2025+ FRC Bumper Testing Report

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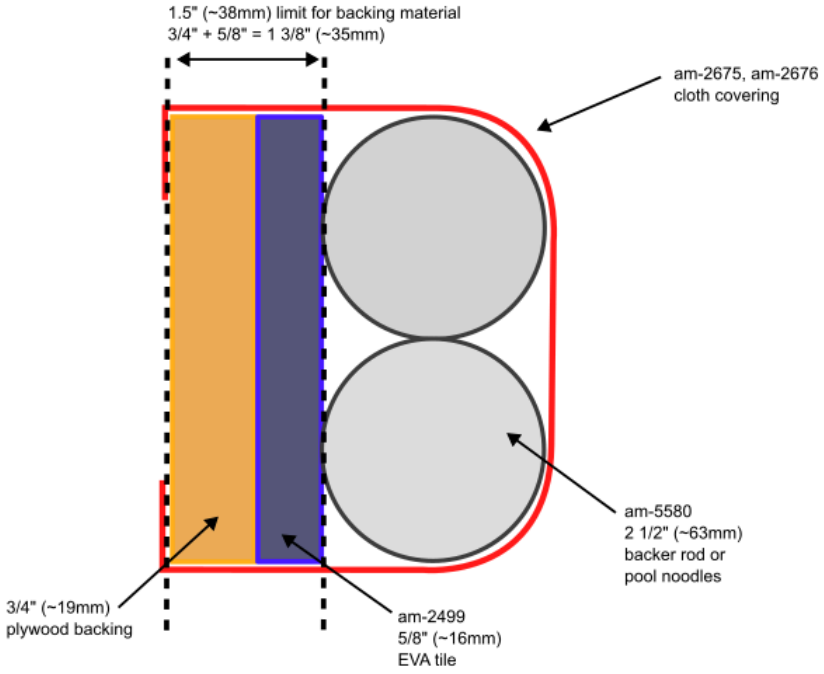
October - December 2024

Overall Recommendation

With the announcement of the 2025 *FIRST*® Robotics Competition Bumper Rule Changes allowing for an increased variety of legal bumper materials. AndyMark has tested a number of different bumper and backer configurations in order to give our best recommendation to the community for the 2025 FRC season. This is just a recommendation on one configuration - you may want to test and adapt this design based on the needs of your team.

The test results indicate 2.5” diameter solid noodles (density 2 lb/cu ft) with an EVA tile (density 2.8 lb/cu ft) and plywood backer material provide the best impact dissipation of any accessible material to teams. The diagram below shows a cross-section of these materials.



For a 32.3” by 27.0” chassis, we used eight am-5580 noodles and five am-2499 soft tiles.

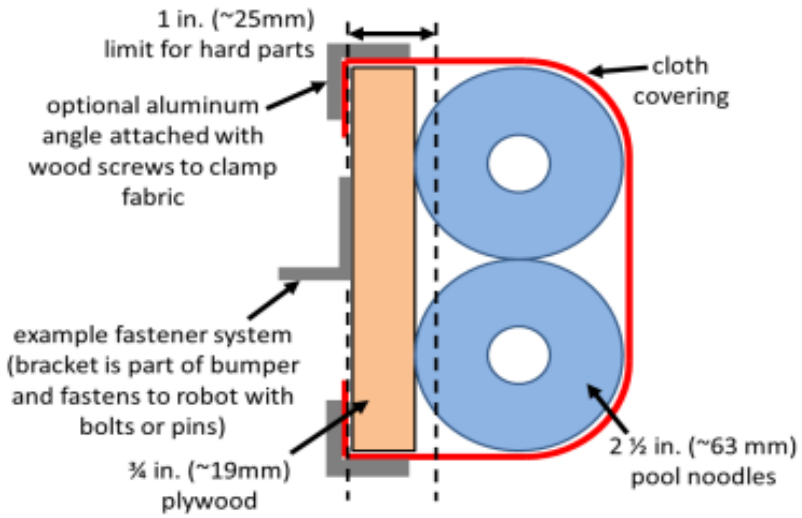
EVA foam floor tiles provide a great harder layer between noodles and the force of impact. The pre-release rules do not indicate if multi-material foams will be allowed, so we recommend positioning the EVA foam as part of the “hard parts” backer.

Even if your team only has access to hollow noodles for the upcoming season, we recommend the addition of an EVA foam floor tile to your backer.

Introduction

In October 2024, *FIRST* released new standards for both bumper backers and bumper foams in an effort to reduce robot and field damage from collisions. These are detailed in *FIRST*'s documentation on 2025 *FIRST* Robotics Competition Bumper Rule Changes, in the field and robot damage blog post, and in the 2025 Rule Updates.

For reference, here is a cross section of a legal bumper from the FRC 2024 manual:

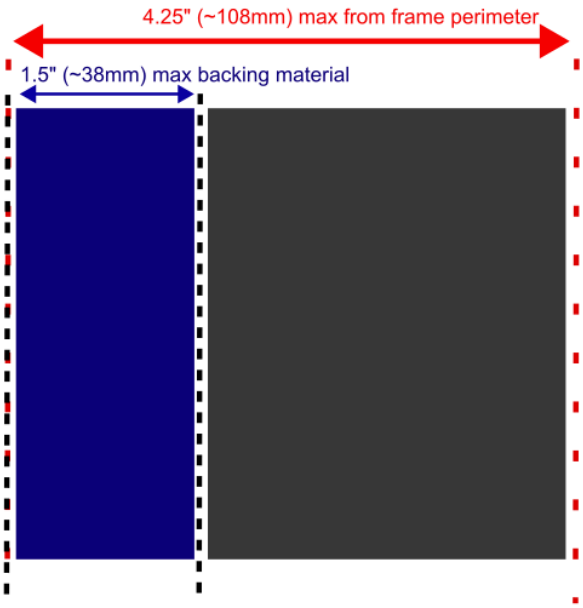


"Hard parts" will be referred to as the "backer material" or "backer". In the 2024 FRC rules, the backer material was required to be ¾" wood. Everything in front of the backer material, not including the fabric, will be referred to as the "bumper foam" or "foam". In the 2024 FRC rules, the bumper foam was required to be a 2.5" pool noodle. We did not test any variants of fabrics or mounting systems.

The 2025 bumper rules changes are summarized as follows:

- **Foam Dimensions:** Extended bumper foam area to 4.25" from perimeter
- **Foam Materials:** Allowed material list expanded to include backer rod, foam floor tiles, solid polyethylene (PE) closed cell foam with density between 1.5 and 3 lb/cu ft., EVA closed cell foam with density between 2 and 6 lb/cu ft. *This testing and recommendation operates under the assumption that like other years, bumpers may only contain one type of foam.*
- **Backer Dimensions:** Extended hard parts limit to 1.5" from frame perimeter
- **Backer Materials:** Any

Here is a cross section representation of the new standards, where the backer material is represented in blue and the bumper foam is represented in gray.



AndyMark tested some of the most promising new bumper foam and backer materials in a variety of ways to determine which performed best under ideal and non-ideal conditions. We used the following tests to assess these materials.

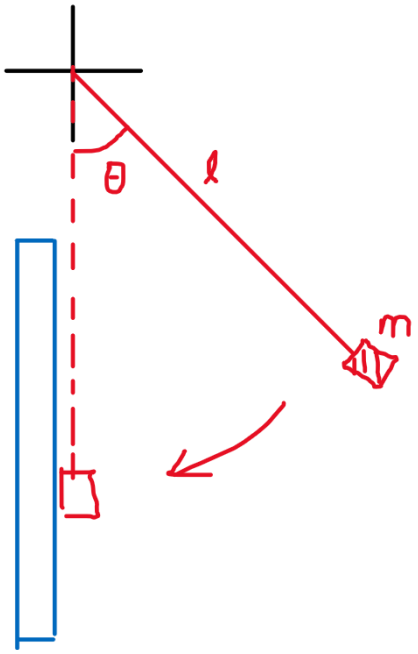
Pendulum Impact Test: Swung a 7.75lb weight onto a secured plate and measured force experienced behind the plate. This was performed originally with only foam and repeated with foam plus backer.

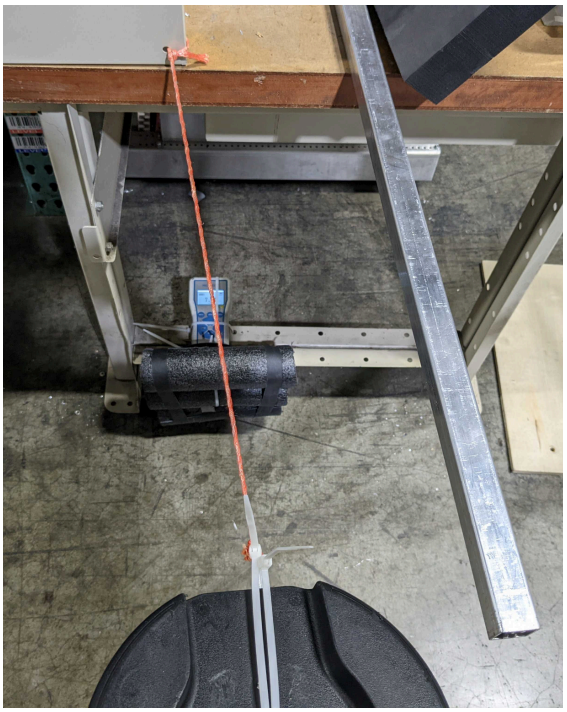
Truss Leg Impact: Installed a bumper on a 115 lb AM14U5 chassis and drove into a 2024 stage truss leg repeatedly at speed.

Our full results are available in our AndyMark Bumper Foam Testing spreadsheet, and elaborated on below.

Pendulum Impact Test: Foam

The pendulum impact test was set up as per this diagram, where ℓ = 18”, m = 7.75lbs, and θ = 90°. The mass was hard and inflexible, and the foam (outlined in blue on the diagram below), was treated as a spring obeying Hooke’s Law with k = 1 for thinner foams. As foam thickness increased, k was increased proportionally.





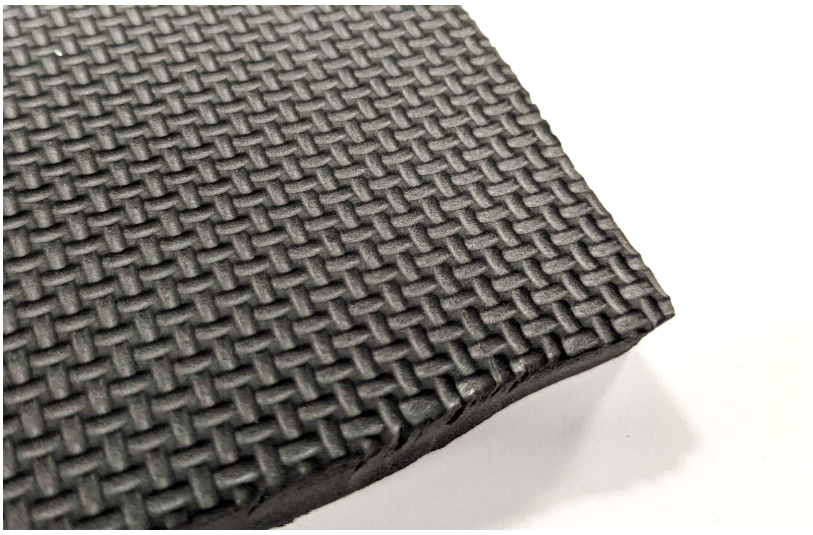
Material	Description	Density (lb/cu. ft)	Firmness**
Hollow Noodle	Current FRC/AndyMark standard	1.3	Low
C-Shaped Hollow Noodle	Hollow noodles were cut in half and linked together to provide a “solid” foam surface	1.3	Medium
Solid Noodle Backer Rod	Can also be found as backer rod, has a ‘crust’ around the outside that closes the foam off like a pool noodle	2.0	High
AW150	Closed cell PE foam	1.5	Medium
AB200	Closed cell PE foam	2.0	Medium
XL2000-EVA	Cross-linked PE foam with an EVA blend, not explicitly 2025 legal	2.0	Low
XL4000	Cross-linked PE foam at a higher density, not explicitly 2025 legal	4.0	High
Foam Floor Tiles	AndyMark FTC floor tiles, ⅝” thick, weave pattern on one side pictured below.	2.8	Very High
EVA/Hollow Noodle	Combination floor tile and hollow noodle, with tile on the outside	*	Medium
Hollow Noodle/EVA	Combination floor tile and hollow noodle, with tile on the inside	*	Medium
EVA/Solid Noodle	Combination floor tile and solid noodle, with tile on the outside	*	Medium
Solid Noodle/EVA	Combination floor tile and solid noodle, with tile on the inside	*	Medium

*Multiple densities present.

**The firmness or “squish factor” of foam can vary greatly depending on a number of factors other than density.

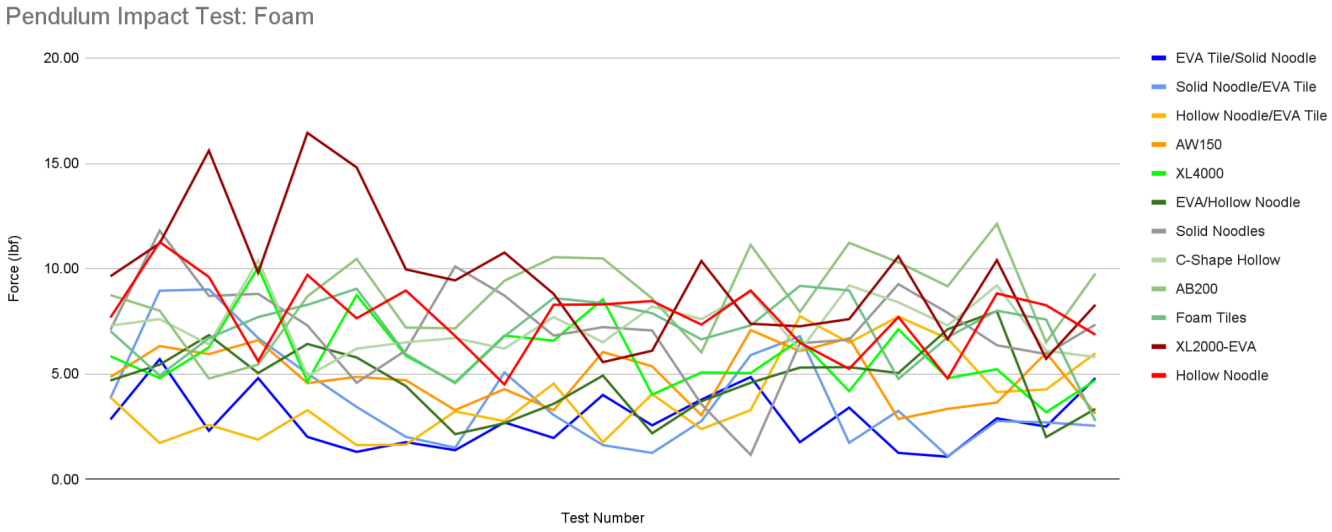
For pool noodles and other PE foams, there is not a direct correlation between density and firmness. It can be used as a guideline, but in some cases, you may have a high-density part that feels softer. Other things, like the overall size of a profile and additives, can play a role in perceived firmness.

Foam floor tiles can also vary greatly based on face pattern. The AndyMark FTC Soft Tile has a thin weave pattern on one side that squishes very little, as seen below.



We confirmed densities in house by measuring new, untested foam. We measured each density by weighing the foam and dividing it by the volume. These often varied from the specification provided by foam suppliers. Densities can vary greatly by supplier and some may even vary by production run. Be sure to measure the density of any foam that you intend to use for accurate comparisons.

Each foam was secured in the pendulum and the force observed behind the foam was measured from 20 tests. The plot below shows the performance of each foam across these tests.



We believe that most data variance was observed due to the small target area on the force gauge, differences in how the weight was dropped, and variation in the foams. We measured the expected force vs the actual force in these tests, based on the calculation that foam with a thickness of around 2” and a spring constant k of 1 would generate an expected force of 15 lbf, and thicker foams would have a higher spring constant, resulting in a lower expected force. This allowed us to draw conclusions on how much force was dissipated by each bumper material, charted below, sorted from most force dissipated to least.

Material	**Average Force Dissipated**	**Comments**
EVA Tile/Solid Noodle	76.0%	Use of a harder and softer foam performed best, unsure of legality of combined bumper foams
Solid Noodle/EVA Tile	64.5%	
Hollow Noodle/EVA Tile	64.0%	
AW150	64.0%	Became very squishy after 20 tests, different behavior
XL4000	61.6%	Unsure of legality
EVA/Hollow Noodle	55.0%	
Solid Noodles	53.3%	
C-Shaped Hollow	50.4%	Better than just hollow noodle
AB200	40.6%	
Foam Tiles	39.1%	
XL2000-EVA	35.0%	Unsure of legality
Hollow Noodle	24.8%	

Conclusions:
The best performing legal foams from this test were the combinations of EVA Foam Floor Tiles and Pool Noodles. The other PE foams (AW150 and AB200) also had notable performances, but became noticeably squishier after testing. This indicates that the durability of PE foam is less than ideal, and will not hold up well to the rigors of an FRC match. The cross-linked foams performed well, but are not explicitly legal.

Pendulum Impact Test: Foam and Backer

This test used the same pendulum setup as the previous tests, but measured from behind a backer material instead of just the foam. We tested these in two rounds, one varying the backer, and one varying the foam to verify our results from the previous tests. Each chart is sorted from least amount of force observed behind the bumper to most force observed.

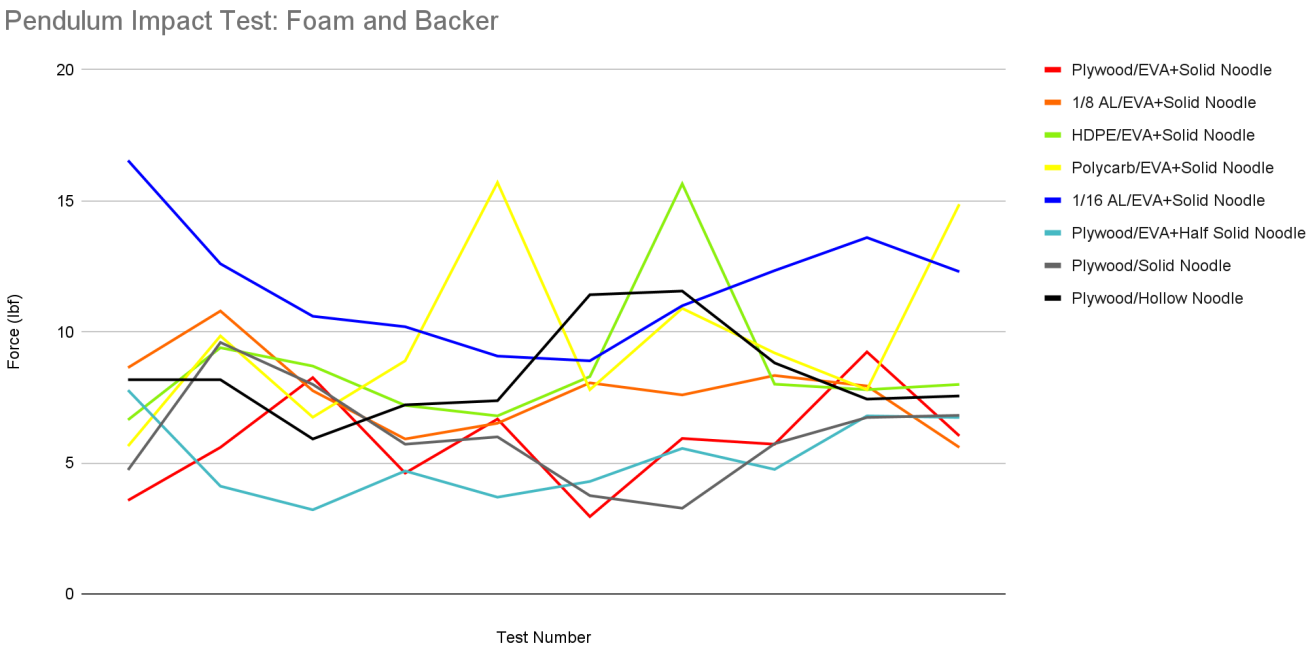
Backer Materials Tested

Backer Material	**Bumper Material**	**Avg. Force (lbf)**	**Comments**
¾" Plywood	EVA (Interior) + Solid Noodle	5.86	Sturdy and helped dissipate some of the worst hits
⅛" AL	EVA (Interior) + Solid Noodle	7.72	Did not help or hurt the force dissipation. Have concerns about bending out of shape, which did not occur in this test
¼" HDPE	EVA (Interior) + Solid Noodle	8.65	High average force dissipated with some of the highest spikes in force seen as the backer flexed in
¼" Polycarb	EVA (Interior) + Solid Noodle	9.74	Very high spikes in force and very mid average force. Flexible backer did not help to dissipate force
1/16" AL	EVA (Interior) + Solid Noodle	11.72	Worst option tested out of these options, flexed like the plastics and did a poor job of dissipating forces

Bumper Materials Tested

Backer Material	**Bumper Material**	**Avg. Force (lbf)**	**Comments**
¾" Plywood	EVA (Interior)+ Half Solid Noodle	5.17	Half noodles helped to spread out the force measured better than any other foam at less damaging hits
¾" Plywood	Solid Noodle	6.04	Solid noodle performed well on their own, outperforming the force dissipated by the hollow noodle
¾" Plywood	Hollow Pool Noodles	8.37	Since this is the current FRC standard, all other measurements were compared to this one

Overall, our data based on these tests looked like this:

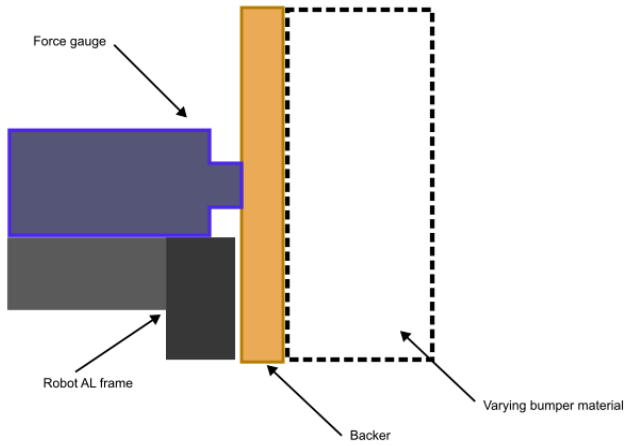


Conclusions:
The best performing backer in this test was clearly wood, which helped dissipate some of the largest hits and kept the average low. Another material we wanted to test further was ⅛" AL, which did not flex like the other materials tested, but could possibly bend like many robot frames did during the 2024 season.

This test addressed low speed collisions in ideal conditions. To round out our testing, we still needed to address high speed collisions in non-ideal conditions.

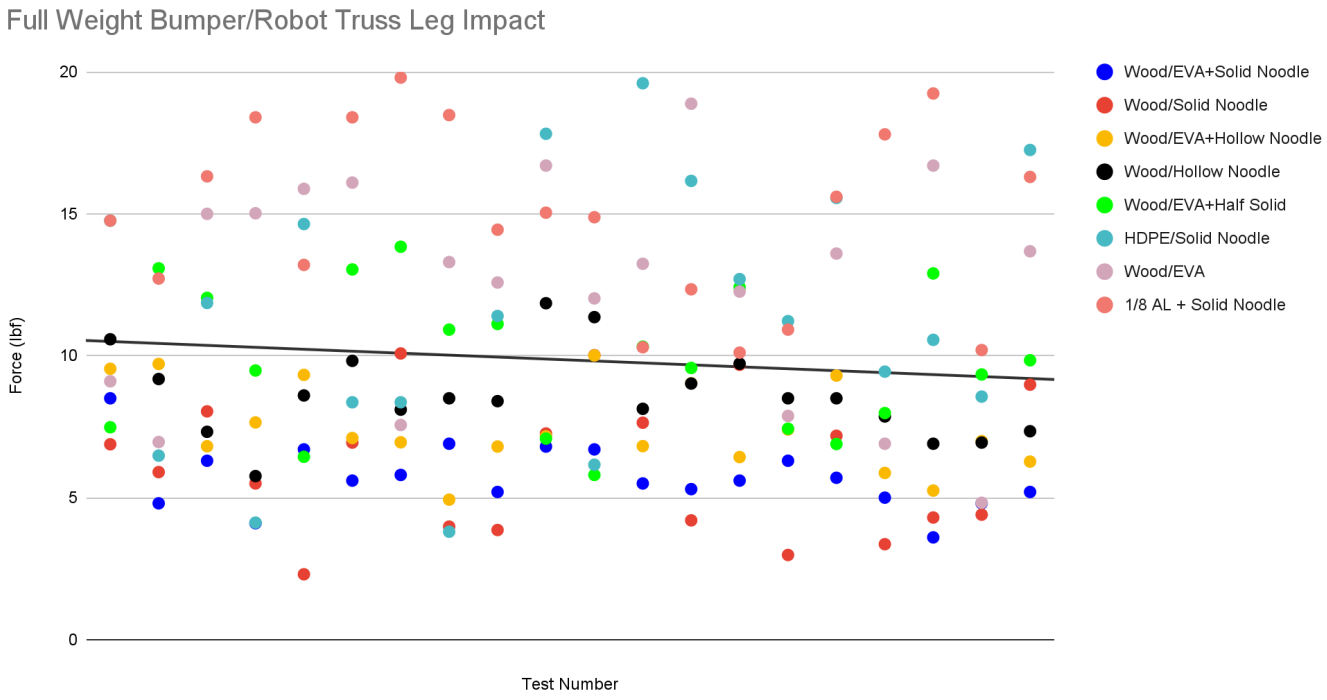
Full Weight Bumper/Robot Truss Leg Impact

Legal 2024 bumpers were created with new 2025+ legal materials and put on an 115lb AM14U5 chassis to run into a 2024 stage truss leg at speed. A force gauge was face mounted to the center of the front bumper, and the maximum force experienced at this point was measured. Speed varied unintentionally, but the test was performed to simulate the worst conditions a bumper would see on the field. In this test, we varied backer material and bumper material to verify what we had seen in previous tests under more realistic conditions.



Results are plotted below. Note the black trendline represents the current 2024 legal bumper with standard hollow noodles. Anything that is below that group will dissipate more force.

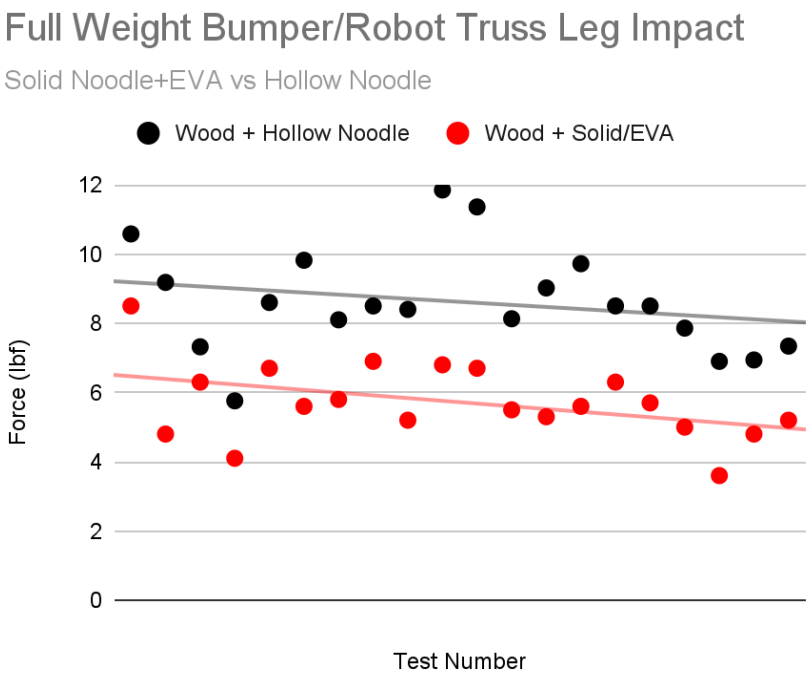
Solid noodles with an EVA plus wood backer performed the best on average. Note the consistency in the dark blue (Wood+Solid/EVA) group - no hit goes above 8.5lbf.



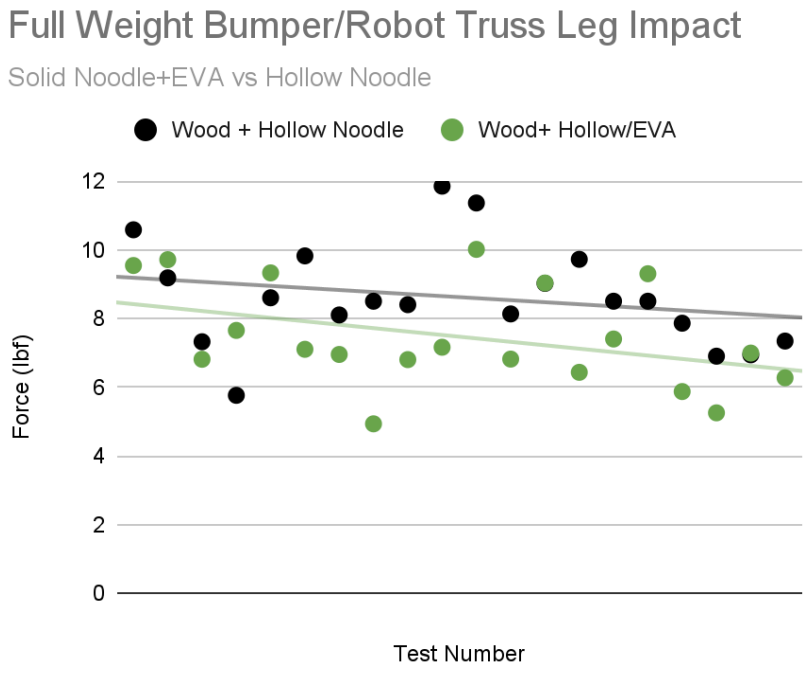
Materials Tested

Backer Material	Bumper Material	Scatter Plot Color	Average (lbf)	Comments
¾” Wood+ EVA tile	Solid Noodle		5.73	Very consistent behavior, EVA tile added an extra layer of cushioning
¾” Wood	Solid Noodle		6.17	¾” wood backing continued to perform well
¾” Wood+ EVA Tile	Hollow Noodle		7.47	Great option for teams still using hollow noodles in 2025
¾” Wood	Hollow Noodle		8.62	Performed consistently, but force experienced by the chassis was higher than the solid noodles
¾” Wood+ EVA Tile	Half Solid Noodle		9.85	Although half solid noodles performed well in pendulum testing, in this test they did not dissipate many of the harder hits as expected
¼” HDPE	Solid Noodle		11.44	HDPE is too flexible to reduce heavy hits, and often exaggerates the forces seen by the frame
¾” Wood	2.5” EVA Block		12.41	EVA foam floor tiles by themselves did very little to dissipate higher force hits
⅛” AL	Solid Noodle		14.96	Although aluminum performed well on the pendulum test, higher force hits had more of an impact on the inside faces of the bumper

Plotted only against the hollow noodles, solid noodles + EVA outperformed hollow noodles on average.



This test also indicated that hollow noodles with an EVA backer are an acceptable solution if your team only has access to hollow noodles for the 2025 season. Although not as consistent as solid noodles, it does perform better on average than just using hollow noodles alone.



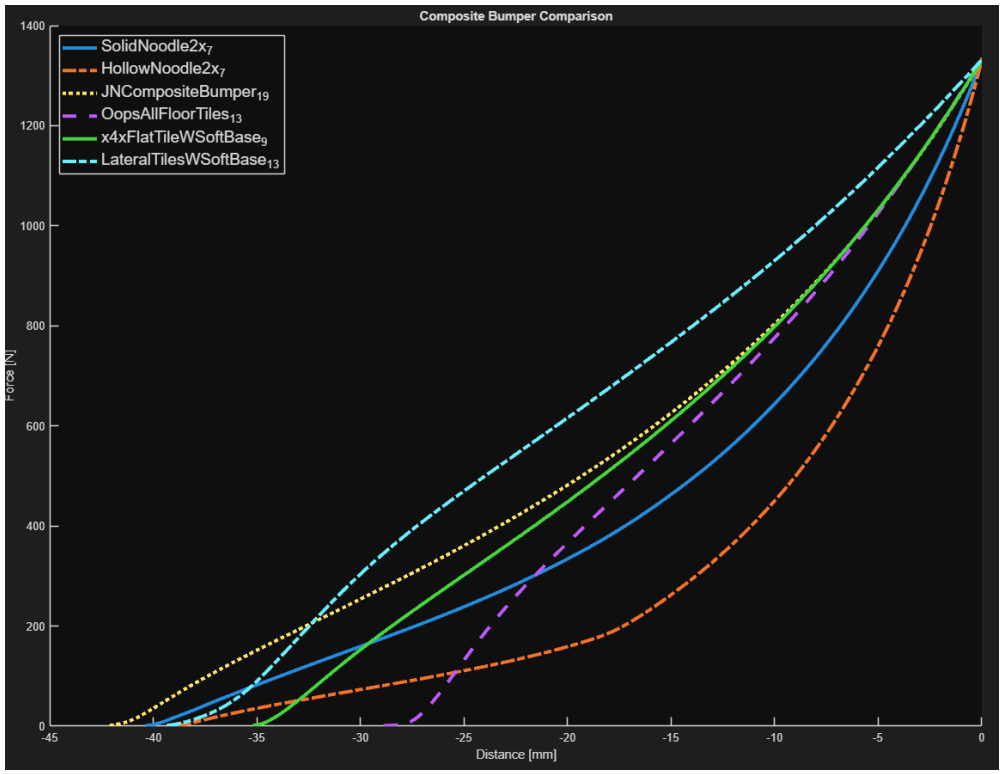
Conclusions:
Most of these materials behaved similarly to the tests performed on the pendulum. The hits on the HDPE had a median average hit, but had very high maximum forces seen. EVA foam tiles on their own, which present one of the most dense legal options, do very little to dissipate hits.The backer material that saw the most change between tests was the ⅛" aluminum. While the pendulum test indicated that this would be similar to wood at lower forces, when subjected to more force, the bending became more obvious. The flexing under this force indicated that at higher force hits, aluminum is not a preferred backing material.

Solid noodles with a wood backing, especially when backed by an EVA foam floor tile, perform the best of any option that we tested.

Other Test Data

James Cole-Henry from FRC 95 has done some excellent work testing how foams squish under load. While this direct application is rarely seen in an FRC match, it tells us how a foam will deflect under large amounts of sustained pressure. Most hits in an FRC match are glancing but violent hits, and are rarely sustained. For a better understanding of his tests, we recommend reading his thread here: https://www.chiefdelphi.com/t/lets-talk-about-squishing-foam/474541

Most of our results align - EVA foam is very hard and takes a lot of force to squish down completely, while PE foam is much softer. Composites like the EVA floor tile + pool noodle combination (shown as the JN composite on the graph) offer the benefits of both. The graph below compares those options in terms of distance squished under N of force.



Near the end of this thread he concludes that, “I really like the horizontal floor tiles, bonded, with finger-jointed corners as a harder shell with an inch or so of something softer inside. It is on the better end of performance and is likely easy to source and inexpensive.”

EVA foam tiles on their own proved to be too hard to dissipate much force in our testing, but our findings align where we use solid noodles as the “softer” material. If multi-material bumper foams are allowed, this is a good method to pursue.

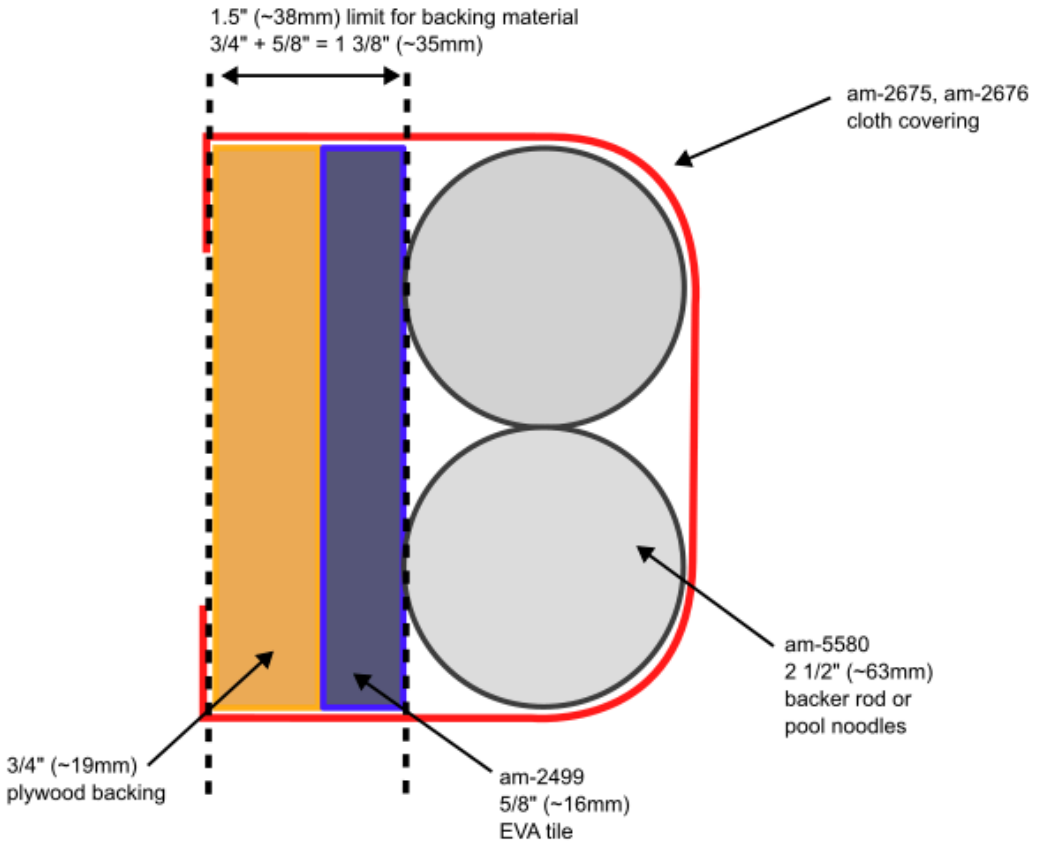
Conclusions & Recommendations

Based on these tests, there is a clear indication that the community should progress towards wood backed solid noodles as the standard for bumpers versus the current hollow noodle standard.

EVA foam floor tiles provide a great harder layer between a soft and backer, but should not be used on their own as a foam.

If your team only has access to hollow noodles for the upcoming season, we recommend a floor tile in between your backer and the hollow noodles, based on the results from test 3.

Based on the current rules, we do not know if multi-material foams will be allowed, so we recommend positioning the EVA foam as a backer.



In compliance with the known rules, AndyMark's recommendation for the 2025 season is a Wood/EVA foam tile backer with solid pool noodles as the bumper material.