are added to the nude weight. The general idea is to lengthen the chest jacket covering the normally exposed shoulder. There are no specific guide lines for shoulder extensions but sometimes they are made from 1/8 thick aluminum plates that are bent in the shape of the clavicle and bolted in pace to the clavicles. A foam type pad sometimes made of skin covered or tape covered is either Velcro or taped in place to fill the area between the aluminum extension and the chest jacket. On an average, both sides adds about 3/4 pounds.











Chaps

Chaps are sometimes used as part of the manikin buildup and are added to the nude weight. Chaps can be made from materials, sown together. They are generally laced in place on the upper legs to somewhat close off the opening between the upper legs and the pelvis in hopes of keeping the harness from sliding into this gap. On an average this adds about 1 1/2 pounds.





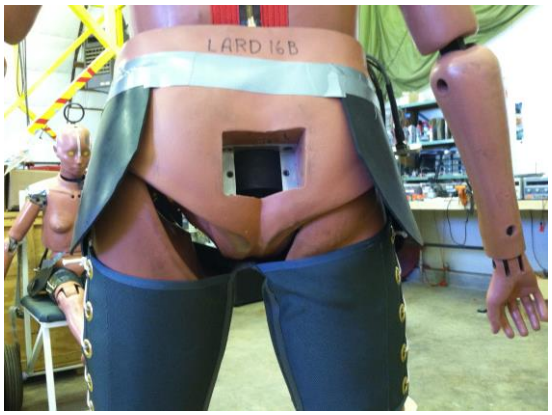


Skirts

Skirts are sometimes used as part of the manikin buildup and are added to the nude weight. Skirts can be 1/8 thick rubber and sometimes manikin bib material. They are generally duck tapped in place, on the pelvis, to somewhat close off the opening between the upper legs and the pelvis in hopes of keeping the harness from sliding into this gap. There is no specific place on the pelvis for location. On an average, both adds about 1 1/2 pounds.



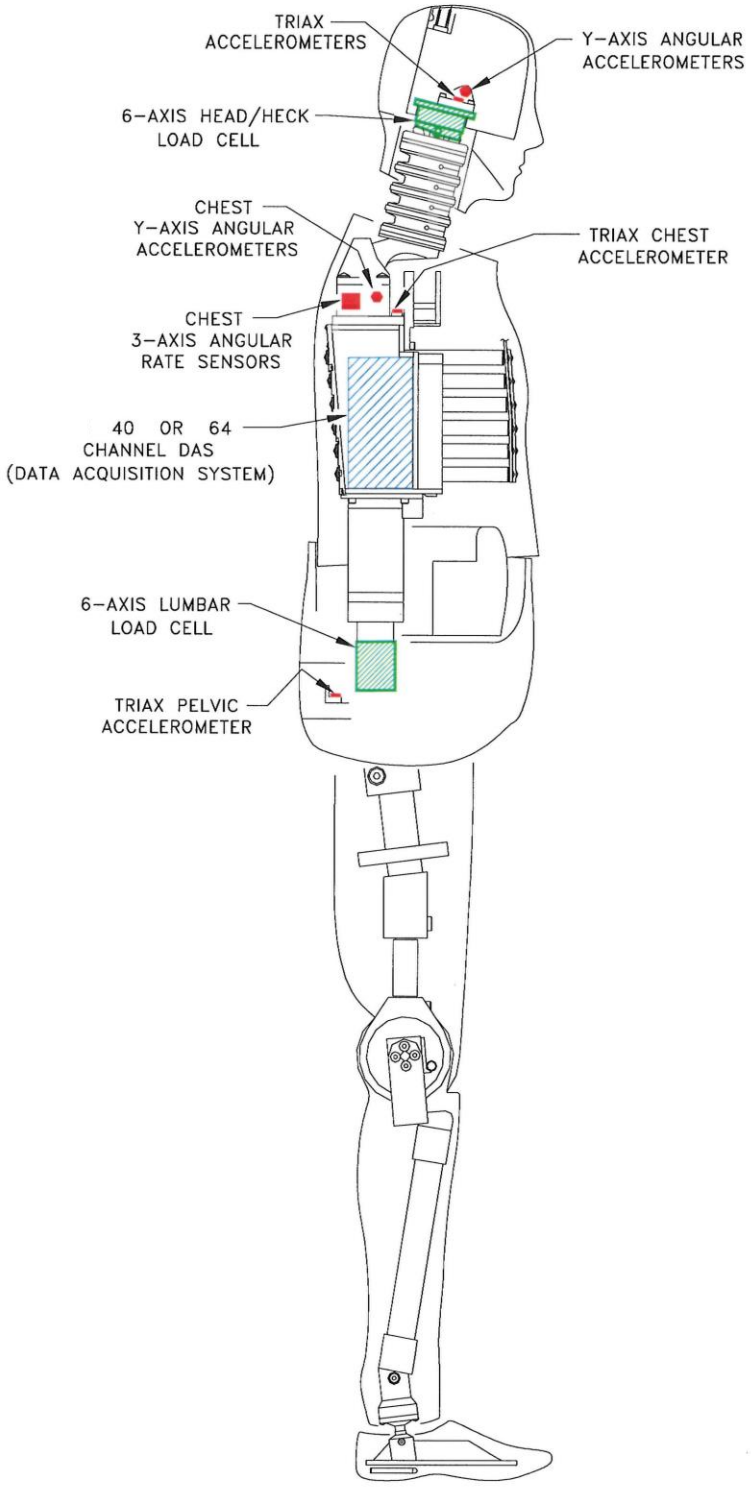






Instrumentation

Shown below is a general location and instrumentation that can be used with the LARD manikin.



Appendix D-5

5% Male Aerospace Dummy May 2016

Model: H3-5MAS

This document describes the anthropometry and configuration of the 5% male aerospace model H3-5MAS dummy.

Background

The Aerospace line was developed by Alderson in the 1970's and 80's following civilian and military sizes and weights. They were produced at Humanoid Systems in Carson, California to support ejection seat testing for the US Navy. First Technology Safety Systems, of Plymouth Michigan began producing them in 1991 and continues to produce them under the company name of Humanerics.

Manikin Development

The 5% male aerospace dummy is based upon the 95% aerospace with some components used from the 50% Hybrid III automotive dummy. A pedestrian type pelvis is used to enable it to stand along with a straight spine and a femur load cell for the ability to obtain 6 channels of data. An additional chest box was developed to house an EME data acquisition system (DAS) along with battery packs. The manikin total weight is 147 pounds with the possible addition of 11 pounds of instrumentation. This instrumentation weight consisted of a DAS, battery packs, instrumentation sensors, sensor mounting blocks and wiring.



5% Male Aerospace
Dummy

Anthropometry

The table below gives the anthropometry measurements.

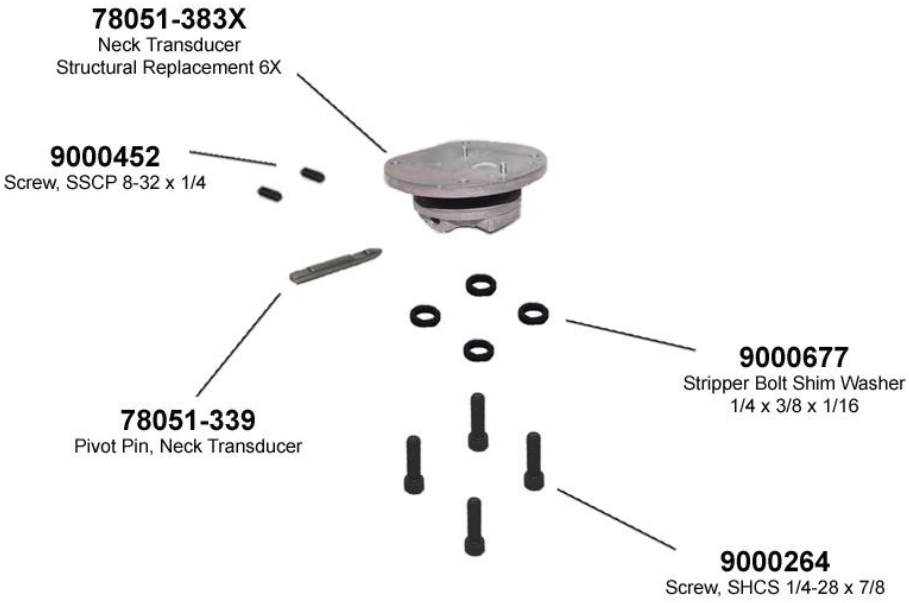
5% Male Aerospace Model: H3-5MASAnthropometry Measurements – in inches	
Stature (With the Standard Head)	65.9
Head Length (With Standard Head)	7.6
Head Breath (With Standard Head)	5.8
Head Circumference (With Standard Head)	21.7
Sitting Height (With Standard Head)	35.0
Eye Height Sitting (With Standard Head)	31.2
Stature (With an ADAM type head)	65.8
Head Length (With ADAM Type Head)	8.0
Head Breath (With ADAM Type Head)	6.0
Head Circumference (With ADAM Type Head)	23.1
Sitting Height (With ADAM Type Head)	34.9
Eye Height Sitting (With ADAM Type Head)	30.4
Thumb Tip Reach	27.4
Shoulder Breath	18.8
Chest Depth	9.8
Chest Breath	11.7
Chest Circumference	37.1
Waist Circumference	32.1
Hip Breath	14.7
Thigh Circumference	20.2
Buttock-Knee Length	22.6
Knee-Height Sitting	21.0
Foot Length	10.2

A 5% male aerospace dummy model: H3-5MAS without instrumentation normally has a weight of 147 pounds. Fully instrumented tests could have a weight variance of 158 pounds.

Head

Two head sizes are used . The standard head is part number 80020-61X with a weight of 8.1 pounds with instrumentation and 12 inch wire lengths.





Items mounted in the head

The second head used is the large ADAM with a weight of 9.6 pounds.

HEAD DESCRIPTION

Large ADAM



Production or MFG. Part Number: 6886-16-7198-30

Average Weight ~ 9.6 Pounds

Average durometer shore "A " reading ~ 58.7

– Hybrid II mold with ears attached afterwards –

Normally used with – Large ADAM manikin

Flight Equipment Required :

Large – Helmet LW HGU-55/P (CE MOD)

Large – Zeta Liners

M / N – Oxygen Mask – MBU- 20/P

Head Size :

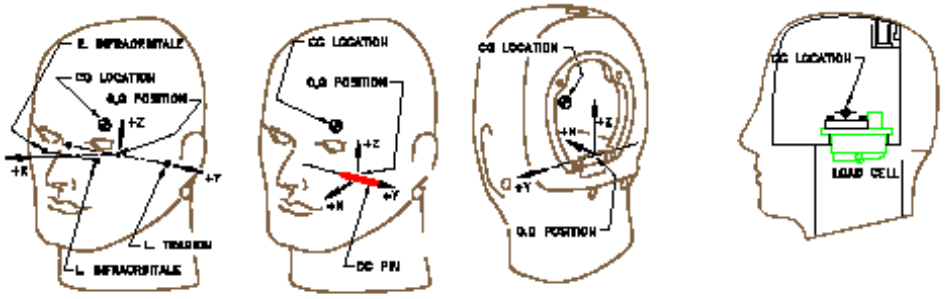
Breath - 6.0 In. Length - 8.00 In.

Circumference - 23.1 In.

Neck Size :

Normally use with a 95% Hybrid III & bushings

Part No: FTSS & Denton ~ 880995-1260



Average Measurements

Landmarks	X (cm)	Y (cm)	Z (cm)	X (in.)	Y (in.)	Z (in.)
CG Anatomical Location	-1.46	0.20	2.70	-0.57	0.08	1.06
CG Head/Neck Joint Location	0.35	0.62	5.22	0.14	.024	2.06
CG Manufacturer Location	-1.02	0.00	3.30	-0.40	0.00	1.30

Components used when measured:



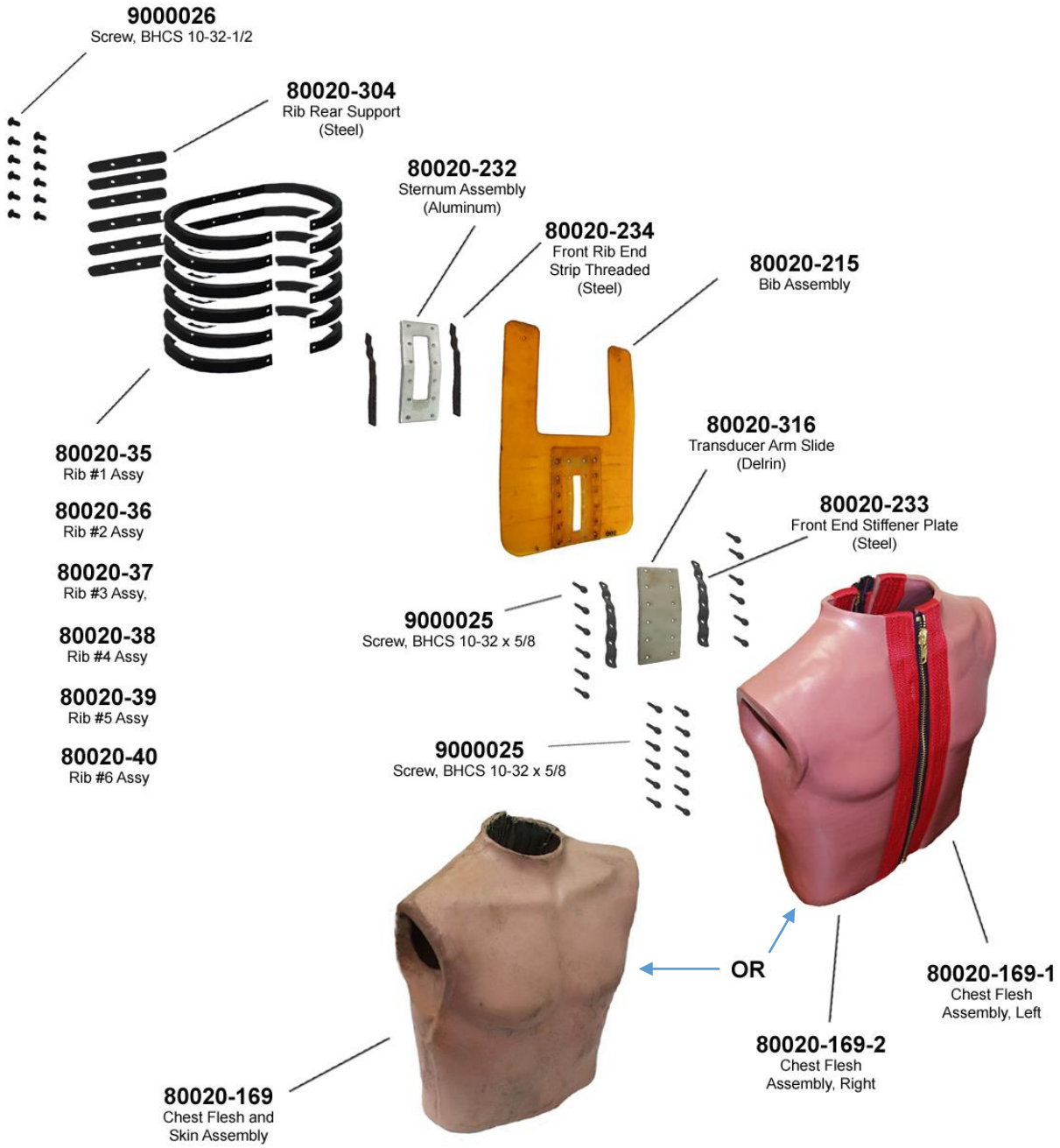
GT Nov. 2010

Neck Assembly

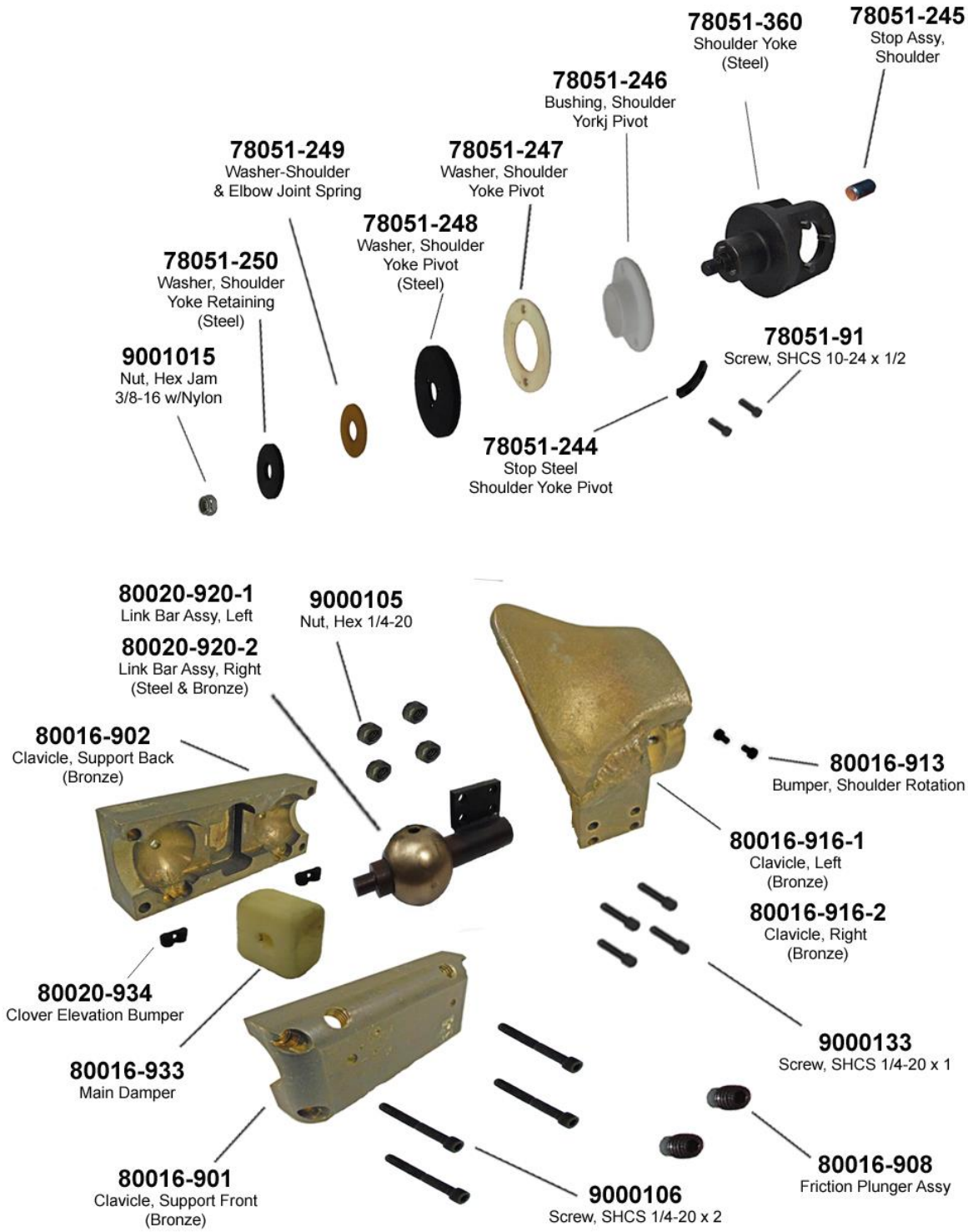
The neck used is the same one used on the 50% Hybrid III automotive crash test dummy (PN: 78051-336). Necks are in calibration for a year.



Chest Components

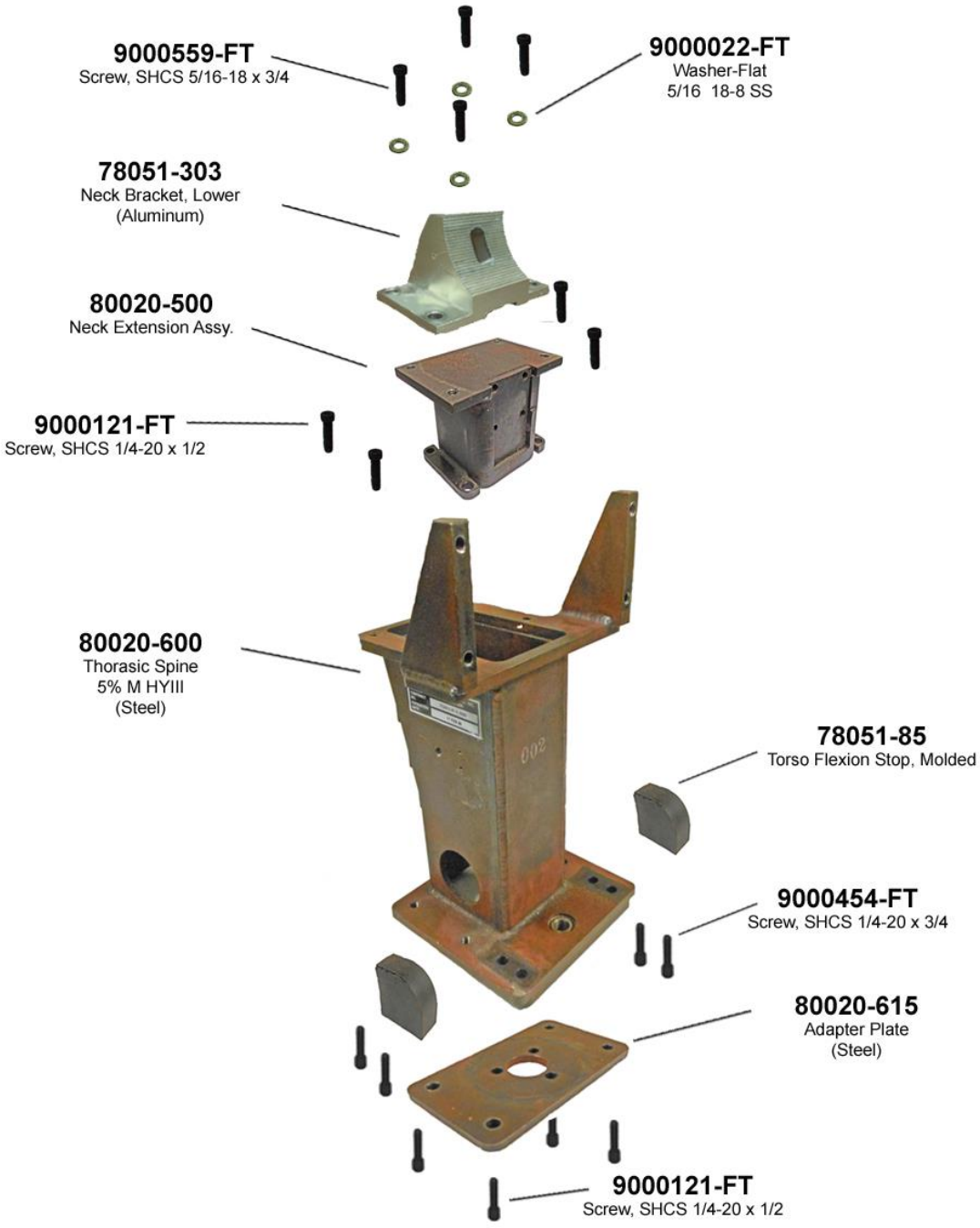


Shoulder Components



Chest Box Components

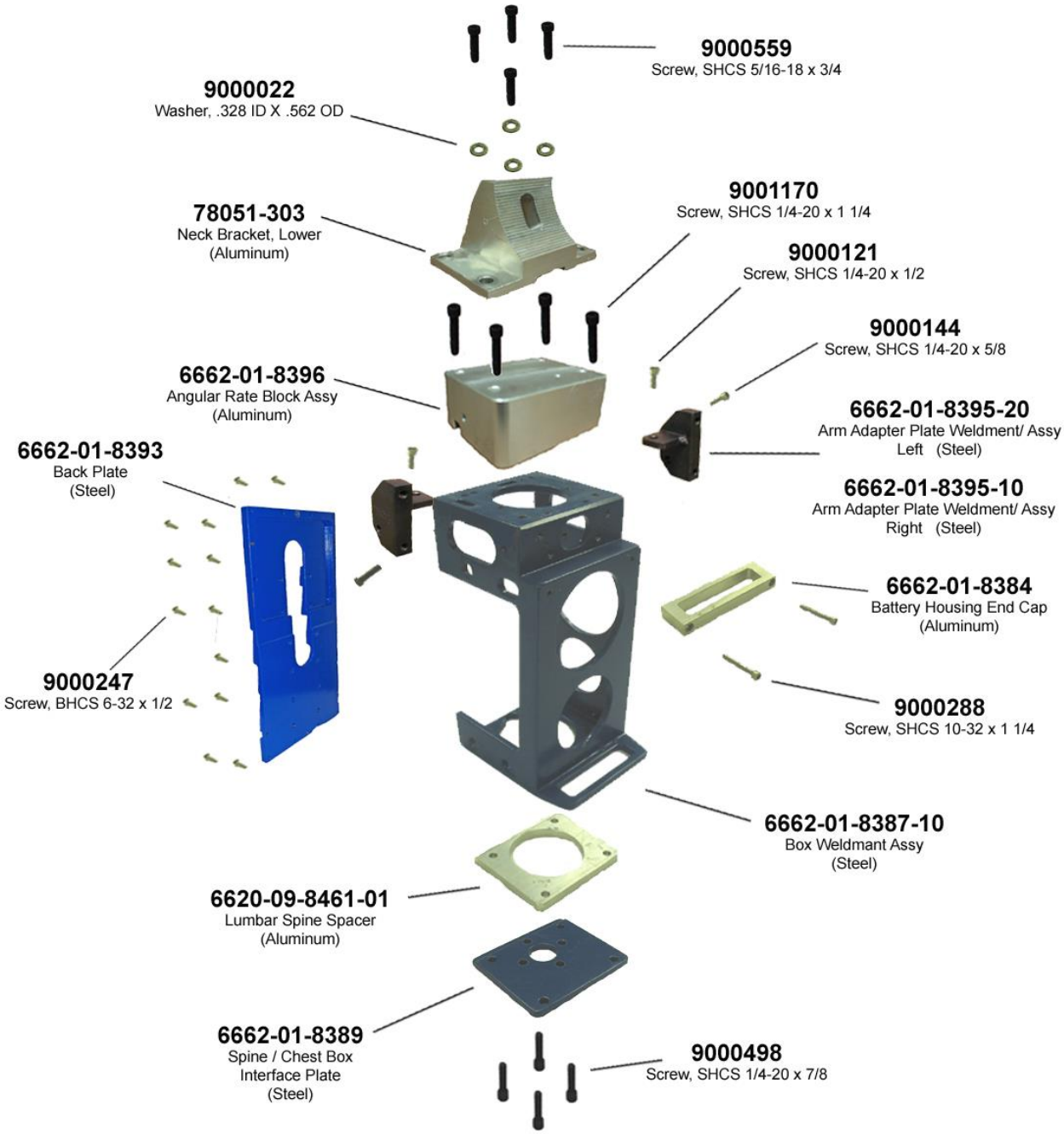
There are two chest boxes that can be used. The one that came with the dummy and a universal chest box.



Standard Chest Box

Chest Box Components

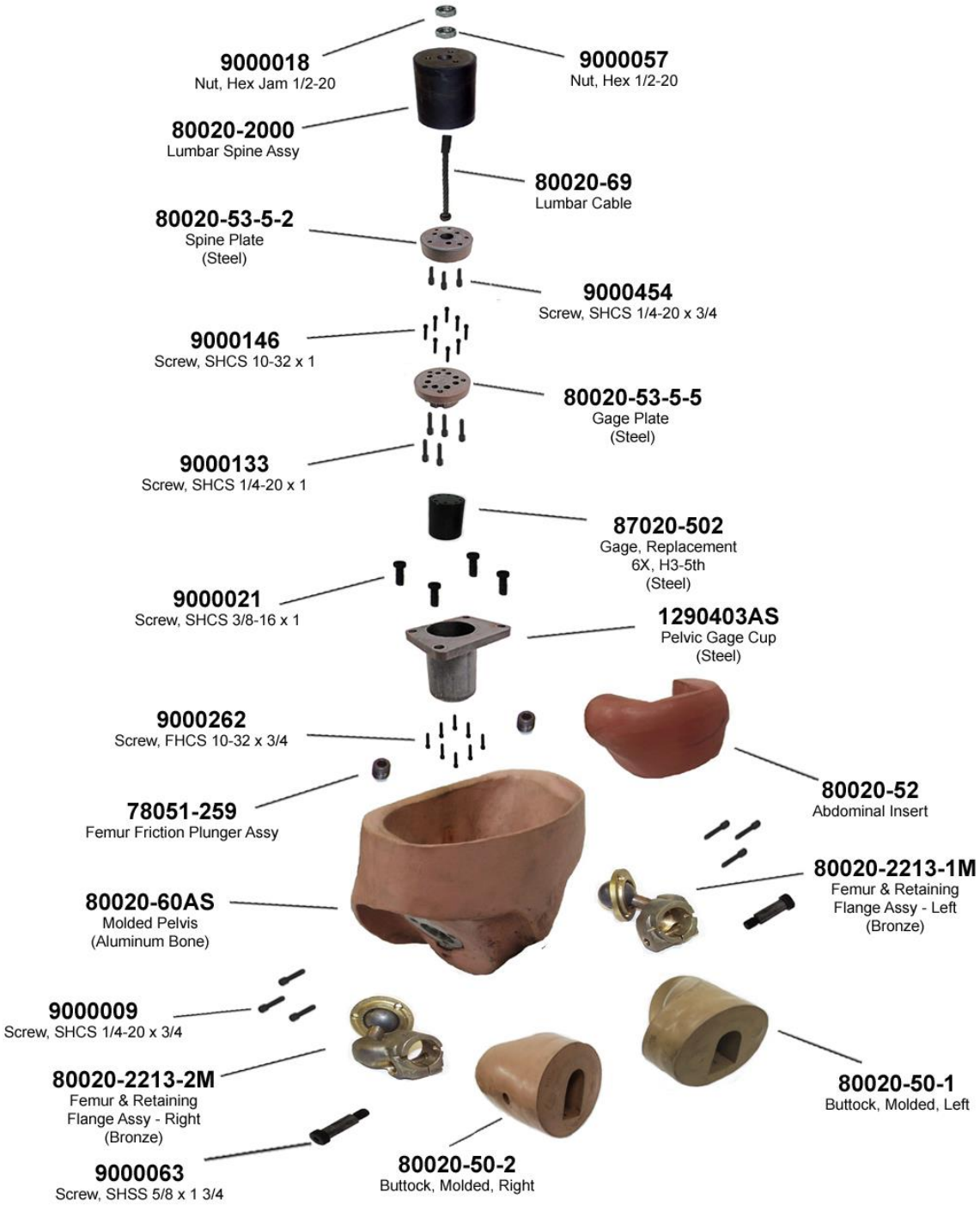
The other chest box which could be used is the universal.



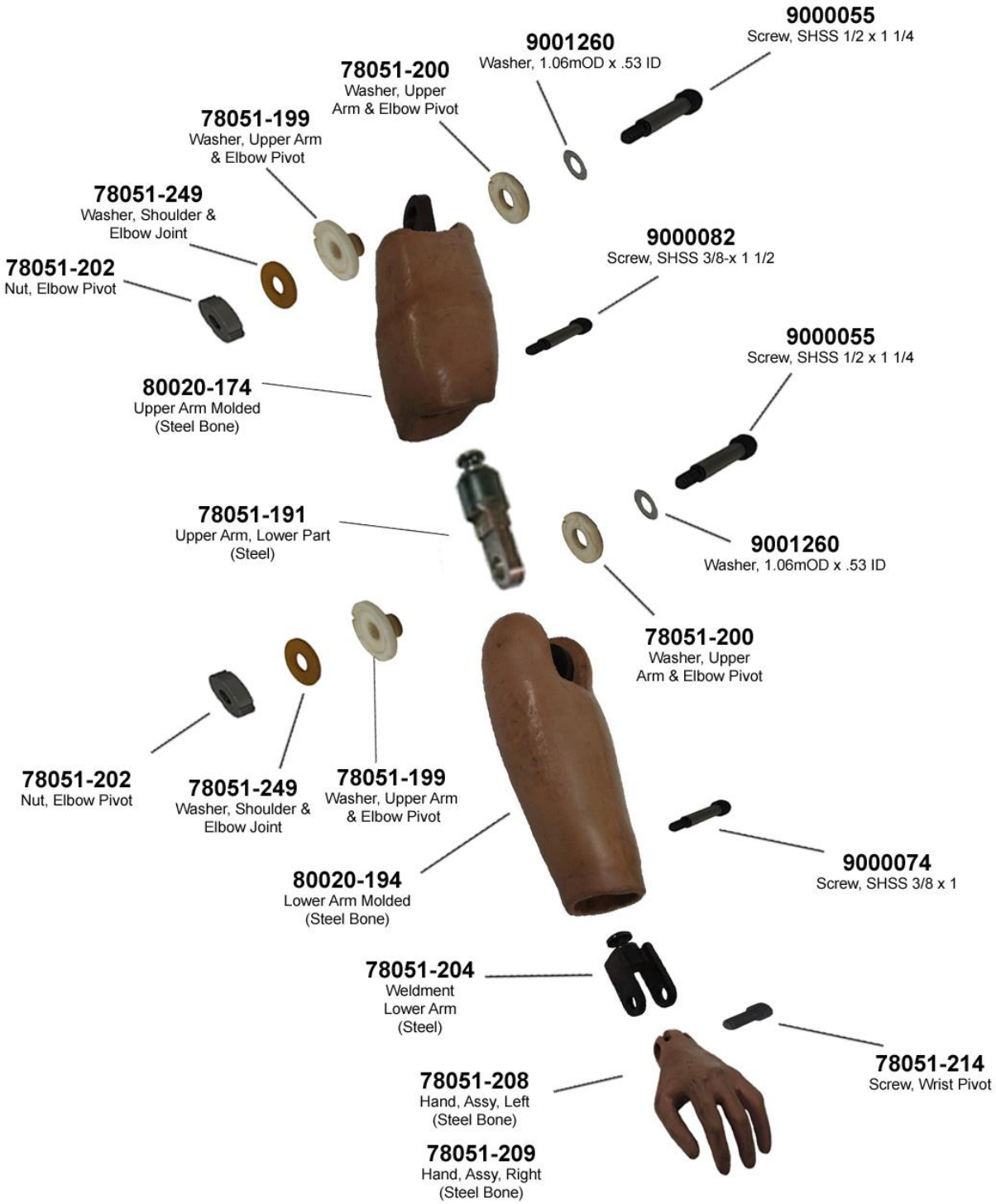
Universal Chest Box

Lower Torso Pelvis

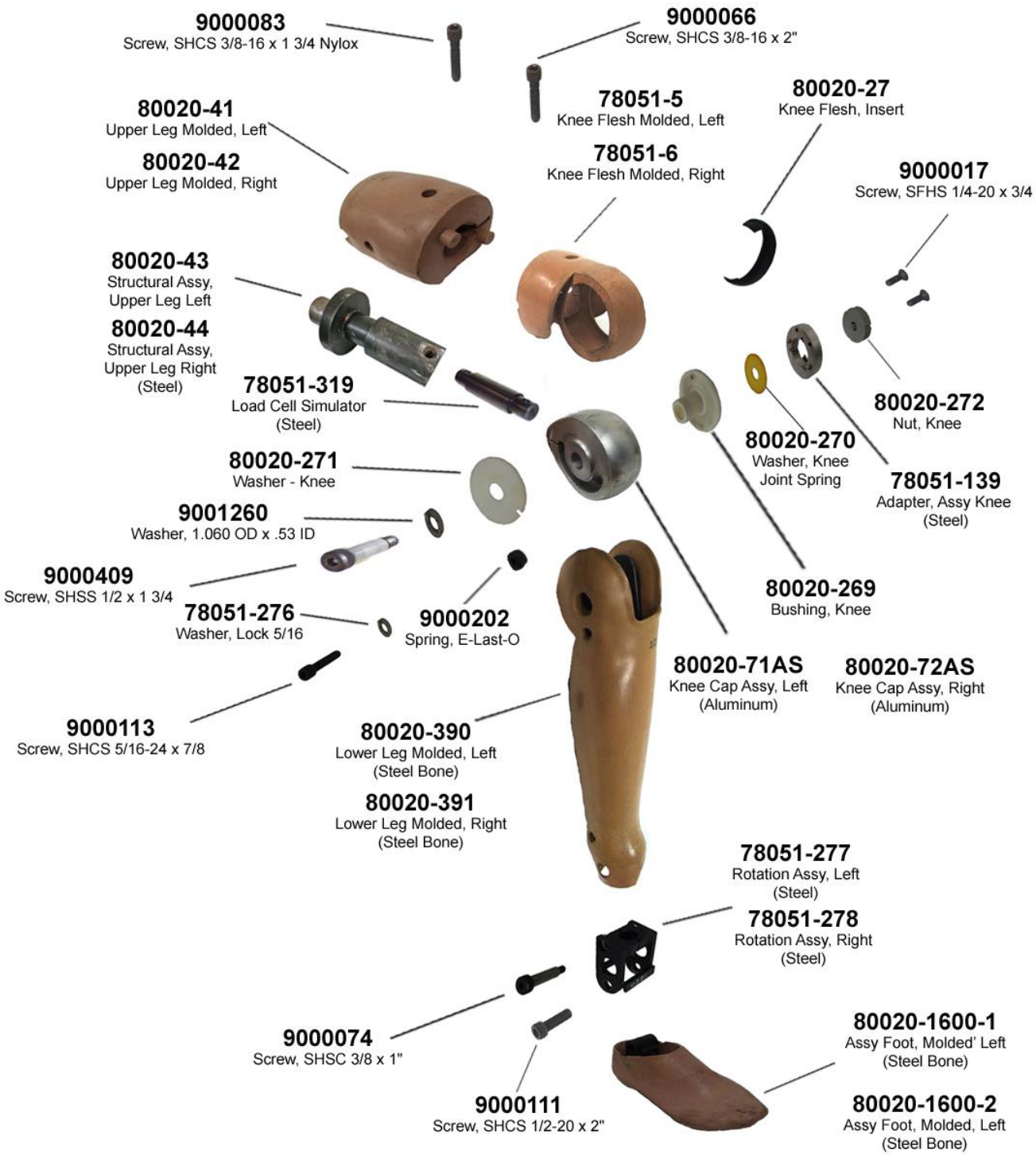
The pelvis is a pedestrian design for standing along with a straight spine.



Arm Assembly

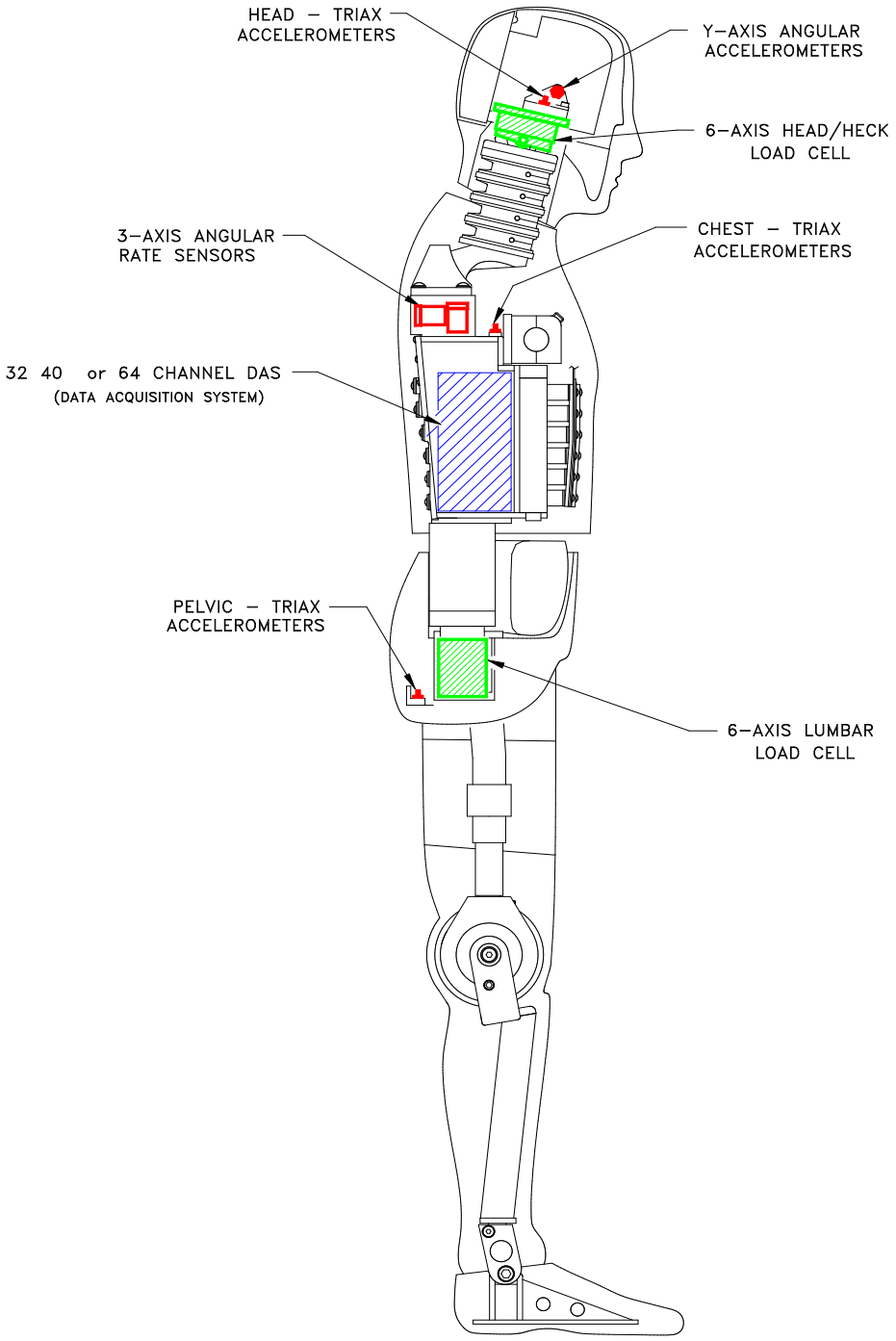


Leg Assembly



Instrumentation

Shown below is a general location and instrumentation that can be used with the 5% male aerospace dummy model H3-5MAS.



Appendix D-6 Manikin Trousers

The manikin trousers have been designed to replace the chaps and skirts used on all the manikins. The trousers are shown in the photos below.













The following Technical Data Package (TDP) information is provided in order to manufacture the trousers.

TDP for LARD/LOIS Dummy Garment

1. Scope

This document describes the Technical Data Package (TDP) requirements for the manikin garment designed to prevent intrusion of parachute harness into mannequin joints during tests to be used in the Materials and Testing Laboratory. The garment is constructed of elastic sports knit type fabric with leather reinforcement panels, and hook- and loop-adjusted webbing straps. The garment is designed in two sizes, namely in large (*Largest Anthropomorphic Research Dummy*, or *LARD*) and in small (*Lightest Occupant In Service*, or *LOIS*).

1.2. Classification. The manikin garment shall be of one type in two sizes, small and large.

2. Salient Requirements

2.1 Cloth. The base cloth for the garment shell will be a jersey knit with 91% nylon and 9% spandex blend.

2.1.1 Weight. The weight of the cloth will be 10.5 (± 1.5) ounces per square yard.

2.1.2 Width. The width of the fabric will be 60.0 inches.

2.1.3 Color. The color of the fabric will be a good match to shade Graphite, or as requested by requesting personnel.

2.2 Leather. The leather used for reinforcement padding will be 100% leather. The leather will be smooth and free of coarse loose flesh. The leather will be suitable for use in garments and equipage.

2.2.1 Weight. Weight of leather will be 6.0 (±0.5) ounces per square yard.

2.2.2 Thickness. Thickness of leather will be 0.1 (±0.05) inch.

2.2.3 Color. The color of the leather will be a good match to shade Sage Green, or as requested by requesting personnel.

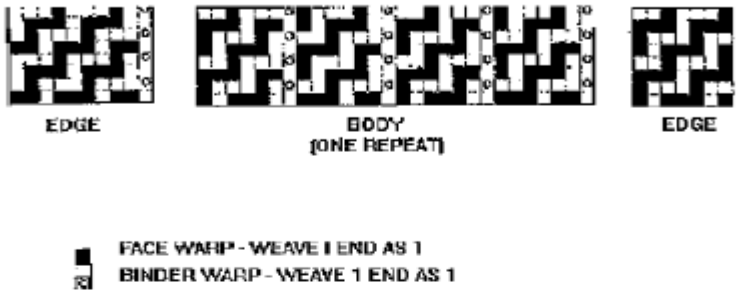
2.2.3 Finishing. The leather will have a light application of finish and dye containing only sufficient pigment to assist in making the color uniform. The finish on the leather surface shall not crack or part from the leather and shall not affect its performance properties.

2.3 Webbing. The webbing used for adjustment straps and stirrups will be 100% textured nylon.

2.3.1 Width. Width of webbing will be 1.0 inch in width.

2.3.2 Color. The color will be a good match to shade Tan, or as requested by requesting personnel.

2.3.3 Weave. The webbing will be a tubular weave bound together by a plain weave binder. 1/



1/ Nylon webbing weave

Material Specifications

Material	Cloth	Leather	Webbing
Content	91% nylon, 9% spandex	100% leather	100% textured nylon
Thickness (in.)	N/A	0.1	0.046 (± 0.007)
Width (in.)	60.0	N/A	1.0 (±0.0625)
Color	Graphite	Sage Green	Tan
Weight (oz/sq. yd)	10.5 (± 1.5)	6.0 (±0.5)	0.5
Supplier	Rockywoods	Belleville	Cordura
Alt. supplier	Darlington	Danner, Buckskin	Calweb

2.4 Thread. The manikin currently uses a cotton covered, polyester core thread for stitching the leather panels, and is a good match to the shell cloth color. The thread size will be Tex 40.

The manikin currently uses a nylon thread for stitching the webbings, and is a good match to the shell cloth color. The thread size will be Tex 76.

Thread Specifications

	Thread 1 (leather stitching)	Thread 2 (webbing stitching)
Material	Polyester, cotton wrap	Nylon
Thread size	Tex 40	Tex 76
Color	Foliage green	Foliage green
Supplier	A&E	Eddington Thread

3. Components

The manikin garment currently uses 100% nylon touch fastener hook and loop throughout the garment. The garment also uses a polyester webbing for the elastic waist band. Width of the elastic webbing will be 1.5 inches.

4. Notes

The Air Force has a preference for materiel procured for this garment from Berry compliant suppliers. However, non-Berry compliant suppliers will be considered for contracting when necessary if there is urgent need for materiel procurement.

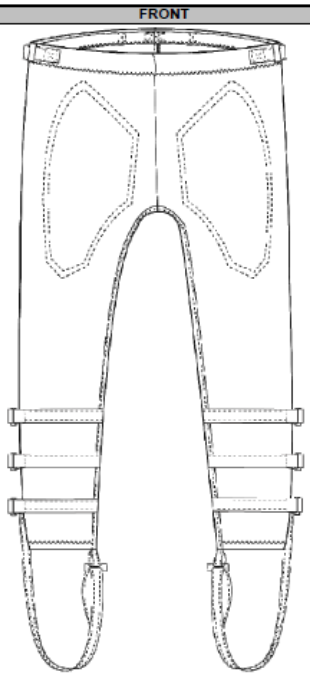
Materials used for the production of the garment can be procured through other suppliers than the ones listed, if necessary.

Specific data to manufacture trousers for the LOIS manikin is given below.

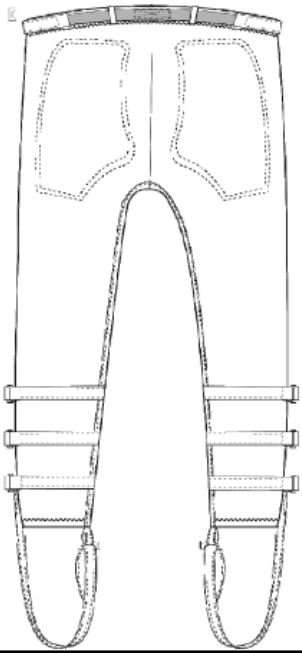
STYLE DESCRIPTION				
LOT #: LOIS	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LOIS	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LOIS 5%	
DESCRIPTION: Garment for 5% Research Dummy (LOIS)			PRODEV: JF	

ADDITIONAL ATTRIBUTES: Garment for 5% Research Dummy (LOIS) to prevent intrusion of parachute harness into mannequin joints during tests. Garment is constructed of stretchy sports knit type fabric with leather reinforcement panels and hook and loop adjusted webbing straps.

FRONT



BACK



BILL OF MATERIALS				
LOT #: LOIS PATTERN #: LOIS	DATE CREATED: 3-2-16 DATE REVISED: 3-21-16	IN DC DATE: CUSTOMER: AFRL	MANUFACTURER: AFUO SIZE RANGE: LOIS 5%	THUMBNAIL
DESCRIPTION: Garment for 5% Research Dummy (LOIS)			PRODEV: JF	

FABRIC DETAIL							
FABRIC TYPE	CONTENT	CONSTRUCTION	WEIGHT PER SQ YD	FINISHING/ COATING	COLOR	RM#	FABRIC SUPPLIER
SHELL	91% Nylon / 9% Spandex *	Jersey	10.5oz +/- 1.5oz	Wicking	Graphite	NYSPAN-TCJERSEY	Rocky Woods
LEATHER	100% Hide	Leather	6oz	NA	Sage Green	NA	Belleville

* While having the same content, stretch and recovery can vary. Recommend evaluating stretch and recovery to patterns prior to manufacture.

TRIM DETAIL							
TRIM TYPE	DESCRIPTION	SIZE	COLOR (Optional)	QTY	PLACEMENT	SUPPLIER	POST PICK (Y/N)
THREAD 1	Cotton Wrap Poly	TEX 40	Foliage Green 504		Sew-Serge, ZigZag, Leather Panel Sew Down.	A&E	
THREAD 2	E/3 Nylon	TEX 76	Foliage Green		Adjuster strap assemblies, Stirrup assemblies	Eddington Thread	
HOOK FASTENER	100% Nylon Touch Fastener Hook	1 In.	Foliage Green	1.5 Yards	Adjustment Straps		
WEBBING	Solution Dyed Nylon Webbing	1 In.	Tan 499	9.3 Yards	Adjustment Straps	Cordura	
PLASTIC LOOP	Nexus Looploc	1 In.	Tan 499	10			
ELASTIC	Polyester Webbing Non Roll Elastic	1.5 In.	Foliage Green	1 Yards	Waist		
LOOP FASTENER	100% Nylon Touch Fastener Loop	1 In.	Foliage Green	3.06 Yards	Adjustment Straps		

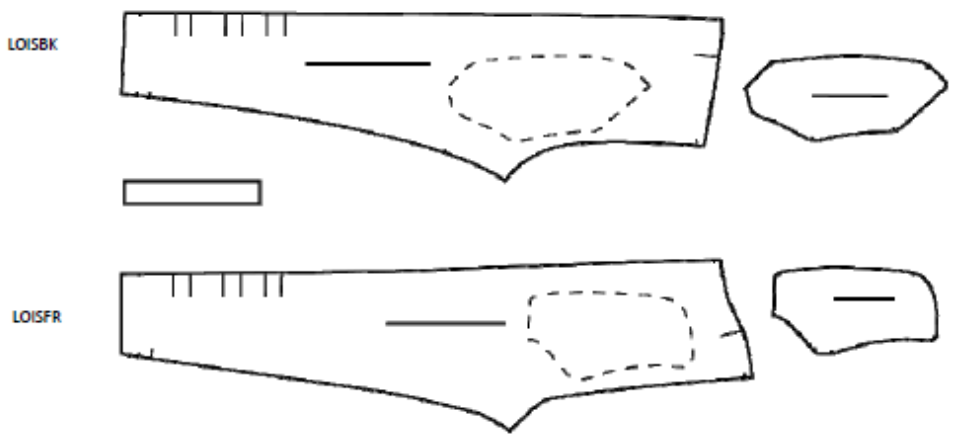
MEASUREMENT (INCHES)			
LOT #: LOIS PATTERN #: LOIS	DATE CREATED: 3-2-16 DATE REVISED: 3-21-16	IN DC DATE: CUSTOMER: AFRL	MANUFACTURER: AFUO SIZE RANGE: LOIS 5%
DESCRIPTION: Garment for 5% Researoh Dummy (LOIS)			PRODEV: JF

THUMBNAIL

POINT OF MEASUREMENT DESCRIPTION	MEASUREMENT	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	+/- TOL
1/2 Waist at Top Edge, Relaxed	13																	
1/2 Low Hip (from widest part, folded edge to folded edge)	16 1/4																	
1/2 Thigh 1" Below Crotch	8 1/2																	
1/2 Leg Opening	4																	
Inseam to Finished Hem	22 1/2																	
Outseam to Finished Hem	32																	

PATTERN				
LOT #: LOI8	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LOI8	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LOI8 6%	
DESCRIPTION: Garment for 6% Research Dummy (LOI8)			PRODEV: JF	

LOI8 PATTERN



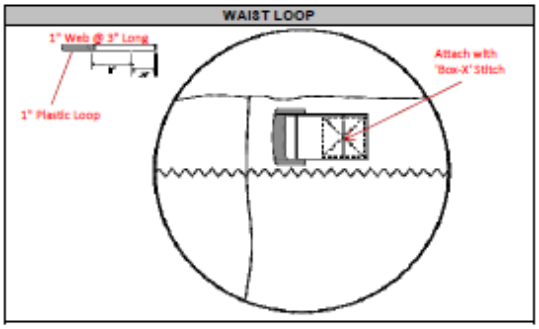
ADDITIONAL FEATURES	
LOI8BK	Back Pant, Cut 2 (1R 1L)
LOI8FR	Front Pant, Cut 2 (1R 1L)
LOI8PDBK	Back Pad, Cut 2 (1R 1L)
LOI8PDFR	Front Pad, Cut 2 (1R 1L)
LOI8_INSEAM	Leather Inseam Piece, Cut 1

NOTE: Accumark 9 patterns are available from Air Force Uniform Office, 1901 10th Street, Wright Patterson AFB, OH 45433. Email: Sarah.Tanner.ctr@us.af.mil

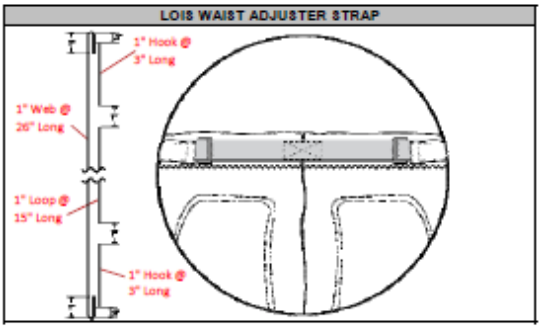
CONSTRUCTION DETAIL (1 of 2)

LOT #: LOIS	DATE CREATED: 3-2-18	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LOIS	DATE REVISED: 3-21-18	CUSTOMER: AFRL	SIZE RANGE: LOIS 5%	
DESCRIPTION: Garment for 5% Research Dummy (LOIS)			PRODEV: JF	

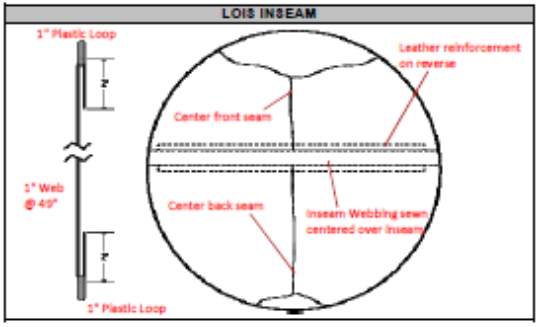
WAIST LOOP



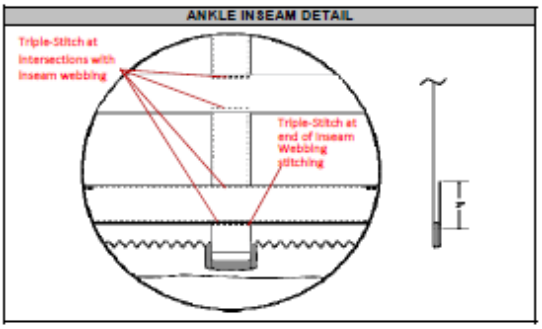
LOIS WAIST ADJUSTER STRAP



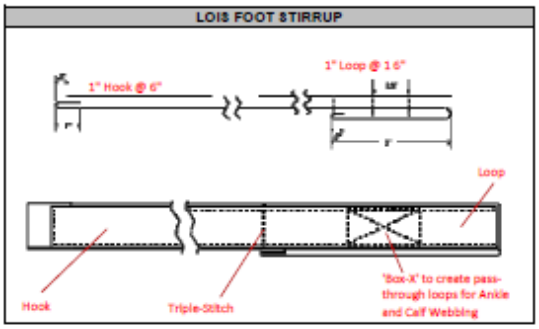
LOIS INSEAM



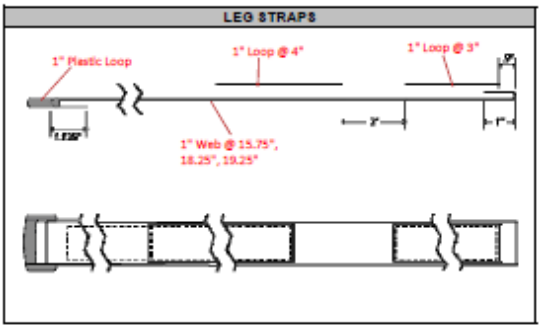
ANKLE INSEAM DETAIL



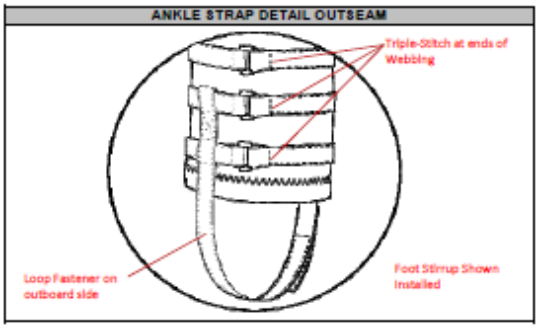
LOIS FOOT STIRRUP



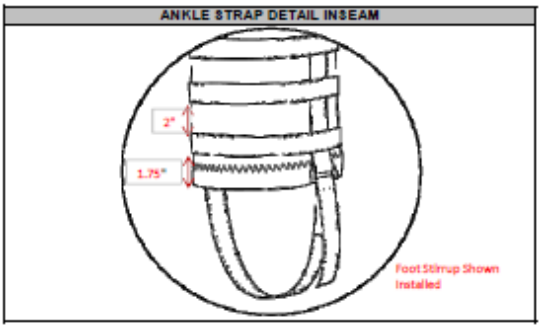
LEG STRAPS



ANKLE STRAP DETAIL OUTSEAM

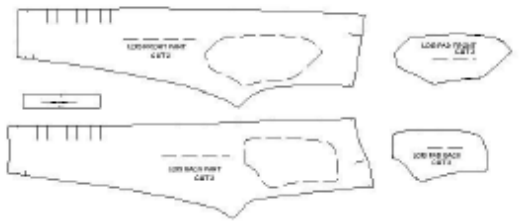


ANKLE STRAP DETAIL INSEAM



CONSTRUCTION DETAIL (2 of 2)				
LOT #: LOIS	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LOIS	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LOIS 5%	
DESCRIPTION: Garment for 5% Researoh Dummy (LOIS)			PRODEV: JF	

PATTERN PIECES



ADDITIONAL FEATURES	
ROLLOVER WAISTBAND	The waist band is 3/4" rollover, 1.5" elastic webbing @ 26.5" long
WAIST LOOP ADJUSTER	One strip of 1" webbing @ 26" long, four strips of 1" webbing @ 3" long, two pieces of hook fastener tape @ 3" long, one piece of loop fastener tape @ 15" long, four 1" plastic loops
LEATHER INSERT INSEAM	Leather reinforcement piece LOIS_INSEAM sewn inside garment centered over inseam
INSEAM WEBBING	One strip of 1" webbing @ 49" long, two 1" plastic loops sewn centered over inseam on outside of garment
KNEE WEBBING	Two strips of 1" webbing @ 19.25" long, two pieces of 1" hook tape fastener @ 3" long, two pieces of 1" loop tape fastener @ 4" long, two 1" plastic loops
CALF WEBBING	Two strips of 1" webbing @ 18.25" long, two pieces of 1" hook tape fastener @ 3" long, two pieces of 1" loop tape fastener @ 4" long, two 1" plastic loops
ANKLE WEBBING	Two strips of 1" webbing @ 15.75" long, two pieces of 1" hook tape fastener @ 3" long, two pieces of 1" loop tape fastener @ 4" long, two 1" plastic loops
FOOT STIRRUP	Two strips of 1" webbing @ 36" long, two pieces of 1" hook tape fasteners @ 6" long, two pieces of loop tape fastener @ 16" long
ROLLOVER ANKLE	The ankle cuff has 1" fold over hem
PATTERN PIECES	Pattern pieces list: LOISFR, LOISBK, LOISPDFR, LOISPDBK, LOIS_INSEAM

CONSTRUCTION PROCEDURE				
LOT #: LOIS	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LOIS	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LOIS 5%	
DESCRIPTION: Garment for 5% Research Dummy (LOIS)			PRODEV: JF	

OPERATION	DESCRIPTION
Pant Leg Assembly	• Sew leather pads LOISPDFR (left and right) to wrong side of fabric pieces LOISFR (left and right) with double row stitching.
	• Sew leather pads LOISPDBK (left and right) to wrong side of fabric pieces LOISBK (left and right) with double row stitching.
	• Sew serge (safety stitch) LOISFR left and right, right-sides together along front center seam, sew serge (safety stitch) LOISBK left and right, right-sides together along center back seam.
Inseam Construction	• Sew serge (safety stitch) LOISFR and LOISBK assemblies right-sides together along inseam.
	• Sew leather inseam reinforcement pad LOIS_INSEAM centered along inseam on wrong side of fabric.
	• Sew webbing and plastic loops along inseam on outside of assembly.
Leg Straps	• Assemble hook and loop fastener to webbing for KNEE, CALF, and ANKLE STRAPS.
	• Sew KNEE, CALF, and ANKLE STRAP assemblies to leg as indicated on pattern.
	• Sew serge (safety stitch) leg assembly closed, right-sides together along outside seams. Turn garment right side out.
Cuff Hem	• Hem ankle cuffs approximately 1" with zig-zag stitch.
Waistband	• Sew 1.5" elastic band ends right sides together with half inch seam allowance. Fold ends down on wrong side and sew.
	• Sew elastic band to garment waist right sides together. Roll elastic waistband inside garment. Sew edge of elastic waistband with zig-zag stitch.
	• Assemble side adjustment straps hook and loop fastener and webbing.
	• Sew 1" plastic loop and webbing and side adjustment strap assembly to outside waist.
Stirrup	• Assemble stirrup hook and loop fastener and webbing (see attached diagram). Attach stirrup assembly to garment.

LABEL AND PACKAGING INFORMATION				
LOT #: LOIS	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LOIS	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LOIS 5%	
DESCRIPTION: Garment for 5% Research Dummy (LOIS)			PRODEV: JF	

MAIN LABEL	PLACEMENT
Information may be supplied by Acquisition	Determined by Acquisition

SIZE LABEL	PLACEMENT

OTHER	PLACEMENT

LABEL TEXT INFORMATION	
CARE/ CONTENT FRONT	
CARE/ CONTENT BACK	

PACKAGING INFORMATION: 1

CARTON DIMENSIONS:

REVISION HISTORY				
LOT #: LOIS	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LOIS	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LOIS 5%	
DESCRIPTION: Garment for 5% Research Dummy (LOIS)			PRODEV: JF	

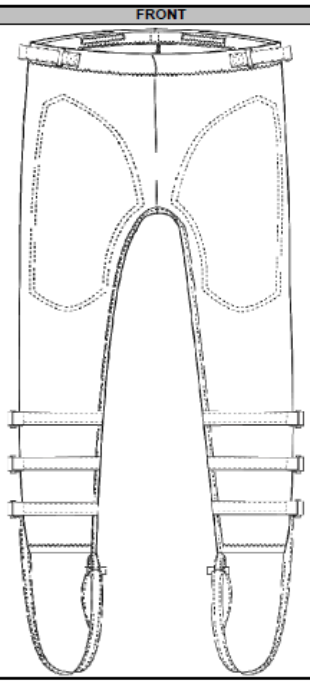
DATE	ENTERED BY	NOTES:
1-May-2014	JF	First prototype. LARD "Shorts"- decent fit, garment not sufficient to hold harness straps back in crotch
1-May-2014	JF	Second Prototype LOIS "shorts- too large in waist created without access to mannequin.
10-Nov-2015	JF	Third prototype. LARD "Pants" Addition of longer pant legs, adjustment straps on lower leg. Minor changes need including additional strap below knee.
10-Jan-2016	JF	Fourth Prototype. LARD "Pants" final fabric and strap placement. Required leather pad placement change and adjustment to waitline
10-Jan-2016	JF	Fifth prototype LOIS "Pants" Final material and straps. Required position change of leathe rpads and waist line adjustment
1-Mar-2016	JF	Final LARD and LOIS garments created.

Specific data to manufacture trousers for the LARD manikin is given below.

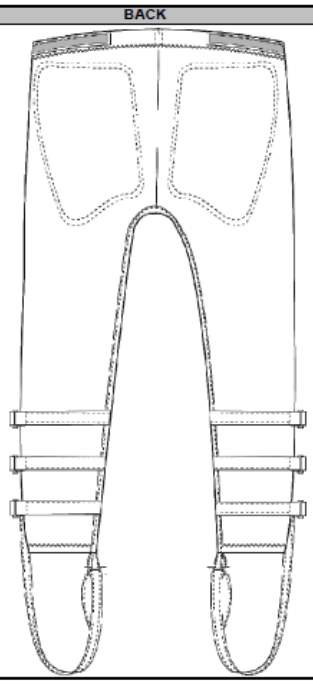
STYLE DESCRIPTION				
LOT #: LARD	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LARD	DATE REVISED:3-21-16	CUSTOMER: AFRL	SIZE RANGE: LARD 95%	
DESCRIPTION: Garment for 95% Research Dummy (LARD)			PRODEV: JF	

ADDITIONAL ATTRIBUTES: Garment for 95% Research Dummy (LARD) to prevent intrusion of parachute harness into mannequin joints during tests. Garment is constructed of stretchy sports knit type fabric with leather reinforcement panels and hook and loop adjusted webbing straps.

FRONT



BACK



BILL OF MATERIALS				
LOT #: LARD	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LARD	DATE REVISED:3-21-16	CUSTOMER: AFRL	SIZE RANGE: LARD 95%	
DESCRIPTION: Garment for 95% Research Dummy (LARD)			PRODEV: JF	

FABRIC DETAIL

FABRIC TYPE	CONTENT	CONSTRUCTION	WEIGHT PER SQ YD	FINISHING/ COATING	COLOR (Optional)	RM#	FABRIC SUPPLIER
SHELL	91% Nylon / 9% Spandex *	Jersey	10.5oz +/- 1.5oz	Wicking	Graphite	NYSPAN-TCJERSEY	Rocky Woods
LEATHER	100% Hide	Leather	6oz	NA	Sage Green	NA	Belleville

* While having the same content, stretch and recovery can vary. Recommend evaluating stretch and recovery to patterns prior to manufacture.

TRIM DETAIL

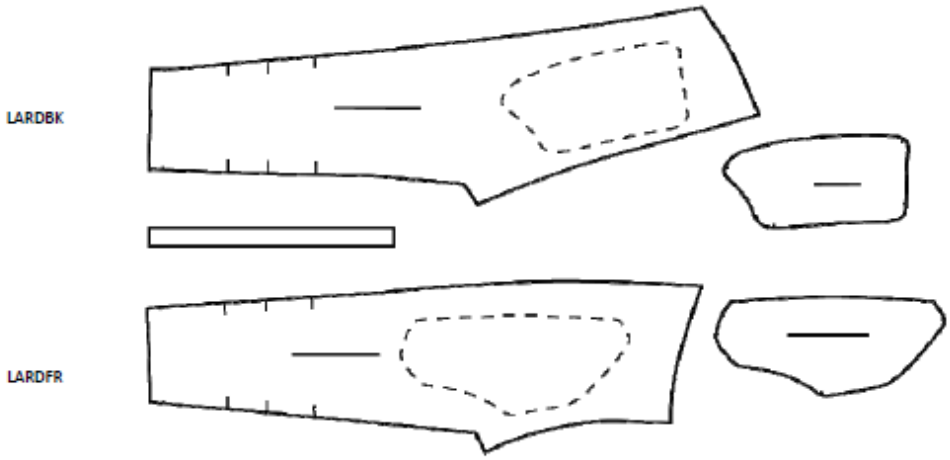
TRIM TYPE	DESCRIPTION	SIZE	COLOR (Optional)	QTY	PLACEMENT	SUPPLIER	POST PICK (Y/N)
THREAD 1	Cotton Wrap Poly	TEX 40	Foliage Green 504		Sew-Serge, ZigZag, Leather Panel Sew Down.	A&E	
THREAD 2	E/3 Nylon	TEX 76	Foliage Green		Adjuster strap assemblies, Stirrup assemblies	Eddington Thread	
HOOK FASTENER	100% Nylon Touch Fastener Hook	1 In.	Foliage Green	1.5 Yards	Adjustment Straps		
WEBBING	Solution Dyed Nylon Webbing	1 In.	Tan 499	9.3 Yards	Adjustment Straps	Cordura	
PLASTIC LOOP	Nexus Looploc	1 In.	Tan 499	10			
ELASTIC	Polyester Webbing Non Roll Elastic	1.5 In.	Foliage Green	1 Yards	Waist		
LOOP FASTENER	100% Nylon Touch Fastener Loop	1 In.	Foliage Green	3.06 Yards	Adjustment Straps		

MEASUREMENT (INCHES)				
LOT #: LARD PATTERN #: LARD DESCRIPTION: Garment for 86% Regearoh Dummy (LARD)	DATE CREATED: 3-2-16 DATE REVISED: 3-21-16	IN DC DATE: CUSTOMER: AFRL	MANUFACTURER: AFUO SIZE RANGE: LARD 86% PRODEV: JF	THUMBNAIL

POINT OF MEASUREMENT DESCRIPTION	MEASUREMENT	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	+/- TOL
1/2 Waist at Top Edge, Relaxed	19 1/2																	
1/2 Low Hip (from widest part, folded edge to folded edge)	23 1/4																	
1/2 Thigh 1" Below Crotch	11 1/2																	
1/2 Leg Opening	6																	
Inseam to Finished Hem	25 1/2																	
Outseam to Finished Hem	38 1/2																	

CONSTRUCTION DETAIL				
LOT #: LARD PATTERN #: LARD	DATE CREATED: 3-2-16 DATE REVISED: 3-21-16	IN DC DATE: CUSTOMER: AFRL	MANUFACTURER: AFUO SIZE RANGE: LARD 86%	THUMBNAIL
DESCRIPTION: Garment for 86% Regearoh Dummy (LARD)			PRODEV: JF	

LARD PATTERN



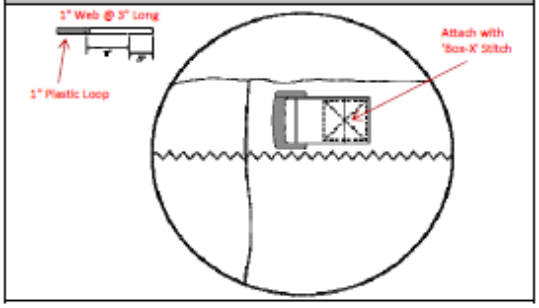
ADDITIONAL FEATURES	
LARDBK	Back Pant, Cut 2 (1R 1L)
LARDFR	Front Pant, Cut 2 (1R 1L)
LARDPDBK	Back Pad, Cut 2 (1R 1L)
LARDPDFR	Front Pad, Cut 2 (1R 1L)
LARD_INSEAM	Leather Inseam Piece, Cut 1

NOTE: Accumark 9 patterns are available from Air Force Uniform Office, 1901 10th Street, Wright Patterson AFB, OH 45433. Email: Sarah.Tanner.ctr@us.af.mil

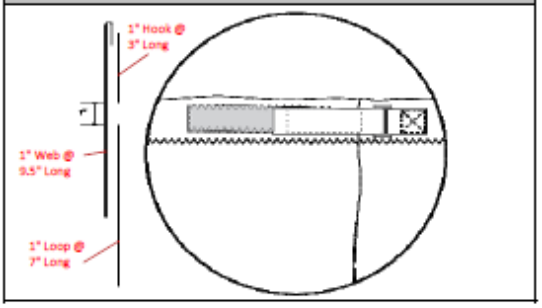
CONSTRUCTION DETAIL (Page 1 of 2)

LOT #: LARD	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LARD	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LARD 95%	
DESCRIPTION: Garment for 95% Research Dummy (LARD)			PRODEV: JF	

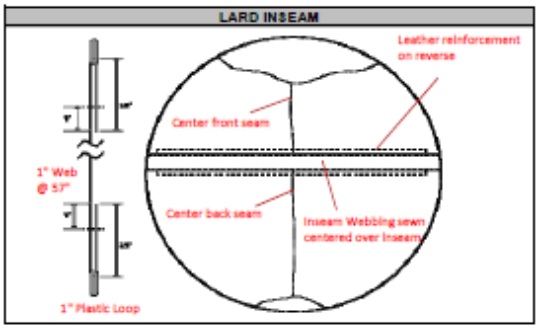
WAIST LOOP



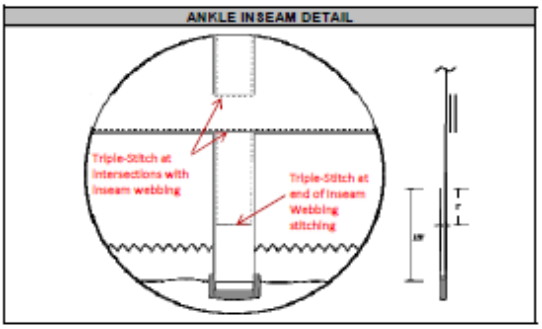
LARD WAIST ADJUSTER STRAP



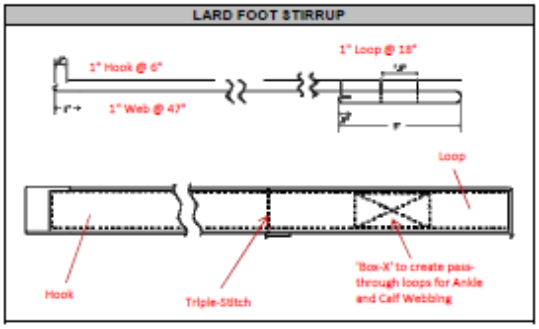
LARD INSEAM



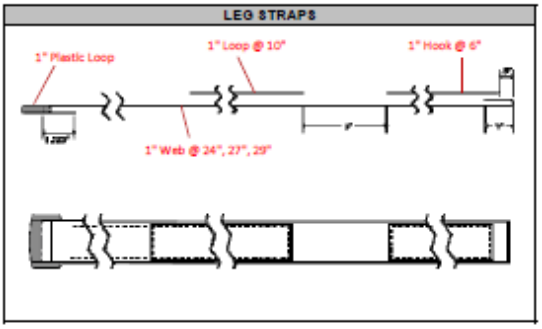
ANKLE INSEAM DETAIL



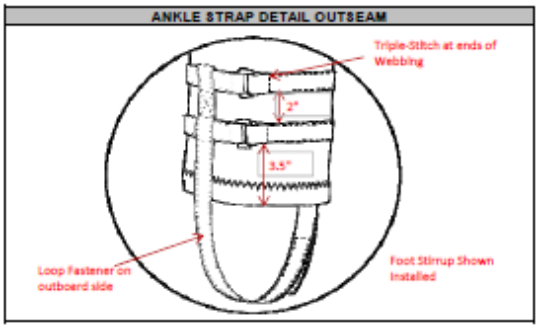
LARD FOOT STIRRUP



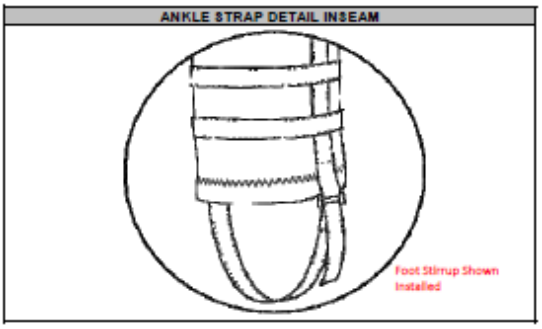
LEG STRAPS



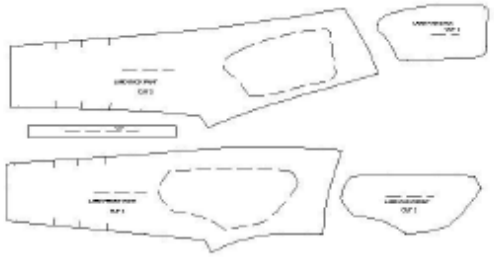
ANKLE STRAP DETAIL OUTSEAM



ANKLE STRAP DETAIL INSEAM



CONSTRUCTION DETAIL (Page 2 of 2)				
LOT #: LARD	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LARD	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LARD 95%	
DESCRIPTION: Garment for 95% Research Dummy (LARD)			PRODEV: JF	

PATTERN PIECES


ADDITIONAL FEATURES	
ROLLOVER WAISTBAND	The waist band is 3/4" rollover, 1.5" elastic webbing @ 36" long
WAIST LOOP ADJUSTER	Two strips of 1" webbing @ 3" long, two strips of 1" webbing @ 9.5" long, two pieces of 1" hook tape fastener @ 3" long, two pieces of 1" loop tape fastener @ 7" long, two 1" plastic loops
LEATHER INSERT INSEAM	Leather reinforcement piece LARD_INSEAM sewn inside garment centered over inseam
INSEAM WEBBING	One strip of 1" webbing @ 57" long, two 1" plastic loops sewn centered over inseam on outside of garment
KNEE WEBBING	Two strips of 1" webbing @ 29" long, two pieces of 1" hook tape fastener @ 6" long, two pieces of 1" loop tape fastener @ 10" long, two 1" plastic loops
CALF WEBBING	Two strips of 1" webbing @ 27" long, two pieces of 1" hook tape fastener @ 6" long, two pieces of 1" loop tape fastener @ 10" long, two 1" plastic loops
ANKLE WEBBING	Two strips of 1" webbing @ 24" long, two pieces of 1" hook tape fastener @ 6" long, two pieces of 1" loop tape fastener @ 10" long, two 1" plastic loops
FOOT STIRRUP WEBBING	Two strips of 1" webbing @ 47" long, two pieces of 1" hook tape fasteners @ 6" long, two pieces of loop tape fastener @ 18" long
ROLLOVER ANKLE	The ankle cuff has 1" fold over hem
PATTERN PIECES	Pattern pieces list: LARDFR, LARDBK, LARDPDFR, LARDPDBK, LARD_INSEAM

CONSTRUCTION PROCEDURE				
LOT #: LARD	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LARD	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LARD 95%	
DESCRIPTION: Garment for 95% Research Dummy (LARD)			PRODEV: JF	

OPERATION	DESCRIPTION
Pant Leg Assembly	• Sew leather pads LARDPDFR (left and right) to wrong side of fabric pieces LARDFR (left and right) with double row stitching.
	• Sew leather pads LARDPDBK (left and right) to wrong side of fabric pieces LARDBK (left and right) with double row stitching.
	• Sew serge (safety stitch) LARDFR left and right right-sides together along front center seam, sew serge (safety stitch) LARDBK left and right right-sides together along center back seam.
Inseam Construction	• Sew serge (safety stitch) LARDFR and LARDBK assemblies, right-sides together along inseam.
	• Sew leather inseam reinforcement pad LARD_INSEAM centered along inseam on wrong side of fabric.
	• Sew webbing and plastic loops along inseam on outside of assembly.
Leg Straps	• Assemble hook and loop fastener to webbing for KNEE, CALF, and ANKLE STRAPS.
	• Sew KNEE, CALF, and ANKLE STRAP assemblies to leg as indicated on pattern.
	• Sew serge (safety stitch) leg assembly closed, right-sides together along outside seams. Turn garment right side out.
Cuff Hem	• Hem ankle cuffs approximately 1" with zig-zag stitch.
Waistband	• Sew 1.5" elastic band ends right sides together with half inch seam allowance. Fold ends down on wrong side and sew.
	• Sew elastic band to garment waist right sides together. Roll elastic waistband inside garment. Sew edge of elastic waistband with zig-zag stitch.
	• Assemble side adjustment straps hook and loop fastener and webbing.
	• Sew 1" plastic loop and webbing and side adjustment strap assembly to outside waist.
Stirrup	• Assemble stirrup hook and loop fastener and webbing (see attached diagram). Attach stirrup assembly to garment.

LABEL AND PACKAGING INFORMATION				
LOT #: LARD	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LARD	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LARD 95%	
DESCRIPTION: Garment for 95% Research Dummy (LARD)			PRODEV: JF	

MAIN LABEL	PLACEMENT
Information may be supplied by Acquisition	Determined by Acquisition

SIZE LABEL	PLACEMENT

OTHER	PLACEMENT

LABEL TEXT INFORMATION	
CARE/ CONTENT FRONT	
CARE/ CONTENT BACK	

PACKAGING INFORMATION: 1

CARTON DIMENSIONS:

REVISION HISTORY				
LOT #: LARD	DATE CREATED: 3-2-16	IN DC DATE:	MANUFACTURER: AFUO	THUMBNAIL
PATTERN #: LARD	DATE REVISED: 3-21-16	CUSTOMER: AFRL	SIZE RANGE: LARD 95%	
DESCRIPTION: Garment for 95% Research Dummy (LARD)			PRODEV: JF	

DATE	ENTERED BY	NOTES:
1-May-2014	JF	First prototype. LARD "Shorts"- decent fit, garment not sufficient to hold harness straps back in crotch
1-May-2014	JF	Second Prototype LOIS "shorts- too large in waist created without access to mannequin.
10-Nov-2015	JF	Third prototype. LARD "Pants" Addition of longer pant legs, adjustment straps on lower leg. Minor changes need including additional strap below knee.
10-Jan-2016	JF	Fourth Prototype. LARD "Pants" final fabric and strap placement. Required leather pad placement change and adjustment to waitline
10-Jan-2016	JF	Fifth prototype LOIS "Pants" Final material and straps. Required position change of leathe rpads and waist line adjustment
1-Mar-2016	JF	Final LARD and LOIS garments created.