Truck Tire Antisplash Feature

Development and Testing of Michelin 275/80R22.5 XZA2 Antisplash

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ABSTRACT

Michelin has developed a new socially responsible technology for Truck tires named Antisplash (U.S. Patent No. 6,460,584 B1) and is introducing it to the North American market on the 275/80R22.5 XZA2 Antisplash long haul steer tire. The primary advantage of this development is the significant reduction in the splash height/trajectory of water projected by a steer tire when the vehicle passes through accumulations on the highway/road surface.

Tire development and validation testing were completed by Michelin Americas Research and Development Corporation.

The tire has a unique shoulder/sidewall profile (chine) which acts as a splash deflector (see photos 1 & 2). The fluid is redirected to a lower height with a modified volume to height relationship. Intended benefits include improved visibility realized by oncoming and passing vehicles and the improved visibility experienced by the driver when using side mirrors.

photo 1

photo 2

INTRODUCTION

The Antisplash chine feature was added to the serial number side of the existing 275/80R22.5 XZA2. This is the side opposite the DOT marking and will require mounting the tire on the rim so that the Antisplash chine is oriented to the outside of the vehicle. Using a steer tire for the technology is based on the theory that the front tires clear a path by displacing the large fluid accumulations on the road surface first. Therfore, the Antisplash chines' effectiveness for improving driver visibility can best be utilized on the steer tire position.

Michelin also provided the definition of the maximum envelope dimensions for grown, one-sided, chine type, steer axle tires in service. This design guide was accepted by the Tire and Rim Association, Inc. (T&RA) and can be used by vehicle manufacturers in designing for tire clearances. The definition can be found on page 3-31 of the T&RA

Engineering Design Information manual and was a critical step in the development of the Antisplash technology for use on U.S. public roads.

The Antisplash chine is on one side of the tire only. It is to be mounted toward the exterior of the vehicle in order to provide splash reduction and to prevent interference with steering/suspension and frame components. For retreading, it is to be completely removed in order to maintain dual spacing and tire clearance during second and subsequent life fitments on drive or trailer positions.

This paper will discuss the tire testing outlined in Cooperative Agreement #DTFH61-03-X-00030 to the U.S. Department of Transportation, Federal Highway Administration, Turner Fairbank Highway Reseach Center.

TESTING AND DEVELOPMENT

The following testing (table 1) was conducted per phase one Task 1.3 (Internal and Track Testing and Final Reporting) of the above proposal.

Machine Testing
Tire Rolling Resistance and Temperature Tire Endurance 1 (Speed) Tire Endurance 2 (Cornering) Ozone Testing Tire Footprint and Contact Stress
Track Testing
Curb Scrub Tire Sidewall Cracking (not available until March 31, 2006) Splash Height Test Splash Volume Test Splash Video Production

Table 1

Tire Rolling Resistance and Temperature

The Antisplash chine on the 275/80 R22.5 XZA2 required additional rubber to be added to one side of the tire for an asymmetric profile (see diagram A). Adding rubber to the tread and shoulder areas of a tire prompts design verification of temperature and rolling resistance. The hysteretic nature of rubber will create a rise in both temperature and rolling resistance with increased volume.

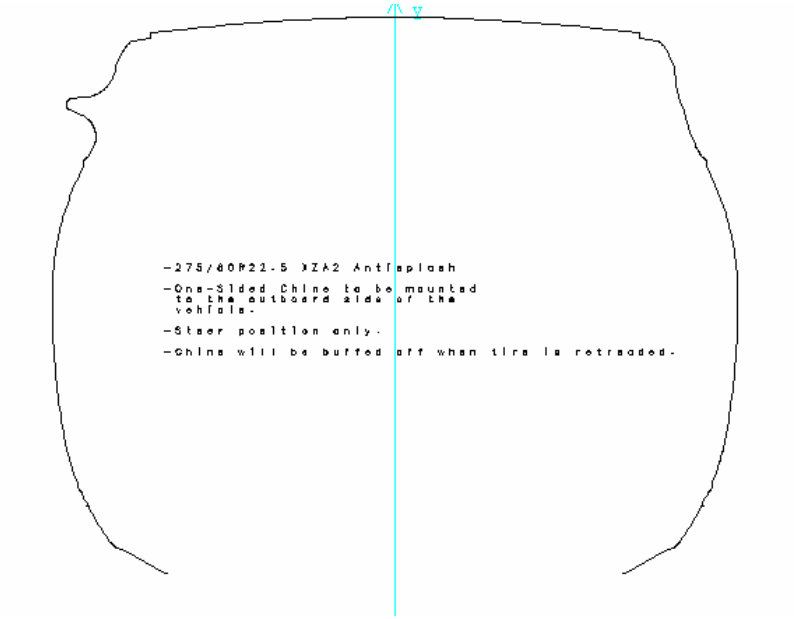


diagram A

Four Antisplash tires were tested and the rolling resistance and tire tread temperature data can be found in diagrams B and C. The addition of the chine profile to the shoulder of the 275/80R22.5 XZA2 did not generate a significant change in rolling resistance. This result is favorable for the Antisplash technology. An increase in rolling resistance would have been a negative attribute giving rise to fuel consumption concerns.

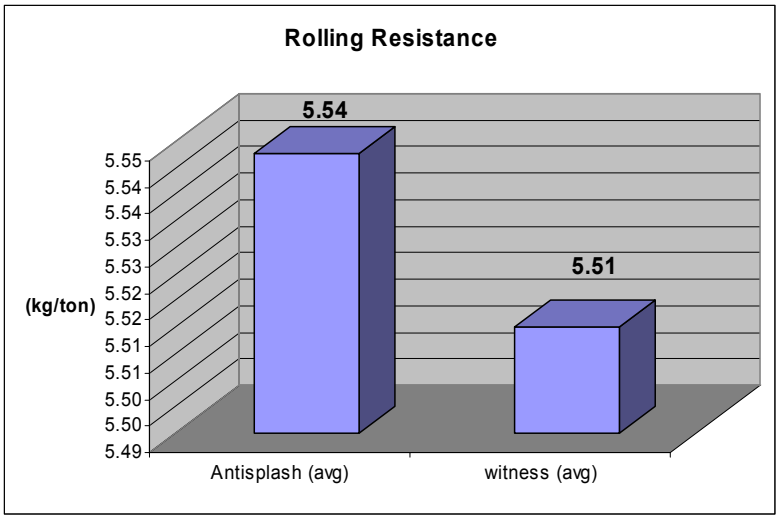


diagram B

(note : kg/ton is the rolling resistance coefficient and represents the rolling resistance resistance force (kg) normalized per metric ton of load (1000 kg), witness 275/80R22.5 XZA2)

Temperature measurements were made in conjunction with the evaluation of rolling resistance. The tread temperatures were found to be higher on the side of the tire with the chine. An average increase of 2.5 ^{o} C was measured between the chine side and the chine

free side. This increase was expected and is not considered significant. The temperature is well below levels that would create issues with tire endurance.

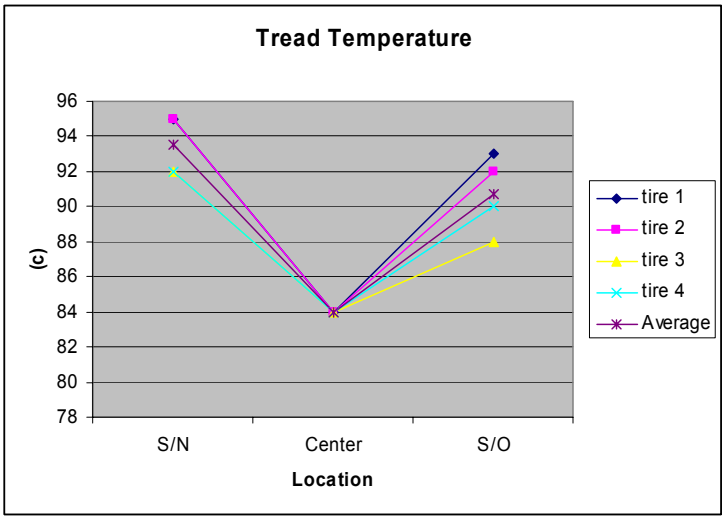


diagram C

Tire Endurance 1 (Speed)

Testing was also conducted to evaluate the short duration speed endurance capabilities of the 275/80R22.5 XZA2 Antisplash. Two tires were tested at increasing speed and identical results were obtained. Tread separation stopped the test at 93.8 mph. The published maximum speed rating for this tire is 75 mph.

Tire Endurance 2 (Cornering)

In this evaluation the tire is subjected to vertical and lateral forces at intervals which maintain tire temperature as the tires tread wears. The steer angle required to generate the lateral force set point changes as the tire wears and as the products in the tire begin to separate.

Two 275/80R22.5 XZA2 Antisplash tires were evaluated during this test. Both tires produced similar plots of steer angle vs. distance (see diagrams D.1, D.2). The ending distances were well within the expected range for steer applications.

Tire 1

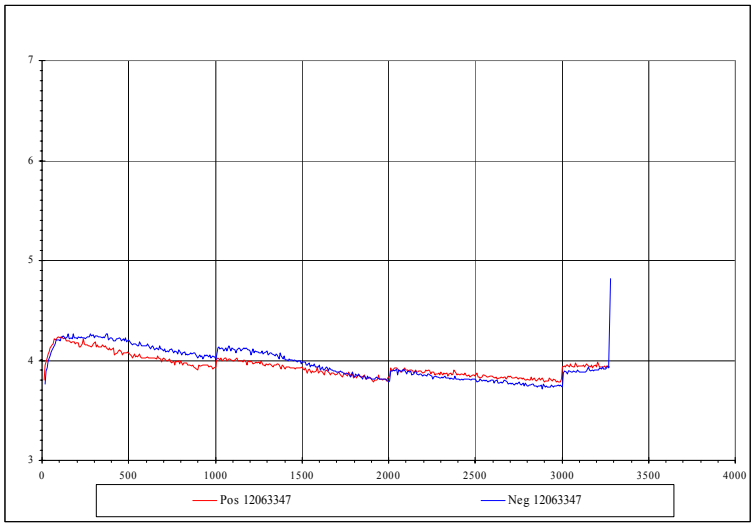


diagram D.1

Tire 2

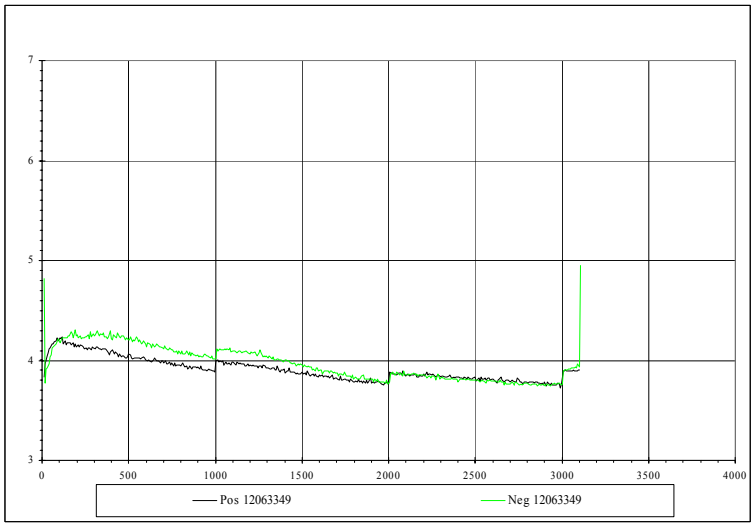


diagram D.2

Each cycle of alternating steer angles required less steer angle to generate the Y force set point. This is due to the reduction in tread depth that occurs when the tire wears during the test. During the last step it is evident that the steer angle begins to creep up slightly. This is the beginning of belt separation and requires higher steer angles to produce the same Y force. The distance and failure mode observations were consistent with expected results from this test.

Ozone Testing

Two 275/80R22.5 XZA2 Antisplash tires were tested in an ozone rich atmosphere with an applied torque. This testing situation produces additional strain in the tire sidewall and allows the high concentration of ozone to prematurely degrade the stressed rubber. The test results showed no sensitivity to the ozone. Tire sidewall lettering and profiles were well defined and crack free after test. The Antisplash chine remained pliable without change in texture or profile (see photos 3 & 4).

photo 3

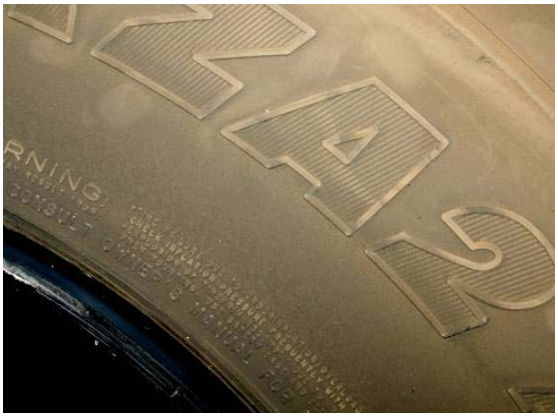
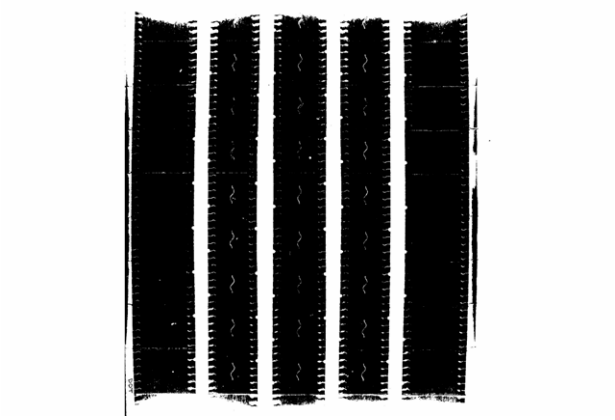


photo 4

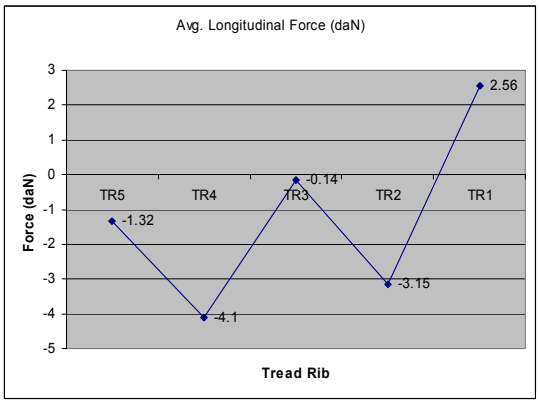
Tire Footprint and Contact Stress

Tire footprint and contact stress tests were completed on the 275/80R22.5 XZA2 Antisplash. The prototype tire tested provided slightly braking longitudinal force plots and low stress values (see figures 1, 2.1, 2.2) and produced a symmetric footprint. These measurements of a prototype tire provide indications of production capabilities. An optimized footprint for even wear is achievable for a tire with the Antisplash technology.



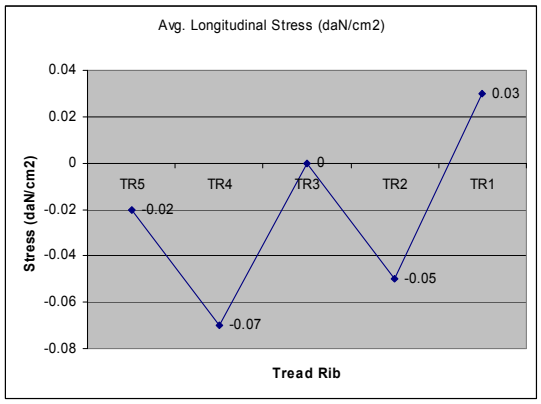
chine side

figure 1



chine side

figure 2.1



chine side

figure 2.2

Curb Scrub

Curb scrub/climb testing is performed on a vehicle and consists of a set number of curb climbs and drop offs. First the tires are used on the vehicle until they reach a standard operating temperature and then the shoulder endurance of the tire is evaluated. The concern with the Antisplash chine was the sensitivity of the shoulder profile to curbing.

The Antisplash chine proved to be very durable. No tears or permanent deformations existed on the chine profile. The photograph below shows where the Antisplash chine was scuffed from a curb climb (see photo 5).

photo 5

Tire Sidewall Cracking

The results of this test were not available. Testing is ongoing and should be available by March 31, 2006.

Splash Height Test Development

In order to evaluate the effectiveness of the 275/80R22.5 XZA2 Antisplash for splash height reduction Michelin created a test method at the Laurens Proving Grounds. This is the Michelin Americas R&D track testing facility. A straight section of track was modified to allow the track surface to be continuously covered with 7 – 10 mm of water. A splash screen was installed 2.7 m from the vehicle path and was used to capture the splash height of the water trajectory from the passing vehicle. The vehicle speed was 45

mph. Multiple passes were made with the 275/80R22.5 XZA2 Antisplash and with a witness tire (275/80R22.5 XZA2). Photo 6 shows the test vehicle during test where the left front tire (in cab facing forward) is the witness 275/80R22.5 XZA2 and the right front tire is the 275/80R22.5 XZA2 Antisplash (see photo 7). The splash screen can be seen in photo 6 on the left side of the photo.

photo 6

photo 7

The Antisplash chine provided a 48.5 % reduction in splash height. This was with an average water depth on the track of 8.4 mm (see diagram E).

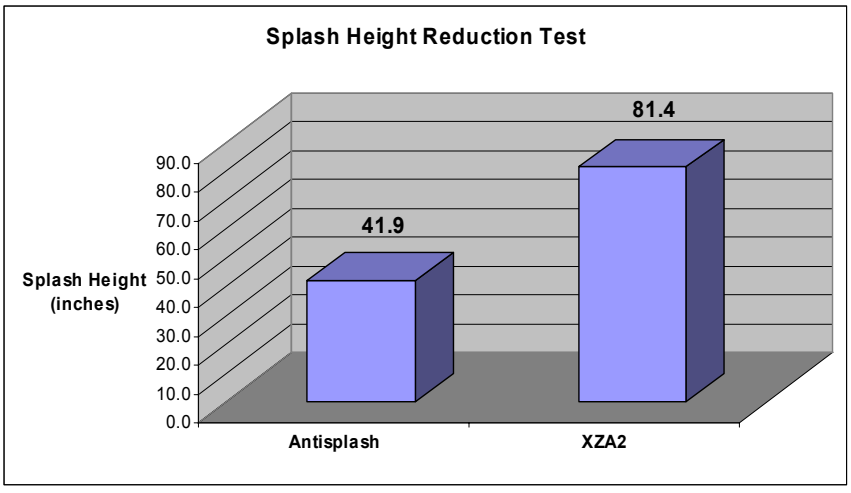


diagram E

Splash Volume Test

The splash volume vs height test was developed to demonstrate the effectiveness of the Antisplash technology and give a better understanding of water displacement. Again, the witness tire was the 275/80R22.5 XZA2. Testing utilized the same track and test vehicle as the splash height test. However, the volume test required the design and fabrication of a vertical test stand with capture trays. The trays were evenly spaced (4 inches) and allowed the water to be removed for measure. Again, multiple passes were made with the test vehicle to provide the water volume vs. splash height relationship. The bar chart below shows the volume vs. height for the Antisplash (AS) and the witness (MC) tires (see diagram F). Total displaced volume for the witness was 362 ml vs. 107.5 ml for the Antisplash.

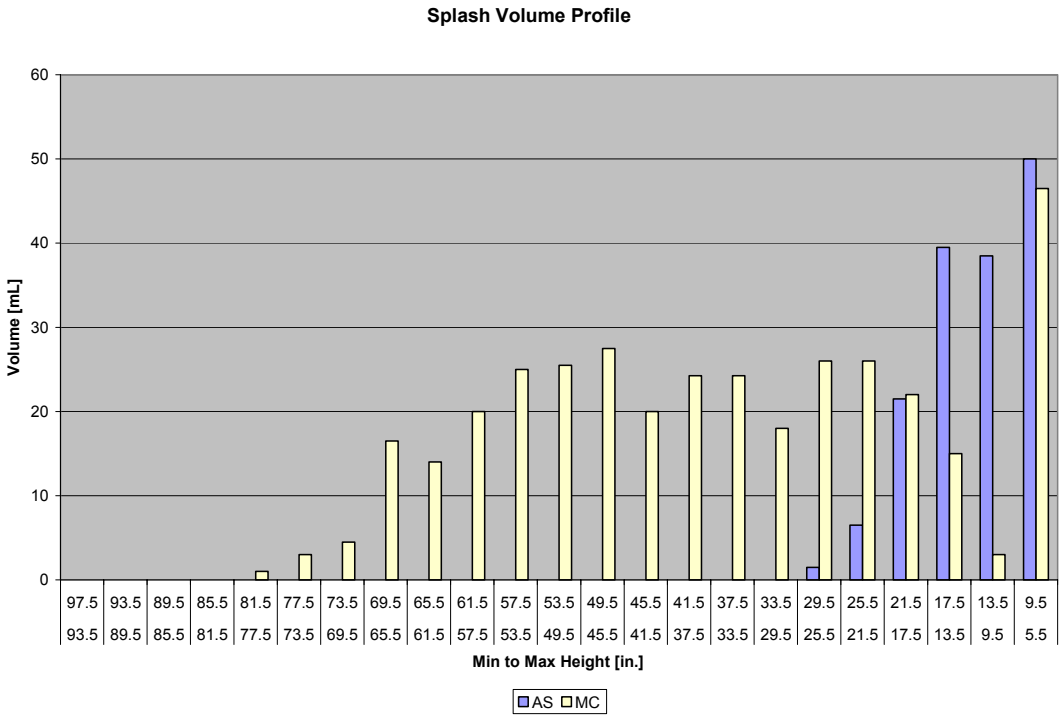


diagram F

Michelin also evaluated the tire at ½ tread depth. This was to simulate the performance of the Antisplash technology with a worn tire. With 7 – 10 mm of track water depth and both tires at ½ tread depth (9/32") the tread voids of the tires were completely filled. The bar chart below shows the volume vs. height for the Antisplash (AS) and the witness (MC) tires at ½ tread depth (see diagram G). Total displaced volume was 377.5 ml for the witness vs. 259 ml for the Antisplash.

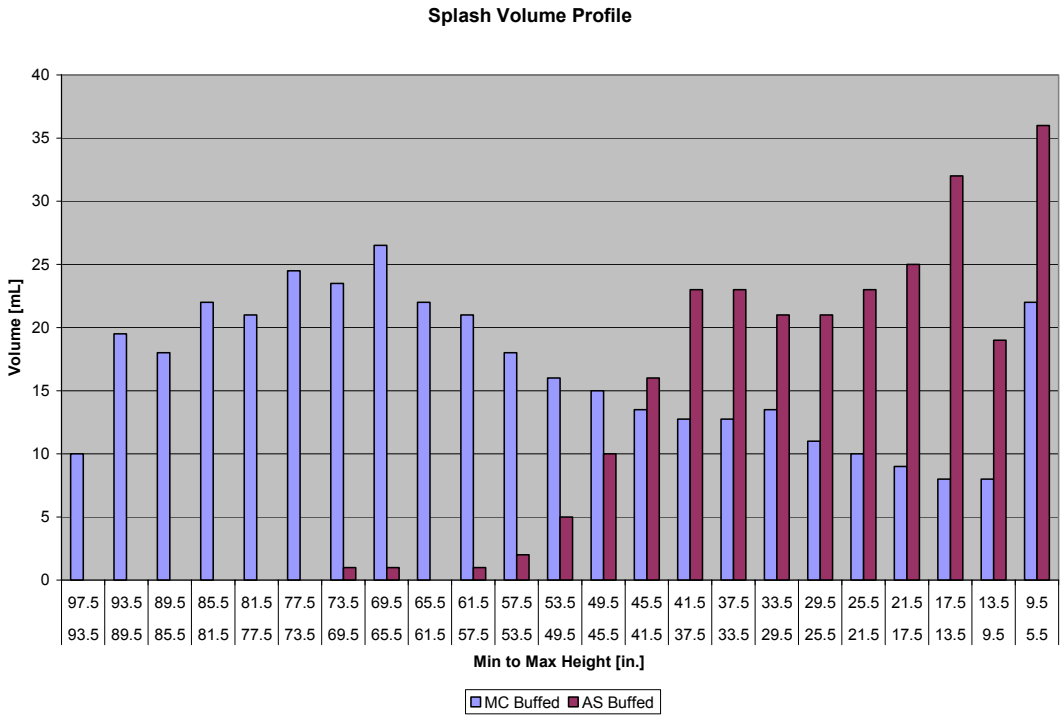


diagram G

The splash volume vs. height characterization was also completed for full and ½ tread depth tires (with and without the Antisplash technology) at a track water depth of 3 -4 mm. The bar chart below shows the volume vs. height for the Antisplash (AS) and the witness (MC) tires at full tread depth and ½ (buffed) tread depth (see diagram H). Total displaced volume for the witness buffed was 43.5 ml vs. 30.5 ml for the Antisplash. The witness with full tread depth displaced 13 ml of water. The full tread Antisplash at the 3-4 mm water depth did not displace a measurable volume of water.

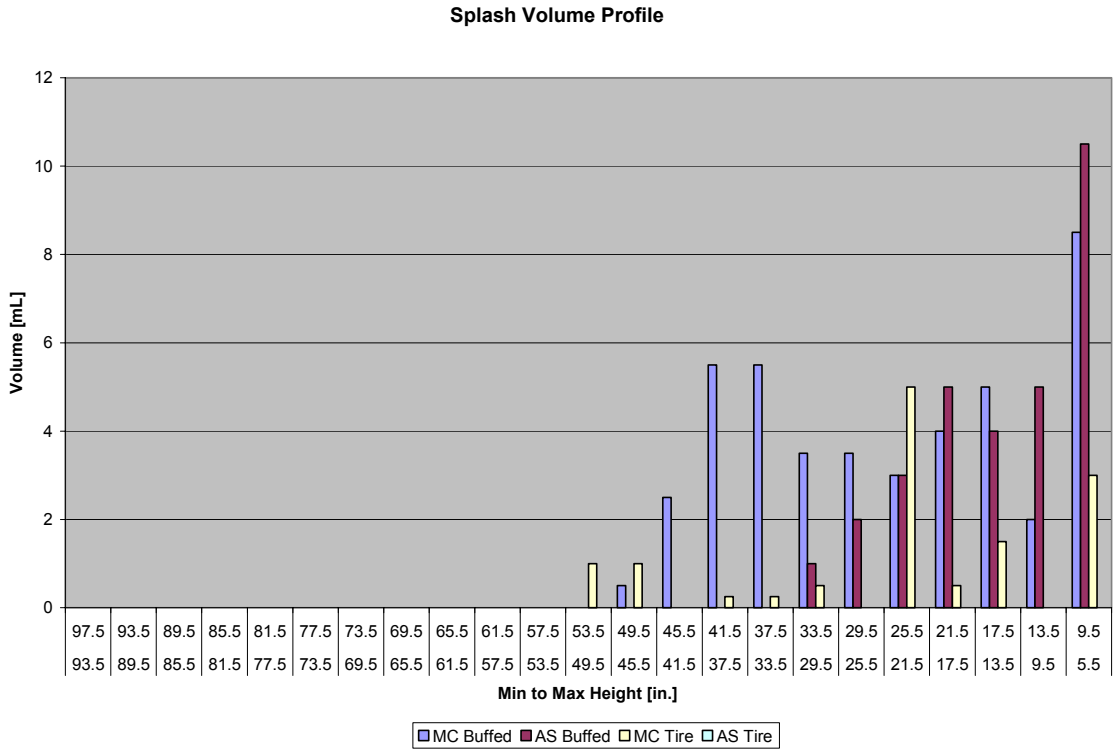


diagram H

Conclusions

All of the development and testing of the 275/80R22.5 XZA2 Antisplash has been favorable. Michelin's Antisplash technology provided a reduction in water splash height. The water volume vs. splash height testing gave a clear representation of the advantage this new truck tire technology. The Antisplash XZA2 provided reductions in splash height and significant reductions of splashed water volume with respect to height. Half tread depth testing supplied data that gave the advantage to the Antisplash XZA2 and provided insight to the performance of this technology with tires in a partially worn condition. Machine testing data indicated no issues with rolling resistance, tire temperature, tire endurance, or wear performance were created by the addition of the Antisplash technology to the 275/80R22.5 XZA2.