Determination of the transverse rupture stress of cemented carbide GT-20 cut by wire-spark-erosion

Vosmer, J.

Published: 01/01/1982

Document Version
Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

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Download date: 11. Dec. 2018
DETERMINATION OF THE TRANSVERSE RUPTURE STRESS OF CEMENTED CARBIDE GT-20 CUT BY WIRE-SPARK-erosion.

WPT-nr.: 0549

EINDHOVEN UNIVERSITY OF TECHNOLOGY
19820628
J. Vosmer
Introduction.

The aim was the determination of the transverse rupture stress (T.R.S.) $R_{tr15}$ in Newtons per square millimetre, of cemented carbides GT-20 when machined by several wire cut spark-erosion machines. Test-pieces were made at the universities of Aachen, Louvain and Eindhoven, to find out if the eroded surfaces were good enough reproducible. Besides there was talk of it to compare the T.R.S.-value of unipolar eroded test-pieces with the T.R.S.-value of bipolar eroded ones. All this with the background-thought that the T.R.S.-value can be a possible life endurance criterion of cemented carbides, what should replace the preparation-making.

Testprocedure.

The proportions of the test-pieces ( 20(±1)x 6.50 (±0.25)x 5.25 (±0.25) mm$^3$) were according ISO 3327 (Appendix A.1 to A.4), which don't agree with those of ANSI/ASTM B 406-76. The test-pieces were eroded at two sides, namely the supporting sides. For each machining condition, four measurements were carried out. The conditions for wire spark-erosion were: pulse duration $t_e = 1.5 \mu s$, pulse current $i_e = 75$ A and open voltage $u_1 = 400$ V (to make this possible, the pulse energy determining capacitors had to be raised from 50 nF to 75 nF). In Eindhoven we also eroded with a $t_e = 1.1 \mu s$, $i_e = 65$ A and an $u_1 = 430$ V, this to compare the T.R.S.-value of unipolar eroded and bipolar eroded carbides. Bipolar eroding hasn't yet been done owing to the circumstances. The rupture tests are carried out on a Tensometer type 'W' (serialnr. 9817, (WT 4293)), maximum load up to 20 kN. To change the tensile force in a pressure force, we used a resource (see picture), in which the rupture-matrix could be placed. The construction-drawings of the matrix are put together in appendices B.1 up to and inclusive B.11. The matrix is completely constructed
according to ISO 3327. The pressure force is registered by a Kirst-ring (Klag Swiss 902 A SN 60699; see picture) of which the signal is recorded via a charge-amplifier (Kistler; $f_c = 180 \text{ kHz};$ T.S.- range 1:1; Range 5000 mech. un./V; (adjustment of the potmeter nr. WT 2402 was 7.245)) by a digital voltmeter (connected with the $100 \Omega$ output of the charge amplifier) and an X-Y-writer (Philips) to store the measurements. The construction for measuring is calibrated with the help of a loadtransducer of 30 kN (Peekel; type D203 nr. 176 (WE 299)) and a digital transducer loadindication CA 320 (Peekel Division, (WE 2726)), by which the reading of the voltmeter and digital transducer loadindication are compared; which resulted in a calibrationgraph (appendix C). A scheme shows the hallmark construction.
DIGITAL VOLT METER
X-Y-WRITER

CHARGE-Amplifier

CALIBRATION GRAPHIC

DIGITAL LOADINDICATION CA 320

RESOURCE

KIRST-RING LOAD-INDICATOR

SCHEME.
The transverse rupture stress is calculated according to the formula:

\[ R_{tr15} = \frac{3x Fx l}{2x b x h^2} xK \ (N/mm^2) \]

where
- \( F \) is the load, required for fracture, measured at the moment of breakdown of the testpiece (N).
- \( l \) is the distance between the supports (here 14 mm).
- \( b \) is the width of the testpiece at right angles to its height (mm).
- \( h \) is the height (thickness) of the testpiece parallel to the direction of the test load application (mm).
- \( K \) is the correction factor to adjust the results for the existence of the chamfer (here \( K = 1 \)).

The results follow after this page. I'll give here a summary:

- \( t_1 = 15 \) \( \mu \)s
  - Eindhoven: \( R_{tr15} = 1643 \pm 127 \ N/mm^2 \)
  - Louvain: \( R_{tr15} = 1520 \pm 43 \ N/mm^2 \)
  - Aachen: \( R_{tr15} = 1529 \pm 126 \ N/mm^2 \)

- \( t_1 = 11 \) \( \mu \)s
  - Eindhoven: \( R_{tr15} = 1531 \pm 72 \ N/mm^2 \)
  - ground Eindhoven: \( R_{tr15} = 2234 \pm 60 \ N/mm^2 \)

Conclusions:
- The results of Eindhoven show a rather great difference with those of Louvain and Aachen. Some more testpieces should be made in Eindhoven.
- The tests are only done at one value of \( t_1 \), further research is necessary, with different pulse durations.
- The results differ from those published in Lit.(1), figure 5, concerning the T.R.S.-value, which should be about a factor two higher, for the T.R.S.-value of ground test-pieces is about 2100 \( N/mm^2 \) (Lit.(5)) instead of 1200 \( N/mm^2 \).
### A. Metingen

**Draadvonkmachine:** AIGE G'T

**Procescondities:**

<table>
<thead>
<tr>
<th>Materiaal:</th>
<th>Hardmetaal GT 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dikte:</td>
<td>6,30 mm.</td>
</tr>
<tr>
<td>Hardheid:</td>
<td></td>
</tr>
<tr>
<td>Traject:</td>
<td>20 mm.</td>
</tr>
<tr>
<td>Diëlectricum:</td>
<td>water met geleidbaarheid 20 μS/cm ±10 %</td>
</tr>
</tbody>
</table>

**Vloeistofdubben (onder tegen de vonkspleet):** 1/min.

**Afstand uitstroom tot werkstukoppervlak:** 20 mm.

**Tegen spannin (u):** 400 V

**MAXIMALE PULSSTROOM:** 75 A

**Electrodedraadmat.:** 4,5 mm

- **diam.:** 0,20 mm.
- **snelh.:** 35 mm/s
- **spankracht:** 4,5 N

**Snedebreedte:** 0,365 mm

<table>
<thead>
<tr>
<th>Proefreeks</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pulsperiodetijd (tₚ) ms</strong></td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>pulsontandingstijd(tₚ)ms</strong></td>
<td>1,3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>generatorpulsduur (tₚ)ms</strong></td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U ; i</td>
<td>320 V; 4,6 A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>proefnr.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>breedte (b) mm</td>
<td>6,30</td>
<td>6,30</td>
<td>6,30</td>
<td>6,30</td>
</tr>
<tr>
<td>hoogte (h) mm</td>
<td>5,85</td>
<td>5,85</td>
<td>5,25</td>
<td>5,25</td>
</tr>
<tr>
<td>ruwheid (Rₐ) mm</td>
<td>5,11</td>
<td>5,11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tafelsnelheid mm/min.</td>
<td>4,65</td>
<td>4,65</td>
<td>4,65</td>
<td>4,65</td>
</tr>
<tr>
<td>vonksnelheid mm/min.</td>
<td>7,71</td>
<td>7,71</td>
<td>7,71</td>
<td>7,71</td>
</tr>
<tr>
<td>σ₀</td>
<td>17,76</td>
<td>17,76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>σ₀ N/mm²</td>
<td>7076</td>
<td>2191</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Commentaar:**

\[ \sigma₀ = 16,43 N/mm² \]

\[ \sigma₀ = 12,77 N/mm² \]

*Kernwending in de CPM van de gemiddelde*
B. Metingen.

Draadvonkmachine: AGIL C'UT

Procescondities:

| Materiaal:    | GT 20          |
| Dikte:        | 6,30 mm.      |
| Hardheid:     |               |
| Traject:      | 20 mm.        |
| Dielectricum: | Water met geleidendheid 7,5 μS/cm ±10 % |

Vloeistofdebiet (onder tegen de vonkspleet): 1/l/min.

Afstand uitstroming tot werkstukoppervlak: 20 mm.

Uitgangsspanning (U i): 420 V

Aximale pulststroom: 65 A

Electrodedraadmat.: Messing

- " diam.: 0,2 mm.
- " snelh.: 35 mm/s
- " spankracht: 4,5 N

Snedebreedte: 9,265 mm

<table>
<thead>
<tr>
<th>Proefreeks</th>
<th>Eindhoven</th>
</tr>
</thead>
<tbody>
<tr>
<td>pulsperiodetijd (t p) μs</td>
<td>60</td>
</tr>
<tr>
<td>pulsontladingstijd (t a)μs</td>
<td></td>
</tr>
<tr>
<td>generatorulpadoer (t i)μs</td>
<td>11</td>
</tr>
<tr>
<td>proefnr.</td>
<td>1</td>
</tr>
<tr>
<td>breedte (b) mm</td>
<td>6,30</td>
</tr>
<tr>
<td>hoogte (h) mm</td>
<td>5,16</td>
</tr>
<tr>
<td>ruwheid (R a) μm</td>
<td></td>
</tr>
<tr>
<td>tafelsnelheid mm/min.</td>
<td>0,05</td>
</tr>
<tr>
<td>vonksnelheid mm/min.</td>
<td>&quot;</td>
</tr>
<tr>
<td>F breuk N</td>
<td>130,90</td>
</tr>
<tr>
<td>sigma_b N/mm²</td>
<td>163,6</td>
</tr>
</tbody>
</table>

Opmerking: \( \sigma_b = \frac{1531}{\text{N/mm}^2} \)

\( \bar{\sigma} = 72 \text{ N/mm}^2 \)
Proefreeks  

<table>
<thead>
<tr>
<th>Proefnr.</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breedte (b) mm</td>
<td>6.375</td>
<td>6.12</td>
<td>6.32</td>
<td>6.12</td>
<td>6.27</td>
</tr>
<tr>
<td>Hoogte (h) mm</td>
<td>5.27</td>
<td>5.26</td>
<td>5.27</td>
<td>5.27</td>
<td>5.27</td>
</tr>
<tr>
<td>Ruwheid (Rₐ) µm</td>
<td>630</td>
<td>548</td>
<td>548</td>
<td>548</td>
<td>548</td>
</tr>
<tr>
<td>Tafelsnelheid mm/min</td>
<td>533</td>
<td>533</td>
<td>533</td>
<td>533</td>
<td>533</td>
</tr>
<tr>
<td>Vonksnelheid mm/min</td>
<td>533</td>
<td>533</td>
<td>533</td>
<td>533</td>
<td>533</td>
</tr>
</tbody>
</table>

- **Fₜₚ** - 12.45, 12.22, 12.83, 13.60, 14.93
- **σₜₚ** - 14.85, 14.68, 15.37, 15.74, 15.34

Opmerking: \( \sigmaₜₚ = 15.20 \text{ N/mm}² \) \( \sigmaₜₚ = 4.5 \text{ N/mm}² (2.0\%) \)
Metingen.

Draadvonkmachine: AGIE C'TT

Procescondities:

<table>
<thead>
<tr>
<th>Materi SEP</th>
<th>GT 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>dikte</td>
<td>mm</td>
</tr>
<tr>
<td>hardheid</td>
<td>mm</td>
</tr>
<tr>
<td>traject</td>
<td>mm</td>
</tr>
</tbody>
</table>

Diëlektircum: water met geleiding + 10% 
Vloeistofdebet (onder tegen de vonkspleet): 1/min.
Afstand uitstroom tot werkstukoppervlak: mm.
Open spannin (u): 7
Maximale pulstroom: A
Electrodedadmat: 
  "" diam.: mm.
  "" snelh.: mm/s
  "" spankracht: N

Snedebreedte : mm

<table>
<thead>
<tr>
<th>Proefreeks</th>
<th>(Duitsland) Aachen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulsperiode tijd (t) µs</td>
<td>generatorpullduur (t) µs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>proefnr.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>ruwheid (R_a) µm</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
</tr>
<tr>
<td>Tafelssnelheid mm/min.</td>
<td>1595</td>
<td>1610</td>
<td>1675</td>
<td>1368</td>
<td>1602</td>
<td>1281</td>
<td>1562</td>
<td>1555</td>
<td>1537</td>
<td></td>
</tr>
<tr>
<td>Vonksnelheid mm/min.</td>
<td>2580</td>
<td>1370</td>
<td>1380</td>
<td>1300</td>
<td>1280</td>
<td>1070</td>
<td>1200</td>
<td>1320</td>
<td>1320</td>
<td>1320</td>
</tr>
<tr>
<td>Fbreuk N</td>
<td>12580</td>
<td>13360</td>
<td>13800</td>
<td>1300</td>
<td>1280</td>
<td>1070</td>
<td>1200</td>
<td>1320</td>
<td>1320</td>
<td>1320</td>
</tr>
<tr>
<td>Sigma p N/mm²</td>
<td>1515</td>
<td>1610</td>
<td>1675</td>
<td>1368</td>
<td>1602</td>
<td>1281</td>
<td>1562</td>
<td>1555</td>
<td>1537</td>
<td></td>
</tr>
</tbody>
</table>

Opmerking:

\[ \overline{\sigma} = 1595 \text{ N/mm}^2 \]
\[ \sigma = 126 \text{ N/mm}^2 (8.7\%) \]
LITERATURE

Hardmetals — Determination of transverse rupture strength

Métaux durs — Détermination de la résistance à la flexion

First edition — 1975-04-01
FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3327 was drawn up by Technical Committee ISO/TC 119, Powder metallurgical materials and products, and circulated to the Member Bodies in December 1973.

It has been approved by the Member Bodies of the following countries:

Austria | Ireland | Spain
Bulgaria | Italy | Sweden
Canada | Mexico | Thailand
Chile | Poland | Turkey
Egypt, Arab Rep. of | Portugal | United Kingdom
Finland | Romania | U.S.S.R.
France | South Africa, Rep. of | Yugoslavia

The Member Bodies of the following countries expressed disapproval of the document on technical grounds:

Japan
U.S.A.

© International Organization for Standardization, 1975

Printed in Switzerland
Hardmetals — Determination of transverse rupture strength

1 SCOPE
This International Standard specifies methods of determining the transverse rupture strength of hardmetals.

2 FIELD OF APPLICATION
This test is applicable to hardmetals of negligible ductility. If it is applied to hardmetals showing significant plastic deformation before breaking, incorrect results may be obtained. In such instances the test may be used for comparison purposes only.

3 REFERENCE
ISO ... , Hardmetals — Sampling and preparation of test pieces. 1)

4 PRINCIPLE
Breaking of a test piece lying freely on two supports by application of a load at the midpoint of the span under conditions of short-term static loading.

5 APPARATUS
5.1 Testing equipment of any system providing a static condition of loading and an accuracy of 1% may be used.

5.2 The fixture for testing shall have two freely lying support cylinders (rollers) with a fixed distance between them and a freely lying load cylinder (roller). The three cylinders shall be of equal diameter between 3.2 and 6 mm.

Alternatively, the load may be applied by a ball having a diameter of 10 mm.

The support and load components shall be made of tungsten carbide hardmetal which will not be visibly deformed by the applied load. Surface roughness Ra of the cylinders and the ball shall be not greater than 0.63 μm.

5.3 The support cylinders shall be mounted parallel, with the span between them 30 ± 0.5 mm for long test pieces and 14.5 ± 0.5 mm for short test pieces. The measurement of the span used for calculation shall be made to an accuracy of 0.1 mm for short test pieces and 0.2 mm for long test pieces.

5.4 The mounting of the cylinders shall be such as to account for the permitted deviation from parallelism of the top and bottom faces of the test piece.

6 SAMPLING
6.1 Sampling shall be carried out in accordance with ISO ...

6.2 The test pieces shall be of rectangular cross-section and shall have the dimensions shown in table 1.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Dimensions in millimetres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Length</td>
</tr>
<tr>
<td>A</td>
<td>35 ± 1</td>
</tr>
<tr>
<td>B</td>
<td>20 ± 1</td>
</tr>
</tbody>
</table>

NOTE — In general, test pieces of type B result in about 10% higher strength values compared with those of type A, provided they have the same surface conditions. The repeatability is similar for both types.

6.3 In the preparation of test pieces, heating and cold-working shall be minimized. The finishing shall be done on the four longest faces of the test piece. The edges shall have a chamfer of 0.15 to 0.2 mm at an angle of 45°. The thickness of the layer taken off each side shall be not less than 0.1 mm and the roughness Ra of the finished surface shall be not greater than 1.0 μm.

It is also permitted to use the test pieces in the as-sintered condition. Such test pieces shall have a chamfer of 0.4 to 0.5 mm at an angle of 45°, made before sintering.

6.4 The deviation from parallelism of opposite longitudinal sides, in both longitudinal and transverse directions, shall not exceed 0.03 mm for each 10 mm length for as-sintered test pieces and 0.01 mm for each 10 mm length for ground test pieces.

1) In preparation
6.5 Width and thickness measurements used for calculation of results shall be carried out at the middle of the test piece to the nearest 0.01 mm.

6.6 The test piece shall be free from surface cracks and structural defects.

7 PROCEDURE

7.1 Place the test piece flat on the support cylinders so that its longitudinal axis is perpendicular to the longitudinal axis of the support cylinders. In the case of a short test piece, place its wider surface on the support cylinders.

7.2 Bring the load cylinder or ball gradually into contact with the test piece.

The deviation of the line or the point of application of the load from the middle of the span shall not exceed 0.5 mm for a long test piece and 0.2 mm for a short test piece.

7.3 Increase the stress in the test piece at a uniform rate not exceeding 100 N/mm² per second.

NOTE — This corresponds to a load increasing at a maximum rate of 800 N per second for a short test piece and 300 N per second for a long test piece.

8 EXPRESSION OF RESULTS

8.1 The transverse rupture strength $R_{tr}$, in newtons per square millimetre, is given by the formula:

$$R_{tr} = \frac{3FL}{2bh^2} \times K$$

where

- $F$ is the load, in newtons, required for fracture, measured at the moment of breakdown of the test piece;
- $l$ is the distance, in millimetres, between the supports;
- $b$ is the width, in millimetres, of the test piece at right angles to its height;
- $h$ is the height (thickness), in millimetres, of the test piece parallel to the direction of the test load application;
- $K$ is the correction factor to adjust the results for the existence of the chamfer, the value of which is given in table 2.

<table>
<thead>
<tr>
<th>Test piece type</th>
<th>Chamfer mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.4 to 0.5</td>
</tr>
<tr>
<td>A</td>
<td>0.15 to 0.2</td>
</tr>
<tr>
<td>B</td>
<td>0.4 to 0.5</td>
</tr>
<tr>
<td>B</td>
<td>0.15 to 0.2</td>
</tr>
</tbody>
</table>

NOTE — The formula for calculating the transverse rupture strength does not take into account the effect of any plastic deformation that may occur.

8.2 If fracture occurs on the tension side of the test piece at a point whose distance from the line of application of the load is more than 5 mm for a long test piece and more than 2.5 mm for a short test piece, the test shall be considered invalid.

8.3 Report the arithmetical mean of at least five transverse rupture strength determinations, rounded to the nearest 10 N/mm².

9 TEST REPORT

The test report shall include the following information:

a) reference to this International Standard;

b) all details necessary for identification of the test sample;

c) the type of the test piece and the method of preparation of its surface;

d) the method of applying the load;

e) the result obtained. The following additional subscripts shall be added to the symbol indicating transverse rupture strength:

for long test pieces: 30

for short test pieces: 15

Example: $R_{tr30}$

f) all operations not specified by this International Standard, or regarded as optional;

g) details of any occurrence which may have affected the result.
### Pos. 1 zonder verzonken gat ø 6
### Pos. 2 met verzonken gat ø 6

**MAT:** ST.37 K.

### Montageplaat

<table>
<thead>
<tr>
<th></th>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bestemming**

**Pos. 1 en Pos. 2 van Tek. WT 1398-00**

**Omschrijving**

**Montageplaat**

**CENTR. TECHN. DIENST T.H.E.**

**Schaal:** 1:1

<table>
<thead>
<tr>
<th>Tek. nr.</th>
<th>WT 1398-01</th>
</tr>
</thead>
</table>
Bestemming

POS. 2 VAN TEK. WT 1336-00

Omschrijving

DRIJFSTUK (ONDER)

CENTR. TECHN. DIENST
T.H.E.

schaal: 1:1
get. con.
gec. gez.

Formaat A4
Tek. nr. WT 1336-02

DRUKSTUK (ONDER)
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**Pos. 3 VAN TEK. WT 1398-00**

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**Pos. 5 VAN TEK. WT 1396-00**

**Omschrijving**

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**Reg. nr. T.H.E.**

**Formaat**

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**Tek. nr.**

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**Bestemming**

Pos. G VAN TEK. WT 1398-00

**Omschrijving**

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Pos. 12 VAN TEK.WT 1398-00

Omschrijving
DRIJKSTUK (BOVEN)

CENTR. TECHN. DIENST
T.H.E.

sch. 1:1
get. con.
gec. gez.

Formaat: A4
Tek. nr. WT 1398-09
**Bestemming**

**Pos. 11 van tek. WT 1398-00**

**Omschrijving**

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Verv. dr.

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Bestemming

Pos. 13 VAN TEK. WT. 1398-00

Omschrijving

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