MICHELIN AIRCRAFT TIRE

The Impact of Tire Maintenance on Aircraft Safety

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Purpose

To improve aircraft safety by exploring the impact of inflation pressure and FOD (Foreign Object Debris) on aircraft tire performance.

"The purpose of this presentation is to educate the public about aircraft tire safety. It is strictly for educational purposes only. The content and imagery found within this presentation is based on Michelin's expertise in the tire industry. It is not intended to address all possible scenarios and should only be used to illustrate the importance of tire inflation pressure within the manner that it is explained. The content within this presentation is the property of Michelin North America, Inc. and should not be altered without Michelin's prior written consent."

Agenda

- Why Proper tire maintenance is critical
- Common causes for tire related events
- Focus on inflation pressure
- Focus on FOD
- Conclusion

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WHY PROPER TIRE MAINTENANCE IS CRITICAL

Learjet 60 Crash – Columbia, SC
Sept 2008 - Tire related : Under Inflation

Concorde Crash – France
July 2000 - Tire related : FOD

Common Causes for Tire Related Events

- **Under-inflation (resulting in over-deflection)**
- **Foreign Object Debris (FOD)**
- Locked brakes
- Runway conditions
- Aircraft operations
- Fuse plug release (dragging brake heat)
- Frozen brakes due to operations in “slush”

Why Proper Tire Maintenance is Critical

As a committed partner to the aviation industry, Michelin strongly urges that the following maintenance actions be implemented in order to improve aircraft safety.

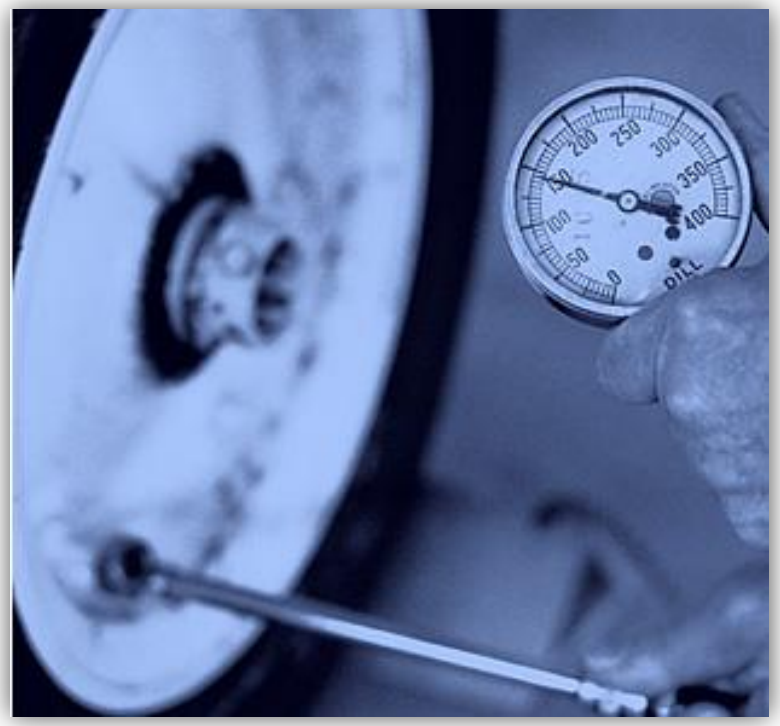
Focus on Inflation Pressure

The single most important action that you can do to prevent tire-related events is :

Maintain Proper Inflation Pressure

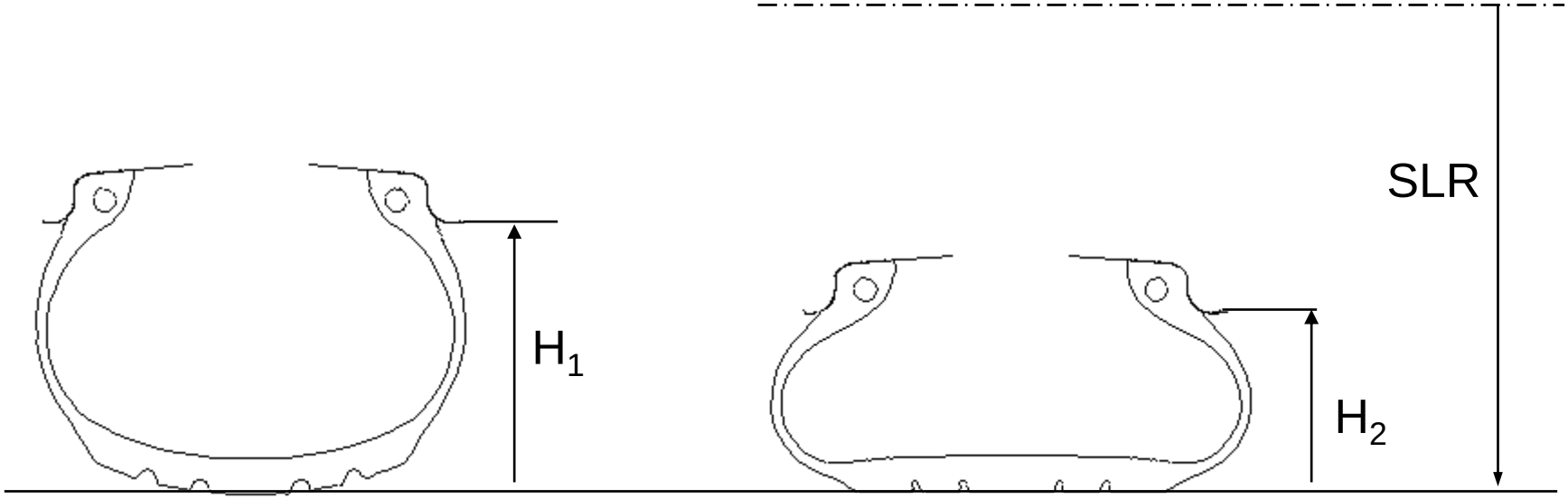
Under-Inflated Tires May Cause:

- **Thrown tread from heat build up**
- **Tire failure from heat build up and ply compression**
- Irregular shoulder wear from tread distortion
- Faster wear rate from squirm
- Wheel slippage from low tire/wheel interface pressure
- Tire/wheel damage from tire movement



Deflection

Definition: The difference between the unloaded and loaded tire section heights.

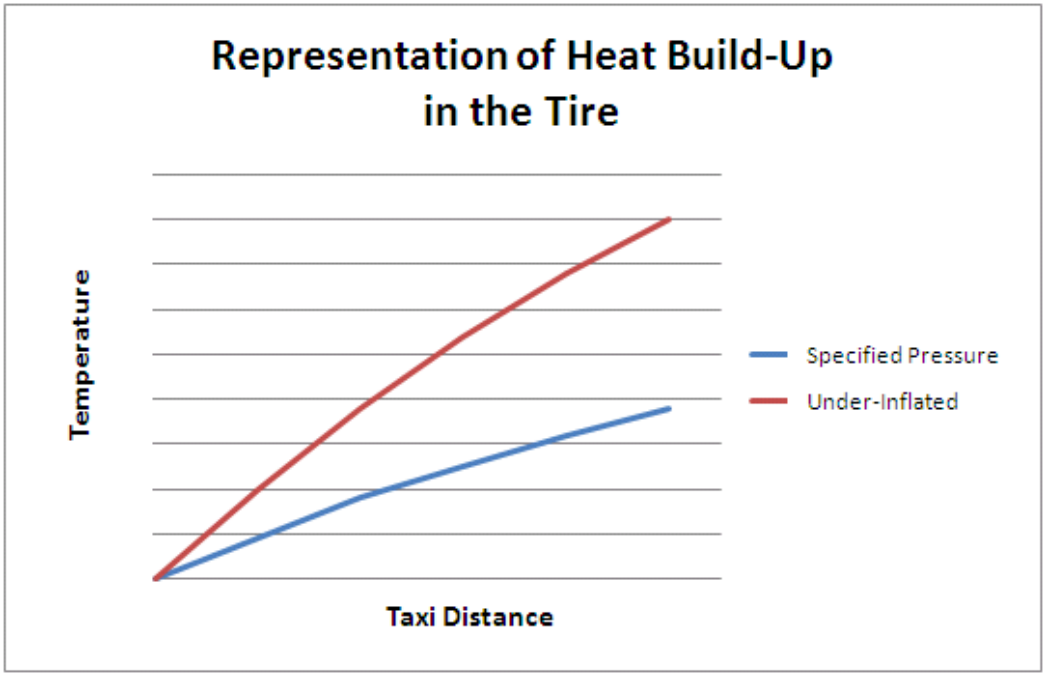


DEFLECTION = H1 – H2
% Déflection = (H1 –H2)/H1

Typical Deflection	
Trucks:	**12%**
Cars:	**18%**
Aircraft:	**32%**

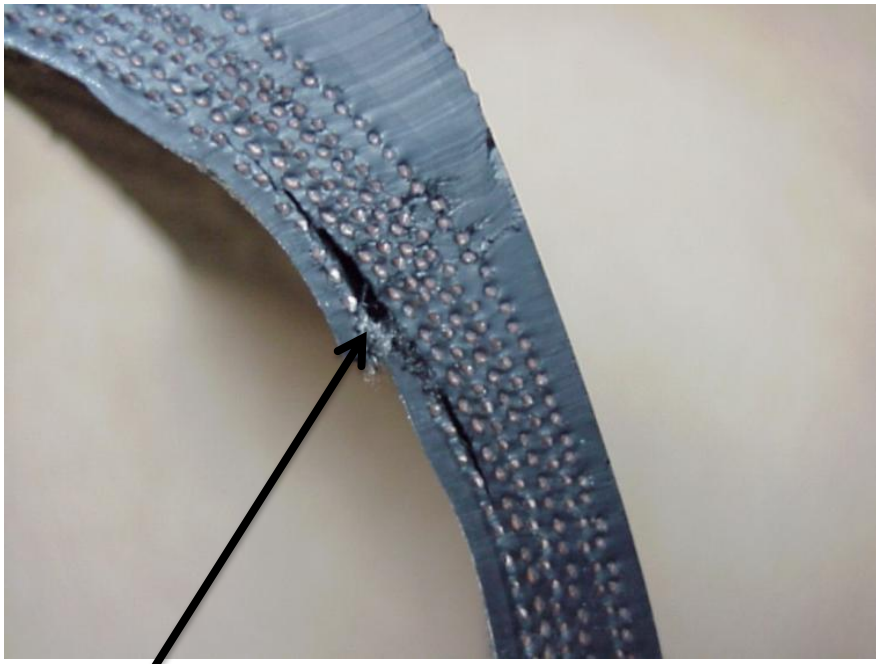
Why is Inflation Pressure Important?

- The over-deflection caused by an under-inflated tire will result in an accelerated build-up of heat.
- This heat will adversely affect both the lower and upper sidewall areas of the tire.

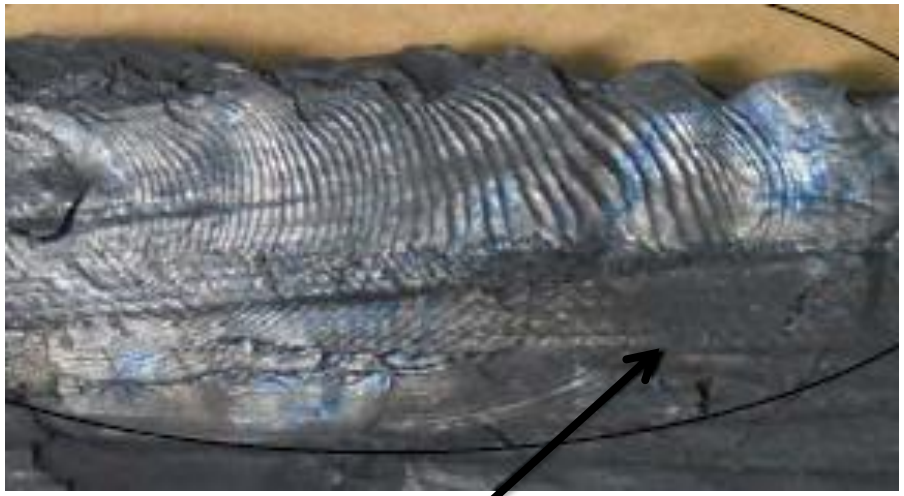


Under-Inflated Tires May Cause:

Thrown tread from heat build up and ply compression



Ply compression



Tread reversion

Over-Inflated Tires Could Cause:

- **More susceptibility to FOD damage**
- Faster wear rate (less contact patch)
- Irregular wear in the center ribs

Specified Inflation Pressure

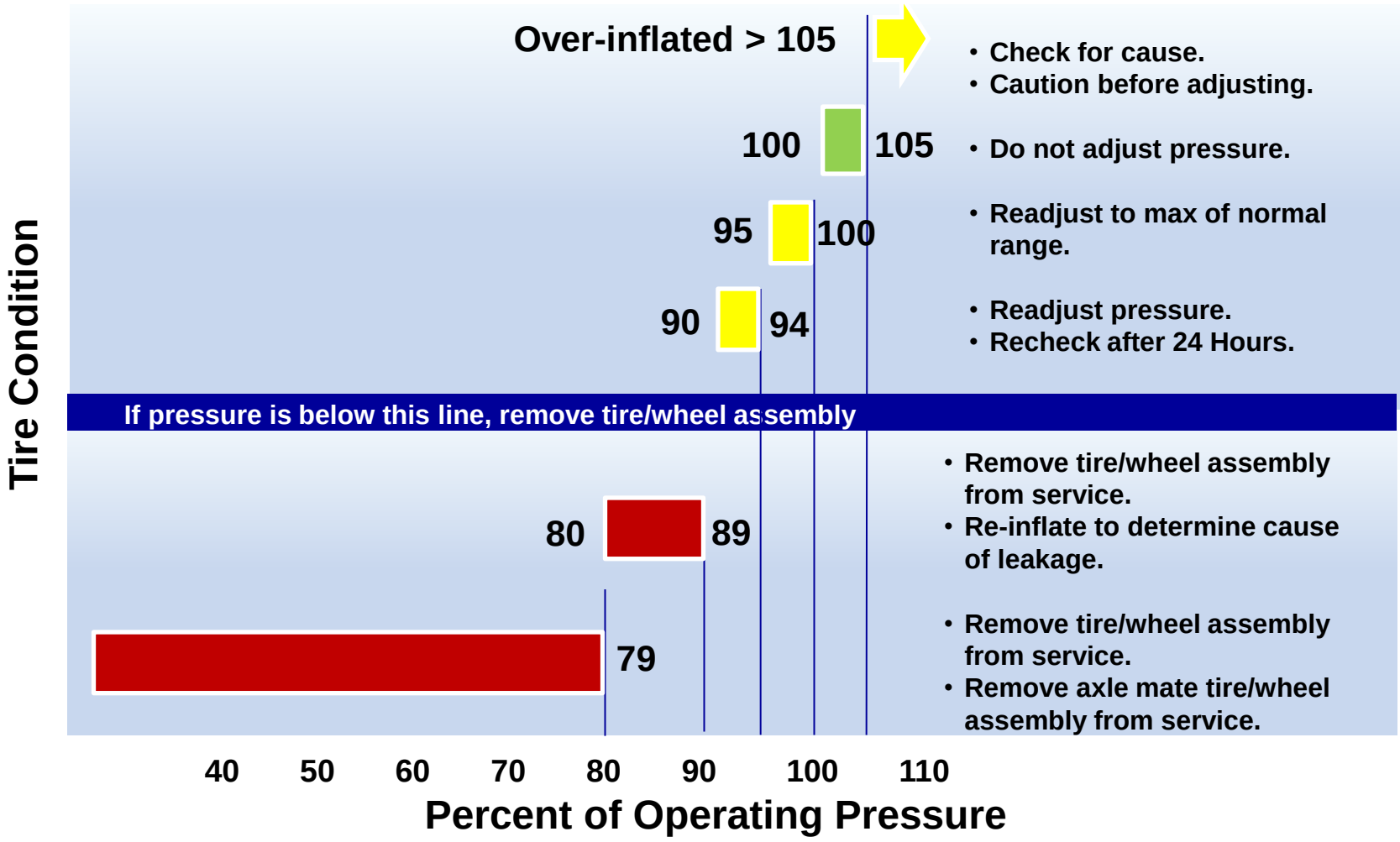
- Tire Manufacturers design and test tires to “Rated” conditions. (max load, pressure, speed & deflection as specified by the
  Tire & Rim Association/ETRTO)
- Airframers specify inflation pressure based on aircraft loading conditions.
- Operators must be in compliance with the aircraft maintenance manual (AMM).

Pressure Check Schedule

- Aircraft tire/wheel assemblies are allowed a pressure loss of up to 5% daily.
- Therefore, Michelin recommends checking the inflation pressure before the first flight of the day or before each flight if not flown daily.
- Operators must be in compliance with the aircraft maintenance manual (AMM).
- An underinflated tire is very difficult to detect visually. Pressure must be checked with an accurate gage

Specified Inflation Pressure

Pressure Monitoring–Course of Action



Effect on Tire Pressure due to a Temperature Drop or Rise

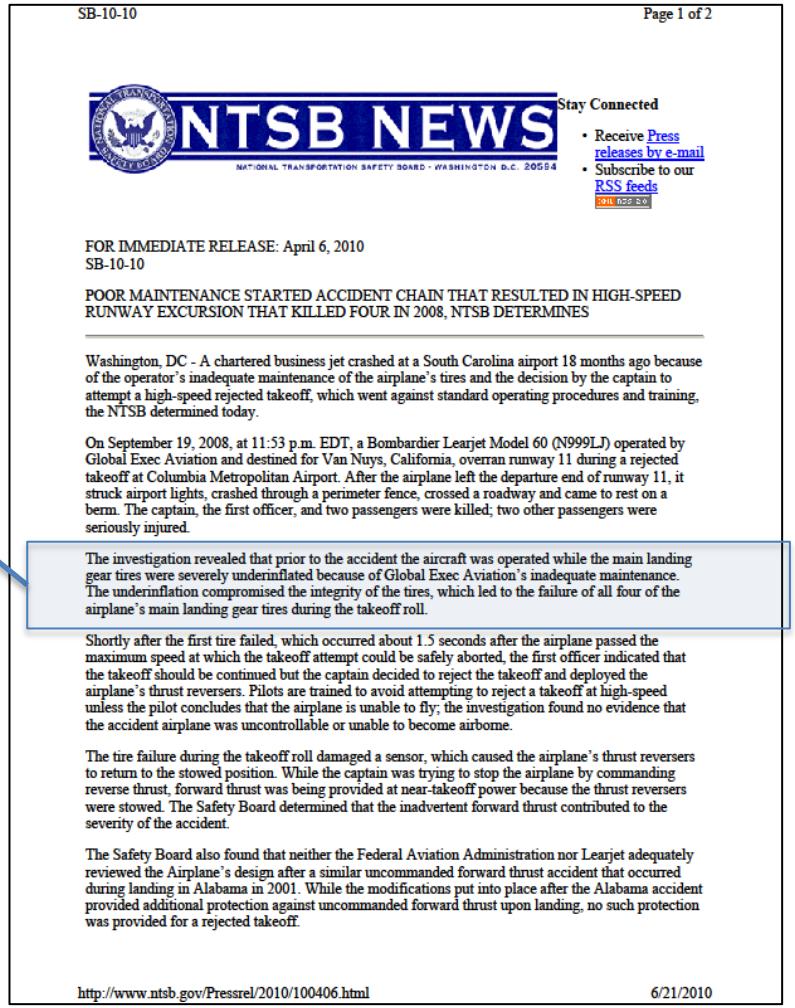
Rule: Pressure changes by 1% for each 5° F (3°C)

Example Calculation:	Temp °F/°C	Pressure (PSI)
Temperature Rise	+60 °F (+36°C)	112
	+40 °F (+24°C)	108
	+20 °F (+12°C)	104
Operating Pressure at:	Ambient Temp	**100**
Temperature Drop	-20 °F (-12°C)	96
	-40 °F (-24°C)	92
	-60 °F (-36°C)	88

e.g.: A flight from Florida to Minneapolis with a 60°F change could require the removal of the tire from service

Learjet 60 Crash at Columbia, SC:

"The investigation revealed that prior to the accident the aircraft was operated while the main landing gear tires were severely underinflated because of ------ inadequate maintenance. The under-inflation compromised the integrity of the tires, which led to the failure of all four of the airplane's main landing gear tires during the takeoff roll."



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POOR MAINTENANCE STARTED ACCIDENT CHAIN THAT RESULTED IN HIGH-SPEED RUNWAY EXCURSION THAT KILLED FOUR IN 2008, NTSB DETERMINES

Washington, DC - A chartered business jet crashed at a South Carolina airport 18 months ago because of the operator's inadequate maintenance of the airplane's tires and the decision by the captain to attempt a high-speed rejected takeoff, which went against standard operating procedures and training, the NTSB determined today.

On September 19, 2008, at 11:53 p.m. EDT, a Bombardier Learjet Model 60 (N999LJ) operated by Global Exec Aviation and destined for Van Nuys, California, overran runway 11 during a rejected takeoff at Columbia Metropolitan Airport. After the airplane left the departure end of runway 11, it struck airport lights, crashed through a perimeter fence, crossed a roadway and came to rest on a berm. The captain, the first officer, and two passengers were killed; two other passengers were seriously injured.

The investigation revealed that prior to the accident the aircraft was operated while the main landing gear tires were severely underinflated because of Global Exec Aviation's inadequate maintenance. The underinflation compromised the integrity of the tires, which led to the failure of all four of the airplane's main landing gear tires during the takeoff roll.

Shortly after the first tire failed, which occurred about 1.5 seconds after the airplane passed the maximum speed at which the takeoff attempt could be safely aborted, the first officer indicated that the takeoff should be continued but the captain decided to reject the takeoff and deployed the airplane's thrust reversers. Pilots are trained to avoid attempting to reject a takeoff at high-speed unless the pilot concludes that the airplane is unable to fly; the investigation found no evidence that the accident airplane was uncontrollable or unable to become airborne.

The tire failure during the takeoff roll damaged a sensor, which caused the airplane's thrust reversers to return to the stowed position. While the captain was trying to stop the airplane by commanding reverse thrust, forward thrust was being provided at near-takeoff power because the thrust reversers were stowed. The Safety Board determined that the inadvertent forward thrust contributed to the severity of the accident.

The Safety Board also found that neither the Federal Aviation Administration nor Learjet adequately reviewed the Airplane's design after a similar uncommanded forward thrust accident that occurred during landing in Alabama in 2001. While the modifications put into place after the Alabama accident provided additional protection against uncommanded forward thrust upon landing, no such protection was provided for a rejected takeoff.

http://www.ntsb.gov/Pressrel/2010/100406.html 6/21/2010

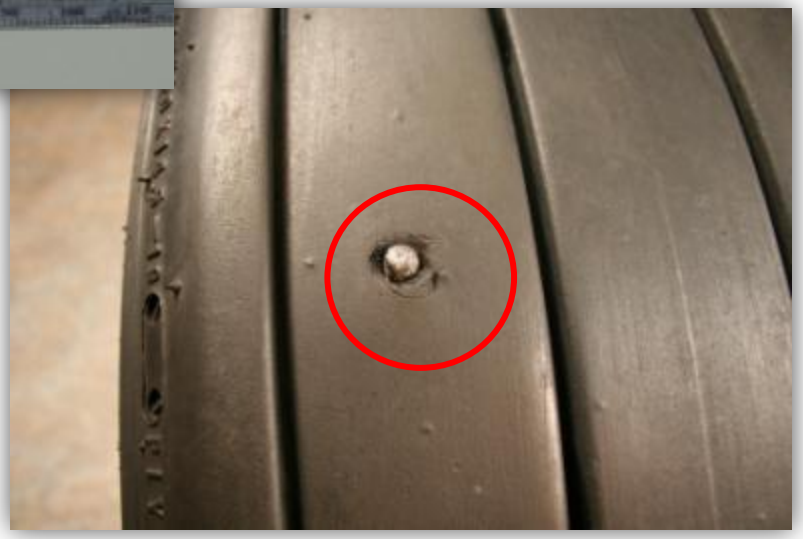
Key Points : Inflation Pressure

- **Target the highest pressure recommended by the AMM**
- **Perform daily pressure checks**
- **Compensate for ambient temperature**

Common Causes for Tire Failure Events

- Under-inflation (which causes over-deflection)
- **Foreign Object Debris (FOD)**
- Locked brakes
- Runway conditions
- Aircraft handling
- Fuse plug release (dragging brake heat)
- Frozen brakes due to operations in “slush”

Focus on Foreign Object Debris (FOD)



Tire In-Service Removal Criteria

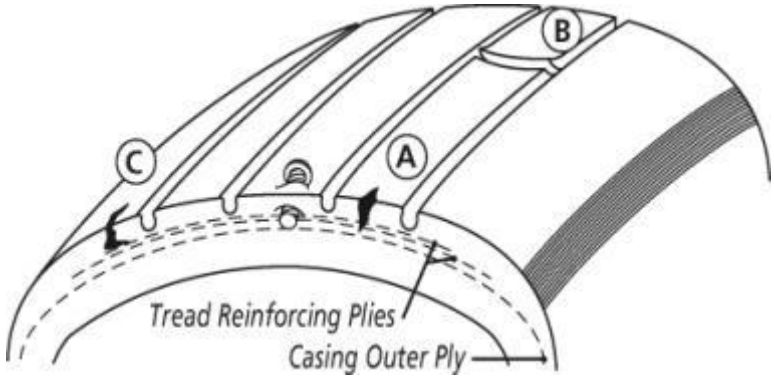
Remove tires when FOD damage to the tread area:

A/ Reaches carcass/belt plies

B/ Severs or extends across a rib

C/ Undercuts at the base of any rib

- Is caused by round objects >3/8” diam.



Remove tires when FOD damage to the sidewall area:

- Reaches carcass/belt plies

Prevention of FOD Damage

- Enforce Regular Aircraft Operating Area (AOA) inspections to remove debris from Runway/taxiway/ramp

FOD is everyone's responsibility

- Appeal to airport authorities for preventative programs
- Educate all involved airport personnel:
  - Pilots, Mechanics, Handlers, Tug drivers, Airport maintenance personnel, etc…

Prevention of FOD Damage

The Benefits of reducing FOD:

- Aircraft Safety
- Cost savings:
  - Tire damage
  - Aircraft damage
  - Lost time due to delays/cancellations
  - Less overtime required to manage events
  - Environmental impact (fewer tires used)

Key Points:
Foreign Object Debris (FOD)

- **Prevent FOD generation**
- **Remove FOD through regular inspection**
- **Follow tire damage removal criteria**

EVERYONE'S RESPONSIBILITY

Conclusion

- Our goal as an industry is to reduce the likelihood of tire-related aircraft incidents by focusing on the following key areas:
  - Adherence to proper inflation pressure
  - Reduction of FOD in Aircraft Operating Areas

- ***<u>Michelin Aircraft Tire is committed to playing a major role in this process by sharing our expertise with our clients.</u>***