

Design, Development and Testing of an Improved Stock Car Driver's Window Net Mounting System

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ABSTRACT

First required in 1970 in NASCAR® (National Association for Stock Car Auto Racing, Inc) the driver's window safety net or driver's window net has continually evolved and improved. The driver's window net has played an important role in protecting race car drivers from injury.

Driver's window nets were originally used to help keep the driver's upper torso, head and arms inside the interior of the race vehicle during crashes. As restraint systems were improved, the role of the driver's window net in stock car racing has transitioned to keeping flailing hands inside the interior of the car while also serving as a shield to protect the driver from intruding debris.

This paper describes three separate window net and window net mounting tests and the use of these tests to design an improved window net mounting system. Also shown are test results of previously used window net mounting systems and the improved NASCAR system which has been incorporated into the 2013 NASCAR Sprint Cup, Nationwide Series, and Camping World Truck Series vehicles.

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INTRODUCTION

The driver's window net was first required in NASCAR competition in 1970. The original purpose of the window net was to contain the driver's extremities inside of the race vehicle. This containment was important in reducing the likelihood of flailing injuries to the hand, arms, head and neck during rollover and side impacts. [Figure one](#) shows AJ Foyt with a driver's window net during the 1972 Daytona 500.

BACKGROUND

From their introduction in 1970, the window nets remained largely unchanged in purpose and design for many years. In time NASCAR added rulebook requirements for size, shape and material of the window nets. These requirements were used to control functionality and addressed issues such as net strength, visibility and driver egress. Requirements were also enacted to address the placement and position of the window nets to ensure adequate coverage of the window opening and regulate the use of window nets as aerodynamic devices.

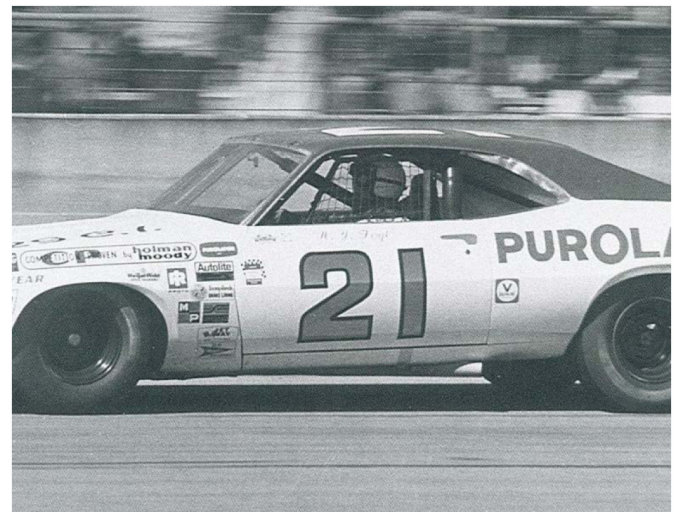


Figure 1.

In 2005 the NASCAR rulebook recommended the use of window nets which complied with SFI 27.1. The SFI Foundation Incorporated Window Net Specification 27.1 establishes a uniform test procedure and a minimum standard for evaluating and determining the performance capabilities of window nets used in competitive motorsports ¹. By 2007 use of a SFI 27.1 window net was mandatory in the NASCAR Sprint Cup series.

SFI WINDOW NET TESTING

SFI 27.1 consists of two drop tests onto a horizontal fixed window net. The window net is mounted in a horizontal plane by two 5/8 inch diameter solid steel dowels. The first drop test consists of a 3.00 (+/-0.06) inch diameter steel ball weighing 4.00 (+/-0.25) pounds dropped from 2.00 (+/-0.12) inches. The center of the ball is aligned with the geometric center of a webbing opening near the center of the net. This test is repeated three times on three different webbing openings. The second drop test consists of an impact bag made of leather or other heavy weight material. The bag is 10.00 (+/- 0.25) inches in diameter at the bottom, or impact side and is long enough to contain 175 pounds of "OO" or smaller lead shot. The bag is dropped from a height of 26.5 (+/- 0.5) inches directly over the center of the net. This drop height was increased from 15.0 inches to 26.5 inches in 2006. Three out of four nets are required to pass each drop test. Passing is defined as preventing the steel ball from passing through the webbing as well as preventing the bag from passing through the net. The impact bag drop test must also not separate more than 50% of the inner cross-section webbing joints, the webbing ends to border joint, and the border material stitching at the dowel loops. The SFI 27.1 window net test fixture is shown in [Figure two](#).



Figure 2.

In the NASCAR National series each window net is custom made to the individual race team's specifications. Customization of the nets accounts for variations in the manufacturers body shapes or window sizes and the team or driver preferences. Customized window nets are required to comply with the NASCAR rulebook and SFI 27.1. While the window net itself is made by vendors, the NASCAR National series teams usually fabricate the window net mounting assemblies themselves. [Figure three](#) shows an example of a custom sewn driver's window net with the SFI 27.1 conformance label on the left side.

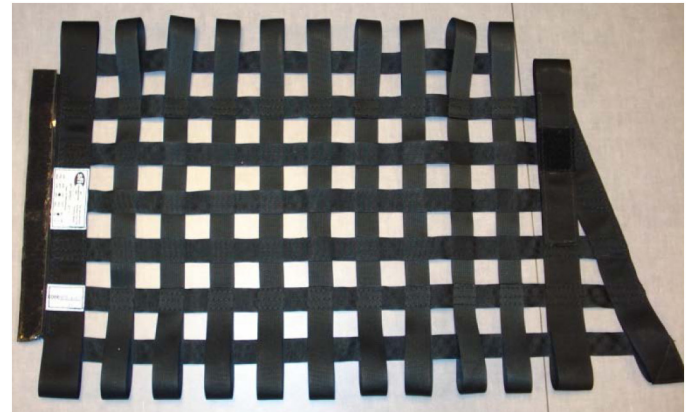


Figure 3.

As the NASCAR race vehicle structures and driver restraint systems have improved, the injury risk due to flailing injuries received outside of the vehicle to the head and neck have been greatly reduced. These structures and restraint systems are detailed in other publications and have proven to greatly improve driver restraint and containment ^{2,3,4}. The use of the window net is still required however to reduce the injury risk of flailing injuries to the hands and arm. Secondly, the driver's window net has also now been utilized as a debris barrier for the driver. Starting in 2013 the NASCAR Sprint Cup series mandated the use of a laminated polycarbonate windshield. The laminated windshields provide increased resistance to penetration from on-track debris and were tested against ballistic projectiles ⁵.

BALLISTIC WINDOW NET TESTING

An SFI 27.1 window net was also tested against a ballistic projectile using the same windshield test setup. Specifically, a full 12 ounce water bottle weighing 0.814 pounds was propelled into the center of a window net at 308 feet per second (210 mph) at 45° to the plane of the net. This test represented debris which could originate from spectator areas and strike a vehicle while on track and at speed. The water bottle ruptured during impact. The net remained intact and did not allow any pass through of plastic bottle material, but a forward Velcro adjustment strap did become unfastened. The net was mounted with upper and lower bars fabricated from 3/4 inch outer diameter steel tubing with 1/4 inch walls. While the net withstood the impact, large deflections were noted in the 3/4

inch top and bottom bars. The test setup and a post-test picture are shown in [Figures four and five](#). [Appendix A](#) contains sequential high speed video frames of the test. [Appendix C](#) contains details of the test setup.



Figure 4.

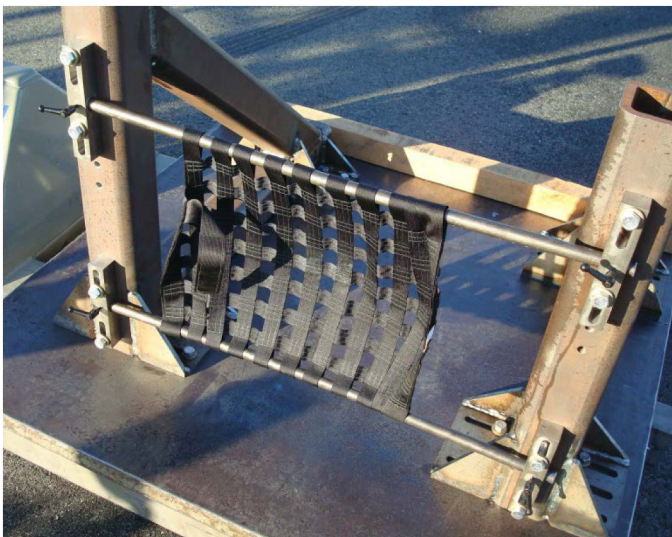


Figure 5.

While the SFI 27.1 window nets themselves were found to be very robust, the existing 2012 window net mounting assemblies needed improvement to achieve the goal of lowering the risk of debris penetrating the driver's window net.

QUASI-STATIC TESTING

A representative and repeatable quasi-static strength test was designed to load the window net mounting assembly. This loading was applied to a window net (and thus the mounting) via a 1.75 inch diameter section of steel roll bar placed on the outboard side of the net through an existing webbing hole and pulled inward, toward the center of the chassis. The roll bar ends were bent outward to prevent the tubing edges from cutting the webbing. The test setup is shown in [Figures six and seven](#). [Appendix C](#) contains details of the test setup.

Force and displacement data were captured for each test at 100 samples per second. The load was applied at 0.5 inches per second until system failure. Two current (2012 and prior) commonly used window net mounting assemblies were tested as well as a NASCAR designed assembly.

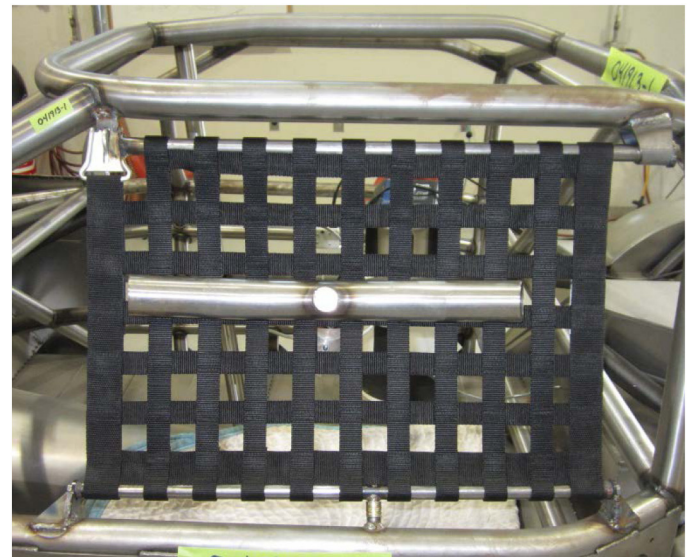


Figure 6.



Figure 7.

Window Net Mounting Assembly #1

A window net mounting assembly consisting of a 3/8 inch diameter round solid steel top bar and latch assembly was tested with provided upper mounting tabs. The lower mounting bar consisted of a one inch wide steel flat strap mounted to the chassis on each end and the center. This system represented an exemplar window net mounting assembly from a NASCAR series vehicle in 2012 and prior. Pretest photos are shown in [Figures eight, nine and ten](#).

The force deflection plot for Assembly #1 is shown in [Figure eleven](#). The slope of the displayed black linear trend line is 138.9 pounds per inch. The linear trend line was applied between two and three inches of displacement. Displacement

from zero to two inches was not included in the trend line in order to discount any differences in pre-test window net webbing tension.

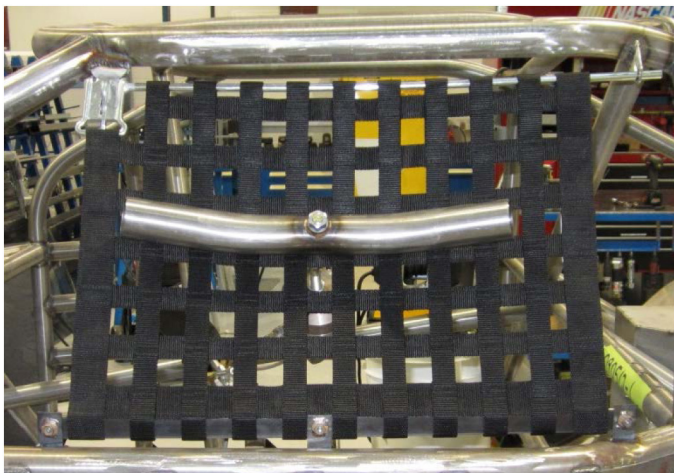


Figure 8.



Figure 9.

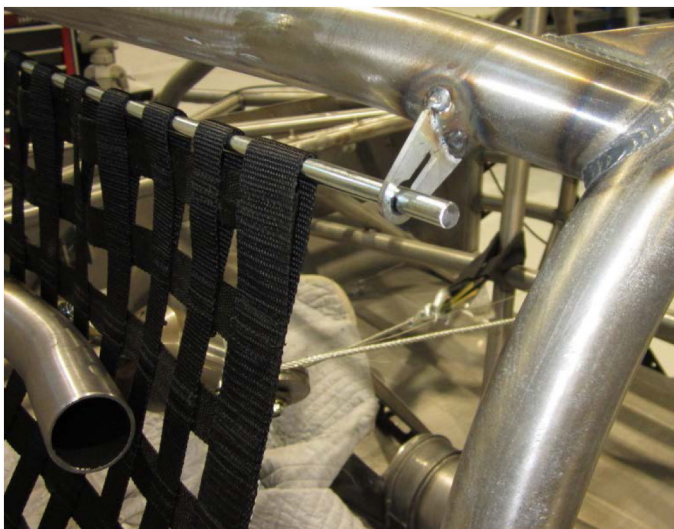


Figure 10.

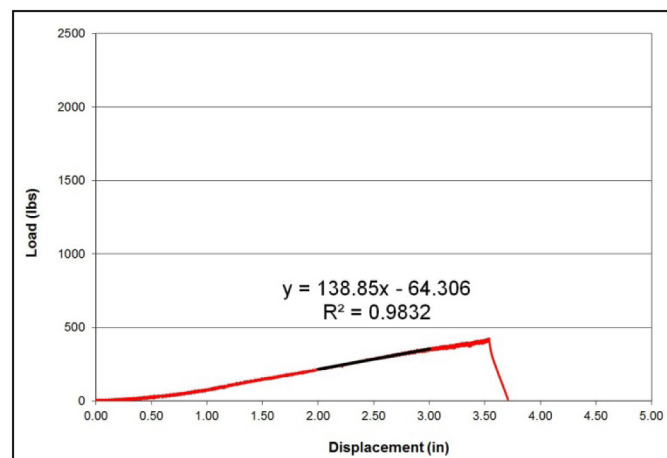


Figure 11.

Post-test pictures of the 3/8 inch diameter round solid steel top bar are shown in [Figures twelve](#) and [thirteen](#).

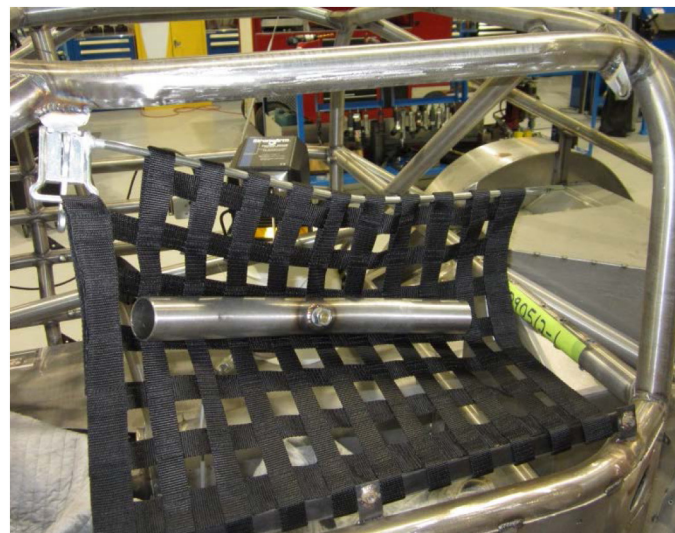


Figure 12.



Figure 13.

A peak load of 425.0 pounds was achieved prior to the rear top mount sliding through and separating from the rear keyhole mounting tab. The front latch remained secured to the tab.

Window Net Mounting Assembly #2

A second window net mounting assembly consisting of a 1.0 inch wide by 1/8 inch thick solid flat steel top bar and latch assembly was tested with the provided upper mounting tabs. The lower mounting bar consisted of a one inch wide steel flat strap mounted to the chassis on each end and the center. This

system also represented an exemplar mounting assembly from a NASCAR series vehicle in 2012 and prior. Pretest photos are shown in [Figures fourteen and fifteen](#).

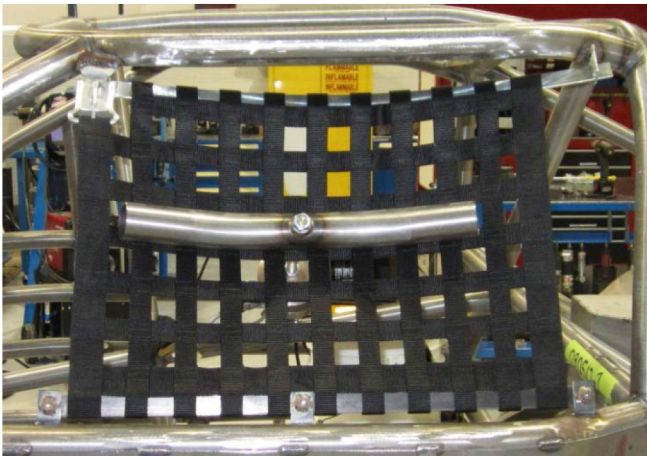


Figure 14.

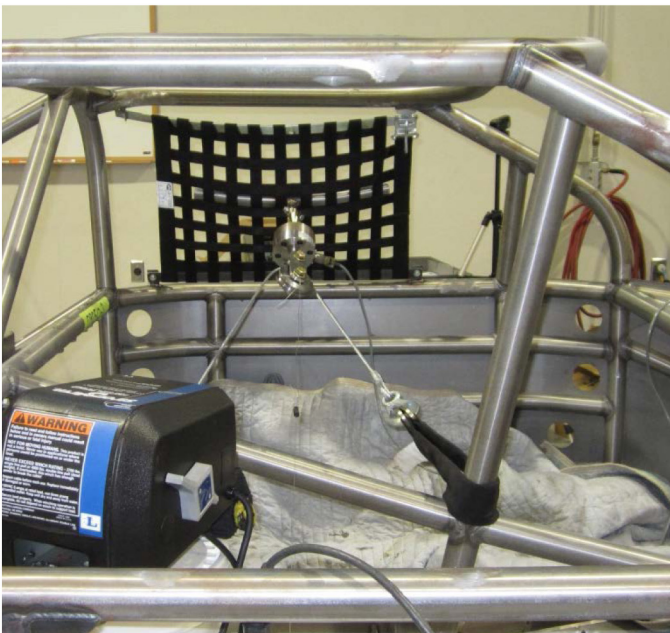


Figure 15.

The deflection of the top bar of Assembly #2 noticeable in [Figure fifteen](#) is from the combined weight (5.14 pounds) of the load cell, roll bar and pulley. Measured system displacement was zeroed with this pretest induced deflection.

The force deflection plot for Assembly #2 is shown in [Figure sixteen](#). The slope of the displayed trend line is 39.2 pounds per inch. The linear trend line was not able to be applied from two to three inches due to system failing prior to this displacement range being reached. The linear trend line was applied between one and two inches of displacement. Displacement from zero to one inch was not included in the trend line in order to discount any differences in pre-test window net webbing tension

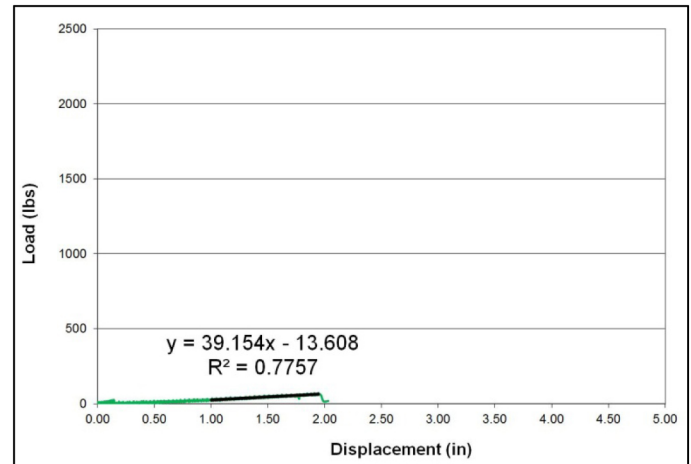


Figure 16.

A post-test picture of the 1.0 inch wide by 1/8 inch thick solid flat steel top bar is shown in [Figure seventeen](#).

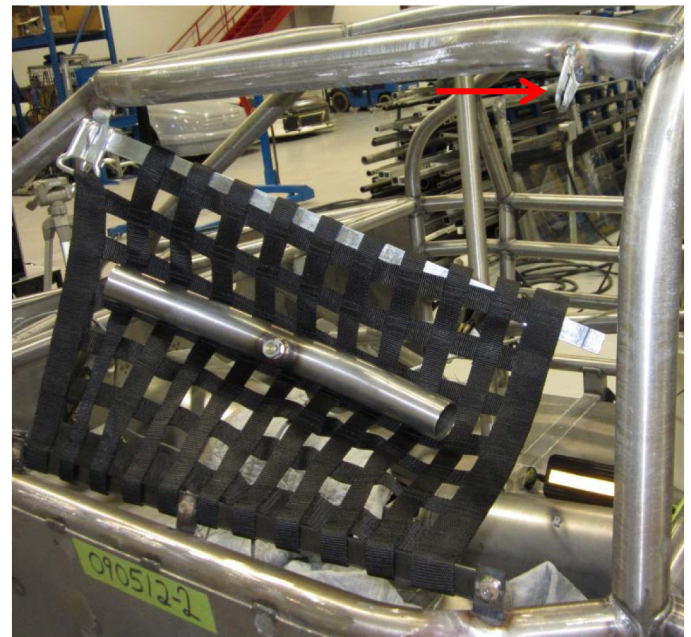


Figure 17.

As shown in [Figure seventeen](#) the top bar separated from the rear top mount due to sliding through the keyhole mounting tab, highlighted by the red arrow. The front latch remained secured to the tab. The recorded peak load was 74.4 pounds.

Window Net Mounting Assembly #3

The final version of the NASCAR designed window net mounting assembly is presented here as Assembly #3. Several iterations were tested prior to arriving at this design. The specific design details are shown in [Appendix B](#). The top and bottom bars of Assembly #3 consist of 3/4 inch diameter steel tubing. Pretest photos are shown in [Figures eighteen, nineteen, twenty and twenty-one](#).



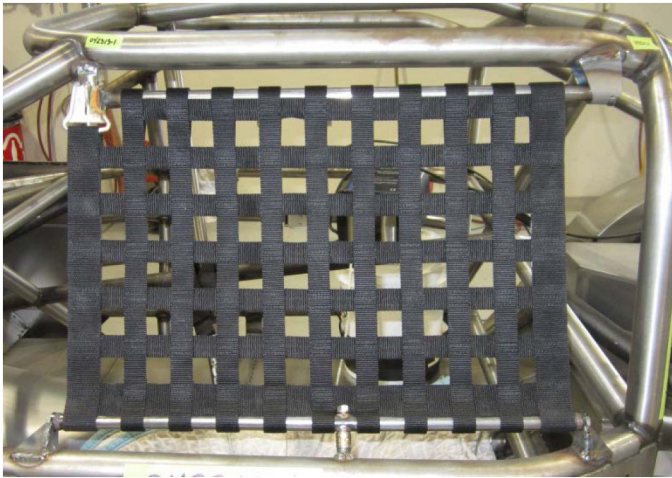


Figure 18.



Figure 19.



Figure 20.

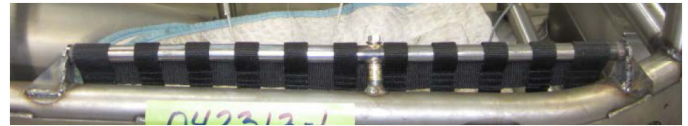


Figure 21.

The force deflection plot for Assembly #3 is shown in [Figure twenty-two](#). The slope of the displayed trend line is 1,035.4 pounds per inch. The linear trend line was applied between two and three inches of displacement. Displacement from zero to two inches was not included in the trend line in order to discount any differences in pre-test window net webbing tension.

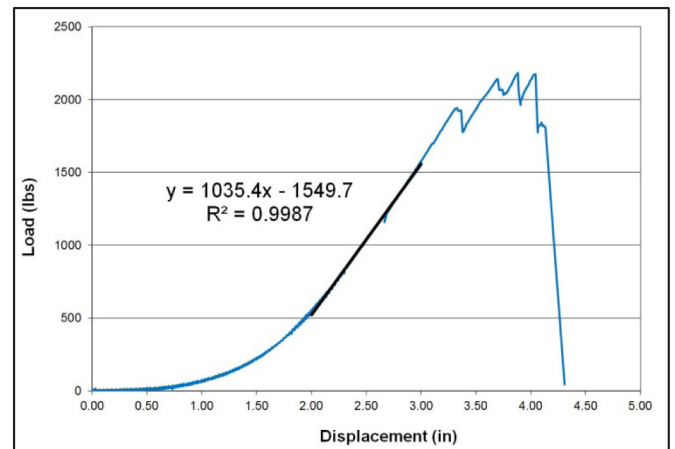


Figure 22.

Post-test pictures of Assembly #3 are shown in [Figures twenty-three](#), [twenty-four](#) and [twenty-five](#).



Figure 23.

As shown in [Figure twenty-three](#) the top bar separated from the forward top mount. The recorded peak load was 2,184.0 pounds.