sapa:

7 July 2017 Version

# Sapa 40/30 RIG Test at 40 mph

## 2012 Chevrolet Malibu / 1995 Vanco Trailer

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sapa:

17 May 2018, Version 1.1

# Table of Contents

17 May 2018, Version 1.1

# 1. Test Specifications

**1995 Vanco Outfitted with Gen 3 Sapa RIG**

| | |
|---|---|
| Vehicle identification number: | 1VVW5321S1009996 |
| Body style: | 53 ft. dry van semi-trailer |

**2012 Chevrolet Malibu**

| | |
|---|---|
| Vehicle identification number: | 1G1ZC5EU2CF379178 |
| Body style: | Midsize 4-door sedan |
| Engine/transmission: | Transverse 2.4 liter 4 cylinder, 6 speed automatic front wheel drive |

**Vehicle Specifications (Provided by Manufacturer)**

| | |
|---|---|
| Wheelbase: | 285.2 cm |
| Overall length: | 487 cm |
| Overall width: | 179cm |
| Curb weight: | 1549 kg |

**Test Protocol**

The Sapa protocol is a modified version of the IIHS 30% Overlap Semi-Trailer Underride Evaluation Crash Test Protocol.

**Nominal Test Parameters**

64 km/h (40 mph), 30% overlap of Malibu's width (measured from the trailer's outer wall surface, not the outer edge of the RIG horizontal member as in the IIHS protocol).

**Crash Test Date**

April 19, 2017

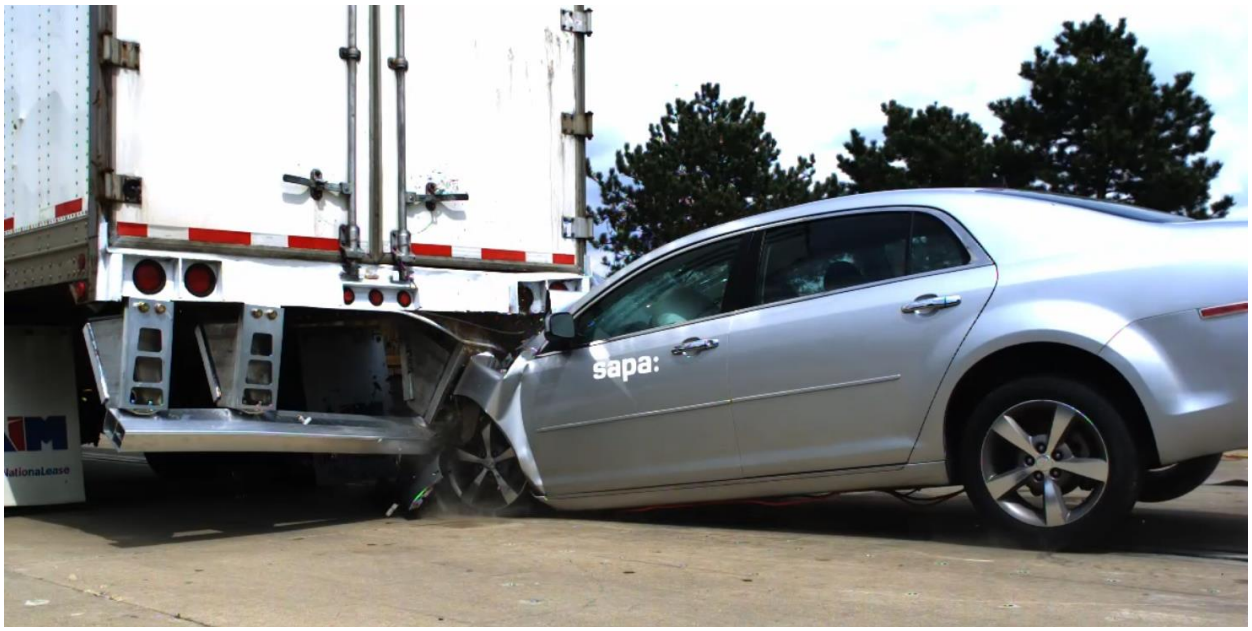


*Figure 1*
*Video Frame Capture – 2017 Sapa 40/30 RIG and 2012 Chevrolet Malibu*

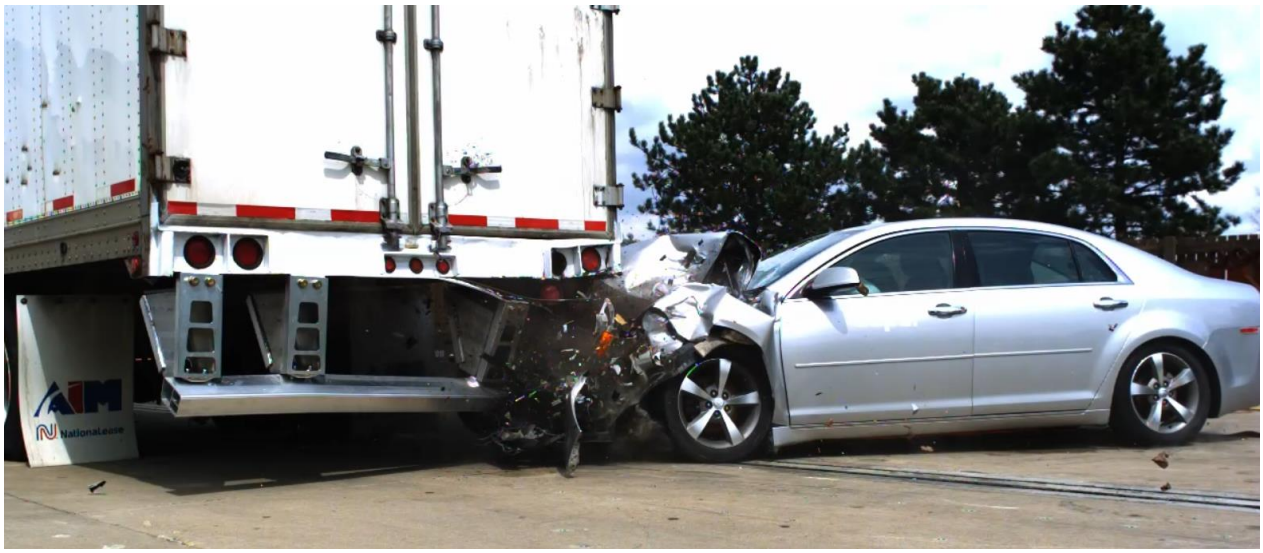

*Figure 2*
*Video Frame Capture – 2017 Sapa 40/30 RIG and 2012 Chevrolet Malibu*

# 2. Summary

On April 19, 2017 SAPA and The Center for Advanced Product Evaluation (CAPE) in Westfield, IN conducted a crash test with a 1995 Vanco 53-foot dry van semi-trailer and a 2012 Chevrolet Malibu 1LT. The Vanco trailer was fitted with a Sapa 40/30 (40 mph, 30% overlap) aluminum rear impact guard (RIG). The front of the Malibu struck the rear of the Vanco at 63.97 km/h (40 mph) and a 30 percent overlap (17.59 in) measured from the trailer's outside wall.

During the crash, the horizontal member and two right supports of the RIG were deformed forward and downward. Each of the four vertical supports remained attached to the horizontal member and to the trailer frame (despite some deflection and material failure of the trailer at the connection of the rightmost support). The guard exerted sufficient loadings against the bumper and frame structure of the Malibu to prevent the Malibu's passenger compartment from contacting the trailer body.

The Malibu's windshield was cracked due to contact from the hood. The driver's A-pillar did not have visible direct or induced damage. The driver's door was easily opened but had minor contact with induced collision damage on the left front quarter panel. There was no passenger compartment intrusion (PCI).

Post-crash deformation of the Sapa RIG was maximally 49.53 cm at the right outboard end in the forward direction. The Malibu's post-crash wheelbase was 274.3 cm (108.0) on the driver's side compared to 285.2 cm (112.2 in) prior to the crash.

## 2.1 Test Conditions

The Malibu was aligned to produce a 30 percent overlap on the driver side with the outer most portion of the trailer's side wall. This is a deviation from IIHS Semi-Trailer Underride Evaluation Crash Test Protocol (Version 10) 2016 which specifies:

"30 percent overlap: The midsize car is aligned with the rear of the semi-trailer such that the right edge of the trailer underride guard's horizontal member is offset to the left of the midsize car's centerline by 20 percent of the vehicle's overall width, resulting in a 30 percent vehicle overlap"

This testing reduced the Malibu / RIG overlap to approximately 44.67 cm (17.59 in) compared to the IIHS 30% protocol of 535.5 cm (21.09 in). This overlap resulted in a more rigorous evaluation.

The trailer was connected to a 2012 Freightliner Cascadia Day Cab. The trailer was loaded with 5,300 kg of steel plate placed approximately 50.8 cm (20 in) forward of the rear door sill. The sliding axles were placed near their middle position. The tractor and trailer parking brakes were set by exhausting air pressure from the brake system. The parking brake application was judged to be similar to a driver's partial brake application while being stopped in traffic.

*Figure 3*
*Test Configuration – Bumper Height*

## 2.2 Underride Guard Performance and Vehicle Structural Interaction

Pre-crash static measurements indicated that the Sapa 40/30 RIG horizontal member had a ground clearance of 44.5 cm (17.5 in) and a height of 10.48 cm (4.13 in) prior to the test. The RIG's four vertical support members were attached to the trailer frame with four bolts each. The horizontal member was fastened with two bolts to each vertical support.

*Figure 4*
*2017 Sapa 40/30 RIG – Pre-Crash*

As the Malibu struck the 40/30 RIG, the right two vertical supports deflected forward and downward, partially tearing the rear sill of the trailer from the door frame and bending it downward. The RIG horizontal beam pivoted downward against the support fasteners and bent forward around the right side vertical supports, but it did not fracture. The RIG remained intact; all the fasteners remained attached to the trailer and the RIG horizontal member.

*Figure 5*
*2017 Sapa 40/30 RIG – Post-Crash Right Vertical Support*

The RIG exerted substantial offset loadings into the Malibu's bumper and frame structure, causing the Malibu to rotate approximately 90 degrees counterclockwise, to sideslip, to rebound away from the trailer body, and to come to rest adjacent to the right rear corner of the trailer. The Malibu's windshield and A-pillar did not contact the trailer body. The strength and stiffness of the RIG was sufficient to prevent PCI.


*Figure 6*
*2017 Sapa 40/30 RIG and Malibu – Post-Crash*

Crash energy was absorbed by deflection of the RIG horizonal and vertical supports, by deflection and material failure of the trailer body, and by deformation of the bumper, unibody, and subframe of the Malibu. Deformation of the Malibu's A-pillar and roof header was negligible and the occupant survival space was preserved.


*Figure 7*
*2012 Malibu – Post Crash*


*Figure 8*
*2012 Malibu – Post Crash*

The 40/30 RIG horizontal member is custom profile of Crash Alloy 24 (CA24). This proprietary alloy exhibits high strength and stiffness and extreme ductility during compressive loading.

*Figure 8*
*2017 Sapa RIG 40/30 – Post-Crash CA24 Bumper Deformation*

The novel application of this alloy to a semitrailer RIG via custom extrusion profiles enables superior strength/weight ratios, enhanced energy absorption, and more efficient crash performance compared to traditional RIG designs and materials. In this collision, the CA24 deformed substantially with no evidence of brittle fracture.

The 40/30 RIG deformed significantly further during the crash pulse than did the 35/30 RIG (49.53 cm compared to 2.54 cm). This deformation, which was largely due to the material failure of the trailer door sill, reduced the peak loading and the deceleration rate of the 2012 Malibu during the collision. Optimization of the RIG profiles with CA24 alloy will enable controlled deflection and energy absorption while avoiding uncontrolled material failure.

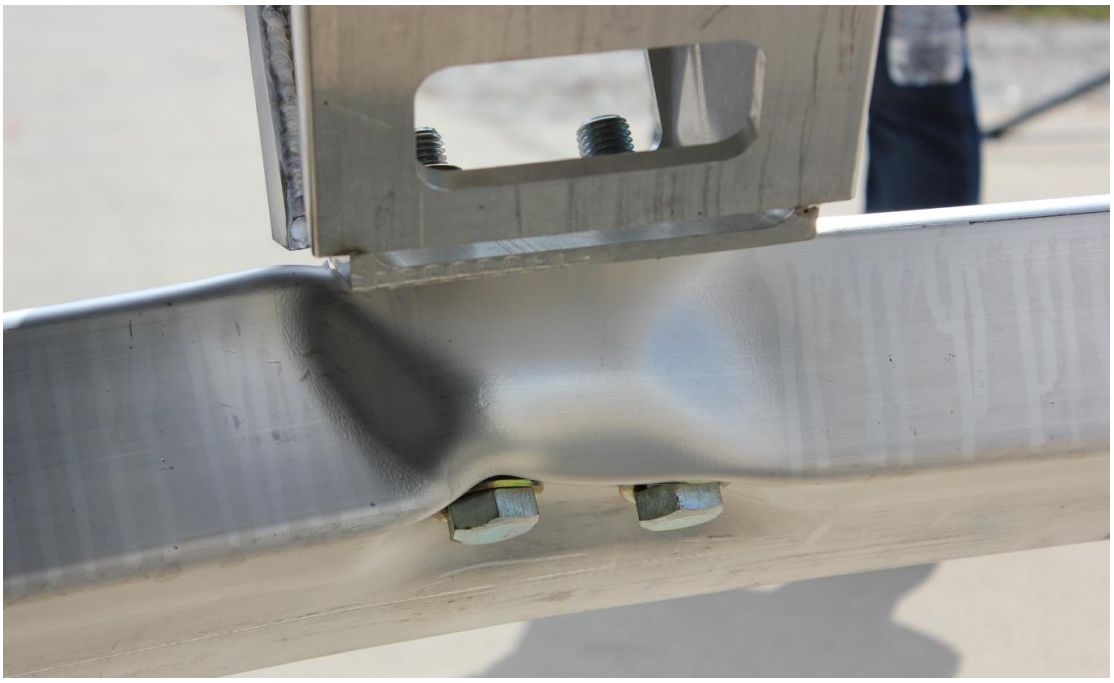

*Figure 9*
*2017 Sapa 40/30 RIG – Post-Crash CA24 Bumper Deformation*

## 2.3 Collision Data

The 2012 Malibu's has event data recorder (EDR) functionality built into the airbag control module (ACM). This data was imaged via Bosch Crash Data Retrieval System version 17.2 following the testing. The EDR data indicated pre-collision velocity and longitudinal and lateral velocity change during the collision. The pre-crash velocity was approximately 40 mph while the combined velocity change was approximately 39.0 mph in 180 ms.

**CDR File Information**

| | |
|---|---|
| User Entered VIN | 1G1ZC5EU2CF379178 |
| User | |
| Case Number | Sapa 40 mph Crash |
| EDR Data Imaging Date | 04/19/2017 |
| Crash Date | 04/19/2017 |
| Filename | 1G1ZC5EU2CF379178_ACM.CDRX |
| Saved on | Wednesday, April 19 2017 at 14:52:07 |
| Imaged with CDR version | Crash Data Retrieval Tool 17.2 |
| Imaged with Software Licensed to (Company Name) | Accident Research Specialists, PLLC |
| Reported with CDR version | Crash Data Retrieval Tool 17.2 |
| Reported with Software Licensed to (Company Name) | Accident Research Specialists, PLLC |
| EDR Device Type | Airbag Control Module |
| Event(s) recovered | Deployment |

*Figure 12*
*2012 Malibu – CDR File Information*

**Pre-Crash Data**

| Parameter | -5 sec | -4 sec | -3 sec | -2 sec | -1 sec |
|---|---|---|---|---|---|
| Vehicle Speed (MPH) | 22 | 27 | 32 | 37 | 40 |
| Engine Speed (RPM) | 0 | 0 | 0 | 0 | 0 |
| Percent Throttle | 30 | 30 | 30 | 30 | 30 |
| Brake Switch Circuit State | OFF | OFF | OFF | OFF | OFF |
| Accelerator Pedal Position (percent) | 0 | 0 | 0 | 0 | 0 |
| Antilock Brake System Active (If Equipped) | No | No | No | No | No |
| Lateral Acceleration (feet/s²)(If Equipped) | -0.82 | -0.82 | -0.82 | -0.82 | -1.64 |
| Yaw Rate (degrees per second) (If Equipped) | -1 | 0 | -1 | -1 | -1 |

1G1ZC5EU2CF379178 Page 3 of 10 Printed on: Wednesday, April 19 2017 at 14:53:23

*Figure 13*
*2012 Malibu - CDR Pre-Crash Data*

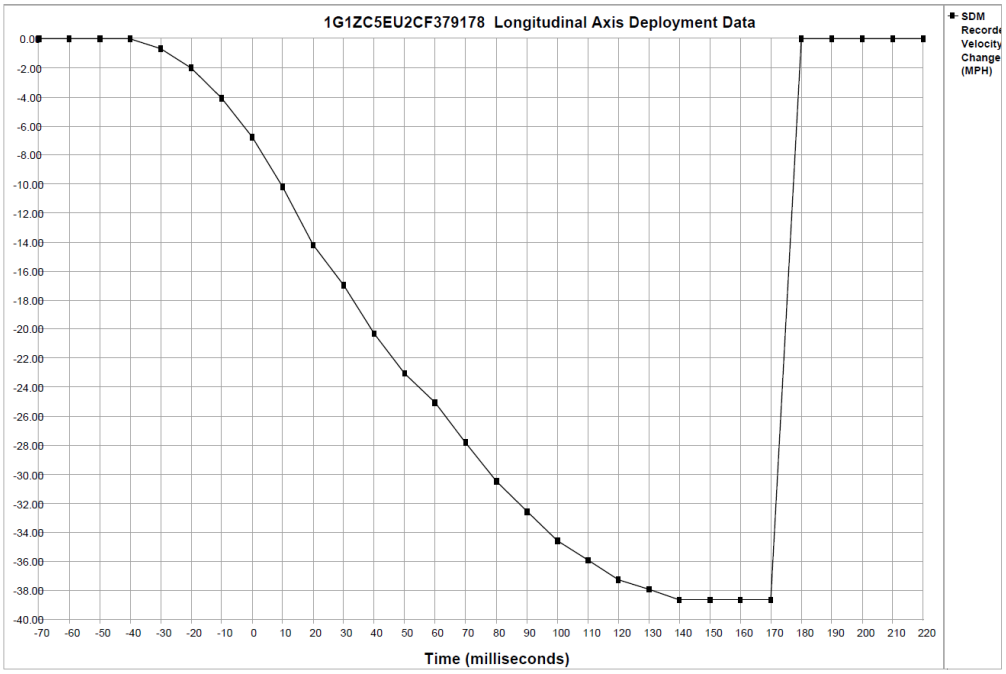


*Figure 14*
*2012 Malibu - CDR Longitudinal Axis Deployment Data Graph*

| Time (milliseconds) | -70 | -60 | -50 | -40 | -30 | -20 | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SDM Longitudinal Axis Recorded Velocity Change (MPH) | 0.00 | 0.00 | 0.00 | 0.00 | -0.68 | -2.03 | -4.07 | -6.78 | -10.17 | -14.23 | -16.94 | -20.33 | -23.04 | -25.07 | -27.79 |
| Time (milliseconds) | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 220 |
| SDM Longitudinal Axis Recorded Velocity Change (MPH) | -30.50 | -32.53 | -34.56 | -35.92 | -37.27 | -37.95 | -38.63 | -38.63 | -38.63 | -38.63 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Figure 15*
*2012 Malibu - CDR Longitudinal Axis Deployment Data Table*

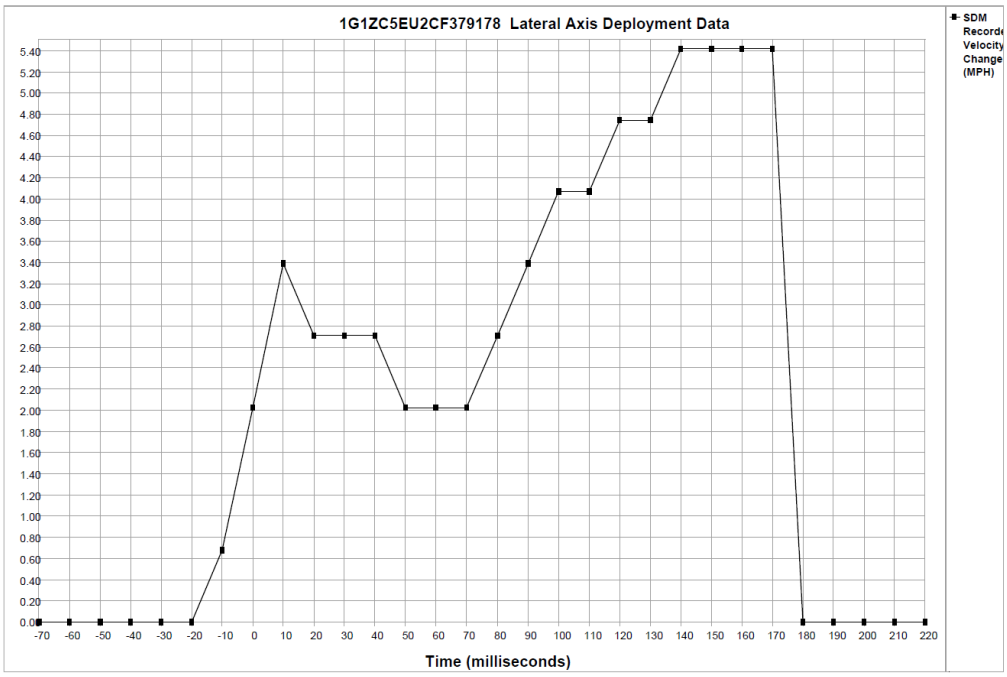


*Figure 15*
*2012 Malibu - CDR Lateral Axis Deployment Data Graph*

| Time (milliseconds) | -70 | -60 | -50 | -40 | -30 | -20 | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SDM Lateral Axis Recorded Velocity Change (MPH) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.68 | 2.03 | 3.39 | 2.71 | 2.71 | 2.71 | 2.03 | 2.03 | 2.03 |
| Time (milliseconds) | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 220 |
| SDM Lateral Axis Recorded Velocity Change (MPH) | 2.71 | 3.39 | 4.07 | 4.07 | 4.74 | 4.74 | 5.42 | 5.42 | 5.42 | 5.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Figure 16*
*2012 Malibu - CDR Lateral Axis Deployment Data Table*

Sapa Representative:

I have reviewed engineering report of Malcolm Deighton, (28 June 2017 version 1.0) describing 40 mph / 30% overlap rear guard testing of April 19, 2017. The reporting systematically and accurately describes the methodologies and results of the testing to the best of my knowledge.

I have incorporated minor formatting and content edits into this draft (7 July 2017 version 1.1).

Respectfully Submitted,

Aaron Kiefer, MSME, PE
Founder and Principal Engineer
Collision Safety Consulting, PLLC