Foam Feasibility Study

Final Report

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Acronyms and Abbreviations

CFD	Compression Force Deflection
CRS	Child Restraint System
FMVSS	Federal Motor Vehicle Safety Standards
HR	High Resilience
IFD/ILD	Indentation Force Deflection/Indentation Load Deflection
MDI	Methylene diphenyl diisocyanate; 4,4-diphenylmethane diisocyanate
NCMS	National Center for Manufacturing Sciences
NHTSA	National Highway Traffic Safety Administration
PFA	Polyurethane Foam Association
RH	Relative Humidity
VRTC	Vehicle Research and Test Center

1. Executive Summary

NHTSA specifies test equipment used to dynamically certify child restraint systems in accordance with federal regulations. Polyurethane foam material is one component of that test equipment. Currently, procuring and qualifying polyurethane foam to the specifications established by NHTSA presents numerous challenges to test laboratories and child restraint manufacturers. NHTSA was seeking to identify suppliers of foam meeting the new updated NHTSA FMVSS No. 213 bench specifications in the application of child restraint testing. Under contract DTNH22-14-D-00321L/0003 (effective September 19, 2016) , the National Center for Manufacturing Sciences (NCMS) and Calspan was tasked to find a minimum of three suppliers as viable sources for foams that had been developed for use on the upgraded FMVSS No. 213 test bench.

At the start of the project, the Polyurethane Foam Association (PFA) was contacted for insight regarding the type of foam specifications being sought. The PFA identified that there are two methods of producing the required foam products to meet specifications; the slabstock method and molding method. Potential suppliers using both methods were evaluated. PFA indicated that there are three grades of foam: conventional, microcellular and high resilience. PFA recommended using High Resilience (HR) foam to meet NHTSA's specified requirements.

Videos were provided to potential suppliers reflecting how the foam products are tested. A Foam Supplier Questionnaire (Appendix B) was developed and provided to all suppliers. Three potential suppliers provided responses. A Foam Handling Questionnaire (Appendix C) was developed and provided to select test facilities. Six test facilities provided responses. Fifteen foam suppliers were contacted. Foam suppliers were comprised of foam manufacturers and foam distributors.

Five suppliers indicated they could meet all or some of the NHTSA specifications. Two potential suppliers are manufacturers and verified their ability to meet NHTSA requirements. Those suppliers were Lear Corporation and The Woodbridge Group. There were three possible suppliers that were distributors that indicated they could meet the NHTSA requirements; however, did not provide all the required foam specifications.

2. Introduction

NHTSA specifies test equipment used to dynamically certify child restraint systems in accordance with federal regulations. Polyurethane foam material is one component of that test equipment. Currently, procuring and qualifying polyurethane foam to the specifications established by NHTSA presents numerous challenges to test laboratories and child restraint manufacturers. This feasibility study is the initial step in identifying applicable foam experts and manufacturers who are willing and able to facilitate addressing the various challenges with the current FMVSS No. 213 foam.

The laboratories that conduct child restraint dynamic tests (herein referred to as "Std. 213" or "FMVSS No. 213") procure foam from foam manufacturers. In order to identify the appropriate foam, the laboratories provide the foam characteristics specified by NHTSA in the Std. 213 drawing package. However, foam manufacturers have not reliably been able to provide products that meet the foam characteristics required by NHTSA for Std. 213 testing.

With respect to procuring test bench foam, the quantity of foam that would be procured by NHTSA and Std. 213-industry stakeholders is very small compared to the quantity of foam that other customers typically procure. In addition, the specifications and tolerances for Std. 213-compliant foam are relatively stringent compared to other industries. These two market factors combine to create a situation which makes procuring foam that reliably meets NHTSA's FMVSS No. 213 specification difficult.

In efforts to address these challenges, NHTSA informally collaborated with test laboratories and foam manufacturers to develop preliminary specifications and parameters to evaluate for the new bench foam.

NCMS and Calspan was tasked to find a minimum of three suppliers as viable sources for foams that had been developed for use on the upgraded FMVSS No. 213 test bench (referred to as "new updated foam" throughout this report) as specifically stated in section C.3 of the original proposal:

> *NHTSA seeks to identify multiple sources of procurement, of the foam specified by NHTSA, for the new updated FMVSS 213 bench specifications. The Contractor will identify experts within the foam industry and scan the marketplace to identify three (3) acceptable vendors. This feasibility study will include ensuring that those vendors specified can meet the NHTSA required technical testing specifications (e.g. 50% Indentation Force Deflection (IFD) or 25/65% IFD, 50% Compression Force Deflection (CFD) and density). This Task Order is intended to identify key requirements to further pursue addressing the full scope of challenges currently experienced with the FMVSS No. 213 test bench foam, from procuring to using foam for child seat testing.*

As noted above, NHTSA's foam specifications are 50% CFD, 25/50/65% IFD and density. Values are shown in Table 4-2 in Section 4 of this report. However, the seat pan and seat back specifications provided by NHTSA are noted below:

Specification for the four-inch seat pan foam:
101.6 x 482.6 x 711.2 mm (4" x 19" x 28")

Foam Supplier	Density Kg/m^3 (lb/ft^3)	IFD* 25% N (lb)	IFD 50% N (lb)	IFD 65% N (lb)	CFD** 50% kPa (lb/in^2)
NHTSA Specifications on Preliminary Bench	47 (2.9) ±10%	237 (53.3) ±15%	440 (98.9) ±10%	725 (162.9) ±15%	6.6 (0.96) ±10%

Specification for the two-inch seat back foam:
50.8 x 558.8 x 711.2 mm (2" x 22" x 28")

Foam Supplier	Density Kg/m^3 (lb/ft^3)	IFD* 25% N (lb)	IFD 50% N (lb)	IFD 65% N (lb)	CFD** 50% kPa (lb/in^2)
NHTSA Specifications on Preliminary Bench	47 (2.9) ±10%	157 (35.3) ^for reference	300 N (67.4) ±15%	480 (107.9) ^for reference	6.6 (0.96) ±10%

* Indentation Force Deflection (IFD)
** Compression Force Deflection (CFD); Per ASTM D3574-11
^ At the time of this effort the 25%/65% IFD tolerances were not finalized.

NHTSA provided foam specifications based on previous efforts in collaboration with The Woodbridge Group. Foam parameters resulting from the previous development work were used as the benchmark specifications or starting point in determining other potential suppliers.[1]

The project initiated with Calspan becoming familiar with the foam industry. The Polyurethane Foam Association (PFA) was identified and contacted for further information. PFA proved to be a valuable resource in identifying potential foam manufacturers, experts, providing assistance

[1] Wietholter, K, et al., (2016). Evaluation of Seat Foams for the FMVSS No. 213 Test Bench. (Docket No. NHTSA-2013-0055-0013). Washington, DC: National Highway Traffic Safety Administration. https://beta.regulations.gov/document/NHTSA-2013-0055-0013

in understanding the foam industry and confirming the applicability of current foam being sought.

PFA was interested to understand how the current and updated FMVSS No. 213 foam was manufactured in order to provide a recommendation. Calspan provided PFA with an in-depth description of the FMVSS No. 213 test procedure. Videos of actual child restraint tests conducted with the current foam and the new updated foam were provided. PFA was made aware of the FMVSS No. 213 test environment, such as test speed, accelerations, child restraint system (CRS) loads and interactions on the foam bench.

Upon a better understanding of the test environment and needs for the foam, PFA was able to educate and provide a recommendation for Calspan to move forward. PFA stated that there are two different ways to manufacture foam: slabstock method and molding method. The slabstock production method is used to produce most foam for furniture cushions, carpet cushions and bedding. The polymer mix is poured onto a moving conveyor with sides which can be 3" to 4" high, where it reacts and expands into a slab. The continuous slab is then cut, stored and allowed to cure for up to 24 hours, then undergoes fabrication into useful shapes for a wide range of applications. The molding production method is used primarily for automotive cushioning and office furniture. This process produces individual items by pouring the foam mixture into shaped molds where the foam reaction takes place within the enclosure.

Slabstock foam is the largest segment of flexible polyurethane foam in the industry. Flexible polyurethane foam is manufactured as a product of the reaction of two key raw materials, a polyol and a diisocyanate with water. When the raw materials are combined, the reaction forms bubbles and the mixture expands, like bread rising. In a matter of minutes, the reaction is complete and the raw materials are converted to usable products.[2]

PFA indicated that there are three grades of foam: conventional, microcellular and high resilience. High resilience foam, or HR foam, is open-cell, flexible polyurethane foam that has a less uniform (more random) cell structure that helps add support, comfort, and resilience (or bounce). HR foams have a high support factor and greater surface resilience than viscoelastic foams (i.e. memory foam). The recommendation from PFA was that a HR molded product was best to meet the foam specification. The HR foam product is predominantly used in automobile seats. This was later confirmed by both The Woodbridge Group and Lear Corporation, who are leading manufacturers for a large portion of the world's automobile seats.

PFA indicated that The Woodbridge Group would be a good vendor and additionally identified three other suppliers: FXI Corporation, Plastomer Corporation, and Future Foam, Inc.

A total of fifteen suppliers were contacted during the project duration, including both foam manufacturers and distributors. Contact information (i.e. name, address, phone number, main contact, and email address) of all suppliers contacted is provided in Appendix D. It is noted whether these suppliers are a distributor or a manufacturer, and whether they stated they can or cannot supply the foam to specification.

[2] www.pfa.org

This final report provides details of the responses of the fifteen foam suppliers contacted. Specifically, foam suppliers that represented themselves as able to meet all or some of the foam specifications were identified as: Century Foam Products, Comcast Urethane, Lear Corporation, Perfect Fit-McDonald Inc. and The Woodbridge Group. Century Foam Products and Comcast Urethane indicated they could meet the specifications, but did not provide their CFD and IFD values, respectively as shown in Appendix D. The Woodbridge Group did not provide a specifications sheet. However, The Woodbridge Group did specify the applicable foam. Values listed in the table were provided by NHTSA in collaboration with The Woodbridge Group.

Input from suppliers and stakeholders was sought in effort to better understand general foam handling practices. These questionnaires were developed with the intent to solicit insight about the use and storage of foam per the supplier, test labs and CRS manufacturers.

A Supplier Foam Questionnaire was sent to various suppliers and was completed by the following companies: Comcast Urethane, Lear Corporation, and The Woodbridge Group. See Appendix B for the Suppliers Foam Questionnaire. A summary of responses is included for each applicable supplier in Section 3 of this report. Lastly, a Foam Handling Questionnaire (Appendix C) was completed by two independent test labs and four CRS manufacturers who have their own test facilities. A summary and comparison of results are provided in Appendix F.

3. Foam Feasibility Study

The Foam Feasibility Study identified fifteen foam suppliers, consisting of both distributors and manufacturers of foam, both small and large suppliers based on production and volume of sales. The study included: 1) the current supplier (The Woodbridge Group), 2) suppliers originally contacted by NHTSA's Vehicle Research and Test Center (VRTC) and 3) additional suppliers identified by Calspan.

A summary of each supplier, contacted by Calspan, is listed below in alphabetical order. Some suppliers were more responsive than others and subsequently the amount of information varies for the individual companies.

1. Century Foam Products

Century Foam Products (Century) was referred by Penz Products. Century is a **small foam distributor** who works with foam manufacturers, such as, Carpenter Foam and Premier Foam. Century stated that they are able to meet the NHTSA required parameters but did not provide the CFD values for the selected foams as reflected in Appendix D.

The FMVSS No. 213 test procedure was discussed in-depth with Century Foam. Videos were provided of an actual child restraint test with the current foam and with the new updated foam. Century was educated on the FMVSS No. 213 test environment conditions and the need for repeatability. However, Century did not respond to the Suppliers Foam Questionnaire.

Century supplied price quotes on three grades of HR foam that they represented as meeting all or part of NHTSA's specifications. The HR foams are B-255565-103, R-25550-000, and Q41. Century supplied specifications sheets on all three foams and provided two samples of each foam type, 50.8 x 482.6 x 711.2 mm (2" x 19" x 28"). The applicable parameters for these foams are noted below and are summarized in Appendix E, Foam Suppliers Product Information. More details are provided on each foam per the specification sheets in Appendices H, I and J, respectively.

For foam type B-25565-103, the following specifications were provided. The density ranges from 39.25 to 42.45 kg/m^3 (2.45 to 2.65 lbs/ft^3), CFD was not provided and for certification IFD at 25% deflection of 101.6 mm (4"), ranges from 267 to 311N (60 to 70 lbs). See Appendix H for more specifications details. It is worth noting that only a portion of the density and IFD at 25% ranges fall within the updated NHTSA specifications. However, it is not clear whether the foam will fall fully within scope to comply with all specifications. For example, for IFD at25% the lower limit of this foam falls on the upper end of the NHTSA specifications for certification.

For foam type R-25550-000, the density ranges from 39.25 to 42.45 kg/m^3 (2.45 to 2.65 lbs/ft^3), CFD was not provided and for certification IFD at 25% deflection 101.6 mm (4"), ranges from 200 to 245N (45-55 lbs). For more details see Appendix I. Again, it is worth noting that a portion of the density range fall within the NHTSA specifications. However, the IFD at 25% overlaps more closely with the updated NHTSA specifications.

Thus, for foam type Q41, the density ranges from 41.65 to 45.65 kg/m^3 (2.60 to 2.85 lbs/ft^3). For certification, IFD at 25% deflection 101.6 mm (4”), ranges from 178 to 222N (40 to 50 lbs). The CFD was not provided. However, for more details see Appendix J. Again, it is worth noting that only a portion of the density and IFD at 25% ranges fall within the updated NHTSA specifications. They both fall within the lower range of the updated NHTSA specifications.

Finally, as foam distributor, there are no tooling charges for the three Century Foam products. The foam would be molded in a block and then cut to a required size.

2. Comcast Urethane

Comcast Urethane (Comcast) is a **small foam manufacturer** and stated that they are able to meet the NHTSA required parameters. Comcast did not provide any IFD values for the selected product. Comcast supplied a price quote for resin F 210-01 US colorless (RN 3542) HR foam that they represented as meeting NHTSA’s specifications.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Comcast was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. Comcast responded to the Suppliers Foam Questionnaire.

In response to the Suppliers Foam Questionnaire, Comcast noted that they are able to meet NHTSA’s specifications and understood how the foam was used. Without molding and testing the new updated foam, no comment was made as to the adequacy of the specifications. There is no recommendation of changing the current storing conditions in regards to temperature and humidity. Parts at Comcast are placed on racks flat and after cooling the parts are put inside the box on their side, not flat. This relieves pressure on the part. The recommendation for stacking is five parts high if laid flat and three high if set on side. Concerning the time period for foam storage, six months would not be a problem. Without testing, Comcast had no recommendation concerning the maximum amount of tests.

Comcast supplied a price quote on F 210-01 US colorless (RN 3542) HR foam and shows it meeting part of NHTSA’s specifications. The quotation was for a 101.6 x 482.6 x 711.2 mm (4” x 19” x 28”) seat foam and 50.8 x 482.6 x 711.2 mm (2” x 19” x 28”) seat back foam. The quote is based on the minimum of a 60 sets per order, fully utilizing a 30 gallon unit. Comcast would need to build an aluminum mold that would be made out of aluminum bar stock. Each piece would be molded separately which means it will have a skin on all six sides. Delivery of the molds, at the time of this effort, would be six weeks and delivery of the material would be two weeks.

Comcast uses a resin manufactured by Otto Bock Polyurethane Technologies, Inc. and assures that this will meet the required specifications. For foam type F 210-01 US colorless (RN 3542),

the following specifications were provided.[3] DIN EN ISO). The density ranges from 55 to70 kg/m^3 (3.43 to 4.37 lbs/ft^3). Per ASTM D3574-11, 50% CFD ranges from 3.5 to 6.0 kPa (0.51 to 0.87 lbs/in^2). The IFD values were not provided to confirm compliance with specifications. Additionally, no foam samples were provided to allow testing.

3. The Foam Factory

The Foam Factory is a **small foam distributor** that was originally contacted by the VRTC. The Foam Factory stated that the specifications could not be met.

The Foam Factory reviewed the specifications and determined the specifications could not be met. Foam Factory did not provide any details on any other possible specifications their foam could meet. The Suppliers Foam Questionnaire was not completed.

4. Future Foam

Future Foam was referred by Wisconsin Foam Products and PFA. Future Foam is a **large foam manufacturer** and stated that the specifications could not be met. Future Foam's response was simply due to insufficient volume from a business perspective and the limitation that Future Foam does not make a product with MDI.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Future Foam was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. The Suppliers Foam Questionnaire was not completed.

Future Foam reviewed the specifications. After checking with all of their pour plants, it was determined that none of the plants made a foam grade that met the required specifications. Future Foam indicated that the specifications are for a molded 4,4-diphenylmethane diisocyanate (MDI)[4] based foam and determined the specifications could not be met. This was determined mainly due to the limited potential volume to be generated for the foam. Future Foam's position was primarily based on their inability to produce molded foam using MDI and economy of scale was also a business concern.

5. FXI Corporation

FXI is a **large foam manufacturer** and stated that the specifications could not be met.

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[3] Note that the provided specification sheet denotes that values are met in accordance with European Standards (DIN EN ISO).

[4] Methylene diphenyl diisocyanate, most often abbreviated as MDI, is an aromatic diisocyanate. MDI reacts with polyols in the manufacture of polyurethane. The major application of 4,4'-MDI is the production of rigid polyurethane. These foams are typically good thermal insulators and used in nearly all freezers and refrigerators worldwide.

The FMVSS No. 213 procedure was discussed in depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. FXI was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. The Suppliers Foam Questionnaire was not completed.

FXI reviewed the specifications. FXI determined they could not meet the specifications. This was determined mainly due to the limited potential volume to be generated for the foam. However, FXI did recommend IR Specialty Foam, LLC as a possible supplier.

6. IR Specialty Foam, LLC

IR Specialty Foam (referred by FXI Corporation) is a **small foam manufacturer**.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. IR Specialty Foam was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. The Suppliers Foam Questionnaire was not completed.

IR Specialty Foam was unresponsive to follow-up communications. Therefore, no information was provided to (nor received from) IR Specialty Foam. It remains unclear as to whether IR Specialty Foam is able or unable to meet the specified foam.

7. Lear Corporation

Lear Corporation (Lear) is a **large foam manufacturer** and stated that they are able to meet the NHTSA required parameters.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Lear was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. Lear completed the Suppliers Foam Questionnaire.

In response to the Suppliers Foam Questionnaire, Lear noted they are able to meet the NHTSA specifications and understood how the foam was used. It was stated that the current foam specifications are adequate. Pertaining to the controlled humidity and temperature, long-term storage (more than 3 months) may require ambient conditions; however, it is recommended to store foam at lab conditions, 23 ±3°C (73 ±5.4°F) and 50 ±5% relative humidity (RH) prior to its use for testing application. For the test setup in FMVSS No. 213, it is recommended that foam be stored vertically without stack up. Based on the application of the foam blocks, three months would be the optimal storage time. Longer than six (6) months storage would require clean and controlled ambient conditions, 4.4 to 26.7°C (40 to 80°F) and 30 to 70% RH. A maximum of three to five tests per set was recommended. After each test (and prior to its use for new test), the foam should be inspected for any foam split damage, thickness loss and/or

foam collapse. Additionally, Lear strongly recommended measuring the foam hardness prior to usage. Also, it is noted that the foam must be conditioned overnight at 23°C (73°F)/50% RH prior to the hardness test. Lear did not provide the details on the hardness test.

Lear was one of two foam manufacturers who commented on the foam cover. They did not recommend using the "Christmas Packaging" wrapping method for the foam cover.[5] It was noted that this type of cover method increases variability; thus, reducing repeatability between labs and/or even within lab if multiple people were doing the wrapping. Designing a cover for the foam was highly recommended.

Since the updated NHTSA specifications were developed in collaboration with The Woodbridge Group, Calspan provided a sample of The Woodbridge Group foam to the Lear team. The Lear team immediately recognized and identified the type of foam.

Lear supplied a price quote and specification data sheets on their HR molded foam blocks that they represented as meeting all of NHTSA's specifications. Two samples of 1704-9 800G and 1704-10 805G foam were provided, measuring 101.6 x 393.7 x 393.7mm (4" x 15.5" x 15.5"). The applicable parameters for these foams with more details are in Appendix E.

For typical molded foam blocks, the following specifications were provided. The density was not provided. For certification, IFD at 50% is 191N (42.93 lbs). The CFD was provided per ASTM D3574 - Procedure J2 which is a percent of loss and not the compressed force deflection. The NHTSA CFD specification is load-force per surface area (KPa or lbs/in^2).

Lear provided pricing information. The final costs would be contingent on the amount of foam seat pad sets and time period of contract. The number of foam seat pad sets to be ordered are a variable in the tooling charge cost being waived or not. Volume variability affects pricing and economy of scale directly. Lear suggested that if volume was high enough, tooling charges could be waived.

8. Ohio Foam Corporation

Ohio Foam is a **large foam distributor** that was originally contacted by the VRTC. Ohio Foam reviewed the specifications and determined the specifications could not be met. Ohio Foam did not provide any details on any other possible specifications their foam could meet. Thus, Ohio Foam did not complete the Suppliers Foam Questionnaire.

9. Penn Foam

Penn Foam is a **small foam manufacturer** that currently supplies the current FMVSS No. 213 foam. Penn Foam reviewed the specifications and determined the specifications could not be met. The determination was made primarily due to the limited potential volume to be

[5] Wietholter, K., Louden, A., Sullivan, L., & Burton, R. (2016, June). Evaluation of seat foams for the FMVSS No. 213 test bench. Washington, DC: National Highway Traffic Safety Administration. This report cites the referenced wrapping technique,"Christmas Packaging".

generated for the foam. It is unclear as to whether Penn Foam is able or unable to make the specified foam. The Suppliers Foam Questionnaire was not completed.

10. Penz Products, Inc.

Penz Products (Products) is a **small foam manufacturer** and stated that the specifications could not be met.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Penz was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. Penz did not complete the Suppliers Foam Questionnaire.

Penz reviewed the specifications and determined the specifications could not be met. Penz stated that their equipment is geared to run much higher density foam. The lowest density they are able to manufacture is a little over 8 lbs/ft^3. Penz recommended Century Foam Products.

11. Perfect Fit-McDonald, Inc.

Perfect Fit-McDonald (Perfect-Fit) is a **large foam distributor** that was originally contacted by the VRTC. Perfect Fit stated that they are able to meet the NHTSA required parameters.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Perfect Fit was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. The Suppliers Foam Questionnaire was not completed.

Perfect Fit supplied price quotes on two grades of HR foam that they presented as meeting all or part of NHTSA's specifications. The HR foams are H250-21S1 Foamex and H270-40S1 Foamex. Perfect Fit also supplied five specification sheets and two samples of two types of foam with dimensions 101.6 x 660.4 x 711.2mm (4" x 26" x 28") and 50.8 x 660.4 x 711.2mm (2" x 26" x 28"). However, the two sample foams provided was the H290-55S1 Foamex and H270-40S1 Foamex. Samples of the above noted H250-21S1 Foamex were not provided.

Perfect Fit, as a foam distributor, does not require molding charge costs. The foam would be molded and cut to size. A price was quoted for a seat back cushion 50.8 x 558.8 x 711.2 mm (2" x 22" x 28") and a seat pan cushion, 101.6 x 482.6 x 711.2 mm (4" x 19" x 28").

12. Plastomer Corporation

Plastomer is a **large foam manufacturer** and stated that the specifications could not be met.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Plastomer was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads,

interactions on the foam bench and the need for repeatability. The Suppliers Foam Questionnaire was not completed.

Plastomer reviewed the specifications and determined the specifications could not be met. Plastomer noted that they could not test to 440N. The highest load Plastomer could test is 370N. Calspan advised that the 440N was not final, thus, requested a quote based on the 370N. No price quote and/or specification data sheet was received.

13. Unique Molded Foam

Unique Molded Foam is a **small foam manufacturer**.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Unique Molded Foam was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability.

Unique Molded Foam was unresponsive to follow-up communications. Therefore, no information was provided to (nor received from) Unique Molded Foam. It remains unclear as to whether Unique Molded Foam is able or unable to meet the specified foam.

14. Wisconsin Foam Products

Wisconsin Foam Products is a **small foam distributor** that was originally contacted by the VRTC. Wisconsin Foam Products stated that the specifications could not be met.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Wisconsin Foam Products was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. The Suppliers Foam Questionnaire was not completed.

Wisconsin Foam Products is a foam distributor that does not supply a MDI-based foam. Wisconsin Foam Products reviewed the specifications and determined the specifications could not be met. However, Wisconsin Foam Products recommended Future Foam.

15. The Woodbridge Group

The Woodbridge Group (Woodbridge) is a **large foam manufacturer** and worked with the VRTC to establish the new updated foam specifications. Woodbridge stated that they are able to meet the NHTSA required parameters.

The FMVSS No. 213 procedure was discussed in-depth. Videos of an actual child restraint test with the current foam and with the new updated foam were provided. Woodbridge was educated on the FMVSS No. 213 test environment, such as, test speed, accelerations, CRS loads, interactions on the foam bench and the need for repeatability. Woodbridge completed the Suppliers Foam Questionnaire.

In response to the Suppliers Foam Questionnaire, Woodbridge noted they are able to meet the NHTSA specifications and understood how the foam was used. Per ASTM standards, it is recommended that the foam is conditioned in a 50 ±5% RH and 23 ±2°C (73 ±4°F) environment for 24 hours prior to testing. Storing foam pads vertically will minimize the stacking force on any given pad. It is undetermined as to the maximum amount of pieces to be stacked. Pieces at the bottom of a pile that may be suspected of having been compressed during storage should be allowed to rest in the conditioned environment without any other pieces loaded atop them for 24 hours before testing, and the test should verify the initial height of the pad before proceeding. Theoretically, the pads could be stored indefinitely. To mitigate discoloring and other effects of UV light, bag the pieces in an opaque material (i.e. garbage bags). Any given piece could be continuously reused if allowed to rest between tests. Verification of the initial height of the piece prior to test would allow the operator to determine if the pad has taken a set and should be replaced. Based on the video shown, a further recommendation of developing a standard trim cover application and anchoring method may provide increased repeatability to the tests.

Woodbridge described their foam as a poured, molded foam product. Woodbridge explained that they are able to make the foam behave virtually the same way as if the foam were molded singularly in a mold. An individual molded piece would have "skin" on all six sides. Woodbridge noted that there would be negligible differences between what is currently supplied verses forming each piece individually with "skin" on all six sides. Woodbridge provided specifications and a quote on the mold costs for single molds for both the seat pan and seat back.

Woodbridge supplied price quote on HR foam that meet all or part of NHTSA's specifications. The HR foams are Comfortech Trimvisible[6]. Woodbridge also supplied specifications sheets on Comfortech Trimvisible and provided a 4" x 19" x 28" and a 2"x 22" x 28"sample of each. The applicable parameters for these foams are noted below (with more details provided in Appendix E).

For foam type Comfortech Trimvisible, the following specifications were provided: the density is 47 kg/m^3, per ASTM D3574-11 50% CFD is 6.6 pcf and for certification 50% IFD 440N.

[6] ComfortTech TrimVisible is the Woodbridge standard molded foam and encompasses the materials used to also make the Woodbridge ComfortSkive parts which is another HR foam that meets the updated specifications.

4. Discussion

During this study fifteen suppliers were identified consisting of five foam distributors and ten manufacturers. Five suppliers indicated that they were capable of providing the foam products at the required NHTSA specifications. Again, there are two methods of producing the required foam products, the slabstock method and molding method. Century Foam Products supplies slabstock foam. Slabstock foam does not require additional fees such as tooling and/or molds. Comcast Urethane, Lear Corporation, Perfect Fit-McDonald, Inc., and The Woodbridge Group all supply molded foam. Mold and tooling costs varied between vendors. Variability in cost was centered around annual production volume and how tooling and mold costs are established. All suppliers' information is included in Appendix E, Foam Suppliers. Table 4-1 provides the suppliers and foams that were defined as meeting the NHTSA specifications. The Verified Suppliers are those suppliers that provided data sheets which included the required NHTSA specifications. The Possible Suppliers are those suppliers who stated they could meet the NHTSA specifications, however, their provided data sheets did not include all of the required NHTSA specifications.

Table 4-1. Foam Suppliers

SUPPLIER	SPECIFICATIONS	
	Foam Grade	Minimum Sets
VERIFIED SUPPLIERS*		
Lear Corporation	Lear Molded Blocks	50
Woodbridge	Comfortech Trimvisible	5
POSSIBLE SUPPLIERS **		
Century Foam	R-25550-000 Premier Foam	50
Century Foam	B-25565-103 Premier Foam	50
Century Foam	Q 41 Century Carpenter Foam	50
Comcast Urethane	F210-01 US colorless (RN 3542) Otto Bock	60
Perfect Fit	H290-55S1 Foamex	0
Perfect Fit	H270-40S1 Foamex	0

*VERIFIED: met all parameters

**POSSIBLE: did not provide and/or meet all parameters

Five suppliers indicated they could meet all or some of the NHTSA specifications. Two of the potential suppliers are manufacturers: Lear and Woodbridge. The three remaining suppliers are distributors: Century Foam, Comcast Urethane and Perfect Fit. For the manufacturers there

will be a one-time tooling investment cost. The distributors have no tooling costs. Distributors typically offer lower price, smaller minimum requirements and faster service. Manufacturers tend to monitor quality and consistency of products better.

Based on discussions, both Lear and Comcast would supply a foam with “skin “ on all sides. Woodbridge is capable of providing “skin” on all sides; however, a molded approach would be required and additional costs included. Perfect Fit and Century’s foam would not have “skin” on all sides.

Calspan IFD Testing of Foam Specimens

For the purpose of this project all the suppliers who submitted a quote were asked to submit a sample specimen. See Appendix D which highlights which specimen/foam manufacturers were within the specifications.

Of the Verified and Possible Suppliers, all except Comcast were able to submit foam specimens. A sample was not received from Comcast at the time of this report. Calspan received a total of 18 sample specimens: 8 specimens of 2” thick and 10 specimens of 4” thick all in varying sizes, the smallest size being 15” x 15”.

The foam specimens were tested, at their respective sizes, at approximately the center of each specimen per ASTM D3574-11 Test B1. This was done on a United Calibration Machine (Figure 4-1) with a 203mm diameter (8”) indenter and perforated plate. The machine is set at zero for both the 2” thick and 4” thick material respectively. The machine is programmed to depress the thickness specified as the test requires.

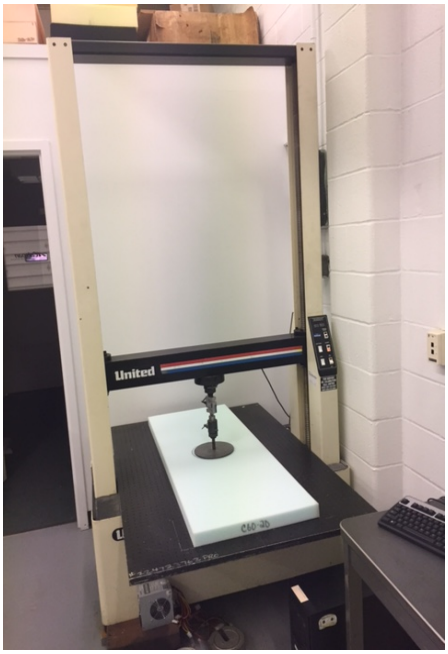

Figure 4-1. United Calibration Machine

The IFD test procedure includes a pre-flex of the test specimen to 75% of its original thickness two times at a rate of 250mm/min ±25mm. Before removing the test specimen from under the

indenter foot, draw the diameter of the indenter foot on top of the test specimen using a felt tip marker. When circumscribing the indenter foot on the test specimen, be certain that the test specimen is not moved laterally in any direction from the exact location where it was pre-flexed with the indenter foot. The circumscribed circle will be used for exact relocation of the indenter foot after the required waiting period. Be sure not to move the foam during waiting period.

After pre-flexing, a waiting period of six minutes ±1 minute is observed before performing the IFD test. The indention speeds are 50mm/minute (±5mm) as specified in ASTM D 3574 – 05 B1. After the six (6) minute waiting period, the test specimen height is again measured by using the one pound preload procedure in ASTM-D3574.

The indenter foot is indented into the foam 25% of specimen thickness and held for 60 seconds, 50% deflection for 60 seconds and held, then indented to 65% of specimen thickness and held for 60 seconds and released to starting height.

The reported IFD value is the force in pounds (lbs. or lbf), (then converted to Newton's) after each 60 second hold. See Table 4-2 with values compared to the NHTSA new updated specifications. Under consideration is IFD at 50%. Thus, an assessment of 50% IFD results was evaluated on the foams provided. NHTSA specifications for 2" and 4" are provided at the bottom of the table. Green on the table indicates where values fell within the NHTSA specifications. Again, note that sample foam sizes varied and are not necessarily the size of the Std. 213 bench foam.

Table 4-2. Calspan IFD Testing of Foam Samples

	Calspan IFD Testing of Foam Samples			6/23/2017
			(N)	(N)
Supplier	**Foam**	**Size of Foam**	**25%/65%**	**50%**
Century Foam Products	R-25550-000 Premier Foam	2”x19”x28”	196/380	282
Century Foam Products	B-25565-103 Premier Foam	2”x19”x28”	230/473	339
Century Foam Products	Q41 Carpenter Foam	2”x19”x28”	1489/441	281
Century Foam Products	R-25550-000 Premier Foam	4”x19”x28”	285/645	463
Century Foam Products	B-25565-103 Premier Foam	4”x19”x28”	303/682	480
Century Foam Products	Q41 Carpenter Foam	4”x19”x28”	193/629	387
Comcast Urethane	F210-01 US colorless (RN 3542)	No Sample Submitted	-	-
Lear Corporation	1704-9 800G	4”x15.5”x15.5”	187/583	363
Lear Corporation	1704-10 805G	4”x15.5”x15.5”	187/595	365
Perfect Fit-McDonald, Inc	H290-55S1 Foamex	2”x26”x28”	224/529	358
Perfect Fit-McDonald, Inc	H290-55S1 Foamex	2”x26”x28”	222/544	359
Perfect Fit-McDonald, Inc	H270-40S1 Foamex	2”x26”x28”	138/338	234
Perfect Fit-McDonald, Inc	H270-40S1 Foamex	2”x26”x28”	140/363	237
Perfect Fit-McDonald, Inc	H290-55S1 Foamex	4”x26”x28”	227/586	386
Perfect Fit-McDonald, Inc	H290-55S1 Foamex	4”x26”x28”	231/610	397
Perfect Fit-McDonald, Inc	H270-40S1 Foamex	4”x26”x28”	173/430	290
Perfect Fit-McDonald, Inc	H270-40S1 Foamex	4”x26”x28”	172/436	290
The Woodbridge Group	Comfortech Trimvisible	2”x22”x28”	191/501	345
The Woodbridge Group	Comfortech Trimvisible	4”x19”x28”	257/692	465
Notes:				
ASTM D3574-05 Test mode				
NHTSA Specs:		**Within Specifications**		
Seat Pan Cushion (**4” thick**)	50% IFD 440N ±10%	396N – 484N		
Seat Back Cushion (**2” thick**)	50% IFD 300N ±15%	255N – 345N		

Appendix A – Lessons Learned

- During this research effort, it was a challenge to find large manufacturers interested in assessing the foam requirements. Calspan attributes this observation as a results of limited projected volume.

- It was determined that there are two methods to manufacture foam: Slabstock and Molding. The slabstock production method is used to produce most foam for furniture cushions, carpet cushions and bedding. The molding production method is used primarily for automotive cushioning and office furniture.

- There are 3 kinds of foam: Conventional, Microcellular and High Resilience. Per PFA recommendation, high resilience (HR) foam (a mold production foam) is the best grade of foam to meet NHTSA's specifications. Throughout the study, HR was the foam recommended for use for the automotive industry.

- There is a mix of strengths and weakness with the five potential sources of supply identified in the report. Additional assessments and testing may be required to confirm compliance with specifications. The cost factors should be assessed for distributors verses manufacturers, including quality control of manufacturers verses distributors.

- The "Foam Handing Questionnaire" was completed by three independent labs and four CRS manufacturers. The variety of storage conditions across the different labs and suppliers suggest that having consistent storage guidelines might be beneficial to minimize any possible variability that could affect FMVSS No. 213 testing repeatability.

- Every potential supplier whether distributor or manufacturer, who viewed the two videos of the FMVSS 213 test(s) with the current foam and the new updated foam all agreed that the "Christmas packaging" used on the new updated foam was not a good situation. They all agreed that there could be variability between labs and even within a lab as multiple technicians install the covers during testing.

- It was a consensus by all respondents that a specified (fitted, custom) cover should be used.

Appendix B – Suppliers Foam Questionnaire

Suppliers Foam Questionnaire

1. What type of foam is it? Conventional, Micro Cellular or High Resilience?
2. How is the foam made? Slabstock or Molded?
3. Can you supply foam that meets the following specifications?
   - Density 47 kg/m3 (2.9 pcf) ±10%
   - Per ASTM D3574-11 50% CFD 6.6 kPa ±10%
   - For Certification 50% IFD 440 N ±10%
4. Do you understand how this foam is used?
5. Have you seen how the foam is used? Pictures? Videos?
6. The current foam is IFD tested to 25%/50%/65%. Do you feel this would be adequate for the foam?
7. The current foam is stored in Humidity controlled environment of 50% to 55% and a temperature of 69 degrees to 72 degrees. Should the new foam be in a controlled humidified environment? If so, what would you recommend that be?
8. What would be your recommendation for how the foam should be stored? Vertically or Horizontally? Does it make a difference?
9. What would be the maximum amount of pcs to be stacked if any?
10. How long should foam be stored for period? (i.e. one, two six months?)
11. Can you offer an expert opinion on what the maximum amount of tests should be per set based on your understanding of how it is used?
12. Do you have any recommendations about the foam that are not specified based on your overall foam experience and how we intend to use it?

Appendix C – Current FMVSS No. 213 Foam Handling Questionnaire

Current FMVSS 213 Foam Handling Questionnaire

1. Do you store your foam horizontally or vertically?
2. Do you stack your foam?
3. Do you store it in a controlled temperature environment? If yes, please provide details.
4. Do you store in a humidity controlled environment? If yes, please provide details.
5. Do you test the IFD/ILD in your lab? If so, how often? How do you perform testing?
6. Do you have the Foam Supplier do this function?

Appendix D – Foam Suppliers

APPENDIX D
FOAM SUPPLIER'S

Companies	Address	City	State	Zip Code	Phone	Name	Email	Distributor / Manufacturer	Quoted a Foam(s)	Received written response from supplier	Supplier states can meet all specifications	Supplier states can meet all specifications, all specs were reported/received
Century Foam Products	1235 W. Hively Avenue	Elkhart	IN	46517	574-295-8888	Jack Bowman	jbowman@centuryfoam.com	Distributor	Yes	Yes	Yes	No
Comcast Urethane	425 Leggit Road	Marshall	MI	49068	888-732-3894	Mark Warner	mwarner@ccurethane.com	Manufacturer	Yes	Yes	Yes	No
The Foam Factory	17500 23 Mile Road	Macomb	MI	48044	586-627-3626	Linda	www.foambymail.com/contact-us	Distributor	No	No	No	No
Future Foam	2210 Parview Road	Middleton	WI	53562	608-770-2532	Jim Mulvey	jmulvey@futurefoam.com	Manufacturer	No	No	No	No
FXI Corporation	1400 N. Providence Road	Media	PA	19063	610-744-2300	Doug Karp	dkarp@fxi.com	Manufacturer	No	No	No	No
IR Specialty Foam, LLC	3500 20th Street, Suite B	Fife	WA	98424	800-426-7944	Todd Olstad	tolstad@irfoam.com	Manufacturer	No	No	No	No
Lear Corporation	21700 Telegraph Road	Southfield	MI	48033	248-447-7832	Russ Davidson	rdavidson@lear.com	Manufacturer	Yes	Yes	Yes	Yes
Ohio Foam Corporation	529 S. Kibler Street	Washington	OH	44854	419-492-2151	Peter Kesler	www.ohiofoam.com/contact	Distributor	No	No	No	No
Penn Foam	2625 Mitchell Avenue	Allentown	PA	18103	610-797-7500	Bob Fromknecht	bob@pennfoam.com	Manufacturer	No	No	No	No
Penz Products, Inc.	1320 S. Merrifield Avenue.	Mishawaka	IN	46544	574-255-4736	Roy Szymanski	rszymanski@penzproductsinc.com	Manufacturer	No	No	No	No
Perfect Fit-McDonald, Inc.	18249 Olympic Avenue South	Tukwila	WA	98188	253-220-4412	Mark Roddy	markr@perfectfit.com	Distributor	Yes	Yes	Yes	Yes
Plastomer Corporation	37819 Schoolcraft Road	Livonia	MI	48150	734-464-0700	Bill Christoferson	william.christofferson@plastomer.com	Manufacturer	No	No	No	No
Unique Molded Foam	13221 Allman Road	Concord	MI	49237	517-524-9010	Tim	N/A	Manufacturer	No	No	No	No
Wisconsin Foam Products	4601 Tompkins Drive	Madison	WI	53716	608-221-4385	Jim Olson	jim@wifoam.com	Distributor	No	No	No	No
The Woodbridge Group	1515 Equity Drive	Troy	MI	48084	248-280-6314	David Ludberg	david.ludberg@woodbridgegroup.com	Manufacturer	Yes	Yes	Yes	Yes

Appendix E – Foam Suppliers Product Information

APPENDIX E

FOAM SUPPLIER'S PRODUCT INFORMATION

Test methods are specified to ASTM Standards

Density, 50% Indentation Force Deflection (IFD) or 25/65% IFD, and 50% Compression Force Deflection (CFD)

Supplier	Name	Email	Foam Grade	Type	Density (PFC = lbs/ft^3)	Indentation Force Deflection (IFD)	Compression Force Deflection (CFD) (PSI = lbs/in^2)
National Highway Traffic Safety Administration (NHTSA) Speifications					47 kg/m^3 (2.9 pcf) ± 10% 2.9 ± 10% (2.62 - 3.19)	**25% IFD** 237 N (53.2lbs) ± 15% 53.2 ± 15% (45.2 - 61.2) **50% IFD** 440 N (98.9lbs) ± 10% 98.9 ± 10% (89.0 - 108.8) **65% IFD** 725 N (162.9lbs) ± 15% 162.9 ± 15% (138.5 - 187.3)	5**0% CFD** 6.6 kPa (0.95 psi) ± 10% 0.95 ± 10% (0.86 - 1.05)
Century Foam Products	Jack Bowman	jbowman@centuryfoam.com	R-25550-000 Premier Foam	Slabstock	42.45 kg/m^3 (2.65 pcf)	@ 25%; 200.17 - 244.65 N (45.00 - 55.00 lbs) @ 50%; not reported @ 65%; not reported	Did Not Supply
Century Foam Products	Jack Bowman	jbowman@centuryfoam.com	B-25565-103 Premier Foam	Slabstock	42.45 kg/m^3 (2.65 pcf)	@ 25%; 266.89 - 311.38 N (60.00 - 70.00 lbs) @ 50%; not reported @ 65%; not reported	Did Not Supply
Century Foam Products	Jack Bowman	jbowman@centuryfoam.com	Q 41 Carpenter Foam	Slabstack	45.65 kg/m^3 (2.85 pcf)	@ 25%; 177.93 - 222.41 N (40 - 50 lbs) @ 50%; not reported @ 65%; not reported	Did Not Supply
Comcast Urethane	Mark Warner	mwarner@ccurethane.com	F 210-01 US colorless (RN 3542)	Molded	70 kg/m^3 (4.37 pcf)	Did Not Supply	Did Not Supply
Lear Corporation	Russ Davidson	rdavidson@lear.com	Lear Molded Blocks	Molded	49.98 kg/m^3 (3.12 pcf)	@ 25%; 123.57 - 204.62 N (22.78 - 46.00 lbs) @ 50%; 190.96 N (42.93 lbs) @ 65%; not reported	Did Not Supply
Perfect Fit-McDonald, Inc.	Mark Roddy	markr@perfectfit.com	H290-55S1 Foamex	Molded	48.86 kg/m^3 (3.05 pcf)	@ 25%; 222.41 - 266.89 N (50.0 - 60.0 lbs) @ 50%; not reported @ 65%; 524.89 N (118.0 lbs min)	Did Not Supply
Perfect Fit-McDonald, Inc.	Mark Roddy	markr@perfectfit.com	H270-40S1 Foamex	Molded	45.33 kg/m^3 (2.83 pcf)	@ 25%; 164.58 - 191.27 N (37.0 - 43.0 lbs) @ 50%; not reported @ 65%; 422.58 N (95.0 lbs min)	Did Not Supply
The Woodbridge Group	David Ludberg	david.ludberg@woodbridgegroup.com	Comfortech Trimvisible	Molded	47 kg/m^3 (2.93 pcf)	@ 25%; not reported @ 50%; 440 N (98.92 lbs) @ 65%; not reported	6.6 kPa (0.96 psi)

*All price quotes are for new 213 bench foam

Category	Range
Seat Pan Price / each	$13.50 - $160.00
Seat Back Price / each	$8.00 - $230.00
Cost per Set	$21.72 - $460.82
Minimum Sets	5 - 60
Mold Costs	$7,600 - $45,000

Appendix F – Foam Handling Comparison Data Sheet

Current FMVSS 213 Foam Handling Comparison Data Sheet

Questions	Respondant #1	Respondant #2	Respondant #3	Respondant #4	Respondant #5	Respondant #6	Respondant #7
1) Do you store your foam horizontally or vertically?	Vertically	Horizontally	Vertically	Horizontally	Horizontally	Horizontally	We store our foam vertically on the front/back edge.
2) Do you stack your foam?	No	Yes, in short stacks no higher than 2'6"	No	Yes	Yes	Yes	No. We have a specially built rack system that holds the foam vertically in pairs (2" and 4" piece together).
3) Do you store in a controlled temperature environment? If yes please provide details.	Yes. Between 20.6 and 22.2 °C	Yes, foam is stored in the sled lab at the same environment in which it is tested. (69-72°F)	Yes. We store it in a controlled environment of 69 - 72 degrees F.	Yes, All the foam is stored between 20.6 and 22.2 degrees C	Yes, Storage is in a test lab area at 75 degrees captured digitally	No	Foam is stored in our office that is kept at 70 degrees F nominal.
4) Do you store in a humidity controlled environment? If yes please provide details.	Yes. Between 10 and 70%	Yes, foam is stored in the sled lab at the same environment in which it is tested. (10-70% RH)	Yes we store the foam in a controlled humidity environment of 50-55%.	Yes, all the foam is stored between 10 and 70 percent humidity	Yes, Storage is in test lab area at 60% humidity captured digitally	No	No, not beyond normal HVAC system's ability to control humidity.
5) Do you test the IFD/ILD in your lab? If so how often? How do you perform testing?	Yes, as per protocol, for every dynamic tests. Our automated compression foam device follows steps from ASTM D3574-08 subsection Test B1	Yes. After a dynamic sled test, foam is allowed a 12 hour recovery period. It is then requalified with the ILD test and allowed an additional 12 hour recovery period before being used again in a dynamic sled test. Foam is not used in consecutive sled tests unless specifically requested by the customer. Testing is performed using a foam testing machine as outlined by ASTM D3574. The process is automated using LabView software and validated in terms of time, distance, and load before put into use	Yes, we test the foam once a month with a United Calibration machine to ASTM D3574.	Yes. Each piece of foam is tested at a minimum 24 hours after each time that is on the sled. The machine that performs the testing is a Schap PC Based IFD tester.	Yes, we replace and test foams daily	Yes. At least a day or 24 hours after a crash test. With an Instron with foam standard	After three sled tests the foam is removed from the test bench and allowed to recover for 24 hours. It is then tested for IFD using an Instron load frame using the test methodology and apparatus described in ASTM Standard D1564-71 "Standard Method of Testing Flexible Cellular Materials-Slab Urethane Foam."
6) Do you have your foam supplier do this function?	No	While we do ask that the foam supplier test each piece before sending it out, this information is used only as a reference. Differences in laboratory conditions, test performance, and equipment all have an effect on ILD testing results. Because of this, we only consider the results obtained in our laboratory environment.	Yes, we expect supplier to do a batch testing on every order to insure the foam meets specifications on PO. We test all foam before it is used. We find at times the foam comes inn stiffer than required. We put it though a roller machine to bring it into tolerance.	The supplier tests a couple pieces from the initial batch to ensure that it is on the high side of the allowable range. If the foam is delivered over the range, we use it in overload testing until it drops into range. If the foam comes in too low, we reject it.	Yes, our supplier provides data meeting the requirements and we test upon receipt of foam orders. Any receipt of foam that does not meet is discarded and purchase credit is issued.	They do their own testing before shipping out the batch of foam.	The supplier tests the foam before they send it to us. We test it again at in coming inspection and from then on as described above.

Appendix G – Comcast Urethane Otto Bock Specifications Sheet

TECHNICAL DATA SHEET

ottobock.

Issue date: 04-14-2015

Flexible Polyurethane Foam System
F 210-01 US colorless (RN 3542)

Application: HR cold cure flexible foam system for all kinds of upholstery, especially in the furniture industry. The low odour and low emission system (e. g. BHT free) F 210-01 US Colorless RN 3542 passes several burning tests.

Properties of the components

		polyol component			isocyanate component		
Density at 20°C	[g/cm^3]	1.02	±	0.02	1.21	±	0.05
Viscosity at 25°C	[mPa·s]	1100	±	150	40	±	20
Mixing ratio		100 pbw polyol			39 pbw isocyanate		

Reaction profile (hand mix) at 24 °C material temperature

Cream time	[s]	11	±	3
Rise time	[s]	73	±	7
Free rise density (FRD)	[kg/m^3]	56	±	6

Mechanical properties (machine test samples)

		foam			tested acc. to
Density	[kg/m^3]	55	-	70	DIN EN ISO 845
Tensile strength	[kPa]	100	-	120	DIN EN ISO 1798
Elongation	[%]	100	-	110	DIN EN ISO 1798
Compression strength at 40% compression	[kPa]	3.5	-	6.0	DIN EN ISO 3386
Tear strength	[N/mm]	0.14	-	0.37	DIN EN ISO 53 356
Compression set (50%)	[%]	3.5	-	8.5	DIN EN ISO 1856

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TECHNICAL DATA SHEET

ottobock.

Issue date: 04-14-2015

Instructions for use

Attention: While using polyurethane chemicals, it is necessary to wear personal protective equipment incl. safety glasses! For specific details, please consult MSDS of the product. The polyol has to be stirred before processing and during production. Containers must be kept tightly closed and protected from moisture and impurities. High pressure as well as low pressure mixing and dosing equipment can be used for processing. It is required to use conventional release agents for the production of molded parts.

Recommended parameters

Material temperatures	[°C]	30	±	5	
Mixing pressure (high pressure)	[bar]	160	±	40	
Mold temperature	[°C]	55	±	10	
Demolding time	[min]	3	±	1	depending on design of the part

Storage / shelf life

Component	storage temperature	shelf life, closed container
Polyol A	15-30°C	6 months
Isocyanate B	15-30°C	6 months

Transport temperature / short-term deviation

Component	transport temperature	short-term deviation from transport temperature
Polyol A	0-50°C	no effect
Isocyanate B	15-50°C	<15°C: potential crystallization* >50°C: no effect

*This type of crystals can be dissolved almost completely by slow and short-term heating up to 50°C, preferably using a hot-air oven.

Please note

The values listed in the data sheet were measured on test pieces. All information and technical advices are based on our current knowledge and experience, but should be considered to be non-binding in nature. No legal claims can be derived from this information. The relevant requirements for the end use must be verified by the processor in independent tests.
This technical data sheet replaces all previous versions.

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Appendix H – Century Premier-B 25565 103 Specifications Sheet

Premier Foam™

Polyurethane Foam Grade Specification

B-25565-103

Property	Requirement		Test Method
Density	2.45 - 2.65	lbs/ft³	ASTM D3574
IFD @ 25% Deflection 4"	60.00 - 70.00	lbs/50 in²	ASTM D3574
Elongation	100%	minimum	ASTM D3574
Tensile Strength	10 lbs/in²	minimum	ASTM D3574
Tear Resistance	1.00 lbs/lineal inch	minimum	ASTM D3574
Support Factor	1.80	minimum	
Color	Very Pale Yellow		
Bio-Polyol	Yes		
Fire Retardant	Pass		Cal 117-2013 (smolder) / NFPA260
Anti-microbial	Pass		Method G21, Method 30, Method 147

Last Revision: 08/3/2016

Note: The Cal 117-2013 Smolder test is not intended to reflect performance presented by this material under actual fire conditions. Only "F" and "FB" grades will contain a fire retardant additive.

Appendix I – Century Premier-R 25550 000 Specifications Sheet

Premier Foam™

Polyurethane Foam Grade Specification

R-25550-000

Property	Requirement		Test Method
Density	2.45 - 2.65	lbs/ft³	ASTM D3574
IFD @ 25% Deflection 4"	45.00 - 55.00	lbs/50 in²	ASTM D3574
Elongation	100%	minimum	ASTM D3574
Tensile Strength	8 lbs/in²	minimum	ASTM D3574
Tear Resistance	1.00 lbs/lineal inch	minimum	ASTM D3574
Support Factor	1.80	minimum	
Color	White		
Bio-Polyol	Yes		
Smolder Resistant	Pass		TB117-2013 (smolder) / NFPA 260

Last Revision: 07/15/2014

Note: The Cal 117-2013 Smolder test is not intended to reflect performance presented by this material under actual fire conditions.

This material does not contain a fire retardant additive.

Appendix J – Century Carpenter-Q 41 Specifications Sheet

CARPENTER CO. - ELKHART DIVISION
FOAM SPECIFICATION SHEET

Q-41

FOAM TYPE	QVZ40265GD
PHYSICAL FOAM PROPERTY	CARPENTER SPECIFICATION
Density (pcf)	2.60 - 2.85
Identation Force Deflection (lbs) 25% IFD @ 4 x 15 x 15	40 - 50
Tensile Strength (psi)	10 min.
Tear Strength (ppi)	1 min.
Elongation (%)	100% min.
Flammability Federal Motor Vehicle Safety Std 302 California T.B. 117-2013	Pass

Physical testing performed based upon Carpenter Test Methods unless otherwise specified.
Carpenter Test Methods are based upon ASTM D3574 and/or other applicable standards.
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Appendix K – Lear Foam Specifications Data Sheet

Molded Foam Blocks **Lear Foam Spec Data Sheet** 4/4/2017

Typical Physical Properties

Item #	Properties	Test Method	Units	Test Results	
1	Density	ASTM D3574-08	kg/m3	35.00	50.00
2	Indention Force Deflection	ASTM D3574 Test B1 or ISO 2439 Method C	Lbf		
	original 25 % IFD, Ibf			22.78	46.00
	original 40% IFD, Ibf			33.27	65.50
	original 50% IFD, Ibf			42.93	0.00
3	Constant Force Pounding Height Loss and IFD Loss	ASTM D 3574 Test I3 Procedure B	%	2.03	2.10
				18.37	21.00
4	Hysteresis Loss	ASTM D 3574 App.X6 , Procedure A	%	22.33	24.25
5	Tensile Strength	ISO 1798	kPa	109.74	165.47
6	Tensile Elongation	ISO 1798	%	105.92	94.50
7	Tear Resistance	ASTM D624 Die C or ISO34	N/m	670.22	569.15
8	Comp Set - 50% @ 70C	ASTM D3574 D or ISO1856 A	% max	5.28	7.00
	Comp Set after steam autoclave	ASTM D3574 D procedure J2 -5 hour @120C	% max	14.00	18.50
9	CFD Loss after Steam autoclave	ASTM D 3574 D, procedure J2	%	13.73	22.50
10	Flammability	Must Comply with FMVSS 302 Test	mm/min	Pass	Pass

Appendix L – Perfect Fit-McDonald Inc. Specifications Sheets

APPENDIX K
Perfect Fit-McDonald, Inc.

Foamex

SALES SPECIFICATION
HIGH RESILIENCE (HR) POLYETHER POLYURETHANE FOAM

FOAM GRADE: H250-21S1
COLOR: PEACH

EFFECTIVE: 10-11-07
SUPERSEDES: 05-24-06

TEST ITEM	UNIT	RANGE	TEST METHOD
DENSITY	PCF	2.37-2.62	ASTM 3574
I.F.D. @ 4" THICK			
- 25% DEFLECTION	LBS.	18.0-24.0	ASTM 3574
- 65% DEFLECTION	LBS.	45.0 MIN.	ASTM 3574
SUPPORT FACTOR	RATIO	2.40 MIN.	
RECOVERY	%	85 MIN.	
HYSTERESIS LOSS	%	15 MAX	
CONSTANT DEFLECTION COMPRESSION SET			
- 90% DEFLECTION	%	10 MAX.	ASTM 3574
- 75% DEFLECTION	%	8 MAX.	ASTM 3574
- 50% DEFLECTION	%	3 MAX.	ASTM 3574
STEAM AUTOCLAVE AGING - COMPRESSION SET @ 50% DEFLECTION	%	N/A	ASTM 3574
DRY HEAT AGING - COMPRESSION SET @ 50% DEFLECTION	%	5 MAX.	ASTM 3574
AIR FLOW	CFM	1.0 MIN.	ASTM 1564
RESILIENCE (BALL TEST)	%	60.0 MIN.	ASTM 3574
TENSION TEST - TENSILE STRENGTH	PSI	12.0 MIN.	ASTM 3574
- ULTIMATE ELONGATION GRIP SEPARATION	%	100 MIN.	ASTM 3574
TEAR RESISTANCE	PLI	1.40 MIN.	ASTM 3574
STATIC FATIGUE 75% - I. F. D. LOSS @ 25%	%	10 MAX.	ASTM 3574
- THICKNESS LOSS @ 75% COMPRESSION	%	1 MAX.	ASTM 3574

FLAMMABILITY PERFORMANCE *	
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. A, PART I	PASS
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. D, PART II	PASS
- FEDERAL M.V.S.S. 302	PASS
- FAA, FAR 25.853 (B)	MEETS

* THIS FLAMMABILITY DATA IS NOT INTENDED TO REFLECT HAZARDS PRESENTED BY THIS OR ANY OTHER MATERIAL UNDER ACTUAL FIRE CONDITIONS.

NOTE: FAA , FAR 25.853 (B) MUST BE TESTED EACH RUN BY A INDEPENDENT CERTIFIED LAB TO CERTIFY FOR USE ON AIRCRAFT. THIS MATERIAL HAS BEEN TESTED AND MEETS THIS STANDARD.

e above specifications have been reviewed and approved. Steve Gould — Signature
Plant Line Manager — Title
7/11/08 — Date

APPENDIX K
Perfect Fit-McDonald, Inc.

Foamex

SALES SPECIFICATION
HIGH RESILIENCE (HR) POLYETHER POLYURETHANE FOAM

FOAM GRADE: H250-28S1
COLOR: PEACH

EFFECTIVE: 02-13-01
SUPERSEDES: 12-04-00

TEST ITEM	UNIT	RANGE	TEST METHOD
DENSITY	PCF	2.37-2.62	ASTM 3574
I.F.D. @ 4" THICK			
- 25% DEFLECTION	LBS.	25.0-31.0	ASTM 3574
- 65% DEFLECTION	LBS.	63.0 MIN.	ASTM 3574
SUPPORT FACTOR	RATIO	2.50 MIN.	
RECOVERY	%	85 MIN.	
HYSTERESIS LOSS	%	N/A	
CONSTANT DEFLECTION COMPRESSION SET			
- 90% DEFLECTION	%	10 MAX.	ASTM 3574
- 75% DEFLECTION	%	8 MAX.	ASTM 3574
- 50% DEFLECTION	%	5 MAX.	ASTM 3574
STEAM AUTOCLAVE AGING - COMPRESSION SET @ 50% DEFLECTION	%	N/A	ASTM 3574
DRY HEAT AGING - COMPRESSION SET @ 50% DEFLECTION	%	N/A	ASTM 3574
AIR FLOW	CFM	1.0 MIN.	ASTM 1564
RESILIENCE (BALL TEST)	%	60.0 MIN.	ASTM 3574
TENSION TEST - TENSILE STRENGTH	PSI	13.0 MIN.	ASTM 3574
- ULTIMATE ELONGATION GRIP SEPARATION	%	100 MIN.	ASTM 3574
TEAR RESISTANCE	PLI	1.20 MIN.	ASTM 3574
STATIC FATIGUE 75% - I. F. D. LOSS @ 25%	%	10 MAX.	ASTM 3574
- THICKNESS LOSS @ 75% COMPRESSION	%	1 MAX.	ASTM 3574

FLAMMABILITY PERFORMANCE *	
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. A, PART I	PASS
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. D, PART II	PASS
- FEDERAL M.V.S.S. 302	PASS
- FAA, FAR 25.853 (B)	MEETS

* THIS FLAMMABILITY DATA IS NOT INTENDED TO REFLECT HAZARDS PRESENTED BY THIS OR ANY OTHER MATERIAL UNDER ACTUAL FIRE CONDITIONS.

NOTE: FAA , FAR 25.853 (B) MUST BE TESTED EACH RUN BY A INDEPENDENT CERTIFIED LAB TO CERTIFY FOR USE ON AIRCRAFT. THIS MATERIAL HAS BEEN TESTED AND MEETS THIS STANDARD.

The above specifications have been reviewed and approved. Signature Pauline Manger Title 7/11/09 Date

APPENDIX K Perfect Fit-McDonald, Inc.

PERFECT FIT-McDONALD, INC.
18249 OLYMPIC AVE S.
TUKWILA WA 98188

Foamex

SALES SPECIFICATION
HIGH RESILIENCE (HR) POLYETHER POLYURETHANE FOAM

FOAM GRADE: **H250-35S1** EFFECTIVE: 02-13-01
COLOR: PEACH SUPERSEDES: 12-04-00

TEST ITEM	UNIT	LIMITS	TEST METHOD
DENSITY	PCF	2.37-2.62	ASTM 3574
I.F.D. @ 4" THICK			
- 25% DEFLECTION	LBS.	32.0-38.0	ASTM 3574
- 65% DEFLECTION	LBS.	80.0 MIN.	ASTM 3574
SUPPORT FACTOR	RATIO	2.50 MIN.	
RECOVERY	%	80 MIN.	
HYSTERESIS LOSS	%	20 MAX	
CONSTANT DEFLECTION COMPRESSION SET			
- 90% DEFLECTION	%	10 MAX.	ASTM 3574
- 75% DEFLECTION	%	8 MAX.	ASTM 3574
- 50% DEFLECTION	%	3 MAX.	ASTM 3574
STEAM AUTOCLAVE AGING - COMPRESSION SET @ 50% DEFLECTION	%	N/A	ASTM 3574
DRY HEAT AGING - COMPRESSION SET @ 50% DEFLECTION	%	5 MAX.	ASTM 3574
AIR FLOW	CFM	1.0 MIN.	ASTM 1564
RESILIENCE (BALL TEST)	%	60.0 MIN.	ASTM 3574
TENSION TEST			
- TENSILE STRENGTH	PSI	15.0 MIN.	ASTM 3574
- ULTIMATE ELONGATION GRIP SEPARATION	%	100 MIN.	ASTM 3574
TEAR RESISTANCE	PLI	1.50 MIN.	ASTM 3574
STATIC FATIGUE 75%			
- I. F. D. LOSS @ 25%	%	10 MAX.	ASTM 3574
- THICKNESS LOSS @ 75% COMPRESSION	%	1 MAX.	ASTM 3574

FLAMMABILITY PERFORMANCE *	
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. A, PART I	PASS
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. D, PART II	PASS
- FEDERAL M.V.S.S. 302	PASS
* FAA , FAR 25.853 (B)	MEETS

- THIS FLAMMABILITY DATA IS NOT INTENDED TO REFLECT HAZARD PRESENTED BY THIS OR ANY OTHER MATERIAL UNDER ACTUAL FIRE CONDITIONS.

NOTE: FAA , FAR 25.853 (B) MUST BE TESTED EACH RUN BY A INDEPENDENT CERTIFIED LAB TO CERTIFY FOR USE ON AIRCRAFT. THIS MATERIAL HAS BEEN TESTED AND MEETS THIS STANDARD.

The above specifications have been reviewed and approved. Steve Smith (Signature) Operative Manager (Title) 7/11/08 (Date)

APPENDIX K
Perfect Fit-McDonald, Inc.

Foamex

SALES SPECIFICATION
HIGH RESILIENCE (HR) POLYETHER POLYURETHANE FOAM

FOAM GRADE: H270-40S1 — EFFECTIVE: 01-12-04
COLOR: PEACH — SUPERSEDES: 02-13-01

TEST ITEM	UNIT	RANGE	TEST METHOD
DENSITY	PCF	2.56-2.83	ASTM 3574
I.F.D. @ 4" THICK.			
- 25% DEFLECTION	LBS.	37.0—43.0	ASTM 3574
- 65% DEFLECTION	LBS.	95.0 MIN.	ASTM 3574
SUPPORT FACTOR	RATIO	2.50 MIN.	
RECOVERY	%	80 MIN.	
HYSTERESIS LOSS	%	20 MAX	
CONSTANT DEFLECTION COMPRESSION SET			
- 90% DEFLECTION	%	10 MAX.	ASTM 3574
- 75% DEFLECTION	%	8 MAX.	ASTM 3574
- 50% DEFLECTION	%	3 MAX.	ASTM 3574
STEAM AUTOCLAVE AGING - COMPRESSION SET @ 50% DEFLECTION	%	N/A	ASTM 3574
DRY HEAT AGING - COMPRESSION SET @ 50% DEFLECTION	%	5 MAX.	ASTM 3574
AIR FLOW	CFM	1.0 MIN.	ASTM 1564
RESILIENCE (BALL TEST)	%	50.0 MIN.	ASTM 3574
TENSION TEST - TENSILE STRENGTH	PSI	15.0 MIN.	ASTM 3574
- ULTIMATE ELONGATION GRIP SEPARATION	%	100 MIN.	ASTM 3574
TEAR RESISTANCE	PLI	1.20 MIN.	ASTM 3574
STATIC FATIGUE 75% - I. F. D. LOSS @ 25%	%	10 MAX.	ASTM 3574
- THICKNESS LOSS @ 75% COMPRESSION	%	1 MAX.	ASTM 3574

FLAMMABILITY PERFORMANCE *	
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. A, PART I	PASS
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. D, PART II	PASS
- FEDERAL M.V.S.S. 302	PASS
- FAA, FAR 25.853 (B)	MEETS

* THIS FLAMMABILITY DATA IS NOT INTENDED TO REFLECT HAZARDS PRESENTED BY THIS OR ANY OTHER MATERIAL UNDER ACTUAL FIRE CONDITIONS.

NOTE: FAA , FAR 25.853 (B) MUST BE TESTED EACH RUN BY A INDEPENDENT CERTIFIED LAB TO CERTIFY FOR USE ON AIRCRAFT. THIS MATERIAL HAS BEEN TESTED AND MEETS THIS STANDARD.

The above specifications have been reviewed and approved. S. Carpenter Plant Manager October 14, 2002

PERFECT FIT-McDONALD, INC.
18249 OLYMPIC AVE S.
TUKWILA WA 98188

Foamex

SALES SPECIFICATION
HIGH RESILIENCE (HR) POLYETHER POLYURETHANE FOAM

FOAM GRADE: **H290-55S1**
COLOR: PEACH

EFFECTIVE: 12-04-02
SUPERSEDES: 03-01-00

TEST ITEM	UNIT	RANGE	TEST METHOD
DENSITY	PCF	2.75-3.05	ASTM 3574
I.F.D. @ 4" THICK			
- 25% DEFLECTION	LBS.	50.0-60.0	ASTM 3574
- 65% DEFLECTION	LBS.	118.0 MIN.	ASTM 3574
SUPPORT FACTOR	RATIO	2.50 MIN.	
RECOVERY	%	80 MIN.	
HYSTERESIS LOSS	%	20 MAX	
CONSTANT DEFLECTION COMPRESSION SET			
- 90% DEFLECTION	%	10 MAX.	ASTM 3574
- 75% DEFLECTION	%	8 MAX.	ASTM 3574
- 50% DEFLECTION	%	3 MAX.	ASTM 3574
STEAM AUTOCLAVE AGING - COMPRESSION SET @ 50% DEFLECTION	%	N/A	ASTM 3574
DRY HEAT AGING - COMPRESSION SET @ 50% DEFLECTION	%	5 MAX.	ASTM 3574
AIR FLOW	CFM	1.0 MIN.	ASTM 1564
RESILIENCE (BALL TEST)	%	50.0 MIN.	ASTM 3574
TENSION TEST			
- TENSILE STRENGTH	PSI	20.0 MIN.	ASTM 3574
- ULTIMATE ELONGATION GRIP SEPARATION	%	100 MIN.	ASTM 3574
TEAR RESISTANCE	PLI	1.30 MIN.	ASTM 3574
STATIC FATIGUE 75%			
- I. F. D. LOSS @ 25%	%	10 MAX.	ASTM 3574
- THICKNESS LOSS @ 75% COMPRESSION	%	1 MAX.	ASTM 3574

FLAMMABILITY PERFORMANCE *	
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. A, PART I	PASS
- CALIFORNIA TECHNICAL BULLETIN 117, SEC. D, PART II	PASS
- FEDERAL M.V.S.S. 302	PASS
- FAA, FAR 25.853 (B)	MEETS

* THIS FLAMMABILITY DATA IS NOT INTENDED TO REFLECT HAZARDS PRESENTED BY THIS OR ANY OTHER MATERIAL UNDER ACTUAL FIRE CONDITIONS.

NOTE: FAA , FAR 25.853 (B) MUST BE TESTED EACH RUN BY A INDEPENDENT CERTIFIED LAB TO CERTIFY FOR USE ON AIRCRAFT. THIS MATERIAL HAS BEEN TESTED AND MEETS THIS STANDARD.

The above specifications have been reviewed and approved.

Signature | Plant Mgr (Title) | 6-26-02 (Date)