CERTIFICATION MANUAL

BioRID II

ARA-001

ARA-9901 BioRID II Dummy Certification Manual [Rev. E]

HUMANETICS®
Innovative Solutions

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Introduction

The BioRID II Dummy Certification Procedures are to ensure proper dummy performance. These procedures include tests to verify the certification system is working correctly prior to certification and actual Dummy Certification tests. There are multiple tests to verify system inputs and a test to verify dummy performance. In this document, “BioRID II” will be further referred to as just “BioRID”.

These include:

BioRID Sled and Track System Certification Test – This test gives confidence the energy transfer device (ETD), sled track, and the probe are going to provide consistent test inputs to the BioRID Dummy Certification without Headrest.

BioRID Jacket Certification Test – This test verifies the jacket material stiffness stays consistent through time.

BioRID Pelvis Bottom Certification Test – This test verifies the material inside the pelvis has not changed over time.

BioRID Dummy Certification without Headrest Test – This test ensures the dummy’s neck will provide consistent test results. The test also provides evidence the damper, neck bumpers, muscle substitute springs and cable, are working correctly as a system.

Certification and Maintenance

A typical full dummy certification would follow these certification and maintenance steps:

1) Complete the “Design Checklist” (Appendix) to ensure the BioRID is at the correct build level.
2) Complete the “Maintenance Checklist” (Appendix) to ensure the BioRID is being properly maintained.
3) Make appropriate bumper changes according to Table 1 below.
4) Install Track System and perform BioRID Sled and Track System Certification Test.
5) Change probe and perform BioRID Jacket Certification Test.
6) Perform Pelvis Bottom Certification Test.
7) Change probe and repeat BioRID Sled and Track System Certification Test.
8) Perform BioRID Dummy Certification without Headrest Test.

Humanetics recommends users of the BioRID to conduct all the certification impact tests (including jacket and pelvis) and to complete the checklists during certification according to the recommended intervals in Table 1.

Table 1: Recommended Certification and Maintenance Task Frequency

Recommended Task Completion Intervals	Prior To Certification	After Severe Tests	1 Year	2 year
Design Checklist				X
Maintenance Checklist		X	X	
BioRID Sled and Track Certification	X	X	X	
BioRID Jacket Impact			X	
BioRID Pelvis Impact			X	
Front Neck Bumper Replacement (C1-C7); ARA-220 Qty. 7			X	
Rear Neck Bumper Replacement (C1-C3); ARA-220 Qty. 3				X
Rear Neck Bumper Replacement (C4-C7); ARA-227 Qty. 4				X
Front Thoracic Bumper Replacement (T1); ARA-220 Qty. 1			X	
Rear Thoracic Bumper Replacement (T1); ARA-227 Qty. 1				X
Front Bumper Replacement (T2-T12); ARA-381-37 Qty. 12				X
Rear Bumper Replacement (T2-T12); ARA-381-30 Qty. 12				X
Front Bumper Replacement (L1-L5); ARA-521 Qty. 5				X
Rear Bumper Replacement (L1-L5); ARA-520 Qty. 5				X
BioRID Dummy Certification without Headrest		X	X	

Glossary of Terms

Impact Probe Accelerometer – An accelerometer mounted on the end of test probe opposite to the impact face with its sensitive axis in line with the longitudinal centerline of the impact probe. This accelerometer is recommended to be an Endevco 7231C-750 or equivalent.

Energy Transfer Device (ETD) – (Part Number: TRA-140) – Impact block which is mounted to front of sled and impacted by probe to produce a consistent pulse. The mass of the ETD and ETD attachment bolts is to be 2.900 kg +/- 0.010 kg. The ETD is very sensitive to humidity and is protected by a continuous cover. If the cover gets damaged, the ETDs performance will fluctuate with humidity. Target humidity is 35%RH.

Sled Accelerometer – An accelerometer mounted to the sled so its sensitive axis is parallel to the longitudinal centerline of the impact probe. This accelerometer is recommended to be an Endevco 7264C-2000 or equivalent.

BioRID Impact Probe – (Part Number: TPA-060) – The test probe shall have a mass of 33.55 kg +/- 0.1 kg which includes all attached hardware and 1/3 of the weight of the suspension cables.

BioRID Impact Probe Face – (Part Number: TRA-178) – The impacting end of the probe, perpendicular and concentric with the longitudinal axis of the probe, has a flat, continuous, and non-deformable 254 mm+/- 0.25 mm diameter impact face with a 1mm - 2 mm thick Teflon® covering, extending rearward a minimum of 12.7 mm. The probe face shall have a mass of 4.05 kg +/- 0.01 kg.

Jacket Impact Probe – (Part Number: TF-325-2) – Is a test probe with a rigid metallic construction and concentric about its longitudinal axis having a mass of 13.97 kg +/- 0.023 kg including all attached hardware and 1/3 of the weight of the suspension cables. The combined mass of 1/3 of the probe support cables and all hardware attached to the probe must not exceed 5% of the total impact probe mass. The impacting end of the test probe is to be perpendicular and concentric with the longitudinal axis of the probe, has a flat, continuous, and non-deformable 152.4 mm +/- 0.25 mm diameter impact face, extending rearward a minimum of 25 mm, with an edge radius of 7.6 mm - 12.7 mm. This test probe is also used for the pelvis bottom certification.

Jacket Core Assembly – (Part Number: TRA-340) – Is an insert assembly that attaches to both the sled and to the jacket for the purpose of holding the jacket securely during impact. The mass of the jacket core assembly is to be 11.50 kg +/-0.03 kg.

Pelvis Bottom Fixture Assembly – (Part Number: TRA-370) – Is a fixture assembly which attaches the BioRID pelvis securely to the front of the sled. The fixture assembly has a mass of 5.6kg +/- 0.03kg.

Weight Package – (Part Number: TRA-180) – Is a dummy equivalent fixed weight package which attaches to the sled at the dummy attachment point. The weight package assembly with attachment hardware has a mass of 25.50 kg +/-0.02 kg. The weight package is used for the BioRID sled and track system certification test and the BioRID pelvis bottom certification test.

BioRID Data Processing

Data Channel Filters

- Impact Probe Accelerometer (Channel Class 180 phaseless filter)
- Sled Accelerometer (Channel Class 60 phaseless filter)
- T1 Accelerometer (Channel Class 60 phaseless filter)
- Potentiometers (Channel Class 60 phaseless filter)
- Upper Neck Moment My (Channel Class 600 phaseless filter)

Probe Force Calculation

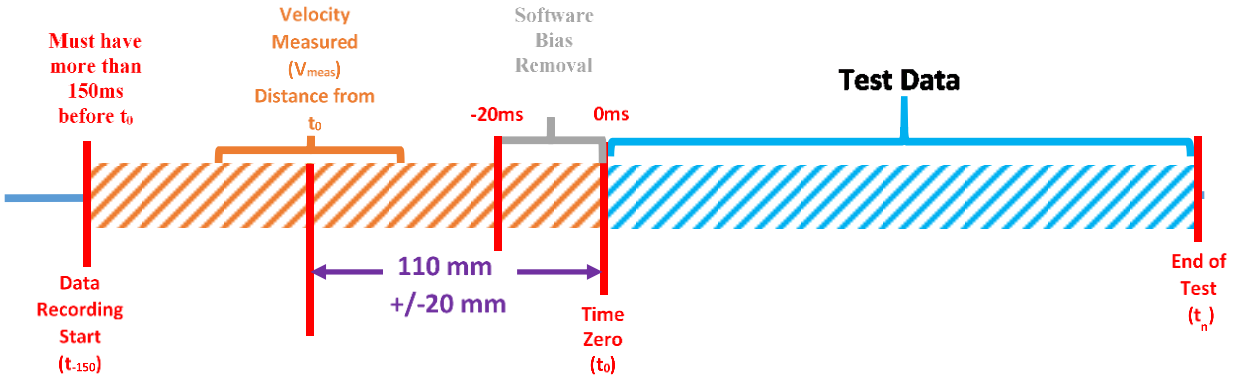
$$Force_{Probe}(N) = Acceleration_{Probe}(m/s^2) * Mass_{Probe}(kg)$$

Part Compression Calculation (Jacket and Pelvis Impact)

1) Record the test data at a minimum of 10Khz.
2) Record the impact probe and sled accelerations using an anti-aliasing filter that meets CFC1000, or prefilter the data using a CFC1000 forward filter (CFC1000F) before doing any further processing.
3) Calculate time zero (t_0). Time zero (t_0) is time when the impact probe contacts the test article and is defined as the time when the CFC1000F impact probe acceleration (A_{probe}) crosses the 1G level. If this results in a time shift from the original recorded time then apply this time shift to all data channels.
4) Remove channel bias by software zeroing all channels using the average of 20ms of data immediately before t_0 (-20ms to 0ms).
5) Use the CFC1000F analog data channels for all integrations.
6) Convert impact probe acceleration (g) to (m/s^2) if needed.

$$A_{probe}(m/s\text{^}2) = impact\ probe\ acceleration_g \times \frac{9.80665_{m/s\text{^}2}}{1_g}$$

7) Measure the velocity of the impact probe (V_{meas}) over a distance centered at 110mm +/- 20mm before contact with the part. It is critical to center the measurement at this point.



8) Calculate the impact probe velocity (V_{probe}) by integrating the impact probe acceleration (A_{probe}).
   a. The impact probe velocity at t_{-150} is set equal to V_{meas} (setting initial condition at -150ms will produce the correct results).

$$V_{probe} = \int_{t_{-150}}^{t_n} A_{probe}\, dt$$

$$Set\ V_{probe} = V_{meas}, when\ t = t_{-150}$$

9) Calculate impact probe displacement (D_{probe}) by integrating the impact probe velocity (V_{probe}).

$$D_{probe}(m) = \int_{t_{-150}}^{t_n} V_{probe}\, dt$$

10) Remove the offset of the impact probe displacement (D_{probe}) at time zero (t_0)

$$D_{probe(zeroed)}(m) = D_{probe} - D_{probeT0}$$

11) Convert sled acceleration to (m/s^2) if needed.

$$A_{sled}(\text{m/s\^2}) = sled\ acceleration_g \times \frac{9.80665_{m/s\text{\^}2}}{1_g}$$

12) Calculate sled velocity (V_{sled}) by integrating the sled acceleration (A_{sled}).

$$V_{sled}(\text{m/s}) = \int_{t_{-150}}^{t_n} A_{sled}\, dt$$

13) Remove the offset of the sled velocity (V_{sled}) at time zero (t_0)

$$V_{sled(zeroed)}(m/s) = V_{sled} - V_{sledT0}$$

14) Calculate sled displacement (D_{sled}) by integrating the offset removed sled velocity ($V_{sled(zeroed)}$)

$$D_{sled}(m) = \int_{t_{-150}}^{t_n} V_{sled(zeroed)}\, dt$$

15) Remove the offset of the probe displacement (D_{sled}) at time zero (t_0)

$$D_{sled(zeroed)}(m) = D_{sled} - D_{sledT0}$$

16) Calculate part compression

$$part\ compression\ (m) = D_{probe(zeroed)} - D_{sled(zeroed)}$$

Where,

t_{-150} = Data collection which must start prior to 150ms before impact
t_0 = When the CFC1000F probe acceleration crosses 1G
A_{probe} = Impact probe acceleration (m/s^2)
V_{meas} = Measured test velocity (m/s) at 110 mm before impact
V_{probe} = Calculated impact probe velocity (m/s) by integrating impact probe acceleration (A_{probe})
D_{probe} = Calculated impact probe displacement (m) by integrating probe velocity (V_{probe})
$D_{probeT0}$ = The value of the probe displacement (D_{probe}) at t_0 (m)
$D_{probe(zeroed)}$ = Probe displacement with t_0 offset removed (m)
A_{sled} = Sled acceleration (m/s^2)
V_{sled} = Calculated sled velocity (m/s) by integrating sled acceleration (A_{sled})
$V_{sled(zeroed)}$ = Sled velocity (m/s) with the t_0 offset removed
D_{sled} = Calculated sled displacement (m) by integrating sled velocity ($V_{sled(zeroed)}$)
D_{sledT0} = The value of the sled displacement (D_{sled}) at t_0 (m)
$D_{sled(zeroed)}$ = Sled displacement with the t_0 offset removed (m)

BioRID Sled and Track Certification without Headrest

Note: The sled and track certification ensures proper rail, sled and ETD installation and function.

Required Test Equipment

- BioRID Impact Probe
- BioRID Impact Probe Face
- Impact Probe Accelerometer
- BioRID Sled Track Assembly
- Sled Fixed Weight Package
- Sled Accelerometer
- Energy Transfer Device (ETD)
- Velocity Measurement

Pretest Preparation

- The BioRID sled is to be a linear bearing guided sled with a mass of 44.25 kg +/- .05 kg including all attachments that move with the sled (except the ETD and ETD mounting screws).
- The mass of the ETD and ETD attachment bolts is 2.900 kg +/- 0.010 kg.
- The mass of the sled fixed weight package including attachment bolts is 25.50 kg +/- 0.01 kg.
- Suspend the BioRID impact probe so the longitudinal centerline of the probe is parallel +/- 0.5 degrees to the flight of the probe.
- Attach the sled track assembly to the lift table so the linear guided rails are parallel to the longitudinal centerline of the probe.
- Attach the sled fixed weight package to the dummy mount on the sled.
- Mount the impact probe accelerometer.
- Mount an accelerometer to the sled so its sensitive axis is parallel to the longitudinal centerline of the test probe.

- With the impact probe free hanging, align the probe centerline to the alignment hole on the face of the impact sled as shown in Figure 1.
- Attach Energy Transfer Device (ETD) to sled face.
- Attach the BioRID impact probe face to the BioRID impact probe.
- While the impact probe is free hanging, slide the sled toward the impact probe until the ETD is just touching the impact probe face.
- Ensure the sled has at least 711 mm of unrestricted travel.
- Figure 2 illustrates the typical sled and track certification setup.

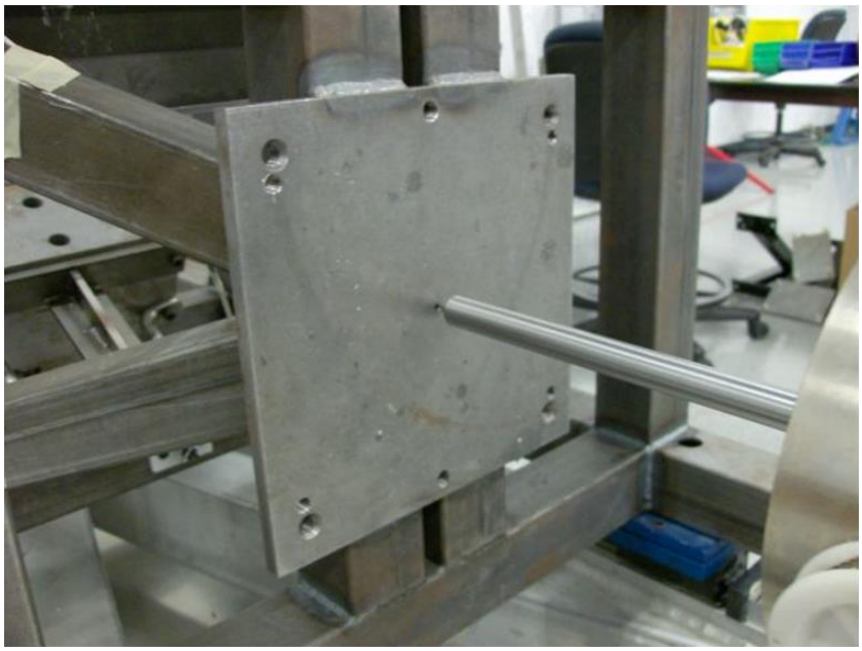


Figure 1: Impact Probe Alignment

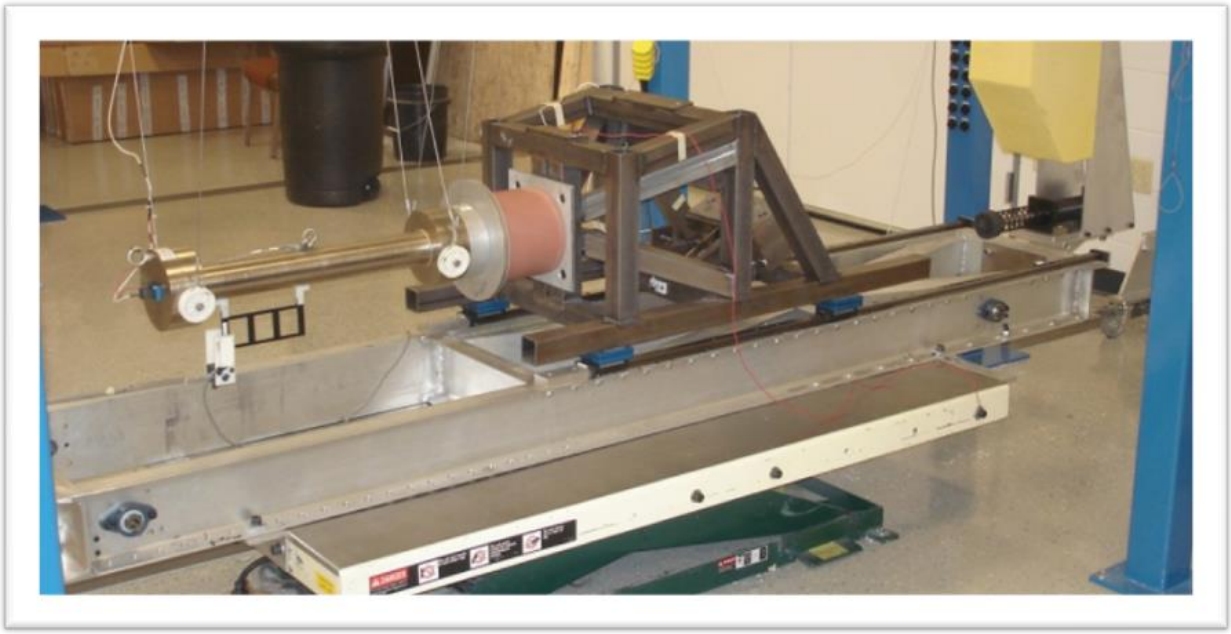


Figure 2: BioRID Sled and Track Certification

BioRID Sled and Track Certification without Headrest Test Procedure

- Soak the test dummy in a controlled environment at any temperature between 19.0°C – 25.0°C and a relative humidity between 10 and 70 percent for a period of time no less than 4 hours prior to testing.
- The data acquisition system should conform to SAE Recommended Practice J211.
- Release the test probe so that it achieves a velocity between 4.7 m/s to 4.8 m/s.
- At instance of contact, the probe should be level within +/- 0.5 degrees and within 2mm of the impact point.
- Filter data channels as defined in the BioRID data processing section of this manual.
- Calculate time zero (t_0) according to step 3 of the part compression calculation in the BioRID data procession section of this manual
- Remove the channel bias according step 4 of the part compression calculation in the BioRID data procession section of this manual
- Calculate the following according to the BioRID data processing section of this manual.
    - Impact probe force
    - Sled velocity is to be calculated according to step 12 of part compression calculation.
- Wait at least 30 minutes between successive impacts on the same ETD.

BioRID Sled and Track Certification without Headrest Performance Specifications

- When the ETD is impacted, the peak impactor probe force shall not be less than 8600 N and no more than 9800 N.
- The peak sled acceleration shall not be less than 118 m/s^2 and not more than 136 m/s^2.
- The peak sled velocity shall not be less than 2.65 m/s and not more than 2.95 m/s.
- The sled velocity decay between 50 ms and 150 ms shall not decay more than -1.5 (m/s)/s.
- The BioRID sled and track certification should be completed prior to performing the BioRID jacket certification, BioRID pelvis bottom certification and/or dummy certification without headrest tests.

BioRID Jacket Certification Procedures

Note: Jacket certification ensures a consistent torso flesh material stiffness amongst jackets.

Required Test Equipment

- Impact Probe Accelerometer (Endevco 7231-750 or Equivalent)
- Sled Accelerometer (Endevco 7264C-2000 or Equivalent)
- BioRID Jacket Impact Probe
- BioRID Sled Track Assembly (without weight package)
- Velocity Measurement
- BioRID Jacket Core Assembly

Pretest Preparation

- Remove the BioRID jacket from the dummy (jacket is to be filled with water).
- The BioRID jacket mass (including 15 torso attachment pins, arm pivot screws and water) is 21.87 kg +/- 0.26 kg.
- Suspend the BioRID jacket impact probe (specified in glossary) so the longitudinal centerline of the probe is parallel +/- 0.5 degrees to the flight of the probe.
- With the impact probe free hanging, align the probe centerline to the alignment hole on the face of the impact sled as shown in Figure 1 above.
- Mount the impact probe accelerometer.
- Mount the sled accelerometer to the sled so its sensitive axis is parallel to the longitudinal centerline of the test probe.
- Install jacket onto the jacket core for impact test.
- The BIORID jacket core assembly is shown in Figure 3.

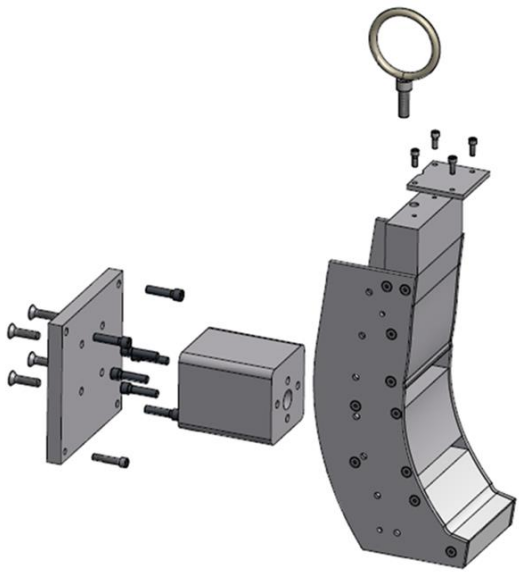


Figure 3: Jacket Core Assembly (TRA-340)

- Attach jacket and jacket core assembly to sled.
    - Jacket and core assembly is to be mounted upside down on the front of sled. The assembly can be seen in Figure 4 and Figure 5.
- With the impact probe free hanging, slide the sled toward the probe until the jacket is just touching the probe face.

NOTE: If jacket hits the track cross members when moving the sled, the attachment plate which holds the core is mounted upside down.

Figure 4: BioRID Jacket Sled Setup

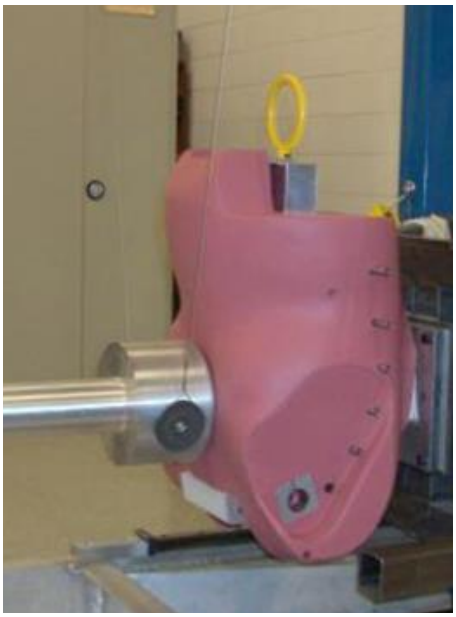


Figure 5: BioRID Jacket Test Setup

BioRID Jacket Certification Test Procedure

- Soak the test dummy in a controlled environment at any temperature between 19.0°C – 25.0°C and a relative humidity between 10 and 70 percent for a period of time no less than 4 hours prior to testing.
- The data acquisition system should conform to SAE Recommended Practice J211.
- Release the test probe so that it achieves a velocity between 1.50 – 1.55 m/s.
- At part contact, the probe should level within +/- 0.5 degrees and within 2mm of the impact point.
- Filter data channels as defined in the BioRID data processing section of this manual.
- Calculate time zero (t_0) according to step 3 of the part compression calculation in the BioRID data procession section of this manual
- Remove the channel bias according step 4 of the part compression calculation in the BioRID data procession section of this manual
- Calculate the following according to the BioRID data processing section of this manual.
    - Jacket compression
    - Impact probe force
    - Sled velocity is to be calculated according to step 12 of part compression calculation.
- Wait at least 30 minutes between successive impacts on the same BioRID jacket.
- Approximately 60 minutes should be allocated for completion of this test.

BioRID Jacket Performance Specifications

- When the anterior surface of the BioRID jacket is impacted the peak impact probe force shall not be less than 1110 N and not more than 1360 N.
- The peak sled velocity shall not be less than 0.378 m/s and not more than 0.422 m/s.
- The peak jacket compression shall be recorded and reported for data gathering purposes for possible future regulations.
- The BioRID jacket is to be certified annually.

BioRID Pelvis Bottom Certification

Note: The pelvis bottom certification ensures consistent material stiffness amongst pelvises.

Required Test Equipment

- Impact Probe Accelerometer (Endevco 7231-750 or Equivalent)
- Sled Accelerometer (Endevco 7264C-2000 or Equivalent)
- BioRID Jacket Impact Probe
- BioRID Sled Track Assembly (with weight package)
- Velocity Measurement
- BioRID Pelvis Bottom Fixture Assembly

Pretest Preparation

- Remove the BioRID pelvis assembly ARA-500 from the dummy. All components shown in Figure 6 are to be installed for this test.

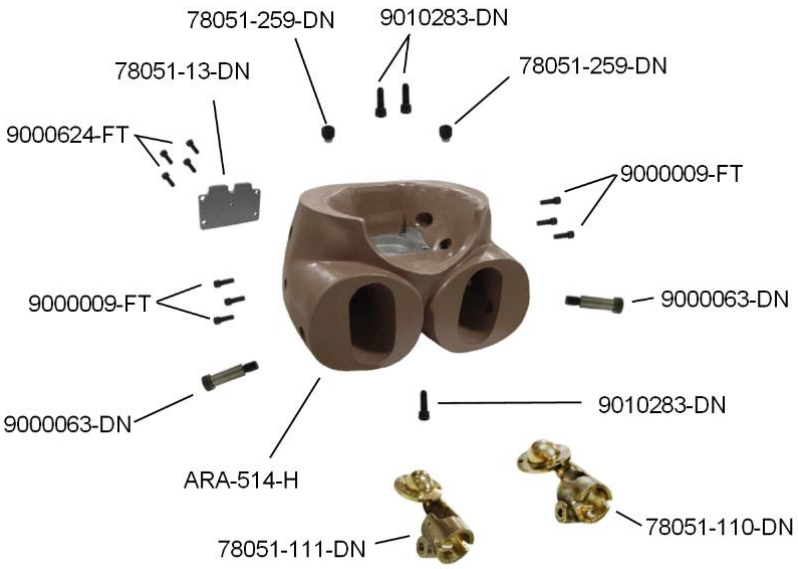


Figure 6: Pelvis Assembly Components

- Suspend the BioRID jacket impact probe (specified in the glossary) so the longitudinal centerline of the probe is parallel +/- 0.5 degrees to the flight of the probe.
- With the impact probe free hanging, align the probe centerline to the alignment hole on the face of the impact sled as shown in *Figure 1*.
- Mount the impact probe accelerometer.
- Mount the sled accelerometer to the sled so its sensitive axis is parallel to the longitudinal centerline of the test probe.

- Attach pelvis to the pelvis bottom test fixture. Figure 7 and Figure 8 illustrates the pelvis bottom fixture assembly.

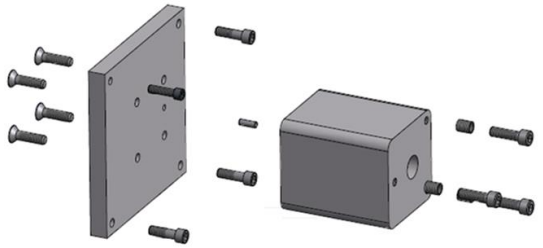


Figure 7: Pelvis Bottom Fixture Assembly (TRA-370)

Figure 8: Pelvis Bottom Test Setup

- Attach entire pelvis assembly sled.

- With the probe free hanging, slide the sled toward the probe until the pelvis bottom is just touching the probe face. Figure 9 illustrates a pelvis mounted on the front of the test sled.

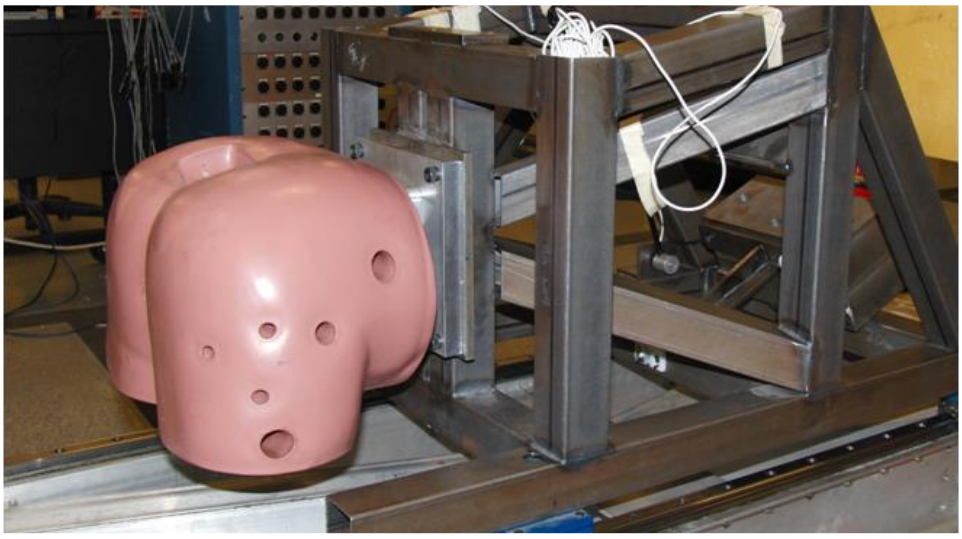


Figure 9: BioRID Pelvis Bottom Impact Test

BioRID Pelvis Bottom Certification Test Procedure

- Soak the test dummy in a controlled environment at any temperature between 19.0°C – 25.0°C and a relative humidity between 10 and 70 percent for a period of time no less than 4 hours prior to testing.
- The data acquisition system should conform to SAE Recommended Practice J211.
- Release the impact probe so that it achieves a velocity between 1.50 – 1.55 m/s.
- At part contact, the impact probe should be level within +/- 0.5 degrees and within 2mm of the impact point.
- Filter data channels as defined in the BioRID data processing section of this manual.
- Calculate time zero (t_0) according to step 3 of the part compression calculation in the BioRID data procession section of this manual
- Remove the channel bias according step 4 of the part compression calculation in the BioRID data procession section of this manual
- Calculate the following according to the BioRID data processing section of this manual.
    - Pelvis compression
    - Impact probe force
    - Sled velocity is to be calculated according to step 12 of part compression calculation.
- Wait at least 30 minutes between successive impacts on the same BioRID pelvis.
- Approximately 60 minutes should be allocated for completion of this test.

BioRID Pelvis Bottom Performance Specifications

- When the BioRID pelvis is impacted on the bottom, the peak impact probe force shall not be less than 3250N and not more than 4620N.
- The peak sled velocity shall not be less than 0.325 m/s and not more than 0.375 m/s.
- The peak pelvis compression shall be recorded and reported for data gathering purposes for possible future regulations.
- The BioRID pelvis is to be certified annually.

BioRID Dummy Certification without Headrest

Note: The BioRID dummy certification ensures the performance of the dummy without using the headrest assembly.

Required Test Equipment

- BioRID Impact Probe
- BioRID Impact Probe Face
- Impact Probe Accelerometer
- BioRID Sled Track Assembly
- Sled Accelerometer
- Velocity Measurement
- Upper Spine (T1) Accelerometer
- Potentiometer Collets for Potentiometers
- Pot A – Neck Rotation at the Occipital Condyle
- Pot B – Neck Rotation at T1
- Pot C – Upper Spine Rotation at T1

- Pot D – Lower Spine Rotation at Sled
- Upper Neck Moment MY
- Digital Inclinometer or tilt sensors
- Head Leveling Tool or tilt sensor

Pretest Preparation

- Must pass BioRID sled and track certification prior to performing this test.
- BioRID jacket must have met BioRID jacket certification within the last year prior to performing this test.
- Check the dummy for any damage, loosen or missing screws, loosen or missing bumpers, etc.
- Remove the accelerometer block located at the C4 location. If not removed, the head might contact the block and produce inaccurate upper neck test results. The C4 mount should never be used in vehicle seat testing either!

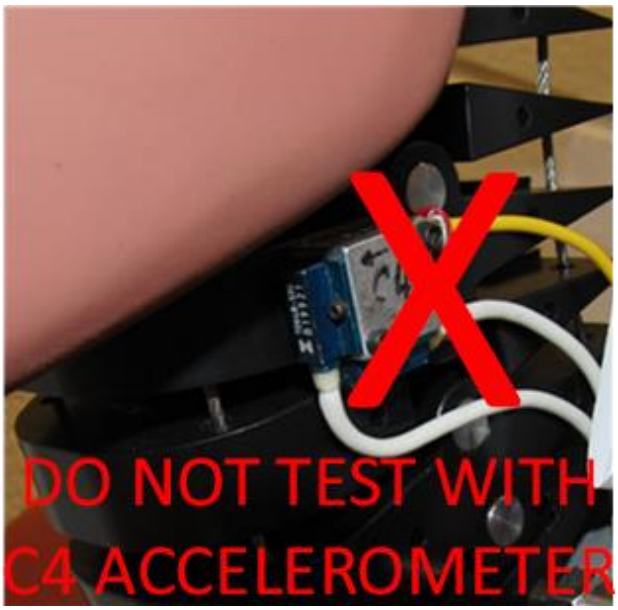


Figure 10: Remove C4 Accelerometer

- Attach the BioRID dummy (without lower torso and arms) to dummy mounting plate on the sled.
- Remove the head.
- Verify the lateral angle of the OC plate is less than +/-0.5 degrees. Use the machined sled track rail as a zero reference. Do not use the welded sled frame. Adjust dummy if necessary.
- Install upper neck load cell if not already in BioRID dummy.
- Reattach the head with the long OC pin in order to attach Pot A.
- Attach Pot A and Pot B to the dummy between T1 and the OC pin.
- Attach Pot C to opposite side of the T1 pin.
    - Tighten the nut against the potentiometer collects to keep them from rotating during the test.

- Install an “X” axis accelerometer to the T1 load cell shown in *Figure 11*.

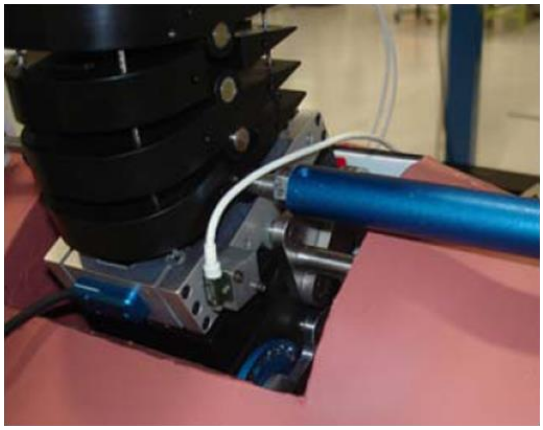


Figure 11: X Accelerometer at T1

- Suspend the BioRID impact probe so the longitudinal centerline of the probe is parallel +/- 0.5 degrees to the flight of the probe.
- Mount the impact probe accelerometer.
- Mount an accelerometer to the sled so its sensitive axis is parallel to the longitudinal centerline of the test probe.
- With the impact probe free hanging, align the probe centerline to the alignment hole on the face of the impact sled as shown in *Figure 1*.
- Attach the BioRID impact probe face to the BioRID impact probe.
- Attach the ETD to sled face.

- With the probe free hanging, slide the sled toward the probe until the ETD is just touching the probe face as shown in *Figure 12*.
- Level the head fore and aft to less than +/- 0.5 degrees in *Figure* 13.

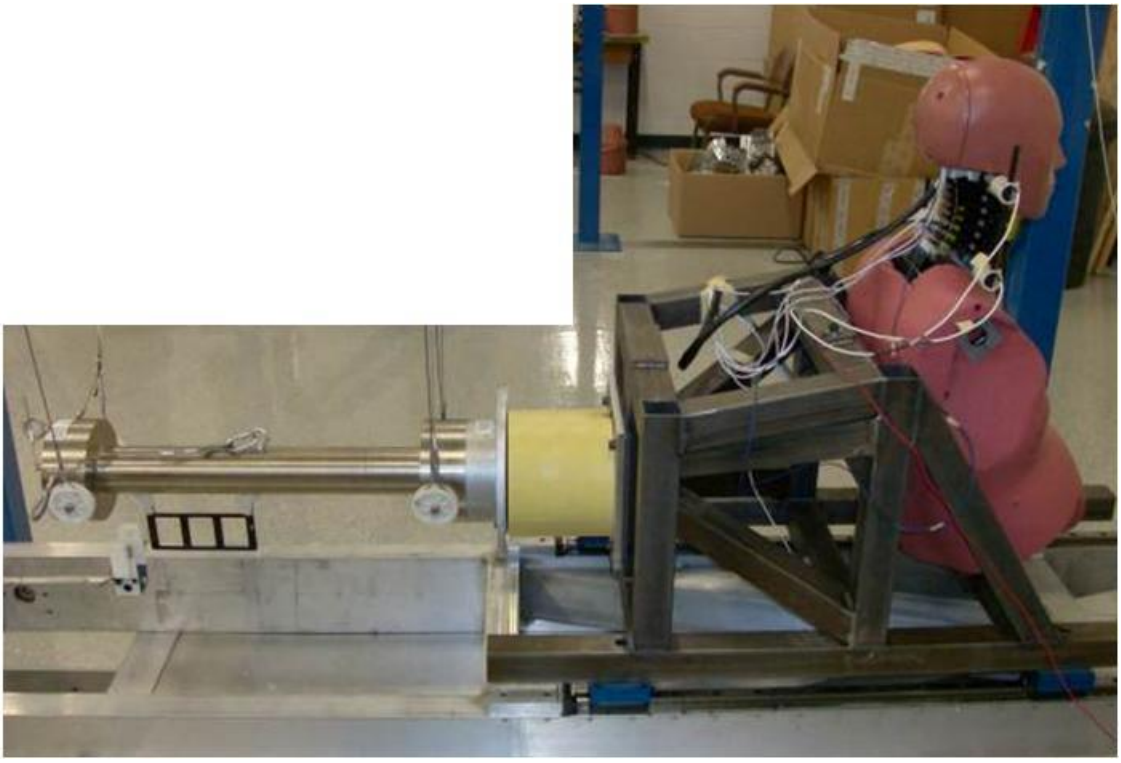


Figure 12: BioRID Dummy Certification without Headrest Test

Figure 13: Head Setup Angle

BioRID Dummy Certification without Headrest Test Procedures

- Soak the test dummy in a controlled environment at any temperature between 19.0°C and 25.0°C and a relative humidity between 10 and 70 percent for a period of time no less than 4 hours prior to testing.
- The data acquisition system should conform to SAE Recommended Practice J211.
- Release the test probe so that it achieves a velocity between 4.7 m/s to 4.8 m/s.
- At instance of contact, the probe should level within +/- 0.5 degrees and within 2mm of the impact point.

- Filter data channels as defined in the BioRID Data Processing section of this manual.
- Calculate time zero (t_0) according to step 3 of the part compression calculation in the BioRID data procession section of this manual
- Remove the channel bias according step 4 of the part compression calculation in the BioRID data procession section of this manual
- Calculate the following according to the BioRID data processing section of this manual.
    - Impact probe force
    - Sled velocity is to be calculated according to step 12 of part compression calculation.
- Wait at least 30 minutes between successive impacts on the same dummy.
- Approximately 60 minutes should be allocated for completion of this test.

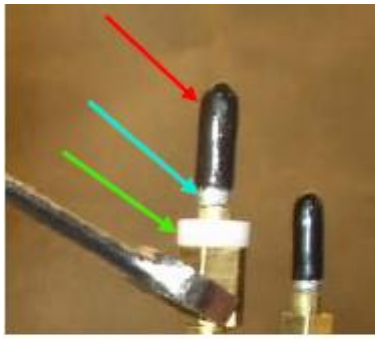
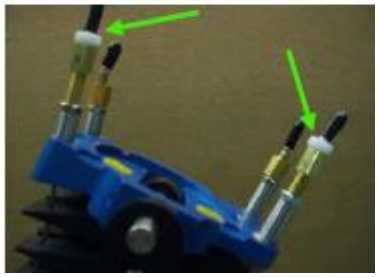
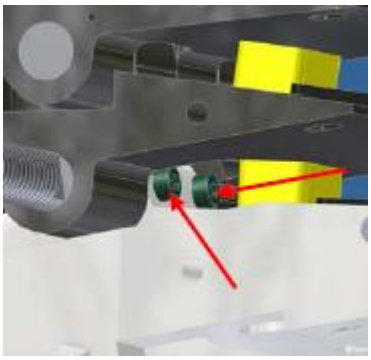
BioRID Dummy Certification without Headrest Performance Specifications

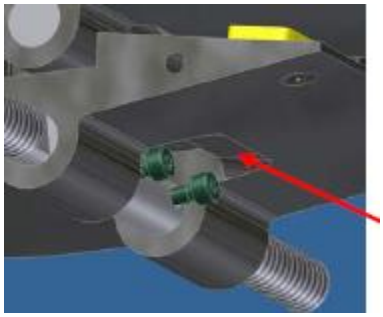
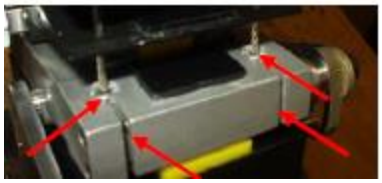
- When the ETD is impacted, the peak impactor force shall not be less than 8000 N and no more than 9700 N.
- The peak sled acceleration shall not be less than 137 m/s^2 and not more than 170 m/s^2.
- The first peak sled velocity shall not be less than 2.25 m/s and no more than 2.50 m/s between 20 ms and 30 ms.
- The sled velocity shall be no less than 2.1 m/s at 135 ms to 2.0 m/s at 140 ms and no more than 2.5 m/s at 135 ms to 2.4 m/s at 140 ms.
- The peak T1 X axis acceleration shall not be less than 183 m/s^2 and not more than 267 m/s^2 occurring between 18.5 ms and 30.50 ms.
- The peak head rotation about OC (Pot A) shall not be less than 10.1 degrees and not more than 15.1 degrees occurring between 25 ms and 70 ms.
- The peak head rotation must also be between 2 degrees and -9 degrees between 125 ms and 135 ms.
- The peak neck link rotation (Pot B) shall not be less than 4.00 degrees and no more than 6.5 degrees between 18.5 ms and 28.5 ms.
- The peak neck link rotation (Pot B) must also be no less than -30.0 degrees between 98 ms and 108 ms, no less than -29.0 degrees between 165 ms and 175 ms and at no time should the data be more than -36.0 degrees.
- The T1 rotation (Pot C) must be no less than -16.5 degrees between 73 ms and 78 ms and at no time be more than -19.0 degrees.
- The total head rotation shall not be less than -25.0 degrees between 100 ms and 110 ms and between 170 ms and 190 ms and shall not be more than -41.0 degrees between 100 ms and 190 ms.
- The total head rotation is the sum of head rotation (Pot A) and neck link rotation (Pot B)
- The total thoracic rotation shall not be less than -10.0 degrees between 125 ms and 135 ms and shall not be more than -21.0 degrees.
- The total thoracic rotation is the sum of T1 rotation (Pot C) and lower spine rotation (Pot D).
- The maximum upper neck moment My shall less than 17.8 Nm and more than 7.7 Nm between 20 ms and 35 ms.
- The minimum upper neck moment My shall less than -23.5 Nm and more than -15.0 Nm between 66.0 ms and 83.0 ms.

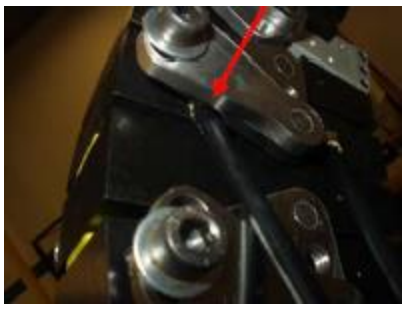
Appendix A- BioRID II Design Checklist

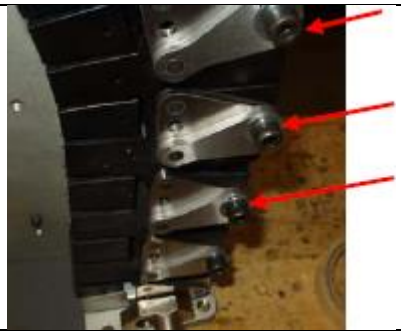
BioRID II Design Checklist		✓
	**VERIFY THE SKULL CAP IS FOR BIORID, AND THAT IT HAS THE CORRECT SIZE CABLE CLEARANCE SLOT.** **REFER TO GTR DWG # ARA-104, ARA-106**	
	**VERIFY SKULL AND CAP CONTAINS ERROR PROOFING PIN-HOLE COMBINATION.** **REFER TO GTR DWG # ARA-108, ARA-104, ARA 106**	
	**VERIFY THE CORRECT SIZE HOLES IN THE HEAD TO CLEAR THE FRONT CABLE ADJUSTERS (12.7 MM).** **REFER TO GTR DWG # ARA-104**	
	**VERIFY THE CORRECT HEAD IS INSTALLED (NON-SKULL CAP LOAD CELL VERSION).** **REFER TO GTR DWG # ARA-103**	

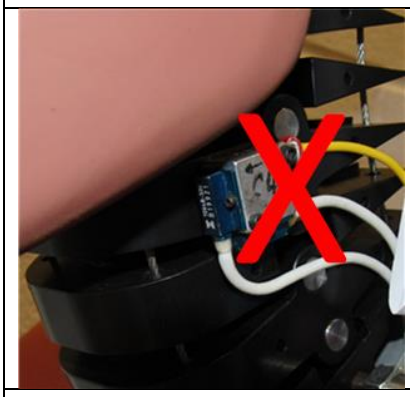
BioRID II Design Checklist		✓
	**VERIFY THE HEAD SKIN IS CUT OUT UNDER THE CHIN (NOT A H-III50M HEAD SKIN).** **REFER TO GTR DWG # ARA-108 G11**	
	**VERIFY THAT THE OC PLATE HAS CLEARANCE FOR INSTRUMENTATION CABLES.** **REFER TO GTR DWG # ARA-100 J6,G2**	
	**VERIFY THE PRESENCE OF OC PIN SET SCREWS.** **REFER TO GTR DWG # ARA-100 J6,G2**	
	**VERIFY HEAD SKIN IS TRIMMED TO AVOID MECHANICAL LOAD PATH AROUND UPPER NECK LOAD CELL.**	

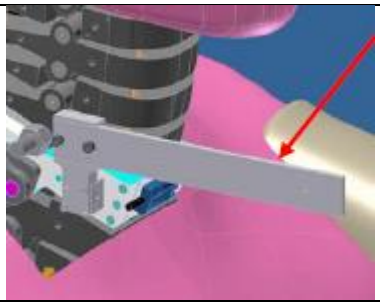
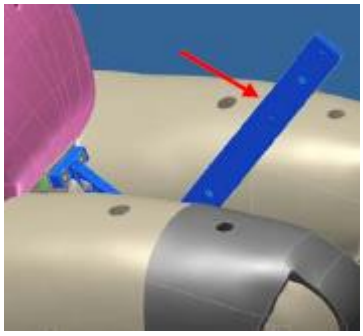
BioRID II Design Checklist		✓
 	**VERIFY THAT PLASTIC CAPS AND ALUMINUM CRIMPS ARE STILL IN PLACE ON TOP OF ALL FOUR CABLES ABOVE THE ADJUSTERS IN THE HEAD, AND THAT BOTH DELRIN SLEEVES ARE IN PLACE ON BOTH MUSCLE SUBSTITUTE CABLE ADJUSTERS.** **REFER TO GTR DWG # ARA-200 B5** **PADI SECTION 10.1.1**	
	**VERIFY PROPER OC PLATE IS INSTALLED. THE THICKNESS SHOULD BE 17.6 MM. IF IS LESS THAN 17 MM, IT SHOULD BE REPLACED.** **REFER TO GTR DWG # ARA-100**	
	**VERIFY THAT PRESENCE OF THE M2.5 SHCS THAT LOCK THE T1 PIN IN PLACE, AND THAT THEY ARE TIGHT.** **REFER TO GTR DWG # ARA-200 C8**	

BioRID II Design Checklist		✓
	**VERIFY THAT BOTTOM OF C7 VERTABRA HAS CLEARANCE FOR T1 LOCKING SCREWS.** **REFER TO GTR DWG # ARA-200 C8, ARA-208 F5, J5**	
 	**CHECK CERVICAL VERTABRAE DIMENSIONAL THICKNESSES FRONT (15.3 +/- 0.25mm) AND BACK (1.2 +/- 0.25mm) AND VERIFY WITH DRAWINGS** **REFER TO GTR DWG # ARA-201 J5** **REFER TO GTR DWG # ARA-203 J2, J6** **REFER TO GTR DWG # ARA-206 J2, J6** **REFER TO GTR DWG # ARA-207 J2, J6** **REFER TO GTR DWG # ARA-208 J2, J6**	
 	**VERIFY T1 LOAD CELL OR STRUCTURAL REPLACEMENT DESIGN WITH REMOVABLE BUSHINGS AND SLOTS TO ALLOW REMOVAL WITHOUT CUTTING CABLES** **REFER TO GTR DWG # ARA-301 GLOBAL, AND** **PADI SECTION 5.2.3**	
	**VERIFY USE OF STAINLESS STEEL NECK PINS (WILL NOT RUST)** **REFER TO GTR DWG # ARA-209, ARA-212 GLOBAL**	

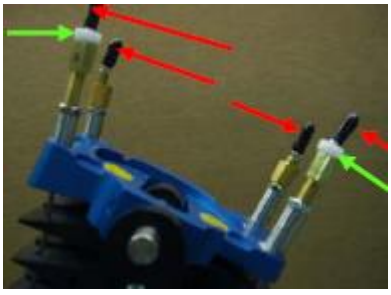
BioRID II Design Checklist		✓
	**CHECK CERVICAL VERTEBRAE HOLES WITH GAUGE PINS: 8.0000 +.0010/-.0000 mm DIA. SHOULD GO IN USING LIGHT SINGLE FINGER FORCE. 8.0300 + .0010/-.0000 mm DIA. SHOULD NOT GO IN USING LIGHT SINGLE FINGER FORCE.** REFER TO GTR DWG # ARA-201 H5 REFER TO GTR DWG # ARA-203 H5 REFER TO GTR DWG # ARA-206 H5 REFER TO GTR DWG # ARA-207 H5 REFER TO GTR DWG # ARA-208 H3	
	**VERIFY DAMPER (ARA-375) IS INSTALLED, IDENTIFIED BY PRESENCE OF CLAMPING BLOCK** REFER TO GTR DWG # ARA-375 GLOBAL, REFER TO GTR DWG # ARA-377 GLOBAL	
	**VERIFY PRESENCE OF LOCK WASHER UNDER THE M8 DAMPER ATTACHMENT SCREW.** REFER TO GTR DWG # ARA-375 A3	
	**VERIFY PRESENCE OF SLOT IN T3 TORSION PLATE FOR MUSCLE SUBSTITUTE CABLE SHEATH CLEARANCE.** REFER TO GTR DWG # ARA-319 A2 REFER TO GTR DWG # ARA-200 D3	

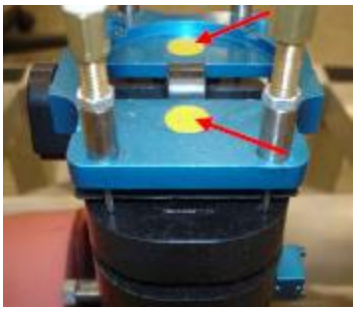
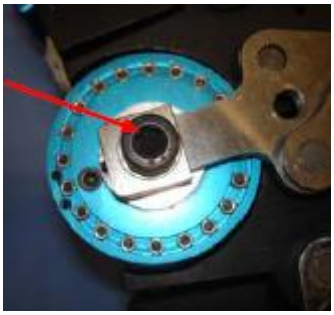
BioRID II Design Checklist		✓
	**VERIFY THE DAMPER CABLE GUIDE WHEEL IS THE CORRECT SIZE/DESIGN/REVISION.** **REFER TO GTR DWG # ARA-343 GLOBAL**	
	**VERIFY THE TORSION PLATE FASTENERS ARE SHCS WITH WASHERS INSTEAD OF BHCS.** **REFER TO GTR DWG # ARA-200 GLOBAL, AND PADI SECTION 5.2.4**	
 	**VERIFY THAT THE S1 SCREW INCLUDES THE TENSION WASHER AND THAT THE SCREW IS TORQUED TO THE PROPER SPECIFICATION.** **REFER TO GTR DWG # ARA-200 J15, AND PADI SECTION 5.2.4**	
	**VERIFY THE NEW DESIGN H POINT LOCATORS ARE INSTALLED** **REFER TO GTR DWG # ARA-933 GLOBAL** **REFER TO GTR DWG # ARA-934 GLOBAL** **REFER TO GTR DWG # ARA-200 J15**	

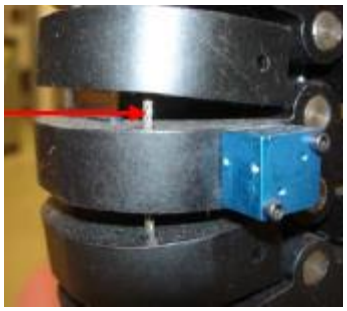
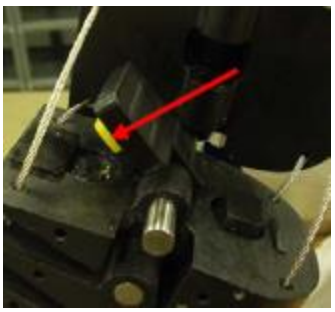
BioRID II Design Checklist		✓
	**VERIFY S1 IS PRESENT, WHICH USES A LUMBAR LOAD CELL OR STRUCTURAL REPLACEMENT TO IMPROVE DURABILITY AND INTERCHANGABILITY.** **REFER TO GTR DWG # ARA-562 GLOBAL,** **REFER TO GTR DWG # ARA-564 GLOBAL** **REFER TO GTR DWG # ARA-200 K10, AND** **PADI SECTION 5.2.4**	
	**Remove C4 Accelerometer and mount. This will cause a load path around upper neck load cell and produce erroneous results.**	
	**SETUP SPINE BY CAREFULLY FOLLOWING THE SETUP PROCEDURE.** **REFER TO PADI SECTION 10.2.5**	
	**VERIFY CORRECT JACKET VERSION (ARMS WILL HANG STRAIGHT DOWN).** **REFER TO GTR DWG # ARA-395 GLOBAL** **REFER TO GTR DWG # ARA-002 GLOBAL**	

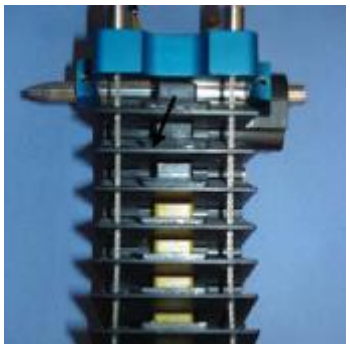
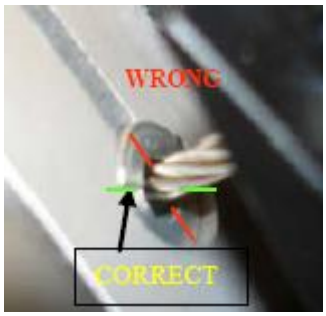
BioRID II Design Checklist		✓
	**VERIFY USE OF NEW T1 ANGLE INDICATOR ATTACHED TO ACCEL. MOUNT LOCATION** **REFER TO GTR DWG # ARA-930 GLOBAL**	
	**VERIFY USE OF NEW PELVIS ANGLE INDICATOR UPDATED TO CLEAR BELT** **REFER TO GTR DWG # ARA-915 GLOBAL**	

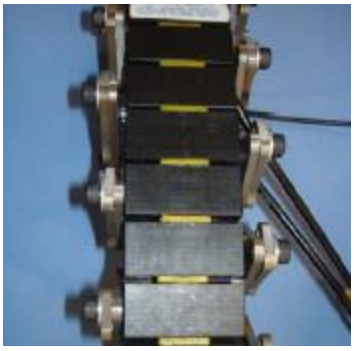
Appendix B- BioRID II Maintenance Checklist

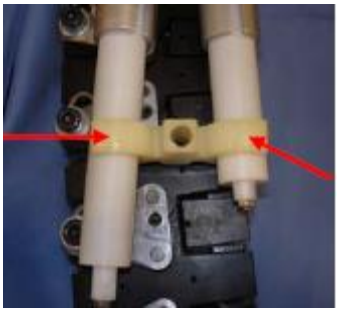
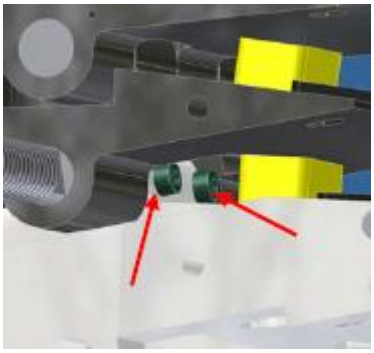
BioRID II Maintenance Checklist		✓
	**VERIFY THE SKULL CAP IS FOR BIORID, AND THAT IT HAS THE CORRECT SIZE CABLE CLEARANCE SLOT.** **REFER TO GTR DWG # ARA-104, ARA-106**	
	**VERIFY THE HEAD SKIN IS CUT OUT UNDER THE CHIN, UNLIKE THE HIII 50TH HEAD SKIN.** **REFER TO GTR DWG # ARA-103 GLOBAL**	
	**VERIFY THE HEAD MASS ASSEMBLY WITH ACCELEROMETERS IS 4.540 +/- 0.045KB (10.000+/- 0.10LB)**	
	**VERIFY THAT PLASTIC CAPS ARE STILL IN PLACE ON TOP OF ALL FOUR CABLES ABOVE THE ADJUSTERS IN THE HEAD, AND THAT BOTH DELRIN SLEEVES ARE IN PLACE ON BOTH MUSCLE SUBSTITUTE CABLE ADJUSTERS.** **REFER TO GTR DWG # ARA-200 GLOBAL** **PADI SECTION 10.1.1**	

BioRID II Maintenance Checklist		✓
	**VERIFY THAT THE 4 LOCKNUTS ON THE O.C PLATE CABLE ADJUSTERS ARE TIGHT.** **REFER TO PADI SECTION 10.1.1**	
	**VERIFY THE PRESENCE AND GOOD CONDITION OF LOAD CELL/O.C. PLATE BUMPERS. IF THE YELLOW O.C BUMBERS ARE COMPRESSED THE HEAD WILL ROCK. VERIFY THAT THERE IS NO PLAY BETWEEN THE O.C PLATE AND THE HEAD WHEN THE PIN IS INSTALLED. REPLACE IF NECESSARY.** **REFER TO GTR DWG # ARA-105 GLOBAL**	
	**VERIFY THAT THE M8 DAMPER MOUNTING SCREW IS TIGHT AND TORQUED TO 5 ft/lbs** **REFER TO PADI SECTION 11.5**	
	**VERIFY THAT THE DAMPER CABLE IS SECURE IN THE SLOT OF THE DAMPER BODY AND THE TWO CLAMPING SCREWS ARE TIGHTENED** **REFER TO PADI SECTION 11.5**	

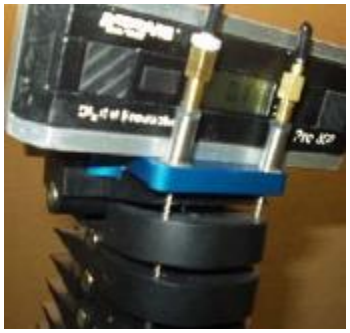
BioRID II Maintenance Checklist		✓
	**VERIFY THAT THE SERRATED LOCK WASHER IS UNDER THE M8 DAMPER ATTACHMENT SCREW** **REFER TO GTR DWG # ARA-375 A3** **PADI SECTION 11.5**	
	**VERIFY THAT THE DAMPER CLAMP TONGUE POSITIONED CORRECTLY IN THE SLOT** **REFER TO GTR DWG # ARA-375 GLOBAL** **PADI SECTION 11.5**	
	**VERIFY THAT THERE ARE NO KINKS, BENDS OR DAMAGE IN ANY OF THE CABLE ASSEMBLIES. AVOID TWISTING THE CABLES DURING THE DUMMY SETUP** **REFER TO PADI SECTION 10.1.1**	
	**FRONT NECK BUMPERS MUST BE REPLACED EVERY 12 MONTHS.** **REFER TO GTR DWG # TRA-086 GLOBAL** **REFER TO GTR DWG # TRA-087 GLOBAL** **REFER TO GTR DWG # TRA-088 GLOBAL** **PADI SECTION 11.1**	

BioRID II Maintenance Checklist		✓
	**VERIFY THE PRESENCE AND CORRECT POSITION OF ALL CERVICAL BUMPERS IN THE NECK ASSEMBLY. CHECK BOTH FRONT AND BACK.** **REFER TO GTR DWG # ARA-200 GLOBAL** **PADI SECTION 11.1**	
	**VERIFY THAT THE T1 CABLE BUSHINGS ARE NOT CLAMPED SO THAT SPLIT BETWEEN HALVES IS PARALLEL TO SIDES OF T1, OR CABLE CAN RIDE ON THE SPLIT RESULTING IN DRAG** **REFER TO GTR DWG # ARA-301 GLOBAL** **PADI SECTION 10.2.2**	
	**CHECK TO SEE IF THERE IS EXCESSIVE WEAR ON THE T1 CABLE BUSHINGS RESULTING IN AN OVAL APPEARANCE** **REFER TO PADI SECTION 10.2.2**	
	**VERIFY THAT THE SPLIT BUSHINGS ARE TIGHT IN THE REPLACABLE T1 LOAD CELL** **REFER TO PADI SECTION 10.2.2**	

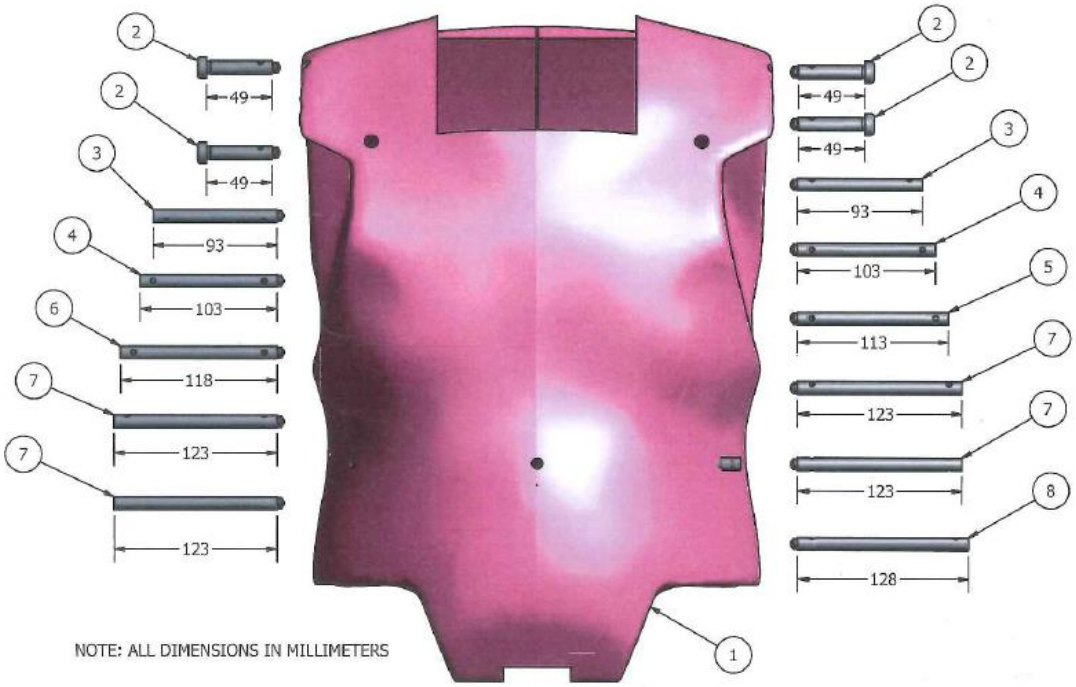
BioRID II Maintenance Checklist		✓
	**CHECK CERVICAL VERTEBRAE HOLES WITH GAUGE PINS: 8.0000 +.0010/-.0000 mm DIA. SHOULD GO IN USING LIGHT SINGLE FINGER FORCE.** **8.0300 + .0010/-.0000 mm DIA. SHOULD NOT GO IN USING LIGHT SINGLE FINGER FORCE.** **REFER TO GTR DWG # ARA-201 H5** **REFER TO GTR DWG # ARA-203 H5** **REFER TO GTR DWG # ARA-206 H5** **REFER TO GTR DWG # ARA-207 H5** **REFER TO GTR DWG # ARA-208 H3**	
	**VERIFY THAT ALL TORSION PLATE FASTENERS ARE TIGHT, BOTH SIDES OF THE DUMMY. INCLUDING THE LOWEST LUMBAR SCREW NOTED WITH AN ARROW.** **REFER TO GTR DWG # ARA-200 GLOBAL** **PADI SECTION 10.2**	
	**VERIFY THE PRESENCE AND CORRECT POSITION OF ALL BUMPERS IN THE THORACIC AND LUMBAR AREA. CHECK BOTH FRONT AND BACK OF SPINE.** **REFER TO GTR DWG # ARA-200 GLOBAL** **PADI SECTION 5.2.4.1**	
	**VERIFY THAT THE MUSCLE SUBSTITUTE CABLE FERRULES ARE GLUED INTO THE T3 VERTEBRA AND NOT LOOSE.** **REFER TO GTR DWG # ARA-200 GLOBAL** **PADI SECTION 5.2.2**	

BioRID II Maintenance Checklist		✓
	**VERIFY THAT THE SPRING HOUSING HOLDER DOES NOT RIDE UP OVER THE END OF THE ADJACENT SHCS.** **REFER TO PADI SECTION 5.2.2**	
	**CHECK TO SEE IF THE SPRING HOUSING COUPLING IS DEFORMED ALLOWING THE HOUSINGS TO SNAP OUT** **REFER TO PADI SECTION 5.2.2**	
	**VERIFY THAT THE M2.5 SHCS THAT LOCK THE T1 PIN IN PLACE ARE TIGHT.** **REFER TO GTR DWG # ARA-200 C8** **PADI SECTION 5.2.3.1**	
	**VERIFY THAT THE S1 SCREW INCLUDES THE TENSION WASHER AND IS TORQUED TO THE PROPER SPECIFICATION.** **REFER TO GTR DWG # ARA-200 J15** **PADI SECTION 5.2.4**	

BioRID II Maintenance Checklist		✓
	**VERIFY THAT THE 2 NUTS ON THE SPRING CABLE THREADED STUDS ARE INSTALLED AND TIGHT.** **REFER TO GTR DWG # ARA-200 GLOBAL** **PADI SECTION 10.1**	
 	**VERIFY THAT JACKET LUMBAR PLATE IS ENGAGED IN SLOT AT BOTTOM OF S1, AND THAT M6 SCREWS ARE TIGHT.** **REFER TO GTR DWG # ARA-002 GLOBAL** **PADI SECTION 5.2.1**	
	**SETUP SPINE BY CAREFULLY FOLLOWING THE SETUP PROCEDURE.** **REFER TO PADI SECTION 10.2.5**	

BioRID II Maintenance Checklist		✓
	**VERIFY THAT THE LATERAL TILT OF THE O.C. PLATE IS ADJUSTED TO ZERO +/- 0.2 DEGREES RELATIVE TO THE LUMBAR PLATE, WHEN ADJUSTING THE DAMPER CABLE TENSION. VERIFY THAT THIS ADJUSTMENT WAS THE FINAL CABLE ADJUSTMENT.** **REFER TO PADI SECTION 10.2**	
	**INSPECT THE JACKET FOR ANY TEARS. MINOR REPAIRS CAN BE ACCOMPLISHED WITH RTV. FOR MAJOR TEARS THE JACKET SHOULD BE REPLACED.** **REFER TO PADI SECTION Appendix B**	
	**VERIFY THE ABDOMEN CONTAINS THE CORRECT AMOUNT OF WATER, WHICH IS 2.06 LITRES (4.35 LB). WEIGHT OF JACKET, PINS, AND WATER SHOULD BE 21.87+/- .30 KG.** **REFER TO GTR DWG # ARA-395 GLOBAL** **PADI SECTION 8.1**	

BioRID II Maintenance Checklist ✓



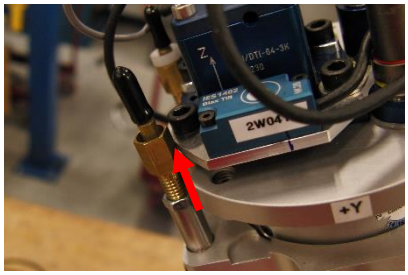
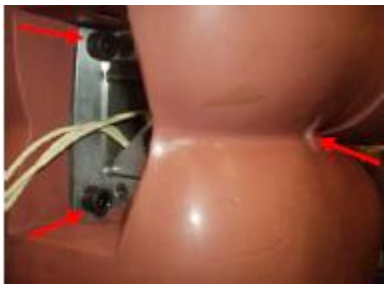
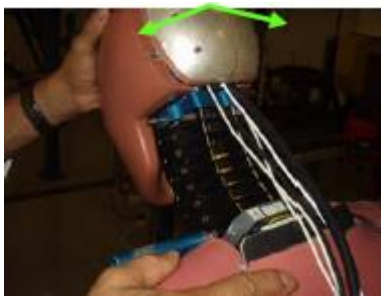
ITEM	QTY	PART NUMBER	DESCRIPTION
8	1	ARA-354-L8	SPINE, TORSO INTERFACE PIN ASSEMBLY
7	4	ARA-354-LR67	SPINE, TORSO INTERFACE PIN ASSEMBLY
6	6	ARA-354-R5	SPINE, TORSO INTERFACE PIN ASSEMBLY
5	1	ARA-354-L5	SPINE, TORSO INTERFACE PIN ASSEMBLY
4	2	ARA-354-LR4	SPINE, TORSO INTERFACE PIN ASSEMBLY
3	2	ARA-354-LR3	SPINE, TORSO INTERFACE PIN ASSEMBLY
2	4	ARA-354-LR12	SPINE, TORSO INTERFACE PIN ASSEMBLY
1	1	ARA-395	TORSO JACKET ASSEMBLY

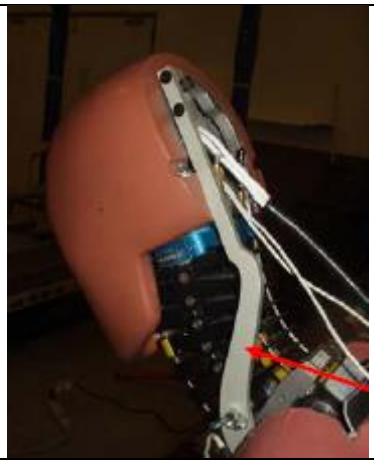
PARTS LIST

VERIFY THAT ALL TORSO INTERFACE PINS ARE INSTALLED IN THE CORRECT LOCATION
***Use care when inserting in order to not damage instrumentation cables.**
REFER TO GTR DWG # ARA-200 GLOBAL
PADI SECTION 5.2.4

VERIFY THE SCREWS AT THE BASE OF THE SPINE ARE TIGHTENED AFTER REINSTALLING JACKET ONTO THE SPINE.

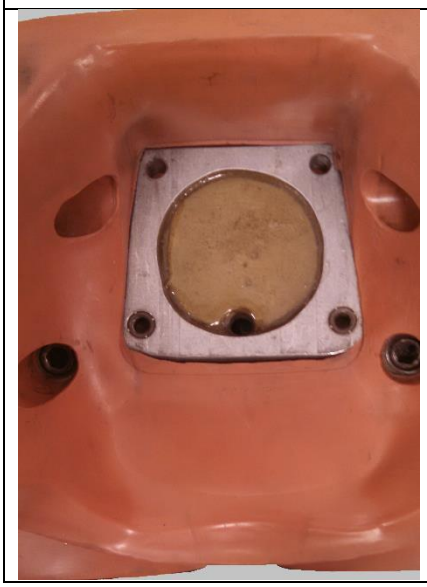
REFER TO GTR DWG # ARA-200 GLOBAL
AND PADI SECTION 5.2.4

BioRID II Maintenance Checklist		✓
	**PRIOR TO HEAD BEING INSTALLED, CHECK THE TILT SENSOR MOUNT TO ENSURE IT WILL NOT TOUCH THE CABLE ADJUSTER. THIS CAUSES A LOAD PATH AROUND THE LOAD CELL AND PRODUCES INCORRECT LOAD CELL READINGS DURING TEST. THE PICTURE TO THE LEFT SHOWS AN INCORRECT MOUNT WHICH IS TOUCHING THE CABLE ADJUSTER.**	
	**VERIFY THE SCREWS AT THE BASE OF THE SPINE ARE TIGHTENED AFTER REINSTALLING SPINE INTO THE PELVIS.** **REFER TO GTR DWG # ARA-002 GLOBAL**	
	**VERIFY THAT THERE IS NO LATERAL PLAY IN THE NECK.** **REFER TO PADI SECTION 10.2.4**	
	**VERIFY THE TEFLON PAD BEHIND THE DUMMY IS INSTALLED CORRECTLY AND IN THE CORRECT POSITION, WITH TEFLON AGAINST VERTEBRAE.** **REFER TO GTR DWG # ARA-002 GLOBAL** **PADI SECTION 5.2.1**	
	**VERIFY THAT THE SPINE ADJUSTMENT IS BALANCED SO THAT IT CAN HOLD THE HEAD AT +4 DEGREES AND –4 DEGREES ON THE CERTIFICATION SLED.**	

BioRID II Maintenance Checklist		✓
	**STORE THE DUMMY WITH THE PELVIS AN JACKET SUPPORTED IN A SLIGHTLY RECLINED POSITION** **REFER TO PADI SECTION 3.1**	
	**CHECK JACKET STIFFNESS ANNUALLY WITH DYNAMIC IMPACT TEST** **REFER TO BioRID Jacket Certification Procedures**	
	**VERIFY THAT THE NECK STABILIZING BRACKET IS BEING USED WHEN THE DUMMY IS NOT IN USE.** **REFER TO PADI SECTION 3.0**	

BioRID II Maintenance Checklist		✓
	**VERIFY THAT THE INSTRUMENTATION CABLE STRAIN RELIEFS HAVE LOOPS AS CALLED OUT IN THE PADI p.14** **REFER TO PADI SECTION 7.3**	
	**VERIFY THAT FEMUR PLUNGERS ARE SET TO 1-2 G.** **REFER TO PADI SECTION 9.1.2**	

BioRID II Maintenance Checklist		✓
	**VERIFY THAT ALL ARM AND LEG JOINTS ARE SET AT 1-2 G.** **REFER TO PADI SECTION 9.1.2**	

BioRID II Maintenance Checklist		✓
	**VERIFY THAT THE PELVIS FLESH IS NOT PULLING AWAY FROM THE FRONT OF THE BONE, IF THE FLESH IS PULLING AWAY, IT IS POSSIBLE FOR THE BONE TO ROTATE WITH IN THE FLESH. THE PELVIS IS IN THE PICTURE IS OF A NORMAL PELVIS.**	

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Certification Manual Update Log

Table 2: Certification Manual Update Log

Revision Level	Revision Date	Revision Author	Revision Description
A	25Apr2016	JDB	Updated corridors, format, and test procedures
B	9Sept2016	JDB	Certification and Maintenance Section, Appendix A and B added, Figure 9 added
C	10May2017	JDB	Clarified the part compression integration routines to match the laboratory software package calculations.
D	14Nov2017	JDB	Corrected error in pelvis mass found in Rev C and earlier
E	03Dec2019	JDB	Changed Pot A corridor to 10.1 – 15.1 degrees to match GTR recommendation Removed Part Compression corridors and changed to collect data for future regulations to match GTR recommendation Added probe 5% rule for 1/3 cable mass on Jacket Probe. Clarified and reworded the part compression calculation routines for better understanding Added clarification regarding when probe velocity is used in the integration equations Add steps in part compression for zeroing the calculations after each integration step Moved channel filtering to Data Processing Section in all tests