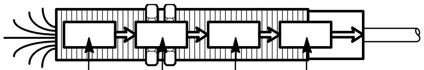
Principles of Operation for Capacitive Proximity Sensors



Capacitive proximity sensors are designed to operate by generating an electrostatic field and detecting changes in this field caused when a target approaches the sensing face. The sensor's internal workings consist of a capacitive probe, an oscillator, a signal rectifier, a filter circuit and an output circuit.

In the absence of a target, the oscillator is inactive. As a target approaches, it raises the capacitance of the probe system. When the capacitance reaches a specified threshold, the oscillator is activated which triggers the output circuit to change between "on" and "off."

The capacitance of the probe system is determined by the target's size, dielectric constant and distance from the probe. The larger the size and dielectric constant of a target, the more it increases capacitance. The shorter the distance between target and probe, the more the target increases capacitance.

Standard Target and Grounding for Capacitive Proximity Sensors

The standard target for capacitive sensors is the same as for inductive proximity sensors. The target is grounded per IEC test standards. However, a target in a typical application does not need to be grounded to achieve reliable sensing.

Shielded vs. Unshielded Capacitive Sensors

Shielded capacitive proximity sensors are best suited for sensing low dielectric constant (difficult to sense) materials due to their highly concentrated electrostatic fields. This allows them to detect targets which unshielded sensors cannot. However, this also makes them more susceptible to false triggers due to the accumulation of dirt or moisture on the sensor face.

The electrostatic field of an unshielded sensor is less concentrated than that of a shielded model. This makes them well suited for detecting high dielectric constant (easy to sense) materials or for differentiating between materials with high and low constants. For the right target materials, unshielded capacitive proximity sensors have longer sensing distances than shielded versions.

Unshielded models are equipped with a compensation probe which allows the sensor to ignore mist, dust, small amounts of dirt and fine droplets of oil or water accumulating on the sensor. The compensation probe also makes the sensor resistant to variations in ambient humidity. Unshielded models are therefore a better choice for dusty and/or humid environments.

Unshielded capacitive sensors are also more suitable than shielded types for use with plastic sensor wells, an accessory designed for liquid level applications. The well is mounted through a hole in a tank and the sensor is slipped into the well's receptacle. The sensor detects the liquid in the tank through the wall of the sensor well. This allows the well to serve both as a plug for the hole and a mount for the sensor.

Target Correction Factors for Capacitive Proximity Sensors

For a given target size, correction factors for capacitive sensors are determined by a property of the target material called the dielectric constant. Materials with higher dielectric constant values are easier to sense than those with lower values. A partial listing of dielectric constants for some typical industrial materials follows. For more information, refer to the *CRC Handbook of Chemistry and Physics (CRC Press), the CRC Handbook of Tables for Applied Engineering Science (CRC Press),* or other applicable sources.

Dielectric Constants of Common Industrial Materials

Acetone	19.5
Acrylic Resin	2.7–4.5
Air	1.000264
Alcohol	25.8
Ammonia	15–25
Aniline	6.9
Aqueous Solutions	50–80
Bakelite	3.6
Benzene	2.3
Carbon Dioxide	1.000985
Carbon Tetrachloride	2.2
Celluloid	3.0
Cement Powder	4.0
Cereal	3–5
Chlorine Liquid	2.0
Ebonite	2.7–2.9
Epoxy Resin	2.5–6
Ethanol	24
Ethylene Glycol	38.7
Fired Ash	1.5–1.7
Flour	1.5–1.7
Freon R22 & 502 (liquid)	6.11
Gasoline	2.2
Glass	3.7–10
Glycerine	47
Marble	8.0–8.5
Melamine Resin	4.7–10.2
Mica	5.7–6.7
Nitrobenzine	36
Nylon	4–5
Oil Saturated Paper	4.0
Paraffin	1.9–2.5
Paper	1.6–2.6
Perspex	3.2–3.5
Petroleum	2.0–2.2
Phenol Resin	4–12
Polyacetal	3.6–3.7
Polyamide	5.0
Polyester Resin	2.8–8.1
Polyethylene	2.3
Polypropylene	2.0–2.3
Polystyrene	3.0
Polyvinyl Chloride Resin	2.8–3.1
Porcelain	4.4–7
Powdered Milk	3.5–4
Press Board	2–5
Quartz Glass	3.7
Rubber	2.5–35
Salt	6.0
Sand	3–5
Shellac	2.5–4.7
Shell Lime	1.2
Silicon Varnish	2.8–3.3
Soybean Oil	2.9–3.5
Styrene Resin	2.3–3.4
Sugar	3.0
Sulphur	3.4
Teflon	2.0
Toluene	2.3
Transformer Oil	2.2
Turpentine Oil	2.2
Urea Resin	5–8
Vaseline	2.2–2.9
Water	80
Wood, Dry	2–7
Wood, Wet	10–30

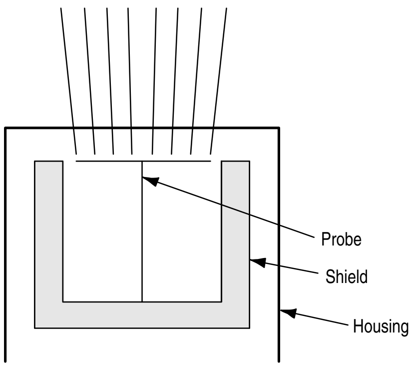
Shielded vs. Unshielded Construction

Each capacitive sensor can be classified as having either a shielded or unshielded construction.

Shielded Probe

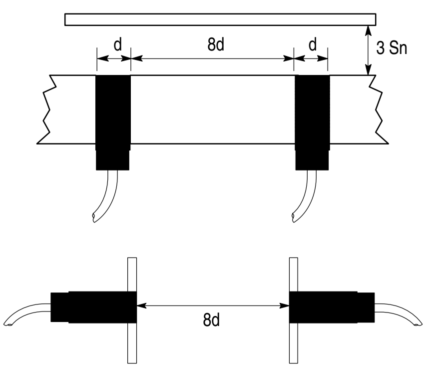
Shielded sensors are constructed with a metal band surrounding the probe. This helps to direct the electrostatic field to the front of the sensor and results in a more concentrated field.

Shielded Probe



Shielded construction allows the sensor to be mounted flush in surrounding material without causing false trigger.

Shielded Sensors Flush Mounted

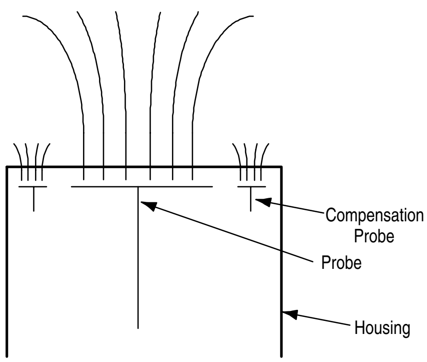


Shielded capacitive proximity sensors are best suited for sensing materials with low dielectric constants (difficult to sense) as a result of their highly concentrated electrostatic fields. This allows them to detect targets that unshielded sensors cannot.

Unshielded Probe

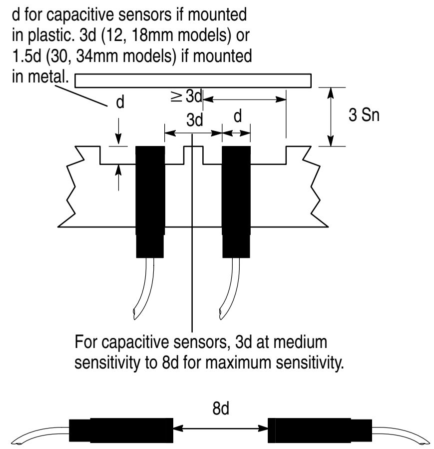
Unshielded sensors do not have a metal band surrounding the probe and hence have a less concentrated electrostatic field. Many unshielded models are equipped with compensation probes, which provide increased stability for the sensor. Compensation probes are discussed later in this section.

Unshielded Probe



Unshielded capacitive sensors are also more suitable than shielded types for use with plastic sensor wells, an accessory designed for liquid level applications. The well is mounted through a hole in a tank and the sensor is slipped into the well's receptacle. The sensor detects the liquid in the tank through the wall of the sensor well.

Unshielded Construction Mounted Above Metal and Mounted in Plastic Sensor Well

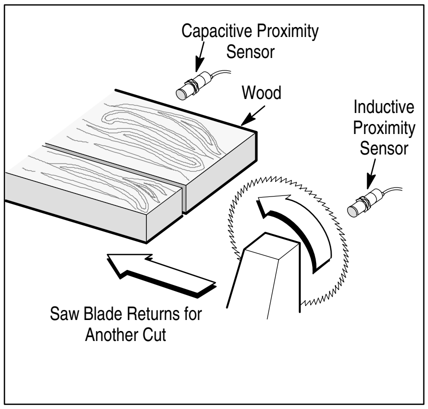


d = diameter or width of active sensing face
Sn = nominal sensing distance

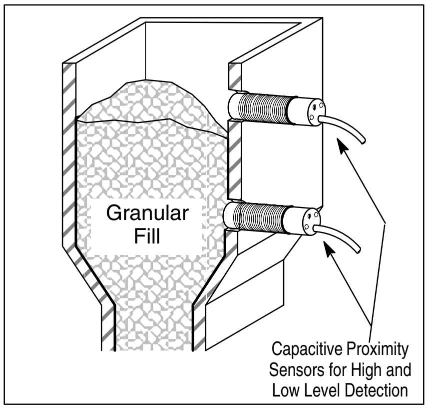
The electrostatic field of an unshielded sensor is less concentrated than that of a shielded model. This makes them well suited for detecting high dielectric constant (easy to sense) materials or for differentiating between materials with high and low constants. For certain target materials, unshielded capacitive proximity sensors have longer sensing distances than shielded versions.

Unshielded models equipped with a compensation probe are able to ignore mist, dust, small amounts of dirt and fine droplets of oil or water accumulating on the sensor. The compensation probe also improves the sensor's resistance to variations in ambient humidity.

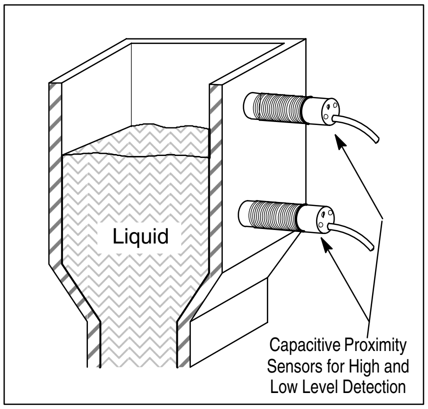
Wood Industry



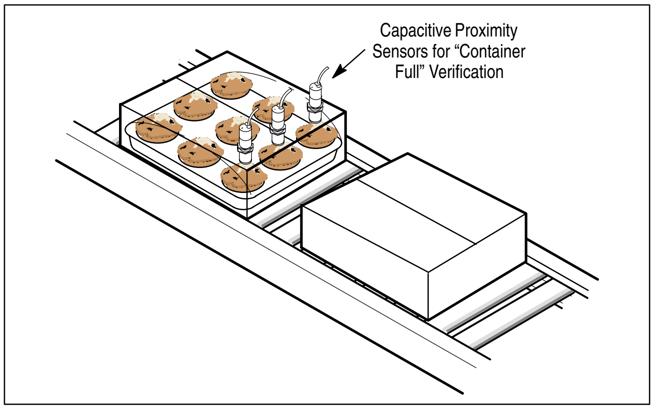
Level Detection



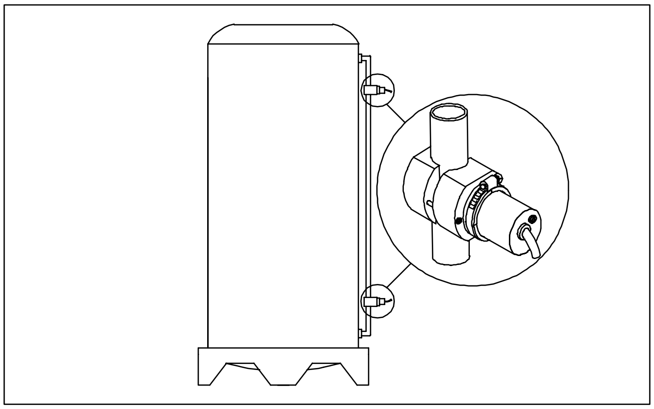
Liquid Level Detection



Food Processing



Sight-Tube Level Detection



Notes