



AMETEK Rotron Whitepaper

How applicable are Ingress Protection (IP) ratings to cooling fans?

IEC 60529: “Degrees of protection provided by enclosures” is an international standard established to classify and rate the degrees of protection provided against the intrusion of solid objects, dust, accidental contact and water in mechanical casings and any type of electrical enclosure. This Ingress Protection (IP) rating system uses a two digit number system to quantify the various levels of protection and includes specific methods of testing to ensure a standardized set of results.

The IP rating is denoted as IPXX where the first ‘X’ represents an enumerated character according to defined protection against solid materials and the second ‘X’ represents an enumerated character according to the level of protection against water.

The first character (IPXX), rates the protection against solid materials ranging from tools to **dust** and for the purposes of our discussion ranges from a value of 3 to 6. Over-simplifying the specification we can define the numbers as follows:

Protection against foreign solid objects (IP X X)	
IP0X	Non-protected
IP1X	Back of hand (50mm dia.)
IP2X	Finger (12.5mm dia.)
IP3X	Tool (2.5mm dia.)
IP4X	Wire (1mm dia.)
IP5X	Dust protected
IP6X	Dust tight

The second character (IPXX), deals with the protection against the ingress of **water** that could cause harmful effects to the enclosed equipment. The specification differentiates between falling water drops, spraying, splashing, and jetting waters as well as submergibility. The specification does not say that water cannot enter the enclosure but does limit the effects of the water entry.

Protection against harmful ingress of water (IP X X)	
IPX0	Non-protected
IPX1	Vertically dripping
IPX2	Dripping up to 15 deg from vertical
IPX3	Limited spraying
IPX4	Splashing (all directions)
IPX5	Hosing jets (all directions)
IPX6	Strong hosing jets (all directions)
IPX7	Temporary immersion (between 150mm and 1m)
IPX8	Continuous immersion (depth to be specified)



Today, the majority of commercial fan manufacturers have adopted this IP protection rating system and use it to characterize the level of environmental resistance of a given cooling fan. In some cases, manufacturers have gone as far as to state “...*designed for harsh environment applications IP54 rated.*” – using the IP rating to advertise harsh duty construction.

Since IEC 60529 was originally created to characterize “electrical enclosures”, there are some basic issues that the reader must be knowledgeable of when evaluating a fan - solely based on its IP rating:

- 1) There are many external influences and conditions where the IP rating does not address the condition:
 - a. - Mechanical impacts (vibration, shock, etc)
 - b. - Corrosion (salt fog)
 - c. - Corrosive solvents (for example cutting liquids)
 - d. - Fungus
 - e. - Vermin
 - f. - Solar radiation
 - g. - Icing
 - h. - Moisture (for example, produced by condensation)
 - i. - Explosive atmospheres
 - j. - EMI/EMC
 - k. - NBC/CBRN
 - l. - Material outgassing
 - m. - Material flammability
 - n. - Temperature (both low and high)

- 2) By virtue of the basic definition of IEC 60529, the rotating blades of a fan immediately cause an IP0X rating. Since the enclosure that the standard refers to is left up to individual technical committees to determine, most commercial fan manufacturers quantify the cavity by the exterior surface of whatever encapsulant is used on the motor and electronics of the fan. This then implies that case, propeller, bearings, shaft, and other associated subassemblies are ignored during the testing and subsequent rating of the fan.

- 3) There is no consideration within IEC 60529 given to the methods or materials used to create fans capable of water immersion. In some cases, commercial



fans will use a silicone based encapsulant – which is a banned substance in various military applications.

- 4) Testing for compliance of an IP rating is up to the manufacturer of product. As such, a combination of external environments (sand and dust with immersion, or vibration with immersion) is not considered or addressed. This leaves the decision for fan suitability up to the user, since a combination of external factors, over time, may degrade the overall resistance of the fan in a real world environment.
- 5) The testing methods and characteristics of results in IEC 60529 do not address an open motor concept. This is especially relevant when attempting to use a small fan for spot cooling as an open motor yields maximum performance in the smallest footprint for fractional horsepower fans. In this case, the mandated test methods were written around the concept of “hermetic sealing” of an enclosure to protect the contents during dust contamination and water immersion testing. These test methods disqualify open motor concepts, which can address dust and immersion and can also address issues such as operation in a condensing environment, where “hermetic sealing” will actually trap moisture within the cavity that is being protected.

Knowing if a product can survive under variable environmental conditions is critical when selecting a fan for a high reliability cooling application. Two particular environmental conditions, dust and water are the focus of the IP (Ingress Protection) rating system established by IEC 60529: “Degrees of protection provided by enclosures”. Since this standard is not openly published and there is no certifying agency, it is up to the manufacturer to test and subsequently rate the product on their own.

A more all-encompassing environmental standard for fans is MIL-STD-810, the environmental standard referenced by the US Military standards for AC and DC fans (MIL-B-23071 and MIL-B-28873) and also forms the basis for the reduced requirements of RTCA/DO160, the aerospace industry equivalent. In both cases, the standards have been developed over the years to identify and test to real world environmental conditions and are therefore considered a much stronger indicator of environmental robustness.



Both MIL-STD-810 and RTCA/DO 160 address:

- Altitude
- Temperatures
- Thermal Shock
- Fluid Contamination
- Solar Radiation
- Humidity
- Fungus
- Salt Fog
- Sand and Dust
- Explosive Atmosphere
- Immersion
- Acceleration
- Vibration
- Acidic Atmosphere
- Gunfire Shock
- Icing
- And more.

In conclusion, it is critical to understand the limitations, stated or implied, of a given product when a new system design is being created. IP ratings for fans can provide insight regarding dust and water affects, but do not address other important considerations which must be accounted for in a high reliability application. For more information on this subject, or any of our mil-spec products, please contact us at www.rottron.com.

