TABER ABRASION
WHAT YOU DIDN’T KNOW (PAST, PRESENT, FUTURE)
• Developed in 1930’s to perform accelerated wear testing

• Referenced in 100+ international test methods

• Abrasion standard for numerous industries
  – Why? Provides reliable data in a matter of minutes compared to the years required by in-use testing
• “Taber test” is simple to perform:
  – Secure flat specimen to a turntable platform
  – Two abrasive wheels, applied at a specific pressure, are lowered onto specimen surface
  – Platform rotates on a vertical axis at fixed speed
  – Characteristic rub-wear action is produced by contact of test specimen against sliding rotation of the abrading wheels
  – Vacuum system removes loose wear debris during the test
• Abrasion marks form a pattern of crossed arcs in a circular band that cover an area approximately 30 cm².
How to Generate Reliable Results?

• Ensure testing is performed in a uniform and consistent basis
  – “Taber” standards used for anodized aluminum
    • AMS 2469
    • ASTM D4060
    • BS 5599
    • FTMS 141C – method 6192.1
    • MIL-A-8625
    • ISO 10074 – Annex B
    • UNI 7796 – Appendix B
Wait . . .

- Users have claimed the Taber test does not offer “sufficient precision to differentiate between varying hard coat quality”
- This lack of confidence has anodizer’s questioning its’ usefulness
There is a general decrease in the abrasion resistance of all the alloys with increase in the time of exposure to both the atmospheric conditions and humidity. The decrease is greater under the high humidity conditions than it is under exposure to atmospheric conditions and in most cases is proportional to the thickness of the coating.”

Based on study conducted by H.G. Arlt in 1940
The deterioration of abrasion resistance is largely a function of the humidity and, in investigating the effect of various sealing treatments, no very pronounced improvement was found.”
“Seasonal fluctuations occur if abrasion-resistance testing (using the Taber Abraser Test) of hard anodized aluminum is performed without humidity control.”
5th World Conference on Aluminum (2000)

“Accuracy of results mainly depends on correct weighing of the specimen, taking care to maintain constant room temperature and relative humidity during the test program.”

Things to watch:
- Accuracy of the weighing equipment
- Effect of static charge and temperature on balance (drift)
- Temperature difference between specimen and air in balance
- Operator skill when using balance
• Metal Finishers Conference (2007)

“Being simple and easy to operate, calibration & maintenance of the Taber Abraser are quite often ignored”

Things to watch:
- Abraser arm misalignment
  (toe-in/out; caster, camber)
- Wheel tracking
- Platform table wobble
- Worn bearings
- Vacuum suction force
Metal Finishers Conference (2007)

“A test panel coated and submitted for testing can cause considerable differences in results”

Things to watch:
- Panel is too thin & bows during processing
- Test specimens are cut from a larger sheet & is not flat
- Anodic build up in the center hole
- Drilling operation leaves a burr in the center hole

“Potential sources of error include bearing wear (looseness), shaft wear and alignment of the arms.”

“Improper alignment of the abrasive wheels can lead to each wheel abrading a different path from its complementary wheel.”

“Path surface area can differ by as much as 20% and the area abraded by both wheels on a sample could be less than 50% of the total abraded area.”
• 5th World Conference on Aluminum (2000)

“The anodic coating has the well-known microcellular structure of fine pores and its density can change through the thickness, the surface layer more porous and softer than the inner layer.”

Things to watch:
- Pretreatment
- Electrolyte bath temperature
- Bath agitation
- Current density
- Bath chemistry & time in solution
- Processing differences (tanks, racking, specimen distance from cathodes, etc.)
variability in the properties of the abrasive wheels, the hardness of which changes with time as the binder compound ages. Added variability may result from the need to dress the surfaces of the wheel; from frictional heating of the wheels and specimen during the test; and from the influence of the wear debris.”

“Freshly exposed anodic oxidation coatings can gain in mass by absorbing water vapour.”

“The standard specimens have inherent variations of ±10%.”
What are your test parameters?

- MIL-A-8625F is commonly referenced for wear tests of hardcoat anodize
  - Used for anodizing in military / aerospace applications and is the basis for many commercial specifications
  - Type III Hard Coated Aluminum Surfaces (0.002” coating thickness, 4,320 mg/ft² coating weight)
    - Taber Abraser wear index = 1.5mg/1,000 cycles
    - 3.5mg/1000 cycles for alloys with >2% Cu
MIL-A-8625F

- “Test specimens **shall be tested in accordance** with Method 6192.1 of FED-STD-141”
  - *FED-STD 141 intended for organic coating materials*

- Should specimens be conditioned?
  - *Unless otherwise specified, condition the test film to 23 ±1.1 °C (73.4 ±2 °F) and 50 ±4% RH*

- Should tests be performed in a controlled environment?
  - *Not specified*

- How many specimens?
  - 3 or 5
– What is the vacuum nozzle height?
  • *Adjust to a distance of 1/32” above the test film*

– What is the vacuum suction level?
  • *Approximately 50 points on the dial (Variac), may be increased to 90*

– How are wheels refaced?
  • *S-11 abrasive disc*
  • *Number of cycles & frequency not specified*

– When should wheels be refaced?
  • *The abrasion wheels shall be refaced at least once every 10,000 cycles*
• ASTM D4060 (2001)

- Should specimens be conditioned?
  • *Unless otherwise specified, condition the test film to 23 ±2 °C and 50 ±5% RH*

- Should tests be performed in a controlled environment?
  • *Conduct the test in the same environment or immediately on removal therefrom*

- How many specimens?
  • *Minimum of 2*
  • *FED-STD-141 method 6192.1 states “3 or 5”*
- What is the vacuum nozzle height?
  • Adjust to a distance of 4mm (1/4") above the test film

- What is the vacuum suction level?
  • Approximately 50 points on the dial, may be increased to 90

- How are wheels refaced?
  • S-11 abrasive disc for 50 cycles

- When should wheels be refaced?
  • Before testing and after every 500 cycles
  • MIL-A-8625 states . . . “The abrasion wheels shall be refaced at least once every 10,000 cycles”
• ASTM D4060 (2007 updates)
  – What is the vacuum nozzle height?
    • Adjust to a distance of 6.5mm (1/4"") above the test film
  – What is the vacuum suction level?
    • Set the vacuum suction force to 100, may be decreased if agreed upon by the interested parties
  – How are wheels refaced?
    • Do not brush or touch the surface of the wheels after they are refaced
  – Calibration?
    • Verify calibration of the Taber Abraser as directed by the equipment manufacturer
  – Should specimens be conditioned?
    • Store in test environment for at least 1 day
    • Test environment not specified
  – Should tests be performed in a controlled environment?
    • Not specified
  – How many specimens?
    • Not specified
  – What is the vacuum nozzle height?
    • Within 0.8 to 1.5mm of the test piece
  – What is the vacuum suction level?
    • Not specified
— How are wheels refaced?
  • Reface for 50 cycles on S-11
  • Every four cycles (tests?) refaced with diamond grinding machine

— When should wheels be refaced?
  • After each test

— Procedure includes 1000 cycle break-in period
  • Mass loss calculated after 1000 cycle break-in

— At conclusion of test
  • Place test piece in desiccator
• American Electroplaters’ Convention (1969)
  – Search for a more rapid test which would remove a greater amount of coating per unit of time
  • H-38 (vitrified wheels)
    – Data was “erratic” & traced to refacing with diamond tool
• H-10 (vitrified wheels)
  – Yielded more reproducible results (reface every 500 cycles)
  – 1.0 mil thick coating could be penetrated in less than 500 cycles
  – Failure noted when two separate bare metal spots were exposed
Attempts to Address Test Variation

- IHAA Wear Test Study (1998)
  - Performed to understand the precision of the more common wear tests
  - “European” Taber test
    - *uses a desiccator to minimize the effects of environmental humidity*
    - *Includes a 1000 cycle break-in period to eliminate surface variation and softer outer coating layers*
  - Confirmed many of the participating labs do NOT control the test environment
• Rotary Abraser Calibration Verification Kit introduced in 2004
  – Reliable system check, not intended as a substitute for regular instrument calibration
Things to watch:
- Wheel alignment & tracking
- Wheel bearing condition
- Vacuum suction force
- Turntable platform position
- Turntable speed
- Load on wheels
• Metalast Int’l - Wear Resistance Study (2001)
  - Specimens (6061-T6) with various post treatments
  - Conditioned in a desiccator for 48 hrs
  - Placed in the weighing environment for 30 min
  - Weighed with an analytical balance to an accuracy of 0.1mg
  - Abraded
  - Placed in the weighing environment for 30 min
  - Weighed
<table>
<thead>
<tr>
<th>Post Treatment</th>
<th>Wear Resistance (mg/10,000 revolutions)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dye or seal</td>
<td>8.4 (2.3)</td>
</tr>
<tr>
<td>Sodium silicate seal</td>
<td>9.2 (2.0)</td>
</tr>
<tr>
<td>Sodium dichromate seal</td>
<td>9.8 (3.7)</td>
</tr>
<tr>
<td>Nickel fluoride seal</td>
<td>11.5 (2.5)</td>
</tr>
<tr>
<td>Black dye</td>
<td>11.8 (3.9)</td>
</tr>
<tr>
<td>DI water seal (30 min)</td>
<td>13.9 (3.5)</td>
</tr>
<tr>
<td>Nickel acetate seal</td>
<td>15.0 (4.4)</td>
</tr>
<tr>
<td>Black dye and nickel acetate seal</td>
<td>17.7 (3.8)</td>
</tr>
<tr>
<td>DI water seal (2 hours)</td>
<td>19.8 (6.5)</td>
</tr>
</tbody>
</table>

* Numbers in parenthesis are standard deviations
• Metalast Int’l - Depth Profile Wear Resistance Test (2001)

“Both pore size and cell size may vary with each alloy and the anodizing parameters.”

“The anodic coatings produced by the new commercial process (MLT-III) have virtually constant wear resistance in the depth profiles. In contrast, the wear resistance of the M.H.C. coating varied with coating depth.”
Comparison of Wear Resistance of Hard Anodic Coatings Produced By New Commercial Processes with that of Other Materials and Coatings
Weight Loss Comparison of Wear Resistance of Hard Anodic Coatings Produced By New Commercial Processes with that of Other Materials and Coatings
Going Forward . . .

- ASTM Test Method for Abrasion Resistance of Hard Anodic Coatings by the Taber Abraser
- Before balloting, looking for input . . .
  - Minimum specimen thickness
  - Vacuum nozzle gap
  - Conditioning period & test environment
  - Include break-in period (1000 cycles)
  - Reface during test
  - End point (wear index or change in thickness)
  - Condition specimens after abrasion
• Thoughts to ponder . . .
  – Variation in results is reduced when coupons are conditioned after abrasion test or placed in a desiccator
  – 10 year study by Olympic Scientific shows no significant difference
    • 1000 precycle or refacing every 500 cycles

<table>
<thead>
<tr>
<th></th>
<th>1000 Precycles</th>
<th>Reface Every 500 Cycles</th>
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<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Std Dev</td>
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<tr>
<td>7075</td>
<td>0.93</td>
<td>0.475</td>
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<tr>
<td>6061</td>
<td>0.78</td>
<td>0.323</td>
</tr>
<tr>
<td>2024</td>
<td>1.29</td>
<td>0.579</td>
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</table>
• Interlaboratory Study with objective to differentiate results
  – Suggestion from Chris Jurey (Oct 2012)
    • 1100 alloy panels (1.0 – 1.5 mil hardcoat)
      – Done in cold (28 °F) tank
      – High current density (40 – 50 asf)
    • 2024 alloy panels (2.0 – 2.5 mil hardcoat)
      – Done in hot (50 °F) tank
      – Low current density (25 – 30 asf)
Questions?

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