Metal Tensile Test: Recent findings out of Round Robin tests – How important is the strain rate for Tensile Strength?

Ulm

Thursday, 17th October 2019

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Christoph Sieg
Since 2004

Since 2000; accredited 2005

Since 2008; accredited 2009
IfEP – Program

Proficiency tests

Reference material

+2,600 participations of 650 labs from 40 Ländern

app. 8,000 sets á 5/6 Proben
Specimen production

Precise machining of all requested specimen geometry
Basics to proficiency testing

ISO 17043: Proficiency testing

“... evaluation of participant performance against pre-established criteria by means of interlaboratory comparisons."

Interlaboratory comparison

“... organization, performance and evaluation of measurements or tests on the same or similar items by two or more laboratories in accordance with predetermined conditions."

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Use of proficiency testing in accreditation

Scope:
This rule conduces to the implementation of international requirements and the summarization of the national requirements for the use of proficiency testing in the accreditation process of testing and calibration laboratories, medical laboratories (in the following described as laboratories) and also inspection bodies\(^1\). It describes the requirements for participation in proficiency test at accredit-
Proficiency testing – general rules

Availability of proficiency tests

Proficiency tests are available, if they are offered by proficiency test providers and the required documents are provided in the national language of the participating body or in English.

Technical adequacy of proficiency tests

A proficiency test is regarded as technically adequate, if its scope similar to the daily practice in the participating body. In case of specific measurement techniques, for which no exact consistent proficiency test is available, it may be adequate to choose a proficiency test, which is similar to the scope or which covers an important partial aspect of the task.

Economical adequacy of proficiency tests

Proficiency test are regarded as economical adequate, if the entire costs of proficiency test have no considerable influence on the price of the test or calibration. In this instance the costs of the proficiency tests plus the costs which would be charged to a third party for this test of such a sample on the market, should be calculated. If for a test normally no prices are obtained (e.g. public CAB) so the internal efforts (staff and material costs) need to be considered.
PT 1810 UM

Tensile test
flat specimens
## Field of participants

<table>
<thead>
<tr>
<th>Country</th>
<th>Labs</th>
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<th>Labs</th>
<th>Country</th>
<th>Labs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>3</td>
<td>Great Britain</td>
<td>1</td>
<td>Poland</td>
<td>1</td>
</tr>
<tr>
<td>Belgium</td>
<td>1</td>
<td>Greece</td>
<td>1</td>
<td>Portugal</td>
<td>1</td>
</tr>
<tr>
<td>Brazil</td>
<td>1</td>
<td>Hungary</td>
<td>1</td>
<td>Romania</td>
<td>1</td>
</tr>
<tr>
<td>Croatia</td>
<td>1</td>
<td>Italy</td>
<td>4</td>
<td>Serbia</td>
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<tr>
<td>Finland</td>
<td>1</td>
<td>Mexico</td>
<td>1</td>
<td>Spain</td>
<td>5</td>
</tr>
<tr>
<td>France</td>
<td>3</td>
<td>Netherlands</td>
<td>2</td>
<td>Sweden</td>
<td>3</td>
</tr>
<tr>
<td>Germany</td>
<td>28</td>
<td>P.R. China</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 71 Labs
- 20 countries
- 44 accredited
Material

<table>
<thead>
<tr>
<th></th>
<th>$R_{p0,2}$</th>
<th>$R_m$</th>
<th>$A$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total mean $\bar{x}$</strong></td>
<td>288 MPa</td>
<td>663 MPa</td>
<td>52.6 %</td>
</tr>
<tr>
<td><strong>Standard deviation between results $s_s$</strong></td>
<td>0.5 %</td>
<td>0.5 %</td>
<td>0.9 %</td>
</tr>
</tbody>
</table>

- 1.4301 („V2A“)
- 19 specimens in final test
- Very sufficient, as standard deviation is clearly under 1 %
Assessment limits

\[ nIQR = 0.7413 \text{ (Q3-Q1)} \]

\[ Z = \frac{MW_{LAB} - X}{\hat{\sigma}} \]

- \(|Z| \leq 2 \text{ satisfactory participation}
- \(|Z| \geq 3 \text{ unsatisfactory participation}
- 2 < |Z| < 3 \text{ result questionable.}

Limits depend on:

- Quality of material
- Variation of participants:
  - Anticipation: very narrow, as very good material
Assessment limits

Summary:
- $S_{Rp}: 2.6\%, N.OK.: +/- 8\%$
- $S_{Rm}: 2.0\%, N.OK.: +/- 6\%$
  - Limits $Rm$ much higher than expected

<table>
<thead>
<tr>
<th>Specific values</th>
<th>$R_{p0.2}$ in MPa</th>
<th>$R_m$ in MPa</th>
<th>$A_{\text{manually}}$ in %</th>
<th>$A_{\text{extensometer}}$ in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X$</td>
<td>296,6</td>
<td>669,4</td>
<td>53,1</td>
<td>53,3</td>
</tr>
<tr>
<td>$\hat{o}$</td>
<td>8,0</td>
<td>13,1</td>
<td>1,6</td>
<td>2,2</td>
</tr>
<tr>
<td>$u_X, k = 1, p = 68%$</td>
<td>1,1</td>
<td>1,8</td>
<td>0,2</td>
<td>0,4</td>
</tr>
<tr>
<td>$Z = -3$</td>
<td>272,6</td>
<td>630,1</td>
<td>48,4</td>
<td>46,7</td>
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<tr>
<td>$Z = -2$</td>
<td>280,6</td>
<td>643,2</td>
<td>50,0</td>
<td>48,9</td>
</tr>
<tr>
<td>$Z = 2$</td>
<td>312,6</td>
<td>695,6</td>
<td>56,2</td>
<td>57,6</td>
</tr>
<tr>
<td>$Z = 3$</td>
<td>320,6</td>
<td>708,7</td>
<td>57,8</td>
<td>59,8</td>
</tr>
</tbody>
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| $\bar{x}$                | 288 MPa           | 663 MPa      | 52,6 %                      |
| $s_s$                    | 0,5 %             | 0,5 %        | 0,9 %                       |

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Tensile strength

Result **OK** from 630 MPa – 709 MPa

“Scrap”-material???????
Analysis of results

Instructions for participants:

- **Rp:**
  30 MPa/s, method B,
  Explanation for the big variation of the outcome: resulting testing speed is commonly unknown in testing labs (became obvious in former publications and systematic comparisons between method A and B)

- **Rm:**
  **strain rate up to max. 0,006/s**
  Even at speed sensitive materials (DC 06) up to now no big influence, not in the focus at all

- Statement of the labs mostly (75 %) at “0,006/s“, different statements, **no correlation.**
Analysis of results, a few steps back

Homogeneity study:

• Clearly more than 19 specimens (summarized in the final report) were tested in the framework of the homogeneity study. Every plate was tested at defined positions (prior production start)

• Questions:
  • All plates from one batch?
  • No effects of rolling, middle to the edges?

• If ok, a number of specimens is tested extracted from running production = homogeneity test, speed sensible material: statement of a value of testing speed (no area), usually 30 MPa/s

• **Very good material** (when tested under **reproducible** conditions)

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Analysis of results, a few steps forward

Retest by IfEP:

- Stress rate was limited to 30 MPa/s
- Variation of strain rate between 0.002/s and 0.008/s at 30 MPa/s constantly

- \( R_m (0.002/s): 674 \text{ MPa} \)
- \( R_m (0.008/s): 658 \text{ MPa} \)
- 16 MPa range, in PT: 70 MPa range

**Assumption**: testing speed after \( R_p \) is ABSOLUTELY unnoticed

- One part of the labs seem to test very slowly, and the other very fast, most probable outside max. permissible of the standard.
- Statements mainly at 0.006/s, no correlation
Summary

- The testing speed (although defined), leads to a high variation between the lab results in terms of Rp.

- The speed control after Rp was not in the focus until now. With given materials one can notice a very high influence of the speed in terms of tensile strength.

- Future proficiency test (2020) will examine this influence in a more detailed way.
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