Federal Motor Vehicle Safety Standard (FMVSS) No. 213 Test Procedure (TP-213-11) Docket No. NHTSA-2023-0067

This document serves as the response of Iron Mountains, LLC ("IM") and the Iron Mountains Testing Center ("IMTC") to NHTSA Docket No. NHTSA-2023-0067. It contains comments on the updated OVSC laboratory test procedure, TP-213-11, which includes instructions for how labs should test for compliance with the recently created FMVSS No. 213a, *Child restraint systems—side impact protection*. Iron Mountains, LLC thanks NHTSA for the opportunity to provide input to this test procedure.

Please note that the comments provided are formatted to align with the corresponding sections of TP-213-11.

2. GENERAL REQUIREMENTS

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

IM recommends updating the reference to specify March 1995 revision of SAE J211-1 per FMVSS 213a Final Rule.

12.E SIDE IMPACT DYNAMIC TEST CONDITIONS AND PROCEDURES (213a, S6)

12.E.1 SIDE IMPACT DYNAMIC TEST EQUIPMENT (213a, S6.1)

12.E.1.1 TEST CONDITIONS AND DEVICES (213a, S6.1.1(a))

IMTC has observed bending of the Rail Bearing Mount Plate over time (see Figure 1 below). IM believes adding a stiffener to the plate may mitigate this tendency.

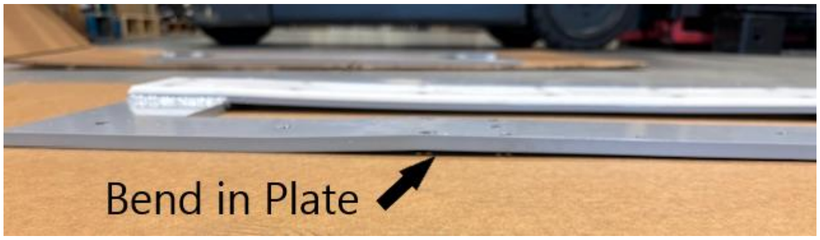

Figure 1: Rail Bearing Mount Plate Bending

IMTC has found that adding a shim plate such as the one shown in Figure 2 below reduces wear and increase the strength of the bumpers. IMTC recommends NHTSA include the option of adding a shim plate or other stiffener design to TP-213-11. Drawings for the shim plate shown in Figure 2 are available upon request.

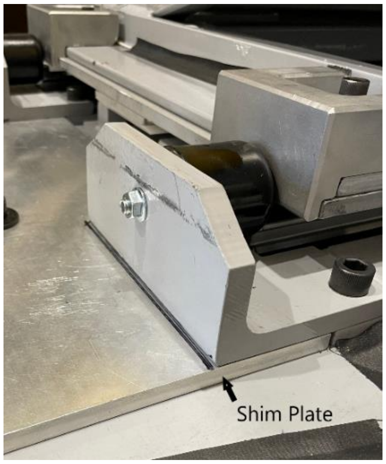

Figure 2: Bumper Shim Plate

DOOR AND ARMREST FOAM

For clarity purposes, the door foam and armrest foam should be referred to individually, rather than as a “set of door foams”. IM therefore recommends the following revision to TP-213-11 (blue text):

> Unless otherwise agreed to by the COR, a new set of door foam and armrest foam should be cut per the drawing package.[9] For every test, install a new set of door foam and armrest foam to the door impact fixture. The door foam and armrest foam should be attached to one another by spray adhesive and then mounted to the steel door fixture plate with duct tape (Figures 25 and 26).

IM is concerned that reusing the door and armrest foams may result in increased foam stiffness due to work hardening. TP-213-11 recommends, but does not require, that a new set of door foams are installed to the door impact fixture for every test, unless otherwise agreed to by the COR. IM has observed that the contract test labs replace the door and armrest foam every 5 tests. In previous NHTSA research testing, the door foam was replaced frequently and the armrest foam was replaced every test because it presented indentations from the impact of a single test.[1] Since the implications of foam work hardening has not been studied in depth and there is no method to retest for the foam compression properties after impact, IM recommends NHTSA study the effect of reusing door and armrest foams on test outcomes (e.g., occupant injury values) and update TP-213-11 based on the Agency's findings.

There are no IFD performance specifications defined for the door and armrest foams. IM recommends updating the TP-213-11 accordingly and specifying the measurement location.

The door foam and the armrest foam are not recyclable, creating a significant amount of waste. IM is generally concerned about the long-term impact on the environment.

Using tape as the sole method for securing the door and armrest foams to the steel door fixture plate is cumbersome and creates variation in foam position. IMTC believes a narrow ledge attached to the bottom of the door fixture to secure the foam could be a robust and cost-effective solution that would reduce variation in test set-up and increase reproducibility (see Figure 3). IM recommends that NHTSA study the feasibility of implementing such a design.

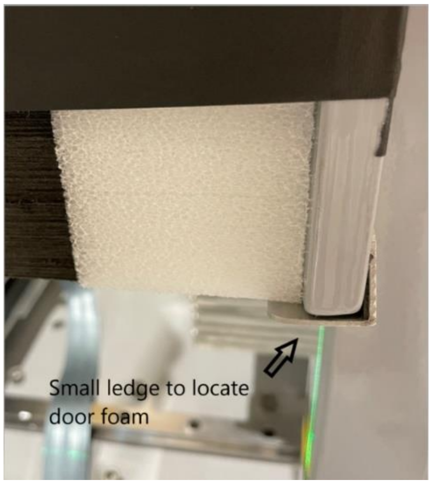

Figure 3: Door Ledge Proposal to Secure Door Foam

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[1] Louden, A., & Wietholter, K. (March 2022). *FMVSS No. 213 side impact test evaluation and revision* (Report No. DOT HS 812 791). Washington, DC: National Highway Traffic Safety Administration (hereinafter Louden & Wietholter (2022)).

Lastly, the door and armrest foams are sold as a set from a single source. The current manufacturer refuses to sell to IMTC directly, requiring IMTC to go through Calspan Corporation ("Calspan") for procurement. Lead time is unpredictable and foam orders must align with Calspan's needs. Ultimately, this could affect throughput and have negative cost implications.

HIGHSPEED IMAGE COLLECTION

Per footnote 10 on page 85 of TP-213-11, OVSC "may define precise locations for imagers". IM supports OVSC defining precise locations for high-speed imagers, as this would enable more accurate data analysis across all test labs and improve the reproducibility of the test. It would also ensure accurate analysis of the requirement described in FMVSS 213a Final Rule S6.1.1(b) and TP-213-11 S12.E.3.2 which states, "The test platform velocity in the direction perpendicular to the SORL during the time of interaction of the door with the child restraint system is no lower than 2.5 km/h less than its velocity at time = T_0."

12.E.1.2 INSTRUMENTATION

TRANSDUCERS (S213a, S5.1.2, S6.1.1, S7.1)

TP-213-11 does not specify the minimum performance requirements for the SISA impact contact switch sensor used to determine T_0 of the seat acceleration. SAE J211-1 (1995) S11 states, "Time of initial contact (real or simulated) should be known within ±1 ms." The contract test labs currently use a 20-lbf. tape switch. Switch actuation is inherently not instantaneous upon SISA contact to the honeycomb; however, the magnitude of the signal delay is unknown. IM therefore recommends specifying minimum performance requirements for the SISA impact contact sensor.

12.E.2 SYSTEMS CHECK

TP-213-11 provides best practice guidelines for how often to check the frictional performance of the SISA bearings, as this can affect the SISA sliding seat acceleration and Relative Velocity. TP-213-11 does not, however, indicate how often to replace the bearings. The frequency with which the bearings are replaced is not consistent across test labs and FMVSS 213a crash test studies conducted by IM show occupant injury values are sensitive to SISA sliding seat acceleration and Relative Velocity. IM therefore recommends NHTSA update TP-213-11 to include lifecycle testing for the bearings and/or specify how often the bearings should be replaced.

TP-213-11 instructs laboratories to check the frictional performance of the SISA bearings by conducting push/pull tests at the lower seat frame of the sliding seat. If either force is greater than 15 lb. (66.7 N), the tracks are to be greased with high performance grease to lube the bearings. IM believes that greasing the track is an inappropriate method to reduce the frictional performance of the SISA bearings. IM recommends revising the procedure as follows (blue text):

1. If installed, clamp the optional anti-rebound fixture down so that it does not interact with the sliding seat.
2. Using a force gauge, conduct a push test at the lower seat frame of the sliding seat, before the CRS is installed, and record the value.
3. Next, use the force gauge to conduct a pull test at the lower seat frame of the sliding seat, before the CRS is installed, and record the value.

4. If either force is above 15 lb (66.7 N), use the Zerk fittings to grease the bearings directly while keeping the bearing surfaces clean and dry.
5. Conduct an additional push/pull test on the sliding seat after the tracks are greased.
6. Record the values and repeat the test until the bearing friction is sufficiently within the target range.

IM also recommends checking the torque of the bolts on the bearings, as this can also affect frictional performance. This may require a change to the drawing package.

12.E.3 SIDE IMPACT DYNAMIC TEST CONDITIONS

12.E.3.2 SIDE IMPACT SPEED (213a, S6.1.1(b))

In general, IM recommends NHTSA revisit the test procedure language and supporting tables and figures to better clarify the parameters of a compliant test. NHTSA should also scrutinize the data processing and test execution practices of the contract test labs. Discrepancies identified by IM are discussed in detail below.

The correct or most appropriate method for measuring time of initial contact, T_0, is unclear. TP-213-11 defines T_0 as the time the SISA sliding seat first contacts the door assembly, as measured by a contact switch sensor between the SISA sliding seat and honeycomb. SAE J211-1 (1995) states, “Time of initial contact (real or simulated) … can be accomplished by recording a switch actuated by the impact or by observing the instant the test acceleration exceeds a predetermined value (for example, 0.5 G).”[2] Internal and external FMVSS 213a crash test studies conducted by IM show that the two methods can yield different results and it is unclear which method should take precedence.

In a FMVSS 213a side impact test, SISA sliding seat contact with the door causes a high rise in the SISA sliding seat acceleration data set. After the CFC 60 filter is applied, the resulting filtered data follows the same pulse response described in SAE J211-1 (1995) Appendix C, Figure C2 and no longer aligns with the T_0 measured by contact strip. This is illustrated by the test data shown in Figure 4 below. Here, the filtered SISA Y Acceleration (CFC 60) curve suggests that the SISA sliding seat acceleration was approximately 8 G at time contact switch actuation (T_0 = ~ 62 ms); however, the unfiltered SISA Y Acceleration curve proves otherwise.

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[2] Post-test correction or re-setting of the T_0 mark to establish time of contact is permitted by later revisions of SAE J211-1; however, it is only permitted when a switch is not applicable.

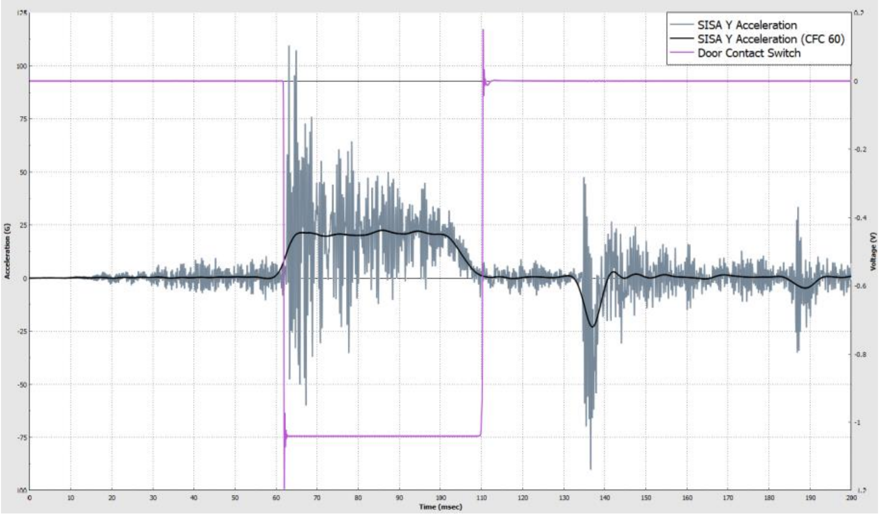

Figure 4: SISA Sliding Seat Acceleration vs. Time of Door Contact

The language of TP-213-11 and the coordinates defining the SISA sliding seat acceleration and Relative Velocity corridors suggest that the corridors begin at time of initial contact, as measured by the contact strip. In the case of the SISA sliding seat acceleration, this is not feasible in practice due to the CFC 60 filter response described above.

The method to define time of initial contact is not consistent between the contract test labs. Calspan uses contact switch actuation to record T_0 at time of initial contact. All data channels are initially time shifted to this value. Calspan will then manually reset T_0 within DIADEM such that the SISA sliding seat acceleration and Relative Velocity curves fall within the respective corridor. Per Calspan sled technicians, the corrected T_0 is typically 3-5 ms later than the initial time of contact measured by the contact switch. All data channels are then reprocessed to reflect the corrected T_0 and then time shifted such that T_0 occurs at 0 ms. MGA Research Corporation ("MGA") follows SAE J211-1 (1995) guidelines and uses a mechanical trigger device mounted on the main sled carriage to observe the instant the carriage experiences a 0.5 G or greater impulse. The contact switch is used to calculate the Relative Velocity. The SISA sliding seat acceleration and Relative Velocity corridors do not begin door contact actuation (see Figure 5).

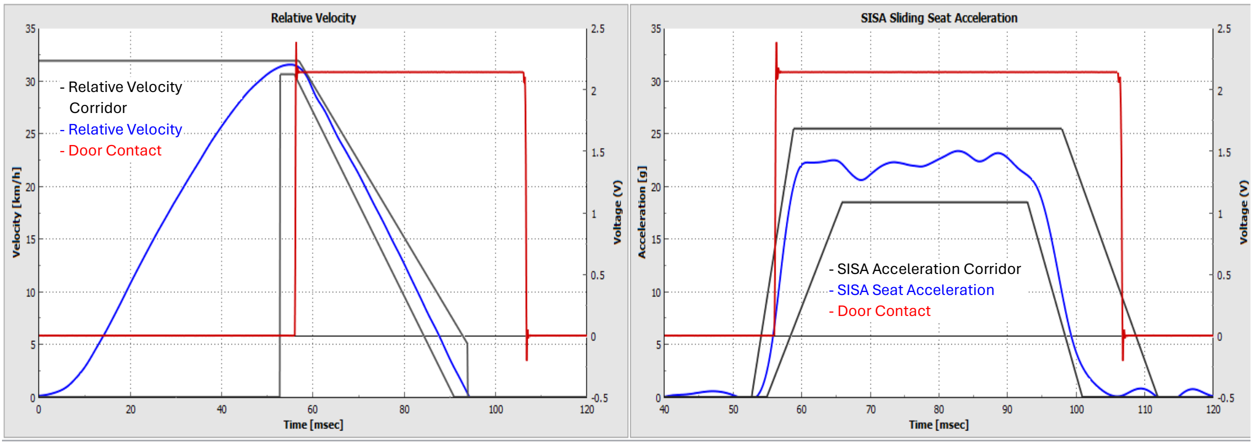

Figure 5: MGA Relative Velocity & SISA Sliding Seat Acceleration vs. Time of Door Contact

Phaseless filters cause time uncertainty and, in turn, cause problems in comparing data to film. Calspan ensures that the post-test T_0 correction is reflected in all data channels; however, this adjustment is not reflected in the test videos. Calspan defines T_0 as time of first visible honeycomb crush when time shifting test videos. A discrepancy between the test videos and time-history data can result depending on the magnitude of the T_0 correction. MGA test videos align with the T_0 measured at the time of 0.5 G change in main carriage acceleration. As shown in Figure 6 below, this typically occurs prior to sliding seat contact to the honeycomb. IM is concerned that the observed discrepancy between test data and film prevents accurate analysis of the requirement stating, “The test platform velocity in the direction perpendicular to the SORL during the time of interaction of the door with the CRS is no lower than 2.5 km/h less than its velocity at time = T_0”.


[redacted]
[redacted]

T_0 = Time of 0.5 G change in test acceleration
(T_0 = ~ 52 ms)

T_0 = Time of contact switch actuation
(T_0 = ~ 56 ms)

Figure 6: Comparison of SISA Sliding Seat Interaction with Door Relative to T_0 Definition

Lastly, the correct method for calculating the Relative Velocity and measuring the Relative Velocity at time of initial SISA sliding seat contact to the door, T_0, is also unclear. Detailed instructions are only available in the NHTSA development study[3] which is not listed under in the general requirements. Determination of a compliant test hinges on this information. IM therefore recommends revising TP-213-11 to include these instructions.

12.E.4 DUMMY PREPARATION

12.E.4.2 PRETEST CONDITIONING AND CALIBRATION REQUIREMENTS

12-MONTH-OLD DUMMY

IM is concerned about the overall robustness of the CRABI-12MO ATD upper arm. As shown in Figure 7 below, the upper arm joint connections have shown to break at the elbow. When this happens, the arm must be replaced entirely. These components are expensive at a piece cost of $1,890.00 (at the time of document creation) and are not readily available from Humanetics (8-12

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[3] Louden & Wietholter (2022)

week lead time). IM recommends NHTSA conduct component lifecycle testing to assess the robustness and overall longevity of the CRABI-12MO ATD beyond the established certification requirements. IM also recommends NHTSA provide interim repair guidelines for the upper arm to enable testing during procurement lead time.

Figure 7: CRABI-12 Arm Joint Fracture at Elbow

Q3s 3-YEAR-OLD DUMMY

IM is concerned about the overall robustness of the Q3s ATD. Per footnote 11 on page 93 of TP-213-11, OVSC is collecting data and may revise the 30-test calibration number defined for the Q3s ATD. IM supports this investigation and believes that component-level lifecycle testing requirements are needed to ensure consistent, representative test data. Test results show a sensitivity to ATD exposure, regardless of compliance with calibration requirements. Internal and external FMVSS 213a crash test studies conducted by IM show that new components can yield a different response compared to those which have undergone significant testing. Additionally, Q3s components are expensive and difficult to acquire from Humanetics with most requiring an 8-month lead time to obtain. The contract test labs anticipate high test volumes and the implications on the overall ATD response over time should be evaluated. IM encourages NHTSA to evaluate variation in the ATD response by comparing all time-history data rather than simply comparing

IMTC is also concerned with the overall robustness of the IR-TRACC, noting frequent damage and significant variation in instrumentation performance sensor to sensor, despite calibration level. The certification tests for the IR-TRACC may not accurately replicate the loading experienced in a side impact test. Off-axis loading of the IR-TRACC during impact can cause the telescoping mechanism to bind and wear over time. Intermittent electrical failure has also been observed. Swapping the orientation of the IR-TRACC is a necessary operation to enable both rear- and forward-facing testing, but only increases the risk of damage due to human error.

The presence of the wetsuit limits access to the arm adjustment screws and hinders proper 1G torque adjustments. IMTC recommends NHTSA improve access to the arm adjustment screws and/or develop a more robust procedure to position the Q3s arms.

Arm detent screws last for approximately 15 side impact tests before the polymer ball wears down and no longer engages the arm detent. This creates a risk of damaging the shoulder ball retaining ring because the metal from the detent screw can scrape the retaining ring. IM recommends NHTSA conduct a lifecycle study on the detent pins.

The slot side of the arm detent screws protrude from the Q3s ATD's back and can tear into the Q3s wetsuit during test, causing tears in the wetsuit and potential contact to the CRS. IMTC testing has shown this interaction to alter ATD kinematics and affect injury results. The wetsuit is costly to replace at a piece cost of $1,360.00 (at time of document creation). IMTC therefore recommends NHTSA investigate design solutions which ensure the arm detent screws are flush or countersunk to the ATD's back.

The upper legs of the Q3s ATD deform (i.e., bend and elongate) during impact and rebound which can result in different length legs and ultimately, breakage. New upper legs are costly and not readily available from Humanetics. IMTC therefore recommends NHTSA investigate the implications of leg length discrepancy on test results (e.g. occupant injury values) and conduct component lifecycle testing to comprehend the testing limits of the Q3s ATD.

12.E.6 RESTRAINT SETUP

12.E.6.1 CHILD RESTRAINT SYSTEM INSTALLATION

Lower anchor belt tension cannot be accurately measured using a tension gage due to the proximal location of the lower anchors and subsequent twist in the lower anchor webbing (see Figure 8 below). Tension can therefore only be confirmed by feel, which introduces test-to-test variation and reduces the overall robustness and reproducibility of the test. IM recommends NHTSA incorporating a load cell into the lower anchors to measure belt tension directly.

Figure 8: Lower Anchor Clearance

Specifying a method to ensure both the CRS <u>and</u> the ATD are centered on the SISA seat will improve the repeatability of the test. For forwarding-facing CRS installations, IM recommends using a laser or FARO arm to verify that the center of the CRS and the center of the ATD are positioned 300 ± 2 mm (11.8 ± 0.08 in.) from the impact side of the SISA sliding seat edge. TP-213-11 should also include instructions to verify that the CRS and ATD are not tilted or twisted after confirming that the final tensions of the attachment belts are within the allowable limits.

12.E.6.2 DUMMY INSTALLATION

12-MONTH-OLD CRABI (S213a, S9.1)

Typos were noted in TP-213-11 S12.E.6.2(1)(iv) and S12.E.6.2(1)(v). Proposed revisions are provided in blue text below.

iv) Using a flat square surface with an area of 2580 mm^2, apply a force of 178 N (40 lb.) to the dummy crotch perpendicular to the plane of the back of the SISA.

v) Using the same flat square surface, apply a force of 178 N (40 lb.) to the dummy thorax in the midsagittal plane of the dummy perpendicular to the plane of the back of the SISA.

Q3s 3-YEAR-OLD (S213a, S9.2)

TP-213-11 does not include a procedure for determining the correct shoulder harness slot position and buckle harness position to be used in dynamic side impact testing. There are known geometry differences between the Q3s ATD and the Hybrid III 3-Year-Old (H3-3Y) ATD which may result in different shoulder harness and buckle harness positions. IM therefore recommends NHTSA include a shoulder harness and buckle harness positioning procedure in the FMVSS 213a test procedure.

IM supports Graco's recommendation to limit arm twist to 0° ± 2°. Results of both internal and external FMVSS 213a crash test studies conducted by IM align with Graco's findings regarding the sensitivity of chest displacement injury values to arm position. IM believes monitoring arm twist will reduce test-to-test variation and improve overall test repeatability and reproducibility.

There is approximately 5° of play in the Q3s arm position after the arm is engaged in the shoulder detent. IMTC has found that using the ATD thorax tilt sensor in conjunction with an inclinometer mounted to the two holes in the elbow skin to be a more accurate measurement of ATD arm angle relative to the thorax. Graco's Q3s Arm Angle Device shown in Figure 9 and Figure 10 has proven to be a useful tool for mounting the inclinometer and IM supports implementation of this device into the FMVSS 213a test procedure.

Figure 9: Q3 Arm Angle Device for Forward-facing Test Conditions

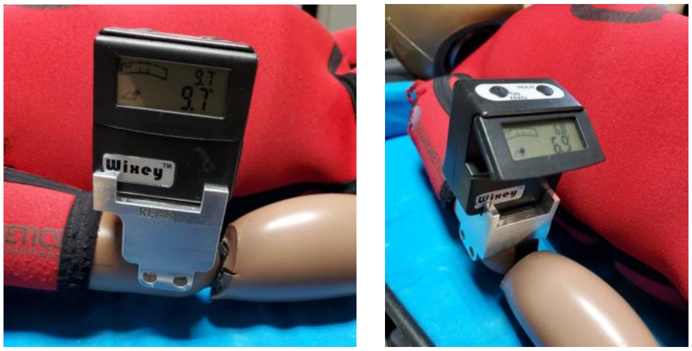

Figure 10: Q3s Arm Angle Device for Rear-facing Test Conditions

The lower anchor, tether, and 3-point seat belt tensions specified in Table 13 of TP-213-11 do not align with the procedure text. IM recommends updating the table as shown below (blue text).

TABLE 13. CRS INSTALLATION BELT TENSIONS

	Lower Anchor	Tether	3PT Seat Belt	Harness
Tension	53.5-67 N (12-15 lb)	45-53.5 N (10-12 lb)	53.5-67 N (12-15 lb)	9-18 N (2-4 lb)

GENERAL TEST REPEATABILITY AND REPRODUCIBILITY – TESTING RESULTS

Figure 11 summarizes the repeatability (within lab) and reproducibility (lab-to-lab) results from a recent (February 2024) FMVSS 213a crash test study conducted by IM and associated companies at the contract test labs. Results show marginal[4] reproducibility with a lab-to-lab coefficient of variation (CV) value greater than 10% for the single, current production rear-facing (RF) convertible CRS model evaluated. The CV values generated in this study are greater than those achieved in the NHTSA repeatability and reproducibility study[5], indicating a need for improvement to the test procedure.

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[4] Based on the scale used in FMVSS 213a Final Rule, published June 30, 2022

[5] Wietholter, K. & Louden, A. (2021, November). *Repeatability and Reproducibility of the FMVSS No. 213 Side Impact Test*. Washington, DC: National Highway Traffic Safety Administration.

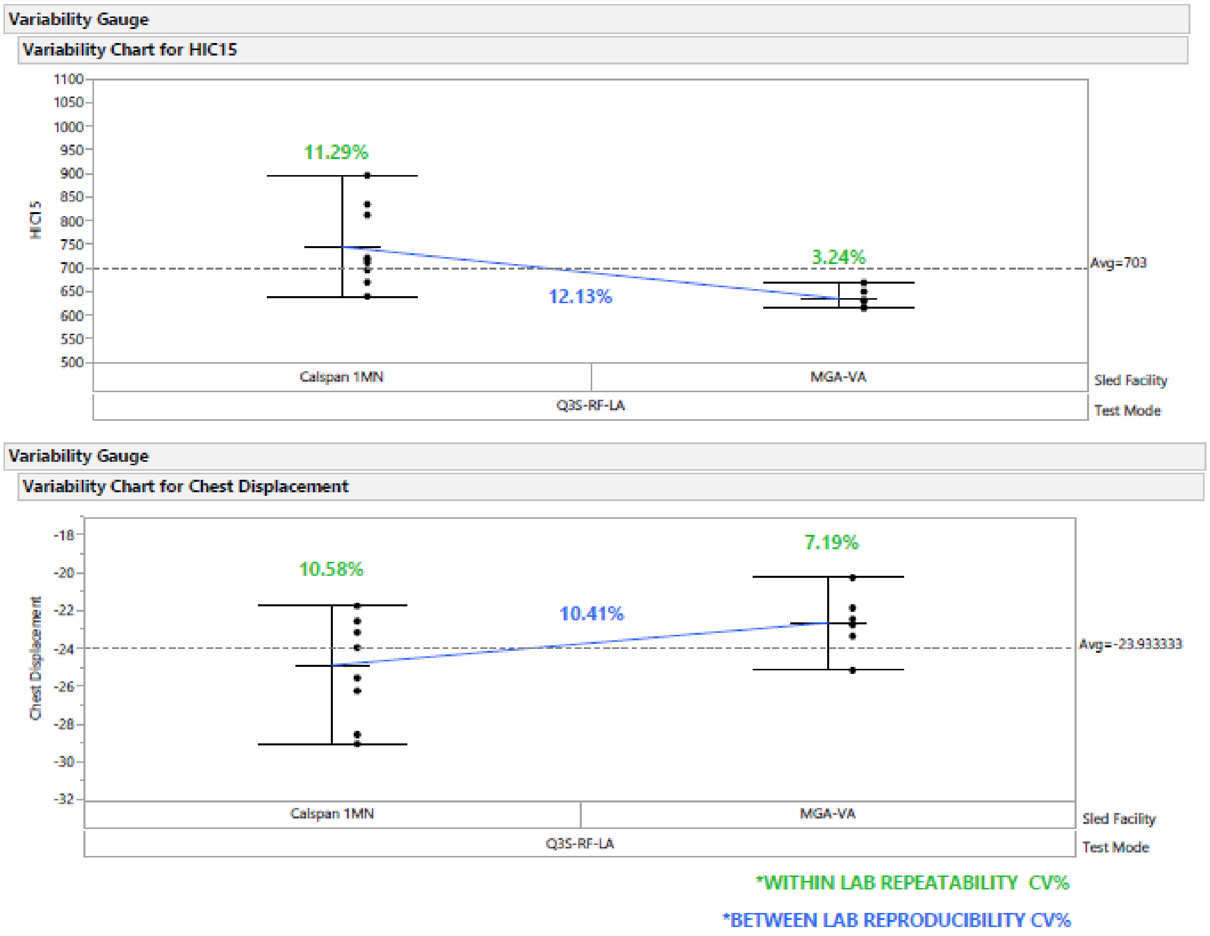

Figure 11: FMVSS 213a Repeatability and Reproducibility Results for RF Convertible CRS

SUMMARY

Iron Mountains, LLC believes incorporating the above feedback into TP-213-11 will increase the overall repeatability and reproducibility of the FMVSS 213a side impact test. Iron Mountains, LLC thanks NHTSA for its consideration and is willing to answer any questions concerning the comments provided.

Sincerely,

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