

# Sensors

Proximity, Photoelectric, and Ultrasonic Sensors, Limit Switches, Pressure Sensors, Machine Safety, Encoders, RFID, and Machine Cabling



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# Degrees of protection provided by enclosures

## IP code

1

Degrees of protection against the penetration of solid bodies, the penetration of water, and the access of personnel to live parts

The European standard EN 60529 dated October 1991, IEC publication 529 (2<sup>nd</sup> edition - November 1989), defines a coding system (IP code) for indicating the degree of protection provided by electrical equipment enclosures against accidental direct contact with live parts and against the ingress of solid foreign objects or water. This standard does not apply to protection against the risk of explosion or conditions such as humidity, corrosive gasses, fungi or vermin. Certain equipment is designed to be mounted on an enclosure which will contribute towards achieving the required degree of protection (for example, control devices mounted on an enclosure). Different parts of the equipment can have different degrees of protection (for example, an enclosure with an opening in the base). Standard NF C 15-100 (May 1991 edition), section 512, table 51 A, provides a cross-reference between the various degrees of protection and the classification of environmental conditions, relating to the selection of equipment according to external factors. Practical guide UTE C 15-103 contains tables showing the specifications required for electrical equipment (including minimum degrees of protection), according to the locations in which they are installed.

### IP ●●● code

The IP code contains **2 characteristic numerals** (for example, **IP 55**) and may include **an additional letter** when the actual protection of personnel against direct contact with live parts is better than that indicated by the first numeral (for example, IP 20C). Any characteristic numeral which is unspecified is replaced by an X (e.g. IP XXB).

#### 1<sup>st</sup> characteristic numeral:















corresponds to protection of the equipment against penetration of solid objects and protection of personnel against direct contact with live parts.

#### 2<sup>nd</sup> characteristic numeral:

corresponds to protection of the equipment against penetration of water with harmful effects.

#### Additional letter:

corresponds to protection of personnel against direct contact with live parts.

Protection of the equipment		Protection of personnel	Protection of the equipment		Additional letter:	
<b>0</b>	Non-protected	Non-protected	<b>0</b>	Non-protected	<b>A</b>	With the back of the hand.
<b>1</b>	 Protected against the penetration of solid objects having a diameter greater than or equal to 50 mm.	Protected against direct contact with the back of the hand (accidental contacts).	<b>1</b>	 Protected against vertical dripping water, (condensation).	<b>B</b>	With the finger.
<b>2</b>	 Protected against the penetration of solid objects having a diameter greater than or equal to 12.5 mm.	Protected against direct finger contact.	<b>2</b>	 Protected against dripping water at an angle of up to 15°.	<b>C</b>	With a Ø 2.5 mm tool.
<b>3</b>	 Protected against the penetration of solid objects having a diameter greater than or equal to 2.5 mm.	Protected against direct contact with a Ø 2.5 mm tool.	<b>3</b>	 Protected against rain at an angle of up to 60°.	<b>D</b>	With a Ø 1 mm wire.
<b>4</b>	 Protected against the penetration of solid objects having a diameter greater than or equal to 1 mm.	Protected against direct contact with a Ø 1 mm wire.	<b>4</b>	 Protected against splashing water in all directions.		
<b>5</b>	 Dust protected (no harmful deposits).	Protected against direct contact with a Ø 1 mm wire.	<b>5</b>	 Protected against water jets in all directions.		
<b>6</b>	 Dust tight.	Protected against direct contact with a Ø 1 mm wire.	<b>6</b>	 Protected against powerful jets of water and waves.		
			<b>7</b>	 Protected against the effects of temporary immersion.		
			<b>8</b>	 Protected against the effects of prolonged immersion under specified conditions.		

# Degrees of protection provided by enclosures

## IK code

1

### Degrees of protection against mechanical impact

The European standard EN 50102 dated March 1995 defines a coding system (IK code) for indicating the degree of protection provided by electrical equipment enclosures against external mechanical impact.

Standard NF C 15-100 (May 1991 edition), section 512, table 51 A, provides a cross-reference between the various degrees of protection and the environmental conditions classification, relating to the selection of equipment according to external factors.

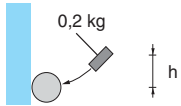
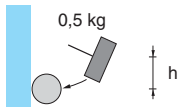

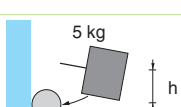
Practical guide UTE C 15-103 contains tables showing the specifications required for electrical equipment (including minimum degrees of protection), according to the locations in which they are installed.

### IK ●● code

The IK code comprises **2 characteristic numerals** (e.g. IK 05).

### 2 characteristic numerals:

corresponding to a value of impact energy.

		h (cm)	Energy (J)
00	Non-protected		
01		7.5	0.15
02		10	0.2
03		17.5	0.35
04		25	0.5
05		35	0.7
06		20	1
07		40	2
08		30	5
09		20	10
10		40	20

# Degrees of protection provided by enclosures

## NEMA and UL classification



The enclosures provide protection for the equipment against environmental conditions and help protect personnel against the risk of incidental contact with the equipment. The following classifications (Types) are required according to the required uses and descriptions:

Type	Use	Description
1	Indoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt.
2	Indoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, drips and gentle splashes of non-corrosive liquids.
3	Indoor and outdoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, rain, sleet, snow, windblown dust and resists the formation of ice on the outside.
3R	Indoor and outdoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, rain, sleet, snow and resists the formation of ice on the outside.
3S	Indoor and outdoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, rain, sleet, snow and windblown dust. The external mechanism must continue to work even when layers of ice are formed.
4	Indoor and outdoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, rain, sleet, snow, windblown dust, splashes and hose-directed water and resists the formation of frost on the outside.
4x	Indoor and outdoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, rain, sleet, snow, windblown dust, splashes, hose-directed water and resists corrosion and the formation of ice on the outside.
5	Indoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, settling airborne dust, lint, fibers, flyings, drips and gentle splashes of non-corrosive liquids.
6	Indoor and outdoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, rain, sleet, snow, hose-directed water, the entry of water during occasional temporary submersion to a limited depth and resists the formation of ice on the outside.
6P	Indoor and outdoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, rain, sleet, snow, hose-directed water, the entry of water during prolonged submersion to a limited depth and resists corrosion and the formation of ice on the outside.
12	Indoor use. (without knockouts).	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, dust, fluff, fibers, particles in suspension, drips and gentle splashes of non-corrosive liquids as well as gentle splashes or leaks of oil and non-corrosive coolants.
12K	Indoor use. (enclosures with pre-routing).	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, dust, lint, fibers, flyings, drips and gentle splashes of non-corrosive liquids as well as gentle splashes or leaks of oil and non-corrosive coolants.
13	Indoor use.	The enclosure provides protection for personnel against incidental contact with the internal equipment and protects said equipment against dirt, dust, lint, fibers flyings and the spraying, splashing, and seepage leaks of water, oil or non-corrosive coolants.

Note: The above recommendations aim to explain the NEMA and UL classifications, but are not the official texts of NEMA or UL.

The exact definitions provided by the organizations are those in standards NEMA 250 and UL 50E.

# Wire size chart

## AWG to metric



Comparison of AWG and Metric Wire Sizes											
Conduit				Resistance at 20 °C		Conduit				Resistance at 20 °C	
AWG Size	Dia., mm	Area, mm <sup>2</sup>	Dia., in.	Ω/ft	Ω/m	AWG Size	Dia., mm	Area, mm <sup>2</sup>	Dia., in.	Ω/ft	Ω/m
29			.01126	.08180	.2684	13	1.900	2.8353	.07480	.001863	.006081
28	.316	.0779	.01240	.06743	.2212	12	2.000	3.1416	.07874	.001673	.005488
			.01264	.06491	.2130				.08081	.001588	.005210
27	.355	.0990	.01398	.05309	.1742	11	2.120	3.5299	.08346	.001489	.004884
			.01420	.05143	.1687		2.340	3.9408	.08819	.001333	.004375
26	.400	.01257	.01575	.04182	.1372				.09074	.001260	.004132
			.01594	.04082	.1339	10	2.360	4.3744	.09291	.001201	.003941
25	.450	.1590	.01772	.03304	.1084		2.500	4.9087	.09843	.001071	.003512
			.01790	.03237	.1062				.1019	.0009988	.003277
24	.500	.1963	.01969	.02676	.08781	9	2.650	5.5155	.1043	.0009528	.003125
			.02010	.02567	.08781		2.800	5.1575	.1102	.0008534	.002800
23	.560	.2463	.02205	.02134	.07000				.1144	.0007924	.002500
			.02257	.02036	.06679	8	3.000	7.0686	.1181	.0007343	.002439
22	.630	.3117	.02480	.01686	.05531		3.150	7.7931	.1240	.0006743	.002212
			.02535	.01614	.05531				.1285	.0006281	.002061
21	.710	.3969	.02795	.01280	.04201	7	3.350	8.8141	.1319	.0005662	.001956
			.02846	.01280	.04201		3.550	9.8980	.1398	.0005309	.001742
20	.750	.4418	.02953	.01190	.03903				.1443	.0004981	.001634
	.800	.5027	.03150	.01045	.03430	6	3.750	11.0447	.1476	.0004758	.001561
			.03196	.01015	.03331		4.000	12.5664	.1575	.0004182	.001372
19	.850	.5675	.03346	.009261	.05038				.1620	.0003952	.001296
	.900	.6362	.03543	.008260	.02642	5	4.250	14.1863	.1673	.0003704	.001215
			.03589	.008051	.02642		4.500	15.9043	.1772	.0003304	.001084
18	.950	.7088	.03740	.007414	.02432				.1819	.0003134	.001028
	1.000	.7854	.03937	.006991	.02195	4	4.750	17.7205	.1870	.0002966	.0009729
			.04030	.006386	.02096		5.000	19.6350	.1968	.0002676	.0008781
17	1.060	.8825	.04173	.005955	.01954				.2043	.0002485	.0008152
	1.120	.9862	.04409	.005334	.01750	3	5.600	24.6301	.2205	.0002134	.0007000
			.04526	.005063	.01661				.2294	.0001971	.0006466
16	1.180	1.0936	.04646	.004805	.01577	2	6.300	31.1725	.2480	.0001686	.0005531
	1.250	1.2272	.04921	.004282	.01405				.2576	.0001563	.0006128
			.05082	.004016	.01317	1	7.100	39.5919	.2795	.0001327	.0004355
15	1.320	1.3685	.05197	.003840	.01260				.2893	.0001239	.0004065
	1.400	1.5394	.05512	.004016	.01317	1/0	8.000	50.2655	.3150	.0001045	.0003430
			.05707	.003414	.01045				.3249	.00009285	.0003223
14	1.500	1.7671	.05906	.002974	.009756	2/0	9.000	63.6173	.3543	.00008260	.0002710
	1.600	2.0106	.06299	.002526	.008286				.3648	.00007793	.0002557
			.06408	.002315	.007596	3/0	10.000	78.5398	.3937	.00006691	.0002196
13	1.700	2.2698	.06693	.002315	.007596				.4096	.00006182	.0002195
	1.800	2.5447	.07087	.002065	.006775	4/0			.4600	.00004901	.0001608
			.07196	.002003	.006571		11.800	109.3588	.4646	.00004805	.0001577

**A**

1

<b>Actuator</b>	An actuator is the mechanism of the switch or enclosure which, when moved as intended, will operate the contacts, i.e. lever arm, plunger, etc.
<b>Adjustable Length</b>	Used where length of arm required is not known when devices are ordered or where length requirements vary.
<b>Adjustable Sensitivity</b>	The ability of the sensor to discriminate between different levels of light incidence on the receiver. Used primarily to black out background objects, discriminate between materials, or transparent objects.
<b>Alignment</b>	Relation of the emitter and receiver. Proper alignment is necessary to achieve maximum sensitivity to objects being sensed.
<b>Ambient Light</b>	Light that is present in a given area; e.g., inside, outside, incandescent, or fluorescent. In some cases, ambient light may set off incandescent photoelectric controls.
<b>Ambient Light Rejection</b>	<p>There are basically 3 different ways for the receiver to differentiate the emitter's signal from the ambient light. As a practical consideration in setting up a system, it is advised to direct the receiver away from strong external light sources, such as the sun or industrial lighting.</p> <ol style="list-style-type: none"> <li>1. Modulation - Pulsed light is different from continuous ambient light.</li> <li>2. Filters - Filters block most of the visible light spectrum so that a modulated signal is more easily detected.</li> <li>3. Focal Arrangement - Lenses are used at the emitter and receiver to focus the beam for optimum signal transmission. This lens arrangement actually makes the image of the emitter focus on the receiver just like a camera would focus an image on a sheet of film.</li> </ol>
<b>Amplifier</b>	A device that enables an input signal to control an output signal of that device.
<b>Analog Sensors</b>	The output current or voltage is proportional to the target distance or surface.
<b>Angular Adjustable</b>	Allows for the fine adjustment of the lever arm angle after the lever arm has been tightened on the lever arm shaft. Used where lever arm adjustment is critical.
<b>Application Selector</b>	Allows the user to select a sensor by identifying application criteria.
<b>Axial Approach</b>	When a target to be detected approaches the sensing face "head on".

**B**

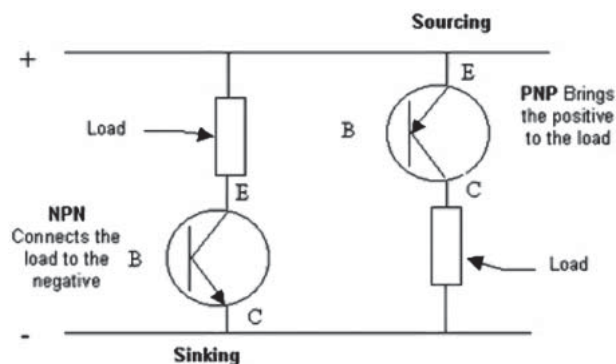
<b>Background Suppression</b>	Proximity (diffuse/technology) sensing mode that eliminates the influence of a background behind the target to be sensed. Also results in practical elimination of the influence of texture and color on the sensing distance.
<b>Ball Bearing Roller</b>	Used where abrasive dusts, such as in cement mills, would cause undue wear of standard rollers. Also used with high-speed cams.

<b>Barrier Device</b>	An intrinsically safe barrier inherently limits the current and voltage that can be transmitted into the hazardous location and has redundant circuitry in case of component failure.
<b>Beam Pattern</b>	In the operation of thru-beam and retroreflective sensors, a degree of deviation from absolute alignment of the emitter and receiver (within which the beam intensity is sufficient to activate the receiver) determines the beam pattern.
<b>Break-Before-Make</b>	The normally closed contact opens before the normally open contact closes.

## C

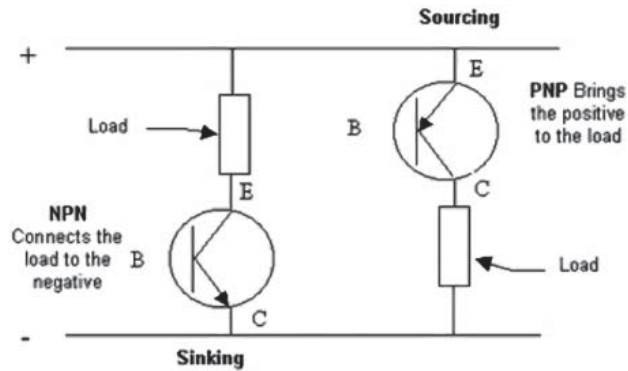
<b>Cable Operated</b>	Used an emergency stop around conveyors and large machines. A cable is attached to the lever arm and is strung around the conveyor or machine so that anyone can shut the machine off by pulling the cable that operates the switch. Slack cable types use a forked lever arm for maintained contact switches and straight arm for spring return (momentary) switches. Taut cable types use a special mechanism which applies a tension on the cable, keeping the cable tight and gives an indication of when the cable is pulled or is loose or cut.
<b>Cam</b>	Machine part or component that applies force to a switch actuator causing the actuator to move as intended. Also called "dog".
<b>Cam Track</b>	The cam track is the distance from the switch mounting surface to a specified point on the actuator.
<b>Capacitive Coupling</b>	Capacitance is the ability of a dielectric material (non-conductor of electricity) to store energy when a difference of potential exists between two conductors. (A conductor is a material that offers little resistance to the flow of an electrical current.)
<b>Cat Whisker</b>	These position switches are suitable for use on conveyors to detect or count parts or as a hand operated safety device. Wobble stick and cat whisker position switches can be operated from any direction. A non-metallic wobble stick such as Delrin or Nylon should be used where a wire extension might scratch the part being detected. Cat whisker switches are used to detect very light weight parts.
<b>CCW</b>	Counterclockwise only (for lever type limit switches).
<b>Coil Spring</b>	Used where object to be detected may not be in a straight line with a standard arm, allowing the switch to be actuated without damaging the arm.
<b>Color Mark Detector</b>	A sensor designed to differentiate between different colored marks, or between a color mark and the background color it appears on. The contrast between the two marks, not the true color of the mark, is used for this detection. The color mark detector is available with either Red or Green LED emitters for this purpose.
<b>Color Registration/ Mark Detection</b>	Proximity (diffuse) sensing mode that detects the contrast between two colors on a surface.

<b>Color Registration Sensor</b>	The color registration sensor is a highly specialized diffuse proximity sensor that has the ability to detect fine changes in contrast on a surface. But unlike the standard diffuse proximity sensor, this type of unit uses a powerful lens system and must be positioned at a specific focal distance from the target.
<b>Complementary Outputs</b>	Sensors with both N.O. and N.C. outputs that change state simultaneously.
<b>Conducting Path</b>	Includes all terminals, inserts, stationary contact material resistance, movable contact material resistance, movable blade assembly, and any other parts in the conducting circuit.
<b>Constant Current Source</b>	Source which provides constant current to the output of a switching transistor, and allows the voltage at the output to vary from zero up to the supply voltage.
<b>Continuous Rating</b>	Indicates the load that the contacts can carry continuously (thermal rating) without making or breaking the circuit.
<b>Conveyor Side Guide</b>	Conveyor belts which move heavy materials may have undesirable lateral movements which, if significant enough, may cause damage to the belt, equipment or product on the conveyor. These conveyors may use one or more limit switches to detect this lateral movement of the belt and stop the belt or sound an alarm. Two types of devices are available for this application: a wobble stick with a special roller, and an arm with a similar roller for use with lever type switches.
<b>Current Consumption</b>	Maximum amount of current required to properly operate a sensor.
<b>Current Sinking</b>	NPN output - an output type such that when it is ON, current flow is from the load into the device's output, then to ground. Output is normal high. The sensor "sinks" current from the load through the sensor to ground. The load is connected between the positive lead of the supply and the output lead of the sensor.



**Current Sourcing**

PNP output - an output type such that when it is ON, current flow is from the device into the load. Output is normally low. The sensor "sources" current to the load. The load is connected between the output lead and the negative ground lead of the supply. Considered safer than NPN outputs due to the way current flows when wired up.



1

**CW**

Clockwise only (for lever type limit switches).

**D****Dark Operation (Mode)**

Dark mode output is energized when the target is present (proximity output is energized when target is not detected).

Output mode that will result in an output from a device when light from the emitter is not being received upon the receiver. The beam is being interrupted, thus creating an output.

**Detectable Object**

Refers to the requirements of an object size, reflection qualities, light transmission properties, in order for that object to be detected by the photoelectric sensor.

**Differential**

The distance between the operating point and the release point as the target is moving away. It is expressed as either a linear dimension or in number of degrees. The distance between the operating point where the target enters the sensing field (sensor energizes) to the release point (sensor de-energizes).

All discrete sensing technologies must have a differential. In some technologies, differential occurs as a by-product of the basic laws of physics; however, in other technologies it must be manufactured through additional circuitry.

Photoelectrics - The distinctive property of a photoelectric sensor that results in the operation point being different from the release point. This distance is expressed as a % of the total sensing distance of the photoelectric sensor. It is the distance difference between the operating point when approaching the photoelectric and the release point when moving away from the photoelectric.

**Diffuse**

Where the unit senses the light directly from the target. The emitter and receiver are in the same housing, the same as retroreflective; however, the receiver is more sensitive to the weaker light that is diffused by the surface of the target.

**DIN**

Stands for Deutsches Institute fur Normung. West German agency which is responsible for standardization of industrial parts.

1

<b>Direct (positive) Opening Contact</b> ⊖	(Also known as positive opening contacts in Europe) - A normally closed (N.C.) contact element coupled with the switch actuator via a nonresilient (non-elastic) member so that full contact opening is obtained when the actuator is moved through the direct (positive) opening travel by applying a direct (positive) opening force against the N.C. moveable contact assembly. The contact element will shear open in the event of sticking contacts or broken springs. Available on both snap action contacts and slow make and break contacts. Proper fusing of the control circuit is required. Most direct opening contacts offered meet IEC 947-5-1 requirements for positive opening contacts.
<b>Direct Opening Contacts</b>	Normally closed contacts that are physically forced open when the actuator is operated. (Also see Direct (positive) Opening Contacts.)
<b>Directional Angle</b>	The angular range within which an emitter, receiver, emitter/receiver pair or reflector can be rotated or shifted about on the optical axis and still have the photoelectric properly operate.
<b>Dog</b>	Machine part or component that applies force to switch actuator causing actuator to move as intended. Also called "Cam".
<b>Double Break</b>	Contacts open circuit at two points.
<b>Double Pole Double Throw (DPDT)</b>	Switches that make and break two separate circuits. This circuit provides a normally open and normally closed contact for each pole.
<b>Dry Circuit</b>	A circuit which has a very low power level, where the power is insufficient to break through the oxide layer present on most hard (silver) contacts.
<b>E</b>	
<b>Effective Sensing Distance</b>	This is the actual sensing distance realized by the actual sensor that you take out of the box and install in the actual application. The effective sensing distance will be no less than the usable sensing distance, and is usually closer to the nominal in average circumstances.
<b>Emitter</b>	A device that emits light when an electric current is passed through it. Emitters can give off visible light (red) but the majority used for industrial applications emits invisible electromagnetic waves (infrared).
<b>Excess Gain Ratio</b>	Maximum light available at a given distance. Level of light intensity needed to operate the photoelectric sensor.
<b>F</b>	
<b>Fiber Optic Cables</b>	The use of transparent glass or plastic fibers to transmit light by internal reflection.
<b>Film Resistance</b>	It is well known that silver accumulates a surface resistance due to chemical reaction with its environment. The most common reaction is with sulfur and oxygen that creates a sulfide and an oxide of silver. Such a surface is known to have some resistance that can be read with a low voltage instrument such as an ohmmeter. These surfaces, however, have the characteristic of being self-cleaning. When current is passed through such a surface, it creates heat which in turn, reduces the compound to pure silver again and restores the contact to a low ohmic value. This is the reason that has made silver such a good selection for contact material.

<b>Flat Steel</b>	Primarily used where high temperatures could cause standard arms to soften and therefore not provide a secure grip on the lever arm shaft, causing arm slippage. These arms are also chosen where the arm needs to be bent slightly to line up with existing cams.
<b>Flush Mounting Type</b>	Flush mounting switches are used where a machine cavity is provided and the standard position switch box is not required. A gasket on the flush plate prevents entrance of contaminants. Wiring is brought in through the machine cavity.
<b>Focusable Diffuse</b>	A diffuse reflective photoelectric sensor that either allows the optical axis of the emitter and receiver to be adjusted to a focal point or it utilizes an aperture to focus on an area in front of the sensor.
<b>Forked Type</b>	Used with maintained contact lever arm type switches. With rollers on the same side, one cam trips and resets the switch. With rollers on opposite sides, one cam will trip the switch and a second cam will reset the switch.
<b>Free Position</b>	The initial position of the actuator when there is no external force (other than gravity) applied on the actuator. Also called "Initial Position" and "Normal Position".

## H

<b>Hazardous Locations</b>	Hazardous locations are those areas that may have flammable gases or combustible dusts or fiber present in quantities sufficient to produce an explosive or ignitable mixture. These gases, dusts and fibers may always be present or may only be present in abnormal situations. The National Electrical Code (NEC) describes these areas in Articles 500 through 503 and divides them into three types of categories: Class, Group, and Division.
<b>Hermetically Sealed Contacts</b>	Sealed in a glass envelope with an inert gas to keep dirt out and prevent oxidation of the contact tips.
<b>Hysteresis</b>	The distance between the operating point and the release point as the target is moving away in order to make a precise determination of target presence without factors of the environment intervening to create a noisy output signal. See Differential.

## I

<b>Inductive</b>	Inductive sensors detect metal and will not be fooled by non-metallic targets. This is a highly accurate type of technology. If you were able to control what metal objects pass in front of the inductive sensor, it would be very accurate in detecting only those metal objects and not be fooled by any other non-metallic objects passing in front of it.
<b>Inductive (Pilot Duty) Ratings</b>	Indicates the non-motor inductive load, such as the contactors, relays and other remotely controlled devices that the contacts can make or break. These ratings are based on a 35% power factor for AC.
<b>Inductive Proximity</b>	A no-touch sensor which determines if a metal target is present or not and turns an output ON or OFF. Detects eddy currents induced in the metal target by the switch.

1

<b>Initial Position</b>	Position of switch actuator when no external force (other than gravity) is applied to the actuator (see Free Position).
<b>Interface</b>	Translates the presence of a target into an electrical signal.
<b>Internal Reflection</b>	Internal reflection occurs whenever a light ray strikes the surface of a medium whose refractive index is less than that of the medium in which the light is traveling. An example of this is a light source in water, where light is internally reflected from the surface of air. The amount of light that is reflected depends upon the angle at which it hits the surface. The critical angle is 49°. At this angle the ray of light is completely contained within the medium.
<b>Intrinsically Safe</b>	Equipment and wiring which is incapable of releasing sufficient energy under any conditions to cause an ignition of the atmosphere in the specified hazardous location.
<b>Isolated Contacts</b>	Single-pole double throw (SPDT) contacts with four terminals that have two isolated contact bars mechanically linked. No polarity restrictions apply. Different (isolated) power supplies can also be applied.
<b>L</b>	
<b>Lateral Approach</b>	When the target to be detected approaches the sensing face from the side (slide by).
<b>Leakage Current</b>	The amount of current that flows through, or leaks from, the output of an energized device when the device is in the OFF state. Most common problem involves leakage current when a device is wired as an input to a programmable logic controller. Leakage current should be less than 1.7mA.
<b>LED (Light Emitting Diode)</b>	Solid state device that produces visible red, green or yellow light or invisible infrared light radiation.  Indicator on a sensor that emits visible light to show operation of the unit. Infrared types are used for emitters. Red or green types are used also as emitters in special applications (polarized, plastic fiber optics, etc.).
<b>Length of Lever Arm</b>	Length of arm is determined by the distance between the cam and the position switch shaft. Length of arm is defined as the distance from the center of the roller to the center of the shaft. Where permissible, the recommended length of the arm is 1.5", since a longer arm is more likely to overshoot if the lever arm is allowed to snap back.
<b>Lever Type</b>	A passing cam operates the lever arm, which in turn rotates a shaft and operates the switch contacts. The switch may be spring return momentary contact or maintained contact.
<b>Lever Type With Arm</b>	Have the lever arm attached to the head assembly from the factory. This arm is not intended as a replaceable component. Used where a wide variety of arms is not required nor desired.
<b>Light Incident</b>	The condition met when light from the emitter is reaching, or incident upon, the receiver.
<b>Light Interrupted</b>	The condition met when light from the emitter is not reaching, or incident upon, the receiver.

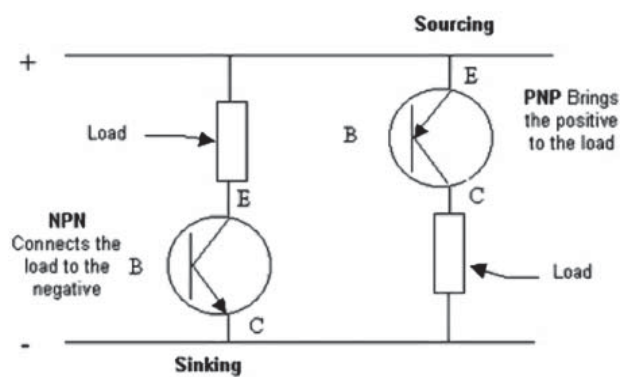
<b>Light Operation Torque Type</b>	Suitable for uses where the object to be detected is lightweight and the operating force required for standard switches would prevent proper actuation. Avoid using lever arms with heavy rollers that must reset against gravity.
<b>Light Source</b>	Type of light used in the emitter portion of the photoelectric. Most common, pulse modulated LED or incandescent lamp.
<b>Light Operation (Mode)</b>	Light mode output is energized when the target is not present (proximity output is energized when target is detected).  Output mode that will result in an output turning ON when light from the emitter is incident upon the receiver.
<b>Limit Switches</b>	A basic snap switch in a protective enclosure and mechanical actuator. When the actuator is operated past a preset point, the contacts of the snap switch change state to turn ON or OFF pilot lights, starters, relays, PLCs etc.
<b>Line-Powered Sensor</b>	A sensor that draws its operating current directly from the line. Its operating current does not flow through the load, and a minimum of three (3-wire) connections is required. A 4-wire has complimentary outputs and requires four connections.
<b>Load-Powered</b>	A sensor that draws its operating current (leakage current) through the load. The sensor is always in series with the load and only two connections are required.
<b>Loads</b>	There are basically two different kinds of loads: <ul style="list-style-type: none"> <li>• Resistive - Lamps, heaters, solid state PLC input modules</li> <li>• Inductive - Relays and solenoid valves</li> </ul>
<b>Low Differential</b>	Suitable for use where the differential, (the distance between trip point and reset point) must be short. In general, these switches should not be selected to provide shorter trip angles as either the lever arm or cam can be adjusted on standard 10° pre-travel switches to provide the required trip point.
<b>M</b>	
<b>Magnetic Operated (Reed Relay)</b>	The magnetic operated sensor (reed relay) senses only magnetic targets, and magnets are rare in industry. If you were to differentiate the target you wanted detected by placing a magnet on it and used a reed relay to detect its presence, the sensor wouldn't be fooled by other objects that did not have magnets attached to them.
<b>Maintained Contact</b>	A switch that remains in a given condition until actuated to another condition, which is also maintained until further actuation. When actuated, requires an intentional force or action to reset the contacts. Designed for applications requiring sustained contact after actuator has been released, but with provision of resetting.
<b>Make-Before-Break</b>	The normally open contact closes before the normally closed contact opens.

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<b>Manifold Mounting</b>	Occasionally, it may be more convenient to run wiring into a wiring trough, panel or raceway and bring the wiring into the switch through the underside instead of through the standard conduit hole. Manifold mounting switches are provided with a gasket and hole on the backside and the conduit hole plugged. The gasket prevents leakage into the manifold hole.
<b>Maximum Load</b>	The most current that can flow through a device continually without damaging the device.
<b>Method of Detection</b>	Sensing technique used by the photoelectric sensor. Three types - Thru Beam, Retroreflective, or Diffuse Reflective.
<b>Minimum Load</b>	Minimum current that the external load must draw to ensure proper operation of the photoelectric sensor. Most often associated with standard AC 2-wire devices.
<b>Modulated LED</b>	Pulsations of light at a specific frequency reduce interference from ambient light and increase sensing distance.
<b>Momentary Contact Limit Switch</b>	A switch which returns from the operated condition to its normal circuit condition when the actuating force is removed. Also referred to as a spring return switch.
<b>Multiple Unit Types</b>	When several surface mounting position switches are mounted in a row and actuated by one or more cams, it may be more economical to install a multiple unit position switch. Only one enclosure need be installed and only one conduit need be run. Also, any interwiring between switches can be done internally. Lever arms are available to provide several different cam tracks if required.
<b>Mutual Interference</b>	A feature in photoelectric sensors that eliminates false-signaling between similar protection sensors mounted next to, or in close proximity to, each other.
<b>N</b>	
<b>N.C. (Normally Closed)</b>	Current flow through the switching device is possible only when the device is in the off state or de-energized. Contacts are closed when the switch is not operated and when there is no external force on the actuator. The sensor opens a circuit to the load when a target is detected or switch is operated.
<b>N.O. (Normally Open)</b>	Current flow through the device is not possible when the device is de-energized (turned OFF). Contacts are open when the switch is not operated and when there is not external force on the actuator. The sensor closes a circuit to the load when a target is detected or switch is operated.
<b>NAMUR</b>	A European standard for intrinsically safe.
<b>Neutral Position</b>	Lever operated switch with a minimum of two contacts. One contact changes state only when the lever moves CW. The second contact changes state only when the lever moves CCW. Used when the direction of a part or cam needs to be identified. This can be used for an indication of the direction of the cam, such as "up, off, down" or "forward, off, reverse".

<p><b>Nominal Sensing Distance</b></p>	<p>The rated operating distance for which the switch is designed. This value should only be taken as a guide, since no manufacturing tolerances or changes in external operating environment are taken into account.</p> <p>You should be aware that manufacturers arrive at performance standards for their products using standardized criteria so you can compare “apples to apples” in determining which product is right for your application. These criteria reflect, to a reasonable extent, the real performance that can be expected in an “average” controlled environment.</p>
<p><b>Non-Inductive Ratings</b></p>	<p>This rating indicates the resistive load only that the contacts can make or break. Resistive ratings are generally based on a 75% power factor for AC.</p>
<p><b>Non-Overriding Cam</b></p>	<p>Cam approaches roller from one direction only and does not travel beyond roller.</p>
<p><b>Non-Plug In</b></p>	<p>Wiring is made directly to snap switch terminals. When the switch needs replacing, wiring must be removed and the complete switch replaced.</p>
<p><b>Non-Incendive</b></p>	<p>Unable to release sufficient electrical or thermal energy under normal operating conditions to cause ignition of specific hazardous materials. Non-incendive equipment can be used without additional precautions in Division 2 hazardous locations where the hazardous materials can be present only in case of accidental rupture or breakdown of the enclosure containing them.</p>

**NPN** A transistor having an n-type semiconductor as its emitter and collector and a p-type semiconductor as its base.



**O**

<p><b>Observable Time</b></p>	<p>Observable time is the real time that the target can be observed by the sensor.</p>
<p><b>Off Delay</b></p>	<p>The time required for the interface to trigger a change of state when a target is removed from the sensing area.</p>
<p><b>Offset Type</b></p>	<p>Used to obtain different cam track dimensions.</p>
<p><b>On Delay</b></p>	<p>The duration of time required for the interface to trigger an output change of state when a target is introduced to the sensing area.</p>

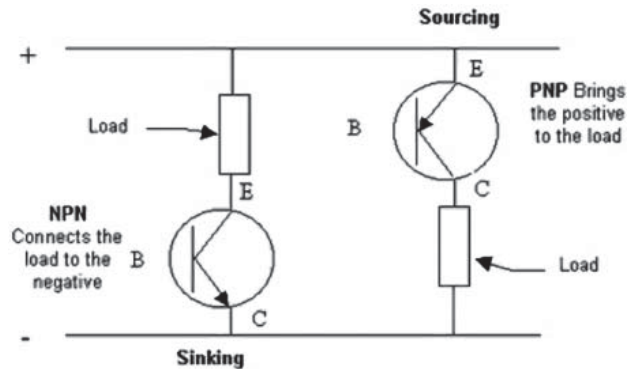
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<b>One Way Horizontal</b>	Used where a non-overriding cam is used, or where a non-reversing overriding cam is used. Cam movement is in the horizontal direction in relation to the limit switch mounting.
<b>One Way Lever</b>	Used with reversible cams where operation in one direction only is required. Easier to set-up than a one way roller type and is recommended for high speed cams where snap back of the lever arm could present a problem.
<b>One Way Vertical</b>	Used where non-overriding cam is used, or where a non-reversing overriding cam is used. Cam movement is in the vertical direction in relation to the limit switch mounting.
<b>One-Shot</b>	An output signal produced for a preset time that is independent of the duration of the input signal. It may begin at the start of the input signal or be delayed.
<b>One-Way Roller Type</b>	Used with reversible cams where operation in one direction only is required. (Used mainly with Type AW since (AW) can be operated in one direction only.) Type C lever arm types can operate in both directions without damage to the switch.
<b>Opaque</b>	Material which neither reflects, emits, nor allows light to pass through it. Photoelectric controls easily detect opaque objects.
<b>Operating Distance</b>	The distance from the sensing face to the plane of the target's path once it reaches the operating point.
<b>Operating Force</b>	Amount of force applied to the actuator to cause contact operation.
<b>Operating Point</b>	The point at which a target is sensed as it approaches the sensing field of the sensor. Also called the "trip point".
<b>Operating Position</b>	Operating position is the position of the actuator at which the contacts change state (see Trip Position).
<b>Operating Range</b>	The range in the x, y, and z plane that will cause the switch to operate when a detectable object is in it.
<b>Operating Torque</b>	Operating torque (force) is the minimum torque (force) value that must be applied to the actuator to cause the contacts to change state.
<b>Operating Mode</b>	Two possible modes that will cause the switch to operate and produce an output: Light-ON or Dark-ON mode.
<b>Output Circuit</b>	Interfaces with data acquisition systems (PLCs, dedicated controllers etc.) or other control circuits (relays, counters, timers etc.).
<b>Output Transistor</b>	A semiconductor device used to provide ON/OFF switching of external loads.
<b>Overlapping</b>	The normally open contact closes before the normally closed contact opens.
<b>Overriding Cam, Non-Reversing</b>	Cam moves in one direction only and travels past roller and allows lever arm (or roller plunger) to reset.

<b>Overriding Cam, Reversing</b>	Cam travels in both directions over roller.
<b>Overtravel</b>	The distance or angle through which the actuator moves when traveling from the operating position to the overtravel limit position. Overtravel limit position is that position of the actuator beyond which further overtravel would cause damage to the switch or actuator.
<b>P</b>	
<b>Particle Resistance</b>	Contamination in the form of foreign material which can produce resistance. Carefully controlled production processes are used to prevent contamination during assembly of a snap switch.
<b>Photoelectric</b>	Photoelectric sensors can be fooled very easily. They work by emitting a beam of light and then detecting whether or not it is broken. However, the object breaking the beam of light could be the target, or it might be any other object that happens to break the beam. For example, if a photoelectric sensor were being used to control the opening of a door to a business, the idea would be for the target (you, the customer) to break the beam and the door would open. However, animals, insects or perhaps even dirt or dust might also break the beam and cause the sensor to open the door.
<b>Photoelectric Sensor</b>	A light sensitive device that converts visible and infrared light waves into an electrical signal. A no-touch sensor consisting of a light emitter and detector. Its output turns on or off, depending on the absence or presence of this light at the detector that is determined by the absence or presence of a target.
<b>Pilot Duty</b>	Rating of contacts when making or breaking inductive loads such as coils and solenoids; based on a .35 power factor.
<b>Plug-In</b>	Wiring is made to a plug-in receptacle, which becomes a permanent part of the machine. The plug-in assembly includes the actuator and the contact mechanism. When the switch needs replacing, only the cover screws need loosening and the plug-in portion replaced - the wiring is not disturbed. Plug-in switches reduce user down time and expense. Also see non-plug-in.
<b>Plunger Type</b>	Plunger type switches are used where short, controlled machine movements are present and where space or mounting does not permit a lever type switch.

**PNP**

A junction type transistor having a p-type semiconductor as its emitter and collector and an n-type semiconductor as its base.

**Polarity**

Single-pole double throw (SPDT) contact with four terminals require the supply to be applied with the same polarity (i.e., L1 or +) on the same side of the contact bar. Two different supplies are not allowed in this configuration. (The loads would always be on the same side of the contact bar.)

**Polarized**

Visible light from the emitter of a retroreflective photoelectric sensor that is filtered so as to be projected in only one plane. The receiver of a polarized unit is filtered to accept only light that is reflected perpendicular to the emitted light. Corner cube reflectors are required to properly rotate the emitted light source.

**Polarized Retroreflective**

A retroreflective system that can detect, in addition to normal opaque objects, the shiny objects that fool a normal reflex sensor. This includes mirrors, metal straps, foils, metal boxes, cans, shrink-wrap and Mylar tape.

**Pole**

A switching unit that contains a set of moveable contacts. These contacts may have stationary contacts for a 1 N.O., 1 N.C. or 1 N.O. and 1 N.C. switching unit. A two-pole device has two sets of movable contacts.

**Power Consumption**

Maximum amount of power required to properly operate the device.

**Power-Up Delay**

A target is present in the sensing area when power is applied, the output state does not change. For confidence, the delay must last longer than the duration of any start-up transient.

**Precision Snap Acting Switch**

An electromechanical switch having predetermined and accurately controlled characteristics and having a spring loaded quick make and break contact action.

**Pretravel**

The distance or angle through which the actuator moves from the free position to the position at which the contacts change state.

**Product Selector**

Allows the user to select a sensor by identifying criteria of a particular product technology needed.

**Proximity Diffuse**

Sensing mode with emitter and receiver in the same housing. Light is bounced back at the receiver by the target. Also called direct detection.

**Pulse Modulated**

Light sources that are pulsed (ON/OFF) at a high frequency by an oscillator circuit. The receiver of a pulse modulated photoelectric only receives light at that frequency, thus minimizing interference from ambient light.

**R****Receiver**

A device that changes its electrical characteristic when light is received. Receivers can be photovoltaic cells, photo-transistors, photodiodes, and photoresistors.

**Reed Contacts**

Contact mechanism consists of a set of contacts hermetically sealed in a glass envelope and actuated by a magnet attached to the operator. This sealed construction keeps contaminants out of the contact area, making the reed switch the ideal switch for low voltage, low current circuits such as PLCs.

**Note:** Because reed switches are operated by a magnet, they should not be installed in areas where strong magnetic fields may be present. The devices should always be checked for proper operation after installation.

**Reed Switch**

Contact mechanism consists of a set of contacts hermetically sealed in a glass envelope and actuated by a magnet attached to the operator. This sealed construction keeps contaminants out of the contact area, keeping the contacts clean and free from oxidation. It has gained a reputation over time as the ideal switch for use with “dry” (low power) circuits, solid state circuits, and intrinsically safe systems.

**Release Point**

The point at which a sensor returns to its original state as the target leaves the sensing field. Also called “reset point”.

**Release Position**

That position of the actuator at which the contacts snap from the operated contact position to the normal contact position. Also called “Reset Position”.

**Release Torque**

The value to which the torque on the actuator must be reduced to allow the contacts to snap from the operated position to the normal contact position.

**Repeat Accuracy**

The measure of variation in operating distance between successive operations under constant operating conditions. This measurement is often expressed as a maximum percentage of the “operating distance” (i.e., 5%).

**Note:** The target must also remain within the sensing field long enough to allow the load sufficient time to respond to the output signal of the sensor.

**Repeatability**

A measure of the maximum variance in the operating distance that can be experienced in successive operations of a sensor under specified operating conditions.

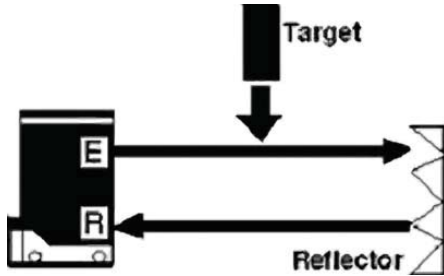
**Reset Position**

Position of actuator at which contacts return to the normal position. Also called “Releasing Position”.

**Resistive Ratings**

This rating indicates the resistive load only that the contacts can make or break. Resistive ratings are generally based on a 75% power factor for AC.

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<b>Response Time</b>	The duration of time required for the interface to trigger an output. Measure of time lapse between receipt of an input signal by a receiver to the activation of its output.
<b>Retroreflective</b>	Where the target passes between the sensor and a reflector, blocking the beam to cause the receiver to change states. The emitter and receiver are in the same housing.
	
<b>Reverse Polarity</b>	Internal circuitry that protects a device from being ruined if proper polarity of voltages is not maintained when wiring the device.
<b>Rod Type</b>	Used generally on conveyor systems or where unusual shapes are required.
<b>Rollers</b>	Diameter and width of roller is determined by the size and shape of cam used. If the cam is free to shift, a larger diameter or width should be used. In general, large heavy rollers are to be avoided to minimize resetting and snap back (telegraphing) problems. Recommended roller material is hardened oil impregnated, sintered iron. Where a metal roller may scratch the actuating surface or where an explosion-proof switch is used, nylon rollers are recommended. Recommended roller size is 0.75" diameter, 0.25" wide where permissible.
<b>S</b>	
<b>Safety Interlock</b>	A safety interlock is defined as a device that ensures the operator's protection when intervention is required on a machine or mechanism that can put the operator's health or safety at risk. Risk factors can include the following: <ol style="list-style-type: none"> <li>1. Stopping a rotating machine</li> <li>2. Turning off a power supply of an electrical circuit</li> <li>3. Turning off a valve</li> <li>4. Turning off a heater</li> </ol>
<b>SCP</b>	Short Circuit Protection without external fusing. In DC it also includes overload protection.
<b>Sensing Distance</b>	The maximum distance at which, under specifications, a photoelectric sensor can detect a target.
<b>Sensing Mode</b>	Dark or Light mode condition to the receiver in activating its output.
<b>Sensing Range</b>	The maximum operating range at which the sensor will reliably detect a standard target under conditions of nominal voltage and temperature. The distance between an emitter and a receiver, reflector, or object in the path of the beam within which nominal operation is achievable.

<b>Short Circuit Protection</b>	Internal circuitry that protects the solid state sensor in the event that the protection load becomes shorted.
<b>Simultaneous Make and Break</b>	The normally closed contact opens at the same time as the normally open contact closes.
<b>Single Pole Single Throw (SPST)</b>	Switches that make or break one circuit. Provides either one normally open or one normally closed contact.
<b>Sinking</b>	A device that sensors the negative supply voltage to a load wired to the positive supply voltage.
<b>Slow Make and Break</b>	The speed of transfer of the movable contacts is dependent on the speed of the operator. The amount of travel of the movable contacts is also dependent on the amount of travel by the operator. Slow make and break contacts have the same trip and reset points, and do not have the differential travel common to snap switches.
<b>Snap Action Contacts</b>	The speed of transfer of the movable contacts is not dependent on the speed of the operator. The amount of travel of the moveable contacts is also not dependent upon the amount of travel by the operator. The movement of the moveable contacts is determined by a preset travel, after this point is reached, the contacts will trip. Snap action contacts have different trip and reset points, the difference is identified as "differential".
<b>Solid State</b>	A device, circuit or system whose operation is dependent upon any combination of optical, electrical, or magnetic phenomena within a solid. Generally referred to as having an infinite life and no moving parts.
<b>Sourcing</b>	A device that sensors a positive voltage to a load wired to the negative supply voltage.
<b>Specular Reflection</b>	A combination of the thru-beam and proximity diffuse photoelectric device.
<b>Spring Rod Type</b>	Used on conveyor or similar systems where jam up may occur. Material backing up against a standard rod arm could move the arm sideways resulting in damage to arm and/or switch. The flexible spring rod allows movement in any direction and eliminates damage.
<b>Stability</b>	The output state of the photoelectric is stable ON, unstable, or stable OFF. Unstable outputs cause the system to perform erratically. Unstable output occurs when the amount of light incident on the receiver is near the trigger level of the device.
<b>Standard Pre-Travel Type</b>	Suitable for actuation by any cam or component whose motion is perpendicular to the shaft axis about which the lever arm rotates.
<b>Standard Target</b>	On object with standardized dimensions or characteristics -- common among manufacturers --- used in the product laboratory to determine benchmark performance characteristics for a sensor.
<b>Supply Voltage</b>	The nominal voltage, or voltage range, at which the device is designed to be operated continuously.

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**T**

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**Taut Cable Principle**

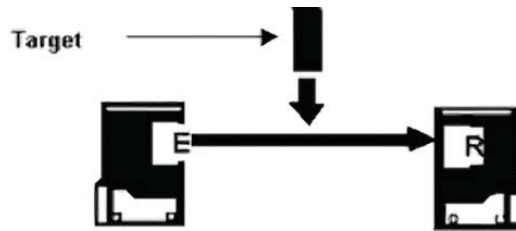
The cable must be tight and have a tension applied on it at all times. This allows the contacts of the cable pull switch to actuate if the cable is broken or pulled.

**Telegraph**

A condition that can occur in a lever type switch when the lever arm is operated to its overtravel condition and then released. This can cause heavier arms to return past the center point and possibly trip the contacts again on switches that operate in both the CW and CCW directions. In severe telegraphing, the arm could return past center again and trip the original contacts that were tripped, even on switches set to operate in one direction only.

**Thru-Beam**

Where the target passes between an emitting unit and a receiving unit, blocking the beam and causing the receiver to change states. These are separate, independently covered units.

**Total Travel**

Total travel is the sum of the pretravel and overtravel.

**Timing**

Links the trigger and the output circuit. The time duration of this link can be as fast as technology will permit, or controlled for a desired effect.

**Translucent**

Material which permits the passage of light to some extent.

**Transparent**

Targets that permit transmission of essentially all incident light.

**Trigger or Threshold Level**

Triggers the output circuit when the signal reaches a predetermined level.

**Trip Position**

Position of the actuator at which the contacts move to the operated position.

**Turret Head**

Actuating mechanism of position switch which may be removed from contact portion of enclosure and rotated to other positions, normally four positions 90° apart.

**Two Stage Position Switch**

Device with two sets of contacts, one of which operates before the other. Device can be wired for either overlapping contacts or sequencing operation.

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**U**
**Usable Sensing Distance**

Taking the actual operating conditions into account, the usable sensing distance is the maximum reliable operating range for a given system. The most important factors to consider are atmospheric environment and the reflective nature of the target.

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**V**

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**Visible Light**

Measured in wavelength. Wavelengths of visible light range between 400 and 700 nanometers.

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**W**

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**Weld Field Immune (WFI)**

The electrical welding process generates a very strong electrical field near the welding points. This field can interfere with the normal operation of an inductive proximity sensor situated nearby, creating false output signals. WFI devices are designed to work in this environment.

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**Weld-On Type**

Used where special operator is required and can be welded to lever arm.

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**Wobble Stick**

These position switches are suitable for use on conveyors to detect or count parts or as a hand operated safety device. Wobble stick and cat whisker position switches can be operated from any direction. A non-metallic wobble stick such as Delrin or Nylon should be used where wire extension might scratch the part being detected. Cat whisker switches are used to detect very light weight parts.

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