Boeing and Airbus
Tire Pressure Test Programs

ALACPA Airport Pavement Seminar
and FAA Workshop

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The Pavement “Club”

Outline

- Review of the 2005 Boeing/FAA high tire pressure tests
- Test plan for the December 2009 Boeing/FAA tests
- Test plan for Airbus tests - Mid October 2009

Pavement Classification Number – PCN

example: PCN 72 F/B/W/T
Tire pressure restriction

- Code W - No tire pressure limit
- Code X - 1.5 Mpa maximum (217 PSI)
- Code Y - 1.0 Mpa maximum (145 PSI)
- Code Z - 0.5 Mpa maximum (73 PSI)

(as defined in ICAO Annex 14)
Background

- The original tire pressure categories were set by the ICAO ACN/PCN working group in the late 1970's and were heavily influenced by Australian airport concerns over thin asphalt surfaced runways.

- Many airports arbitrarily define the tire pressure category in their PCN rating based on highest using aircraft, not an engineering analysis of the pavement. They may also be nervous about publishing a W (unrestricted tire pressure), and may choose X just to be conservative, because it quantifies a specific limit.

- May deprive airports and airlines of new business and revenue opportunities.

Purpose

- FAA Advisory Circular 150/5335-5B states that “A properly prepared and placed mixture that conforms to FAA specification Item P-401 can withstand substantial tire pressure in excess of 218 psi (1.5 MPa)

- Ensure that the combination of higher single wheel loads and tire pressure, that is becoming increasingly common for today’s aircraft, does NOT exceed the capability of the current asphalt mix and pavement thickness design specifications.

- ICAO Annex 14, Aerodromes – Tire pressure category X limit currently set at 1.5 Mpa (217 psi)

- Tire pressure categories established in the late 1970's appear to be outdated for today's aircraft. A340-500/-600, 747-400ER, A380-800F, 777-300ER and the soon to be introduced 787, A350 and 747-8 all exceed category X upper limit.
Proposal – Revise ICAO Tire Pressure Category X, Y Upper Limits

<table>
<thead>
<tr>
<th>Tire Pressure Category</th>
<th>Current ICAO Limits Psi (MPa)</th>
<th>Proposed New ICAO Limits Psi (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Unlimited</td>
<td>Unlimited</td>
</tr>
<tr>
<td>X</td>
<td>217 (1.50)</td>
<td>240 (1.65)</td>
</tr>
<tr>
<td>Y</td>
<td>145 (1.0)</td>
<td>181 (1.25)</td>
</tr>
<tr>
<td>Z</td>
<td>72 (.50)</td>
<td>72 (.50)</td>
</tr>
</tbody>
</table>

2005 Boeing Tire Pressure Tests

- 3 test sections with different asphalt surface thicknesses (5 cm, 10 cm and 15 cm), loaded by a single wheel (49 x 19-20 34 bias ply tire) cycled at 2.5 mph (4 km/hr).

- Initial SWL = 40,000 lb. (18,144 kg) and 140 psi (9.6 bar) tire pressure. Test sections trafficked to 500 passes. Incremental increase in tire pressure of 20 psi every 500 passes, up to 240 psi (16.5 bar).

- Increase SWL to 50,000 lb. (22,680 kg) with tire pressure at 240 psi. No visible signs of significant pavement deterioration after 3,000 cycles.

- SWL increased to 55,000 pounds (240 psi) until failure. Failure - considered to be rutting of about .6 inches, or extensive cracks resulting in a PCI below 55, occurred.

2005 Test Results – Rut Depths vs. Passes

Feedback From the Pavement Community

- Test at higher asphalt temperatures to determine the impact that lower binder viscosity and modulus may have on rutting (will go up to 100F).

- Vary asphalt mix specifications and quality.

- Cycle to higher departure levels (15,000 passes).

- Test to higher wheel loads (>55,000 pounds).

- Too much gap between proposed X = 240 psi and Y = 180 psi.
The pressure distribution in the contact area, $P_z$, is about the same for all radial tire sizes (per Michelin) and is as follows:

$0 < P_z < 1.3 \, P$ (Tread Rib 3) and $2.2 \, P < P_z < 2.5 \, P$ (Tread Rib 1)

2009 Boeing Test-Plan View

- 4 test sections - 12 ft by 25 ft
- 2 sections heated by water tubes, 1 by wire mesh, 1 unheated

Dual and Single Wheel Gears

- Dual Wheel Assembly
- 12" TYP Wander
- 217 psi
- 240 psi

- Single Wheel
- 13.1"
2009 Test Plan

- Three of the four test sections will be heated to between 90 - 100 F (32 - 38 C). This will reduce E to about half of what it was in the 2005 tests that were done at 70 F. The remaining test section will be left unheated and used as a baseline.

- Cycles will be increased to 15,000

- Side by side pavement damage comparison of current 217 psi tire pressure limit and proposed 240 psi limit at two different wheel loads (50K and 60K).

- Test at 50K and 60K single wheel loads to determine if top down cracking is a concern adjacent to wheel path

- Poor quality asphalt mix and Polymer Modified Asphalt (PMA) will be part of Airbus test program

Pavement Test Preparation – Subbase

Pavement Test Preparation – Insulation

Heating Systems
Mesh Heating System

Econocrete Layer - Water Tube Heating

Instrumentation

- Temperature gages located top, bottom and mid-depth of P-401 and top and bottom of P-209 base material
- Strain gages located adjacent to tire edge footprint at bottom and top of P-401 layer
### Test Configurations

<table>
<thead>
<tr>
<th>Test Item Configuration</th>
<th>Section 1</th>
<th>Section 2</th>
<th>Section 3</th>
<th>Section 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel configuration</td>
<td>Single - Radial 52x21-22</td>
<td>Dual - Radial 52x21-22</td>
<td>Dual - Radial 52x21-22</td>
<td>Single - Radial 52x21-22</td>
</tr>
<tr>
<td>Heating System-Temp</td>
<td>Water 90 – 100°F</td>
<td>Water 90 – 100°F</td>
<td>Mesh 90 – 100°F</td>
<td>70°F</td>
</tr>
<tr>
<td>Wheel Load, lbs</td>
<td>50,000</td>
<td>50,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Tire Pressure, psi</td>
<td>217- 1st Run</td>
<td>217 and 240</td>
<td>217 and 240</td>
<td>240-2nd Run</td>
</tr>
</tbody>
</table>

### Data Collection

- Profile survey will be performed on each test section after every 500 passes using the FAA laser profiler.
- Testing will continue up to 15,000 passes, unless failure occurs first.
- After testing is completed, cores will be taken from the wheel path, and from outside of the wheel path, to determine if asphalt cracking or base deformation has occurred.
- Test results will be used in conjunction with the Airbus tests results to determine if increases in the X and Y category tire pressure limits are justified.

### Airbus Test Sections

- **Structure A**: 6 cm SAC 1, 20 cm BAC, 70 cm foundation, CBR A
- **Structure B**: 8 cm SAC 1, 12 cm SAC 1, 18 cm BAC
- **Structure C**: 8 cm SAC 2, 14 cm BAC
- **Structure D**: 8 cm SAC 1, 16 cm BAC
- **Structure E**: 8 cm SAC 1, 18 cm BAC
- **Structure F**: 8 cm SAC 2, 18 cm BAC
- **Structure G**: 8 cm SAC 3, 18 cm BAC

**Nota:**
- **UGA**: untreated graded aggregate 0/20
- **SAC**: surface asphalt concrete
- **SAC 1 gr.**: surface asphalt concrete grooved
- **SAC 2**: surface asphalt concrete- rut resistant
- **SAC 3**: surface asphalt concrete-poor quality sensitive to rutting

### Airbus Test Section and Gear Configuration

- **North**: L4S (Instrumented), L3N (Instrumented)
- **South**: L2S (Instrumented), L1N

- **Levels**:
  - 2 m / 6.5 ft.
  - 25 m / 82 ft.
  - 7 m / 23 ft.
Land Gear Test Device

Modified device from A380 tests

Landing Gear Loading Procedure

1. Selection of P1 (15 bar) / L1 \(\rightarrow\) Tire deflexion, D1
2. L2 = Load for which D2 = D1 at P2 (17.5 bar)
3. Comparison at the same Load L2 \(\rightarrow\) D3 ≠ D1, D2
4. Comparison at the same load L1 \(\rightarrow\) D4 ≠ D1, D2, D3

Landing Gear Configuration

Minimum Load Initially

- Surface rutting initiation (minimum load)
- Tire size: MICHELIN 1400x530R23 40PR

<table>
<thead>
<tr>
<th>Pnz (Bar)</th>
<th>Load (Kg)</th>
<th>Deflexion (mm)</th>
<th>Gross contact area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>19200</td>
<td>78</td>
<td>1280</td>
</tr>
<tr>
<td>218</td>
<td>42300</td>
<td>78</td>
<td>1220</td>
</tr>
<tr>
<td>17.5</td>
<td>21000</td>
<td>78</td>
<td>1220</td>
</tr>
<tr>
<td>254</td>
<td>46300</td>
<td>88</td>
<td>1400</td>
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<tr>
<td>15</td>
<td>21000</td>
<td>88</td>
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</tr>
<tr>
<td>218</td>
<td>46300</td>
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<td>1200</td>
</tr>
<tr>
<td>254</td>
<td>42300</td>
<td>78</td>
<td>1200</td>
</tr>
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</table>

Maximum Load

- Surface rutting continuation and structural damage? (Maximum load)
- Tire size: MICHELIN 1400x530R23 40PR

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<th>Deflexion (mm)</th>
<th>Gross contact area (cm²)</th>
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<tbody>
<tr>
<td>15</td>
<td>28700</td>
<td>114</td>
<td>1904</td>
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<tr>
<td>218</td>
<td>63300</td>
<td>114</td>
<td>2070</td>
</tr>
<tr>
<td>17.5</td>
<td>34300</td>
<td>114</td>
<td>2070</td>
</tr>
<tr>
<td>254</td>
<td>75600</td>
<td>114</td>
<td>2070</td>
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<td>34300</td>
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<td>2420</td>
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<tr>
<td>218</td>
<td>75600</td>
<td>124</td>
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</tr>
<tr>
<td>17.5</td>
<td>28700</td>
<td>97</td>
<td>1840</td>
</tr>
<tr>
<td>254</td>
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<td>97</td>
<td>1840</td>
</tr>
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</table>
What’s Next?

- Airports Council International (ACI) is contacting airports to raise awareness of the higher tire pressures that are becoming increasingly common on new aircraft, and the impact on airport and airline operations.
- Airbus initial testing from October through December 2009 will reach ~4,000 passes. Preliminary results will be presented to ICAO via the Pavement sub group committee in early 2010. Boeing test data will be included, but will be incomplete, since we are starting later (December 2009).
- Airbus testing will recommence during the summer of 2010 to gather hot temperature data.
- The Boeing/Airbus final report needs to be completed in time for the ICAO aerodrome meeting in October 2010.
- Decision to redefine ICAO tire pressure categories expected to be considered at this time.

Summary

- Purpose of the tests is to ensure that the combination of higher wheel loads and tire pressure, that is becoming common on new aircraft, does not exceed the capability of the current airport pavement thickness design and asphalt mix specifications.
- Many airports arbitrarily set the tire pressure category in their PCN rating based on the highest defined limit (1.5 megapascals), not an engineering analysis of the actual pavement capability.
- About 41% of airports worldwide currently limit aircraft tire pressures to 1.5 megapascals. Most new aircraft have tire pressures exceeding 1.5 megapascals.
- Expect testing to confirm that airports can support aircraft with tire pressures exceeding 1.5 megapascals without any consequences to their pavement.
- Assuming positive test results, a final report will be submitted to ICAO proposing that Annex 14 be revised to increase the Y tire pressure limit to 1.25 megapascals (180 psi) and the X category limit to 1.65 megapascals (240 psi).

Thank You!
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