Water Ingress Protection Using 3M Pressure Sensitive Adhesives (PSAs)

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Abstract:

The IP code classifies the protection of devices to ingress from external agents. IPX8 is defined as: "*suitable for continuous immersion in water under conditions which are specified by the manufacturer*." This whitepaper defines the simulated device PSA width (1 mm), the depth (10 m), and the duration (30 min) to which 3M PSA IPX8 is defined.

Introduction:

The International Protection Marking, IEC standard 60529 (IP code) classifies and rates the degree of protection provided against the intrusion of solid particles (such as dust) and liquids (water) by electrical enclosures. The rating is generically a 2 digit code, the first referring to solid particle protection and the second to liquid or water protection. In the case of no protection or where protection isn't of interest, the digit is replaced by the letter X.

IP67 is a typical claim for many electronic device manufacturers. This would refer to dust tight (6 rating for solid particle) and suitable for immersion up to 1 meter for 30 minutes (7 rating for liquid). It is important to note that this is a device level test or characterization and not something that can be tested on the tape itself. A device manufacturer will test and rate their device.

IPX8 has been designated by many manufacturers. There are several concerns with this rating. The first is consistent with other rating questions - this is a device level characteristic, not a tape characteristic. The determination whether a device meets the rating depends on application details such as part fit, tape width, and stress on tape. The second issue is that IPX8 is not specifically defined. The description for the 8 rating is "*suitable for continuous immersion in water under conditions which are specified by the manufacturer*." Typically, it is immersion beyond 1 meter with specific depth and time duration specified by the manufacturer, albeit more extreme than the 7 rating.

As an example, the IPX8 depth requirement might be 3 meters for one manufacturer and 10 meters for a different manufacturer. Answering the question of whether a tape is capable of meeting IPX8 would require knowledge of how the manufacturer defines their standard; any claims regarding meeting IPX8 must include a description of how IPX8 is defined (for example depth, duration and, for generic testing, could include geometry).

For this test development and characterization, IPX8 will be defined as equivalent to 1 Bar (gauge) pressure (about 10 meters depth) for 30 minutes with a line width of 1mm.

Table 1 List of the different immersions tested. If samples passed an immersion, they were tested to the subsequent immersion. The highlighted green column indicates the level that IPX8 holds for 3M adhesives.

Immersion	1	2
Simulated depth (chamber pressure)	3 m (4.3 psi)	10 m (14.2 psi)
Pressurized duration in min	30	30

Test Development:

While IPX7 testing is commonly done in a laboratory by submerging to a depth of 1 meter (perhaps in a pipe or tube plugged on one end and filled with water), this is not practical for increasing depths. Sinking test samples to a prescribed depth in a deep body of water would be possible but not convenient. Instead, a pressure pot was used as shown in Figure 1. The tank is filled about halfway with water while the air gap in the chamber is pressurized. Samples were submersed in the water, the tank was sealed tight, and air was pumped to a pressure level equivalent to what the sample would see at the depth in interest.

Figure 1 Pressure pot used to simulate water depth

To calculate the amount of pressure to use, the following table was used. 1 Bar (gauge) pressure is equivalent to about 14.5 psi and is the same as 10 meters submersion. Samples that pass this testing were subjugated to successive immersions described in Figure 2.

Height of Water Column		Pressure		
(m)	(ft)	(kPa)	(bar)	(psi)
1	3.3	9.8	0.1	1.4
2	6.6	19.6	0.2	2.8
3	9.8	29	0.3	4.3
4	13.1	39	0.4	5.7
5	16.4	49	0.5	7.1
6	19.7	59	0.6	8.5
7	23	69	0.7	10.0
8	26	78	0.8	11.4
9	30	88	0.9	12.8
10	33	98	1.0	14.2
12	39	118	1.2	17.1
14	46	137	1.4	19.9
16	52	157	1.6	23
18	59	177	1.8	26
20	66	196	2.0	28
25	82	245	2.5	36
30	98	294	2.9	43

Figure 2 Chart describing the pressure of water exerted at specific depths.

The design of the PSA cutout needed to include both rounded and square corners as different stresses are applied on these common geometries. However, as described previously, 1mm line widths were used. While not a problem for testing at shallow depth (such as 1 meter with 1.4 psi pressure or less) at the higher pressures simulating higher depth, it is expected that combined water/air pressure will squeeze the substrates together, shrinking the trapped air volume and changing the effective pressure differential between outside and inside. In addition, PSA tapes are soft and resilient and will further allow these panels to squeeze together especially when frame width is very narrow. Squeezing the panels together will likely make the tape become wider, effectively increasing the leak path. To minimize this issue, a PET shim of the same thickness as the PSA was placed in the cavity to help the simulated device hold closer to the original dimensions and maintain the higher air pressure differential across the tape width.

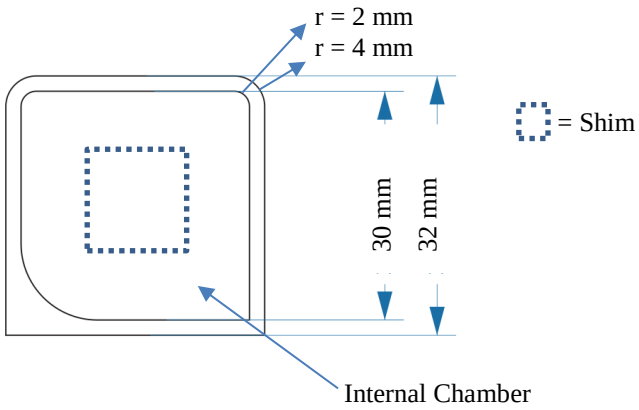

Figure 3 Diecut of PSA used including both rounded and square corners. The line width is 1 mm except for an enlarged corner that is used for better handling while performing the test. The shims were placed around the edges only after the third immersion.

The diecut is placed between a sample of stainless steel and polycarbonate with only the center shim in place. While a variety of materials can be used as substrates, it is important that at least one is clear to allow for inspecting if water leaks in. Substrates can be used as they are or primed for higher adhesion. A variety of tapes can be tested. Examples of a failed and passing sample can be seen in Figure 4.

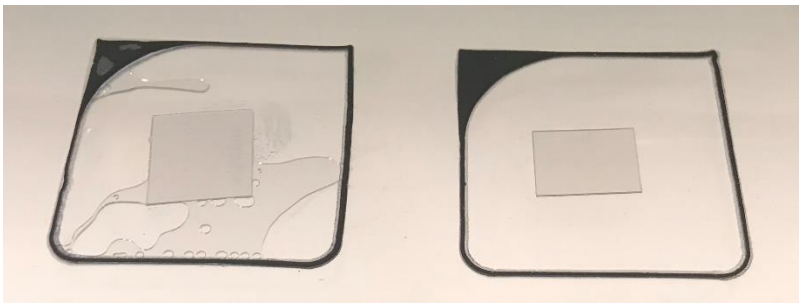

Figure 4 Samples after immersion testing, The left sample has failed while the right has passed.

Note that, even with the relatively large and incompressible spacer tape in the center, it is still expected that the perimeter section of the test panel will squeeze together. The tape will squeeze down and the inner volume will be reduced, changing the pressure differential.

3M™ VHB™ Electronic Tape 86420 is a thin foam tape designed for shock resistance and enclosure bonding. This was the first product tested to the IPX8 standard described above. During initial testing, the tape achieved the following results.

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
3 m																																
10 m																																

Figure 5 Results from testing 86420 to the 3M PSA IPX8 testing protocol.
The green highlighting indicates all samples passed this testing

Summary

3M PSA IPX8 is interpreted as having a device pass (no leaking) after a 10 meter immersion for 30 minutes. This was simulated by submersing a device in a pressure pot filled partially with water and then pumped with air to a prescribed amount, thus simulating water pressure at depth acting on the device. The device design simulates real applications of adhesives in electronic devices. At these high simulated depths, even a small defect in the bond can result in a leak. The test method described can be used for testing/characterizing a variety of tapes and tape types. 3M™ VHB™ Electronic Tape 86420 was the first tape tested and passes the standard of 3M PSA IPX8. The results from this testing are not to be used as a certification of device waterproofness, only to show that if used properly, 3M PSAs may provide a watertight seal.