BRAKE WEAR & DUST: COMPARISON OF TEST PROCEDURES

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TEST METHODS FOR WEAR TESTING: DYNO TESTING

• Wear Dynamometer Tests usually run at temperatures 100°C and higher
  • SAE J2707 General Wear Test  100-500°C
  • SAE J2707 Block Wear Test    100-350°C

• Pros:
  • Fast
  • Good for friction development purposes (comparison of materials)

• Cons:
  • Risk of “conditioning” of pad material at multiply identical brake applications
  • Does not reflect “normal driving pattern” regarding speed, deceleration, application sequence, brake temperature
  • Wear evaluation in the range above 100°C only
• Vehicle brake wear durability testing is combined with brake NVH testing.
• There are generally two methods (with their possible regional substitutions):
  • Mojacar (cross country + city traffic + highway)
  • LACT (LA suburban + city traffic)
• Basically developed as brake noise tests, need higher brake temperatures (above 200°C max)
  • Mojacar average / max temperature: 125-175°C / >250°C
  • LACT average / max temperature: 100-150°C / >200°C
• Reaching above temperature levels require adequate driving pattern and vehicle payload.
BRAKE TEMPERATURE DURING VEHICLE TESTING

Temperature trace during Mojacar durability test (OE1)

Temperature histogram

Temperature Histogram of Mojacar OE1

- Mean: 114.8
- StdDev: 51.54
- N: 22510
**European wear testing: More than 59% of all brake applications are above 100°C**

**But which temperatures does the brake see at a “normal” customer and what are the implications?**
CASE STUDY

• Two brake specs with European performance pads
• Similar brake life evaluated in Mojacar procedure

• Different dust generation on the vehicle in daily usage
COLOGNE TRAFFIC TEST

- Run on vehicle
- Vehicle equipped with data logger
  - Speed
  - Rotor temperature
  - Deceleration
  - Brake pressure
  - Distance
- Run in Cologne
- Mostly “driver only”*

* In Germany, the average pay load is 1,5 persons (Pkw-Besetzungsgrad bei der privaten Autonutzung)

Source:
DLR - Deutsches Zentrum für Luft- und Raumfahrt, Institut für Verkehrsforschung, infas Institut für angewandte Sozialwissenschaft, 2010
http://www.forschungsinformationssystem.de/servlet/is/79638/
More than 90% of brake applications were made at brake temperatures below 100°C.
City Traffic section started with $T>150^\circ C$. 
INITIAL SPEED AND DISC TEMPERATURE ON WIESBADEN CIRCUIT (ADDED CITY TRAFFIC WITH $T_{ini}=50^\circ C$); DATA: FEDERAL MOGUL

City Traffic section run with $T_{ini}=50^\circ C$.

In total: More than 73% of brake applications were made below 100$^\circ C$. 
### VEHICLE WEAR TESTING: BRAKE TEMPERATURE LEVEL

<table>
<thead>
<tr>
<th>Test</th>
<th>% of brake applications above 100°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mojacar OE1</td>
<td>59</td>
</tr>
<tr>
<td>Mojacar OE2</td>
<td>73</td>
</tr>
<tr>
<td>Internal test OE2</td>
<td>68</td>
</tr>
<tr>
<td>LACT OE1</td>
<td>73</td>
</tr>
<tr>
<td>LACT OE2</td>
<td>19</td>
</tr>
<tr>
<td>Cologne</td>
<td>10</td>
</tr>
<tr>
<td>Wiesbaden</td>
<td>27</td>
</tr>
</tbody>
</table>

- (It is known, that) Mojacar does not represent “normal” customer driving pattern - common assumption: approx. **double brake life** in the field compared with life in Mojacar.
- Real daily usage (Cologne) and daily usage simulation (Wiesbaden) show very high percentage of brake applications below 100°C (73-90%).
- What are the implications of this finding on evaluated vehicle?
MODIFICATIONS OF TEST METHODS: DYNO TEST

• Dyno testing
  • Modification of Wear vs. Temperature tests by adding low temperature sections with 60°C and 80°C temperature levels
  • Reduced deceleration level
  • Slight speed increase
  • Number of stops 300 per temperature level

• Affected friction materials tested in the same brake
Both materials show similar disc wear between 100 and 200°C as in current J2707 procedure ........

* Disc wear has high importance for brake dust generation
but different wear under 100°C!
VEHICLE WEAR TESTING: BRAKE TEMPERATURE LEVEL

- Vehicle testing
  - New procedure (distance and speed controlled) as combination of:
    - Deceleration levels
    - Speed levels
    - Distances between the stops
    - Approx. average initial brake temperature of 80°C (brake/vehicle depended due to driving pattern)

- Evaluation of
  - Mass loss for pad and rotors
  - Dust deposition on wheel
Material B (higher TGW), dust generated between stops 400 to 600

Material A (lower TGW), dust generated between stops 400 to 600
CONCLUSIONS

• Typical driving patterns, especially with low vehicle payload (driver only), are characterized by high percentage of brake applications with rotor temperature below 100°C

• These thermal conditions are not sufficiently reflected in current well-established dynamometer and vehicle brake wear procedures

• Dyno SAE J2707 procedures can be easily updated to incorporate conditions critical for dust generation
  
  Remark: brake applications at identical parameters may lead to a negative effects like “friction conditioning” influencing wear ratios

• New vehicle procedures for dust generation (and/or their simulations on brake dynamometers) must be developed or an (significant) update of established procedures must be undertaken to better integrate and reflect “driver only” conditions.

• The simulated driving profile will be dependent on the fact which driving conditions should simulated: mostly city traffic only or a combination of different conditions.
Thank you
Q&A