

# frank händle transfer

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## Plasticity Measurement with the PEN CHECK I and PEN CHECK III

With regard to the concept of plasticity or the measurement of plasticity of ceramic and related plastic bodies, interesting, sometimes relevant and frequently controversial articles can be found in the relevant literature, which possibly prompted the sarcastic remark “Plasticity is like honesty: It is hard to define, but is associated with certain properties” made by the renowned English rheologist Scott Blair.

Since this sarcastic statement by Mr Blair, it has been widely acknowledged that it is useful to differentiate between two different plasticity values:

Deformation pressure (N/mm<sup>2</sup>) and tensile strength (N/mm<sup>2</sup>).



Measuring the deformation pressure



Testing the tensile strength

We take the **deformation pressure** to mean the force necessary to penetrate a plastic body with pins/needles of different geometries – giving us the common name “penetrometer” for the instruments used to measure this force.

We take the **tensile strength** as the force necessary to tear apart a ceramic body, e.g. a clay column with a defined cross-section.

Accordingly, the deformation pressure on the one hand, and the tensile strength on the other describe different characteristics of the deformed plastic ceramic body. For product X, a high level of deformation resistance may be expected to avoid product deformation during handling after shaping, whereas high tensile strength may be of greater relevance for product Y.

In the following, we explain how the deformation pressure is determined with the PEN CHECK I and PEN CHECK III, and how these two instruments differ. In our view, despite considerable efforts, no instrument currently exists for the precise determination of the tensile strength. However, promising new approaches are “on the way”.

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## Determining deformation pressure with the PEN CHECK I



### PEN CHECK I, Type CFG

Penetrometer for manual operation

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- Digital display
- Measurement display in kg, N, kN, oz, lb
- Internal memory
- RS 232 interface for data transfer
- Data transfer with optional software
- Penetration needles of different geometries available
- Accuracy  $\pm 0.5\%$
- Measurement range 0 - 200 N
- Weight 200 g

The PEN CHECK I, type CFG, is a high-grade calibrated instrument for manual operation. It is equipped with an easy-read digital display, along with an option to display and save the measurement readings in different units – kg, N, kN, oz, lb.

To implement the measured and saved data, the PEN CHECK I comes with an RS 232-interface. Special software is available as an option.



Various penetration needles

Depending on the application and body, different penetration needles are available.

The penetration depth of approx. 7 millimetres is marked on the penetration needles, but this can be varied depending on the application.

A deciding factor for the geometry of the needles is also the size and size distribution of the particles and agglomerates. In bodies containing coarse particles, for example refractory bodies, conical needles are recommended, to exclude any "collision" between the coarse particles and cylindrical needles as this can distort measurements as a result of dragging effects.

As the measured deformation pressure depends not only on the plasticity of the plastic body, but also on the geometry of the penetration needles and the speed and depth of the penetration, that is on the manual handling of the instrument, it is important to maintain, as far as possible, identical penetration speeds and depths and to calculate a mean value from several measurements.

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## Determining deformation pressure with the PEN CHECK III



### PEN CHECK III

Penetrometer for laboratory and in-situ measurement

- AFG force gauge for forces 500 – 25 000 N
- Force gauge can be removed to allow manual measurement
- Motorized test rig for precise setting of penetration depth and penetration speed
- Pressure- or displacement-based measurement of the deformation force
- Suitable for pressure and tensile tests
- Internal memory
- Interface for data transfer

The PEN CHECK III has been developed for both laboratory and in-situ measurements of extrudate. It consists of the AFG force gauge – available for forces from 500 to 25 000 N – and the motorized test rig for precise setting of the depth and speed of needle penetration. The scope for error due to improper handling is eliminated thanks to these facilities.

As for the PEN Check I, needles with different geometry are available.



Device for preparing body samples



Clamp for stabilizing the sample

Preconditions for the determination of real plasticity values are representative samples and careful preparation of the samples.

We supply a device to facilitate preparation of suitable samples.

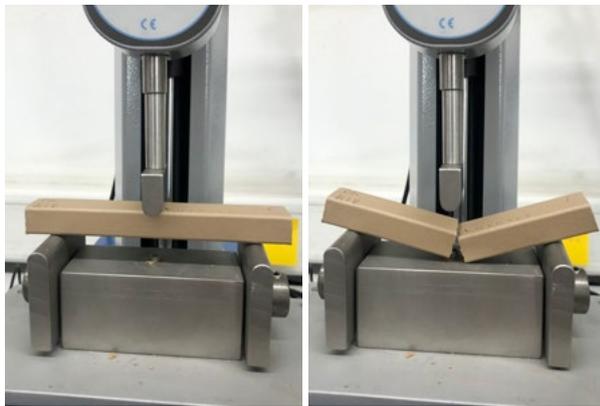
The accuracy of the measurement can be increased if the sample is clamped on three sides to prevent body escaping from the sample as a result of the pressure of the needle. This serves to further guarantee that the sample is deformed because of lateral strain, so as to create the preconditions for a triaxial stress state.

The clamp is also available from us as an option

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The measurement of the deformation force can be performed with the PEN CHECK III based on pressure or displacement. Displacement-based means that the respective pressures are generated and logged as a function of the penetration depth. Pressure-based means that, for instance, the penetration needle penetrates so far into the sample until a defined pressure is reached.

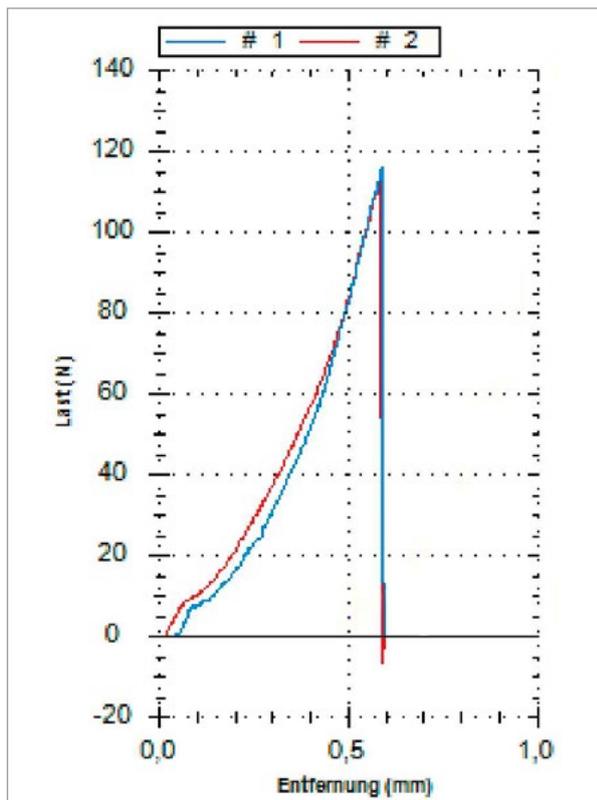


Measuring the bending strength of dried samples with the PEN CHECK III

In this respect, the PEN CHECK III with the available software options is also a very interesting instrument for other pressure and tensile tests, for example for measuring the bending strength of dried samples.

As the AFG force gauges are available for forces up to 2 500 N, the PEN CHECK III can also be used to perform strength tests on fired samples.

Prisms in different versions, i.e. adapted to the specific samples, can be developed and supplied by us.



Measurement with pre-set pressure

This test is a displacement-oriented measurement. The displacement, that is the bending, is measured for the pressure at which the sample breaks.

In this case, we tested whether the dried ceramic sample can be loaded with a force of 100 N and what deflection results at a force of 100 N.

As can be seen in the adjacent graph, the sample can be loaded with a force of 100 N, corresponding to a deflection of 0.55 millimetres.

A load of around 115 N on the sample and a deflection of around 0.6 mm lead to breakage of the sample.

For further information and literature on the subject of the plasticity of ceramic bodies, please refer to the article: F. Händle, K. F. Laenger: "Measuring the Plasticity of Ceramic Bodies – Part 1". in: cfi 2/2021 and Chapter 6 "Plasticity or the Great Unknown" in my book "The Art of Ceramic Extrusion", SPRINGER, 2019