Market Characterization of the U.S. Structural Composite Preformed Polyurethane Foam Industry for Marine and Trailer Use

Prepared for:

Stratospheric Protection Division
Office of Air and Radiation
U.S. Environmental Protection Agency
Washington, D.C. 20460

Prepared by:

ICF
2550 S Clark St.
Suite 1200
Arlington, VA 22202

February 2021

Table of Contents

1. Summary

Structural composite preformed polyurethane (PU) foams are used for increased structural integrity, weight reduction, and thermal efficiency in marine and trailer applications (Composites World 2013, Composites World 2019, EPW 2020a, EPW 2020f, EPW 2020h, EPW 2020i). The structural composite foam industry historically used hydrochlorofluorocarbons (HCFCs) as a foam blowing agent (i.e., HCFC-22) and transitioned to hydrofluorocarbon (HFC) blowing agents as replacements for HCFCs in the early 2000s, specifically HFC-134a.

In 2020, approximately 28 metric tons (MT) of HFC-134a blowing agent was used in structural composite PU foam for marine and trailer use in the United States. The use of HFC-134a blowing agent in structural composite PU foam for marine and trailer use is expected to continue until 2040 in the United States due to performance issues with alternatives (e.g., lack of structural integrity, shrinking); however, by 2040, it is projected that HFC-134a blowing agent will no longer be used in structural composite PU foam for marine and trailer use as it is anticipated that alternatives will completely replace HFC-134a throughout the market.

2. Introduction

Structural composite PU foams differ from regular PU foam in that composite foams are reinforced with fibers and then with polymer resin during the blowing process. The structural composite foam is then preformed into the required shape (e.g., specific boat or trailer design). Structural composite PU foams are used in the marine and trailer industries to increase structural strength, while reducing the weight of such structures (Composites World 2013, Composites World 2019, EPW 2020a, EPW 2020f, EPW 2020h, EPW 2020i). In the late 1980s, structural composite PU foams were developed and employed for marine uses (e.g., recreational boats, commercial fishing boats). This technology then spread to use in the manufacturing of truck trailers (e.g., refrigerated trailers for transportation of perishable goods). It is estimated that this technology expanded into the trailer market roughly five years ago (BASF 2021).

In marine applications, preformed structural composite PU foams allow boat manufacturers to replace either heavier traditional foam cores or wood components with a more efficient, lighter weight, non-decaying product (General Plastics 2021, Composites Manufacturing 2015). In trailer applications, preformed structural composite PU foams increase thermal efficiency, while decreasing the overall weight of the system (EPW 2020a). In both marine and trailer industries, HFC-134a is a commonly used blowing agent. The remainder of this report characterizes HFC use by the marine and trailer industries in the United States, including key market players and historical and current use of HFCs and blowing agents.

3. Market Characterization

This section provides an overview of the marine and trailer foam industries as well as the current market and key manufacturers.

3.1. Overview of the Marine and Trailer Industries

Typically, system houses develop formulations, such as the HFC-134a formulation currently in use, for use in manufacturing structural composite preformed foams. These chemical formulations are then sold to structural preform suppliers who work directly with boat and trailer manufacturers to create specific molds for their intended application. Finally, boat and trailer manufacturers install structural composite preforms into the specific boat and trailer models for sale to consumers (EPW 2020c, EPW 2020d, EPW 2020e, EPW 2020f, EPW 2020h).

3.1.1. Marine

In the marine industry, a variety of foams are utilized for comfort, insulation, structure, and flotation. Structural composite preformed foams are typically used in internal structures of the boat, particularly stringers and bulkheads (Composites World 2013). Stringers are structures that run parallel along the boat's hull and provide structural integrity, e.g., keeping the boat from bending especially when going over waves. Bulkheads are vertical walls that provide structural integrity and partition the boat into watertight compartments to reduce damage in the case of an accident.

Historically, stringers and bulkheads were made of plywood and, more recently, sandwich foam cores (Composites Manufacturing 2015, Composites World 2013). The development of structural composite preformed foams provided a lighter-weight and more durable alternative, which resulted in the ability to use less powerful engines and reduce fuel consumption, thus decreasing the overall purchase and operation cost of boats (EPW 2020e, EPW 2020f). The use of structural composite preform foams are estimated to comprise 10% of the marine foam market (EPW 2020f). BASF (2021) estimates that marine applications of structural composite preform foams make up the majority of the overall structural composite preform foam market.

3.1.2. Trailers

In trailers, foams are used for insulation in two different applications, intermodal containers and reefer trailers. Intermodal containers are refrigerated containers that allow for uninterrupted refrigerated storage during transport. Reefer trailers are insulated cargo space that are designed with a refrigeration system to maintain a certain temperature. These trailers can be found on vans, trucks, or trailer-mounted systems. Normally, these trailers are used to transport perishable or frozen goods (Zandstra 2020). Reefer trailers are moveable on their own while intermodal containers require shipment on a trailer.

Traditionally, both trailer types have used conventional PU foam to provide insulation for their refrigerated system. After the development of structural composite foams for marine applications, structural composite preformed foams began to be used in both intermodal containers and reefer trailers (Composites World 2019). Certain trailer manufacturers have begun transitioning to trailer bodies within the last five years that replace traditional PU foam completely (Composites World 2019, Wabash 2019). Structural composite preformed foams are

estimated to improve thermal efficiency of trailers up to 28% and reduce overall weight up to 10%, compared to traditional foam and aluminum insulation (Composites World 2019).

3.2. Major Manufacturers

As mentioned above in Section 3.1, chemical companies develop formulations, such as the HFC-134a formulation currently in use, for use in manufacturing structural composite preformed foams. These chemical formulations are then sold to structural preform suppliers who work directly with boat and trailer manufacturers to create specific molds for their intended application. In some cases, the boat and trailer manufacturers buy directly from the system houses, bypassing the structural composite foam manufacturer (BASF 2021). For example, BASF and Wabash, a major trailer manufacturer, worked together directly to develop Wabash's all-composite refrigerated trailer and all-composite reefer trailer in 2016 (BASF 2016, FleetOwner 2016).

3.2.1. Structural Composite Foam Manufacturers

The major manufacturers of chemical formulations, or system houses, for use in structural composite preform foam include BASF, Dow, and Carpenter (EPW 2020f, EPW 2020h).

Companies such as Compsys and Structural Composites buy material for foam blowing from the system houses to create preformed structural composite foam for use in boats and trailers (EPW 2020a, EPW 2020b, EPW 2020h)

3.2.2. Marine Manufacturers

Major boat manufacturers that utilize structural composite preform foam include, but are not limited to, Grady White Boats, HCB Center Console Yachts, and Parks Manufacturing, LLC (EPW 2020c, EPW 2020d, EPW 2020e). Additional major boat manufacturers include Boston Whaler, Mastercraft, Sea Ray, Chaparral, Ranger, Cobalt, Contender, and Malibu (Boat Trader 2020). These manufacturers are assumed to use structural composite preform foam as it is assumed that the majority of the recreational boating market utilizes structural composite preform foams (BASF 2021).

3.2.3. Trailer Manufacturers

The trailer market is segmented and no one manufacturer has a controlling share over the entire market. Table 1 shows the estimated market share of each manufacturer in the trailer market. Manufacturers highlighted in blue represent manufacturers known to use structural composite preformed foams (EPW 2020i, Great Dane 2015, Hyundai N.d.).

Table 1. Major Manufacturers of Trailers in the United States

Manufacturer	Estimated Market Share[a]
Utility Trailer Manufacturing	31%
Wabash	16%
Kidron Inc.	13%
Great Dane	14%
Morgan Corporation	9%

Manufacturer	Estimated Market Share[a]
Hyundai Trailers	4%
Other	15%[b]

Source: Skeist (2004), Refrigerated Transporter (2010), and Wabash National (2019).
[a] Totals may not sum due to independent rounding.
[b] Assumed to be comprised of equal shares of Maersk Container Ind. (5%), Danteco (5%), and Vanguard National Trailer Corp. (5%).

4. Subsector Background and HFC Use

4.1. Blowing Agent Use in Structural Composite Preform Foam

Structural composite preform foam was first developed for marine applications using HCFC-22 as the blowing agent. In 2005, it is assumed that HCFC-22 began to be replaced with HFC-134a as the blowing agent for structural composite foams in both the marine and trailer end-uses with the transition occurring over three years (BASF 2021, EPW 2020a, EPW 2020b, EPW 2020h, EPA 2007).

In 2015, manufacturers began research and development programs to establish alternative foam blowing agents for marine and trailer structural composite preform foams (EPA 2020a, EPA 2020f). While most foams used in the marine and trailer industries have transitioned from HFC-134a to methyl formate and hydrofluoroolefin (HFO) formulations, an efficient alternative has yet to be developed for structural composite preform foam (EPW 2020f).

Research for structural composite preform foams has been focused on HFO blowing agents, but has been unsuccessful, as of 2020. Trials by Structural Composites and Wabash with HFO-blown structural composite preform foams have shown instability and shrinkage in the product after 14 days, which could cause safety concerns (EPA 2020a, EPA 2020h). It is assumed that 100% of the current structural composite preform foam marine market uses HFC-134a. Environmental characteristics of the current blowing agent used in structural composite preform foams are summarized in Table 2.

Table 2. Environmental Characteristics of Current Blowing Agents for Structural Composite Preform Foam

Blowing Agent	ODP[a]	GWP
HFC-134a	0	1,430

Note: GWPs are aligned with the exchange values used in the AIM act.
[a] Ozone Secretariat (1987).

Overall use of HFC-134a for use as a structural composite preform foam blowing agent is estimated to be 28 MT in 2020 (EPW 2020h). Based on conversations with BASF (2021) about general market estimates for the structural composite foam market, ICF assumes that marine and trailer applications of structural composite preform foam make up 95% and 5% of the overall market in 2020, respectively. Historic estimates of structural composite preform marine foam were developed using the growth rates of recreational boat registrations from 2015 through 2019 (USCG 2020). Historic estimates of structural composite preform foam in trailer applications were assumed to transition linearly from 2016, when they entered the market, to 2020. Table 3, Figure 1, and Figure 2 show the historic use of HFC-134a blowing agent used in

structural composite preform foam in marine and trailer applications in the United States from 2015 to 2020.

Table 3. Historic HFC-134a Blowing Agent Use in Structural Composite Preform Foam in the United States (2015-2020)

	2015	2016	2017	2018	2019	2020
Amount of HFC-134a Used in Structural Composite Preform Foam (MT)						
Marine	28.4	28.1	28.1	27.6	27.33	26.60
Trailer	-	0.3	0.6	0.9	1.1	1.4
Total	28.4	28.4	28.7	28.4	28.47	28.00
Amount of HFC-134a Used in Structural Composite Preform Foam (MMT CO_2 Eq.)						
Marine	0.04	0.04	0.04	0.04	0.04	0.04
Trailer	-	0.0004	0.0008	0.001	0.002	0.002
Total	0.04	0.04	0.04	0.04	0.04	0.04

Note: Totals may not sum due to independent rounding.
Source: EPW (2020h), EPA (2020), USCG (2020).

Figure 1. Historic HFC Use of Blowing Agents for Structural Composite Preform Foam in the United States (2015-2020) (MT)

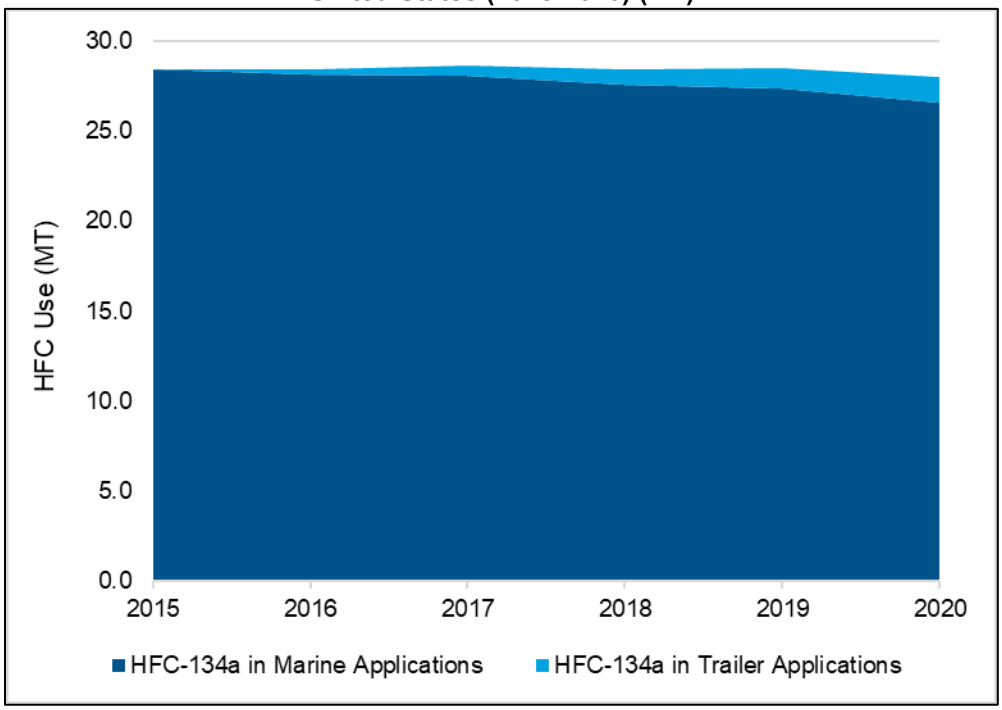
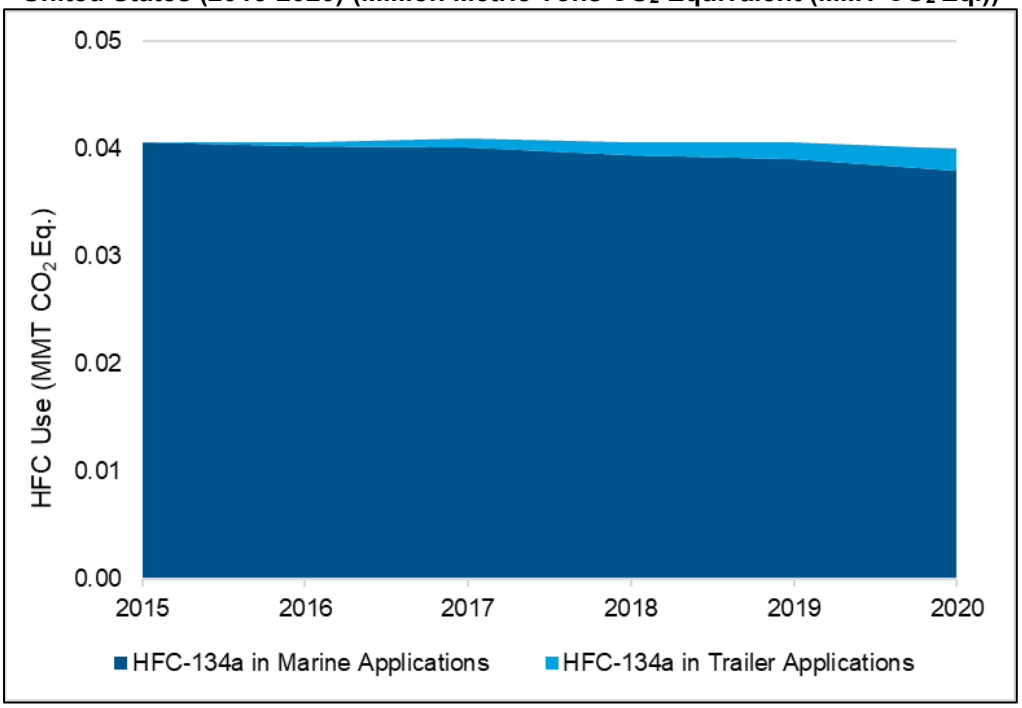


Figure 2. Historic HFC Use of Blowing Agents for Structural Composite Preform Foam in the United States (2015-2020) (Million Metric Tons CO_2 Equivalent (MMT CO_2 Eq.))



4.2. Projected HFC Blowing Agent Use

The overall use of HFC-134a as a structural composite preform foam blowing agent is estimated to be 28 tons in 2020 (EPW 2020h). Although an HFC-134a replacement has not yet been identified, industry stakeholders anticipate an effective replacement for HFC-134a in structural composite preform foams will be developed within the next 15 years (EPW 2020a, EPW 2020b).

Over the last twenty years, recreational boat registrations have decreased on average by 0.38%; however, this value has fluctuated annually (USCG 2020). To conservatively project HFC use in structural composite preform marine foams, it is assumed that boat registrations, and thus HFC-134a use in this sector, will remain constant from 2020 to 2035, when an alternative is anticipated to reach the market. HFC-134a use in structural composite preform trailer foams is assumed to grow at an average rate of 3.6% between 2020 and 2035, in line with the growth rate of intermodal containers in EPA (2020).

For both trailer and marine structural composite preform foams, it is assumed that in 2035 an effective alternative will enter the market and it will take five years for marine and trailer manufacturers to fully transition. The projected HFC blowing agent use for structural composite foams can be found in Table 4, Figure 3, and Figure 4.

Table 4. Projected HFC-134a Blowing Agent Use in Structural Composite Preform Marine Foam in the United States (2020-2040)

	2020	2025	2030	2035	2040
Amount of HFC-134a Used in Structural Composite Preform Foam (MT)					
Marine	26.6	26.6	26.6	26.6	-

	2020	2025	2030	2035	2040
Trailer	1.4	1.7	2.0	2.4	-
Total	28.0	28.3	28.6	29.0	-
Amount of HFC-134a Used in Structural Composite Preform Foam (MMT CO_2 Eq.)					
Marine	0.04	0.04	0.04	0.04	-
Trailer	0.002	0.002	0.003	0.003	-
Total	0.04	0.04	0.04	0.04	-

Note: Totals may not sum due to independent rounding.
Source: EPW (2020h), EPA (2020), USCG (2020).

Figure 3. Projected HFC Use of Blowing Agents for Structural Composite Preform Foam in the United States (2020-2040) (MT)

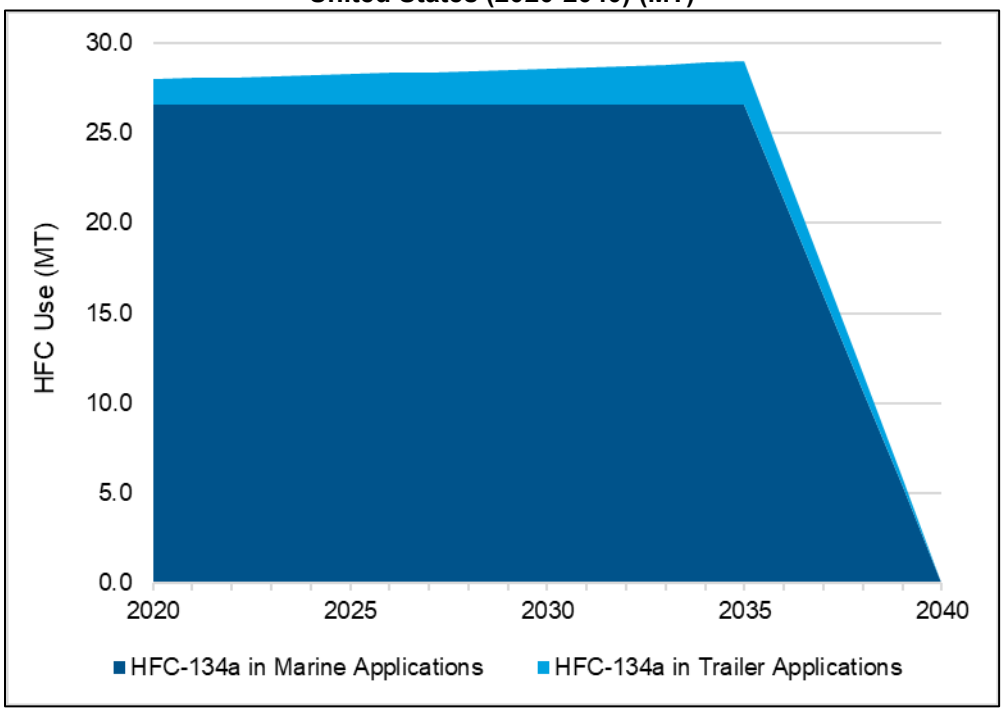
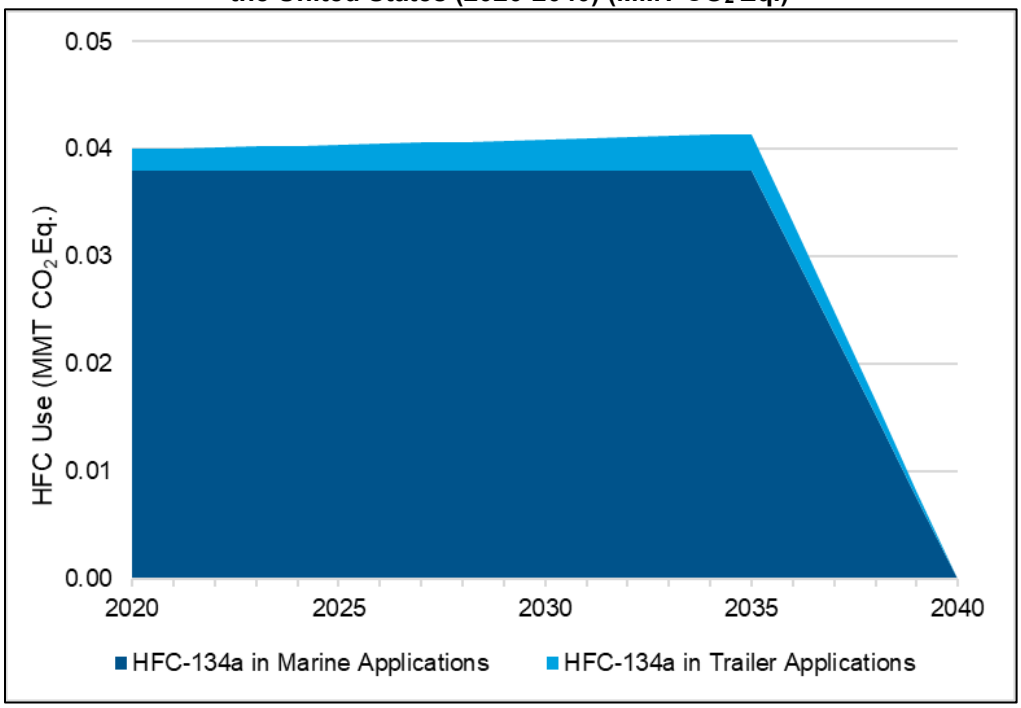


Figure 4. Projected HFC Use of Blowing Agents for Structural Composite Preform Marine Foam in the United States (2020-2040) (MMT CO_2 Eq.)



4.3. Imports and Exports of Trailer and Marine Foam in the United States

The import and export of structural composite preform foams is primarily through the import and export of boats and trailers. While the majority of the boats and trailers using structural composite preform foams are anticipated to stay within the United States, there is some import and export of these materials, especially boats (BASF 2021). The United States is a leading manufacturer in recreational boats globally and exports them throughout the world. In 2017, 37% of recreational boats were exported to Canada, followed by 20% to Central and South America (ICOMIA 2018).

5. References

BASF. 2021. Personal Communication with Mike Krupa of BASF. January 27, 2021.

BASF. 2016. First All-Composite Refrigerated Trailer Hits the Road. March 18, 2016. Available online at: https://www.basf.com/us/en/media/news-releases/2016/03/P-US-16-024.html.

Boat Trader. 2020. Boat Manufacturers and Brands. 2020, Available online at: https://www.boattrader.com/resources/top-ten-boat-manufacturers/.

Composites Manufacturing. 2015. Wonders on the Water. July 1, 2015. Available online at: http://compositesmanufacturingmagazine.com/2015/07/marine-market-making-splash-with-cutting-edge-designs-materials-and-technologies/5/.

Composites World. 2019. Composites Design and Process Engineering Form Next-Generation Truck Body Panels. May 27, 2019. Available online at: https://www.compositesworld.com/articles/the-structural-grid-prefabrication.

Composites World. 2013. The structural grid: Prefabrication. February 1, 2013. Available online at: https://www.compositesworld.com/articles/composites-design-and-process-engineering-form-next-generation-truck-body-panels.

FleetOwner. 2016. Wabash, BASF Roll Out All-composite Reefer Trailer. March 18, 2016. Available online at: https://www.fleetowner.com/equipment/article/21693121/wabash-basf-roll-out-allcomposite-reefer-trailer.

General Plastics. 2021. Marine Foam Sheets. January 2021. Available online at: https://www.generalplastics.com/products/tr-marine.

Great Dane. 2015. Composite Liner Panels Help Reefer Trailers Keep Cool and Cargo Safe. October 2015. Available online at: https://dcpd6wotaa0mb.cloudfront.net/mdms/dms/CSB/10021341/10021341-%E2%80%93-Market-Vision-24-%E2%80%93-Transportation-Composite-liner-panels-cargo-story.pdf?v=1466480838000.

Hyundai. No date. Composite^{XT} Brochure. Available online at: https://d1lngrl7ky5pkf.cloudfront.net/wp-content/uploads/sites/64/2020/01/CompositeXT.pdf.

International Council of Marine Industry Associations (ICOMIA). 2018. Recreational Boating Industry Statistics 2017. Available online at: https://www.bvww.org/fileadmin/user_upload/bvww/PDF_Dateien/ICOMIA_Statistics_Yearbook/ICOMIA_Recreational_Boating_Industry_Statistics_2017_ed2_-_UNPROTECTED.pdf.

Ozone Secretariat. 1987. The Montreal Protocol on Substances that Deplete the Ozone Layer. United National Environment Programme (UNEP). Available Online at: https://ozone.unep.org/treaties/montreal-protocol.

Refrigerated Transporter. 2010. Great Dane Acquires Johnson Refrigerated Truck Bodies. February 3, 2010. Available online at: https://www.refrigeratedtransporter.com/fleet-equipment/vehicles/article/21713955/great-dane-acquires-johnson-refrigerated-truck-bodies.

Senate Environmental and Public Works Committee (EPW). 2020a. S.2754, American Innovation and Manufacturing Act of 2019 Senate Testimony for Composite Application Group. Available online at: https://www.epw.senate.gov/public/_cache/files/6/6/66c5854f-72f6-42c0-9110-924b251f0f2b/97F5EBC37BA4148AB9B9E1B79B72C946.all-hfc-qfr-responses-03.25.2020.pdf.

Senate Environmental and Public Works Committee (EPW). 2020b. S.2754, American Innovation and Manufacturing Act of 2019 Senate Testimony for Compsys Inc. Available online at: https://www.epw.senate.gov/public/_cache/files/6/6/66c5854f-72f6-42c0-9110-924b251f0f2b/97F5EBC37BA4148AB9B9E1B79B72C946.all-hfc-qfr-responses-03.25.2020.pdf.

Senate Environmental and Public Works Committee (EPW). 2020c. S.2754, American Innovation and Manufacturing Act of 2019 Senate Testimony for Grady-white Boats. Available online at: https://www.epw.senate.gov/public/_cache/files/6/6/66c5854f-72f6-42c0-9110-924b251f0f2b/97F5EBC37BA4148AB9B9E1B79B72C946.all-hfc-qfr-responses-03.25.2020.pdf.

Senate Environmental and Public Works Committee (EPW). 2020d. S.2754, American Innovation and Manufacturing Act of 2019 Senate Testimony for HCB Center Consol Yachts. Available online at: https://www.epw.senate.gov/public/_cache/files/9/d/9d52f372-ad63-4ab6-baf0-60f084ef9ac6/53A5744A034ABB9A4936BBA14DDDA374.04.07.2020-hcb-center-console-yachts.pdf.

Senate Environmental and Public Works Committee (EPW). 2020e. S.2754, American Innovation and Manufacturing Act of 2019 Senate Testimony for Parks Manufacturing. Available online at: https://www.epw.senate.gov/public/_cache/files/6/6/66c5854f-72f6-42c0-9110-924b251f0f2b/97F5EBC37BA4148AB9B9E1B79B72C946.all-hfc-qfr-responses-03.25.2020.pdf.

Senate Environmental and Public Works Committee (EPW). 2020f. S.2754, American Innovation and Manufacturing Act of 2019 Senate Questions for the Record for National Marine Manufacturers Association. Available online at: https://www.epw.senate.gov/public/_cache/files/6/6/66c5854f-72f6-42c0-9110-924b251f0f2b/97F5EBC37BA4148AB9B9E1B79B72C946.all-hfc-qfr-responses-03.25.2020.pdf.

Senate Environmental and Public Works Committee (EPW). 2020g. S.2754, American Innovation and Manufacturing Act of 2019 Senate Questions for the Record for National Resource Defense Council. Available online at: https://www.epw.senate.gov/public/_cache/files/e/6/e6f1a3f9-1291-4054-9500-86423e0dc8f9/E9E3E0CD0D0EA8CC99B10EEAFA820B3C.03.26.2020-nrdc.pdf.

Senate Environmental and Public Works Committee (EPW). 2020h. S.2754, American Innovation and Manufacturing Act of 2019 Senate Questions for the Record for Structural Composites. Available online at: https://www.epw.senate.gov/public/_cache/files/6/6/66c5854f-72f6-42c0-9110-924b251f0f2b/97F5EBC37BA4148AB9B9E1B79B72C946.all-hfc-qfr-responses-03.25.2020.pdf.

Senate Environmental and Public Works Committee (EPW). 2020i. S.2754, American Innovation and Manufacturing Act of 2019 Senate Questions for the Record for Wabash National. Available online at: https://www.epw.senate.gov/public/_cache/files/6/6/66c5854f-72f6-

42c0-9110-924b251f0f2b/97F5EBC37BA4148AB9B9E1B79B72C946.all-hfc-qfr-responses-03.25.2020.pdf.

Skeist Incorporated. 2004. Blowing Agents for Polyurethane Rigid Foam. Skeist Inc., 2004. Available online via: Docket ID EPA-HQ-OAR-2004-0507-002, www.regulations.gov.

U.S. Census. 2017. 2017 National Population Projections Tables: Main Series. Available online at: https://www.census.gov/data/tables/2017/demo/popproj/2017-summary-tables.html

U.S. Coast Guard (USCG). 2020. 2019 Recreational Boating Statistics. Jun 4, 2020. Available online at: https://www.uscgboating.org/library/accident-statistics/Recreational-Boating-Statistics-2019.pdf.

U.S. Environmental Protection Agency (EPA). 2020. Vintaging Model. Version VM IO file_v5.1_12.15.20.

U.S. Environmental Protection Agency (EPA). 2007. Protection of Stratospheric Ozone; Listing of Substitutes in the Foam Sector. EPA. March 28, 2007. Available online at: https://www.govinfo.gov/content/pkg/FR-2007-03-28/pdf/E7-5491.pdf.

Wabash National. 2019. Wabash National Delivers 100th Refrigerated Truck Body with New Molded Structural Composite. January 25, 2019. Available online at: https://news.wabashnational.com/wabash-national-delivers-100th-refrigerated-truck-body-with-new-molded-structural-composite/.

Zandstra, Matthew. 2020. What is a Reefer Truck? A Complete Explanation. June 19, 2020. Available online at: https://www.withvector.com/post/what-is-a-reefer-truck.