Tire Aging

NTSB Tire Safety Symposium

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National Highway Traffic Safety Administration

George Soodoo

Background

- What is tire aging?
  - ❖ Tire aging refers to the reduction or loss in a tire's material properties, which over time can compromise its structural integrity and jeopardize its performance

- How does it occur?
  - ❖ Heat and oxygen are two environmental conditions that adversely impact the material properties in a tire

  - ❖ The mechanisms of aging that are most likely to affect the safe performance of a tire are Chemical aging and Mechanical aging:
    - Chemical aging occurs in a tire over time due to combined exposure to heat and oxygen (Thermo-oxidative degradation)
    - Mechanical aging results from stresses that a tire experiences during normal use

Background

- Where does it occur?
  - ❖ Tire aging occurs in every tire that is exposed to heat and oxygen since rubber degrades over time
  - ❖ However, tire aging failures tend to occur in the states with high ambient temperatures, during the summer months while the vehicle is being driven at highway speeds
  - ❖ The thermo-oxidative degradation is accelerated with higher temperatures and is a contributing factor for tire failures, such as tread separations
  - ❖ Tire aging occurs whether a tire is driven or not, which means that it also occurs on spare tires

Timeline: Since TREAD Act

- TREAD Act of 2000 required NHTSA to revise and update FMVSS No. 109, *New pneumatic and certain specialty tires*, among other things
  - ❖ The idea of a tire aging test was mentioned by some Members of Congress during consideration of the TREAD Act
- March 2002: Tire upgrade Notice of Proposed Rulemaking (NPRM) proposed 3 options for a test to evaluate tire aging
  1. Peel strength test
  2. Extended duration roadwheel test, and
  3. Oven-aging plus roadwheel Endurance test
- Late-2002: NHTSA started a comprehensive Tire Aging Research Project
- June 2003: Final Rule establishing new tire standard, FMVSS No. 139, deferred action on finalizing a tire aging test until further research was completed.
  - ❖ Effective date for FMVSS No. 139 was September 1, 2007

Timeline: Since TREAD Act

- 2005: SAFETEA-LU Act directed the Secretary of Transportation to transmit a Report to Congress by August 2007 on research conducted to address tire aging
  - ❖ The NHTSA research program initiated in 2002 was expanded to address issues that were included in the Report to Congress

- August 2007: NHTSA submitted Report to Congress on Tire Aging
  - ❖ The Report to Congress defined the safety problem, and included a summary of the tire aging research and a short list of items the agency needed to complete. The list included:
    - Cost and Lead-time Study – completed in 2008
    - Benefits Study – completed in 2008
    - Validation Testing – completed in 2011

- Summer 2014: NHTSA issued a Summary Report on Tire Aging

Summary of NHTSA Tire Aging Research

- Phase I – Phoenix Tire Field Study
- Phase II – Tire Aging Methods Evaluation
- Phase III – Tire Aging Method Refinement
- Phase IV – Validation Testing of pre-FMVSS 139 tires
- Phase V – Validation Testing of FMVSS 139-compliant Tires

Phase I
Tire Aging Field Study

- Objectives
  - ❖ To gain a better understanding of tire degradation due to aging
  - ❖ To determine if tire aging was quantifiable
  - ❖ To develop an aging test to accelerate the service life of a tire
- What was done
  - ❖ Chose 12 tire models available for purchase in Phoenix, AZ, manufactured between 1998 and 2003 with no significant design change
  - ❖ Obtained 493 tires from Phoenix residents
  - ❖ Tested to evaluate: 1) change in material properties; 2) stepped-up speed performance; and 3) stepped-up load performance
- Findings
  - ❖ 11% of in-service tires and 30% of spare tires were significantly underinflated when acquired from Phoenix residents
  - ❖ Roadwheel tests showed decreased time to failure with increased mileage and/or age
  - ❖ Quantifiable degradation in material properties of critical components with increased mileage and/or age
  - ❖ Full-size spare tires showed similar degradation over time while in storage on the vehicle

Phase II
Tire Aging Methods Evaluation

- Objective
  - ❖ To evaluate 3 accelerated tire aging methods to simulate profile from Phoenix tires

- What was done
  - ❖ Purchased new tires of same make/model as Phoenix tires
  - ❖ Long-term Durability Endurance Test (Michelin) – 500-hour roadwheel test
  - ❖ Passenger Endurance Test (Continental) – 240-hour roadwheel test
  - ❖ Oven Aging Method (Ford) – at 55–65°C (131-149°F) for 3 to 12 weeks

- Findings
  - ❖ Long-term roadwheel methods were not consistent in replicating degradation in material properties of the Phoenix tires
  - ❖ Oven aging was the only method successful at replicating the overall material properties and stepped-up load test results of the Phoenix tires

Phase III
Tire Aging Method Refinement

- Objective
  - ❖ To refine the tire aging method

- What was done
  - ❖ 2-hour break-in on roadwheel at 50 mph
  - ❖ Weekly replenishing of 50/50 mix of Oxygen/Nitrogen inflation gas
  - ❖ Oven temperature refined to 65°C (149°F) and time in oven refined to 5 weeks
  - ❖ Post-oven aging stepped-up load test similar to Endurance test for 34 hours

- Findings
  - ❖ Material properties of new tires after oven aging closely matched 4-6 year-old tires from Phoenix
  - ❖ Failures in belt edge area and tread separation were similar to failures in Phoenix tires

Phase IV
Validation Testing of Pre-FMVSS 139 Tires

- Objective
  - ❖ To evaluate the performance of pre-FMVSS 139 tires to oven aging protocol

- What was done
  - ❖ 20 tire models (3 samples each) tested included passenger car and light truck tires
  - ❖ Tires were inflated with 50/50 mix of Oxygen/Nitrogen
  - ❖ Oven duration included 3, 4, and 5 weeks at 65°C (149°F)
  - ❖ Tested on roadwheel to 35.5 hours (Endurance and Low Pressure tests)

- Findings

In Oven (weeks)	Completed 35.5 hours (%)
3	90
4	70
5	55

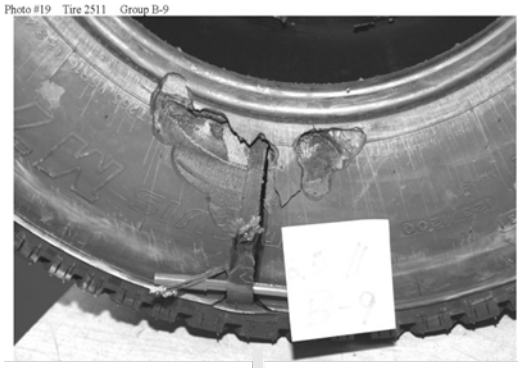
Phase IV
Validation Testing of Pre-FMVSS 139 Tires

- Predominant failure modes
  - ❖ Tread and belt separation
  - ❖ Chunking
  - ❖ Innerliner detachment
  - ❖ Sidewall split and rupture

Phase IV Tire Failures

Belt edge separation

Loss of tread and belt



Sidewall split and rupture

Phase V
Validation Testing of FMVSS 139-compliant Tires

- Objective
  - ❖ To evaluate performance of FMVSS 139-compliant tires to oven aging protocol

- What was done
  - ❖ 20 tire models (3 samples each) tested included a mix of passenger car and light truck tires
  - ❖ Tires were inflated with 50/50 mix of Oxygen/Nitrogen
  - ❖ Oven duration was 5 weeks at 65°C (149°F)
  - ❖ Tested on roadwheel to 35.5 hours (Endurance and Low Pressure tests)

- Findings

In Oven (weeks)	Completed 35.5 hours (%)
5	90

Phase V

Validation Testing of FMVSS 139-compliant Tires

- Predominant failure modes
  - ❖ Cracking in shoulder
  - ❖ Cracking in tread groove
  - ❖ Tread separation at shoulder
  - ❖ Smaller percentage of failures include cracking in the sidewall, chunking, and sidewall bubbles

- Failure modes were mostly cracking, which is much less catastrophic for vehicle safety than tread and belt separation

Phase V Tire Failures

Tread separation at shoulder

Cracking in shoulder

Sidewall bubbles

Summary Findings of NHTSA Tire Aging Research

- What we learned?
  - ❖ Artificially aging a tire in a laboratory oven is a scientifically valid method to accelerate the tire aging process and to simulate a naturally aged tire in service on a vehicle.
  - ❖ NHTSA aging protocol evaluates the risk of tire failure at a period later in life than the current regulation (FMVSS No. 139).
  - ❖ NHTSA research suggests that oven-aged FMVSS 139-compliant tires are more resistant to degradation than oven-aged pre-FMVSS 139 tires.
  - ❖ NHTSA developed a robust test procedure that manufacturers could use for tire development purposes

- All research reports are in the Tire Aging Docket
  - ❖ http://www.regulations.gov
    - NHTSA-2005-21276

NHTSA Observations

- Improved performance of FMVSS 139-compliant tires to the agency's tire aging test protocol, combined with the overall reduction in tire-related crashes, has reduced the concerns about tire failures due to aging
- New tire standard, FMVSS 139, effective since September 1, 2007 is more robust in several ways. **It is the best tire standard in the world!**
- A new FMVSS No. 138, also effective since September 1, 2007, requires all light vehicles to be equipped with a TPMS
- Crash data show a decrease in tire-related crashes with new, upgraded FMVSS 139-compliant tires
- Agency will continue to monitor crash data to determine whether a tire aging requirement is warranted

Guidance for Consumers on Service Life Recommendations

- NHTSA does not have its own research data to develop guidelines for consumers on service life recommendations.

- However, the following recommendations, which were included in the Report to Congress, are from several vehicle and tire manufacturers:
  - ❖ Vehicle manufacturers: Replace your tires after six years regardless of tread wear; this also applies to your spare tire.

  - ❖ Tire manufacturers: Recommends that tires be removed from service ten years after the date of manufacture

NHTSA On-going Work

- Consumer Promotional and Educational Campaign
  - ❖ Purpose is to raise consumer awareness about tire aging issues
  - ❖ Campaign initiatives and outreach efforts to consumers, industry partners and automotive service industry
  - ❖ Helps consumers to understand the importance of tire pressure maintenance and to know when to replace their tires, whether they reside in Jacksonville, FL or Jackson Hole, WY
- Spare Tires
  - ❖ Just as prone to tire aging especially when stored under the vehicle; more exposed to heat from pavement and exhaust
  - ❖ Check inflation pressure just as regularly as your road tires even though it may not be as convenient
  - ❖ Use same guidelines for replacement as for road tires even though it may still have its full tread remaining

NHTSA On-going Work

- Used Tires
  - ❖ Best advice is to avoid purchasing used tires
  - ❖ Typically lack history of previous use, maintenance and duration of previous service
  - ❖ Mismatched tires on the same axle can lead to other vehicle problems such as vehicle instability and rear/center differential wear

- 15-Passenger Vans
  - ❖ Typically use LT load range E tires, which are covered under FMVSS 139
  - ❖ Inflation pressure is different for front tires versus rear tires (55 psi versus 80 psi)
    - Underinflation in rear tires can lead to catastrophic failure and vehicle loss-of-control
  - ❖ Pay very close attention to tire date code and age of tire
  - ❖ Agency Outreach to organizations that own 15-passenger vans

George J. Soodoo
Chief, Vehicle Dynamics Division
National Highway Traffic Safety Administration
Washington, DC 20590
Email: george.soodoo@dot.gov

Thank You!