



White paper

MJF parts waterproofness

Waterproofness is a very common concept used to differentiate a product from others by its tightness and protection against water. There is an international standard, the **IP code**, that rates the level of ingress protection against different materials a mechanical case or an electrical enclosure has and it can be used as a reference to classify the products in that way.

Executive summary

The **IP code** classifies the enclosures by the level of protection they offer against dust and water. It is commonly used in many industries, especially in consumer goods.

The IP protection test done gives a reference of the capabilities of the material and the technology in terms of waterproofness. The **customers could produce cases or enclosures that could arrive to the IP66/IP67**.

The test should be passed by each specific design in case is needed. The IP protection code is given for each specific product, as it highly depends on the geometry of the enclosure.

Applications for MJF printed parts

There are several applications identified where certain levels of waterproofness and IP protection could be useful. The main applications related to the IP protection levels achievable with the HP Multi Jet Fusion 3D parts are electronic enclosures and mechanical cases.

Electronic enclosures

There are different standards that need to be fulfilled by the electronic enclosures, especially if those products are intended to be final products with HP Multi Jet Fusion 3D parts. Apart of a certain level of IP, in most cases they should have a level of protection as Fire and Electrical Enclosures, depending on the voltage and intensity that each device manages inside.

HP 3D High Reusability PA12 is rated as UL94 HB, which is not applicable for most of the Fire Enclosures.

However, the prototypes of electronic enclosures do not have to fulfill all the Fire and Electrical requirements. There will be tests where it will be interesting to produce parts with the IP rate required to validate specific aspects of a product.

A detailed list of possible applications for final parts and prototypes where certain levels of IP protection are required that the HP Multi Jet Fusion 3D parts could fulfill is included below.

Prototypes

Any electronic enclosure prototype where IP protection up to IP66/IP67 is needed could be a good candidate to be printed by the HP Multi Jet Fusion 3D.

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Some possible examples are:

Table 3. Possible HP Multi Jet Fusion 3D applications as electrical enclosure prototypes.

Product	Areas
Vacuum cleaner	Areas at low temperature (below 50°C)
Automatic screw driver	Areas at low temperature (below 50°C)
Sewing machine	All
Air purifier	Areas at low temperature (below 50°C)
Washing machine	Areas at low temperature (below 50°C)
Light fixtures	All

Final parts

There are 2 different possibilities where HP Multi Jet Fusion 3D parts with HP 3D High Reusability PA12 may be introduced as electronic enclosures in final parts:

- HP Multi Jet Fusion 3D parts with HP 3D High Reusability PA12 could be used in any electronic enclosure with Safety Extra Low Voltage (SELV) and Limited Power Source (LPS), such as USB powered devices.
 - SELV definition: A SELV system is an electrical system in which the voltage cannot exceed ELV (Extra-low voltage: AC voltage < 50 V_{rms} and DC voltage < 120 V) under normal conditions, and under single-fault conditions, including earth faults in other circuits.
 - LPS definition: LPS circuits are those circuits powered by the output of a Limited Power Source. LPS circuits are connected to the load side of a fuse, circuit breaker, PTC, or regulating network. Usually LPS circuits limit the power to less than 100 VA or current < 5/8 A, whichever is more restrictive. The circuits on the supply side are not powered by LPS, and must be provided with a fire enclosure.
- HP Multi Jet Fusion 3D parts with HP 3D High Reusability PA12 could not be used neither as a Fire Enclosure nor an Electrical Enclosure. However, they could be used as the mechanical enclosure of an electronic device if another material is included which provides those functions (e.g. a sheet of Mylar inside the HP Multi Jet Fusion 3D enclosure that would work as a Fire Enclosure).

Some examples of products with Safety Extra Low Voltage (SELV) and Limited Power Source (LPS) are listed below:

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Table 1. Possible HP Multi Jet Fusion 3D applications as enclosures for final parts.

Product	Comments
Computer mouse	IP65 design is offered for industrial environments
Speaker	It must be SELV and LPS. Waterproof speakers are classified as IPX5, IPX6 or higher
Fans	It must be SELV and LPS. Fans in bathrooms may require up to IP67, depending on the area where they are located
Light covers	It must be SELV and LPS. Lights in bathrooms may require up to IP67, depending on the area where they are located

Bathroom zones

There are some interesting applications in bathroom equipment where the HP Multi Jet Fusion 3D printed parts with HP 3D High Reusability PA12 could be used. For example, fans or lights. These products used in bathrooms need to have a certain requirement of IP protection, depending on the area where they are located. The zones of the bathroom are split depending on the risk level of water getting close to or touching the electrical supply.

The IP grade required for every zone of the bathroom and the definition of the zones depend on every country legislation. For example, the current version of the UK regulations is BS7671:2008. However, the IP grades used are very similar (from IP64 to IP67) and MJF parts could meet those requirements.

Mechanical Enclosure

The mechanical enclosures do not have requirements in terms of Fire or Electrical enclosure protection. For this reason, there are parts that could be produced with the HP Multi Jet Fusion 3D Printing Solution, both for prototyping and for final part production. Some examples are the case of a gear chain or the cover of an encoder motor.

IP code overview

The degree of protection is most commonly expressed as "IP" followed by two numbers, e.g. IP65, where the numbers specify the environmental protection the enclosure provides.

The IP (Ingress Protection) rating normally has two (or three) numbers:

- Protection from solid objects: the first digit (Foreign Bodies Protection) shows the extent to which the equipment is protected against particles.
- Protection from liquids: the second digit (Water Protection) indicates the extent of protection against water.
- Protection against mechanical impacts: commonly omitted, the third number is not a part of IEC 60529.



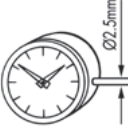
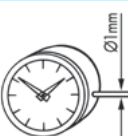


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The IP code (**International Protection Marking**, sometimes interpreted as **Ingress Protection Marking**) is defined in the IEC (International Electrotechnical Commission) standard 529 (international standard EN ISO 60529/UNE 20324).

First Index – Foreign Bodies Protection, Solids

Table 2 Meaning of the first index in the IP code



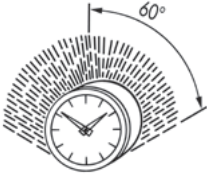

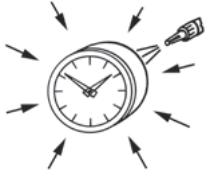

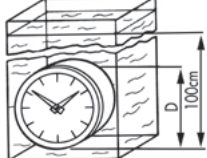
Index	Protection against contact	Protection against solid objects	Graphic example
0	No special protection	No special protection	
1	Back of hand, Fist	Large foreign bodies $\varnothing > 50 \text{ mm}$	
2	Fingers	Medium-sized foreign bodies $\varnothing > 12.5 \text{ mm}$	
3	Tools and wires, etc. with a thickness $> 2.5 \text{ mm}$	Small foreign bodies $\varnothing > 2.5 \text{ mm}$	
4	Tools and wires, etc. with a thickness $> 1 \text{ mm}$	Granular foreign bodies $\varnothing > 1 \text{ mm}$	
5	Complete protection (limited ingress permitted)	Dust protected; dust deposits are permitted, but their volume must not affect the function of the unit	
6	Complete protection	Dust-proof/dust-tight; totally protected against dust	

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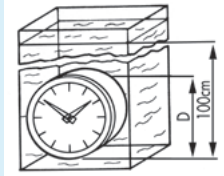
Second Index – Water Protection, Liquids

Table 3 Meaning of the second index in the IP code

Index	Protection against water	Protection from condition	Graphic example
0	No special protection	No special protection	
1	Water dripping/falling vertically	Protected against drops of water - Condensation/light rain	
2	Water sprayed at an angle up to 15° degrees from the vertical	Protected against drops of water - Light rain with wind	
3	Water sprayed at an angle up to 60° degrees from the vertical	Protected against spraying water - Heavy rainstorm	
4	Water sprayed from all directions (limited ingress permitted)	Protected against splashing water from all directions	
5	Low pressure water jets from all directions (limited ingress permitted)	Protected against jets of water from all directions	
6	High pressure jets from all directions (limited ingress permitted)	Protected against jets of water of similar force to heavy seas	
7	Temporary immersion, 15 cm to 1 m	Protected against the effects of immersion	

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8	Permanent immersion, under pressure	Protected against prolonged effects of immersions under pressure to a specific depth	
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Test procedure

Sample part description

The sample used for the IP protection test and its characteristics are included below:

Figure 2. Isometric, front and left view of the part:

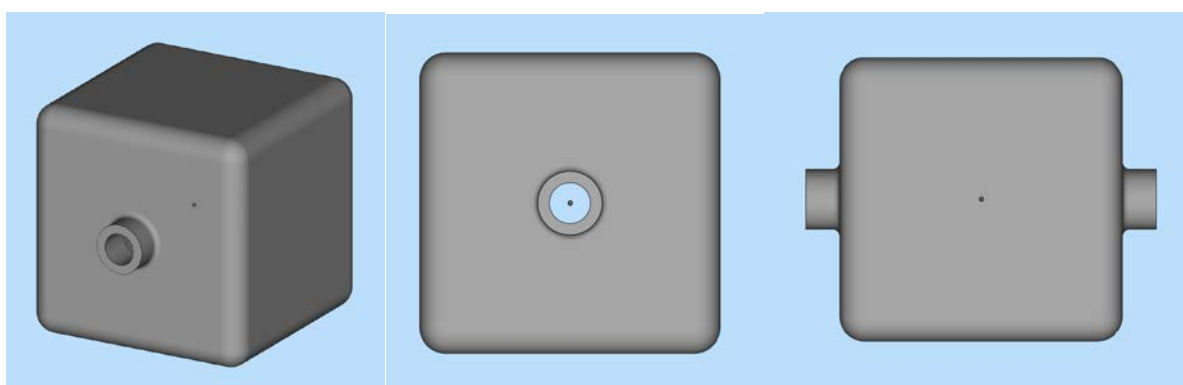
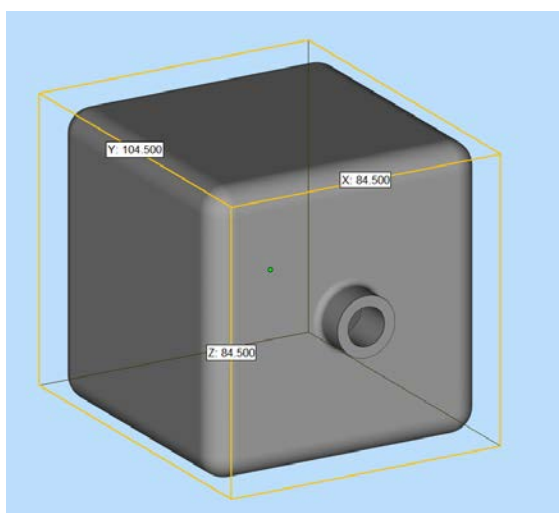


Figure 3. Part bounding box:



- Cube dimensions (without protrusions): 84.50 mm x 84.50 mm x 84.50 mm
- Volume: 96.75 cm³
- Weight: 97.72 g

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Test results

The part has passed the following tests:

- **IP6X**: Dust-proof/dust-tight; totally protected against dust.
- **IPX6**: Protected against jets of water of similar force to heavy seas.
- **IPX7**: Protected against the effects of immersion.

The IPX6 test pass includes the pass of all the previous IP grades: IPX1, IPX2, IPX3, IPX4, and IPX5.

Final parts/builds

The customer assumes all risk related to or arising from the 3D printed parts.

The customer is solely responsible for the evaluation of and determination of the suitability and compliance with applicable regulations of the products and/or 3D printed parts for any use, especially for uses (including but not limited to medical/dental, food contact, automotive, heavy industry, and consumer products) that are regulated by US, EU, and other applicable governments.