



Understanding Ingress Protection Ratings

Keeping Contaminants Out

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In the world of electrical equipment, you will often see terms such as “sealed”, “waterproof” and “dust tight” scattered throughout marketing and technical literature. What do these terms really mean and is there a way to precisely quantify a product’s level of “sealedness”?

International Electrotechnical Commission’s IEC Standard 60529

The answer is yes. There is and has been a standard in place for close to 40 years. The introduction of the International Electrotechnical Commission’s *IEC Standard 60529: Degrees of Protection Provided by Enclosures* in 1976 introduced the concept of quantifying a product’s level of “sealedness” with the establishment of the Ingress Protection (IP) Code. The standard, which is limited to enclosures for electrical equipment with a rated voltage of less than or equal to 72.5 kV, defines an enclosure’s protection against ingress of:

1. Body parts towards hazardous electrical or mechanical components in order to ensure worker safety
2. Solids in order to prevent component damage.
3. Liquids in order to prevent component damage.

For each of the three above-listed ingress protection categories, there are levels of “sealedness” and corresponding tests prescribed by the standard. Protection against ingress of body parts and solids are covered jointly by one range of “sealedness” levels and associated tests. Once a product has successfully passed a body parts/solids test as well as a liquids test, the product can then promote a specific ingress protection rating.

An ingress protection rating is broken down into four distinct alphanumeric, with each identifying a particular level of protection or a specific nuance about a particular protection level. The generic construction of an IP rating is below. Each alphanumeric will be discussed in greater detail in the remainder of this document.

Alphanumeric →	N/A	1	2	3	4
Entry →	IP	Number #1	Number #2	Letter #1	Letter #2
Description →	--	Required element Protection against ingress of body parts and solids (Priority to solids)	Required element Protection against ingress of liquids	Optional element Protection against ingress of body parts if not adequately described in alphanumeric #2.	Optional element Supplementary information alphanumeric.

Alphanumeric #1: Protection Against Ingress of Body Parts and/or Solids

The first alphanumeric of an IP rating indicates protection against both ingress of body parts towards hazardous electrical or mechanical components in order to ensure worker safety as well as ingress of solids in order to prevent component damage. When determining the proper level of protection for this alphanumeric, primary consideration should be given to protection against ingress of solids. If the appropriate solids protection level does not adequately or appropriately describe the correct body parts protection level, then the optional letter in alphanumeric #4 should be used to describe the appropriate body parts protection level.

When a product is rated to a particular level, it can be automatically assumed that that product could also be successfully rated to all other levels below it. Performing the tests associated with the lower levels of protection is not required.

The table below indicates the various IP levels associated with alphanumeric #1 and the corresponding levels' protection against body parts as well as against solids.

IP Level →	IPOX	IP1X	IP2X	IP3X	IP4X	IP5X	IP6X
Protection Against Ingress of Body Parts →	No protection	Hand (50.0 mm ϕ)	Finger (12.0 mm ϕ)	Tool (2.5 mm ϕ)	Wire (1.0 mm ϕ)	Wire (1.0 mm ϕ)	Wire (1.0 mm ϕ)
Protection Against Ingress of Solids →	No protection	Solids ≥ 50.0 mm ϕ	Solids ≥ 12.5 mm ϕ	Solids ≥ 2.5 mm ϕ	Solids ≥ 1.0 mm ϕ	Dust-protected	Dust-Tight

Most of the ingress definitions in the above table are self-explanatory except for the terms “dust-protected” and “dust-tight.” Per the IEC standard, dust-protected is defined as “...ingress of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with satisfactory operation of the apparatus or to impair safety...” while dust-tight is defined as “...no ingress of dust.”

Alphanumeric #2: Protection Against Ingress of Liquids

The second alphanumeric of an IP rating indicates protection against ingress of liquids in order to prevent component damage.

Unlike when determining a product's body part/ solid level of ingress protection, a product's level of liquid ingress protection does not necessarily mean that it automatically passes all the other levels below it.

1. A level up to and including 6 (ie. IPX0 through IPX6) covers that level and all below it. If you successfully pass a given level, you do not need to perform the tests for all of the lesser levels.
2. A level of 7 (ie. IPX7) is NOT valid for any level below it.
3. A level of 8 (ie. IPX8) covers that level and level 7 only.
4. A level of 9 (ie. IPX9) covers that level and levels 1-4 only. It does NOT cover levels 5-8 unless it is multiple coded. Multiple coding involves testing the product repeatedly per each individual level's testing parameters. If multiple levels' tests are passed successfully, then the product can be multiple coded. (ie. Product that passes the continuous immersion and high temperature/high pressure spray tests would be multiple coded as IPX8/IPX9).

IP Level for Water Jets →	IPX0	IPX1	IPX2	IPX3	IPX4	IPX5	IPX6	IPX9(K)
Protection Against Ingress of Liquids →	No protection	Vertically falling water drops	Vertically falling water drops when product is tipped up to 15° of vertical	Spraying water from any direction within 60° of vertical	Splashing water from any direction	Water jets from any direction	High pressure water jets from any direction	High temp, high pressure water jets from any direction

In the “IP Level for Water Jets” table, the level of 9 has a letter “K” suffix in parentheses because industry often uses the IP ratings of IP69 and IP69K interchangeably. While the IP level of 9 is part of the IEC Standard 60529, the IP level of 9K is actually part of the International Standardization Organization *ISO Standard 20653: 2013, Road Vehicles -- Degrees of Protection (IP Code) -- Protection of Electrical Equipment Against Foreign Objects, Water and Access*. While originally designed specifically for road vehicles, the IP69K rating quickly gained popularity among industries in which equipment sanitation is crucial, such as food and beverage manufacturing. As a result, the International Electrotechnical Commission updated IEC Standard 60529 to include a level of 9 in the liquid ingress portion of the standard and adopted the same test as used in ISO Standard 20653.

IP Level for Immersion →	IPX0	IPX7	IPX8
Protection Against Ingress of Liquids →	No protection	Temporary immersion	Continuous immersion

In the “IP Level for Immersion” table, the terms “temporary immersion” and “continuous immersion” are used. Per the IEC standard, temporary submersion is defined as submersion at a depth of no greater than 1 meter (as determined by the lowest point of the enclosure) for 30 minutes in water at a temperature no more than 5 °K different from the temperature of the equipment itself. Per the IEC standard, continuous submersion is defined as submersion where “...test conditions are subject to agreement between manufacturer and user but they shall be more severe than those prescribed for temporary immersion and they shall take account of the condition that the enclosure will be continuously immersed in actual use.”

Alphanumeric #3: Protection Against Ingress of Body Parts Not Adequately Described by Alphanumeric #1

In the portion of this paper entitled “Alphanumeric #1: Protection Against Ingress of Body Parts and/or Solids”, it is notated that, when determining the proper level of protection against ingress of body parts and/or solids, that primary consideration should be given to protection against ingress of solids. In cases when the appropriate solids protection level does not adequately or appropriately describe the correct body parts protection level, then an optional letter can be used in alphanumeric #3 to describe the appropriate body parts protection level.

When a product is rated to a particular level, it can be automatically assumed that that product could also be successfully rated to all other levels below it. Performing the tests associated with the lower levels of protection is not required.

IP Level →	A	B	C	D
Protection Against Ingress of Body Parts →	Hand (50.0 mm ø)	Finger (12.0 mm ø)	Tool (2.5 mm ø)	Wire (1.0 mm ø)

Alphanumeric #4: Other Supplemental Information

A second optional letter can be used for alphanumeric #4 to describe other important nuances about the equipment or the protection that it provides that were not previously described.

IP Level →	H	M	S	W
Important Nuance¹ →	High voltage equipment	Tested for harmful effects due to the ingress of water when the movable parts of the equipment are in motion	Tested for harmful effects due to the ingress of water when the movable parts of the equipment are stationary	Suitable for use under specified weather conditions and provided with additional protective features or processes

IP Ratings for IMI Sensors' Products

All IMI Sensors' products have an IP rating. Please see below for an overview.

Connector Type	Product Category	IP Rating	Notes
2-pin MIL Connector	Accelerometer Vibration Transmitter Smart Switch	IP66 IP68 IP69K	Sensors with a 2-pin MIL or M12 connector have an all-welded design using a hermetic stainless steel enclosure and connector. Every sensor is tested for hermeticity. Due to the design of the sensor and the 100% in-process testing, the individual sensors are considered to have an ingress protection rating of IP68 and are fully-submersible to depths greater than 3 meters. The hermeticity of the sensor seals would withstand the water jet tests' specifications due to the sensor construction. The sensors therefore also have IP66 and IP69K ratings with no additional testing.
M12 Connector	Accelerometer	IP66 IP68 IP69K	
Integral Cable	Accelerometer Vibration Transmitter Smart Switch	IP66 IP68	Sensors with an integral cable or integral armored cable are constructed by attaching raw cable to a stainless steel cable tube with overmold. The assembly is then permanently attached to the sensor housing by welding the exposed portion of the cable tube to the sensor housing.
Integral Armored Cable	Accelerometer Vibration Transmitter Smart Switch	IP66 IP68	The sensor seals would withstand the water jet tests' specifications due to the sensor construction. The sensors therefore also have IP66 rating with no additional testing.
Terminal Block w/o Elbow	Vibration Transmitter Smart Switch	IP50	Sensors with a terminal block but without an elbow have a low IP rating because of the exposed terminal block.
Terminal Block w/ Elbow	Vibration Transmitter Smart Switch	IP54	Sensors with a terminal block and elbow have an IP rating dependent upon proper installation of the conduit elbow to the sensor as well as to the hardline conduit.
Enclosure	Mechanical Switch Electronic Switch	IP66	Mechanical and electronic switches housed in a junction box-style enclosure have an IP rating dependent upon proper sealing of the box cover to the box itself.

IP Ratings for IMI Sensors' Cable/Connector Assemblies

Many of IMI Sensors' connectors and cable/connector assemblies have IP ratings in order to educate the customer about the level of "sealedness" at the sensor/cable connection. Please see below for an overview of those connectors and cable/connector assemblies with an IP rating.

Model Number	Description	IP Rating	Notes
507QSAD	Cable/connector assembly	IP69K	The 507QSAD cable assembly consists of a bright white, polypropylene-jacketed cable (507) with a corrosion-resistant, stainless steel, 4-socket M12 connector (QS) molded on one end and pigtails (AD) on the other end.

For What Applications Are IP Ratings Crucial?

In dusty or wet vibration monitoring applications, IP ratings of both sensors and accessory cable/connector assemblies are of prime importance in order to avoid contamination of the sensor/cable connection. Examples of dusty and wet vibration monitoring applications are listed below:

Application Type	Application
Wet	Industrial Slurry Manufacturing
	Offshore Oil Rigs
	Paper Mills
	Water/Wastewater Treatment
Dusty	Cement Production
	Coal Processing
	Graphite Milling
	Grain Milling
	Metal Machining Operations
	Rice Hulling Facilities
	Rock Quarries
	Technical Ceramics Production

Conclusion

It is crucial that an electrical product's level of "sealedness" can be precisely quantified. The Ingress Protection (IP) Code provides a framework for this quantification by prescribing specific levels of ingress protection against body parts, solids and liquids with a corresponding set of test criteria for each.

All IMI Sensors' products have an IP rating, with most providing the highest levels of protection. As a result, there is an IMI Sensors' product available for even the most demanding of applications that maintain very strict ingress protection requirements.



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