January 25, 2011

· TEST REPORT ·

PN 94504
PO NAKRON1111-Flame

Akron Rubber Development Laboratory, Inc.
ARDL Engineering Department

EVALUATION OF FLAMMABILITY OF TIRE LYNA

Prepared For:

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SUBJECT:
Evaluation of Flammability of Tire Lyna

EXECUTIVE SUMMARY:
The purpose of this work was to determine the propensity of Tire Lyna gel to generate flammable volatiles. A stainless steel 30-cc reactor with high-vacuum valve was filled with Tire Lyna. The closed reactor was placed in an oven for four hours at 280°F. While the reactor was hot, its valve was opened next to a propane burner. A flame could not be sustained.

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PURPOSE AND SCOPE:
The purpose of this work was to determine the propensity of Tire Lyna gel to generate flammable volatiles. A stainless steel 30-cc reactor with high-vacuum valve was filled with Tire Lyna. The closed reactor was placed in an oven for four hours at 280°F. While the reactor was hot, its valve was opened next to a propane burner. Report whether a flame could be sustained.

EXPERIMENTAL TECHNIQUES:
Flammability Test:
A test to determine the flammability of volatiles from Tire Lyna after 4 hours at 280°F was performed. The experiment was designed to determine whether the volatiles support combustion by exposure of the volatiles to a flame. A stainless steel 30-cc reactor with a high-vacuum valve was filled with Tire Lyna. The closed reactor was placed in an oven for four hours at 280°F. While the reactor was hot, its valve was opened next to a propane burner. Report whether a flame could be sustained. Two experiments were performed.

Materials: Tire Lyna gel was tested as received (Table 1).

Table 1: Description of Sample	
ARDL Notebook Number	Description
ERTNB5-24-1	Tire Lyna (half gallon)

RESULTS:

The results of experiment 1 are summarized below.
Figure one shows a picture of the reactor with a high-vacuum valve. The reactor was filled with 29.47 grams of Tire Lyna (Figure 2). After four hours in the oven at 280F the reactor was removed and allowed to cool for fifteen minutes. The reactor valve was placed close the flame (Figure 3) and the valve was opened. After opening the valve, I saw no sign of flammable gases (Figure 3). I did not observe any evidence of pressure in the reactor.

Figure 1: Picture of Reactor Assembly at Start of Experiment

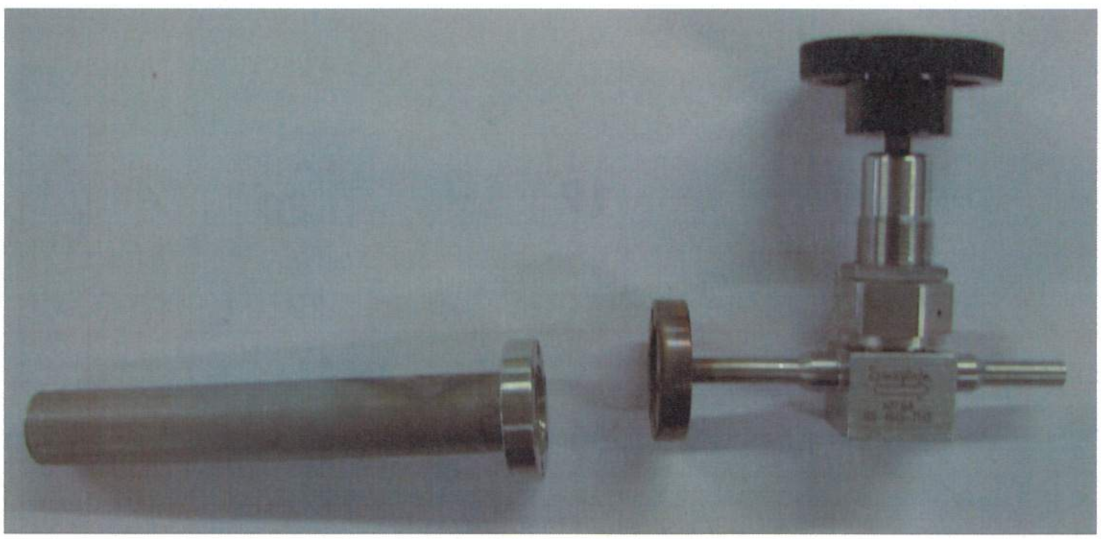


Figure 2: Picture of Reactor after filled with Tire Lyna

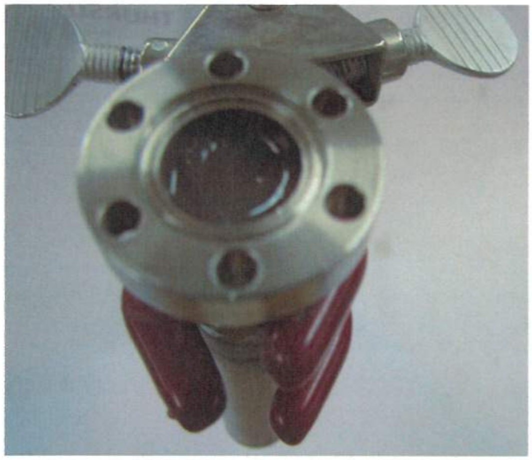
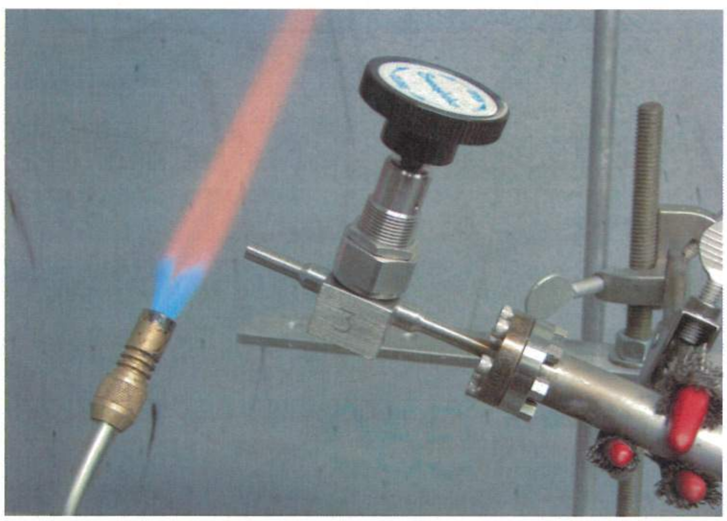


Figure 3: Picture of Reactor Tip and Flame



The results of experiment 2 are summarized below.
The reactor was filled with 29.87 grams of Tire Lyna. After four hours in the oven at 280F the reactor was removed; and, unlike experiment one, it was not allowed to cool. The tip of the reactor valve was placed close to the flame and the valve was opened. There was pressure inside the reactor. Initially, gases came out of the reactor; after which, the gel came out and splattered on the wall of the hood (Figure 4 and 5). The initial gases which came out of the reactor appeared to cause a very slight burning observation in the flame of the propane torch; however, the gases could not sustain a flame. Presumably there was a very slight organic content in the gas, which was mostly water vapor. The pressure came from water vapor and hot air. The Tire Lyna gel which passed through the flame did not burn (could not support combustion).

Figure 4: Picture of Reactor Tip after Opening Valve

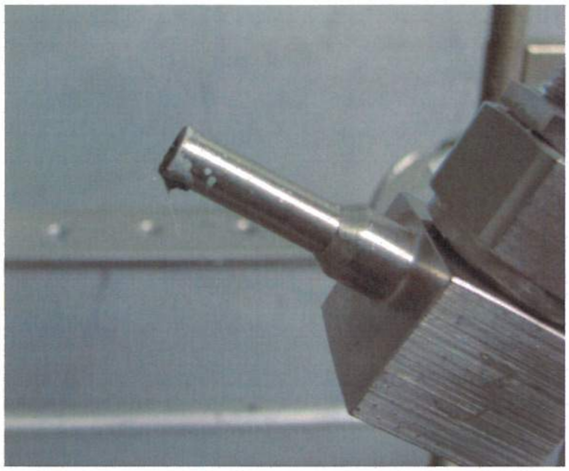
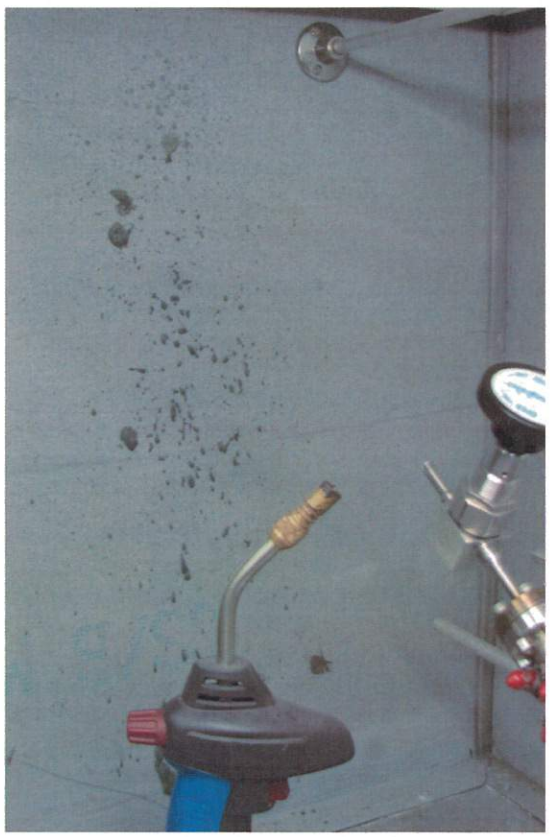


Figure 5: Picture of Tire Lyna which Splattered onto Wall of Lab Hood



Prepared By: *[signature]* Approved By: *[signature]*

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Greg Simms
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February 4, 2011

▪ TEST REPORT ▪

PN 94504
PO NAKRON1111-Flame

Akron Rubber Development Laboratory, Inc.
ARDL Engineering Department

DETERMINE VOLATILES FROM TIRE LYNA

Prepared For:

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*Certificate Numbers 255.01 & 255.02

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SUBJECT:
Determine Volatiles from Tire Lyna

EXECUTIVE SUMMARY:
The purpose of this work was to determine the chemical composition of volatiles generated by Tire Lyna at elevated temperature. In a prior experiment, a stainless steel 30-cc reactor with high-vacuum valve was filled with Tire Lyna. The closed reactor was placed in an oven for four hours at 280°F. While the reactor was hot, its valve was opened next to a propane burner. A flame could not be sustained; however, there was gas pressure. In this study, the chemical composition of the volatiles was examined by headspace gas chromatography/mass spectroscopy (GC/MS). Most of the gas is presumably was water vapor, because it would not support combustion. A small portion of the gas was flammable, so headspace GC/MS was performed to determine the chemical composition of the organic volatile(s). The major organic volatile was determined to be propylene glycol at very low concentration. It is concluded that this product will not support combustion and will not cause fire in a retread chamber.

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PURPOSE AND SCOPE:
The purpose of this work was to determine the chemical composition of the organic volatile(s) generated by Tire Lyna gel. A sealed vial was placed in an oven for four hours at 280°F. The volatiles in the headspace above the Tire Lyna gel were examined by GC/MS.

EXPERIMENTAL TECHNIQUES:
Headspace Gas Chromatography/ Mass Spectroscopy (GC/MS) Test:
Tire Lyna was placed in a sealed vial and heated in an oven for four hours at 280°F. The volatiles in the headspace above the Tire Lyna gel were examined by gc/ms per ARDL Method HEADSPACE M using an Agilent 6890 GC/5973MSD with columns based on bonded poly (5% diphenyl/95% dimethylsiloxane.

Materials: Tire Lyna gel was tested as received (Table 1).

Noorez Devraj
Tire Lyna Manufacturing, Inc.

Table 1: Description of Sample	
ARDL Notebook Number	Description
ERTNB5-24-1	Tire Lyna (half gallon)

RESULTS:

The results of the headspace gc/ms experiment are summarized below. Approximately 2 grams of Tire Lyna was placed in a 10cc sealed vial heated in an oven for four hours at 280°F. The headspace gas was analyzed by GC/MS to determine the chemical composition of the organic volatile(s). The major organic volatile was determined to be propylene glycol at very low concentration. It is concluded that this product will not support combustion and will not cause fire in a retread chamber.

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December 1, 2011

· TEST REPORT ·

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PO ARDLTMCND62011

Akron Rubber Development Laboratory, Inc.
ARDL Engineering Department

EFFECT OF TIRE LYNA ON TIRE DURABILITY
Prepared in-part for the ***TMC Proposed*** *RP 246*

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SUBJECT:

Effect of Tire Lyna on Tire Durability – Prepared in-part for the **TMC Proposed RP 246**

EXECUTIVE SUMMARY:

The purpose of this work is to determine the effect of Tire Lyna on tire durability (particularly its effect on the inner-liner and plycoat compounds). The effect was measured on roadwheel tested tires with and without Tire Lyna. The tire integrity was measured by shearography before and after roadwheel testing. The tire surface running temperatures and inflation pressures were monitored. Tire component (innerliner and plycoat) mechanical properties were measured in new and tested tire with and without Tire Lyna.

The tire tread and sidewall surface temperatures were measured as a function of roadwheel time. The tire inflation pressures were measured as a function of roadwheel time. Slightly better pressure in the tire with Tire Lyna was observed at 15 days and at the end of the roadwheel testing. The innerliner from the tire with Tire Lyna had slightly higher tensile strength and elongation to break, and slightly lower modulus than the tire without Tire Lyna. The tire with Tire Lyna had (significantly improved) lower hardness than the tire without Tire Lyna. The improved property retention is attributed to protection against oxidation provided by Tire Lyna.

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PURPOSE AND SCOPE:

The purpose of this work is to determine the effect of Tire Lyna on tire durability (particularly its effect on the inner-liner and plycoat compounds). The effect was measured on roadwheel tested tires with and without Tire Lyna. The tire integrity was measured by shearography before and after roadwheel testing. The tire surface running temperatures and inflation pressures were monitored. Tire component (innerliner and plycoat) mechanical properties were measured in tested tire with and without Tire Lyna.

EXPERIMENTAL TECHNIQUES:

Materials: Tire Lyna gel was tested as received (Table 1).

Table 1: Description of Sample	
ARDL Notebook Number	Description
ERTNB5-96-1	Tire Lyna (5 gallon)

Three Michelin tires were purchase and tested as received (Table 2).

Table 2: Description of Tires					
ARDL Notebook Number	STL Notebook Number	Manufacturer	Model	DOT Number	Testing Purpose
JHNB1-22-1	ARDL1-0002	Michelin	275/80R22.5 XZA3 LR G	M5EJBN1X4710	Roadwheel testing with Tire Lyna
JHNB1-22-2	ARDL1-0001	Michelin	275/80R22.5 XZA3 LR G	M5EJBN1X4710	Roadwheel testing without Tire Lyna

JHNB1-22-3		Michelin	275/80R22.5 XZA3 LR G	M5EJBN1X4710	New (untested) tire control

Roadwheel Testing:
The roadwheel test conditions were (360 hours at 40 mph, 85% maximum load (5249 pounds), and rated singles inflation pressure (100 psi)). These test conditions (40 mph at 85% load and rated singles inflation pressure) were selected to simulate highway tire conditions (tire running temperatures) according to ASTM test method F 2779-10 Standard Practice for Commercial Radial Truck-Bus Tires to Establish Equivalent Test Severity Between a 1.070-m (67.23-in) Diameter Roadwheel and a Flat Surface.

Shearography Testing:
Shearography was performed using an ITT-1 (Interferometric Tire Tester) from SDS Systemtechnik GmbH. Nine sectors were shearographed. The test conditions were 30-50 mBar vacuum, 99-110 mm horizontal head position, 180-465 mm vertical head position, and 0° to -44° head tilt.

Surface Running Temperature Testing:
Tire surface running temperatures were measured with a FLIR Systems, Inc camera (infrared camera) type T300.

RESULTS:

Initial Shearography:
Shearography was performed to confirm the absence of internal flaws before roadwheel (Figures 1-6). The results showed that these two tires (JHNB1-22-1 and JHNB1-22-1).were free of any anomalies or internal flaws.

Figure 1: Shearograph of JHNB1-22-1 Crown

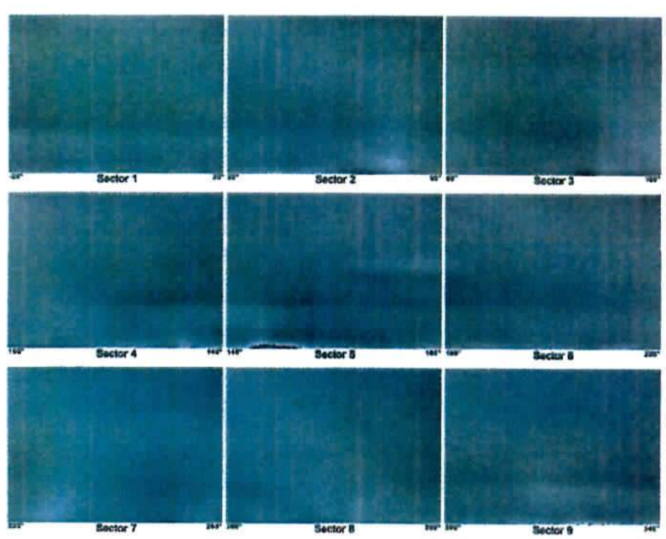


Figure 2: Shearograph of JHNB1-22-1 OSS Bead

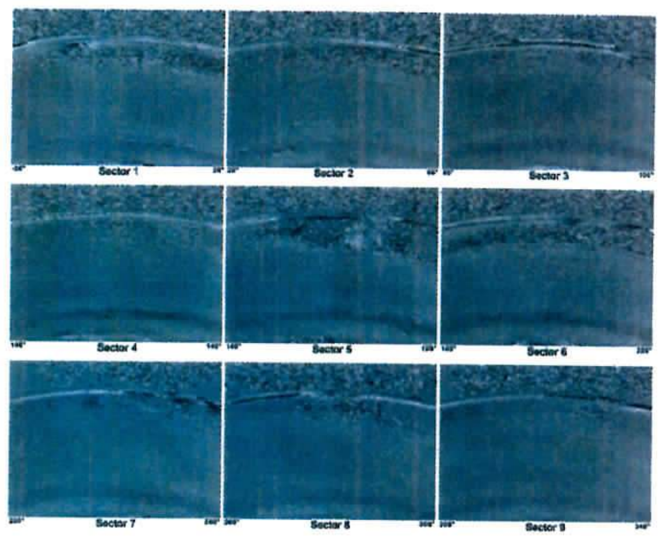


Figure 3: Shearograph of JHNB1-22-1 SS Bead

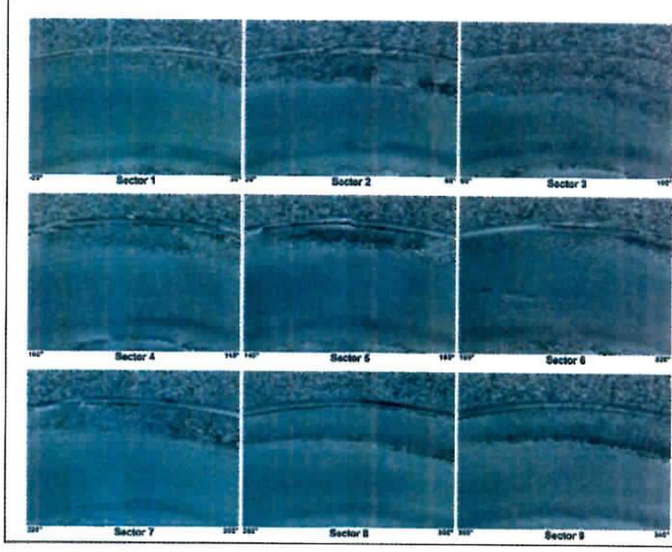


Figure 4: Shearograph of JHNB1-22-2 Crown

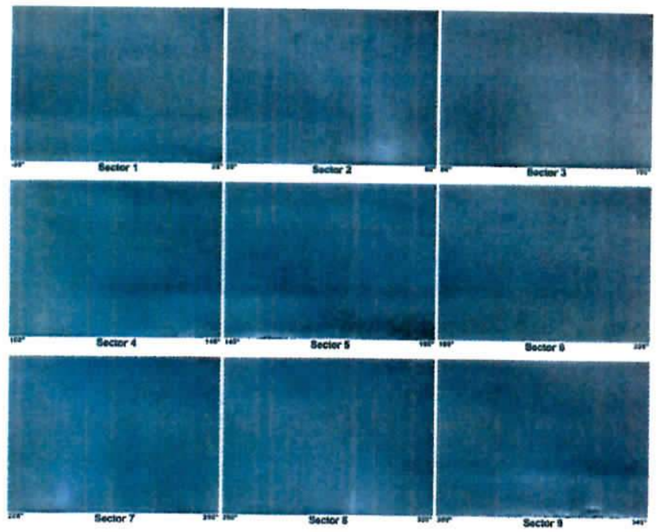


Figure 5: Shearograph of JHNB1-22-2 OSS Bead

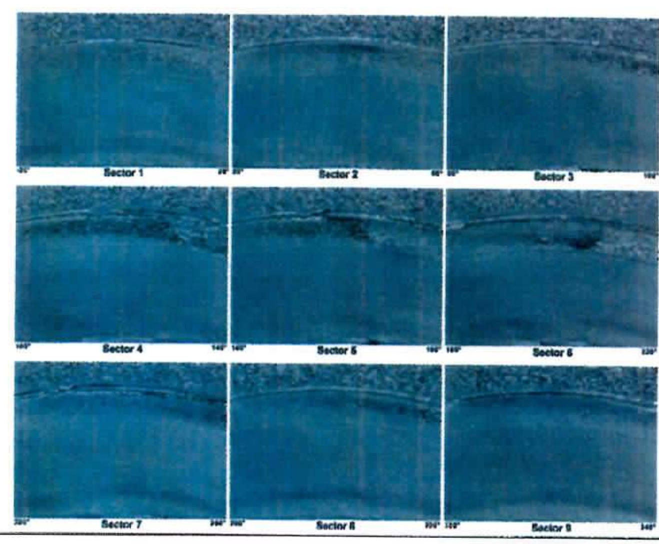
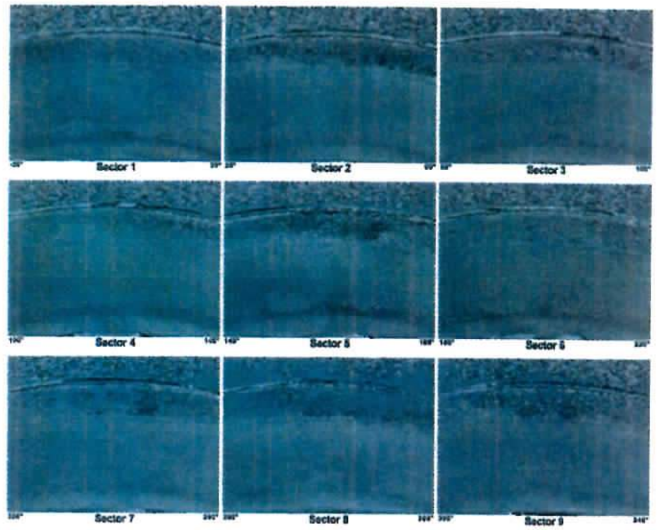


Figure 6: Shearograph of JHNB1-22-2 SS Bead



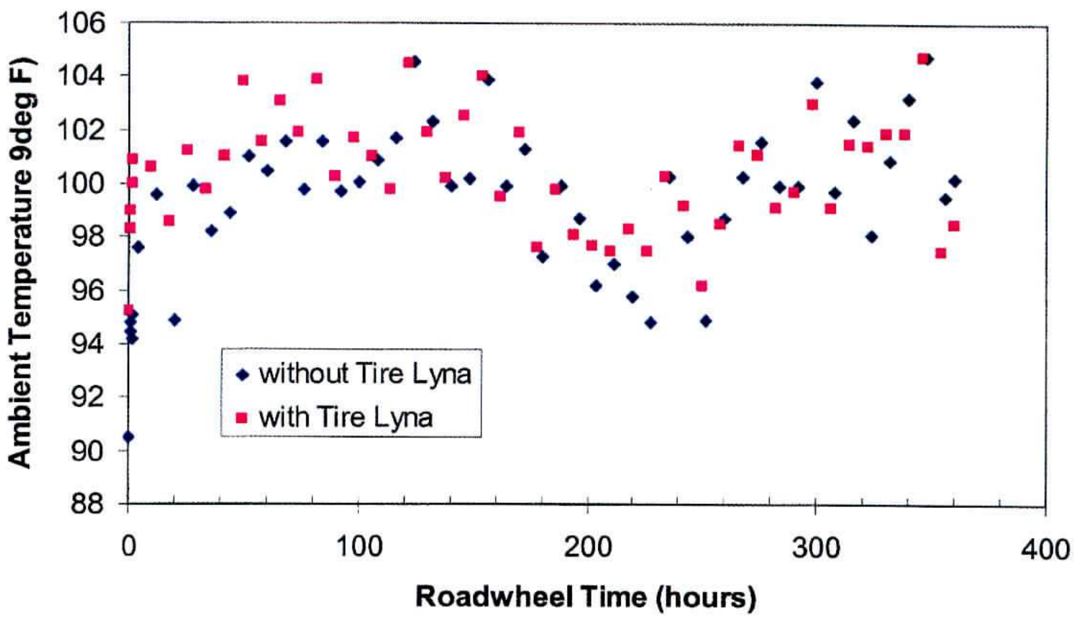
Addition of Tire Lyna:
Tire Lyna was added to tire JHNB1-22-1. 60 fluid ounces (1792 grams) was added through the valve stem (with the valve core removed) with a tire sealant hand pump.

Roadwheel Test:
The roadwheel test set-up is shown in Figure 7. The roadwheel testing was performed at Standards Testing Labs.

Figure 7: Roadwheel Test Setup

Ambient temperature was measured at each tire, both tires were within ASTM ambient temperature specification. JHNB1-22-2 (without Tire Lyna) starting conditions were 100PSI /90.5°F and JHNB1-22-1(with Tire Lyna) starting conditions were 100 PSI /95.2°F. Average temperature during the roadwheel test for JHNB1-22-2 (without Tire Lyna) was 99.3°F and the average temperature for JHNB1-22-1(with Tire Lyna) was 100.4°F. At the end of the roadwheel test, tire JHNB1-22-2 (without Tire Lyna) had 108PSI at 100.2°F and tire JHNB1-22-1(with Tire Lyna) had 110PSI at 98.5°F. Slightly better pressure in the tire with Tire Lyna was observed.

Figure 8: Ambient Temperature as a Function of Roadwheel Time

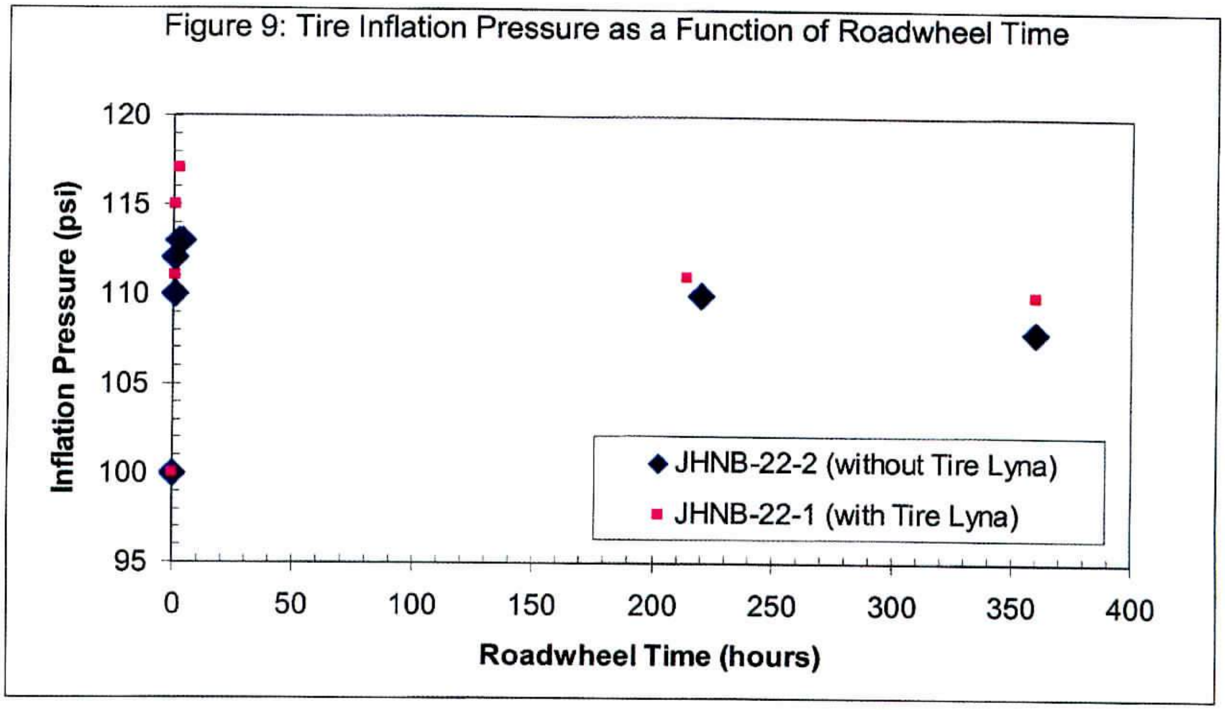


Roadwheel Inflation Pressure:

The tire inflation pressures are shown in Figure 9. The tire with Tire Lyna provided consistently better (higher) inflation pressure retention during and at the end of the roadwheel testing.

The test started with Tire Lyna tire being higher in temperature. During the test the tire without Tire Lyna went up to 99.3F. An increase of 8.86% and the tire with Tire Lyna went up by 5.18%. At the end of the test the tire without Tire Lyna was recorded at 100.2F. An increase of 9.68%. At the end of the test the tire with Tire Lyna was recorded at 98.5 F. A decrease in temperature by almost 2%. The tire inflation pressures are shown in Figure 9. The tire with Tire Lyna provided consistently better (higher) inflation pressure retention during and at the end of the roadwheel testing

It clearly shows and proves that the tire with Tire Lyna will run cooler and if compared to tires run in the real world without Tire Lyna the temperature difference witnessed has been as high as 20%. Tire temperatures varies on speed, elevation, ambient temperature and load and therefore every fleet depending on these factors will vary in the percentage.



Roadwheel Running Temperatures:
The tire tread and sidewall surface temperatures were measured as a function of running time for the first day of roadwheel testing. Tire surface running temperatures were measured with a camera equipped with an infrared (IR) temperature sensor (FLIR Systems model T300) (Figure 10). A plot of the highest and lowest temperatures as a function of time compared the two tires (Figures 11-12). During the first half hour there was a slight difference between the two tires (at the hottest location on the tread and sidewall). The tire with Tire Lyna had slightly higher temperatures (between 2 to 5°F), which was caused by its slightly higher ambient temperature (5°F) at start. The sidewall and tread surface temperatures on the tire with Tire Lyna were not significantly different from the tire without Tire Lyna from 4 to 24 hours of roadwheel testing.

Figure 10: Thermograph of a Running Tire using the FLIR IR Camera

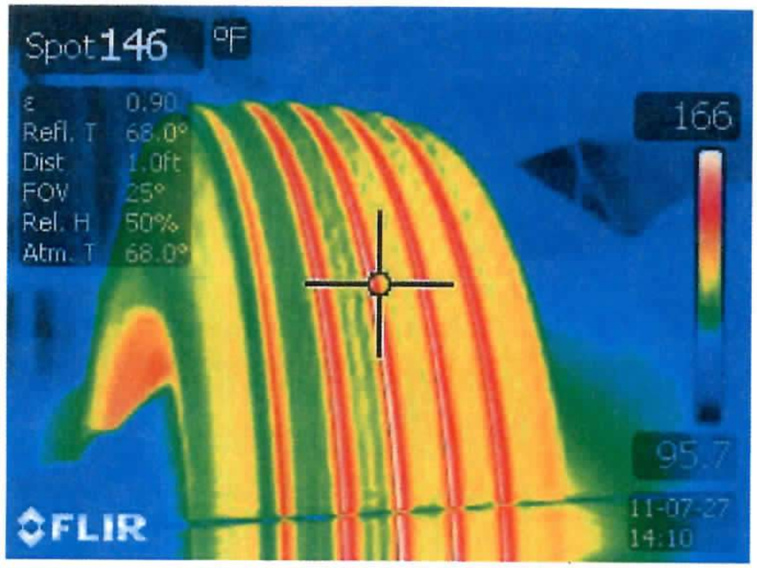


Figure 11: Tire Tread Temperature as a Function of Roadwheel Time

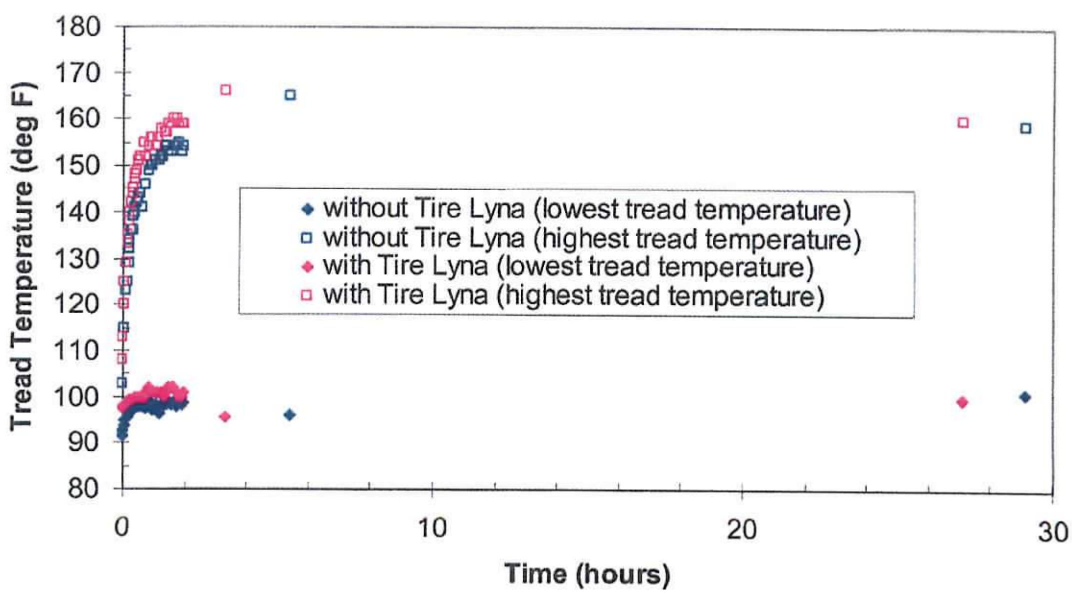
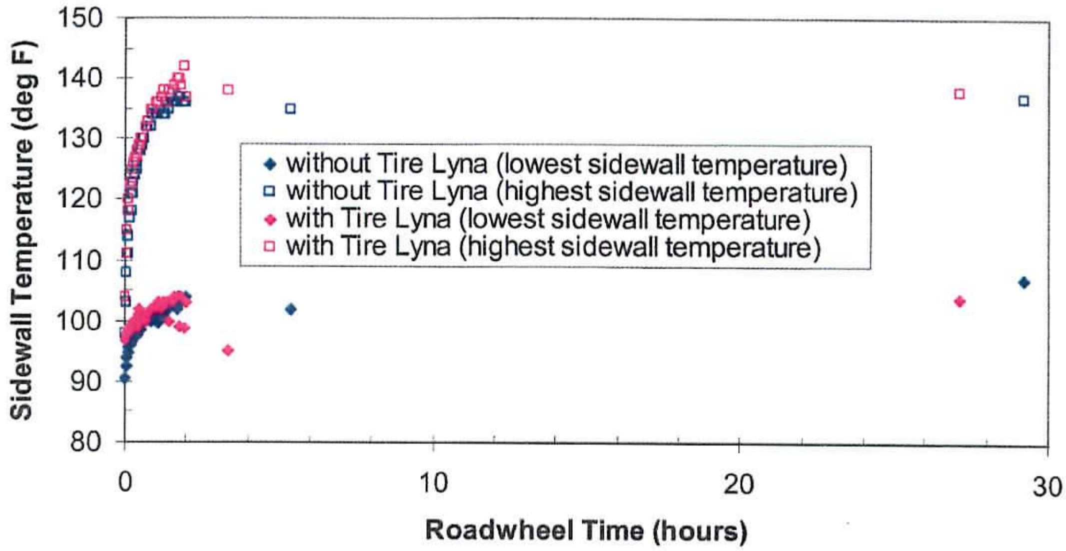


Figure 12: Tire Sidewall Temperature as a Function of Roadwheel Time



Final Shearography:
Shearography was performed to check for the damage to the tire integrity during testing. Both tires were free of internal separations after roadwheel testing (at end of test [EOT]) (Figures 13-18).

Figure 13: Shearograph of JHNB1-22-2 EOT Crown

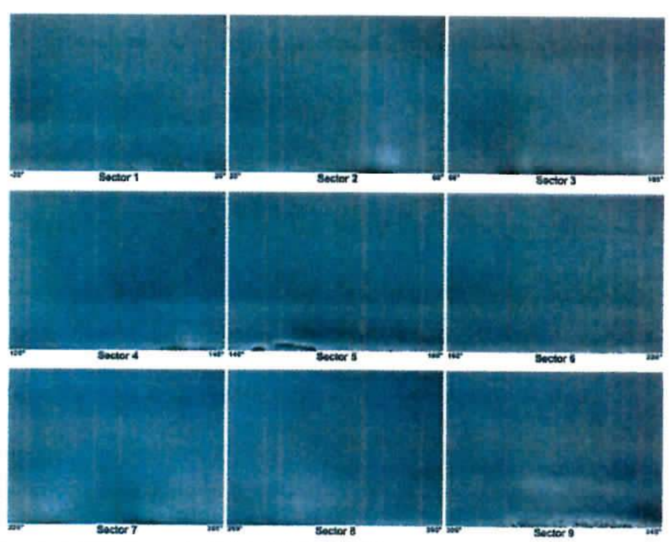


Figure 14: Shearograph of JHNB1-22-2 EOT OSS Bead

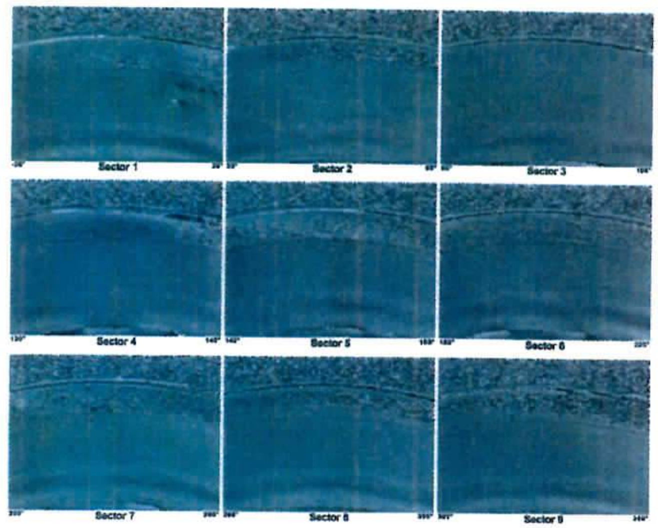
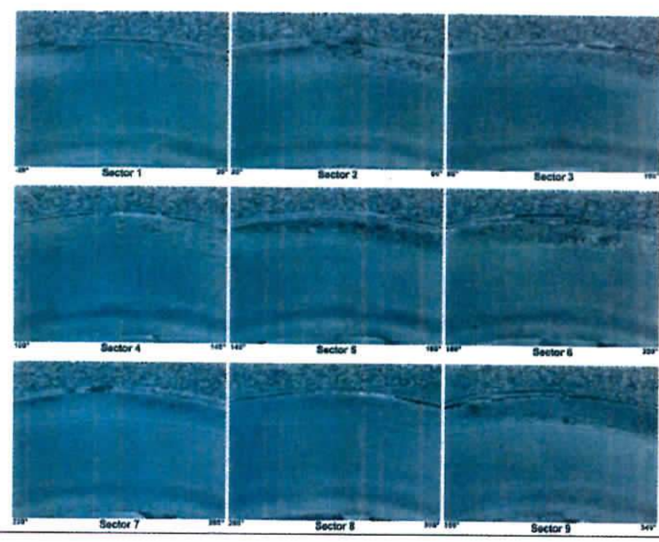


Figure 15: Shearograph of JHNB1-22-2 EOT SS Bead



December 1, 2011

Noorez Devraj
Tire Lyna - Lyna Manufacturing, Inc.

Figure 16: Shearograph of JHNB1-22-1 EOT Crown

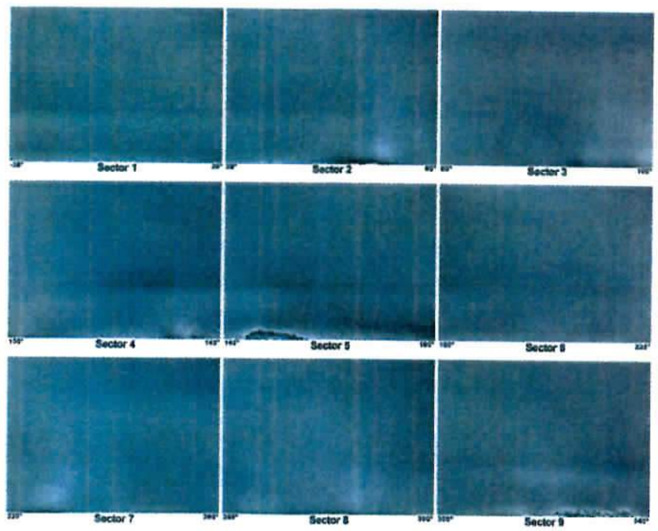


Figure 17: Shearograph of JHNB1-22-1 EOT OSS Bead

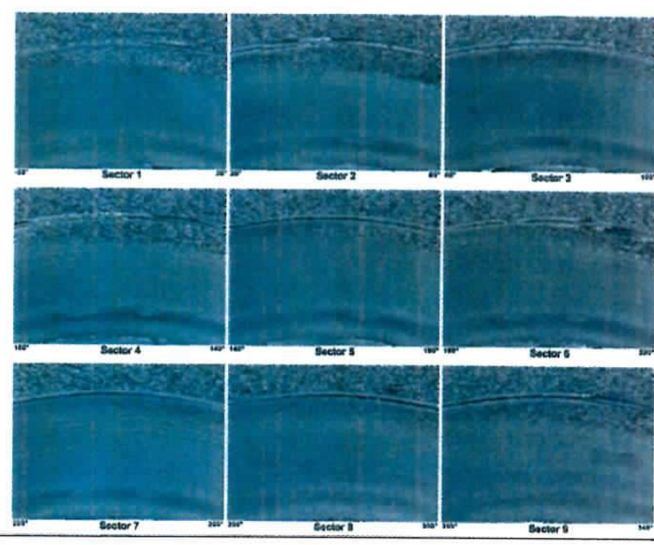
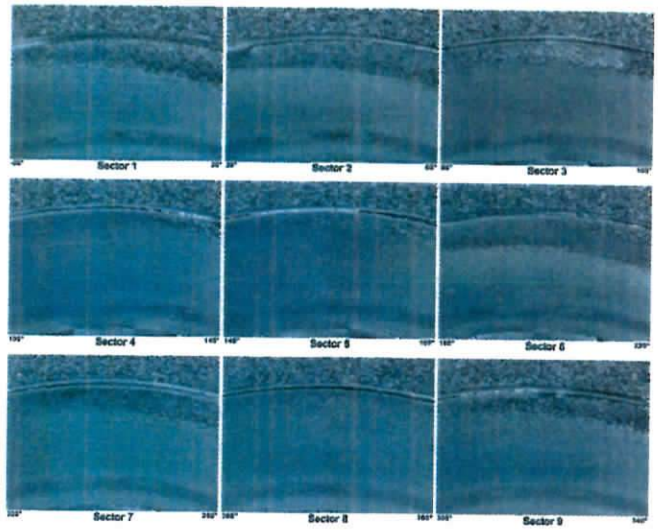


Figure 18: Shearograph of JHNB1-22-1 EOT SS Bead



Innerliner Pictures:
Photographs were obtained of the innerliner to check for damage during roadwheel testing. Both tire innerliners were free of damage at end of test (EOT) (Figures 19-21).

Figure 19: Innerliner of tire without Tire Lyna EOT

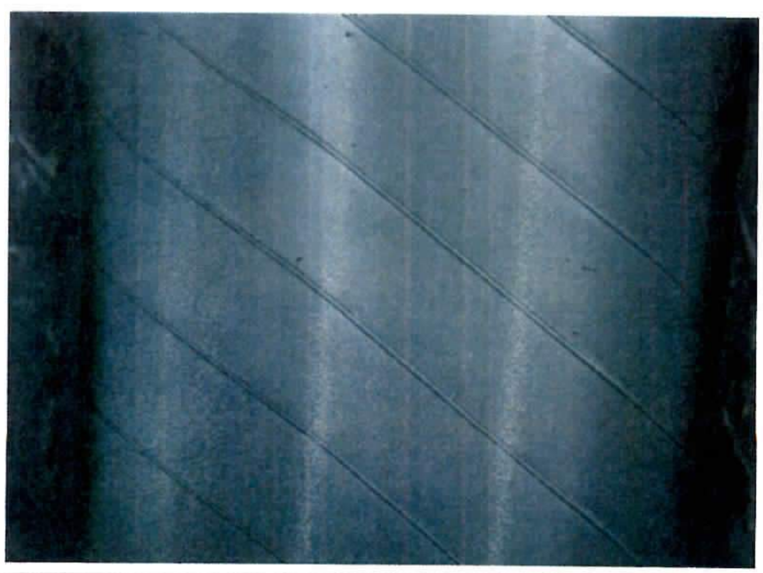
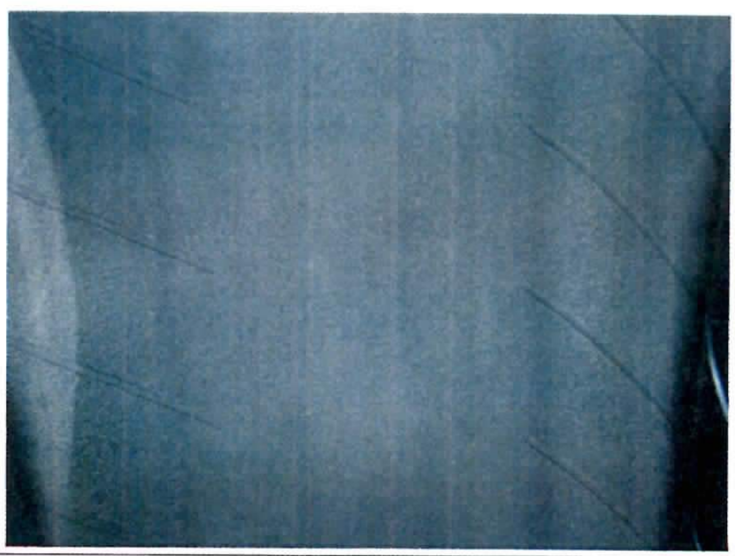


Figure 20: Innerliner of tire with Tire Lyna EOT

Figure 21: Innerliner of an New (Un-tested) tire



Innerliner Tensile Properties:
Innerliner compound was dissected from the crown region of the tires (EOT tires) and tested for tensile properties (Table 3, Figures 22-23 excel file Data template_Noorez_12-1-11_v3). The innerliner from the tire with Tire Lyna had slightly higher tensile strength and elongation to break, and slightly lower modulus than the innerliner from the tire without Tire Lyna. The effect of service on innerliner hardness was observed. The tire without Tire Lyna increased while the tire with Tire Lyna did not change. The tire with Tire Lyna had significantly improved (resistance to change in) hardness than the tire without Tire Lyna. The improved property retention is attributed to protection against heat/oxidation provided by Tire Lyna.

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Table 3: Innerliner Tensile and Hardness Properties of Tires							
Tire Description	Peak Stress (psi)	Peak Strain (%)	Modulus at 50% strain (psi)	Modulus at 100% strain (psi)	Modulus at 200% strain (psi)	Modulus at 300% strain (psi)	Shore A hardness
with Tire Lyna	935	277	138	253	620	984	50
without Tire Lyna	868	259	143	260	624		56
New (untested)							51

Figure 22: Innerliner Tensile Properties of EOT tires

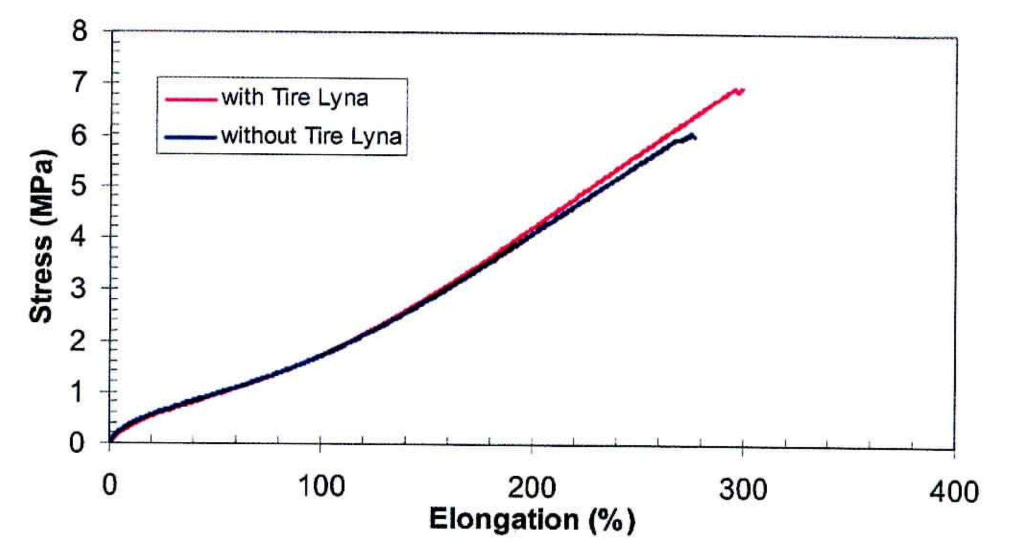
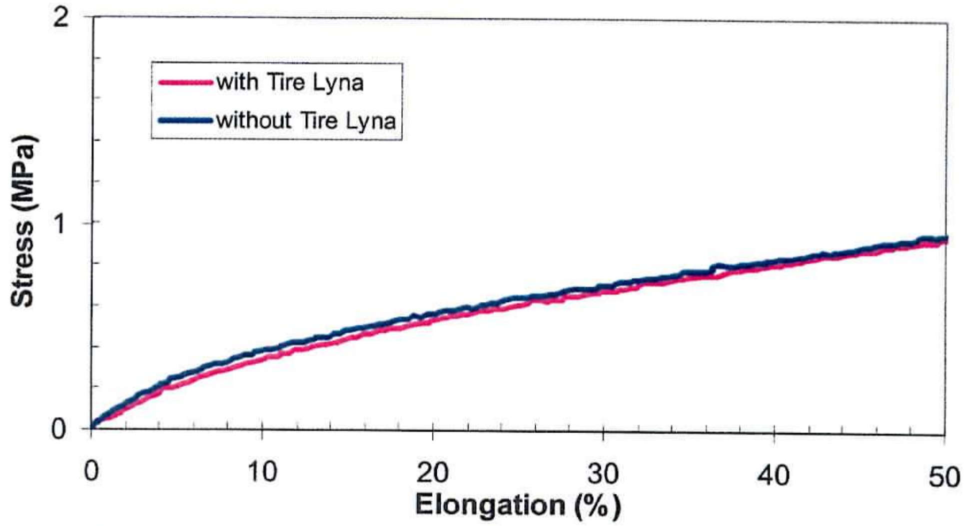


Figure 23: Low Strain Innerliner Tensile Properties of EOT tires



Sidewall Peel Strength:
The integrity of the sidewall was determined in both tires after end of test. Sidewall sections were dissected for testing the mechanical integrity. The sidewall compound was pulled off the plywires in a 180-degree peel test (Table 4). In this test, the tear propagates through the plycoat compound close to the ply wires (Figure 24 and 25). The sidewall peel strength of the tire with Tire Lyna was slightly higher than the tire without Tire Lyna.

Figure 24: Peel Test Specimen

Figure 25: Tear Zone after the Peel Test

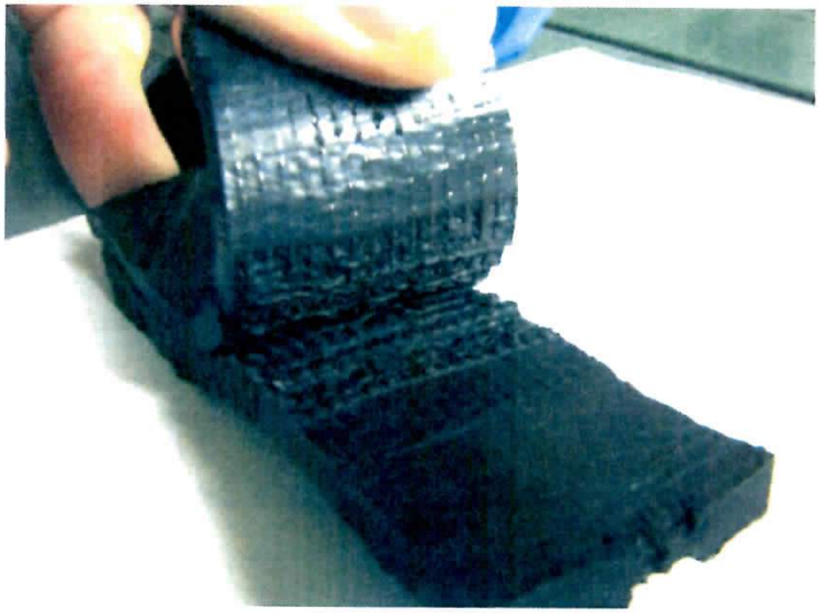


Table 4: Sidewall Peel Strength after roadwheel testing (pounds/in)		
	Tire with Tire Lyna	Tire without Tire Lyna
Specimen #		
1	83.4	92.7
2	80.9	65.2
3	87.6	76.0
4	85.1	80.4
5	83.7	78.5
Average	84	79
Standard deviation	2.5	9.9
Confidence	3.0	12

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