

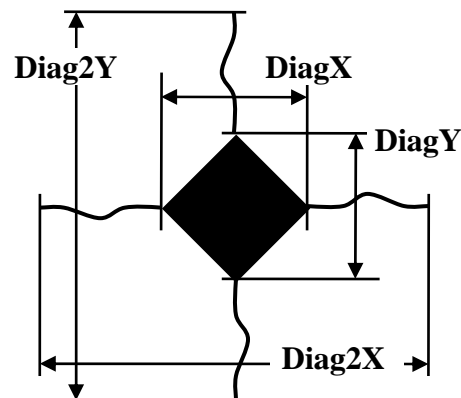
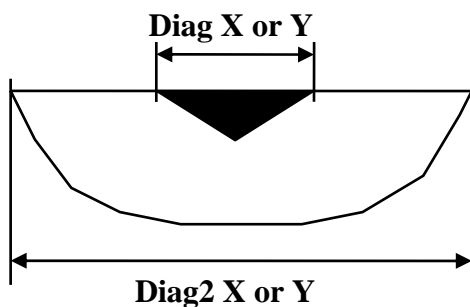
Software Validation Certificate

PRECIDUR V3.89 2007-JAN-08

This certificate is to proof the correct mathematic formulas, used within the **PRECIDUR** Software Version 3.89 released 2007-JAN-08, to calculate the hardness value from the selected test force and the measured diagonals of the indent. This certificate is issued on 2007-JAN-08 and consists of 4 pages.

The Software is distributed on a CD-ROM and is installed by the included installer. The correct transfer of the code is controlled by the computer hardware and software (operating software). Additionally there is included the utility CDTEST, which is also installed in the folder C:\Program Files\Hardtes2\CdTest.exe. This program can be used to apply a checksum calculation to the CD-ROM, to proof integrity of the software on the CD-ROM. The software is ciphered and protected by a SERKEY device to prevent unauthorized tempering.

The following names and units (in [] brackets) are used within the formulas :



DiagX = Diagonal X Direction of Indent [mm]

DiagY = Diagonal Y Direction of Indent [mm]

Diag = Diagonal Mean Value of Indent [mm]

Diag2X = Diagonal X Direction of Crack Tip to Tip [mm]

Diag2Y = Diagonal Y Direction of Crack Tip to Tip [mm]

Diag2 = Diagonal Mean Value of Crack Tip to Tip [mm]

Load = Applied Test Force [kgf]

EModul = EModul of Specimen [GPa]

Hardin = Intermediate Data, only used within formula [No unit specified]

Hardness = Hardness result [Formula dependent, see below]

The measurement of the diagonals (indent and crack) are always defined by two measurement lines with a width of 1 pixel or 3 pixel, which can be defined in the settings of the active user. The distance of the two lines is calculated from two inner borders of the lines. So zero is shown, if the two lines are touching each other with the two inner borders. This will be set in the Equipment Setup by the installing technician.

The following formulas are extracted direct from the source code of the program and are confirmed hereby to be absolute identical. The mathematic used in the computer is IEEE floating point math with double precision (8 bytes). The formula for each test principal is shown in the following list :

- **Vickers**

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Hardness} = (1.8544 * \text{Load}) / (\text{Diag} * \text{Diag}) \quad [\text{HV}]$$

- **Knoop**

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Hardness} = (14.233 * \text{Load}) / (\text{Diag} * \text{Diag}) \quad [\text{HK}]$$

- **Brinell – Balldiameter = 1.0 mm**

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Hardness} = (0.63662 * \text{Load}) / (1.0 - \text{Sqr}(1.0 - \text{Diag} * \text{Diag})) \quad [\text{HB } 1 /]$$

- **Brinell – Balldiameter = 2.0 mm**

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Hardness} = (0.31831 * \text{Load}) / (2.0 - \text{Sqr}(4.0 - \text{Diag} * \text{Diag})) \quad [\text{HB } 2 /]$$

- **Brinell – Balldiameter = 2.5 mm**

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Hardness} = (0.25465 * \text{Load}) / (2.5 - \text{Sqr}(6.25 - \text{Diag} * \text{Diag})) \quad [\text{HB } 2.5 /]$$

• Brinell – Balldiameter = 5.0 mm

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Hardness} = (0.12732 * \text{Load}) / (5.0 - \text{Sqr}(25.0 - \text{Diag} * \text{Diag})) \quad [\text{HB } 5 /]$$

• Brinell – Balldiameter = 10.0 mm

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Hardness} = (0.063662 * \text{Load}) / (10.0 - \text{Sqr}(100.0 - \text{Diag} * \text{Diag})) \quad [\text{HB } 10 /]$$

• KIC – ANSTIS

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Diag2} = (\text{Diag2X} + \text{Diag2Y}) / 2.0$$

$$\text{Hardin} = (2.0 * 9.8067 * \text{Load}) / (\text{Diag} * \text{Diag})$$

$$\text{Hardness} = 0.032 * \text{Hardin} * (\text{Sqr}(\text{Diag} / 2000.0)) * (\text{Sqr}(\text{EModul} * 1000.0 / \text{Hardin})) \\ * ((\text{Diag2} / \text{Diag}) ^ (-1.5)) \quad [\text{M Pa m } ^{1/2}]$$

• KIC - NIIHARA PA

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Diag2} = (\text{Diag2X} + \text{Diag2Y}) / 2.0$$

$$\text{Hardin} = (1.8544 * 9.8067 * \text{Load}) / (\text{Diag} * \text{Diag})$$

$$\text{Hardness} = 0.018105 * \text{Hardin} * (\text{Sqr}(\text{Diag}/2000.0)) * ((\text{EModul} * 1000.0/\text{Hardin}) ^ (0.4)) \\ * (((\text{Diag2} / \text{Diag}) - 1.0) ^ (-0.5)) \quad [\text{M Pa m } ^{1/2}]$$

• KIC - NIIHARA HP

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Diag2} = (\text{Diag2X} + \text{Diag2Y}) / 2.0$$

$$\text{Hardin} = (1.8544 * 9.8067 * \text{Load}) / (\text{Diag} * \text{Diag})$$

$$\text{Hardness} = 0.066729 * \text{Hardin} * (\text{Sqr}(\text{Diag}/2000.0)) * ((\text{EModul} * 1000.0/\text{Hardin}) ^ (0.4)) \\ * ((\text{Diag2} / \text{Diag}) ^ (-1.5)) \quad [\text{M Pa m } ^{1/2}]$$

• CRACK RESIST

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Diag2} = (\text{Diag2X} + \text{Diag2Y}) / 2.0$$

$$\text{Hardness} = 2.4517 * \text{Load} * (2.0 / (\text{Diag2} - \text{Diag})) \quad [\text{N} / \text{mm}]$$

• KIC - SHETTY

$$\text{Diag} = (\text{DiagX} + \text{DiagY}) / 2.0$$

$$\text{Diag2} = (\text{Diag2X} + \text{Diag2Y}) / 2.0$$

$$\text{Hardness} = 0.026547 * \text{Load} * (1.0 / \text{Diag}) * (1.0 / (\text{Sqr}(\text{Diag2} - \text{Diag})))$$

$$[\text{M Pa m}^{1/2}]$$

This certificate is issued by FRITZ MUELLER GMBH – MUENCHEN – DEUTSCHLAND on 2007-JAN-08 and consists of 4 pages and applies to the **PRECIDUR** Software Version 3.89 released 2007-JAN-08 . It is valid only, if an original, in blue color signed, printout on A4 paper with printed watermark logo of Fritz Müller.

MUENCHEN, 2007-JAN-08

General Manager