

# Force Measurement with Load Washers

Type 9001A ... 9051A

Piezoelectric load washers feature in particular the following characteristics: example Type 9031A.

- Extremely small dimensions  
Type 9031A has a force range of 60 kN (6 tonnes weight) with a diameter of only 28,5 mm and a height of 11 mm
- Very large measuring dynamic  
With a max. range of 60 kN, forces of 1 N can also be measured with sufficient quality. The appropriate range selection on the charge amplifier provides a complete output signal for each measuring signal value
- Very high rigidity  
Type 9031A deforms by only 10 micrometer (0,01 mm) under full load. A sensor with high rigidity provides for a measuring setup a high natural frequency and does not change the mechanical characteristics of the machine part significantly
- Practically unlimited life  
Without variation of the specified technical data

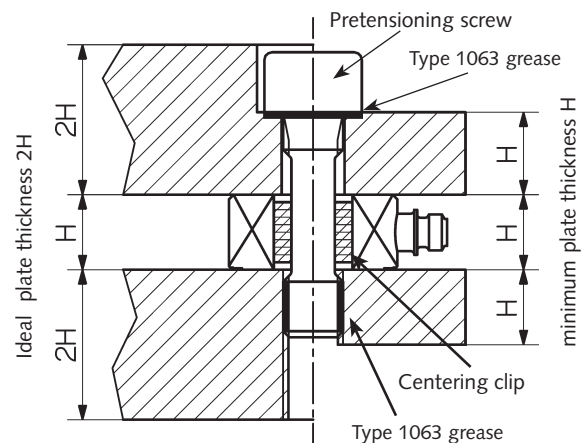
## Mounting

When correctly mounted, the load washers provide precise results with high repeatability. In practice, the sensors are mechanically pretensioned during mounting. The reasons for this are:

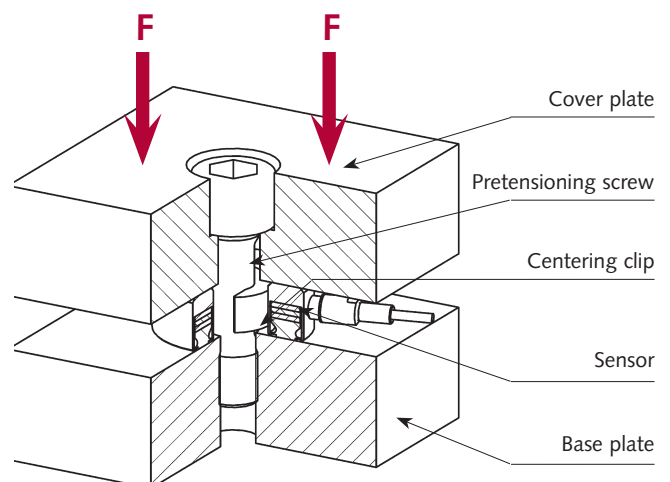
- Both compression and tensile forces can be measured
- Bending moments and transverse forces are taken up but not measured
- Microgaps are closed which ensures a high stiffness and therefore a wide frequency range

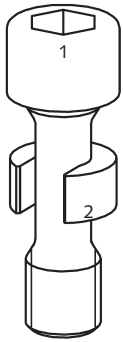
The contact surfaces must be flat and rigid. This is best achieved by grinding. Base and cover plates must be adequately thick in order to avoid undesirable deformations.

In practice, a plate thickness of twice the sensor height has proved successful. A plate thickness of less than the sensor height must not be selected if the entire measuring range of the sensor is to be utilized.



Grease the bearing surface under the head and the thread of the pretensioning bolt before screwing it in.





1 Pretensioning screw  
 2 Centering clip

Sensor Type	Pretensioning screw Dimensions Type 9422A...	maximal pretension force kN	Mounting socket tightening torque per 1 kN pretension force N·m / kN	Mounting socket tightening torque N·m
9001A	...A01/M3x16	2,5	0,548	1,37
9011A	...A11/M5x20	5	0,83	4,16
9021A	...A21/M8x30	10	1,4	14
9031A	...A31/M10x35	20	1,7	34
9041A	...A41/M12x40	30	2,0	60
9051A	...A51/M14x45	40	2,3	93

Load washers are most easily mounted using a screw connection, in which the base and cover plates are pressed onto the two annular contact surfaces of the sensor. The magnitude of the screw pretensioning force will depend on the anticipated forces. The result is a frictionally engaged connection between the sensor and the base and cover plates. Types 9001A ... 9051A load washers are supplied with a suitable pretensioning screw. The centering clip is used for centering the sensor with the screw.

The screw can be used to pretension the sensor by up to approx. 30 % of its force range. The pretensioning force is best measured directly with the load washer. The sensitivity value is shown in the calibration certificate. Use the value of the non pretensioned sensor.

If transverse forces occur (these are not measured by the load washer), these must nevertheless be taken up by the sensor. To ensure that the sensor mounting does not shift, the screw pretensioning force must be selected at least 10 times greater than the transverse force occurring.

Transverse forces usually apply a bending moment to the load washer. The limit values specified in the data sheet must not be exceeded.

In the mounted condition, however, the pretensioning screw forms an additional mechanical connection between base and cover plates. This means that part of the force to be measured also flows through the screw and is not measured by the sensor.

This "force distribution" occurs in proportion to the ratio of rigidity of sensor and pretensioning screw. Extensive tests have been used to determine the percentage of force shunt through

the pretensioning screw. The values for the various screws for sensor Types 9001A ... 9051A are between 7 % and 9 %.

#### Example:

A sensor Type 9021A with 8 kN should be pretensioned. There are 2 opportunities:

1. If a charge amplifier e.g. Type 5015A is available, the calculated sensitivity for a standard pretension e.g.  $-3,846 \text{ pC/N}$  (see calibration certificate on page 3) must be adjusted at the amplifier. For the desired pretension force can be set as precisely as possible with a torque wrench
2. If no charge amplifier is available, the following torque must be set at the torque wrench:  $8 \text{ kN} \times 1,4 \text{ N·m/kN} = 11,2 \text{ N·m}$  (see table)

#### Calibration

The Kistler factory calibration of the load washer is carried out on the sensor without pretensioning and is expressed in pC/N for the full range FSO and the partial range 10 % of FSO.

If the load washer is pretensioning during mounting, this will alter the sensitivity of the measuring device. This sensitivity will reduce because of the force shunt action of the screw.

The calibration certificate shows the sensitivity (pC/N) of the sensor with pretensioning.

If the sensor is mounted using the pretensioning screw supplied, this lower sensitivity value applies to the pretensioned sensor. An accuracy tolerance of  $\pm 1 \%$  can be assumed.

Complicated re-calibration on site is thus rendered unnecessary with many measuring applications.

# Kalibrierschein Calibration Certificate

Type Kistler 9011A

Serial No. 4440249

<b>Kalibriert durch</b> Calibration Technician	<b>Datum</b> Date	
G. Barilli	05. Jul. 2013	
<b>Referenzgeräte</b> Reference Equipment	<b>Typ</b> Type	<b>Serien-Nr.</b> Serial No.
Gebrauchsnorm Working Standard	Kistler 9331BU	3195150
Ladungskalibrator Charge Calibrator	Kistler 5395A	4183238
<b>Umgebungstemperatur</b> Ambient Temperature	<b>Relative Feuchte</b> Relative Humidity	
°C	%	
25	53	

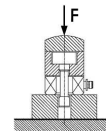
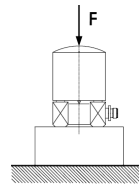
## Messergebnisse Results of Measurement

Kalibrierter Bereich <sup>1)</sup> Calibrated Range	Empfindlichkeit Sensitivity	Lin inkl. Hyst Lin incl. Hyst
kN	pC / N	≤ ± %FSO
0 ... 12	-4,057	0,27
0 ... 1,2	-4,010	0,04

1) mit einer Vorlast von 3kN  
with a preload of 3kN

Berechnete Empfindlichkeit für eine Standardvorspannung 3 ... 5 kN mit Typ 9422A11  
Calculated Sensitivity for a Standard Pretension 3 ... 5 kN with Type 9422A11

pC / N
-3,760



Kistler betreibt die SCS Kalibrierstelle Nr. 049, akkreditiert nach ISO 17025. SCS Kalibrierzertifikate sind auf Bestellung erhältlich.

Kistler operates the SCS Calibration Laboratory No. 049, which is accredited per ISO 17025. SCS Calibration Certificates are available on request.

## Bestätigung Confirmation

Das oben durch die Seriennummer identifizierte Gerät entspricht der Vereinbarung der Bestellung und hält die Herstelltoleranzen gemäß den Spezifikationen der Datenblätter ein. Dieses Dokument erfüllt die Anforderungen von EN 10204 Abnahmeprüfzeugnis "3.1". Alle Messmittel sind auf nationale Normale rückverfolgbar. Das Kistler Qualitätsmanagement System ist nach ISO 9001 zertifiziert. Dieses Dokument ist ohne Unterschrift gültig.

The equipment mentioned above and identified by Serial Number complies with the agreement of the order and meets the manufacturing tolerances specified in the data sheets. This document fulfils the requirements of EN 10204 Inspection Certificate "3.1". All measuring devices are traceable to national standards. The Kistler Quality Management System is certified per ISO 9001. This document is valid without a signature.

### Kistler Instrumente AG

Eulachstrasse 22  
PO Box  
CH-8408 Winterthur

Tel. +41 52 224 11 11  
Fax +41 52 224 14 14  
info@kistler.com

ZKB Winterthur BC 732  
Swift: ZKBKCHZZ80A  
Account: 1132-0374.628

IBAN: CH67 0070 0113 2003 7462 8  
VAT: 229 713  
ISO 9001 certified

[www.kistler.com](http://www.kistler.com)

Seite page 1 / 1