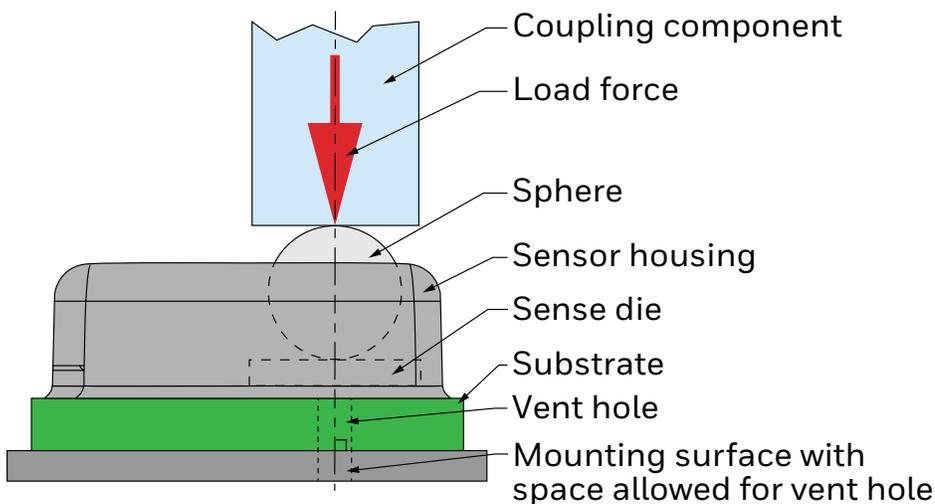


MICROFORCE SENSOR COUPLING

Technical Note

Honeywell's piezoresistive-based MicroForce Sensors are actuated by direct mechanical coupling through a stainless steel sphere mounted directly over a silicone sense die. This package is designed for repeatable and reliable mechanical interface. Achieving these results in the user's product requires correct mechanical coupling and awareness of design constraints. This Technical Note addresses considerations relating to correct force alignment to the sensor, common challenges with coupling, and effective strategies to overcome possible errors.

FIGURE 1. OPTIMAL ALIGNMENT OF A LOAD FORCE TO THE MICROFORCE SENSOR



1.0 OPTIMAL LOAD FORCE ALIGNMENT

Adherence to the following considerations helps to provide optimal sensor results (See also Figure 1):

- **Apply an optimal, theoretical load force to the top center point of the coupling sphere along the vertical axis without any angle discrepancies.** This may be achieved by using a small, flat, hard surface which contacts the sphere at a perpendicular angle to the substrate.
- **Stabilize the contact point** to avoid deformation, vibration, shifting, or slipping.
- **Fully support the sensor** to ensure that neither the substrate nor the sensor housing are placed under stress.
- **Leave an open space for the vent hole** in the mounting surface.
- **Use auto-zeroing techniques to correct for mounting shift if it occurs** in the application. (See the Technical Note "Auto-Zero Calibration Technique for FMA Series MicroForce Sensors" for further details.)
- **Ensure that the total applied force is as close to full scale as possible** for the best resolution.
- **Ensure that the sensor does not exceed its overforce limit rating.** (See the Technical Note "Overforce Design Considerations" for further details.)

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2.0 ROOT CAUSES OF COUPLING ISSUES

Proper sphere alignment and correct sensor mounting to ensure successful coupling are critical to achieving consistent and accurate results. The sphere transfers the load through a contact point. If the contact point is inconsistent or is not perpendicular, the sphere may press or rub against the sensor housing, thereby shifting the sensor's output. Using a mechanical coupling component, such as a pin or bushing, helps keep this critical alignment correct and consistent.

Tolerance variations may also skew the load force or allow for slipping against the coupling surfaces. These resulting package stresses may lead to loss of sensor accuracy and other problems.

Tables 1 and 2 show examples of root cause coupling and mounting errors when using the MicroForce sensor.

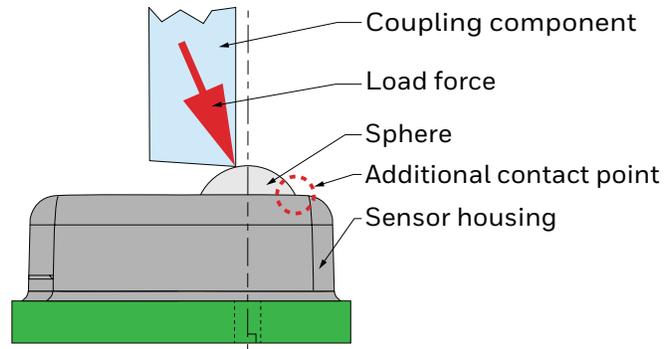
NOTICE

It is up to the customer to design a solution to meet the specific needs of the potential application.

TABLE 1. COUPLING ERRORS

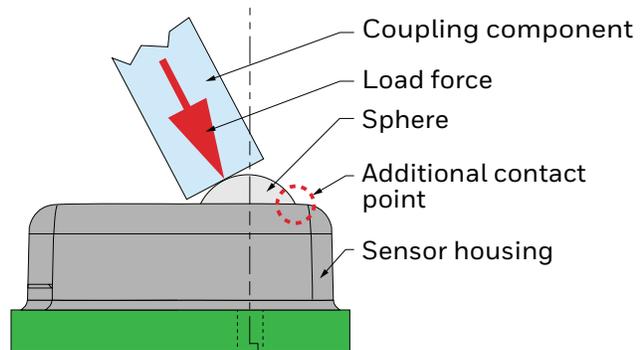
POSITIONING

Occur if the coupling component is narrow or does not have a flat surface. Tolerance stackup may also cause uneven alignment to the contact point, creating an error due to load force misalignment, as well as an additional contact point where the sphere is forced against the sensor housing.



ROTATION

Occur if the coupling component and the sensor are not aligned perpendicularly, creating an error due to load force misalignment and an additional contact point where the sphere is forced against the sensor housing.



HOUSING CONTACT

Occur if the coupling component also contacts the sensor housing, distributing the load force between two contact points. Additionally, if the load force applied to the housing is great enough, the resulting package stresses may lead to loss of sensor accuracy.

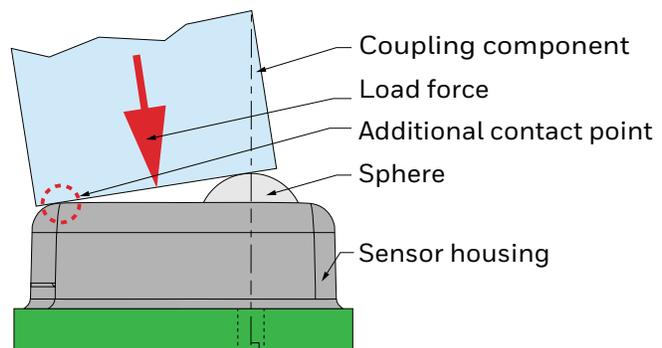
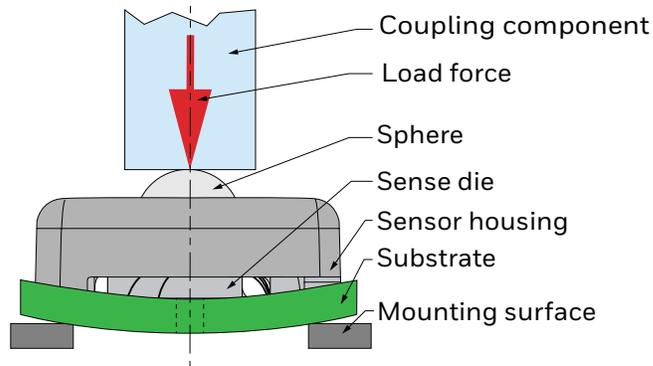


TABLE 2. MOUNTING ERRORS

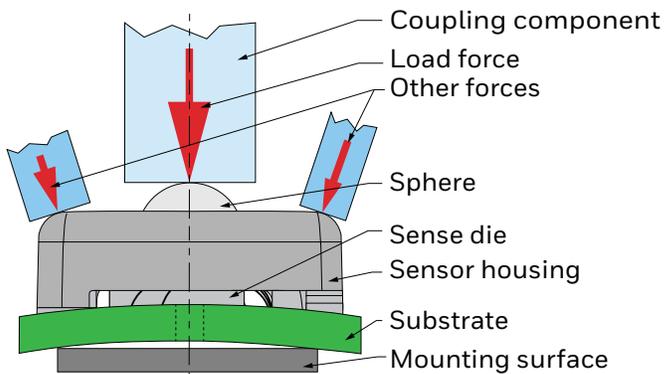
MOUNTING

Occur if the sensor is not correctly soldered to or backed by the mounting surface. Without the correct support a bending stress from the substrate may transfer unwanted stress to the sense die. Some of these errors may be corrected with an auto zero of the sensor.



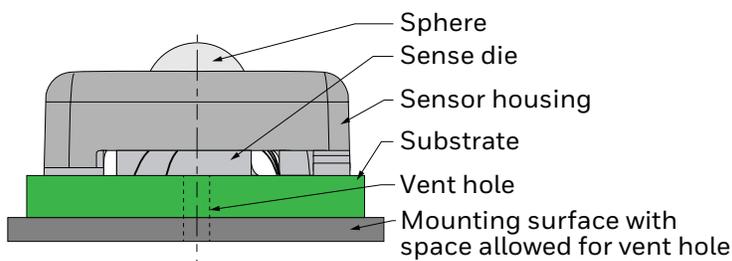
PACKAGE STRESSES

Similar to mounting errors, occur when other outside forces cause package stress which is then transferred to the sense die. Some of these errors may be corrected with an auto zero of the sensor.



VENTING

Occur if the vent hole is blocked. The resulting trapped air may then create a greater pressure when the sphere presses down on the sense die.



3.0 COUPLING MECHANISM EXAMPLES

3.1 USING LEVERAGE TO PROVIDE A LOAD FORCE

A common force sensor coupling strategy is to use a lever to adjust the location and magnitude of the load force. This method allows for control over a flat, level contact surface to couple against the sensor's coupling sphere.

Different lever configurations may be used to save space or to increase the load force accuracy, allowing different force ranges to be used with a single sensor.

Ensure that the sensor is not subjected to an overforce (generally three times the specified range of the sensor).

The following equation shows the amount of load force which is transferred to the sensor in the examples shown in Figures 2 and 3.

$$F_s = \frac{(FX_a + F_g X_g)}{X_s}$$

Where:

F_s : Reaction force at the sensor

F : Load force exerted on lever from the coupling component

X_a : Perpendicular distance of load force from the rotation axis

F_g : Force exerted by gravity

X_g : Perpendicular distance of center of mass of the lever from the rotation axis

X_s : Perpendicular distance from the contact point of the sensor from the rotation axis

FIGURE 2. PARALLEL LEVER

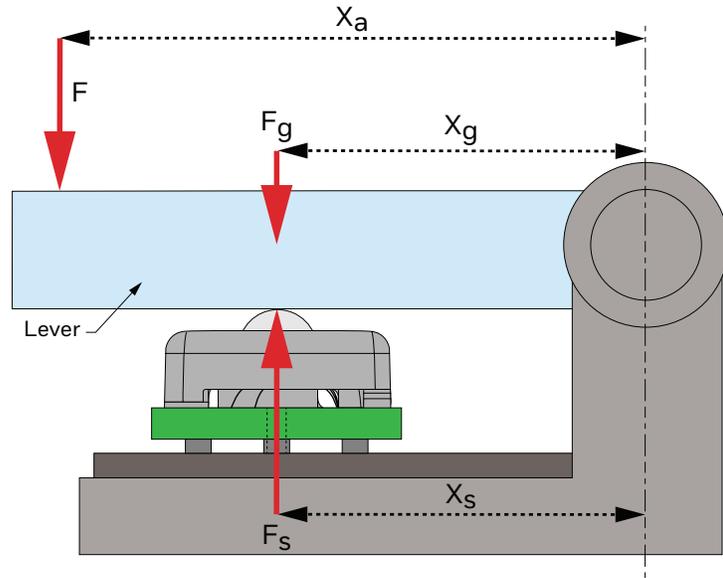
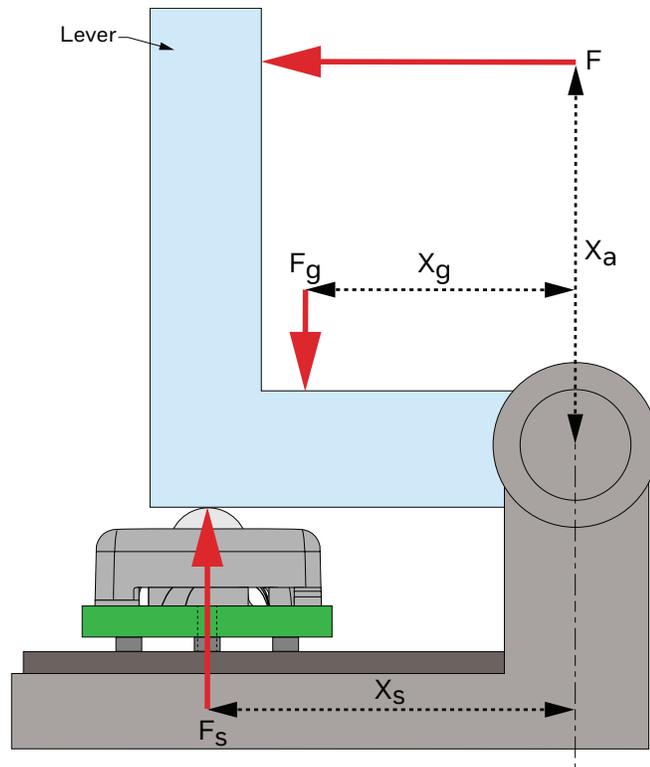


FIGURE 3. RIGHT ANGLE LEVER



3.2 USING TUBING TO PROVIDE A PRESSURE MEASUREMENT TO PROVIDE A LOAD FORCE

Applications may have unique challenges which often change force sensor coupling requirements. In the medical industry, force sensors are used to couple to the outside of tubing to take a pressure reading.

3.2.1 TUBING ALONE

Figure 4 shows the tubing forced against the top of the sensor in a preloaded state. (Note that this preloading takes up part of the sensor’s calibrated range.) Also, the tubing may contact the sensor housing as well as the coupling sphere. Although these methods may create package forces, they can be done in a way which minimizes the output shift.

Variations to the design may affect sensor output. For example, changes to the tubing’s diameter or durometer may change the surface area which contacts the coupling sphere. This example shows how a sensor may be used to calculate pressure when pressed against tubing. The following equation relates the pressure in the tubing to the force output of the sensor.

$$F_s = (2\pi Rh)P$$

Where:

F_s : Force of the sensor

R: Radius of the coupling sphere (1/32")

h: Height of the tubing contact

P: Pressure in the tubing

FIGURE 4. TUBING

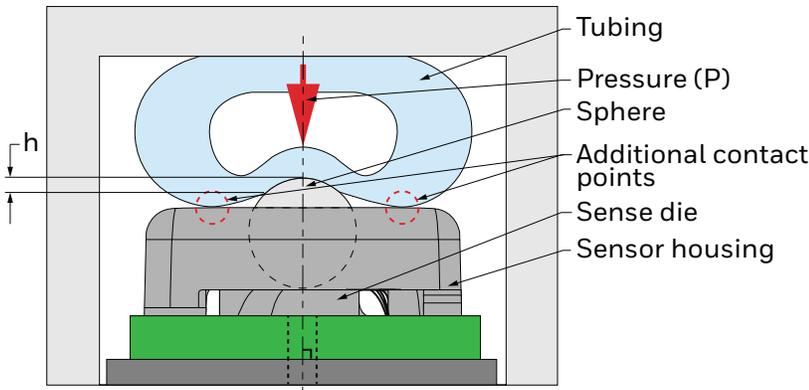
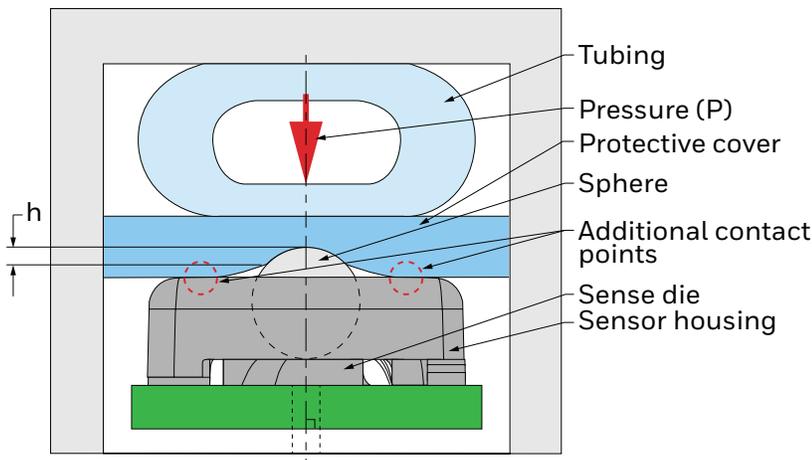


FIGURE 5: TUBING WITH PROTECTIVE COVER



3.2.2 TUBING WITH PROTECTIVE COVER

Figure 5 shows another coupling strategy which is to use a silicone cover between the sensor and the tubing.

This method has the advantage of protecting the sensor from liquids or other environmental factors, as well as adding some protection from system vibration. It may be done in such a way that minimal dampening to sensor output occurs.

Like the example in Figure 4, this method may create some package forces but may be done in a way which minimizes the output shift.

Again, variations to the design may affect sensor output. For example, changes to the cover’s thickness or durometer may change the surface area which contacts the sphere.

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