Q3s Engineering Drawing Changes
Rev. J

May 2016

National Highway Traffic Safety Administration
Washington DC

Table of Contents

1. Overview

Background. In September 2013, Humanetics Innovative Solutions (HIS) provided the National Highway Traffic Safety Administration (NHTSA) with the Q3s drawing package that was specified by the Notice of Proposed Rulemaking (NPRM), which was published in November 2013. From that time until January 2016, HIS made minor changes to the drawing package as they became aware of problems or inconsistencies, either through their production process, their own testing, their interaction with NHTSA, or their interactions with their own customers. The changes were incorporated piecemeal by HIS through several revisions to the Q3s drawing package.

In February 2016, HIS passed control of their Q3s engineering drawings to NHTSA. It is this set of drawings, which contain the piecemeal revisions discussed above, that are represented in the Q3s drawing package specified by the final rule. The revisions included all of those brought forth by HIS in their 2014 comments to the NPRM.

Contents of Drawing Package.

• *Manufactured parts and assemblies*. The drawing package contains 199 engineering drawings of manufactured parts and assemblies, of which 158 describe the Q3s itself and 41 are used to build equipment for qualification testing.

• *Purchased parts (mostly fasteners).* The drawing package contains about 50 purchased parts identified by part number and nomenclature only (not separate drawings), most of which are fasteners. Many of the parts are used in multiples, resulting in 231 total purchased parts.

• *Instrumentation and related parts.* There are 19 engineering drawings that depict instrumentation (IR-Traccs, load cells, angular rate sensors, etc.) and associated mounting plates.

Engineering Change Orders (ECOs). An ECO represents one or more design changes, and typically affects multiple parts and assemblies. There have been about 35 ECOs incorporated into the Q3s by HIS since the NPRM was published, and every drawing in the package has been revised in some way. The ECOs fall into one of the following three general categories, as discussed below.

2. Revisions to engineering drawings since the NPRM (November 2013).

2.1 Category 1. Improved specifications. The majority of the drawings have been revised only to improve part specifications, correct drawing errors, or provide missing information. These are valued-added revisions that either correct drawing errors or provide missing information. These revisions do not change the dummy in any meaningful way or alter the dummy's response in either pre-test qualification testing or dynamic sled testing with child restraint systems (CRSs). Rather, they have been made to improve the production and manufacture of future Q3s units. An older Q3s dummy is not affected by these revisions.

General improvements. Examples of general improvements to all engineering drawings include the following types of revisions:

• *Reformatted drawings.* All drawings were redrawn by HIS using their latest CAD package. This has resulted in a reformat of each drawing, even if it was just a font resize.

• *Errors and missing dimensional information.* Several drawings were changed to correct errors or add missing information. Examples include the use of a standard convention to specify hole locations and diameters in accordance with Geometric Dimensioning and Tolerance (GD&T) guidelines. Also, several drawings were revised to provide additional views (such as isometrics) to clearly show part dimensions and assemblies.

• *Fit and assembly.* Several drawings have revised dimensions that make existing parts fit better and assemble easier. Examples include slight changes on many dimensions, including overall dimensions, hole locations, and the addition of chamfers to parts. Many of these improvements were made due to instances where tolerance stack-up became evident during production. In some instances, "reference" dimensional call-outs have been instituted in sub-assembly drawings to avoid over-specification.

• *Manufacturing preferences.* Revisions have been made on some drawings to accommodate manufacturing material selections and material processes. An example is a change to the finish on the femur bone. Also, some revisions make the material call-outs on parts more general to give the dummy manufacturers more leeway on material selection in meeting qualification requirements. Examples include call-outs for rubber, vinyl, or urethane parts.

Specific revisions. There were a limited number of drawing improvements that were made for highly specific reasons, which merit further explanation.

• *Part numbering of lumbar spine molding*. This change was requested by HIS in their 2014 comments to the NPRM and have been subsequently incorporated into the drawings. The part number is shared with the lumbar spine found on the Q3 Frontal Impact 3-Year-Old dummy. The Q3s and Q3 Lumbar Spines are physically identical. However, each lumbar assembly must comply with its own set of qualification tests and requirements. To avoid confusion with users of both dummies, an "S" designation has been implemented to preclude users from using a Q3 lumbar spine on the Q3s. Three drawings are affected:

020-6000-S, Lumbar spine assembly, side impact
The "S" designation, denoting that it is a "side" lumbar, has been added to this drawing. This drawing is the main spine assembly drawing. The Q3s top-level assembly drawing refers to it.

020-6001-U, Lumbar spine (frontal or side, unspecified)
This is the drawing for the molded part, including specifications for the material and the overall dimensions of the part. This drawing is also used for the frontal version of the dummy.

020-6001-S, Lumbar spine, central molding, side impact. This part is made from 020-6001-U, and it includes an added part etching specification that denotes it to be a "side" lumbar. This is the part (and part number) that is inventoried by end-users.

• *IR-Tracc (part number SA572-S37*). The drawing now contains linearization information needed to calibrate the instrument correctly.

• *Neck and lumbar assemblies: torque specifications*. NHTSA made a change to a note that exists on the assembly drawings of the neck and lumbar spine. Note 1 has been changed as follows to be consistent with the PADI, which specifies 2 in-lbs of torque for the center cables in the neck (p. 21 in the PADI) and lumbar column (p. 103 in the PADI):

Neck assembly (part number 020-2400)
Was: 1.5 in-lbs;
Now: 2 in-lbs.

Spine assembly (part number 020-6000)
Was: Preload spine molding by 1/2 turn of nut.
Now: Preload spine molding to 2 in-lbs.

2.2 Category 2. New and revised parts. Revisions to actual parts are described below.

Neck assembly: revision to aid end-users. In the NPRM, the engineering drawings for the neck cable allowed interference to occur with the lower neck load cell during the assembly of the head and neck (see drawing 020-2415, cable length = 81.3 mm). In the case of the Calspan-owned unit, the cable extended 8.07 mm past the neck when torqued, but the load cell interface plate was only 7.90 mm thick. All components were within the drawing specifications, but since there was no assembled specification, interference occurred.

For the final rule, this situation has been corrected by shortening the cable and adding a new, special-purpose retaining nut that provides the necessary clearance. Additionally, drawings for a wrench designed to accept the specialized nut are also provided. This makes it easier to properly torque the nut on the center cable. Detailed assembly instructions to adjust the nut are provided in the PADI.

The neck cable assembly (part number 020-2415) of an older Q3s unit may be swapped out with a revised cable and new lock nut with no further changes to the dummy. We performed neck qualification tests with our own older units fitted with the revised cable and nut and confirmed that it did not affect the performance of the neck. See Appendix B for results and a full analysis.

In other words, this is a value-added revision that acts only to remove the unwanted affect. We note also that an owner of an older Q3s unit may still use an older, unrevised cable assembly as long as there is clearance between the retaining nut and the surface of the neck end plate.

Jam nuts for lumbar cable. A problem with worn NYLOC nuts was observed during the course of our testing after the NPRM was published. We observed that in the lumbar flexion tests, the first trial tended to register a lower moment than subsequent trials. This was consistent with all dummies at all labs. We then examined the wire cable that runs through the center of the rubber column, which was initially placed under tension by tightening a lock nut with a nylon insert prior to the first trial. But after the first trial, it was apparent that the nut did not stay in its set position and we found that it could be loosened by hand.

Furthermore, the tension on the cable governs the response of the lumbar column. We control this in the PADI by prescribing the torque for the nut on the center cable. But the torque on a nut with a nylon insert is partly depended on the condition of the nut itself. A newer nut can resist more torque without affecting the cable tension than a worn nut. In other words, the tension on the cable (and the lumbar moment) can vary depending on the condition of the nylon insert of the nut. To help alleviate this situation, we have replaced the nut with two jam nuts, i.e., two standard nuts twisted against each other.

2.3 Category 3. Corrections on parts described in NPRM. During the run-up to the NPRM, HIS revised many parts on the Q3s as the design progressed from a pre-production stage. A few of the revisions, however, were overlooked when HIS assembled the drawing package for the NPRM. In other words, some parts that existed on the NHTSA units used to develop the NPRM were not reflected accurately by the NPRM drawing package.

These parts, described below, were highlighted in HIS's 2014 comments to the NPRM. Thus, the drawings have been revised to reflect the physical parts. On newly purchased dummies, the parts themselves are unchanged from those used on the units used to develop the NPRM.

Shoulder assembly. The affected parts include the shoulder cup, the rod end adapter, and the wire rope. The shoulder cable has been altered (lengthened) to double up on the cable through the crimp. However, the whole cable assembly is encapsulated within the molded shoulder (i.e., the cable and crimps are molded over) so that this change is not easily detectable by an end-user (and thus not recognized by the PADI). We did not evaluate this change as it is essentially a better means to assemble the part, and does not affect the performance of the dummy.

Femur assembly (part numbers 020-9511, left, and 020-9511, right). The revised drawing reflects a change on the type of pin used to assemble the femur ball to the femur shaft. A coil pin (p/n 5000188) is used for this purpose. The NPRM drawings incorrectly reflect the use of a roll pin.

3. Changes to specifications for anthropometry and mass.

The main assembly drawing of the Q3s (drawing 020-0100) contains separate sheets that provide mass and anthropometry measurements and tolerances of various body segments. In the NPRM, these measurements were based on the four units owned by NHTSA and the recommendations of HIS.

For the final rule, the sheets have been updated to reflect measurements and tolerances derived from a larger pool of dummies. HIS has provided us with their anthropometry and mass measurements of thirteen Q3s units, including units purchased by MGA, Calspan, Britax, and the Medical College of Wisconsin (MCW).[1, 2] Two of NHTSA's units, S/N 004 and 007, were included among the thirteen.

All revisions are also closer to biofidelity targets. For example, the overall mass has been changed to 14.5 kg (from 14.233 kg), which matches the human target.

3.1 Revisions to dummy anthropometry specifications. When compared to the separate anthropometry specifications listed in the NPRM, only two of the twenty-eight measurements provided by HIS on the latest production Q3s units are outside the prescribed limits (shoulder height and the waist circumference). For all other measurements, the NPRM specifications are met. Nonetheless, we have adjusted many of the measurements in order to better reflect the full pool of ATDs. Each measurement is discussed below.

Unchanged measurements. The following measurements are unchanged from the NPRM specifications. They are very consistent with the larger pool of data and do not need to be changed.

Measurement	Ref.	NPRM, mm
Total Sitting Height	B	556 ± 10
Shoulder Elbow Length	E	186 ± 10
Head Back to Seat Back Line	G	35 ± 2.5
Spine Box to Seat Back Line	H	10 ± 2.5
Knee to Seat Back Line	I	305 ± 13
Chest Depth, Upper	K	151 ± 8
Hip Breadth Sitting	M	202 ± 8
Pelvis Height Above Seat	N	9.5 ± 2.5
Foot Length	O	147 ± 8
Head Width	Q	138 ± 5
Shoulder Width	T	247 ± 10
Head Reference Line	X	81
Chest Circumference Reference Location	Y	246
Waist Circumference Reference Location	Z	90
Heel Back to Back Line Standing	AA	29 ± 2.5
Head Reference Line Angle, Degrees	BB	27

[1] Q3s Certification Database.xls; Q3s Data Analysis – Corridor Review – Final.pdf, Humanetics Innovative Solutions Inc., submitted February 9, 2016. See www.Regulations.gov, Docket no. NHTSA-2013-0118, Document no. 0009.
[2] Tests performed by NHTSA on the MGA, Britax, and Calspan Q3s units were used to set the qualification requirements for the final rule. See "NHTSA's Q3s Qualification Testing, 2014-2015" in the docket folder for the final rule. The MCW unit was used by NHTSA to assess a revision to the neck cable as described in Appendix B herein.

Revised measurements. The following measurements have been changed slightly to be more consistent with the larger pool of data. In each case, the change also makes the nominal measurement closer to the human biofidelity target for a three year old.

Measurement	Ref.	NPRM, mm	Final rule, mm	Human target, mm
Stature	A	986 ± 15	984 ± 15	953
Thigh Clearance	D	86 ± 8	83 ± 8	84
Elbow to Fingertip Length	F	240 ± 10	245 ±10	254
Knee Height Seated	J	284 ± 13	281 ± 13	221
Abdominal Depth	L	173 ± 8	171± 8	155
Foot Width	P	62 ± 8	61 ± 8	59
Head Length	R	180 ± 5	178 ± 8	177
Waist Width Sitting	S	191 ± 8	186 ± 8	152
Head Circumference	U	502 ± 10	499 ±10	498

There are three cases where a change was made to better represent the larger pool of data, but resulted in a measurement further from the biofidelity target.

Measurement	Ref.	NPRM, mm	Final rule, mm	Human target, mm
Shoulder Height	C	340 ±10	347 ±10	334
Chest Circumference	V	523 ± 13	529 ± 13	505
Waist Circumference	W	521 ± 13	539 ± 15	480

For the shoulder height, the range of acceptable measurements in the NPRM was 330-350 mm (340 mm, nominal). When this range is applied to the larger pool of data provided by HIS all units are within range, though three measured 350 mm exactly. The average of all 13 units at HIS was 347 mm. The shoulder heights of our own units, measured by VRTC, were: 345 mm, 346 mm, and 348 mm. Thus, the NPRM nominal value of 340 mm is slightly low even relative to our own measurements. For the final rule, we have specified a nominal value of 347 mm, which is more representative of the larger pool of data.

For the chest circumference, the range of acceptable measurements in the NPRM was 510-536 mm (523 mm, nominal). When this range is applied to the larger pool of data provided by HIS, there was just one unit, serial no. DR5860 (the MGA unit), that was outside the range. According to HIS's measurements, this unit had a chest circumference of 537 mm (over by 1 mm). We note that the next lowest measurement at HIS was only 533 mm (two units).

The chest circumferences of our own units, measured by VRTC, were: 528 mm, 529 mm, and 535 mm. Thus, the NPRM nominal value of 523 mm is slightly low even relative to our own measurements. For the final rule, we have re-calibrated the target around the larger pool of data. The nominal target of 529 mm results in a "pass" in all units measured, including DR5860 measured at HIS and our own three units as measured by VRTC.

For the waist circumference, the range of acceptable measurements in the NPRM was 508-534 mm (521 mm, nominal). When this range is applied to the larger pool of measurements provided by HIS, nearly all dummies (10 of 13) would fail because they are too large (average waist circumference: 539 mm).

Though our own dummies, as measured by VRTC, were within the acceptable range (525 mm, 528 mm, 534 mm, for an average of 529 mm), they were also large relative to the nominal value of 521 mm.

For the final rule, we have recalibrated the nominal waist circumference around the larger pool of data. The nominal target of 539 mm results in a "pass" at all labs and all dummies. Though the larger target circumference is slightly further from the biofidelity target of 480 mm for humans, the change is needed to reflect the pool of available dummies.

For both the shoulder height and the waist circumference, the nominal values specified in the final rule are slightly further from the biofidelity targets (334 mm for the shoulder, 529 mm for the chest circumference). Nonetheless, the changes are warranted considering that no Q3s unit has a measurement less than the nominal values for both measurements, including those older NHTSA units that were used to develop the standard.

For the final rule, we have also slightly expanded the tolerance for acceptability (was: ±13 mm, now: ±15 mm). We note that added variability may exist in the way the measurement is taken at any given lab. On NHTSA's unit, serial no. 007, which was measured at both VRTC and HIS, all measurements were within 8 mm except the waist circumference which was off by 12 mm. Thus, the added tolerance is justified.

3.2 Revisions to dummy mass specifications.

The NPRM specified the mass for eight different body segments and the Q3s fitted suit. An overall mass for the assembled dummy was also specified. When compared against the mass measurements provided by HIS on thirteen Q3s units, the NPRM specifications for the masses of the head, lower arm, and upper arm were consistent with the larger pool of data.

The NPRM specifications for the masses of the upper torso and lower torso, however, would have resulted in "fails" on almost all units, including those measured by HIS and on our own units measured by VRTC. Several units also failed to meet the NPRM mass requirement for the lower leg. Accordingly, we have revised the mass specification for these three body segments to better represent the larger pool of data. The mass specifications for the neck, upper arm, and the total dummy mass have also been revised to better represent the larger pool of data (although all nominal targets would have "passed" the NPRM requirement). In all instances, the changes represent a shift that is closer to the biofidelity target.

The masses specified for the final rule result in a "pass" for all body segments at both VRTC and HIS for all dummies, with one exception. Serial no. 008 (measured at VRTC) had an upper torso with a mass of 2.446 kg, which was greater than 0.125 kg heavier than the next heaviest torso, and 0.15 kg heavier than the average of the entire pool of data. Thus, the torso mass of serial no. 008 (or perhaps only the measurement itself) appears to be an outlier and remains outside the limits of acceptability for the final rule. Including it within the limits of acceptability would require that we specify unreasonably wide mass tolerances.

Revised mass measurements. All revisions are closer to biofidelity targets, closer to the averages of the larger pool of HIS data, and even closer to the averages of the three Q3s units measured at VRTC. Those that aren't changed are very consistent with the larger pool of data.

Body segment	NPRM, kg	Final rule, kg	Human target, kg
Head	2.810 ± 0.100	no change	3.05
Neck	0.318 ± 0.025	0.334 ± 0.025	0.40
Upper Torso	2.051 ± 0.100	2.289 ± 0.100	6.61 (upper and lower
Lower Torso	3.725 ± 0.100	3.847 ± 0.100	torso combined)
Upper Arm	0.330 ± 0.025	0.324 ± 0.025	1.82 (upper and lower
Lower Arm	0.376 ± 0.025	no change	arms combined)
Upper Leg	1.000 ± 0.500	1.000 ± 0.050	2.62 (upper and lower
Lower Leg	0.775 ± 0.025	0.769 ± 0.025	legs combined)
Suit	0.400 ± 0.158	0.333 ± 0.150	n/a
Entire dummy	14.266 ± 1.575	14.5 ± 0.75	14.5

4. Revisions to procedures for assembly, disassembly, and inspection (PADI)

Neck Assembly. Section 5.3, Neck, has been updated to reflect the installation of a protective cap over a revised lock nut for the neck center cable. This change is discussed above. Also, the version of the PADI in the NPRM depicted an outdated version of the neck center cable. Pictures and illustrations of this part have been updated in accordance with drawing 202-2415, Tension cable assembly, which shows a round fitting attached to the cable. Prior to the NPRM, an older version of the dummy had used a square fitting, and we mistakenly depicted the square fitting in the PADI.

Jam Nuts for Lumbar Cable. Section 5.7.3, Lower Torso Assembly and Installation, has been updated to reflect installation of jam nuts in lieu of the NYLOC nut. A problem with worn NYLOC nuts was described in Section 2, Revisions to the Engineering Drawings, Subsection 2.2 Category 2, New and revised parts. The revision to the PADI describes the installation of the new jam nuts and the prescribed torque settings.

New part numbers for several fasteners. Several engineering drawings have been revised to reflect new part numbers for fasteners. Correspondingly, we have revised table listings throughout the PADI to reflect the new part numbers. In most cases, only the part number has changed, not the part itself, so corresponding changes to pictures and descriptions were not necessary. There were, however, a limited number of new parts, such as the new lock nut and snap cap on the neck center cable, that have been added to the PADI with new pictures.

Revised external dimensions and segment masses. Table 25, "Q3s External Dimensions" and Table 26, "Q3s Total and Segment Masses" have been revised to match the revised measurements shown above in Sections 3.1.and 3.2.

Appendix A.
Q3s drawing revisions, Rev. J.

Table A1. Q3s drawing revisions, Rev. J.

Part Number	NPRM Rev. D	Final Rule Rev. J	Description	Nature of revision
Cover Page	---	---	Q3S THREE YEAR OLD CHILD TEST DUMMY	New date: was Sept. 2013, now May 2016
020-0100	D	J	Q3S CHILD SIDE IMPACT DUMMY	Improved specification - reflects all revisions
020-1200	C	E	Q3S HEAD ASSEMBLY	Improved specification - added dimple
020-1220	D	F	FRONT SKULL ASSEMBLY, Q3S	Improved specification - added dimple, vinyl spec, mold dims
020-1222	B	E	SKULL FRONT, Q3S	Improved specification
020-1006	H	K	INNER BRACKET, HEAD	Improved specification
020-1007	C	D	FRONT PLATE (HEAD BRACKET)	Improved specification
020-1008	E	F	LOWER PLATE (HEAD BRACKET)	Improved specification
020-1025	B	D	REAR SKULL CAP ASSEMBLY	Improved specification
020-1023	n/a	C	REAR SKULL CAP SKIN	Improved specification - new drawing
020-1013A	A	C	INSTRUMENTATION BRACKET ASSEMBLY	Improved specification
020-1013	D	F	ACCELEROMETER MOUNTING BRACKET ASSEMBLY	Improved specification
020-2007	F	H	LOAD CELL STRUCTURAL REPLACEMENT	Improved specification
020-2400	H	L	NECK ASSEMBLY, Q3S	Neck cable revision - new and revised parts, preload spec
020-2401	H	L	MOLDED NECK, Q3S	Improved specification
020-2402	F	J	NECK PLATE, TOP, Q3S	Improved specification
020-2416	A	C	KEENSERT, MS MODIFIED (.25")	Improved specification
020-2404	F	H	NECK PLATE, BOTTOM, Q3S	Improved specification
020-2403	E	F	NECK PLATE, MIDDLE, Q3S	Improved specification
020-2415	A	F	TENSION CABLE ASSEMBLY, Q3S	Neck cable revision - part shortened by 5 mm
020-2411	A	C	ROUND FITTING - TENSION CABLE, Q3S	Improved specification
020-2413	A	C	THREADED FITTING, TENSION CABLE, Q3S	Neck cable revision - no shoulder
020-2417	A	G	TENSION CABLE ELEMENT, Q3S	Neck cable revision - part shortened by 4 mm
020-2421	n/a	D	CABLE ADJUST NUT	Neck cable revision - new part
020-2426	n/a	D	CABLE LOCK NUT	Neck cable revision - new part
020-2423	n/a	E	PROTECTIVE SNAP CAP	Neck cable revision - new part
020-2409	F	n/a	CABLE LOCK NUT, Q3S	Neck cable revision - replaced part
020-2418	A	n/a	ELEMENT SPACER, Q3S	Neck cable revision - replaced part
020-4500	E	F	UPPER TORSO ASSEMBLY, Q3S	Improved specification - updated hardware spec
020-4001	Q	U	THORACIC SPINE	Improved specification
020-2017	B	E	NECK/TORSO INTERFACE PLATE, Q3S	Improved specification
020-4018	C	E	RIB CAGE ASSEMBLY, Q3S, TESTED/CERTIFIED	Improved specification
020-4017	C	F	RIB CAGE MOLDING, Q3S	Improved specification
020-4014	C	D	RIB CAGE SKIN, Q3S	Improved specification
020-4505	B	D	BRACKET 1, IRTRACC	Improved specification
020-4502	A	D	BRACKET 2, IRTRACC	Improved specification
020-4507	A	C	CONE SPACER	Improved specification
020-4508	A	D	ROD END MOUNT, BASE END	Improved specification
020-4511	A	D	ROD END ADAPTER	Shoulder revision - part 0.1 mm longer
020-4506	A	C	SHOULDER SCREW, (#4-40 1/8X1/2), MODIFIED	Improved specification
020-3510	B	E	MOLDED SHOULDER ASSY, LEFT	Shoulder revision - new part (crimp)

Table A1. Q3s drawing revisions, Rev. J, cont.

Part Number	NPRM Rev. D	Final Rule Rev. J	Description	Nature of revision
020-3511	B	E	SHOULDER SPINE INTERFACE PLATE, LH	Improved specification
020-3512	A	E	SHOULDER STERNUM INTERFACE PLATE, LH	Improved specification
020-3513	A	D	SHOULDER ARM INTERFACE PLATE	Improved specification
020-3514	A	D	BAR, SHOULDER	Improved specification
020-3515	B	D	WIRE ROPE, CUT, Q3S SHOULDER	Shoulder revision - rope is 157 mm longer
020-3516	n/a	B	OVAL SLEEVE, MODIFIED	Shoulder revision - new part
020-3520	B	D	MOLDED SHOULDER ASSY, RIGHT	Shoulder revision - new parts shown
020-3521	B	E	SHOULDER SPINE INTERFACE PLATE, RH	Improved specification
020-3522	A	E	SHOULDER STERNUM INTERFACE PLATE, RH	Improved specification
020-4515	A	C	ACCELEROMETER ADAPTOR ASSEMBLY	Improved specification
020-4509	A	D	ACCELEROMETER ADAPTOR	Improved specification
020-3535	B	E	Q3S SHOULDER CUP, RIGHT	Improved specification - radius to reduce tearing
020-3534	B	E	Q3S SHOULDER CUP, LEFT	Improved specification - radius to reduce tearing
020-3536	A	D	SHAFT, SHOULDER	Improved specification
020-3537	D	G	BALL, SHOULDER	Improved specification - change AL 2017 to AL 7075-T6
020-3533	E	G	Q3S SHOULDER BALL RETAINING RING	Improved specification
020-4412	A	D	CABLE GUIDE	Improved specification - ref dimensions
020-4503	C	F	BRACKET, IRTRACC	Improved specification
020-3539	B	D	BRACKET ASSY, SHOULDER STRING POT	Improved specification
020-3549	A	F	RETAINER, POT STRING	Improved specification
020-4000	A	D	LOWER TORSO ASSEMBLY, Q3S	Improved specification - add missing abdomen flesh
020-6000	D	n/a	LUMBAR SPINE ASSEMBLY, TESTED AND CERTIFIED	Replaced with 202-6000-S
020-6001	E	n/a	LUMBAR SPINE, CENTRAL MOLDING	Replaced with 202-6001-S, -U
020-6000-S	n/a	B	LUMBAR SPINE ASSEMBLY	Improved specification - new drawing denotes side
020-6001-S	n/a	C	LUMBAR SPINE, CENTRAL MOLDING	Improved specification - new drawing denotes side
020-6001-U	n/a	G	LUMBAR SPINE, UNTESTED	Improved specification - new assembly drawing
020-6003	H	L	PLATE, BOTTOM LUMBAR SPINE	Improved specification
020-6002	J	K	BRACKET, T0P LUMBAR SPINE	Improved specification
020-6100	K	L	LUMBAR SPINE CABLE ASSEMBLY	Improved specification
020-6101	E	F	THREADED END FITIING	Improved specification
020-6102	D	E	FLANGED END FITTING	Improved specification
020-6103	B	C	STEEL WIRE ROPE, 4mm	Improved specification
020-9902	D	E	SCREW, LUMBAR SPINE MOUNTING	Improved specification
020-7500	C	F	PELVIS ASSEMBLY, Q3S	Improved specification
020-7503	B	F	PELVIS, MACHINED	Improved specification
020-7130	B	D	TEFLON STRIP, PELVIS	Improved specification
020-7502	A	C	PELVIS SKIN	Improved specification - urethane material call-out
034-4110	A	C	PUBIC LOAD CELL ASSEMBLY	Improved specification
020-7136	A	C	HIP JOINT SLIDE ASSEMBLY	Improved specification
020-7144	A	D	HIP JOINT SLIDE	Improved specification
020-7139	A	C	SLEEVE, HIP JOINT	Improved specification - revision to plating

Table A1. Q3s drawing revisions, Rev. J, cont.

Part Number	NPRM Rev. D	Final Rule Rev. J	Description	Nature of revision
020-7125	B	E	HIP JOINT SLIDE SPACER	Improved specification
020-7150	C	E	PUBIC LOAD CELL STRUCTURAL REPLACEMENT	Improved specification
020-7128	B	D	PUBIC BUFFER, MOLDED	Improved specification
020-7137	A	C	HIP JOINT SLIDE ASSEMBLY, (SPACER SIDE)	Improved specification
020-7138	A	C	SLEEVE, HIP JOINT (THREAD)	Improved specification - revision to plating
020-7143	A	C	PIN, HIP JOINT SLIDE	Improved specification
020-7113	B	D	HIP JOINT ASSEMBLY, LEFT	Improved specification
020-7114	B	D	HIP JOINT PAIR, LEFT	Improved specification
020-7117	C	F	HIP JOINT, LOWER, METAL	Improved specification
020-7118	B	E	HIP JOINT, UPPER , METAL	Improved specification
020-7103	H	J	DETENT PEG	Improved specification
020-7104	G	J	SPRING RETAINER PLATE	Improved specification
020-7116	B	D	HIP JOINT ASSEMBLY, RIGHT	Improved specification
020-7115	A	C	HIP JOINT PAIR, RIGHT	Improved specification
020-7135	B	E	HIP JOINT SLIDE, COVER	Improved specification
020-5000	D	F	ABDOMEN	Improved specification - material spec.
020-9500	C	E	LEFT LEG ASSEMBLY, Q3S	Improved specification - line art
020-9516	A	A	UPPER LEG MOLDED, LEFT, Q3S	Improved specification
020-9511	A	C	FEMUR, LEFT LEG, Q3S	Improved specification - coil pin 2 mm shorter
020-9507	A	C	FEMUR REINFORCEMENT WELDMENT, LEFT	Improved specification
020-9515	B	D	PIVOT BLOCK, KNEE, Q3S	Improved specification
020-9508	A	D	REINFORCEMENT-1, FEMUR	Improved specification
020-9510	A	C	REINFORCEMENT-2, FEMUR	Improved specification
020-9509	A	D	REINFORCEMENT-3, FEMUR	Improved specification
020-9903	E	F	END STOP	Improved specification
020-9120	A	B	LOWER LEG ASSEMBLY, LEFT, Q3S	Improved specification
020-9108	B	D	TIBIA ASSEMBLY, LEFT	Improved specification
020-9106	B	D	KNEE INSERT, INNER LEFT	Improved specification
020-9110	B	E	KNEE IMPACT INNER PAD, LEFT	Improved specification
020-9915	A	B	CERROBASE BLOCK	Improved specification
020-9901	D	E	STOP SCREW	Improved specification
020-9908	E	F	SHOULDER SCREW, KNEE	Improved specification
020-9600	C	E	RIGHT LEG ASSEMBLY, Q3S	Improved specification - line art
020-9616	A	C	UPPER LEG MOLDED, RIGHT, Q3S	Improved specification
020-9611	A	C	FEMUR, RIGHT LEG, Q3S	Improved specification - coil pin 2 mm shorter
020-9607	A	C	FEMUR REINFORCEMENT WELDMENT, RIGHT	Improved specification
020-9220	A	B	LOWER LEG ASSEMBLY, RIGHT, Q3S	Improved specification
020-9109	B	D	TIBIA ASSEMBLY, RIGHT	Improved specification
020-9107	C	E	KNEE INSERT, INNER RIGHT	Improved specification
020-9111	B	E	KNEE IMPACT INNER PAD, RIGHT	Improved specification
020-9800	B	D	RIGHT ARM ASSEMBLY, Q3S	Improved specification

Table A1. Q3s drawing revisions, Rev. J, cont.

Part Number	NPRM Rev. D	Final Rule Rev. J	Description	Nature of revision
020-9850	B	D	UPPER ARM MOLDED, RIGHT	Improved specification - Skin callout now PU 49 Shore A
020-9704	C	E	HUMERUS	Improved specification
020-9705	B	C	SHOULDER BEARING	Improved specification
020-9830	A	C	LOWER ARM ASSEMBLY, RIGHT, Q3S	Improved specification
020-9820	A	C	ULNA, RIGHT, Q3S	Improved specification
020-9912	A	C	END STOP	Improved specification
020-9913	B	D	SHOULDER SCREW, MODIFIED, ELBOW, Q3S	Improved specification
020-9700	B	D	LEFT ARM ASSEMBLY, Q3S	Improved specification
020-9750	B	D	UPPER ARM MOLDED, LEFT, Q3S	Improved specification - Skin callout now PU 49 Shore A
020-9730	A	C	LOWER ARM ASSEMBLY, LEFT, Q3S	Improved specification
020-9720	A	C	ULNA, LEFT, Q3S	Improved specification
020-8001	A	C	SUIT, Q3S	Improved specification - added master template
020-2400	n/a	B	NECK WRENCHES, CAP REMOVER	Neck cable revision - new parts, toolkit
020-2410	n/a	C	CABLE ADJUST NUT WRENCH	Neck cable revision - new part
020-2420	n/a	D	LOCK NUT WRENCH ASSEMBLY	Neck cable revision - new part
020-2424	n/a	F	LOCK NUT WRENCH	Neck cable revision - new part
SA572-S4	F2	F2	UNIAXIAL PIEZORESISTIVE ACCELEROMETER	No change
SA572-S86	B	D	ACCEL MOUNT BLOCK, Q HEAD 7264-2000	Improved specification
SA572-S88	B	D	ACCEL MOUNT BLOCK, UPPER TORSO	Improved specification
SA572-S89	C	E	ACCEL MOUNT BLOCK, PELVIS	Improved specification
SA572-S8	G	H	Q3 NECK LOAD CELL	Improved specification
SA572-S38	C	D	STRING POT ASSEMBLY, LEFT SIDE	Improved specification
SA572-S39	C	E	STRING POT ASSEMBLY , RIGHT SIDE	Improved specification
SA572-S37	B	B	IRTRACC DISPLACEMENT SENSOR	No change
SA572-S87	E	G	6 AXIS ACCEL/ARS MOUNT, HEAD & PELVIS	Improved specification
SA572-S55	A	C	ANGULAR RATE SENSOR - 1500	Improved specification
SA572-S56	A	C	ANGULAR RATE SENSOR - 8K	Improved specification
SA572-S57	A	C	ANGULAR RATE SENSOR - 12K	Improved specification
SA572-S58	A	C	ANGULAR RATE SENSOR - 18K	Improved specification
SA572-S7	B	E	Q3 PUBIC LOAD CELL	Improved specification
SA572-S44	A	A	2 AXIS TILT SENSOR	Improved specification
SA572-S84	-	C	TILT SENSOR MOUNT	Improved specification
SA572-S45	B	E	THORAX ARS MOUNT	Improved specification
SA572-S46	B	D	PELVIS ACCEL/ARS MOUNT	Improved specification
SA572-S47	B	D	BLOCK ACCEL MOUNT/ARS PELVIS	Improved specification
020-9010	A	C	HEIGHT MEASUREMENT FIXTURE, Q3S	Improved specification
020-9010-1	A	D	BASE, Q3S HEIGHT FIXTURE	Improved specification
020-9010-2	A	D	FOOTBOARD, Q3S HEIGHT FIXTURE	Improved specification - coating
020-9010-3	A	C	CABLE GUIDE SPACER, Q3S HEIGHT FIXTURE	Improved specification
020-9010-4	A	C	HEAD SPACER, Q3S HEIGHT FIXTURE	Improved specification - coating
020-9010-5	A	C	HEEL SPACER, Q3S HEIGHT FIXTURE	Improved specification - coating

Table A1. Q3s drawing revisions, Rev. J, cont.

Part Number	NPRM Rev. D	Final Rule Rev. J	Description	Nature of revision
020-9011-1	A	C	MEASUREMENT SEAT BACK, Q3S	Improved specification - coating
020-9011-2	A	D	MEASUREMENT SEAT PAN, Q3S	Improved specification - coating
020-9011-3	A	D	MEASUREMENT SEAT PELVIC SPACER, Q3S	Improved specification - coating
020-9011-4	A	C	FOOT MEASUREMENT PLATE, Q3S	Improved specification - coating
020-9011-5	A	D	BRACE	Improved specification - coating
020-9050	D	G	CALIBRATION HEAD FORM	Improved specification
020-9052	B	E	CENTRAL BLOCK, Q3S NECK	Improved specification
020-9053	B	D	HEAD FORM DISC	Improved specification
020-9054	C	D	ARS MOUNT ASSEMBLY	Improved specification
020-9055	n/a	C	3 AXIS ARS MOUNT	Improved specification
020-9051	A	C	PENDULUM INTERFACE	Improved specification
020-9057	B	E	1 AXIS ARS MOUNT, Q3S HEAD FORM	Improved specification - screws replace dowel pin
020-9058	A	C	BALLAST, Q3S HEAD FORM	Improved specification
020-9056	B	D	NECK/TORSO INTERFACE PLATE	Improved specification
020-9062	A	C	CENTRAL BLOCK, Q3S LUMBAR	Improved specification
020-1050	B	E	LOAD CELL BLANK (DROP TEST)	Improved specification
DL210-200	-	-	NECK TWIST TEST FIXTURE ASSEMBLY	No change
DL210-105	A	A	TOP PLATE ASS'Y.	No change
DL210-105-1	-	-	TOP PLATE	No change
DL210-106-1	-	-	END PLATE, RIGHT	No change
DL210-108	A	A	MIDDLE SUPPORT PLATE	No change
DL210-109	A	A	MOUNTING PLATE	No change
DL210-110	A	A	SHAFT ASSEMBLY	No change
DL210-112	A	A	SHAFT PLATE	No change
DL210-111	-	-	SHAFT	No change
DL210-113	A	A	PENDULUM ROD ASSEMBLY	No change
DL210-113-1	-	-	PENDULUM DISK	No change
DL210-113-2	-	-	PENDULUM SHAFT	No change
DL210-114	-	-	PENDULUM WEIGHT	No change
SA572-S51	B	B	CHEST ROTARY POTENTIOMETER	No change
DL210-210	-	-	NECK TWIST FIXTURE END PLATE, LEFT	No change
DL210-220	-	-	NECK ADAPTER PLATE ASSY	No change
DL210-221	-	-	NECK ADAPTER PLATE	No change

Appendix B.

Evaluation of the Q3s Neck Cable Revision

Appendix B. Evaluation of the Q3s Neck Cable Revision

Description of revision. Humanetics implemented a change to the neck cable of the Q3s to preclude protrusion of the cable nut such that it could interfere with the assembly of the neck. The revised design includes a shortened center cable with a protective snap cap over the locknut, and a toolkit is provided to remove the cap and adjust the cable nut torque (see 020-2400 Rev. L, sheets 1 and 2). The original and revised parts are shown side-by-side in Fig. B1. The assembled necks of the original and revised designs are shown in Figs. B2 and B3 to illustrate how the interference is precluded.

Fig. B1. NPRM cable design (left); Final Rule cable design (right). Note that the revised design eliminates one washer and uses thinner nuts to achieve a lower total stack height

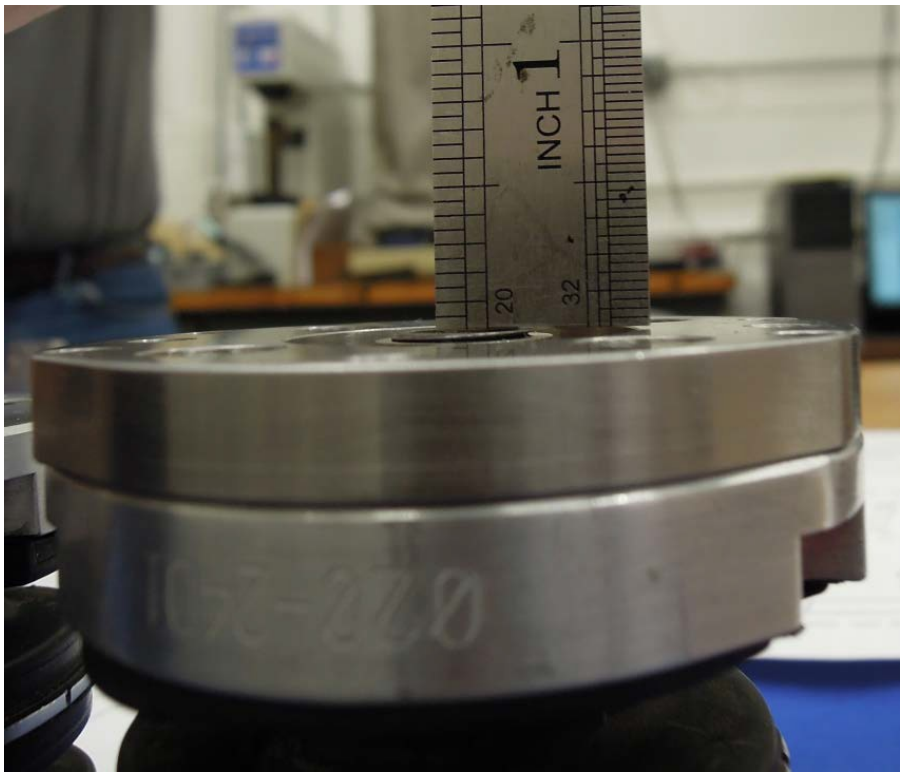

Fig. B2. Original NPRM cable design. Depending on tolerance stack-ups, the cable assembly can protrude slightly beyond the neck-torso interface plate.

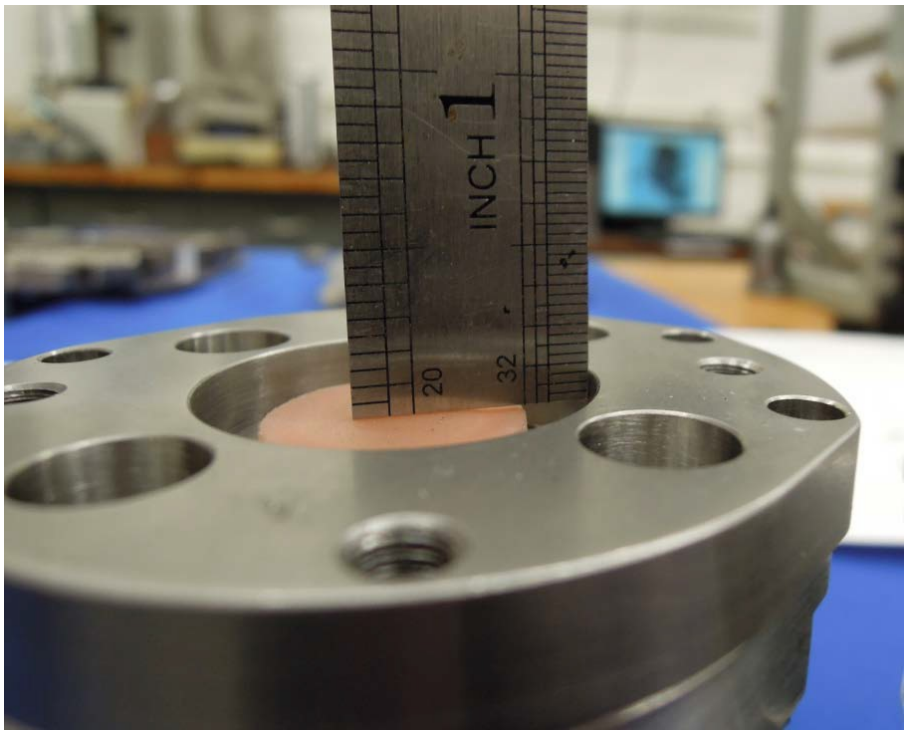

Fig. B3. Revised Final Rule cable design. Lower stack height of the cable assembly results in clearance relative to the neck-torso interface plate.

NHTSA Assessment. Before accepting these changes, we acquired, inspected, and tested the affected parts to assure that the changes did not affect the response of the neck assembly. Tests were performed on two separate neck assemblies:

1. MCW neck. We borrowed a Q3s neck assembly from the Medical College of Wisconsin (MCW). This neck was taken off their own dummy, serial no. DV5579, that was delivered to them by HIS in August 2015 with the revised cable design.

2. NHTSA neck with new HIS cable. We obtained the revised neck cable directly from HIS and installed it in the neck of one of our own Q3s units.

For both, we ran the necks through the complete neck qualification test series. This consisted of five separate tests: frontal flexion, lateral flexion (left and right), and torsion (left and right). The test series also included baseline tests with one of our necks using the old (original) cable design, and then additional tests where we swapped out the old cable with the new cable obtained from HIS. Results of the evaluation passed all of the revised neck requirements for both the MCW neck and our own neck with the revised cable.

Summary of NHTSA Assessment. The test results are summarized as follows:

- The MCW neck with revised cable met all of the neck qualification requirements.
- The NHTSA neck with HIS revised neck cable met all of the neck qualification requirements.
- The HIS revised cable responded similarly to baseline cable in NHTSA neck.

Further test details on the results are given in the data tables and plots on the pages that follow.

Evaluation of
MCW neck with revised cable

Table B1. Summary of neck qualification responses (with revised cable).

Test	Measurement	units	Final Rule Limits		MCW Neck
			Low Limit	Upper Limit	
Neck – Flexion	Maximum rotation	deg	69.5	81.0	77.3
	Peak moment (My)	N-m	43.2	50.7	47.4
	Decay time to 0 from peak angle	msec	45.0	55.0	52.2
Neck – Lateral Left	Maximum rotation	deg	76.5	87.0	84.1
	Peak moment (Mx)	N-m	25.3	32.0	26.5
	Decay time to 0 from peak angle	msec	61.0	71.0	67.9
Neck – Lateral Right	Maximum rotation	deg	76.5	87.0	82.7
	Peak moment (Mx)	N-m	25.3	32.0	26.4
	Decay time to 0 from peak angle	msec	61.0	71.0	67.1
Neck – Torsion Left	Maximum rotation	deg	74.5	90.5	88.6
	Peak moment (Mz)	N-m	8.0	10.0	8.4
	Decay time to 0 from peak angle	msec	85.0	100.0	96.2
Neck – Torsion Right	Maximum rotation	deg	74.5	90.5	89.4
	Peak moment (Mz)	N-m	8.0	10.0	8.5
	Decay time to 0 from peak angle	msec	85.0	100.0	96.4

MCW neck, cont.

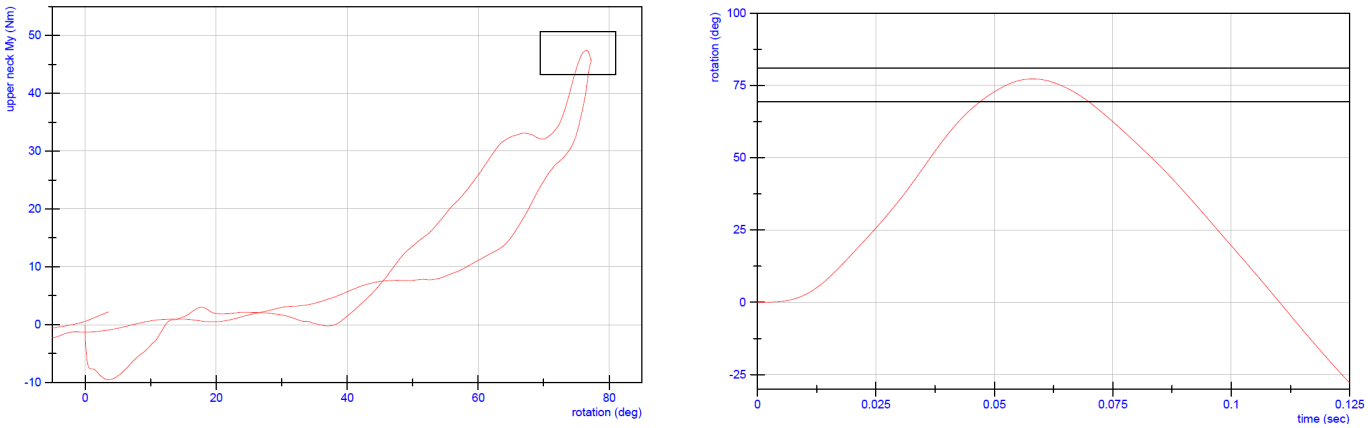

Fig. B4. Frontal flexion, MCW neck with revised cable. Left: moment requirement; right: rotation requirement.

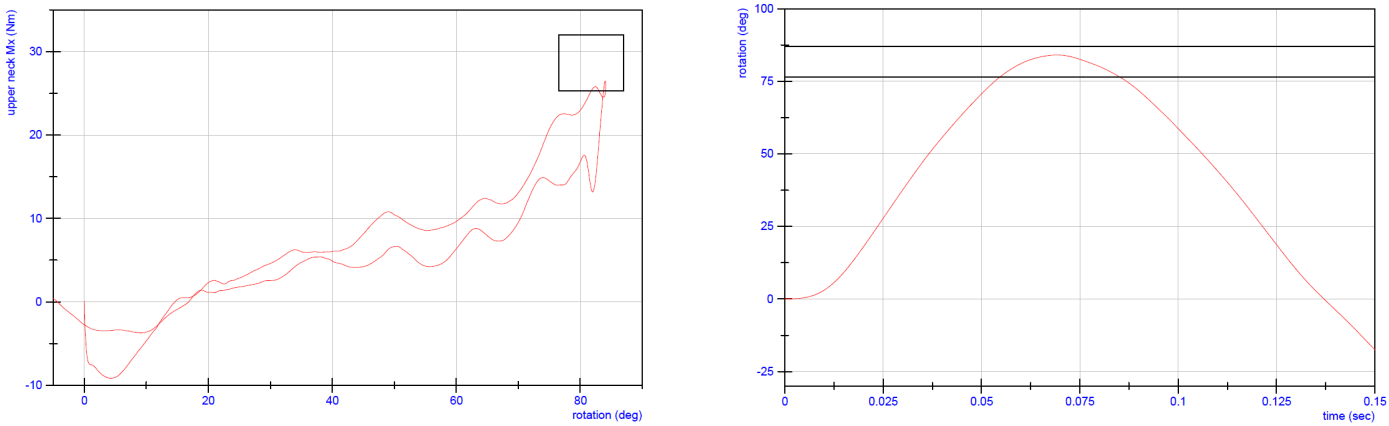

Fig. B5. Lateral flexion, left. MCW neck with revised cable. Left: moment requirement; right: rotation requirement.

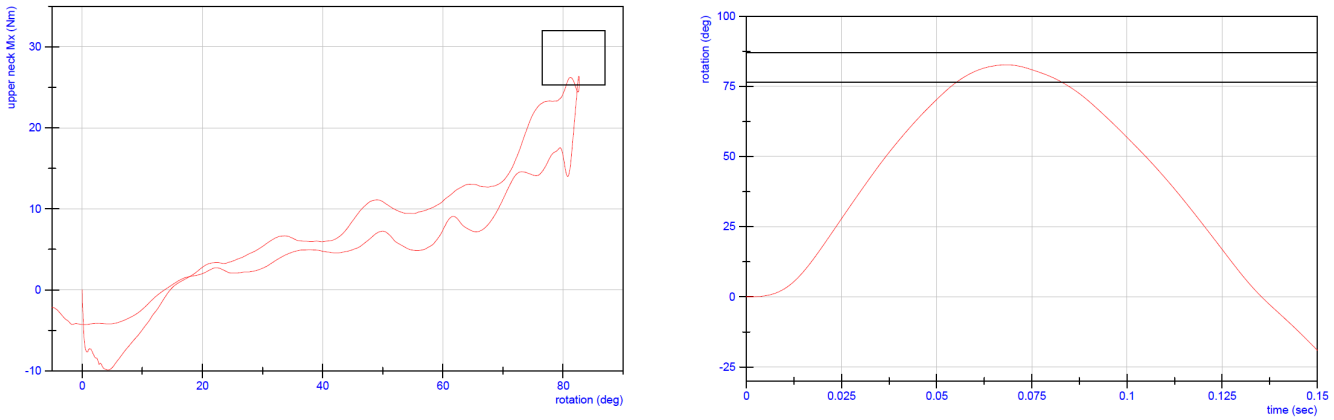

Fig. B6. Lateral flexion, right. MCW neck with revised cable. Left: moment requirement; right: rotation requirement.

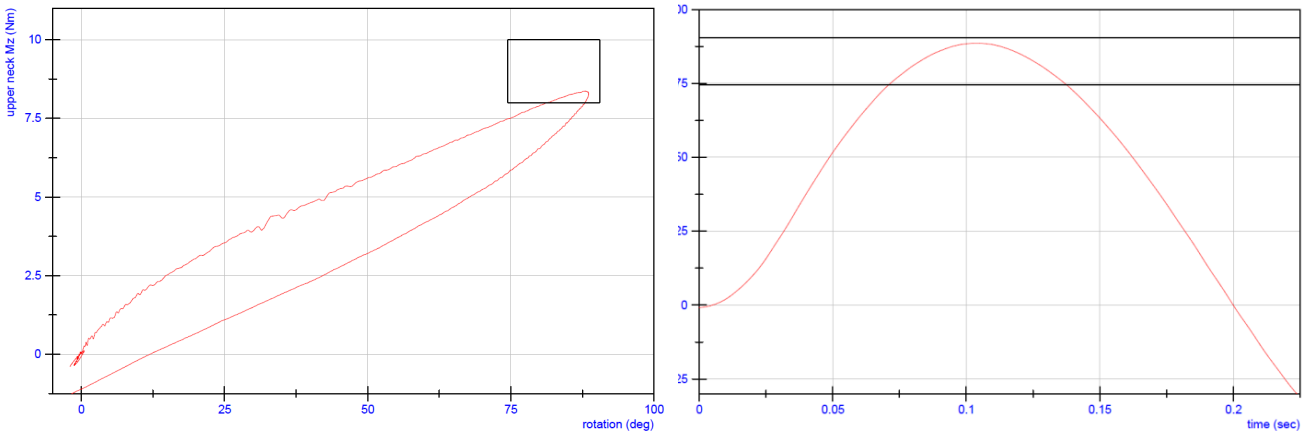

Fig. B7. Torsion, left. MCW neck with revised cable. Left: moment requirement; right: rotation requirement.

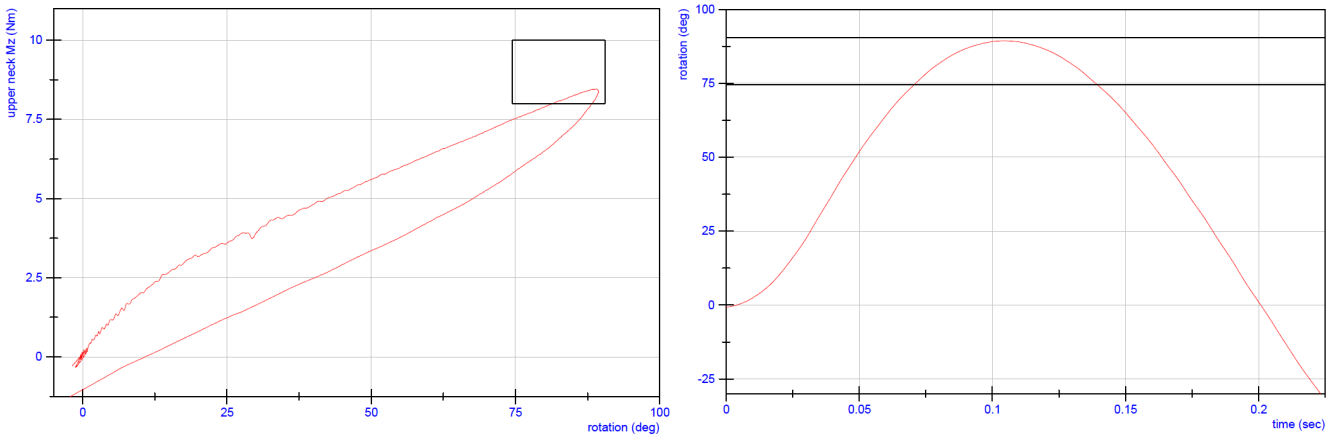

Fig. B8. Torsion, right. MCW neck with revised cable. Left: moment requirement; right: rotation requirement.

Evaluation of
HIS cable vs. baseline cable
installed in a NHTSA-owned neck.

Table B2. Summary of Qualification Responses

Test	Measurement	units	Final Rule Limits		NPRM vs. Revised Cable	
			Low Limit	Upper Limit	NPRM	Revised
Neck – Flexion	Maximum rotation	deg	69.5	81.0	74.2	74.4
	Peak moment (My)	N-m	41.5	50.7	49.8	50.3
	Decay time to 0 from peak angle	msec	45.0	55.0	51.3	51.3
Neck – Lateral Left	Maximum rotation	deg	76.5	87.5	82.1	81.9
	Peak moment (Mx)	N-m	25.3	32.0	26.9	27.3
	Decay time to 0 from peak angle	msec	61.0	71.0	67.3	67.6
Neck – Lateral Right	Maximum rotation	deg	76.5	87.5	81.1	81.7
	Peak moment (Mx)	N-m	25.3	32.0	27.0	27.3
	Decay time to 0 from peak angle	msec	61.0	71.0	66.3	67.0
Neck – Torsion Left	Maximum rotation	deg	74.5	91.0	81.5	88.7
	Peak moment (Mz)	N-m	8.0	10.0	8.8	8.6
	Decay time to 0 from peak angle	msec	85.0	102.0	90.1	96.0
Neck – Torsion Right	Maximum rotation	deg	74.5	91.0	86.5	87.1
	Peak moment (Mz)	N-m	8.0	10.0	9.0	8.3
	Decay time to 0 from peak angle	msec	85.0	102.0	92.4	95.3

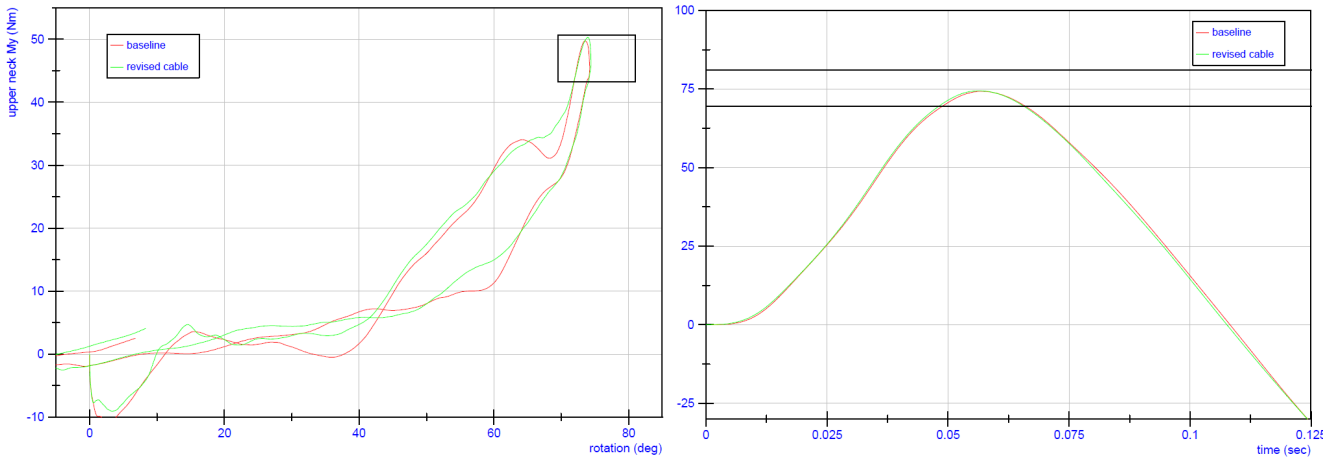

Fig. B9. Frontal flexion, HIS cable revised vs. baseline cable. Left: moment requirement; right: rotation requirement.

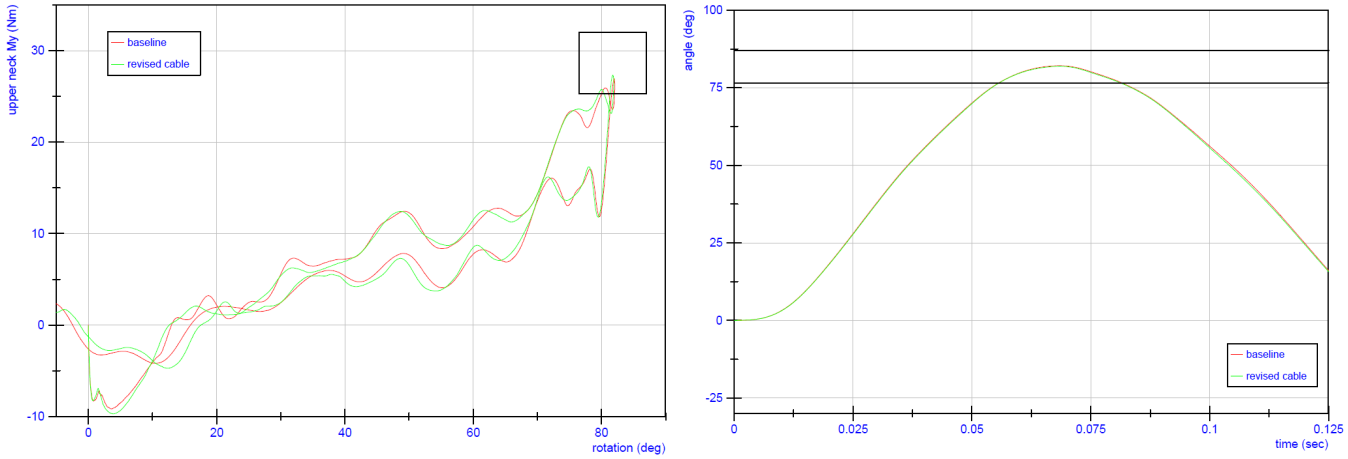

Fig. B10. Lateral flexion, left, HIS cable revised vs. baseline cable. Left: moment requirement; right: rotation requirement.

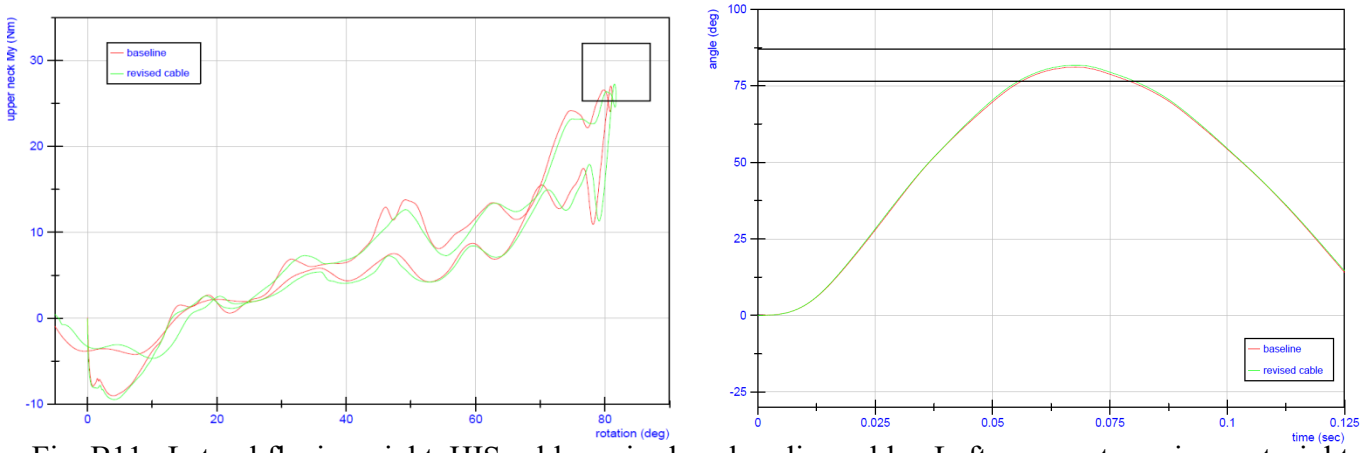

Fig. B11. Lateral flexion, right, HIS cable revised vs. baseline cable. Left: moment requirement; right: rotation requirement.

HIS cable vs. baseline cable, cont.

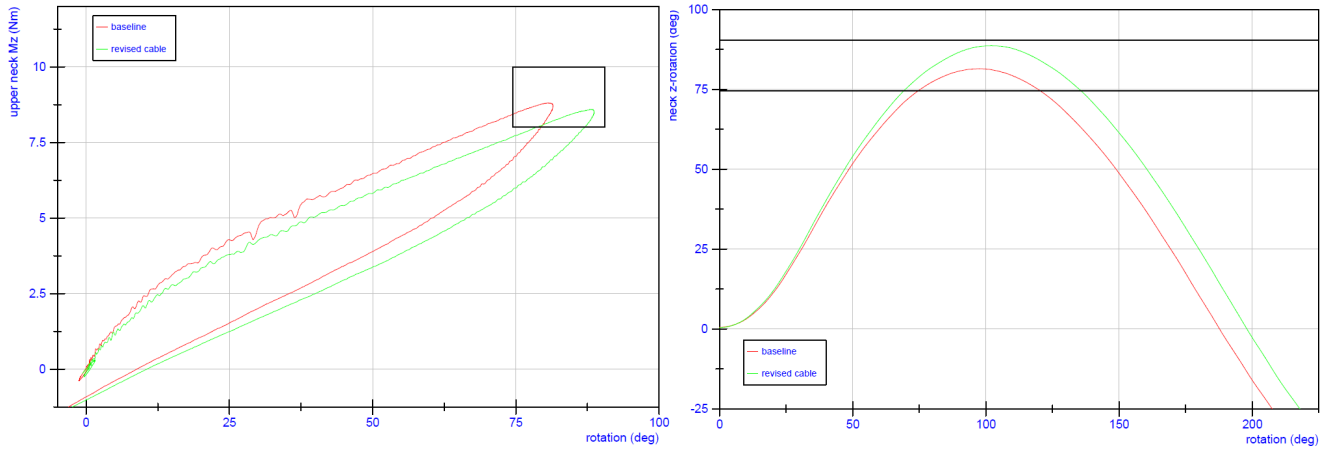

Fig. B12. Torsion, left, HIS cable revised vs. baseline cable. Left: moment requirement; right: rotation requirement.

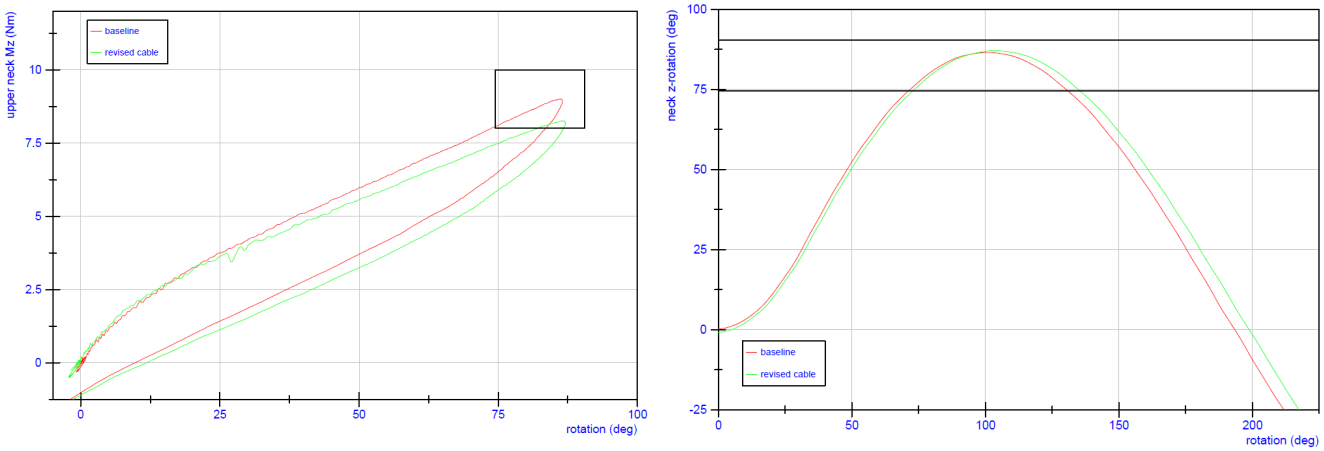

Fig. B13. Torsion, right, HIS cable revised vs. baseline cable. Left: moment requirement; right: rotation requirement.