

## **Miniature Load Cell**

### **8413, 8414 (Overload Protection), 8415 and 8416**

#### **1. Introduction**

The load cells in the model 8413, 8414, 8415 and 8416 series are primarily designed for the measurement of force in production equipment, using Newtons (N) as the unit of measurement.

The local gravitational acceleration ( $g \approx 9.81 \text{ m/s}^2$ ) must be taken into account when determining masses.

#### **2. Preparing for use**

##### **2.1 Unpacking**

- Inspect the sensor carefully for damage.

If you suspect that the unit has been damaged during shipping, notify the delivery company within 72 hours. Keep all packaging materials for inspection by the representative of the manufacturer or delivery company.

- Only transport the model 8413, 8414, 8415 or 8416 sensors in their original packaging or in packaging of equivalent quality.

##### **2.2 Using the instrument for the first time**

- Only connect the sensor to instrumentation amplifiers that are fitted with a safety transformer according to EN 61558.

##### **Note:**

Transmitters connected to the outputs or other devices that are galvanically connected to the sensor's signal lines must also be fitted with safety transformers according to EN 61558.

##### **2.3 Grounding and potential connection**

All connecting wires (including the cable screening braid) are electrically insulated from the sensor body.

The insulation resistance between the connecting wires and the sensor body is measured.

The test certificate states that the minimum resistance is greater than 30 M $\Omega$  (test voltage 45 V).

## 2.4 Storage

- The sensor must be stored under the following conditions only:
  - dry
  - no condensation
  - temperature between 0 °C and 60 °C

### Note:

Provided the storage conditions have been observed, no special steps need to be taken after storage and prior to commissioning.

## 3. Principle of operation

The sensor operates with the aid of a spring element. The force to be measured deforms the spring element elastically.

This deformation is transformed into an electrical signal by strain gauges. They, together with the spring element, constitute the measuring element of the sensor.

### 3.1 Spring element

The spring element is the most important mechanical part of a load cell. Its purpose is to take the force being measured and convert it into a linear extension. It relies on the elastic properties of the material in order to determine the force indirectly.

The materials of which load cells are made must satisfy other conditions in addition to their elastic properties. As a result, only a small number of carefully selected materials come into question for high-quality load cells.

burster is going one step further than this, using mainly materials from the aeronautical industry that satisfy additional quality requirements in the place of DIN materials

### 3.2 Mechanical design

In the 8413, 8414, 8415 and 8416 devices, a horizontally-mounted elastic membrane with central load button is used as the spring element.

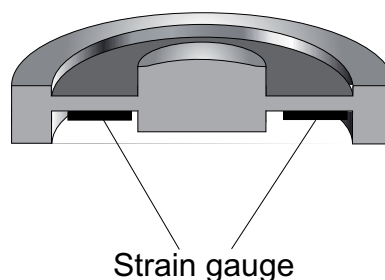


Figure 1: horizontally mounted membrane

This elastic membrane is deflected by the applied force, resulting in a reduction in the sensor's overall height. This deformation cannot be seen by the naked eye. It is measured by strain gauges. In the 8413, 8414, 8415 and 8416 devices, the strain gauges are mounted on the underside of the spring element. This ensures that they are subject to the same deformation as the spring element.

A key feature of the 8413, 8414, 8415 and 8416 devices is their relatively small and especially low-profile design for their rated force. The combination of compact size and high spring constant ensures a high resonant frequency, making the 8413, 8414, 8415 and 8416 devices suitable for rapid measurements.

### **3.3 Function of the strain gauge**

The electrical resistance of a wire rises with increasing length and falling cross-section. When a wire is pulled, it becomes thinner and longer – both of these effects result in an increase in its electrical resistance.

This is the principle on which the function of strain gauges is based. In practice, however, strain gauges do not consist of a single wire, but of a metal foil laminated onto a carrier material. The metal foil is etched to create a meandering structure (see. Figure 2:).

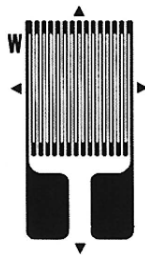


Figure 2: Foil strain gauge

Special techniques are used to mount strain gauges manufactured in this way onto the surface of the spring element.

### 3.4 Strain gauge wiring

In order to reduce undesirable influences on the measurement, the strain gauges in the models 8413, 8414, 8415 and 8416 are connected as a Wheatstone bridge. The figures 3 and 4 illustrate this wiring in a simplified form.

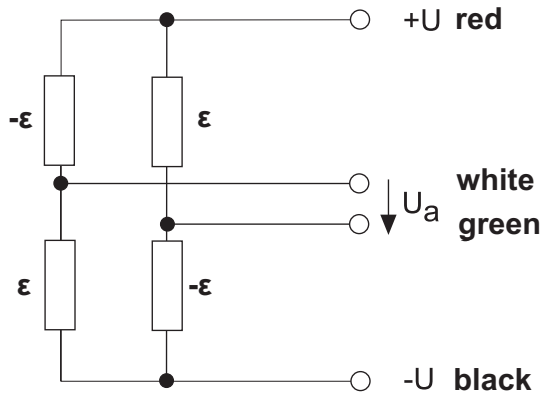


Figure 3: Full-bridge strain gage models 8413 and 8414

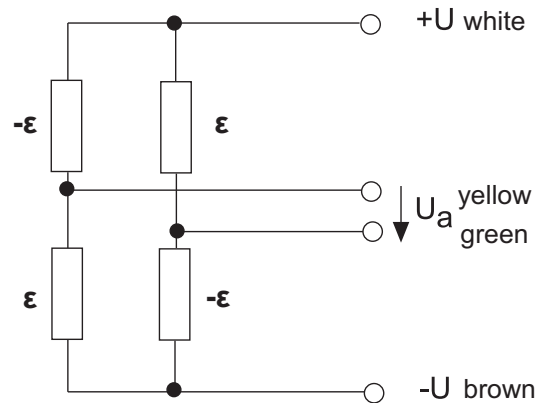


Figure 4: Full-bridge strain gage models 8415 and 8416

In addition to the four strain gauges shown here, compensation resistors to reduce the effect of temperature and balancing resistors to balance the bridge circuit are also incorporated.

Depending on the sensor model, further resistors for the purpose of standardizing the rated characteristic are integrated into the cable or the connector.

The output voltage of the sensor at maximum load,  $U_a$ , is calculated as follows:

$$U_a = c \times U_b$$

- $U_b$ : excitation voltage
- $c$ : characteristic value (sensitivity) of the sensor.

The sensitivity parameter "c" can be found in the test report. For foil strain gauges it is typically in the range between 0.8 bis 2.0 mV/V. For semiconductor strain gauges it is in the range of 15 mV/V.

If excitation voltages ( $U_b$ ) in the range 2.5 V up to 5 V are used, 0...100 % loading of the sensor yields output voltages ( $U_a$ ) between 2 mV and 10 mV for foil strain gauges and output voltages between 35 and 70 mV for semiconductor strain gauges.

### 3.5 Deflection full scale

For sensors with diaphragm, the load lowers the middle of the measuring element. This deformation, known as the deflection full scale, is so small that it cannot be seen with the naked eye. For sensors of the model 8413, 8414, 8415 und 8416 it can range from approx. 20  $\mu\text{m}$  up to 80  $\mu\text{m}$  at max. load, dependent on the sensor's measurement range. The deflection is directly proportional to the load.

### 3.6 External forces



#### **Caution!**

**Sensor will be damaged!**

**Avoid vibrations, even if the loads caused by these vibrations are less than the rated maximum. Design your measuring system in such a way as to prevent these external forces.**

#### **Note:**

External forces, acting on the sensor, adulterate the result materially.

External forces here refer to any force that acts outside the sensor's axis of symmetry - transverse forces, bending moments and twisting moments in particular.

### 3.7 Overload protection

- Diaphragms are sensitive to overload. Install an overload protection mechanism.

Place the sensor on a spring using a guided base support. The spring deflection increases the measurement travel. It is then easier to implement a mechanism for restricting travel.

Only the 8414 has a factory-provided overload protection.

- Provide pressure limiters for any hydraulic or pneumatic cylinders acting on the sensor.
- Absolutely avoid any load that applies a sudden force (pulse).

The high spring constant of the sensor results in high negative accelerations for moving objects. This generates extremely high forces.

## 4. Installation

### 4.1 Surrounding mechanical parts and fastening

#### 4.1.1 Adaptation

#### **Mounting surface**

A high quality measurement depends on a defined deformation of the measuring element under load. In order to be certain of excluding any unwanted deformations, the sensor must lie flat on the mounting surface.

The mounting surface must satisfy the following requirements:

- adequately stable

- hardened, minimum hardness 60 HRC
- polished, preferably lapped, surface quality: N3 (Rz 1), evenness 2 µm
- not coated in any material
- must contain no holes or milled slots.

## Applying the force

- Apply the force in the center.

This means that you must apply the force exactly along the axis of symmetry of the sensor. The force must act in a direction perpendicular to the sensor.

- Eliminate any lateral forces and torques.

These are generated by an eccentric load, force applied at an angle and by friction. You can avoid friction by using parts with an adequate surface quality and hardness (minimum 60 HRC).

Parts that are used to apply the force to the sensor must satisfy the following requirements:

- flat surface
- surface hardness 60 HRC
- polished, preferably lapped, surface quality: N3 (Rz 1), evenness 2 µm
- not coated in any material
- must contain no holes, not even centering holes for lathes

### 4.1.2 Mounting



#### **Caution!**

**Risk of damage to sensor!**

**The sensor cable contains components that affect the sensitivity of the sensor.**

**Never shorten the sensor cable.**



#### **Caution!**

**The spring body will be damaged if you clamp the load cell by its sides or press-fit the load cell in a hole!**

**Only fix the sensor in place as specified in these instructions.**

The model 8413, 8414, 8415 und 8416 sensors are solely intended for measuring compression forces. Fastening components are therefore only suitable for the task of fixing the sensor in place.

There are two fixing options depending on the application:

### Initial load

- Connect the sensor in situ to a measuring instrument and monitor the measurement signal while mounting the sensor.

The measurement signal must remain below the rated force during and after the mounting operation.

- Position the sensor correctly on the mounting surface.
- Now apply the initial load.

The sum of initial load and maximum measured load must be less than the rated load.

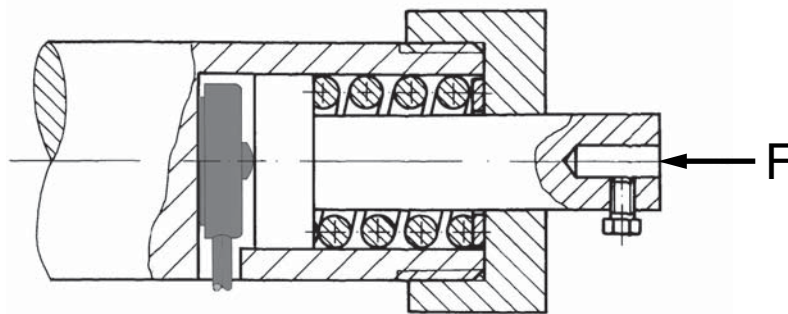


Figure 5: When using a spring element to mount the sensor, an initial load is applied to hold the sensor in position.

### Adhesive bonding

#### Note:

If mounting the sensor in a recess as a means of centering and fixing the sensor, a minimum radial gap of min. 0.5 mm must be maintained around the sensor case.

- Connect the sensor in situ to a measuring instrument and monitor the measurement signal while mounting the sensor.

The measurement signal must remain below the rated force during and after the mounting operation.

- Position the sensor correctly on the mounting surface.
- Now bond the sensor, **from above**, by its flange firmly onto the mounting surface.

**Note:**

There must be no adhesive on the mounting surface of the sensor. There must be **no** adhesive underneath the sensor.

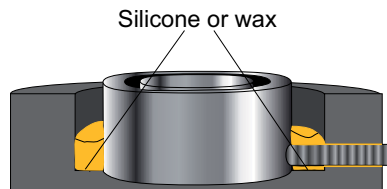


Figure 6: Bond the sensor fast from above. Do not let adhesive run underneath the sensor.



## 4.2 Electrical system, evaluation instrumentation



### **Caution!**

If the cable sheath is damaged, fluids can penetrate and damage the sensor.

For this reason:

Take suitable precautions to relieve the bending stress exerted by the connecting cable on the cable bushing at the sensor housing. In particular, pulsating or alternating loads acting on this bushing will damage it and hence the cable will come loose.

**Make sure that you lay the cables with sufficiently large bend radii.**

**Avoid vibration on the cables.**

**Protect the cables from strain.**

**Protect the sensor from vapors and liquids.**

The output signals from the 8413, 8414, 8415 and 8416 normally lie between 2 and 7.5 mV (foil strain gage) or in the range of approx. 70 mV (semiconductor strain gauge). Hence for a measurement accuracy of 1 % you will need a resolution of approx. 10  $\mu$ V or better. Hence interference will be picked up by the sensor, cables and measurement electronics.

### **The following points apply to the sensor's electrical connection:**

- Locate the sensor, the cable and the measuring instrument outside the fields of high-energy equipment.

This includes transformers, motors, contactors, frequency converters and so forth. Otherwise the electromagnetic fields from such equipment will act with their full effect on the measuring chain, causing incorrect measurements.

- Lay the measuring lines separately from high-power cables.

If the measuring lines are laid parallel to such cables, interference will be coupled in inductively and capacitatively.

In some cases it will be helpful to place an extra shield as additional protection over the measuring cable, or to lay it in a metal tube or pipe.

## **5. Measuring chain adjustment**

The sensors of the models 8413, 8414, 8415 and 8416 are calibrated ex works. Because of this, every sensor has an individual test and calibration report.

However, you basically have to align every following electronic to the particular sensor. After this adjustment you have done a basic adjustment of the measuring chain.

### **5.1 Adjustment using the data of the test and calibration report**

Depending on the type of the following electronic, you are able to insert the data of test and calibration report directly or you have to use strain gauge simulator or a shunt resistor. With the help of this strain gauge simulator or a shunt resistor you are able to pretend the electric values to the electronic.

### **5.2 Adjustment using calibration offset (shunt calibration)**

#### **Function**

During shunt adjustment, a precision resistor (the calibration shunt) is connected between the negative pin of the signal input and the negative pin of the reference supply voltage. The imbalance thus created in the bridge circuit corresponds to a specific change in length, i.e. to a particular load applied to the load cell. An offset, defined in this way, appears at the same time in the output signal, and can be used to adjust the entire measurement chain. The magnitude of the change in the output signal, and the value of the associated calibration shunt, can be found in the sensor's test certificate.

### **5.3 Adjustment with a physical magnitude**

#### **Function**

The sensor is subjected to a known physical magnitude. In this way, the calibration is carried out over the entire measuring chain, consisting of the sensor and display device or amplifier.

#### **Adjustment**

- Remove any load from the sensor.
- Adjust the zero.
- Load the sensor with a known reference weight.
- Adjust the reference scale value.

If desired, we can prepare factory calibration or recalibration certificates for the sensor or for the entire measuring chain.

These measurements are carried out at the factory on measurement installations.

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## **5.4 Adjustment using a strain gauge simulator**

### **Function**

A strain gauge simulator is a bridge simulation circuit, built from precision resistors, which can be put into various output states. The strain gauge simulator (e.g. the burster strain gauge simulator model 9405) is connected to the instrumentation amplifier instead of the sensor.

## **5.5 Adjustment using a precision voltage source**

### **Note:**

The supply voltage of full-bridge strain gauge sensors affects the result of the measurement. It is possible that the actual supply voltage will vary slightly from the rated supply voltage. If you want to verify the proper function of the instrumentation amplifier using a voltage source, you must measure the sensor supply voltage with a precision digital voltmeter, and then calculate the calibration voltage.

### **Function**

The sensor is simulated by a precision voltage source (e.g. the burster DIGISTANT<sup>®</sup> model 4411 or 4423), which you connect to the instrumentation amplifier.

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## **6. Note**

### Exclusion of warranty liability for operating manuals

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