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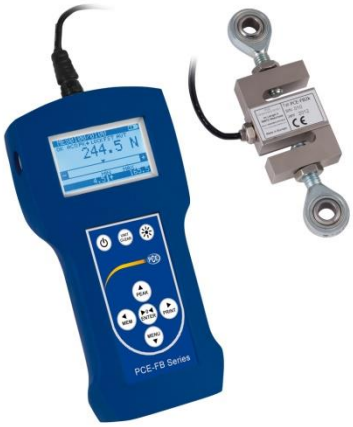
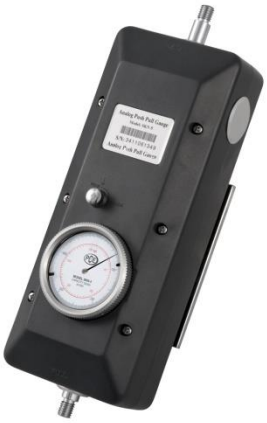
Force Gauge and ISO norms

General Information

To measure force is one of the essential tasks that cannot be ignored. It should take place in all possible industries and production processes to avoid mistakes during the production as well as accidents that may follow after. It helps to guarantee the correct reliable and long-lasting functioning of the machines and devices which brings to saving time and costs in future. To carry out the accurate and exact measurements it is necessary to use the correct devices and techniques and follow the set of rules and norms that has been accepted internationally.



Force gauge or dynamometer is a name that can be applied to a very wide range of measuring devices. The main task of the device – it should measure force (power). Some of the models are simpler and mechanical; the others are able to conduct more complicated measurements and are electronic. Nevertheless, there are certain absolutely permanent things that should not be changed, for example, units system. It has been accepted that kg stands for kilogram, mass, m – for meter, length and s – for second, as time unit.



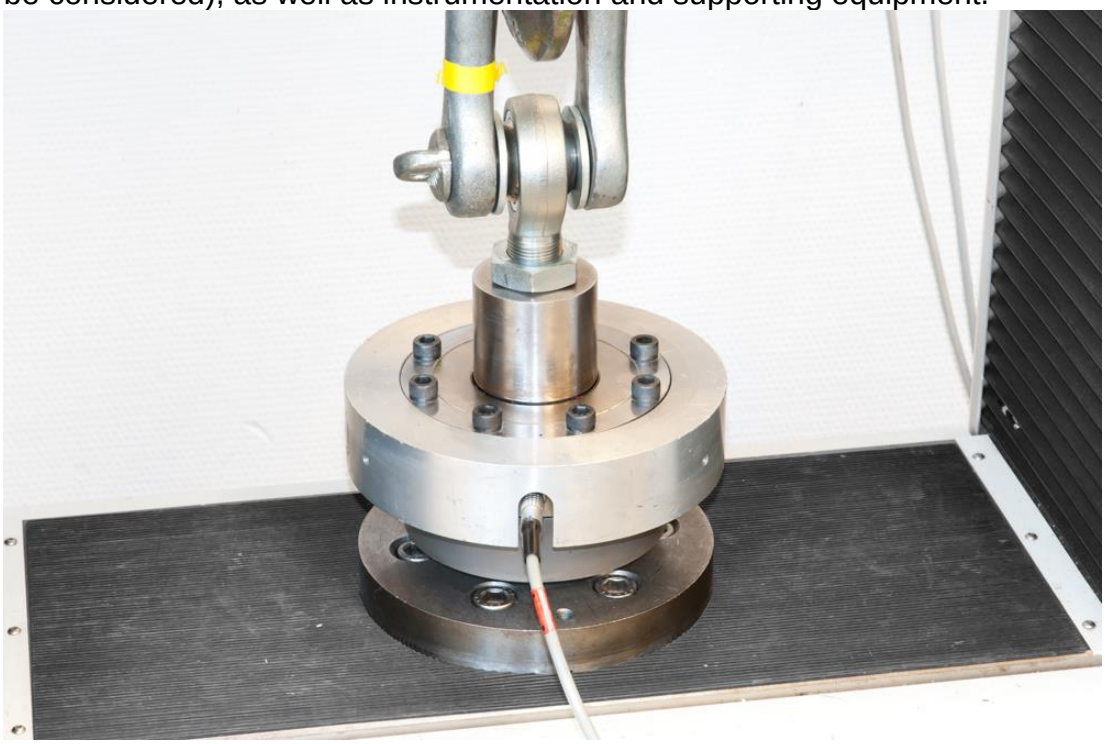
As the measured force can be different, it has been internationally recognized to use the prefixes, like Tera (T), Giga (G), Mega (M), milli (m), micro (**µ),** nano (n) and pico (p). The permanent nit of force is newton (N) – a unit of force which gives acceleration equal to 1 m per s to a mass equal to one kg (only general definition). Actually, for the unit of force it is important that certain masses cause

certain force on the stable support placed on earth after the gravitational force influenced it (the notion of deadweight machine).

In reality force has got both, direction and magnitude. In spite the fact that, depending on the position of the body to which the force is applied (in equilibrium, the force acts the body and the change in velocity times mass of the latter will be equal to the force, the body is held and then the reaction from that supporting structure has its influence on the body), the majority of measurements are made on bodies in equilibrium which creates a sort of structure. The latter can be cut at any part allowing the force to act only at some particular point. The force gauge in fact replaces the link at the structure and in that way the force influencing the particular point.

One of the requirements to consider is also the level of uncertainty. It definitely may vary depending on the force gauge or force measuring system applied, but the lowest possible level is required. In force transfer standards it is not more than 0.005% fso (full scale output). For the majority of cases the range is 0.1%-2% fso, in heavy industry (overload protection of cranes or vessel weighing) – 5%-10% fso.

As an essential part of any force gauge is a transducer, it should be chosen carefully (range and direction of force, quantity of loading points, environmental conditions to be considered), as well as instrumentation and supporting equipment.



To make sure that the device is able to function perfectly well it should correspond to the international standards. Force standard machines (primary and secondary) have been created for providing force calibrations. A raw of calibrations brings to traceability – all the tests have been carried out by the certified laboratories and organizations.

The calibration, or verification, of ***materials testing machines*** for uniaxial testing is covered in the UK by BS EN ISO 7500-1 [11] for machines operating in both tension and compression. The document dealing with the calibration and classification of transfer standards (or ***force-proving instruments***) is BS EN ISO 376 [6].

Types of force standard machine

Machine Type	Principle of operation	Uncertainty*	Category
Deadweight machines	A known mass is suspended in the Earth's gravitational field and generates a force on the support	0.001 %	Primary or Secondary
Hydraulic lifting equipment	A small deadweight machine applies a force to a piston-cylinder assembly and the pressure thus generated is applied to a larger piston-cylinder assembly	0.02 %	Secondary
Lever amplification machines	A small deadweight machine with a set of levers which amplify the force	0.02 %	Secondary
Reference force transducer machines	One or more force transfer standards are placed in series with the instrument to be calibrated (typically in a materials testing machine)	0.02 %	Secondary
Strain gauged hydraulic machines	The force applied to an instrument is reacted against by strain gauged columns in the machine's framework	0.05 %	Secondary

* "Uncertainty" relates to the lowest value typically attainable in a laboratory environment

The separate filed, covered by ISO norms and regulations, is about measurement of force, weight and pressure (ISO ICS 17.100).

The list of the documents covering force measurements includes the following documents, though every few years they are updated and changed if necessary.

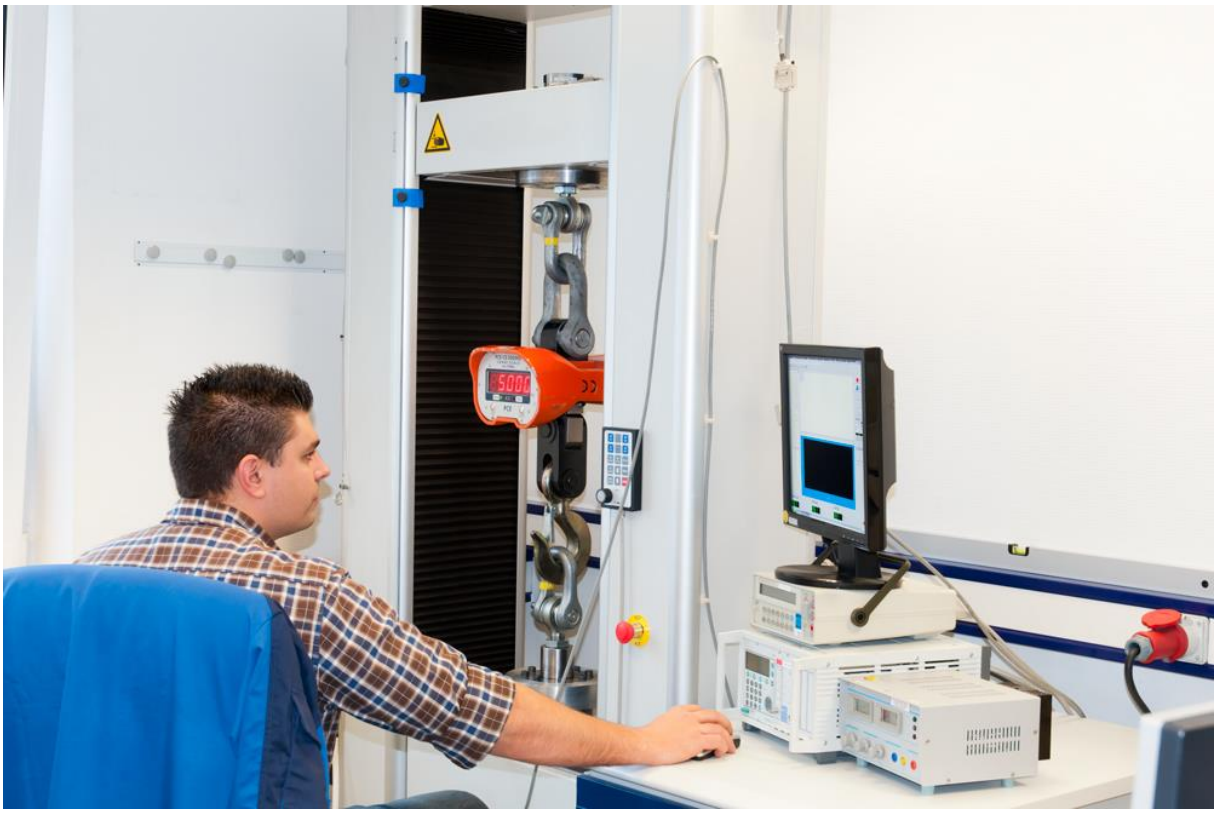
ASTM E 74, 2006, Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines

The purpose of this practice is to specify procedures for the calibration of force-measuring instruments. Procedures are included for the following types of instruments:

- elastic force-measuring instruments
- force-multiplying systems, such as balances and small platform scales

This practice is intended for the calibration of static force measuring instruments. It is not applicable for dynamic or high speed force calibrations, nor can the results of calibrations performed in accordance with this practice be assumed valid for dynamic or high speed force measurements.

BS EN ISO 376, 2004, Metallic materials – Calibration of force–proving instruments used for the verification of uniaxial testing machines



This Standard covers the calibration of force-proving instruments used for the static verification of uniaxial testing machines (e.g. tension / compression testing machines) in accordance with BS EN ISO 7500-1, and describes a procedure for classifying these instruments. A force proving instrument is defined as the whole assembly including the transducer and the indicator. The Standard generally applies to instruments in which the force is determined by measuring the elastic deformation of a loaded member or a quantity which is proportional to it.

The Standard includes two informative Annexes. Annex A gives examples of dimensions of force transducers and corresponding loading fittings and Annex B gives additional information on overload tests, bearing pad tests, and temperature corrections.

EA-10/04, 1996, Uncertainty of Calibration Results in Force Measurements

Previously designated EAL-G22 and EA-4/15, this document was produced to improve the harmonization in determination of uncertainties in force measurements. It provides information on measurement capabilities achieved by force calibration

machines and gives guidance to calibration laboratories to establish a procedure for the expression of the overall uncertainty of calibration results of force transducers for calibrations performed according to EN 10002-3 (now superseded by BS EN ISO 376).

SAMPLE GmbH Akkreditiertes Kalibrierlabor gemäß DIN EN ISO/IEC 17025

STROM , SPANNUNG , FREQUENZ , EMV , DRUCK , DREHMOMENT , KRAFT, LÄNGE , TEMPERATUR

KaliZert V10

Kalibrierschein-Nr. 1234

Calibration Certificate

Gegenstand : Object	Kraftmessgerät / Force Gauge
Hersteller : Manufacturer	PCE Instruments
Typ : Type	PCE-CS 3000HD
Ident./Serien Nr.: Ident./Serial No.	D207615
Auftraggeber : Customer	Sample GmbH Sample Street 1234 1234 Sample Town
Anzahl der Seiten : Number of pages	3
Datum der Kalibrierung: Date of calibration	16.02.2010
Nächste Kalibrierung : Date of next calibration	16.02.2011

Die Kalibrierung erfolgt durch Vergleich mit Bezugsnormalen bzw. Bezugsnormalmesseinrichtungen. Gemäß DIN EN ISO/IEC 17025 wurden diese in einer akkreditierten Kalibrierstelle kalibriert und sind damit rückgeführt auf die nationalen Normale der Bundesrepublik Deutschland oder anderer anerkannter Staatsinstitute. Diese stellen die physikalischen Einheiten in Übereinstimmung mit dem internationalen Einheitensystem (SI) dar.
Dieser Kalibrierschein darf nur unverändert weiterverbreitet werden. Auszüge bedürfen der Genehmigung.

The calibration is a comparison between reference standard and test item. This calibration certificate documents the traceability to the national standards of Germany or other accepted state institutes, which realize the physical units of measurement according to the International System of Units (SI).
This calibration certificate may not be reproduced other than in full except with the permission.

Umgebungsbedingungen / Ambient conditions:
Temperatur/Temperature: 22 °C , Feuchte/Humidity: 26 %rF , Luftdruck/Atm. pressure: 993 hPa

Kalibrieranweisung/Calibration instruction:
PCE Kalibrieranweisung für Waagen und Gewichte V2-05/08

Bezugsnormale / Measuring devices:
Universalprüfmaschine H&P 100kN, rückgef. auf DKD-K-00902,29101, Nr. 10737,1081
Kraft Normal 50 kN (Id.Nr.M15-10), rückgef. auf K-BNME 209/56/01,PTB 1.21-405/94

Der Kalibriergegenstand hat die protokollierten Abweichungen gegenüber der Referenz.
The measurement device has the recorded deviation compared with the reference assessment.

Sample GmbH * Kalibrierung für DIN EN ISO 9000 ff * KALIBRIERDIENST

Ausstellungsdatum
Date of issue

17.02.2010

Bearbeiter
Person in charge

Manfred Schlügel

VDI/VDE 2638, 1989, Characteristic data of force transducers; terms and definitions

Establishes uniform terms and definitions restricted to force transducers. It has two main sections: Criteria for metrological evaluation of force transducers, which lists the characteristic features important for metrological evaluation, and Characteristic data - terms and definitions, which defines all the relevant terms. Reference is made to applicable national and international standards.

As it has been mentioned above force gauges may differ a lot. When it goes about portable handheld Force Gauge is should be calibrated according to
the directives DKD R3-3 or ISO 376 in a DaKKs accredited calibration laboratory. The uncertainty calculation must also be included in the certificate.
the methods how to determine the relationship between the dynamic force which influences a sample in unixial, sinusoidal and constant amplitude and force range given by a testing system are presented in ISO 4965-1:2012. It relates to the systems where the error in dynamic force measurement is either unknown or exceeding 1% of the applied force
The error is usually defined by comparing the top forces results given by dynamic testing system to the results given by the dynamic calibration device (which previously needs to go through static calibration against the testing system indicator.