ASTM D3803 Precision and Bias for New Versus Used Activated Carbon, Revisited

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ASTM D3803 Precision & Bias


• Tests performed on presumably identical materials under presumably identical circumstances do not, in general, yield identical results.
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- Many different factors (apart from random variations between supposedly identical specimens) may contribute to the variability in application of a test method,
- These include: the operator, equipment used, calibration of the equipment, and environment (temperature, humidity, air pollution, etc.).
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- Precision, when evaluating test methods, is expressed in terms of two measurement concepts, repeatability and reproducibility.
- Under repeatability conditions the factors listed above are kept or remain reasonably constant and usually contribute only minimally to the variability.
- Under reproducibility conditions the factors are generally different (that is, they change from laboratory to laboratory) and usually contribute appreciably to the variability of test results.
- Thus, repeatability and reproducibility are two practical extremes of precision.
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- Current values for D3803 precision following E691 are:
  - Repeatability = 0.76 at 1 % Penetration
    (95 % Confidence Interval: 0.32 to 1.85 % Penetration)
  - Repeatability = 1.77 at 10 % Penetration
    (95 % Confidence Interval: 8.30 to 11.84 % Penetration)
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• Current values for D3803 precision following E691 are:

  • Reproducibility = 0.77 at 1 % Penetration
    (95 % Confidence Interval: 0.31 to 1.85 % Penetration)
  
  • Reproducibility = 1.77 at 10 % Penetration
    (95 % Confidence Interval: 8.30 to 11.84 % Penetration)
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- Current D3803 precision following E691
- This data is shown in detail for the six participating laboratories in Appendix 5 of the standard
- It represents testing new and used carbon at 95% RH
  - New Carbon average result: 1.082% penetration
  - Used Carbon average results: 10.072% penetration
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• Current D3803 bias statement:
  • “Bias depends on exact conformance to the empirical conditions of the test.
  • Interlaboratory comparisons have shown that results from laboratories which do not rigorously follow the specifications for test system design, operation, and calibration often exhibit a very significant bias.
  • This bias cannot be corrected for because of the non-uniformity of the effects of variations of the specified parameters and procedures on different carbons.”
ASTM D3803 Precision & Bias

- This testing at 30 °C and 95% RH works well for new carbons tested to AG-1 (batch test)
- And for new and used carbons tested according to Reg. guide 1.52 for ESF systems and 1.140 for non-ESF systems
- But both 1.52 and 1.140 allow testing at 70% RH for systems with RH control
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- In order to add this test to D3803 we need round robin data to develop a E691 precision statement
- But a minimum of six labs are needed!
- So decided to go data mining!
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- Data were presented at the 19th DOE/NRC NACC
  - By Chris Scarpellino and Claude Sill of INEL sponsored by the NRC
- Although not the final data, 70% RH tests on used carbon were performed by the same labs that participated in the final round robin (except for one)
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- The data for six labs was used, each performing three tests on the same sample:

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Penetration ± STD. DEV, %</th>
<th>Final moisture Content, %</th>
<th>Test Bed Density, g/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.5 ±1.0</td>
<td>26.5 ±0.4</td>
<td>0.573 ±0.011</td>
</tr>
<tr>
<td>3</td>
<td>19.0 ± 0.3</td>
<td>23.6 ±0.5</td>
<td>0.572 ±0.002</td>
</tr>
<tr>
<td>6</td>
<td>19.1 ±0.6</td>
<td>26.1 ±0.7</td>
<td>0.600 ±0.006</td>
</tr>
<tr>
<td>7</td>
<td>24.1 ±0.6</td>
<td>21.3 ±0.08</td>
<td>0.570 ±0.017</td>
</tr>
<tr>
<td>9</td>
<td>22.8 ±1.1</td>
<td>24.7 ±0.6</td>
<td>0.571 ±0.005</td>
</tr>
<tr>
<td>11</td>
<td>24.9 ±0.5</td>
<td>24.6 ±0.8</td>
<td>0.556 ±0.003</td>
</tr>
</tbody>
</table>
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Results:
Average penetration: 22.4%
Repeatability at 95% confidence level: 2.7%
( 19.7 - 25.1% ), \( S_r = 0.545 \% \)
Reproducibility at 95% confidence level: 7.6%
( 14.8 - 30.0% ), \( S_R = 2.73 \% \)
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The question then is this acceptable precision for used carbon at the 22% penetration level?
The floor is open for discussion and questions.