May 22, 2024

Docket Management Facility
U.S. Department of Transportation
West Building, Ground Floor, Room W12-140
1200 New Jersey Avenue S.E.
Washington, D.C. 20590

RE: ***Comments to Docket NHTSA-2020-0067***

Graco Children's Products Inc. ("Graco" or the "Company") respectfully submits these comments to the NHTSA's Docket No. NHTSA-2020-0067 for Federal Motor Vehicle Safety Standard (FMVSS) No. 213 Test Procedure (TP–213–11). Graco has been a manufacturer of child restraint systems since the 1970s and has been a leading innovator in child passenger safety for many years. Graco offers these comments to based on our experience as a manufacturer as well as the company's extensive test program.

Graco Testing Program

Since July 2022, the Company has performed 3642 dynamic tests across 71different models of child restraint systems ranging from rear-facing only infant seats to backless belt-positioning boosters, as detailed in Table 1. The tests were performed at Calspan Corporation, MGA Corporation, and at the Graco test center in Atlanta, GA.

Table 1. Graco Test Program Summary.

Test Bench	Quantity
FMVSS 213	1275
FMVSS 213a	1900
FMVSS 213b	467

Accordingly, the comments to TP-213 offered by Graco are based on the Company's experience testing using the equipment and methods presented in the subject docket, including detailed reviews of test series to identify the root causes of test-to-test variations and elements of the test setup that can influence the results.

Procedures Related to the Side Impact Seat Assembly

The following items were identified in the course of Graco' test program related to procedures pertaining to the NHTSA Standard Seat Assembly, FMVSS No. 213a, NHTSA-213a-2021 (SISA).

(1) Base Plate Bending and Base Plate Inspection

As shown in Figures 1 through 7, the structure of the SISA base plate that supports the Impactor Frame Assembly (door and hexcell support structure) is bending during testing. This phenomenon was identified at five different laboratories. Newell Brands recommends that a base plate flatness check method be added to TP-213, where the gap between the base plate and the sled base is measured directly and should be no greater than 3 mm. These measurements are important to identify when the SISA is out of tolerance due to the base plate bending, and to trigger a requirement to repair or replace the affected structure.

A frequency for this check step should also be added to TP-213 to ensure that damaged structures do not bias test outcomes. Because the door foam is attached to the door structure, bending of the structure can position the door foam so as to affect the arm rest height, which is a critical factor to the outcome of chest displacement with the Q3s and head contact with the CRABI dummies.

Though out of scope of this docket, we recommend that the tolerance on the door height from the base plate also be reviewed. Currently, the dimension for the Impactor Frame Assembly provided on drawing 2921-240 is given as 32.45 inches with a tolerance of ± .010 and an angle tolerance of ±.5 degrees. These are extremely tight tolerances for a welded structure of such a large overall dimension. Longer term, NHTSA should consider updates to the structure to prevent bending altogether.

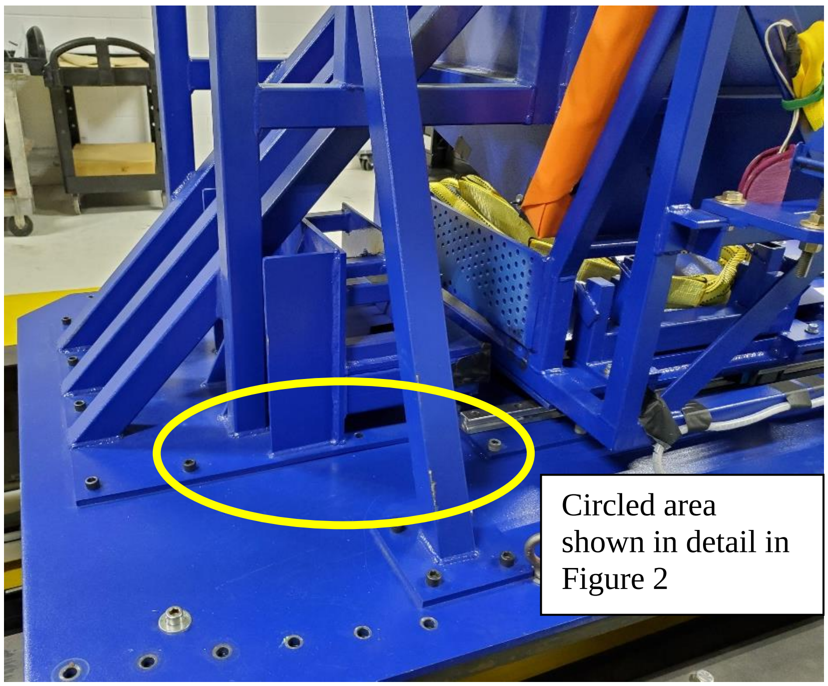


Figure 1. Graco Impactor Frame Assembly and Base Plate.

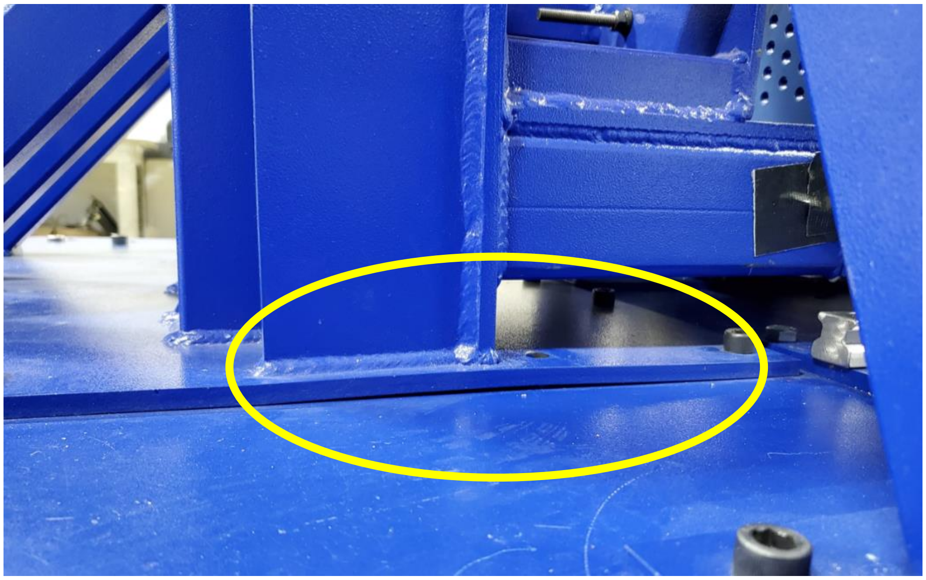


Figure 2. Detail of Graco Base Plate Showing Gap.

Figure 3. Calspan Impactor Frame Assembly and Base Plate.

Figure 4. Detail of Calspan Base Plate Showing Gap; Calspan Added Shims at the Right Corner to Compensate for the Bending.


Figure 5. Detail of MGA-Virginia Base Plate Showing Gap.

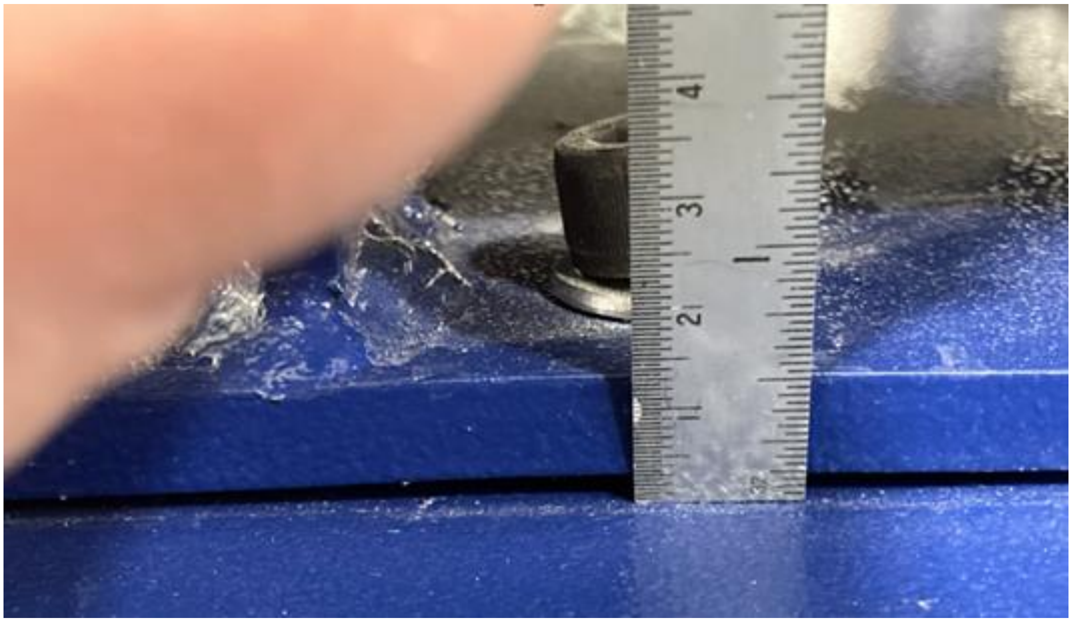


Figure 6. Detail of Evenflo Base Plate Showing Gap.

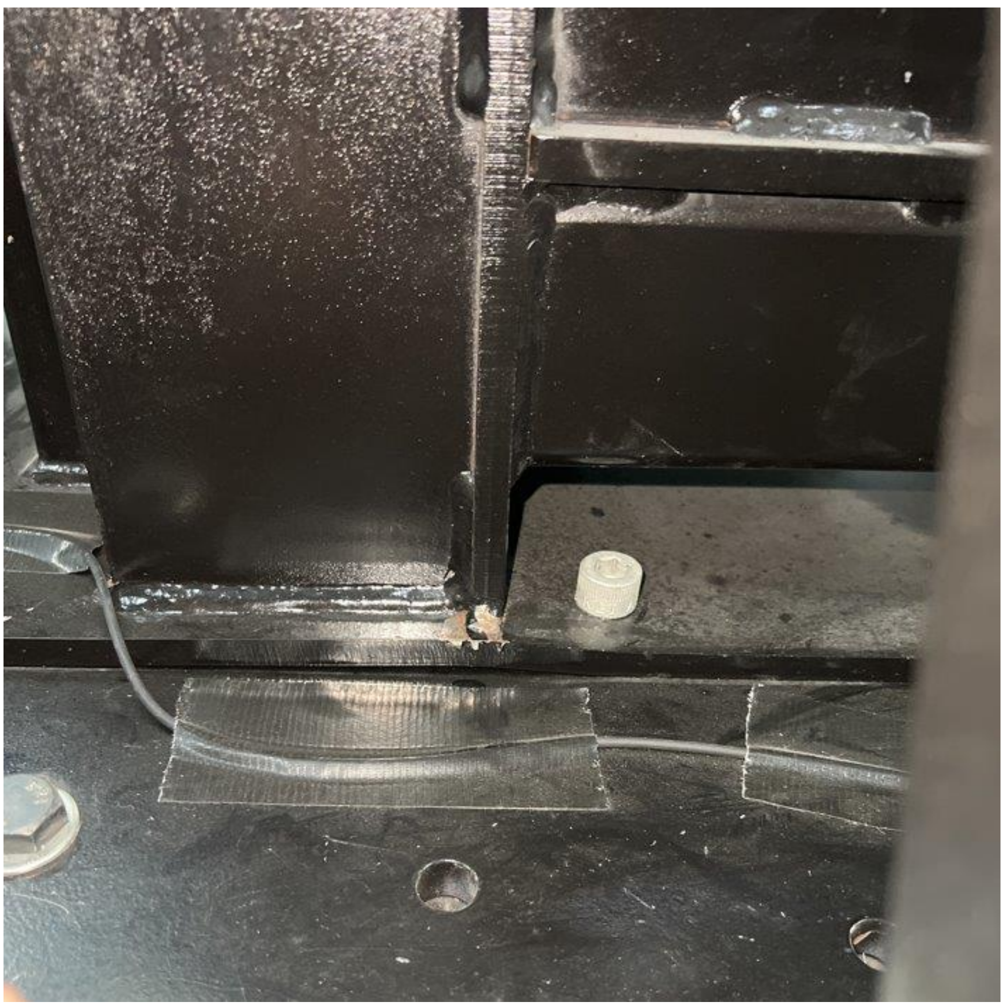


Figure 7. Detail of China Supplier's Base Plate Showing Gap.

(2) Anchor Gap Gauge

Section 12.E.6.1 directs that the Anchor Gap Gauge (NHTSA Drawing 2921-950) be used to assess the inboard lap belt anchor and the shoulder belt D-ring prior to each test. Because these components bend during normal testing, energy from the deceleration is absorbed via this deformation and thus not transmitted to the test article, thereby altering the results from test to test. Graco recommends that Section 12.E.6.1 be updated to direct that the Anchor Gap Gauge be used before and *after* each test to ensure that the SISA did not change configuration during the most recent test. Graco further recommends that any post-test deformation detected using the Anchor Gap Gauge render the preceding test invalid.

(3) Vehicle Belt Webbing Specification

Section 12.E.1.3 requests that laboratories ensure that the elongation under load for by 8 ± 2%. Graco, working with third-party test labs, has found that webbing with 6-8% elongation under load can be reliably obtained. Graco recommends that Section 12.E.1.3 be updated to *require* the elongation under load for the webbing be *7 ± 1*% to better ensure consistency. Specification of the materials to this degree is no different than providing detailed specification for other features on the FISA and SISA, such as the fabric seat covers.

<u>Procedures Related to Child Restraint Attachment to FISA and SISA</u>

(1) Pre-test Tether Tension Measurement Location

Sections 6.1.2(a)(1) and 6.1.2(a)(2) of FMVSS 213a and FMVSS 213b Sections 6.1.2(d)(1)(ii) and 6.1.2(d)(1)(iii) specify the range of acceptable pre-test tension values. The tether routing on the FISA and SISA do not reflect actual vehicle geometry and materials, particularly the routing of the tether across a steel box beam at the top of the seat back before turning the strap more than 90 degrees to the anchor location. This effectively creates two segments of the tether strap.

Because of the effective segmentation of the tether strap, we are concerned that the tether tension may be different between the child restraint seat back and the top of the bench versus the tension in the segment between the top of the seat back and the tether anchor. This in turn may result in pre-test under- or overtightening of the tether, which can then lead to inconsistent results for otherwise like-to-like tests.

Graco recommends capturing pre-test tether tension values at the approximate midpoint of the section of the tether between the top of the seat back structure and the Tether Anchor Assembly, as shown in Figure 8. Using this location has proven to result in more consistent readings. The Company has found that taking the measurement closer to either end of this span results in higher tension values.

Accordingly, the Company suggests updating Sections 12.E.6.1(1)(v) and 12.E.6.1(3)(v) to take the tether tension measurement at the approximate midpoint between the top lateral bench frame tube and the tether anchor assembly. Graco further recommends that Section 12.D.6.1 A be updated to conform to these changes when TP-213 is updated to include FMVSS 213b.

Figure 8. Tether Tension Measurement with 3-Prong Gauge at Proposed Location.

(2) Non-Rigid Lower Anchor Pre-Test Tension

In response to comments from Britax and Evenflo related to capturing pre-tension lower anchor tension where the 3-prong gauge cannot be used, NHTSA stated in the final rule for FMVSS 213b that it would consider incorporating the "Alternate Tension Adjustment Method" from the VRTC Research Test Procedure[1]. Graco recommends that NHTSA does not adopt this method for the reasons set forth below.

The VRTC method during the pre-test setup directs the installer to "firmly pull" twice on each side of the installed child restraint system, and then pull the CRS forward and push it back two times. The CRS must not move than 25 mm from its initial location during this assessment (often referred to as the "1-inch rule"). Because of the vagueness and the amount of interaction with the installed CRS, Graco is concerned that test-to-test variation will be introduced because:

[1] 88 FR 84558

(a) Locations for the forces are not defined beyond "at the belt path," and it is unclear exactly how the force should be applied to accomplish the pull (e.g., hand inside the belt path, hand on outside edge of CRS near the belt path; above or below the belt path, etc.);
(b) Lateral forces will serve to move the CRS off of the location specified in Section 12.E.6.1 of TP-213;
(c) The fore-aft assessment can cause the seat back angle of the CRS to change relative to the FISA or SISA seating surface;
(d) The forces are not specified beyond "firmly pull," which inherently will vary from installer to installer; and
(e) The installer is directed to stand in front of the CRS to conduct the fore-aft assessment, and the standing height and arm span of the installer will vary the angle at which the CRS is pulled.

As part of a study on CRS installation with standard and non-standard lower spacing[2], the authors observed the types of variations in installation when applying the "1-inch rule" described above, especially with regards to the interpretation of what the Research Test Procedure means by "firmly pull." This supports the concerns above that variation between test technicians can materially alter test setup in the course of assessing how well the CRS is secured to the FISA or SISA.

In addition to the concerns about introducing test variations that cannot be accounted for, the method described in the VRTC Research Test Procedure will add significant time for each CRS installation, reducing laboratory capacity and increasing testing costs.

Graco recommends that NHTSA continue to engage with the commercial test laboratories, CRS manufacturers, and other researchers to identify a suitable means to capture flexible lower anchor attachment tension and incorporate that in a future update to TP-213.

Procedures Related to Child Restraint System Set Up

Based on testing experience, Graco is also offering some laboratory practice recommendations to better ensure repeatability and reproducibility between individual tests and between test laboratories.

(1) Harness Tension Measurement

VRTC's Research Test Procedure included use of a 3-prong gauge to collect pre-test harness tension, and NHTSA stated they "will consider" incorporating the 3-prong gauge (88 FR 84560, col. 2). Graco recommends revising the setup procedure in Section 12.D.6.5 Belt Adjustment to remove the paragraph citing the use of device in Figure 16 and replace with the use of a 3-prong gauge to measure harness tension. As of the date of this comment, suitable seat belt tension gauges are commercially available from Arete Products (https://arete-usa.com/products/, model BT3329S).

(2) Placement of the Child Restraint on the SISA

To better ensure that the CRS is consistently located relative to the belt anchorages, Graco suggests modifying Section 12.E.6.1 Child Restraint System Installation to provide more detail for the

[2] Julie A. Mansfield, Yadetsie N. Zaragoza-Rivera & John H. Bolte IV (2018): Usability of non-standard lower anchor configurations for child restraint system (CRS) installation, Traffic Injury Prevention, DOI: 10.1080/15389588.2018.1540040; https://doi.org/10.1080/15389588.2018.1540040

installation procedure. The proposed additions are already incorporated into the procedures used at the two third-party laboratories used by industry, and will not add to cost or installation time. In the paragraph following Figure 34, add the italicized sentence as provided below:

> Place the add-on child restraint on the seat cushion of the sliding seat and push the CRS back until the seat back of the CRS contacts the seat back of the sliding seat. The restraint should sit flat on the SISA sliding seat bottom. *Use a laser to align the center of the CRS is positioned 300 mm ± 2 mm from the impact side of the SISA. Utilize the laser to align the bottom and top center of the CRS with the 300 mm point.* Follow the manufacturer's instructions provided with the CRS to properly level and install the CRS by any one of the means as described below:

In each of the three subsections for forward-facing installation with child restraint anchorage systems, rear-facing installation with child restraint anchorage systems, and installations with Type II belt systems, add a final step (step (v) or (vi)):

> *Adjust the CRS utilizing the laser to ensure the CRS is centered and is not tilted or twisted on the seating surface.*

(3) Placement of the ATD into a Child Restraint Installed on the SISA

To better ensure that the Q3s dummy is consistently placed into the child restraint, Graco suggests modifying Section 12.E.6.2 Dummy Installation to provide more detail for the installation procedure. The proposed addition is already incorporated into the procedures used at the two third-party laboratories used by industry, and will not add to cost or installation time. In step 1, sub-step ii, add the italicized text as follows:

> ii. Position the test dummy so that the midsagittal plane of the test dummy's *head torso and pelvis* are centered in line with the center of the CRS. *Ensure the ATD's Head, Torso and Pelvis are perpendicular with the SISA and not twisted or tilted. Check and adjust the CRS and ATD utilizing a laser to ensure that it is centered with the 300 mm point.*

(4) Q3s Arm Angle Measurement

Side impact testing to FMVSS 213a with the Q3s dummy conducted at several labs has shown a correlation between pre-test arm angle and the Chest Displacement and HIC injury values. Reducing pre-test variables will improve the repeatability of results, removes spurious results that are an artifact of the pre-test positioning of the Q3s arm, and helps when analyzing differences between tests over time and between labs.

To better control the repeatability and reproducibility a device was created to measure the arm angle and later revised to also determine the arm twist. Graco has shared both the device (CAD files) and setup procedure with the contract labs and several other CRS manufactures that have internal crash sleds. Graco has conducted crash test studies and determined that these devices have improved the repeatability of the injury values. The use of the device and data collection does not significantly increase the test time and is of great value when studying the final test results.

Accordingly, Graco recommends that NHTSA add to the side impact dynamic test setup procedure at Section 12.E.7 in the first group of instructions (the portion prefaced with "Before conducting the…") a new step (4), as follows:

(4) Follow the Q3s Arm Angle Device Instructions (see Instructions in attachment)

Collect and report the following information:

On the Arm closest to the door collect the arm angle from horizontal and the arm twist noting positive rotation (towards the ATD) negative rotation (away from the ATD). The arm twist should be set to 0° ±2°

Collect and report the ATD thoracic spine tilt angle from horizontal.

As a check, subtract the arm angle from the ATD spine tilt angle. The result should be approximately 25°. Report the result as relative arm angle.

Mark the Seat back angle for all tests both Forward facing and Rear Facing report the seat back angle.

Details of a Graco and an intra-industry design of experiments with this proposed device and instructions for using the device are found in the appendices. A guide for using the proposed device is also provided as an appendix. The CAD files to fabricate the proposed device have been provided to other manufacturers and Graco will provide them to NHTSA separately because the file types are not supported by the electronic portal at regulations.gov.

Other Laboratory Practices

Based on the Company's testing experience, Graco is offering some laboratory practice recommendations to better ensure repeatability and reproducibility between individual tests and between test laboratories.

(1) Camera and Photograph Locations

With respect to chest deflection, it can be difficult to detect what causes variation in results. Having consistent setup photos from run to run is helpful in determining possible sources of variation. The view taken as shown in Figure 9 gives a reference for CRS and ATD placement on the SISA bench. Figure 10 shows a pre-test photograph taken with the camera at this location and orientation.

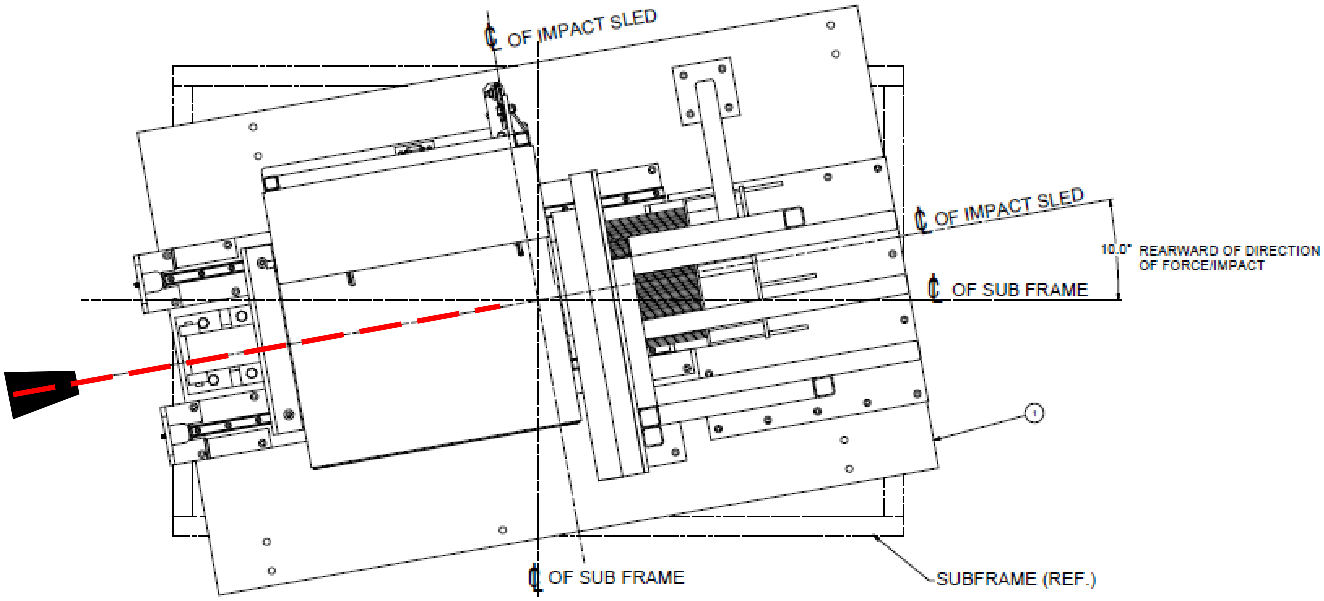


Figure 9. Recommended Camera Location for Pre-Test Photograph.

Figure 10. Sample Pre-Test Photograph from Recommended Camera Location.

Accordingly, Graco recommends an update to the side impact dynamic test setup procedure at section 12.D.7 in the second group of instructions (following the statement "When all pretest requirements are met"), specifically in step (3), to add a new sub-step ix:

> xii. A photo from a camera mounted on a tripod, perpendicular to the sliding sled and at a height in alignment with the top of the vehicle door arm rest foam, far enough away from the CRS to capture the entire SISA.

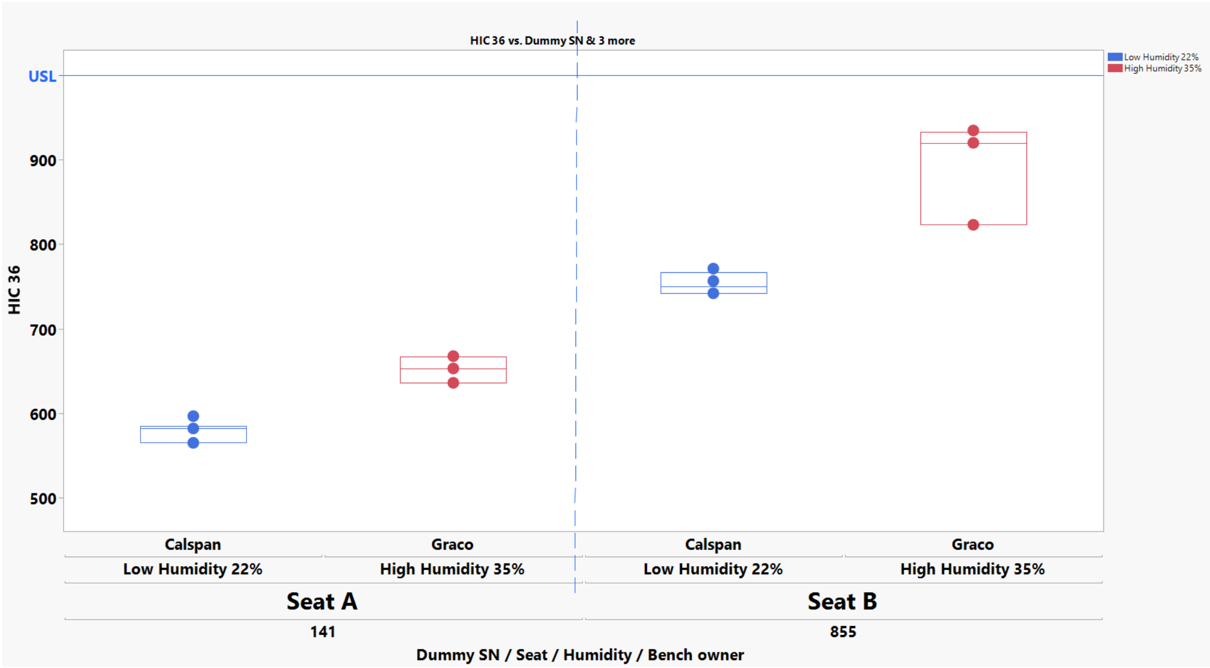
(2) Foam Storage and Pre-Test Conditioning

Graco contracted with Calspan to fabricate a frontal impact bench for FMVSS 213b (NHTSA Standard Seat Assembly; FMVSS No. 213, No. NHTSA–213–2021). During a qualification series at Calspan, Graco performed comparison testing using the same child restraint system models, Hybrid III 6-year-old dummies, and sled, with the only variable being the new Graco bench and the existing Calspan bench. In the course of this testing, it was determined that one of the largest driving factors in HIC was the Relative Humidity of the lab. Newell Brands believes that the foam should be stored and tested in a tight temperature and humidity-controlled environment.

Table 2 provides a summary of the experiment design. Figure 11 shows the relative effect of relative humidity in the laboratory on HIC scores at values of 22% RH versus 35% RH. These findings are consistent with prior NHTSA research cited in Section 12.E.1.1 footnotes 4 and 5.

Table 2. Relative Humidity Experiment Design.

Date	Lab RH	Bench	Seat A	Seat B
February 2024	22%	Calspan production 213b bench	Forward-facing, Type 1, no tether	Forward-facing, Type 2, no tether
April 2024	35%	Graco 213b bench, built by Calspan	Forward-facing, Type 1, no tether	Forward-facing, Type 2, no tether



<u>Figure 11</u>. <u>HIC Score Variance at Differing Laboratory Relative Humidity Values</u>.

To improve test consistency and to be consistent with side impact testing using the SISA, Graco recommends the following information provided for side impact at Section 12.E.1.1 be added to the frontal test setup at Section 12.D.1.1 A

> NHTSA Research has shown that best practices for foam IFD response include storing the foam cushion in a temperature and humidity-controlled environment for at least 24 hours prior to conducting a test. If foam is continuously used, best practice is that under this contract, test labs shall store to foam cushions in an enclosed temperature and humidity-controlled room whenever the cushions are not being used for dynamic testing or undergoing force-deflection calibration. The enclosed room shall meet the following environmental conditions:
>
> Temperature 18.3°C (65°F) to 23.9°C (75°F)
>
> Relative Humidity 50% to 60%

Miscellaneous

Table 13 uses a value of 54 N as a limit for lower anchor, tether, and type 2 belt pre-test tension. The value provided in FMVSS 213a as the limit is 53.5 N. Graco requests that Table 13 be updated to be consistent with the standard.

Summary

Graco is committed to assist in the development of reliable and repeatable test methods. We welcome the opportunity to share any of our research data with NHTSA and we invite the agency to send us inquiries about any of the data underlying our comments today, and to partner with us on research testing to aid our common goal of a robust test methodology that reflects the reality of today's motor vehicles and the safety needs of child passengers.

Thank you for your time and consideration of these comments.

Graco Children's Products Inc.,

Sean Beckstrom
Chief Product Safety Counsel
6655 Peachtree Dunwoody Road NE
Atlanta, GA 30328

/attachments: Appendix A – Q3s Arm Angle Device Guide
Appendix B – FMVSS 213a Design of Experiments Q3s Arm Twist
Appendix C - JPMA DOE Control vs Uncontrol Arm angle and twist, ATD laser aligned, door foam height