

### Enclosure Ratings

#### Index of Enclosure Protection—General

The UL®, NEMA® and IEC organizations (and other international groups) define degrees of protection provided by electrical enclosures with respect to personnel, equipment within the housing and the ingress of water.

Subtle differences do exist between the test procedures and specifications of these organizations.

To claim ratings to NEMA specifications, the testing is performed and certified by the manufacturers themselves.

To comply to UL and IEC specifications, the manufacturers must submit product samples, materials used and other data to an independent testing laboratory before ratings can be claimed.

In addition, IEC “IP” ratings differ from NEMA in that they do not apply to protection against the risk of explosion or conditions such as humidity, corrosive gases, fungi or vermin. In addition, different parts of the equipment can have different degrees of protection and still comply.

The table shown below is a comparison of the NEMA/UL/IEC enclosure specifications to be used as an approximate reference only. Do not use the table to convert from IEC to NEMA designations. For a definition of the ratings listed, see examples below and tables on **Page V8-A2-2**.

#### NEMA/UL/IEC Enclosure Type Cross-Reference

##### Enclosure Type Cross-Reference—Approximate

IEC 529 does not specify equivalents to NEMA Enclosure Types 7, 8, 9 or 10.

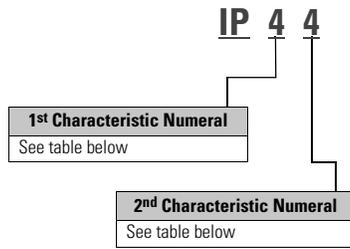
NEMA Enclosure Rating	IP10	IP20	IP21	IP22	IP23	IP30	IP31	IP32	IP33	IP40	IP41	IP42	IP43	IP50	IP51	IP52	IP53	IP54	IP55	IP56	IP60	IP61	IP62	IP63	IP64	IP65	IP66	IP67	IP68	
1	X	X	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
2	X	X	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—
3R	X	X	X	X	X	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
3S	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—
4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—
4X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	
6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—
6P	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	
13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	

# Appendix 2

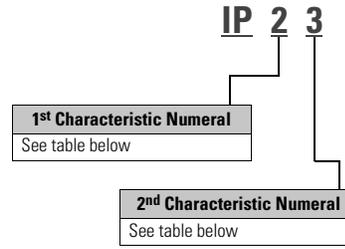
## Enclosure Ratings

### IEC Environmental Enclosure Ratings

#### Examples of Designations



An enclosure with this designation is protected against the penetration of solid objects greater than 1.0 mm and against splashing water.



An enclosure with this designation is protected against the penetration of solid objects greater than 12 mm and against rain.

### Index of Enclosure Ratings—IEC

#### 1st Characteristic Numeral

Numeral	Description
<b>Protection Against Contact and the Penetration of Solid Bodies</b>	
0	Not protected
1	Protection against solid objects greater than 50 mm
2	Protection against solid objects greater than 12 mm
3	Protection against solid objects greater than 2.5 mm
4	Protection against solid objects greater than 1.0 mm
5	Dust protected
6	Dust-tight

#### 2nd Characteristic Numeral

Numeral	Description
0	Not protected
1	Protection against dripping water
2	Protection against dripping water when tilted up 15 degrees
3	Protection against rain
4	Protection against splashing water
5	Protection against water jets
6	Protection against heavy seas
7	Protection against the effects of immersion
8	Protection against immersion

### NEMA Definitions Pertaining to Non-hazardous Locations—NEMA Standard 250

#### Type 1

Enclosures are intended for indoor use, primarily to provide a degree of protection against contact with the enclosed equipment.

#### Type 3

Enclosures are intended for outdoor use, primarily to provide a degree of protection against windblown dust, rain, sleet and external ice formation.

#### Type 3R

Enclosures are intended for outdoor use, primarily to provide a degree of protection against falling rain, sleet and external ice formation.

#### Type 4

Enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against windblown dust and rain, splashing water and hose-directed water.

#### Type 4X

Enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water and hose-directed water.

#### Type 6

Enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against the entry of water during occasional temporary submersion at a limited depth.

#### Type 6P

Enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against the entry of water during prolonged submersion at a limited depth.

#### Type 12

Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, falling dirt, and dripping non-corrosive liquids.

#### Type 13

Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, spraying of water, oil and non-corrosive coolant.

**NEC Definitions Pertaining to Hazardous Locations—Article 50**

E51 Limit Switch Type Proximity Switches are rated for use in the following locations:

***Class I Division 2, Groups A, B, C or D—Indoor Use***

For the definition of a Class I Division 2 location, see National Electrical Code Article 500-5, paragraph (b).

For the definitions of Class I Group A, B, C, D Classifications, see the National Electrical Code Article 500-3, paragraph (a).

***Class II Division 2, Groups For G—Indoor Use***

For the definition of a Class II Division 2 location, see National Electrical Code Article 500-6, paragraph (b).

For the definitions of Class II Group F and G Classifications, see the National Electrical Code Article 500-3, paragraph (b).

***Class III Division 2—Indoor Use***

For the definition of a Class III Division 2 location, see National Electrical Code Article 500-7, paragraph (b).

For the definitions of Class III Classifications, see the National Electrical Code Article 500-7.

# Appendix 2

## Glossary of Terms

### Glossary of Terms

**Acid-Resistant Enclosure**—So constructed that it will not be injured readily by exposure to acid fumes.

**Actuator**—Mechanism of the limit switch that operates the contacts.

**Alignment**—Positioning of light source and detector, reflector or target in order to obtain maximum signal strength (see also *Excess Gain*).

**Ambient Light**—Light reaching a sensor detector that is not generated by its light source.

**Amp or Ampere**—A unit of measurement of electric current produced by one volt acting through the resistance of one ohm.

**Axial Approach**—(Head-On) The target approaches the sensing face of the sensor with its center moving along the reference axis of the coil/core. The target surface is parallel to the sensor face.

**Bend Radius**—The minimum radius that a fiber optic cable can withstand without breaking the fibers.

**Break**—To open an electrical circuit.

**Break Distance**—The effective open gap distance between the stationary and movable objects.

**Burden Current**—The operating current of a line powered, three-wire, solid-state sensor. This current does not pass through the load.

**Cam**—Machine part or component that applies force to the switch actuator, causing it to move as intended.

**Capacitance**—The ability of insulators to store an electrical charge.

**Capacitive Proximity Sensor**—A sensor that operates on the principle of dielectric capacitance with a target. It detects the presence or absence of metallic or nonmetallic objects without physical contact. It is a self-contained, solid-state device with no moving parts. Sensitivity adjustment provided.

**Celsius**—See *Fahrenheit/Celsius*.

**CENELEC**—European Committee for Electro-Technical Standardization.

**Complementary Output**—Sensors with normally open (NO) and normally closed (NC) outputs, both of which change state simultaneously.

**Contrast**—The ratio between excess gain under light conditions and excess gain under dark conditions. The higher the contrast ratio, the higher the reliability of the sensing application.

**CSA**®—Canadian Standards Association, Canada.

**Current**—The rate of flow of electric charge in an electrical circuit.

**Current Sinking Sensor (NPN) or N Type**—The negative terminal of a DC system is called the sink, because conventional current normally flows into it. A current sinking sensor “sinks” the current from the load.

**Current Sourcing Sensor (PNP) or P Type**—The positive terminal of a DC system is called the source, because conventional current normally flows from it. A current sourcing sensor “sources” the current to the load.

**Damping**—A loading effect due to eddy currents being induced into the surface of a sensed metallic target, causing a reduction in amplitude of the inductive proximity sensor’s oscillator signal.

**Dark Operate**—A dark operate sensor generates an output when the source light intensity is sufficiently reduced at the detector (the sensor sees “dark”).

**Detector**—See *Thru-Beam Detector*.

**Dielectric**—The insulator separating the plates in a capacitor.

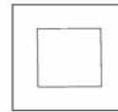
**Differential or Differential Travel (D.T.)**—Plunger or actuator travel from point where contacts “snap over” to point where they “snap back.”

**Diffuse Reflective Sensing**—A photoelectric sensing method in which the light from the source hits the target surface and is then diffused from the surface in all directions. Part of this light returns to the detector. If the intensity is high enough, the sensor generates an output. This is sometimes referred to as photoelectric “proximity” sensing.

**DIN**—Deutsch Industrie Norm, Federal Republic of Germany (dimensions).

**Double Break Contacts**—Circuit “breaks” in two places.

**Double Insulated Enclosure**—An insulation system with the two insulations physically separated and so arranged that they are not simultaneously subjected to the same deteriorating influences (temperature, contaminants, and so on) to the same degree.



Symbol Representing Double Insulated Enclosures

**Double Pole, Double Throw (DPDT)**—A switch that makes and breaks two different circuits. Example, (2) NO and (2) NC contacts.

**Drip-Proof Enclosure**—So constructed or protected that falling dirt or drops of liquid will not interfere with the successful operation of the apparatus under specified test conditions.

**Dust-Tight Enclosure**—So constructed as to meet the requirements of a specified dust-tightness test.

**Dwell Time**—The time that the target is present in the sensing field and is detected by the sensor.

**Eddy Current**—Current induced into the body of a metallic object by an oscillating electromagnetic field.

**Effective Beam**—The light beam travelling directly between a thru-beam source and detector that must be completely blocked for detection to occur.

**Electromechanical Limit Switch**—A pilot control device that converts a mechanical motion via physical contact with a target into an electrical control signal. The rotary arm or push rod on the switch body housing is mechanically connected to the switching element inside. The cam, machine component or moving object comes into contact with the limit switch at a pre-determined position.

**Embedded**—A shielded core/coil sensor “embedded” in the surrounding metal mounting. The sensor operation is not affected by surrounding metal. Also referred to as “Flush Mounting.”

**Emitter**—See *Thru-Beam Source*.

**Enclosed Switch**—A basic switch unit enclosed in a metal housing to provide increased durability and conduit connection.

**Excess Gain**—Measurement of the sensing power of a photoelectric sensor to detect an object in a given environment.

**External Mounting Enclosure**—Enclosure mounting provisions external to the apparatus cavity.

**Fahrenheit/Celsius**—Temperature scale conversion.  
 $F^{\circ} = 9/5 (C^{\circ}) + 32$   
 $C^{\circ} = 5/9 (F^{\circ}) - 32$

**Ferrous**—Metallic material which contains steel, nickel or cobalt.

**Fiber Optic**—Sensor with remote optics comprised of thin plastic or glass fibers, for detection in very tight places or extremely harsh environments.

**Field of View**—The region illuminated by the light source and seen by the detector. Field of View is sometimes referred to as “spot size” and may be expressed as a circle diameter at a given range, or in degrees emanating from the sensor. In both cases, Field of View is a three-dimensional area roughly the shape of a cone.

**Fixed Focus**—A sensing mode where the light source and the detector are angled towards one another, forming a focal point. The target will only be detected in this area where the source and detector fields of view cross.

**Flush Mounting Enclosure**—So designed as to have a minimal front projection when set into and secured to a flat surface.

**Free Position (F.P.)**—Position of switch plunger or actuator when no external force is applied other than gravity.

**Hysteresis**—The difference between the sensor operate point, where the target is detected, and release point, where the target is no longer detected.

**IEC**—International Electrotechnical Commission. Writes recommended performance and safety standards for electrical products.

**Inductive Proximity Sensor**—A non-contact proximity sensor that operates on the principle of induced electromagnetic field (for example, eddy currents) in the surface of a metallic target. It detects the presence or absence of a metal object without physical contact. It is a self-contained, solid-state device with no moving parts.

**Infrared**—Invisible light radiation at wavelengths of 690 nanometers and longer.

**Lateral Approach**—(Side-By-Side) Approach path of a target perpendicular to the reference axis, target approaches the sensor from the side.

**Leakage Current**—Small current flowing through a solid-state output when in the OFF state.

**LED (Light Emitting Diode)**—Semi-conductor that generates monochromatic light when current flows in the conductive direction. Shock/vibration resistant, long life, low current draw alternative to incandescent lamps. As a low power, no heat source of light, the LED is the standard light source for photoelectric sensors.

**LED Indicators**—Light emitting diodes (LEDs) provide diagnostic information as to the status of the sensor (operated or not operated). Diagnostic indications are switch status, power ON/OFF status and/or short circuit conditions.

**Light Curtain**—Specialized reflex sensor head that emits a fan-shaped beam of light.

**Light Operate**—A light operate sensor generates an output when the source light intensity is sufficiently increased at the detector (the sensor sees “light”).

**Line-Powered Sensor**—(Three-wire) A sensor that draws its operating current (burden current) directly from the line. Its operating current does not flow through the load. Three connections are required.

**Load-Powered Sensor**—(Two-wire) A sensor that draws its operating current (residual current) through the load. Load Powered Sensors require only two connections (exclusive of ground) and are always in series with the load.

**Load Release Time**—The time delay which occurs between the point at which the sensor output restores to the not operated state and the load restores to OFF-state condition.

**Maintained Contact**—Sustained contact after plunger has been released, but can be reset.

**Make**—To close or establish a path for electrical current.

**Minimum Holding Current**—Current required to sustain a solid-state sensor in an operating condition.

**Modulated Light Sensors**—A photoelectric sensor that operates on light pulses rather than on constant light intensity.

**Momentary Contact**—Contacts return from operated position to normal condition when actuating force is removed.

**Nanometer (nm)**—This is the typical unit of measure for the wavelength of source light in a photoelectric sensor.  
 1 Nano-meter is equal to  $10^{-9}$  meter.

**NEMA**—National Electrical Manufacturers Association, United States.

**Non-embeddable**—An inductive style that requires a generous metal-free area surrounding the sensor face to allow for the longest sensing distances, often four times the shielded range.

**Non-ferrous**—Metallic material which does not contain steel, nickel or cobalt. Example: Aluminum

# Appendix 2

## Glossary of Terms

### Normally Closed (NC)

**Output**—Solid-state output configuration which emulates a normally closed relay contact condition.



Normally closed

### Normally Open (NO)

**Output**—Solid-state output configuration which emulates a normally open relay contact condition.



Normally open

**NPN (Current Sink)**—The sensor derives (“sinks”) its current from the load.

**Opaque**—An opaque object is impervious to the passage of light through it. Opaque objects offer high reliability in sensing because they provide the highest contrast between light beam blocked and unblocked conditions. See also *Contrast* and *Translucent*.

**Operate Point**—The point, at a distance from the sensor face, at which a target is detected.

**Operating Force**—That straight line force in the designated direction applied to the actuator to cause the switch contacts to snap to the operated contact position.

**Operating Mode**—See *Light Operate* and *Dark Operate*.

**Operating Position (O.P.)**—The position of the actuator at which the contacts snap to the operated contact position.

**Outdoor Enclosure**—Suitable for installation where exposed to the weather.

**Over-Travel (O.T.)**—The movement of the actuator beyond the contact trip position without damage occurring to the switch.

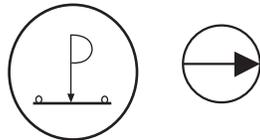
**Perfect Prox®**—A sensor used to detect an object at or inside a given range while ignoring a nearby background.

**Photoelectric Sensor**—An electronic device capable of recognizing changes in light intensity and converting these changes into a change in output state. It is also referred to as a “Photoeye.”

**PNP (Current Source)**—The sensor provides (“sources”) the current to the load.

**Polarized Reflex Sensor**—A reflex photoelectric sensor that uses a visible light source, polarizing filters and a prismatic retroreflector to help the sensor distinguish light returning from the retroreflector from that returning from a shiny target surface, thus increasing the reliability of the sensing application.

**Positive Opening Operation (on NC contacts)**—The achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (for example not dependent upon springs). Also called Direct Opening and Positive Break.



Symbol representing positive opening NC contacts

**Precision Snap-Action Switch**—A mechanically operated electric switch having predetermined and accurately controlled characteristics.

**Pre-Travel (P.T.)**—The distance or angle through which the actuator moves before reaching the point at which the contacts are tripped.

**Programmable Output**—Sensor output functions that can be wired to output normally open or normally closed, but not simultaneously.

**Proximity Sensor**—See *Inductive Proximity Sensor*.

**Radio Frequency Interference (RFI)**—Interference caused by radio transceiver signals (for example, walkie talkie devices).

**Rainproof Enclosure**—So constructed, protected or treated as to prevent rain under specified conditions from interfering with successful operation of the apparatus.

**Receiver**—See *Thru-Beam Detector*.

**Reference Axis**—The axis that is perpendicular to and passes through the center of the sensor face.

**Reflex Sensing**—A sensing mode where source light emitted from the sensor is reflected directly back to the detector by a prismatic retroreflector. When this light beam is blocked by a target, the sensor changes output state.

**Release Force (R.F.)**—Amount of force still applied to switch plunger or actuator at the moment contacts snap from the operated position to the unoperated position.

**Release Point**—The point, at a distance from the sensor face, at which the target is no longer detected by the sensor.

**Release Time**—The time delay from when a target reaches the release point to when the output restores to the not operated state.

**Repeat Accuracy**—Variations in sensing distance between successive sensor operations due to component tolerances when all operating conditions are kept constant.

**Resistance**—The opposition to the flow of electricity in an electric circuit measured in ohms.

**Response Time**—Time interval from when the target reaches the operate point to when the output goes into the operated state.

**Retroflective Sensing**—See *Reflex Sensing*.

**Retroreflector**—A highly reflective material that returns light that strikes it back in a direction parallel to its original course.

**Return Force**—Amount of force still applied to a switch plunger or actuator at the moment the contacts snap from the operated position to the unoperated position.

**Reverse Polarity Protection**—Internal circuitry that prevents damage to the sensor in case of accidental reverse polarity connection (plus-to-minus, minus-to-plus).

**Rust-Resistant Enclosure**—So constructed, protected or treated that rust will not exceed a specified limit when subjected to a specified rust-resistance test.

**Semi-Shielded**—An inductive style that still requires a metal-free zone around the sensor face, but the required area is greatly reduced. Range for this type is typically two to three times the range of a similar shielded sensor.

**Sensing Face**—The surface from which the sensing field is projected from a sensor.

**Sensing Distance**—The physically measured distance from a particular sensor to a particular target. The three specific definitions of sensing distance are:

**Effective Sensing Distance (Sr)**—The operating range of a sensor measured at nominal voltage and temperature.

**Nominal Sensing Distance (Sn)**—The distance at which a sensor is designed to detect a standard target at rated voltage and temperature.

**Usable Sensing Distance (Su)**—The distance at which a particular sensor should sense a standard target over the operating temperature and voltage limits recommended by the manufacturer.

**Sensing Range**—See *Sensing Distance*.

**Shielded**—An inductive style that allows the user to mount the sensor flush in metal up to the sensor face without the sensor detecting the presence of that metal.

**Short Circuit Protection**—Internal circuitry that protects the sensor from electrical damage due to excessive current from a wiring short circuit.

**Sleet-Proof Enclosure**—So constructed or protected that the accumulation of sleet (ice) under specified test conditions will not interfere with the successful operation of the apparatus including external operation mechanism(s).

**Slow Break Contacts**—Contacts for which the speed of the contact make/break is dependent upon the speed of the operator.

**Snap Action Contacts**—Contacts for which the speed of the contact make/break is independent of the operator speed. Different tripping and reset points occur in each direction (differential travel).

**Snubber Circuit**—Circuit composed of a resistor and a capacitor in series, and connected across the device. This circuit serves to protect a sensor against electrical transients.

**Source**—See *Thru-Beam Source*.

**Standard Target**—A metallic object used for sensing distance measurement with inductive proximity sensors. For similar sensor models the standard target is a square mild steel plate 1 mm thick. The length of each side is equal to the diameter of the sensing face.

**Submersible Enclosure**—So constructed as to prevent water ingress when submerged in water under specified test conditions of pressure and time.

**Thru-Beam Detector**—The component of a thru-beam sensing system that receives the light being emitted by the source.

**Thru-Beam Sensing**—A sensing mode where the light source and detector are directed at each other across an area in which a target passes. Detection occurs when the target blocks the light beam travelling directly between the source and detector (called the “effective beam”).

**Thru-Beam Source**—The component of a thru-beam sensing system that emits light.

**Time Delay Before Availability**—Time delay from when power is initially supplied to a solid-state sensor device and the time when it will be ready to detect a target.

**Total Travel (T.T.)**—The sum of the pretravel and total overtravel expressed by distance or angle.

**Translucent**—A translucent object allows some reduced level of light to pass through it. Translucent objects can result in reliability problems in sensing if the contrast between light beam blocked and unblocked conditions is too low. See also *Contrast* and *Opaque*.

**UL®**—Underwriters Laboratories, Inc., United States. Independent facility which tests and certifies electrical equipment.

**Unshielded**—An inductive style that requires a metal-free zone surrounding the sensor face when mounting. Range for this type is typically 1.5–2 times the shielded range.

**VDE**—Verband Deutscher Electro-techniker, Federal Republic of Germany.

**Watertight Enclosure**—So constructed as to prevent water ingress applied in the form of a hose stream under specified test conditions.

**Wavelength**—Distance traveled by light while completing one complete sine-wave expressed in nanometers (nm). Each color has a specific wavelength.

**Zero Crossing**—The point in an AC cycle when the sine wave is at zero.