Sensitivity Adjustment

Capacitive sensors can be adjusted two ways in order to sense a target consistently.

1. **Physical adjustment** - moving the sensor towards or away from the target is the preferred method of adjusting sensitivity when the sensor is not in direct contact with the target. This allows materials to be moved into or out of range while leaving the sensor at the factory setting or after re-calibration to the nominal operating distance Sn.

2. **Adjustment of the potentiometer** - turning the potentiometer in a clockwise direction increases the sensitivity of the sensor. The potentiometer is factory-set for an operating distance of 0.7 to 0.8 Sn to a grounded standard target (Figure 5). It should be adjusted in increments of no greater than a quarter-turn (Figure 6). Increasing the sensitivity results in a greater operating distance to both conductive and non-conductive targets.

Figure 5

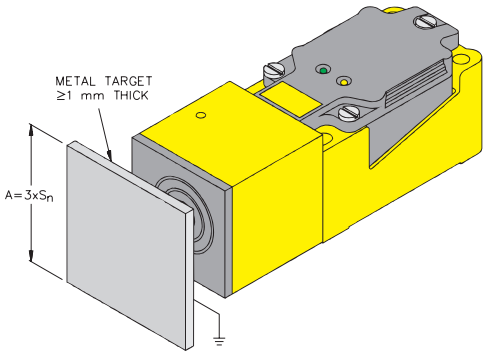
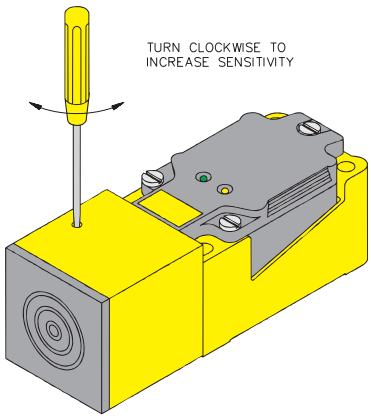
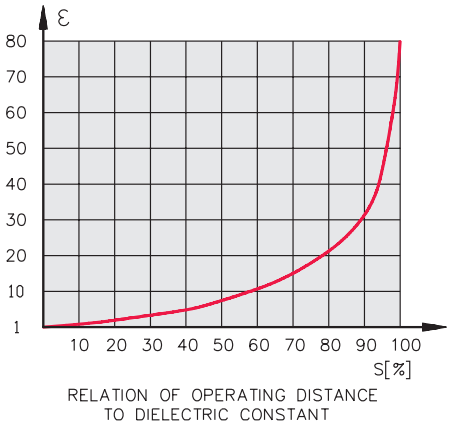


Figure 6



When sensing non-conductive targets, the larger the dielectric constant of a material, the greater the achievable operating distance (Figure 7). Adjusting the potentiometer affects the total curve; for example, if the potentiometer is adjusted for less sensitivity, it will have less operating distance to all materials.

Figure 7



RELATION OF OPERATING DISTANCE
TO DIELECTRIC CONSTANT

In general terms, the larger the dielectric constant of a material, the greater the achievable operating distance.

When detecting organic materials the sensing distance will depend largely on the water content ($\varepsilon_{water} = 88$).

It should be noted that a large increase in sensitivity will cause the sensor to become nonembeddable, and may result in an unstable switching point that can be influenced by environmental changes such as temperature, humidity, dust, etc.

At adjustments of S > Sn, the differential travel (hysteresis) can also increase.

Example Application 1 - Adjustment

Problem:

Can a BC20-K40SR-FZ3X2 be used to sense the presence of ammonia from behind a .125" glass panel?

Solution:

The dielectric constants for these materials can be found on pages 15 and 16.

Dielectric (ε_r) of ammonia:	20
Dielectric (ε_r) of glass:	10

From Figure 7, $\varepsilon_r = 20$ corresponds to 80% Sn; $\varepsilon_r = 10$ corresponds to 60% Sn.

Since Sn = 20 mm for a BC20:	S for ammonia = 16 mm
	S for glass = 12 mm

The difference is 4 mm. The glass thickness = .125", or 3.1 mm. This application will work with a 0.9 mm margin. This means that by adjusting the potentiometer there should be a reasonable distinction between the glass and the ammonia as seen by the sensor.

To set up the sensor for this application, the sensing face of the sensor should be flush against the sight glass.

1. With no ammonia present (if possible) turn the potentiometer clockwise until the sensor turns on. If the sensor is already on, skip step one.
2. Next, turn the potentiometer counter clockwise until the sensor turns off.
3. Now add the ammonia so that it covers the glass panel.
4. Once again, turn the potentiometer counter clockwise, *counting the number of turns* until the sensor turns off.*
5. Divide the number of turns by two and turn the potentiometer back clockwise that amount.

Using this process will allow for a margin of error in either direction. If this application had called for something other than ammonia, like molasses, that tends to leave buildup behind, step 1 above should be performed *with the buildup present (if possible)*.

* If sensor does not turn off after 10 full turns, turn back the potentiometer clockwise between 3 to 5 turns. Minor adjustments may need to be made to achieve desired setting.

Example Application 2 - Mounting

Problem:

A metal tank containing a water-based solution has a 1" outside diameter sight glass. What sensor and bracket could be used for monitoring the liquid level?

Solution:

The QF 5.5 flat style can used on non-conductive tubing up to 1.0 inch in diameter with the standard mounting straps provided with the sensor (Figure 8).

Other mounting straps for larger diameters are available upon request (consult factory).

Figure 8

Plastic Material Descriptions

ABS - Acrylonitrile-Butadiene-Styrene	Impact resistant, rigid. Resistant to aqueous acids, alkalis, salts, alcohols, oils, concentrated hydrochloric acid; disintegrated by concentrated sulfuric or nitric acids, esters, ketones.
PA - Polyamide (nylon)	Good mechanical strength, temperature resistant.
PA, Amorphous (Trogamid T)	Similar properties to nylon, but transparent. Hard, rigid, good chemical resistance.
PA 12-GF30	Nylon 12, 30% glass filled.
PA 66-GF25-V0	Nylon 66, 25% glass filled, self-extinguishing.
PBT - Polybutylene Terephthalate (when glass reinforced, Crastin®)	Good mechanical strength; resistant to abrasion; resistant to alcohols, oils, some acids, trichloroethylene.
PBT-GF30-V0	PBT, 30% glass filled, self-extinguishing.
POM - Polyoxymethylene / Polyacetal (Delrin®)	High impact resistance; good mechanical strength; good resistance to oils, alcohols, alkalis, gasoline, xylene, toluene. Dielectric constant 3.7.
PP - Polypropylene	Good mechanical strength. Resistant to acids. Temperature resistant.
PTFE - Polytetrafluoroethylene (Teflon®)*	Optimum resistance against high temperature and chemicals; low dielectric constant (2.0).
PUR - Polyurethane	Elastic, resistant to abrasion, impact-resistant, oil- and grease-tolerant.
PVC - Polyvinylchloride	Good mechanical strength, viscosity to impact; resistant to acids, alkalis.
PVDF - Polyvinylidenefluoride (Kynar®)	Resistant to high and low temperatures, good resistance to chemicals (similar to PTFE), high mechanical strength.

Matrix of TURCK Sensor Materials

Housing Style	ABS	PA, Trog. T	PA	PBT	PP	PUR	PVC	PVDF	Brass	Zinc
CP40			X*	X						
CP80		X	X*	X						
G, M (potted-in cable)			X			X*	X*		X	
G, M (connector)			X						X	
K40SR, P30SR	X		X*							
K34			X*	X			X*			
KT34								X		
P, S (potted-in cable)			X			X*	X*			
P, S (connector)			X							
PT30								X		
Q08			X				X*		X*	X
Q10, Q14, Q20				X		X*	X*		X*	
QF5.5					X	X*				
S185						X*	X*	X		

* Optional part, ie cable gland, connector, cable, bracket, etc.

Chemical Compatibility

The information in this chart is derived from reputable industry sources and is to be used only as a guide in selecting materials suitable for your application. **TURCK** does not warrant in any fashion that the information in this chart is accurate or complete, or that any material is suitable for any purpose.

Most ratings listed here apply to a 48-hour exposure period.

Ratings: A - No effect B - Minor effect C - Moderate effect D - Severe effect
φ - No specific data, but probable rating. nd - no data

	ABS	Trog. T	PA 12	PBT	POM	PTFE	PUR	PVC	PVDF	306 SS	Brass	Zinc	PP
Ammonia, liquid	B	B	A	B	C/D	A	C	A	A	B	D	A	A
Chlorine anhydrous liquid	nd	nd	D	D	C	A	C	D	A	C	D	nd	D
De-ionized water	nd	nd	A	nd	nd	A	nd	A	A	A	A	nd	A
Formic acid	D	D	D	A	C	A	C	A	A	A/B	D	D	A
Gasoline	D	A	A	A	A	A	A	C	A	A	A	nd	B
Hydrochloric acid <40%	A	A/B	D	A	C	A	D	B	A	D	D	D	B
Hydrofluoric acid <50%	C	D	D	B	D	A	C	B	A	D	D	nd	A
Methanol	D	D	B	A	A	A	B	A	A	A	A	A	A
Phosphoric acid <40%	B©	D	B	A	D	A	Dφ	B	B	D	D	D	A
Potassium hydroxide <15%	A	A	C	B	B	A	C	A	A	B	D	nd	A
Sodium hydroxide <55%	A	A	C	B	B	A	B	A	D	B	D	D	A
Sodium hypochlorite ≤13%	B	nd	B	A	C	A	B	A	A	C	D	A	A
Sulfuric acid <75%	B	A	D	A	D	A	C	A	A	D	D	D	A
Toluene	D	A	A	A	A	A	C	D	A	A	A	nd	C
Trichloroethylene	D	A	C	A	B	A	D	D	B	A/B	A	A	C

Industrial Products and their Dielectric Constants

Material	Dielectric Constant
ABS resin, pellet	1.5 - 2.5
Acetic Acid	4.1
Acetone	19.5
Acetyl bromide	16.5
Acrylic resin	2.7 - 4.5
Air	1.0
Alcohol, industrial	16 - 31
Alcohol, isopropyl	18.3
Ammonia	15 - 25
Aniline	5.5 - 7.8
Aqueous solutions	50 - 80
Asbestos	3.0
Ash (fly)	1.7
Bakelite	3.6
Barley powder	3.0 - 4.0
Benzene	2.3
Benzyl acetate	5
Butane	1.4
Cable sealing compound	2.5
Calcium carbonate	9.1
Carbon Dioxide	1.6
Carbon tetrachloride	2.2
Celluloid	3.0
Cellulose	3.2 - 7.5
Cement	1.5 - 2.1
Cement powder	5 - 10
Cereal	3 - 5
Charcoal	1.2 - 1.8
Chlorine, liquid	2.0
Coke	1.1 - 2.2
Corn	5 - 10
Ebonite	2.7 - 2.9

Material	Dielectric Constant
Epoxy resin	2.5 - 6
Ethanol	24
Ethyl bromide	4.9
Ethylene Chloride	10.5
Ethylene Dichloride	11.0
Ethylene glycol	38.7
Ethylene Oxide	14.0
Ferrous Oxide	14.2
Fired Ash	1.5
Flour	2.5 - 3.0
Formic Acid	59.0
Freon® R22 & 502, liquid	6.1
Gasoline	2.2
Glass	3.1 - 10
Glass, raw material	2.0 - 2.5
Glycerine	47
Hexane	1.9
Hydrochloric Acid	4.6
Hydrogen cyanide	95.4
Hydrogen peroxide	84.2
Ice, -5C	2.85
Ice, -18C	3.16
Isobutylamine	4.5
Lime, shell	1.2
Marble	8.0 - 8.5
Melamine resin	4.7 - 10.2
Methane, liquid	1.7
Methanol	33.6
Mica, white	4.5 - 9.6
Milk, powdered	3.5 - 4
Nitrobenzene	36
Neoprene	6 - 9

Industrial Products and their Dielectric Constants

Material	Dielectric Constant
Nylon	4 - 5
Oil, for transformer	2.2 - 2.4
Oil, paraffin	2.2 - 4.8
Oil, peanut	3.0
Oil, petroleum	2.1
Oil, soybean	2.9 - 3.5
Oil, turpentine	2.2
Paint	5 - 8
Paraffin	1.9 - 2.5
Paper	1.6 - 2.6
Paper, hard	4.5
Paper, oil saturated	4.0
Perspex	3.2 - 3.5
Petroleum	2.0 - 2.2
Phenol	9.9 - 15
Phenol resin	4.9
Polyacetal (Delrin®)	3.6
Polyamide (nylon)	2.5
Polycarbonate	2.9
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
Press board	2 - 5
Propane, liquid	1.6
Propylene, liquid	11.9
Quartz glass	3.7
Rice, dry	3.5

Material	Dielectric Constant
Rubber	2.5 - 35
Salt	6.0
Sand	3 - 5
Shellac	2.0 - 3.8
Silicon dioxide	4.5
Silicone rubber	3.2 - 9.8
Silicone varnish	2.8 - 3.3
Soybean	2.8
Styrene resin	2.3 - 3.4
Sugar	3.0
Sugar, granulated	1.5 - 2.2
Sulfur	3.4
Sulfuric acid	84
Teflon®, PCTFE	2.3 - 2.8
Teflon, PTFE	2.0
Toluene	2.3
Trichloroethylene	3.4
Urea resin	6.2 - 9.5
Urethane	3.2
Vaseline	2.2 - 2.9
Vinyl Chloride	2.8
Water	48 - 88
Wax	2.4 - 6.5
Wood, dry	2 - 7
Wood, pressed board	2.0 - 2.6
Wood, wet	10 - 30
Xylene	2.4
Zinc Oxide	1.7
Zirconium Oxide	12.5
Zirconium Silicate	5.0

Temperature and Environmental Conditions

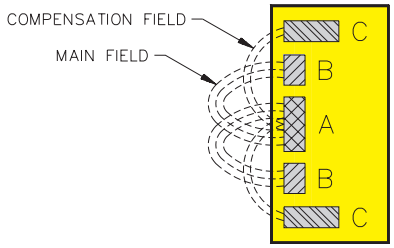
Compensation Electrode

In practice, sensors can be affected by water droplets, humidity, dust, etc., causing false outputs. To combat this effect each **TURCK** sensor incorporates a compensating electrode (C) which forms part of a negative feedback circuit (Figure 9).

When contaminants are on the sensor face, they affect the sensor's main field, as well as its compensation field. The negative feedback circuit detects the increase in both fields, and can filter out the effects of the contaminants.

When a large target comes into the sensor's main field, the compensation field is not affected, thus the negative feedback circuit can distinguish a difference between the two fields, and the sensor generates an output.

Figure 9



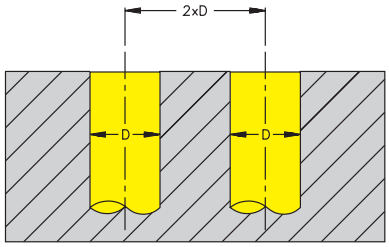
A and B – SENSOR ELECTRODES
C – COMPENSATION ELECTRODES

Mounting

Most capacitive sensors manufactured by **TURCK** are embeddable, which ensures that the electric field is only effective in front of the active face. They are suitable for flush mounting at the factory setting in any material (conductive & nonconductive).

When sensors are flush mounted, the effect on the operating distance is minimal and can be overcome by adjustment of the potentiometer. Minimum separation distances must be observed to avoid the possibility of interference between the two sensors' fields. (Figure 11)

Figure 11



Operating Distance (Sensing Range) Considerations

The operating distance (S) of the different models is basically a function of the diameter of the sensing coil. Maximum operating distance is achieved with the use of a standard or larger target. Rated operating distance (Sn) for each model is given in the manual.

Standard Target

An earth-grounded square piece of carbon steel having a thickness of 1 mm (0.04 in) is used as a standard target to determine the following operating tolerances. The length and width of the square is equal to three times the rated operating distance.

Operating Distance = S

The operating distance is the distance at which the target approaching the sensing face along the reference axis causes the output signal to change.

Rated Operating Distance = Sn

The rated operating distance is a conventional quantity used to designate the operating distance. It does not take into account either manufacturing tolerances or variations due to external conditions such as voltage and temperature. (Figure 10)

Effective Operating Distance = Sr $0.9\ Sn \leq Sr \leq 1.1Sn$

The effective operating distance is the operating distance of an individual proximity sensor at a constant rated voltage and 23°C (73°F). It allows for manufacturing tolerances.

Usable Operating Distance = Su $0.72\ Sn \leq Su \leq 1.32Sn$

The usable operating distance is the operating distance of an individual proximity sensor measured over the operating temperature range at 85% to 110% of its rated voltage. It allows for external conditions and for manufacturing tolerances.

Assured Operating Range = Sa $0 \leq Sa \leq 0.72Sn$

The assured actuating range is between 0 and 72% of the rated operating distance. It is the range within which the correct operation of the proximity sensor under specified voltage and temperature ranges is assured. (Figure 12)

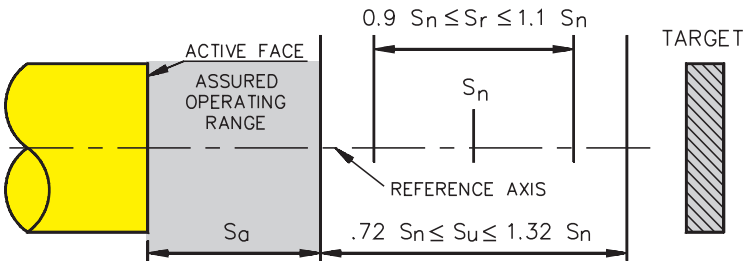



Figure 12