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Principle of Operation

Introduction

The BlueLevel Technologies Model CPH and CPU Capacitive Proximity Switches are compact sensors that are used for detecting the presence and absence of material within proximity or contact of the sensor. They are low cost, low profile sensors offering high value as automatic level control instruments. They are used to detect the presence/absence of liquids, powders and granular materials at predetermined levels within tanks, hoppers, bins, silos and other types of vessels. The Model CPH and CPU operate efficiently within a wide array of industrial settings.

Use

The Model CPH/CPU can be used for high (full detection), low (empty detection) and intermediate (demand detection) level monitoring, as well as sight-tube level detection and the detection of non-metallic targets on moving conveyor belts and also in conveyor belt positioning and material stacking. These sensors operate based on a proven principle.

Function

Capacitive Proximity Switch sensors are designed to operate by generating an electrostatic field and detecting changes in this field caused by the presence of a target or material approaching or contacting the sensor face. Capacitive Proximity Switches consist of an RC-oscillator with a special multi-part sensing electrode. When the target material is removed from within the field created by the sensor, the oscillator becomes inactive and the amplitude decreases. As a target approaches the sensor field, it increases the capacitance of the sensor 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 sensor system is determined by the dielectric constant of the target material, its proximity or distance from the sensor face and the size or mass of the target. The larger the size, the higher the dielectric constant and the closer it is to the sensor, the more it increases capacitance.

Level sensing and control applications will place the material in contact with the Capacitive Proximity Switch sensor face. Adjusting or calibrating the sensor to respond when it is in contact with or close to the target material is accomplished simply using the built-in potentiometer. Adjusting this potentiometer adjusts the oscillator amplifier voltage and hence the sensitivity of the sensor, increasing it or decreasing it.

Sensing Distance

The maximum sensing distance (from sensor face to target material) remains constant with a conductive target (like metal or water). Many materials have dielectric constants (ε_r) making them non-conductive. The sensing distance declines as the conductivity of the target declines.

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Applications

General

The Model CPH/CPU Capacitive Proximity Switches can be used to limit the level in tanks, bins, hoppers and other vessels and containers. High, low and intermediate level controls are typical applications. The contents of these vessels can be liquids, pulverized or granulated materials such as PVC powder, dyes, flour, sugar, powdered milk, etc. In addition, common applications include use as an end or limit switch for checking and regulating machinery settings, even if the materials are non-metallic as in conveyor belt positioning and material stacking. They can also be used as detectors for counting metallic and non-metallic components. BlueLevel Technologies provides White Papers, Podcasts, Video and other Media about the use and considerations when selecting level measurement and monitoring instrumentation at our website www.blueleveltechnologies.com

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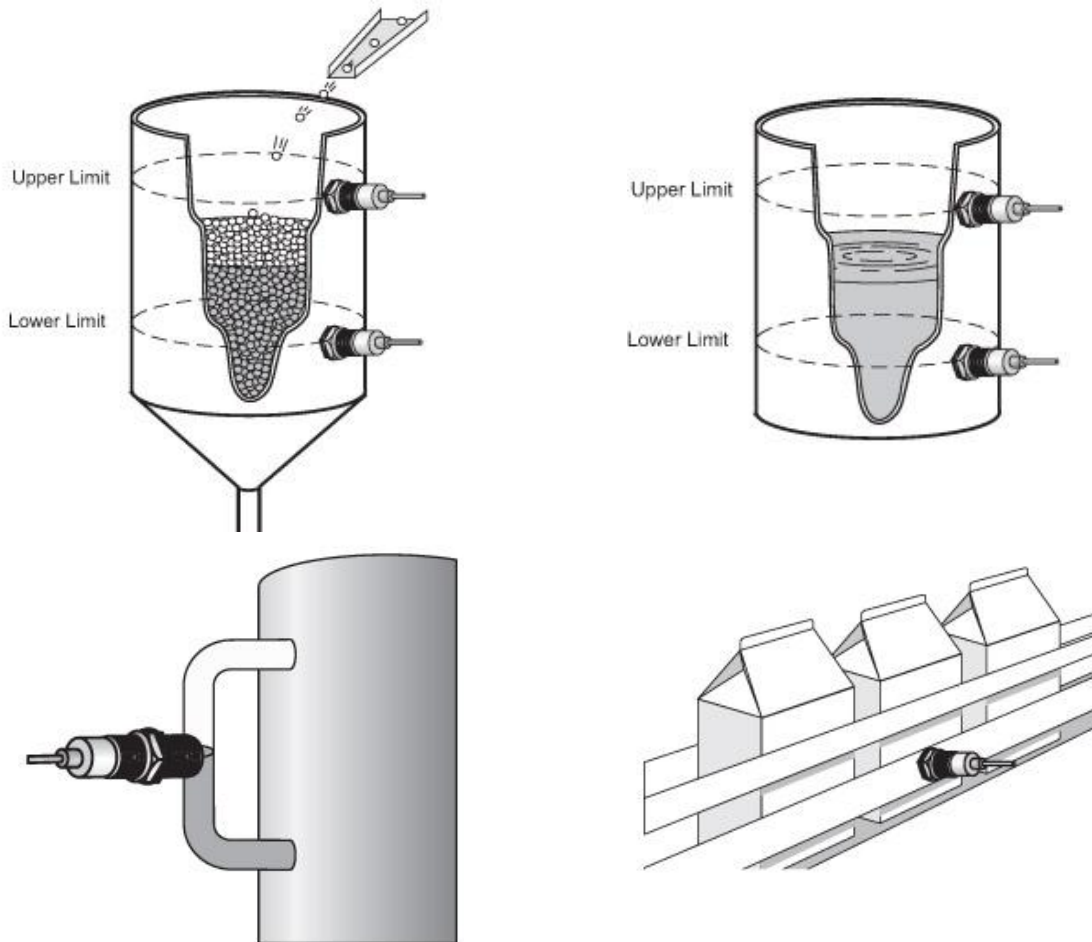
Shielded Vs. Unshielded Sensor Construction

Model CPH and CPU Capacitive Proximity Switches are available in either shielded or unshielded construction. The following briefly explains each and their typical use.

Shielded Sensor Construction: Sensors that are considered to be "shielded" are made with a metal band or shield surrounding the sensor probe. This focuses the electrical field with a straight-line path in front of the sensor resulting in a more concentrated field. The primary advantage of shielded sensors is that they can be mounted flush in surrounding material without causing a false trigger. Unshielded sensors cannot. Shielded sensors are usually best suited for detecting low dielectric materials as a result of the more concentrated electrostatic field.

Shielded Sensor Probe

Shield   Ferrite   Shield
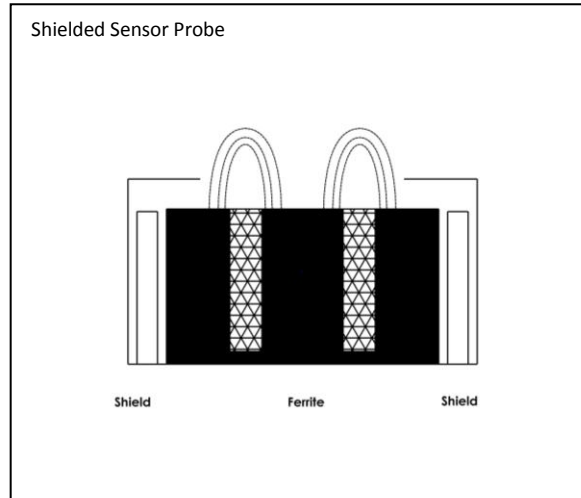
Unshielded Sensor Construction: Unshielded sensor construction does not have a metal band surrounding the probe and these sensors have a less concentrated field than shielded sensors. Unshielded sensors therefore have a spherical electrical field. As such these sensors are designed to touch the target product such as liquids or bulk powder and granular materials, including plastic pellets, sugar, flour, corn, sand, oil and water. Shielded Model CPH and CPU Capacitive Proximity Switches are also available. Contact the BlueLevel factory to discuss your application and find the correct sensor.

Unshielded Sensor Probe

Ferrite

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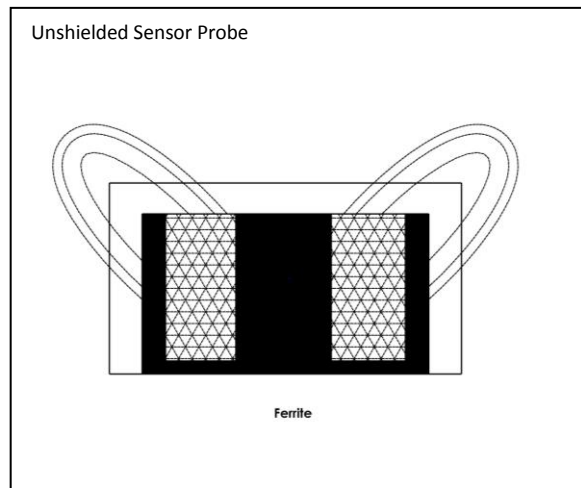
Sensitivity

The Model CPH and CPU Capacitive Proximity Switches have a 14-turn potentiometer that needs to be adjusted to suit the application. Turning the potentiometer clockwise will increase the sensitivity of the unit, counterclockwise will decrease the sensitivity. Adjustment is typical in all level sensing applications and is dependent upon the dielectric constant (ε_r) of the material to be sensed. Refer to the Model CPH / CPU Installation, Operation and Maintenance instruction manual for more information regarding sensitivity adjustment for level control applications.

Sensing Distance

Sensitivity adjustment for target detection applications will affect a change in the sensing distance as shown in the chart relating potentiometer adjustment (number of turns) to the % of specified nominal sensing distance (typically 30mm for unshielded Model CPH sensors; refer to Technical Data section in this document).
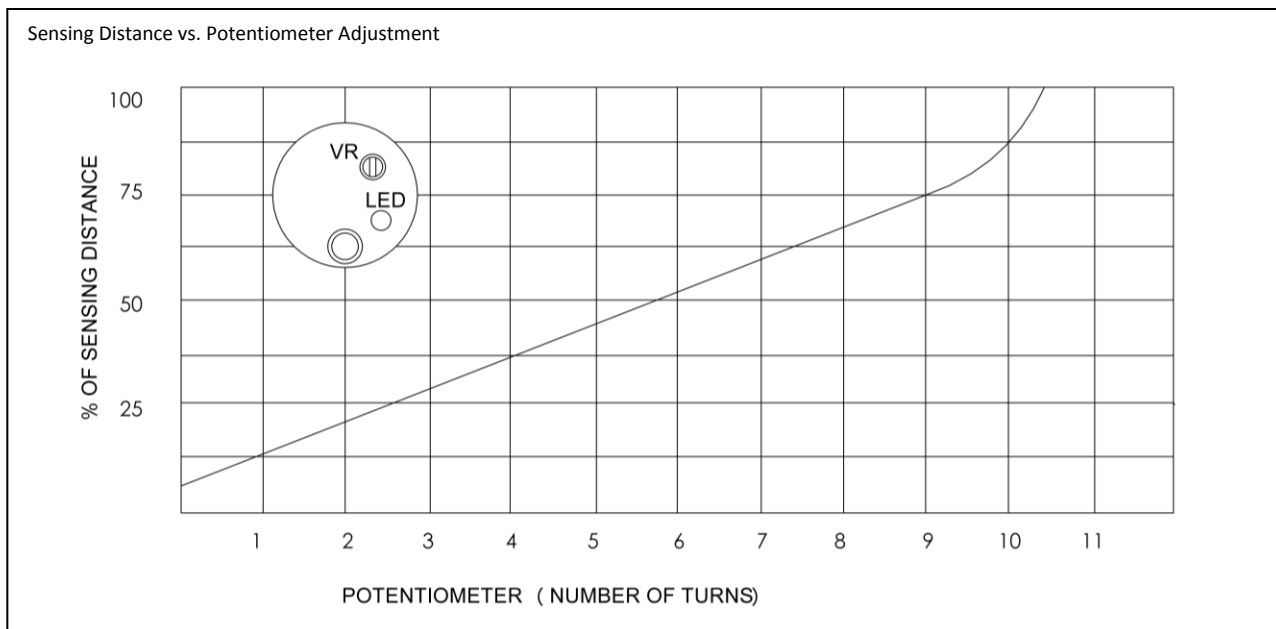
Sensing distance is important to understand when you desire to detect the presence of an object close to but not in contact with the sensor. The maximum sensing distance specification is based on using a 1mm thick square steel plate as an actuator, with a side length equal to 3 times the nominal sensing distance (S_n). The steel plate is grounded and tests performed according to CENELEC EN 50010. The largest possible sensing distance is defined as the nominal sensing distance with a tolerance ± 10%. If the target material to be detected is made from a different material or has a smaller diameter than the sensor, the sensing distance will be reduced.

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Materials

Typical materials that can be monitored using the Model CPH and CPU Capacitive Proximity Switches include a wide variety of clean liquids, and pulverized or granulated materials such as PVC powder, dyes, flour, sugar, powdered milk, etc.   If the material to be sensed is not metal or water, the sensing distance specified is reduced. The reduction factors are based on the dielectric constant of the material.

Target Material	Distance Reduction Multiplier
Acetone	0.75
Acrylic Resin	0.10 - 0.25
Alcohol	0.85
Ammonia	0.70 - 0.85
Bakelite	0.20
Celluloid	0.15
Cement Powder	0.25
Cereal	0.15 - 0.30
Epoxy Resin	0.15 - 0.35
Ethanol	0.85
Fly Ash	0.05
Flour	0.05
Gasoline	0.10
Glass	0.20 - 0.55
Marble	0.50
Nylon	0.20 - 0.30
Paper	0.10
Petroleum	0.05
Polyester Resin	0.15 - 0.50
Polyethylene	0.10
Polypropylene	0.15
PVC Resin	0.15
Porcelain	0.25 - 0.40
Powdered Milk	0.20
Press Board	0.10 - 0.30
Quartz Glass	0.20
Rubber	0.15 - 0.90
Salt	0.35
Sand	0.15 - 0.30
Soybean Oil	0.15
Styrene Resin	0.15
Sugar	0.15
Sulphur	0.15
PTFE	0.10
Water	1.0
Wood, Dry	0.10 - 0.40
Wood, Wet	0.60 - 0.85

Installation

BlueLevel Technologies Model CPH and CPU Capacitive Proximity Switches can be mounted using the provided mounting hardware or with optional accessories including our sensor mounting wells used for liquid level control applications. Consult the factory for availability of mounting accessories.

Refer to the Installation, Operation and Maintenance Instruction document supplied with the Model CPH or CPU for specific details and safety precautions.

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Features

Features that make the Model CPH / CPU the best choice for many material sensing applications include the following:

- All Model CPH and CPU Capacitive Proximity Switches are very compact in size [1" (30mm) diameter and overall length of just over 3" (80mm)] making them ideal for applications where space is very tight and where insertion length needs to be minimized or eliminated.

- Low purchase cost makes the Model CPH and CPU a high value affordable sensor. Call for your quote today!

- AC or DC (PNP or NPN) switches make the Model CPH very versatile. These units can switch up to 300mA in load current and are ideal for interfacing with PLC's and DCS control systems.

- The Model CPU is a universal 2-wire AC/DC switch providing even more versatility in a single unit.

- With a completely solidstate design there is no moving parts to wear out or break. A long life comes at no charge with every Model CPH and CPU unit.

- The Model CPH and CPU are flexible in their application, being capable of sensing liquids, powders and granular materials.

- Each Model CPH / CPU standard unit comes with a 6.5ft (2m) length prewired cable for easy connection. Other wiring options, such as standard connectors, may be available. Consult the factory.

- Shielded sensors can be mounted flush with the inside wall of a bin, while Unshielded sensors are minimally invasive.

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Options/Accessories

BlueLevel Technologies offers a variety of options and accessories for the Model CPH and CPU Capacitive Proximity Switches. These include Sensor Wells, Sight Glass Mounts and Flat and Angle Mounting Brackets. In addition, other accessory items may be available. Consult the factory for your mounting accessory needs.
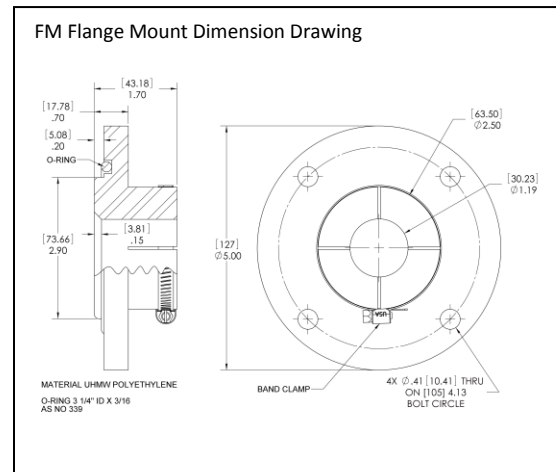
Sensor Wells

Sensor Wells are used to adapt round style proximity sensors to a wide variety of vessels for level detection application. Sensor Wells keep your vessels sealed before sensor installation as well as during sensor replacement. In addition, reliability and performance can be improved because the sensor is isolated from the process medium.

Available Sensor Well accessories include:
- FM: Flange Mount (bolts on via 4-bolt flange)
- PT: NPT Thread Mount (threads into pipe coupling)
- BH: Bulkhead Mount (through-hole mounting)
- CT: Conduit Type Mount (threads into conduit or pipe)
- WO: Weld-On Mount (for welding onto plastic tanks)

The **FM Flange Mount** (PN 474100) is a smooth bore mount for the Model CPH / CPU Capacitive Proximity Switches. It is fabricated using UMHW polyethylene. The O-Ring, with an OD of 3.46" (88.0mm) produces the seal and is supplied with the sensor well. The FM Flange Mount allows for a virtual flush mounting of the Model CPH / CPU sensors with a 0.20" (5.08mm) insertion distance. To be used with Shielded sensors only.


FM Flange Mount Dimension Drawing

The **CT Conduit Type Mount** (PN 474105) sensor well is fabricated from [1]Teflon®. This sensor well allows for the mounting of an M30 Model CPH / CPU Capacitive Proximity Switch sensor threads into a conduit or pipe with a 1¼" x 11.5NPT threaded connection. The sensor installs in the sensor well with the internal M30 x 1.5 threads within the well. To be used with shielded sensors only.


CT Conduit Type Mount Dimension Drawing

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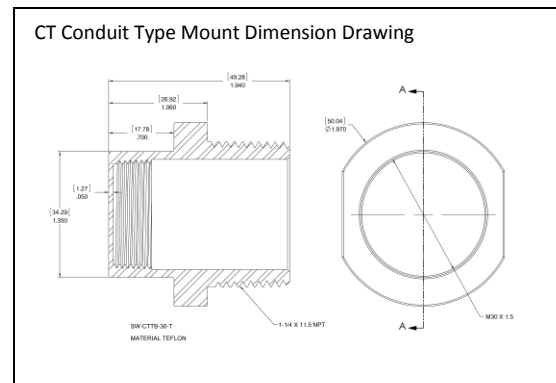
[1] Teflon is a registered trademark of E. I. DuPont De Nemores Company

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The **PT NPT Thread Mount** sensor wells are fabricated from either [2]Delrin® (PN 474110) or Teflon® (PN 474110-01) material. The Model CPH / CPU Capacitive Proximity Switches mount inside the smooth bore 30.1mm opening of the sensor well and are held in place by tightening the band clamp. The NPT thread mount is 1¼" and will thread into standard couplings mounted on the bin or tank at the level monitoring point. The **Weld Flange** accessory can be used to provide a 1¼" NPT process connection on a tank or bin. PT NPT Thread Mount sensor wells are typically used with unshielded sensors.

PT NPT Thread Mount Dimension Drawing
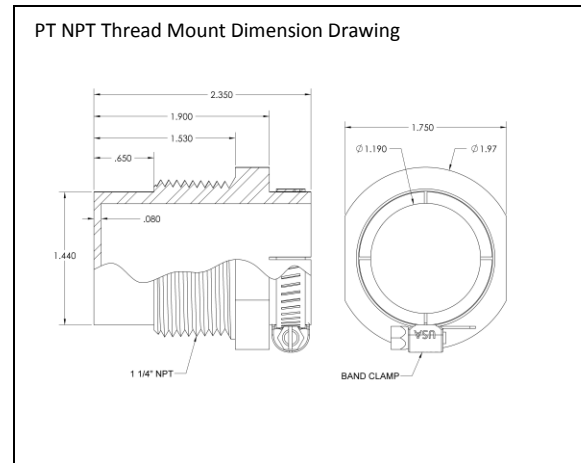
The **BH Bulk Head Mount** (PN 474115) sensor well is fabricated from Delrin® material and is available for mounting through an approximate 1½" hole in the bin or tank wall. Gaskets and mounting nuts are supplied for mounting with the 1½ x 12 UNF threads on the sensor well. The M30 sensor mounts inside the sensor well 30.1mm diameter smooth bore opening and is held in place by tightening the band clamp. The BH Bulk Head Mount sensor well is typically used with an unshielded sensor.

BH Bulk Head Mount Dimension Drawing
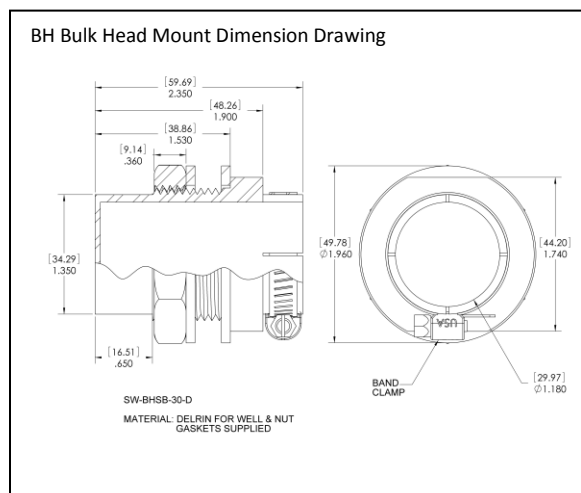
The **WO Weld-On Mount** sensor well is available fabricated from polyethylene (PN 474120) or polypropylene (PN 474120-01). This sensor well allows for mounting of the Model CPH / CPU Capacitive Proximity Switch onto a bin or tank by using a weld-on type sensor well. This sensor well is used with shielded sensors only.


WO Weld-On Mount Dimension Drawing

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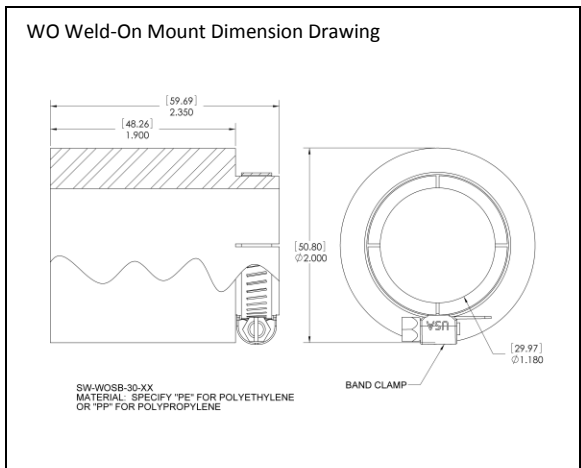
[2] Delrin is a registered trademark of the E. I. Dupont De Nemores and Company

The **Weld Flange** (PN 474125) accessory is a weld-on forged steel alloy 1¼" coupling that can be welded to bins and tanks in order to provide a 1¼" NPT process connection in which a **PT NPT Thread Mount** sensor well can be installed.

Weld Flange Dimension Drawing
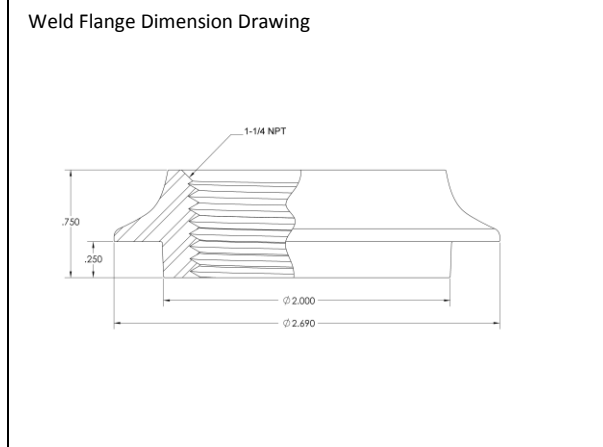
Sight Glass Mount

The Sight Glass Mount accessory allows for quick attachment of Model CPH / CPU Capacitive Proximity Switches to glass and plastic tubes for level detection. Often the Model CPH / CPU is used in pairs in order to detect the presence or absence of liquids in a sight glass attached to a tank in order to activate pumps and drains in process control applications. The Sight Glass Mount is fabricated of Delrin material with stainless steel fasteners. This accessory can be used with sight glasses with a diameter from ⅜" (9.5mm) to 1¾" (44mm). To be used with shielded sensors only.

Sight Glass Dimension Drawing
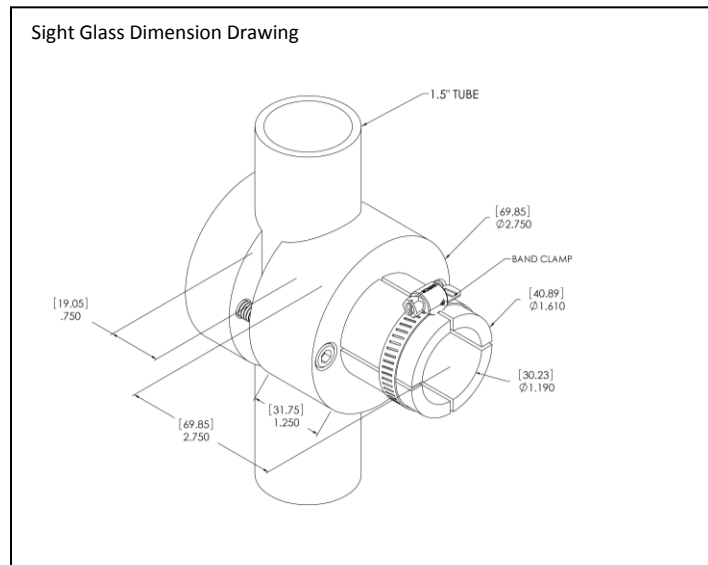
Benefits of the **Sight Glass Mount** (PN 474130) includes:
  - Quick and easy installation of level sensor to tanks with a sight glass for automation
  - Non-process material contact
  - Simple sensor change-out
  - Secure mounting

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Mounting Brackets

Flat and Angle Mounting Brackets are available. These mounting brackets are used in non-tank/bin applications and provide for maximum sensor adjustment without shimming or machinery equipment modification.

Flat Brackets are available in two styles, Slotted and Fixed.

The **Slotted Flat Brackets** provide for maximum adjustability and are manufactured out of either;
 - zinc-plated cold rolled steel (PN 475100), or
 - 303 stainless steel (PN 475100-01).

Slotted Flat Brackets
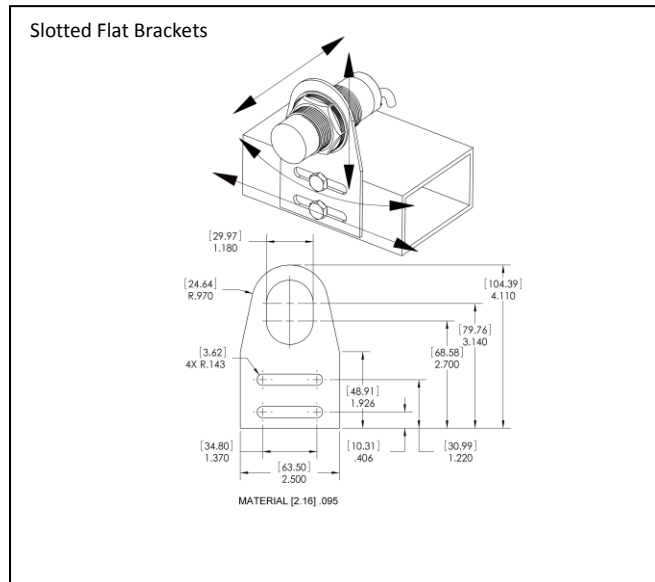
The **Fixed Flat Brackets** are similar in shape and size but offer very limited adjustability. They are also available in either;
 - zinc-plated cold rolled steel (PN 475105), or
 - 303 stainless steel (PN 475105-01).

Fixed Flat Brackets

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Right Angle Mounting Brackets are similar to the Flat Brackets except that they provide for right angle mounting. They are available in Slotted and Fixed.
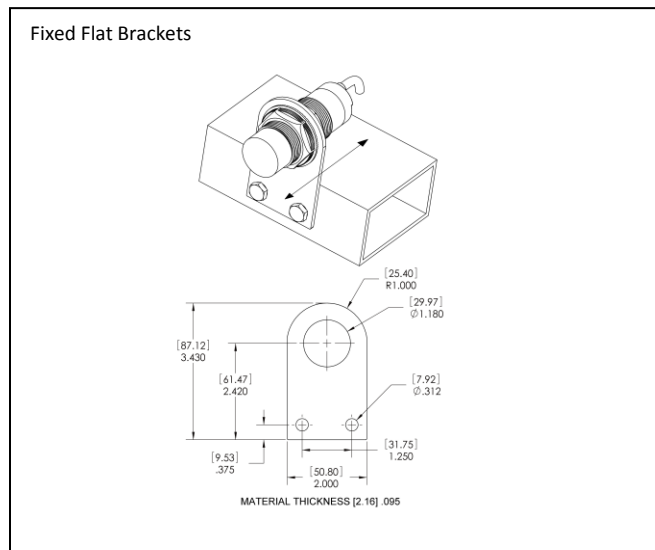
The **Slotted Right Angle Brackets** provide for maximum adjustability and are manufactured out of either;
 - zinc-plated cold rolled steel (PN 475110), or
 - 303 stainless steel (PN 475110-01).

Slotted Right Angle Bracket Dimensions

The **Fixed Right Angle Brackets** are similar in shape and size but offer very limited adjustability. They are also available in either;
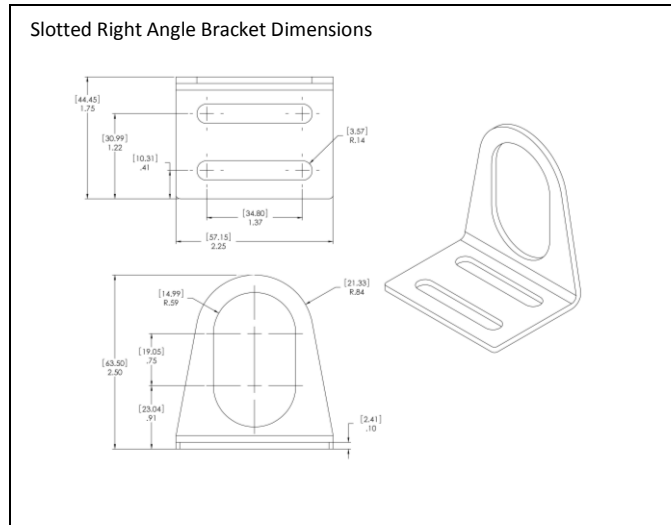 - 303 stainless steel (PN 475115).

Fixed Right Angle Bracket Dimensions

The **Next Level**
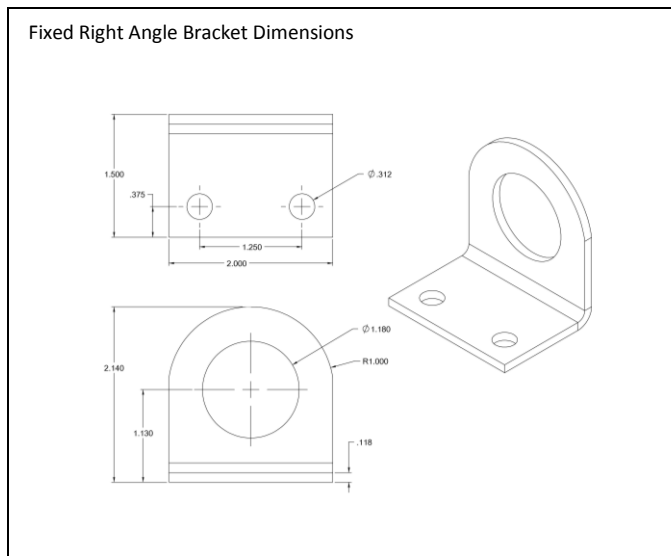
Ordering Information

Model CPH Capacitive Proximity Switch

Part Number Structure

4 7 – X X X 1 – 1 X X

Process Connection

       1 – M30

Approvals

       1 – Ordinary Locations

Output Configuration

       1 – N.O. (AC only)

       2 – N.C. (AC only)

       3 – N.O. / N.C. (DC only)

Supply/Wiring

       1 – AC 2-wire

       2 – DC NPN 4-wire (CONSULT FACTORY for Shielded)

       3 – DC PNP 4-wire (CONSULT FACTORY for Shielded)

Model

       1 – Unshielded
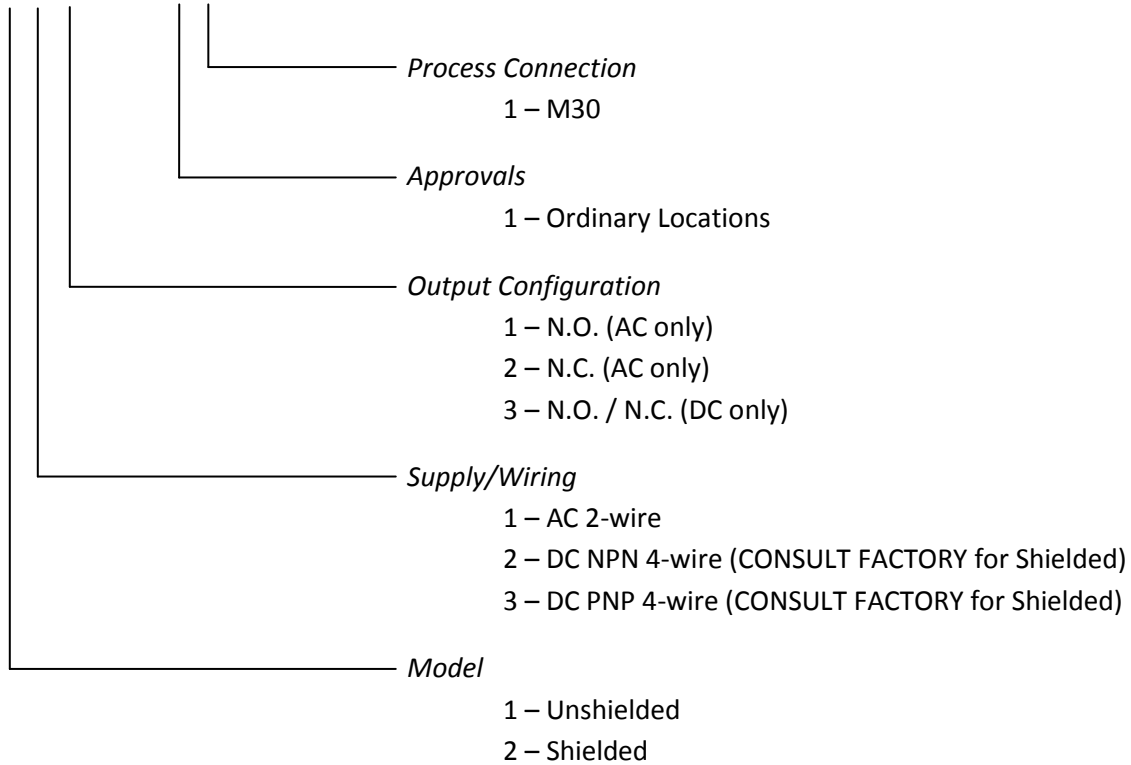
       2 – Shielded

Ordering Information

Model CPU Capacitive Proximity Switch
Part Number Structure

4 7 – X 4 X 1 – 1 X X

Process Connection
       1 – M30

Approvals
       1 – Ordinary Locations

Output Configuration
       1 – N.O.
       2 – N.C.

Supply/Wiring
       4 – AC/DC 2-wire

Model
       1 – Unshielded
       2 – Shielded

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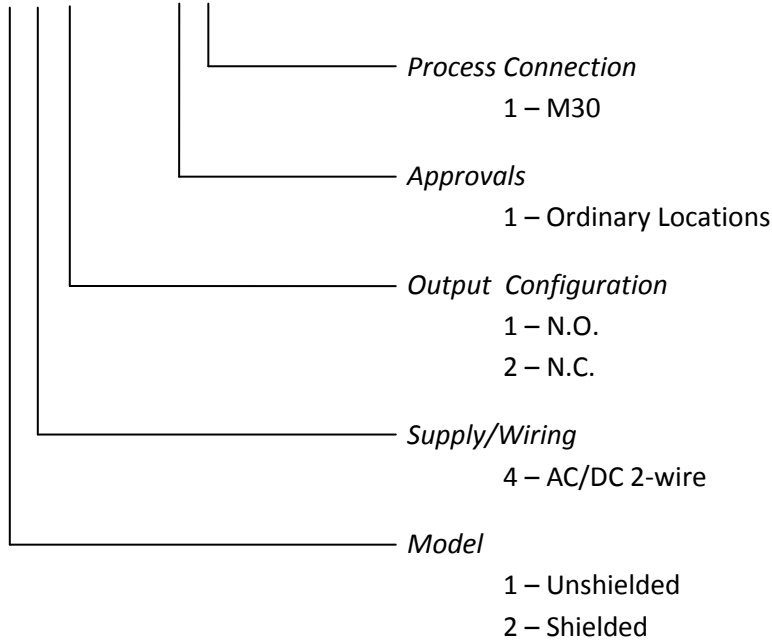
Technical Data

Model CPH 2-Wire AC Switches

Sensing Distance:	
Unshielded Sensors	30mm
Shielded Sensors	20mm
Operating Voltage:	20-250VAC
No Load Current:	< 2.5mA
Maximum Load Current:	300mA
Leakage Current:	< 2.5mA
Surge Current:	5A
Minimum Load Current:	5mA
Voltage Drop:	< 9VAC @ 300mA
Switching Frequency:	25Hz
Response Time:	10ms
Switching Hysteresis:	<15% (Sensing Range)
Repeat Accuracy:	< 5% (Sensing Range)
Housing Protection Category:	IP 67
Operating Temperature:	-13° F to +158° F (-25° C to +70° C)
Temperature Drift:	< 10% (Sensing Range)
Short Circuit Protection:	No
EMC:	
RFI	≤3V/m
EFT	≤1KV
ESD	≤4KV (contact)
Shock/Vibration:	IEC 60947-5-2, Part 7.4.1 and Part 7.4.2
Active Face Material:	PBT (Polybutylene Terephthalate)
Housing Material:	PBT
Certifications:	CE Mark
	$_c$CSA$_{us}$ Ordinary Locations

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Model CPH 4-Wire DC Switches

Sensing Distance:

Unshielded	2-30mm
Shielded	CONSULT FACTORY

Operating Voltage: 10-30VDC

Ripple: < 10%

No Load Current: < 10mA

Maximum Load Current: 300mA

Leakage Current: 0.01mA

Voltage Drop: < 2VDC

Switching Frequency: 100Hz

Response Time: 1.5ms

Switching Hysteresis: <15% (Sensing Range)

Repeat Accuracy: < 5% (Sensing Range)

Housing Protection Category: IP 67

Operating Temperature: -13° F to +158° F (-25° C to +70° C)

Temperature Drift: < 10% (Sensing Range)

Short Circuit Protection: Yes

Overload Trip Point: 220mA

Time Delay Before Availability: <25ms

EMC:

RFI	≤3V/m
EFT	≤1KV
ESD	≤4KV (contact)

Shock/Vibration: IEC 60947-5-2, Part 7.4.1 and Part 7.4.2

Active Face Material: PBT (Polybutylene Terephthalate)

Housing Material: PBT

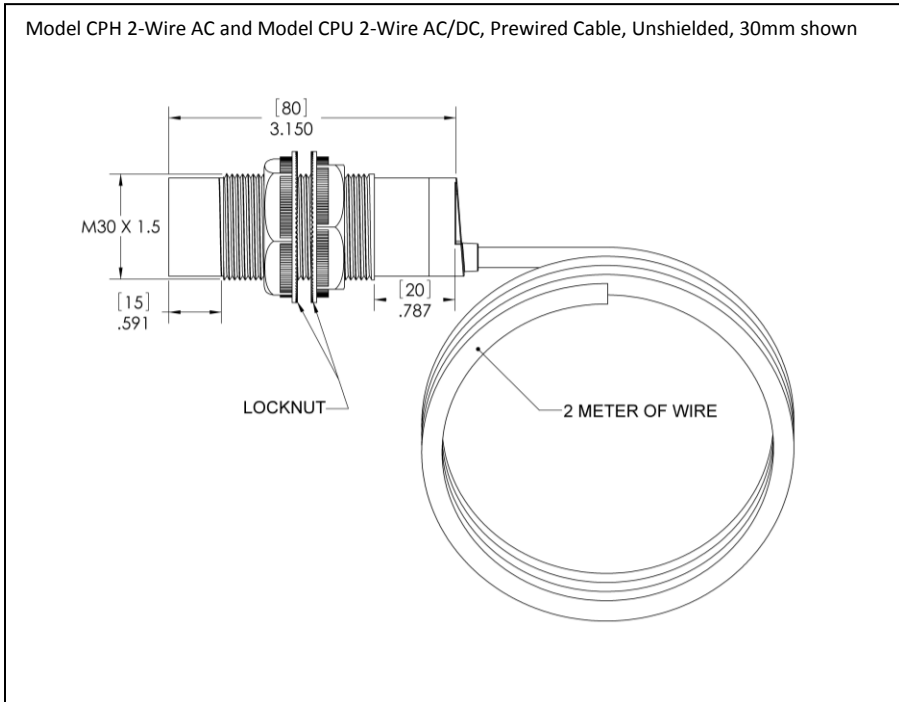Certifications: CE Mark

$_c$CSA$_{us}$ Ordinary Locations

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Model CPU 2-Wire AC/DC Switches

Sensing Distance:

Unshielded   2-20mm

Shielded   2-15mm

Operating Voltage: 20-250VAC/VDC

DC Ripple: < 10%

No Load Current: < 2.5mA

Maximum Load Current: 200mA

Leakage Current: < 2.5mA

Voltage Drop: ≤ 10VAC / 8VDC

Switching Frequency: 25Hz (AC) / 40Hz (DC)

Response Time: 10ms

Switching Hysteresis: <15% (Sensing Range)

Repeat Accuracy: < 1% (Sensing Range)

Housing Protection Category: IP 67

Operating Temperature: -13° F to +158° F (-25° C to +70° C)

Temperature Drift: < 15% (Sensing Range)

EMC:

RFI   ≤3V/m

EFT   ≤1KV

ESD   ≤4KV (contact)

Shock/Vibration: IEC 60947-5-2, Part 7.4.1 and Part 7.4.2

Active Face Material: PBT (Polybutylene Terephthalate)

Housing Material: PBT

Certifications: CE Mark

$_c$CSA$_{us}$ Ordinary Locations

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Dimensions

Model CPH 2-Wire AC and Model CPU 2-Wire AC/DC, Prewired Cable, Unshielded, 30mm shown

BlueLevel Technologies, Inc.
3778 Timberlake Drive, Richfield, OH 44286
Ph: 330-523-5215 | Fx: 330-523-5212

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