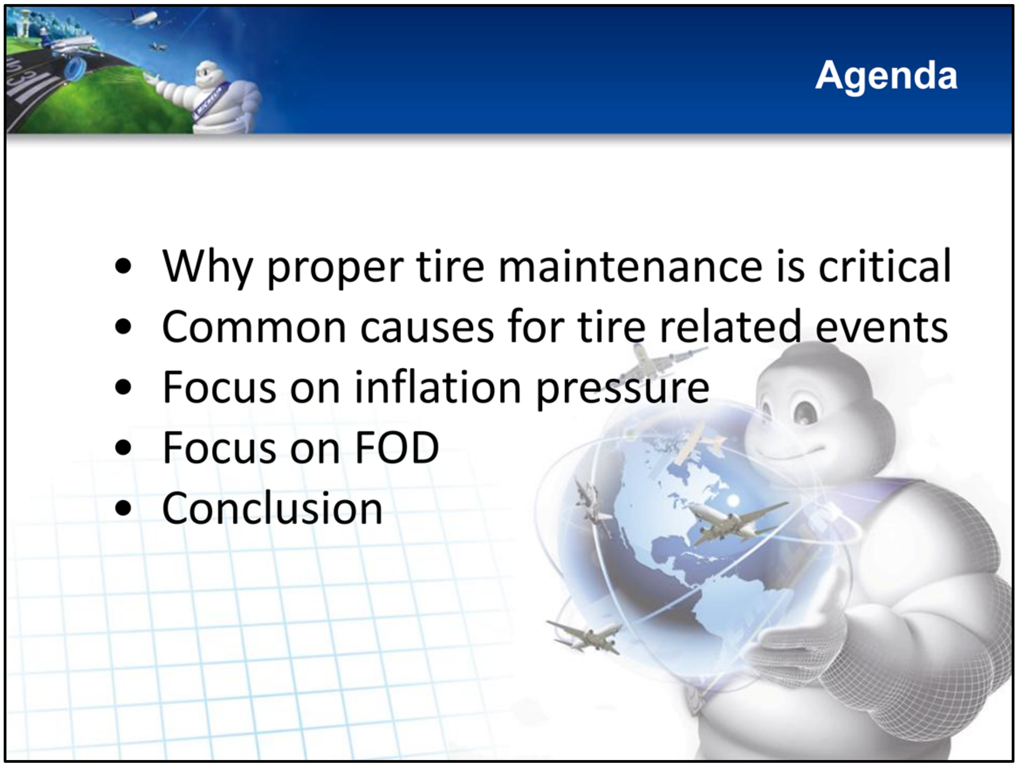
Hello! Welcome to this important aviation safety topic: The Impact of Tire Maintenance on Aircraft Safety

My name is Keat Pruszenski. I am an engineer with the Michelin Aircraft Tire Company

The purpose of this module is to help you improve aircraft safety by exploring the impact that tire inflation pressure and foreign object debris has on aircraft tire performance.



In this module, we are going to discuss;

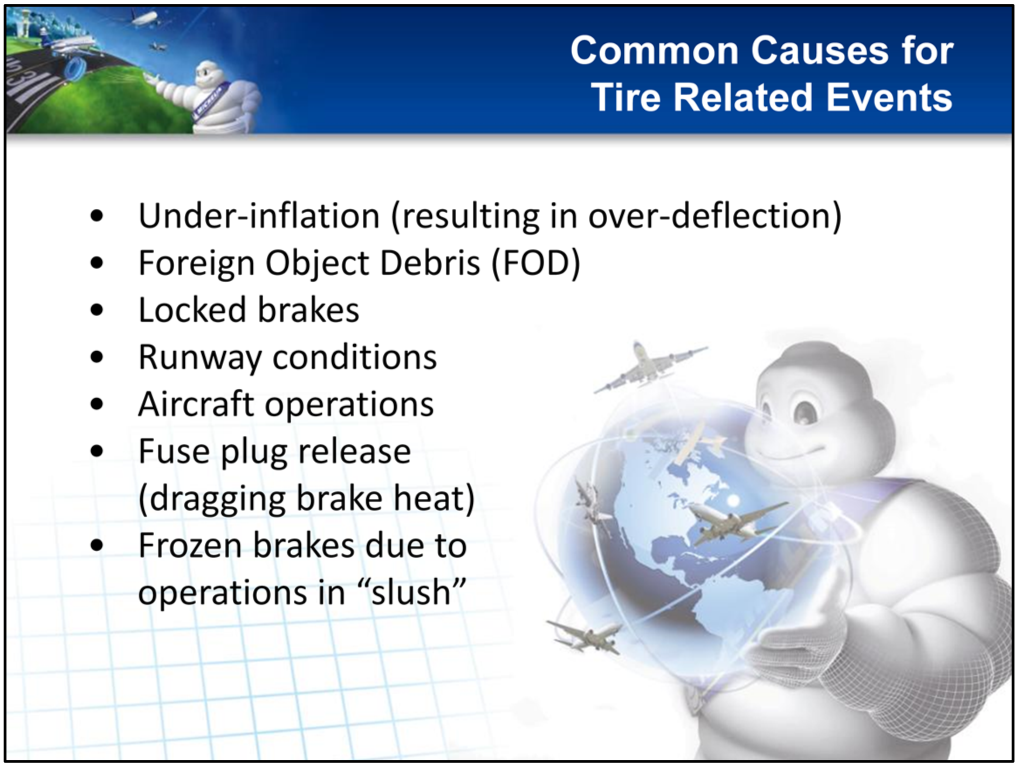
- Why proper tire maintenance is critical
- Common causes for tire related events
- Focus on inflation pressure
- Focus on FOD
- Conclusion

So lets get started. Lets discover why tires are so important.

I think this picture shows the potential danger that can occur if tires are neglected. This crash was deadly. This Lear 60 crashed during the takeoff roll in September of 2008. Four people were killed, and two more had serious burns.

The root cause of the accident: under-inflated tires.

Almost everyone remembers the catastrophic Concorde crash in Paris in 2000. It proved to be tire related as well. A tire failed due to contact with debris on the runway. All on board perished.



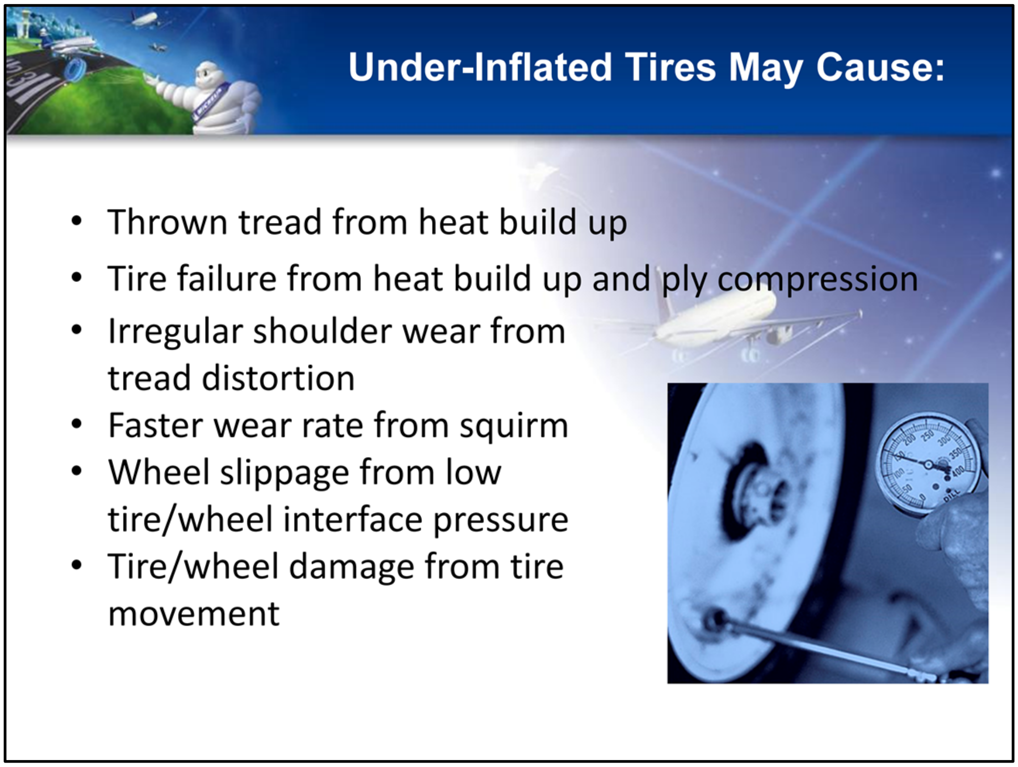
We have identified a number of common causes that occur with some frequency:

- 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"

Lets focus on the two that we can work on with some ease: under-inflation, and foreign object debris.

The need is great, the consequences can be foreboding. Michelin strongly urges implementation of the following maintenance actions to improve aircraft safety.

The single most important and easy action to prevent tire-related events that you can have an impact on is maintaining proper inflation pressure.



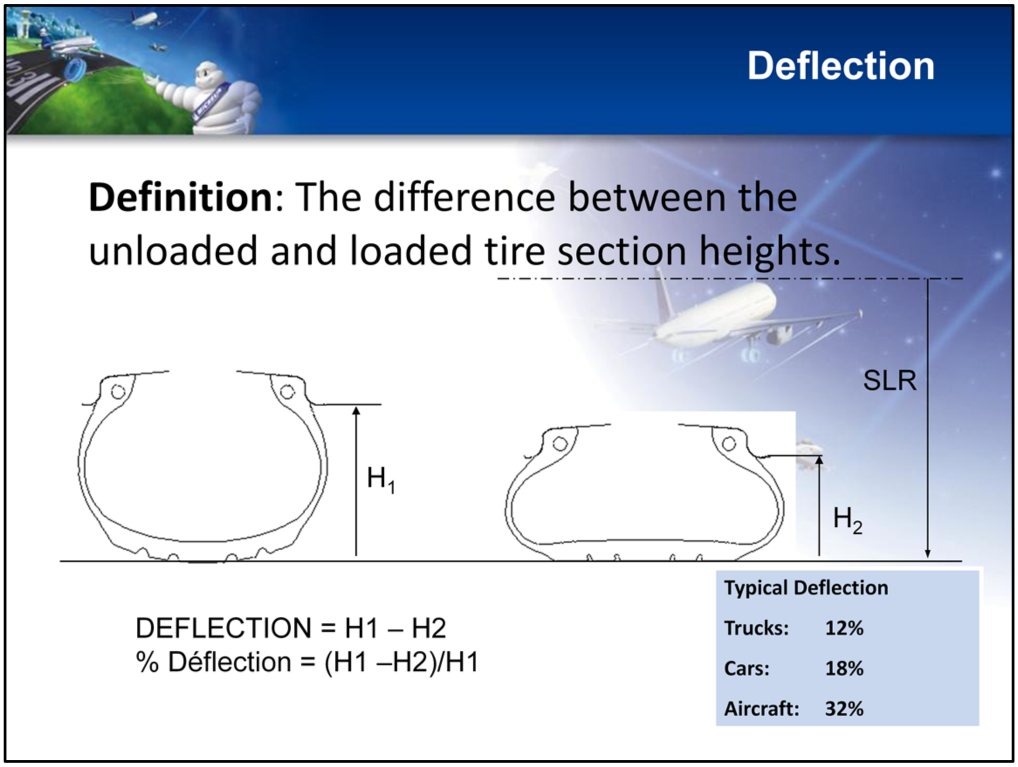
Let’s examine what can happen when under-inflated tires become over-deflected:

In the extreme cases, there is corresponding extreme shearing of the rubber in the tire as the tire deforms. This results in a more rapid build-up of heat within the rubber. At some point the heat can cause the rubber to revert, or reverse cure. This reverted rubber is like grease with no strength to contain the structure. This can allow the tire to decompose. The tread can come off, or the casing can fail.

Also, the casing plies can compress during high deflection. This unravels the plies which eventually results in separation of the plies and a weakening of the structure. This ultimately can result in the failure of the tire.

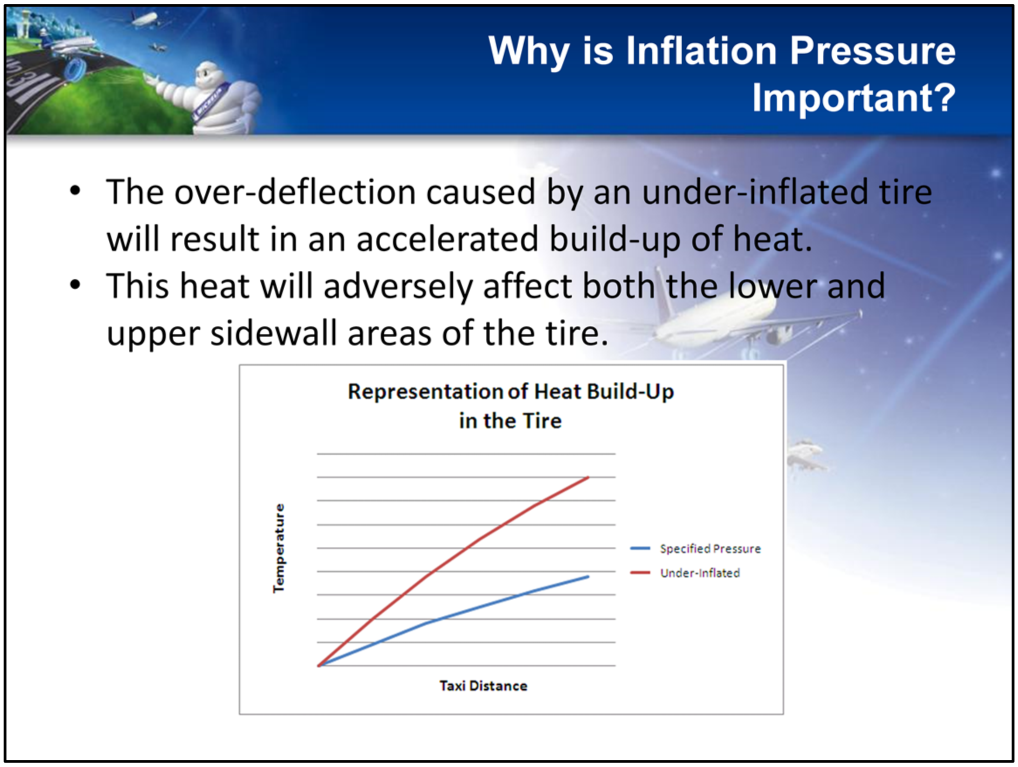
Another effect - as the tread distorts, the tire rides on the shoulder ribs. This causes irregular shoulder wear and accelerates the rate of wear. This effect begins immediately as the pressure falls below the specification.

One more possible consequence is tire/wheel slippage. The tire/wheel interface requires high pressure to anchor the tire to the wheel flange. Low pressure can result in slippage during braking damaging both the tire and the wheel.

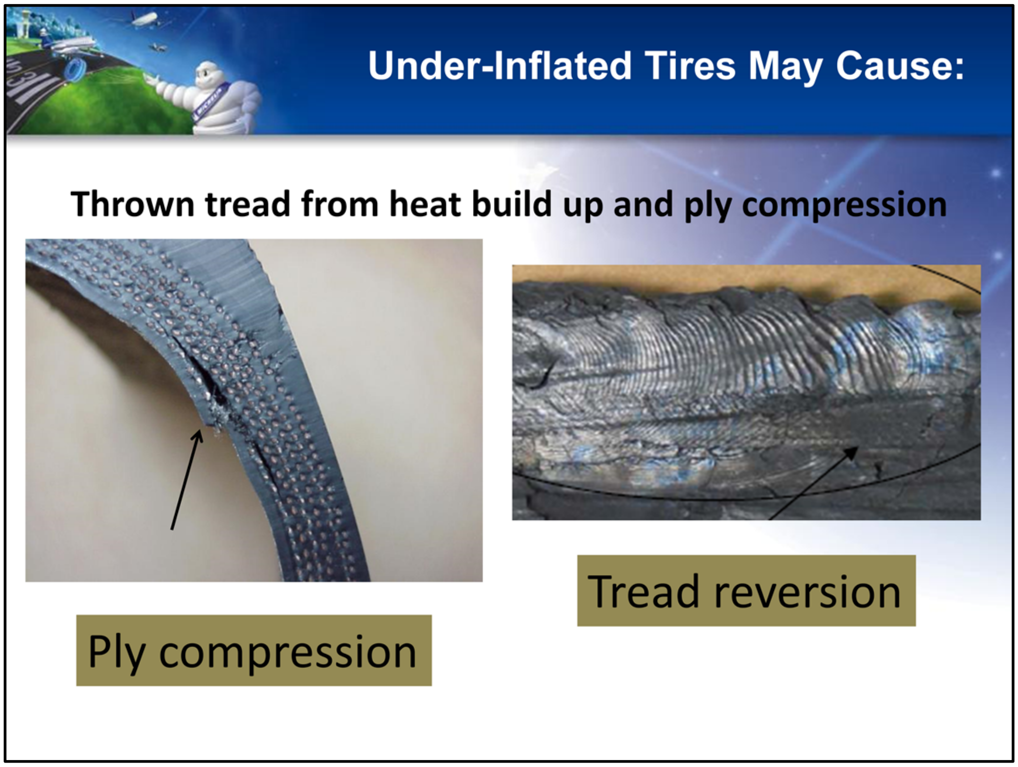


Before we go further, let's focus on deflection. Aircraft tires operate at a very high deflection by design. It is almost twice that of a car tire, and three times that of a truck tire. The high deflection allows for a smaller tire to be used for the same load which helps the designers address limited spacing in the aircraft wheel well.

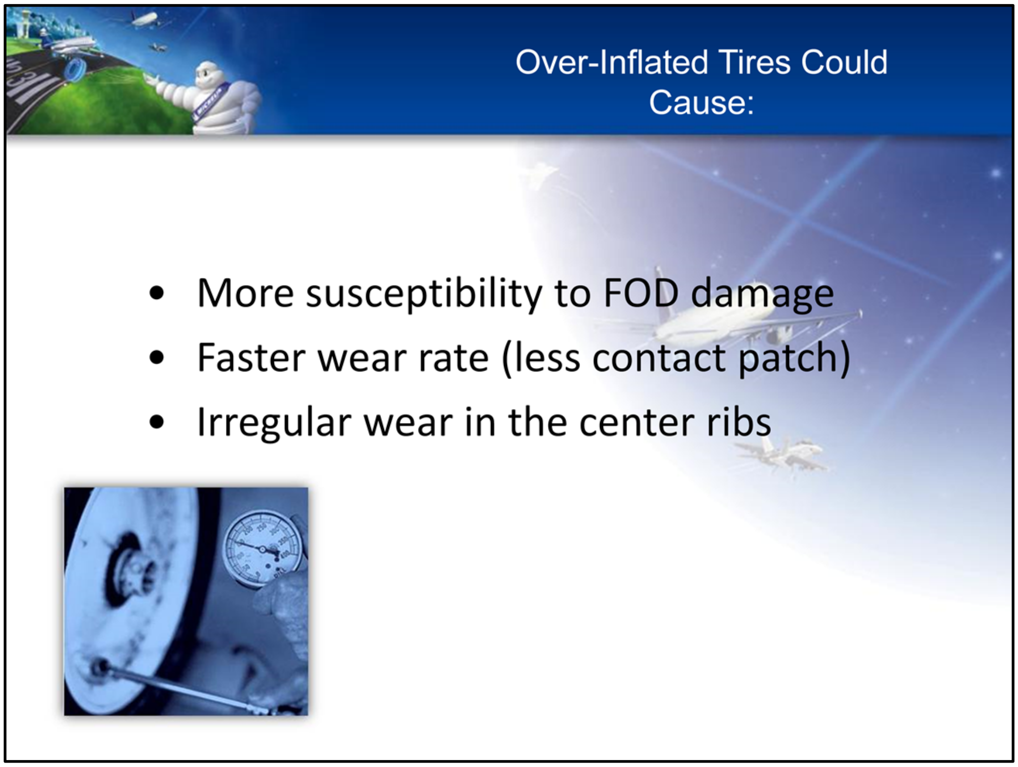
With this high deflection, heat begins to build up within the tire every time the tire rolls. It is safe to operate at this high deflection for aircraft service because aircraft tires operate only intermittently for takeoff and landing. However, this deflection must be maintained or heat build-up begins to accelerate at a very rapid rate when over-deflected. The limited roll distance the tire can survive diminishes very fast



Here you can see what we mean by accelerated heat build up. This adversely affects the upper and lower sidewall areas of the tire. The upper level sidewall heating usually leads to a thrown tread.



This illustration demonstrates both the effect of ply compression and that of a thrown tread due to reverted rubber. The plies in this tire eventually broke weakening the structure. They broke through the inner liner allowing gas to leak into the casing. You can see the ply separation in the picture on the left.
Here is a good illustration of reversion that occurred in the ultimate thrown tread consequence in the picture on the right."



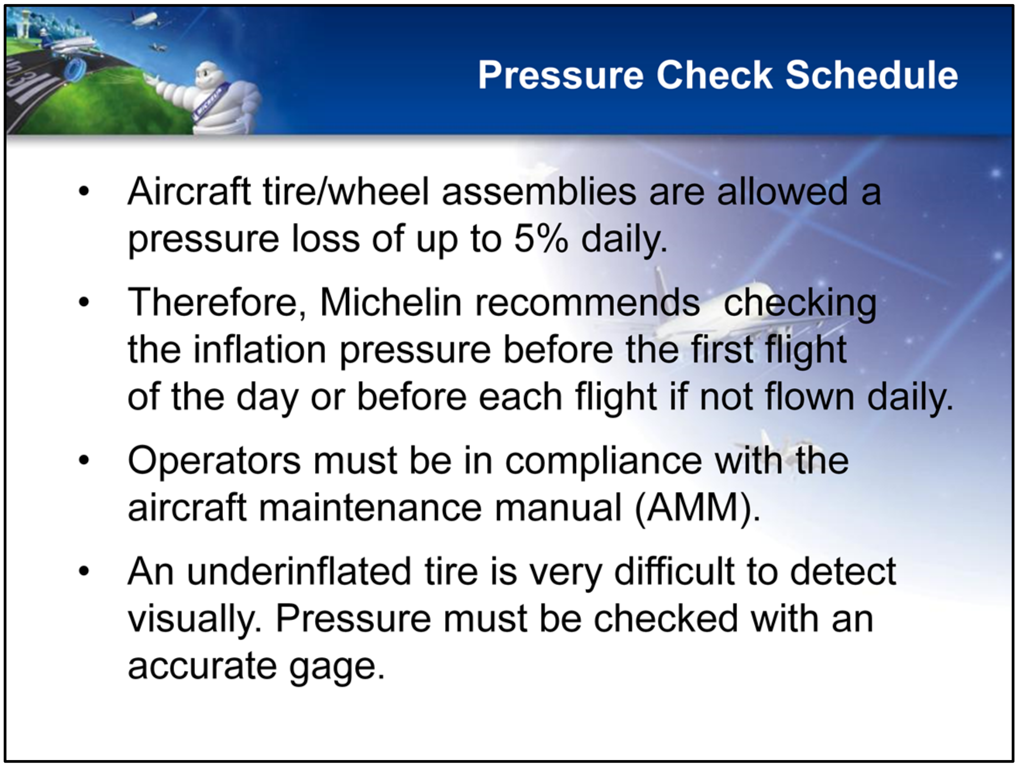
What about over-inflation. Too much pressure causes the nylon casing cords to stretch more allowing higher tire growth. This also stretches the rubber. Rubber cuts more easily when stretched, making the tire more sensitive to contact with foreign object debris.

The tire also rises up and rides mostly on the center ribs. This affects the contact patch, and accelerates wear on the central 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)

Tire manufacturers design and test tires to “rated” conditions. This means at the maximum capability of the tire both in load and speed. Aircraft manufacturers usually design the aircraft to lesser operational conditions. Therefore, they are the ones who set the operational pressure. This means the pressure established in the Aircraft Maintenance Manual must be respected.

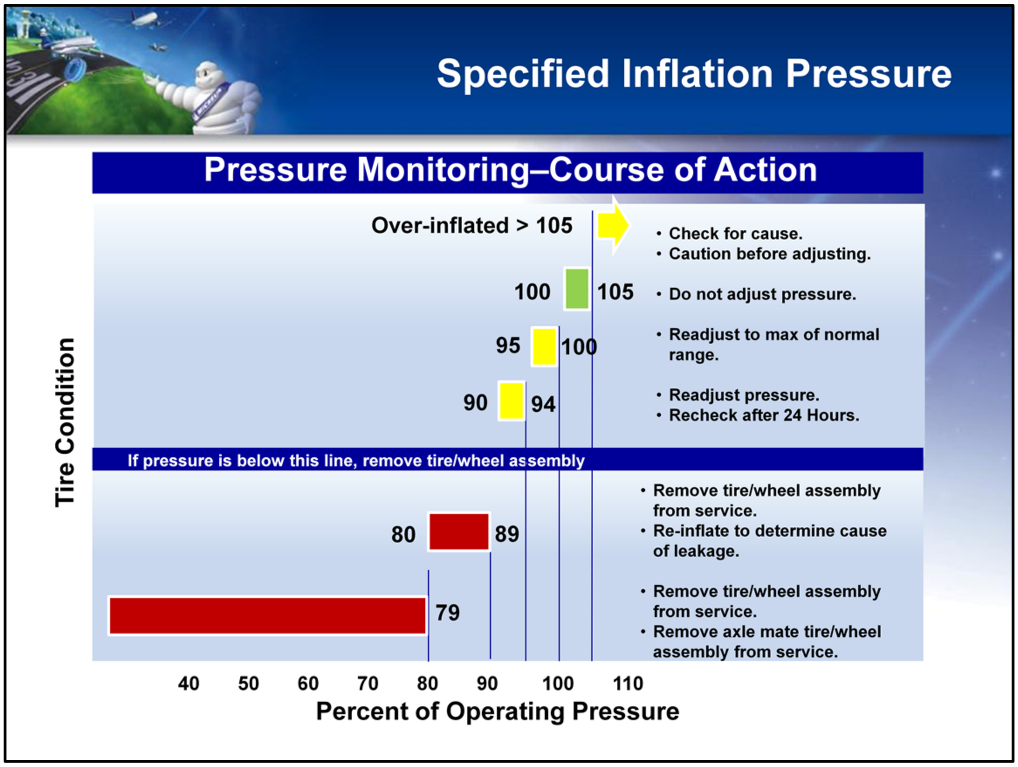


Due to the high pressures used to inflate aircraft tires, there will always be diffusion through the inner liner and at the interface between the inner liner and the wheel surface. Although typically it is much less than 5%, the maximum allowable pressure loss in a 24 hour period is 5%.

Because of this diffusion, aircraft tires should be checked before the first flight of the day, or before each flight if not flown daily.

Of course, the procedures and specifications of the aircraft maintenance manual must be respected.

Take note: an under inflated tire is very difficult to detect visually, pressure must be checked with an accurate gate.



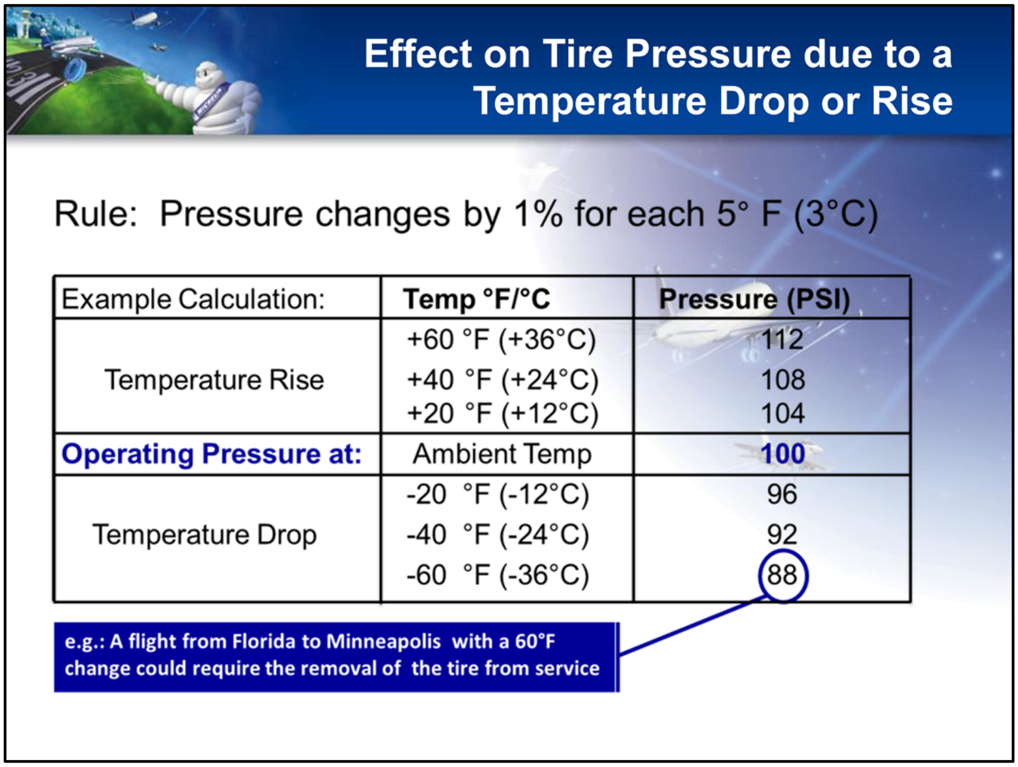
This is the Michelin recommended inflation pressure monitoring schedule. It is recommended that tires be operated within 100% to 105% of the nominal specified pressure. Since tires will always leak down, it is recommended that the actual inflation pressure be targeted to the top of the range, or 105%.

Since up to 5% loss can be expected, it is normal to see pressure loss to 95% of the nominal value.

A leakage to between 90 and 94% of nominal is suspicious. The tire should be re-inflated, logged, and inspected again in 24 hours to confirm a higher than acceptable leak rate. It should be removed and inspected in the repair shop if this high leak rate is confirmed.

Tires that leak to below 90% of nominal are no longer acceptable for service if the tire was operated and it must be removed.

If the tire is found below 80% of the nominal pressure, it and its mate must both be removed since the mate most likely is now damaged as well.



"Lets get into the effect on pressure due to ambient temperature change.

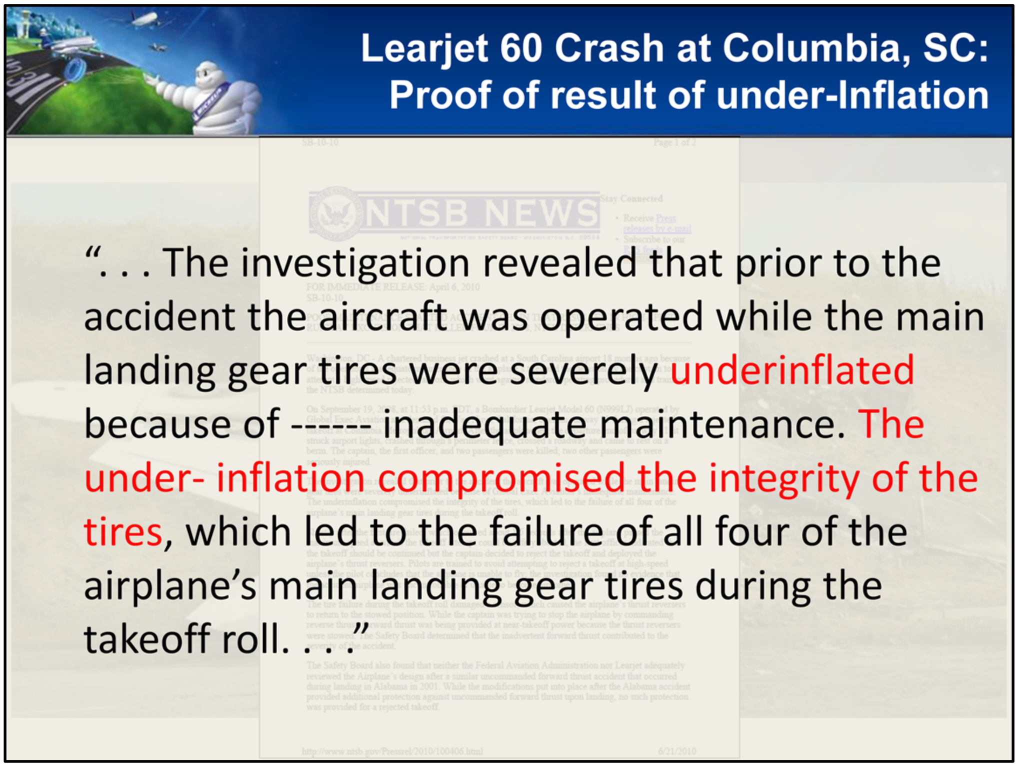
The ideal gas law states that for every 5 degrees Fahrenheit, there is a 1% change in pressure, either up or down. In this example we can see if an aircraft lands at an airport with a 60 degree lower temperature change, there will be a 12% loss in pressure. This means that based upon an earlier slide, the tire would no longer be serviceable because it would be below 90% of the nominal pressure.

This is another reason why inflation to 105% of the nominal value would be recommended. If this situation had occurred, the tires would be at 93% and acceptable for further service.

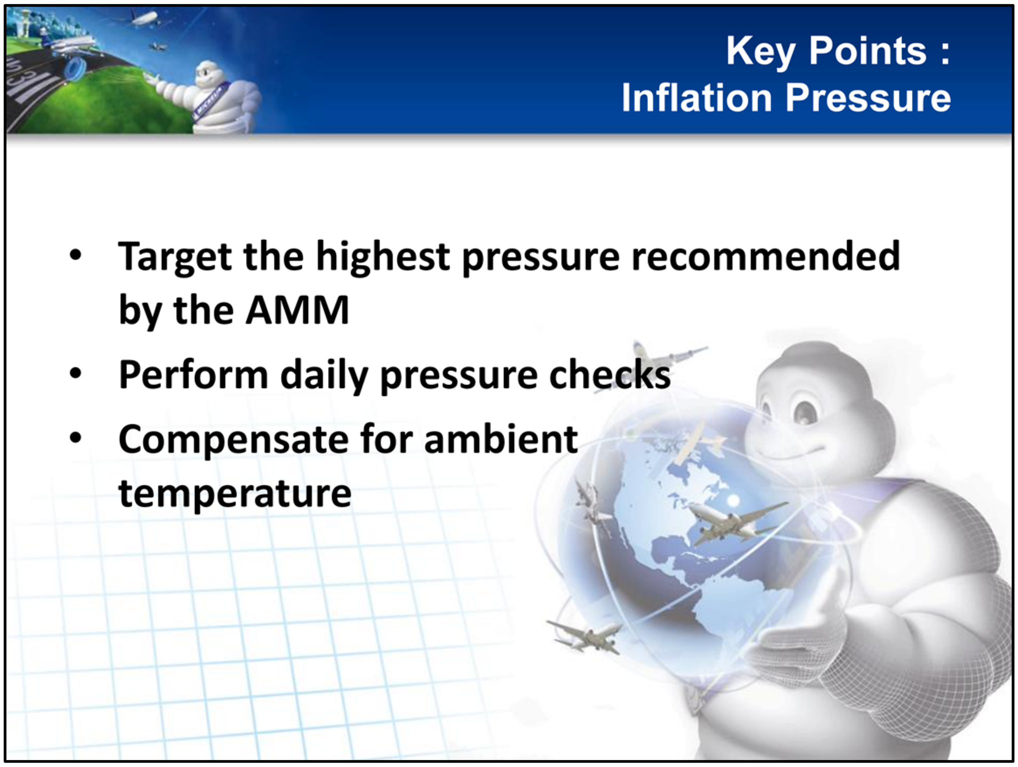
The bottom of the 100%-105% range should be used for operation to warmer airports to lessen the effect of higher pressure upon arrival.

The temperature of the airport with the lowest temperature of the aircraft's operation should be used when computing the compensation value for inflation.

Remember, the aircraft maintenance manual procedure must be respected in any case."

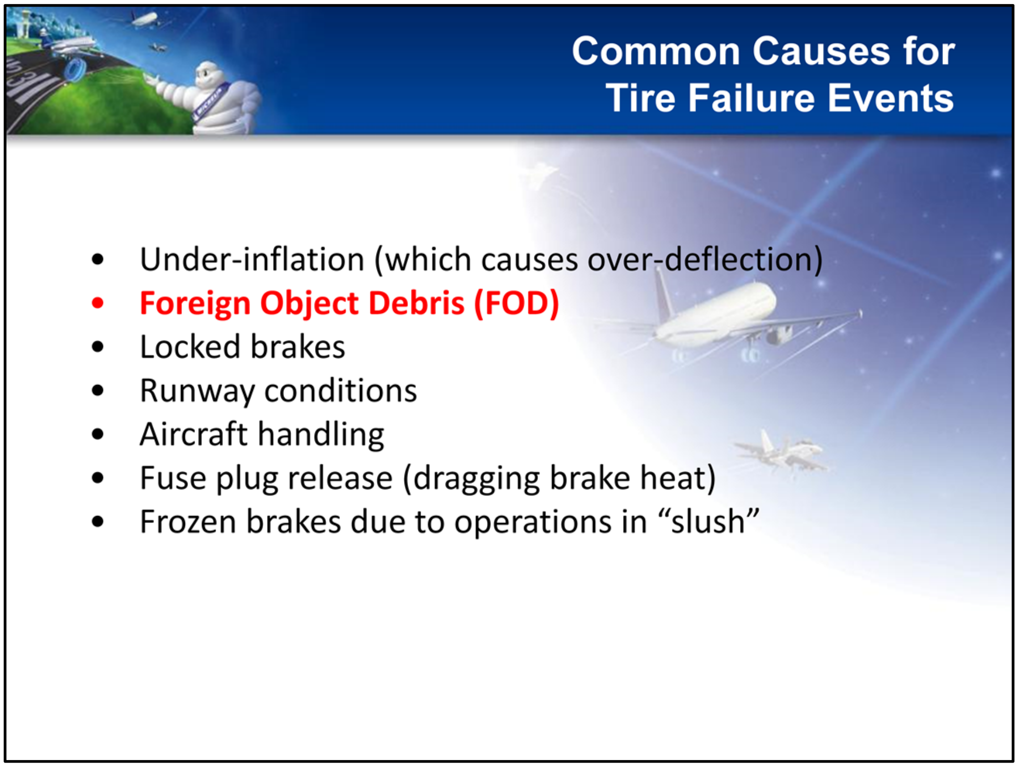


So, lets go back to the Lear 60 crash in South Carolina. The NTSB reviewed the maintenance records which revealed that the tires were severely under-inflated because of inadequate maintenance. The under-inflation compromised the integrity of the tires, which led to the failure of all four of the airplane's main landing gear tires during the takeoff roll.



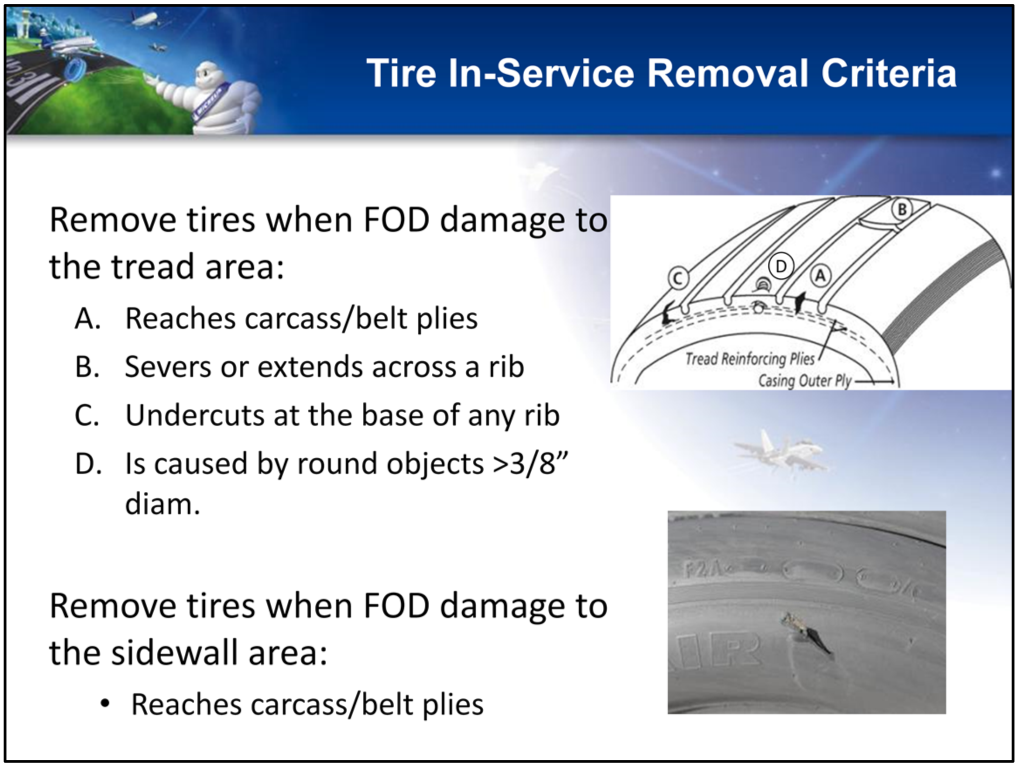
So let's summarize the key points for our focus on inflation pressure:

- Target the highest pressure recommended by the aircraft maintenance manual.
- Perform pressure checks daily
- Compensate the target value for a change in ambient temperature at destination airports.



Now let’s focus on Foreign Object Debris, commonly referred to as FOD.

"Here are some examples of FOD sources and damage to tires. In the upper left picture we see pieces of luggage. In the upper right we can see the ramp surface crumbling releasing aggregate. The lower two pictures are self explanatory.
On the central part in this slide we see the aggregate collected from the area in the upper right.
Do you think any of these items could cause damage to tires or aircraft?



Here are the limits for damage caused by FOD. In illustration A, the tire must be removed if a cut extends into any casing ply. In B, a cut that extends across the entire rib will likely end in a stripped rib. In C, the tire must be removed if there is any undercutting. In D, punctures are permitted up to 3/8" in diameter provided they do not extend into the casing plies.

Tires must be removed for any sidewall damage that exposes the tire carcass or belt piles such as the case shown in the lower picture.

So, what can be done about FOD on our air operations area surfaces? Since FOD is continuously generated from various airport operations, frequent inspections cannot be avoided. And, there is no one airport entity responsible.

The attitude that everyone is responsible must be adopted and respected.

Airport authorities need to take the lead to develop FOD preventative programs. This should include education of all personnel who operate at the airport.

To be effective, it truly must become a culture, and a never ending activity.

Besides safety, the benefits are many, and the cost to control FOD can be minimalized.

Airport surface inspections can be organized on a frequent basis and spread around the tenants to minimize impact on everyone. Most airports who have established programs have been surprised how quickly an inspection can be accomplished with limited resources. Some airports have made it competitive among the tenants.

There are also vendors who manufacture equipment that can better automate the collection of debris. These are worthwhile investments when considering the cost of the consequences. Listed here are a few of the many benefits that can be realized with an active FOD removal program.

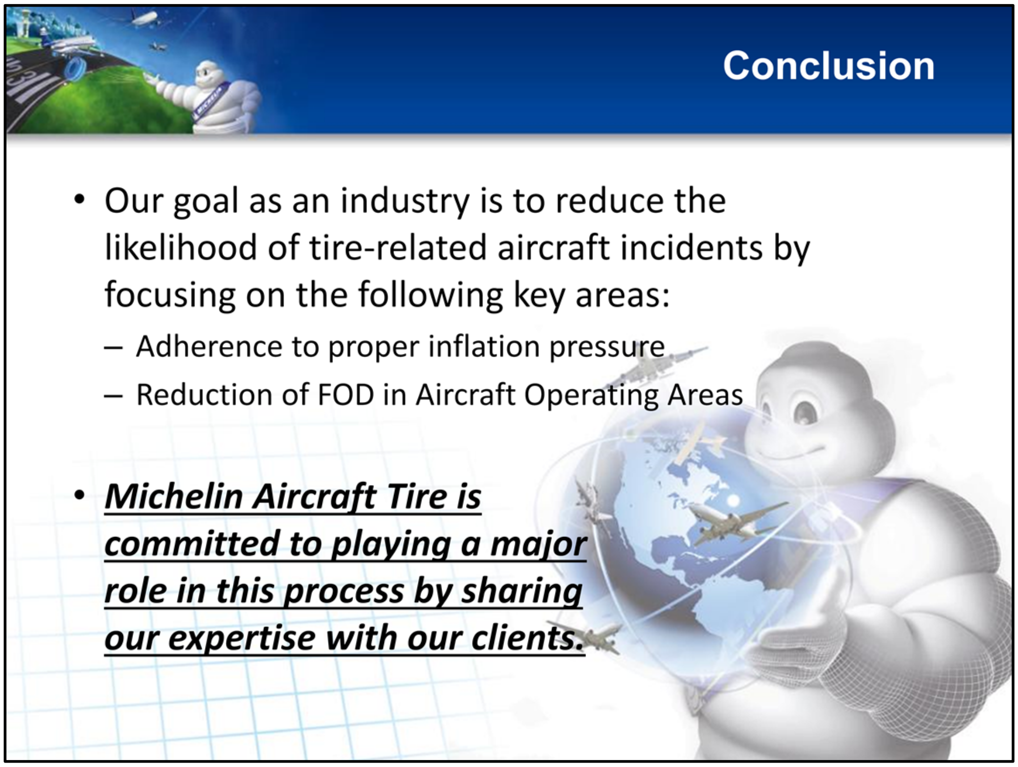
–Tire damage
–Aircraft damage
–Lost time due to delays/cancellations
–Less overtime required to manage events
–Environmental impact (fewer tires used)

And lets not forget aircraft safety.

Summarizing FOD,

- Try to prevent the generation of FOD through awareness and housekeeping
- Remove FOD from surfaces through regular inspections
- If tire damages are discovered, follow the removal criteria specified in the aircraft maintenance manual, or the tire manufacturers care and service manuals.

Remember, FOD is everyone's responsibility!



In conclusion, our goal is to reduce the likelihood of tire-related aircraft incidents by focusing on two key areas:

- Adherence to proper inflation pressure
- Reduction of foreign object debris in the aircraft operating areas

Michelin is committed to playing a major role in this process by sharing our expertise with our clients.