Performance. Surface. Solutions.

Enabling IPX Level 7/8
PCB Waterproof Protection

Introduction

The miniaturization of electronic products continues to drive printed circuit board (PCB) manufacturing towards smaller and more densely packed boards with increased electronic capabilities. With virtually every electronic device containing at least one PCB, they are a modern marvel and one of the most disruptive innovations of the last one hundred years. However, they have an Achilles heel: water!

Aculon® NanoProof® treated board and with UV lighting

Most circuit board enclosures are satisfactory for protecting the delicate components from being damaged by accidental drops or static electricity, but provide limited protection from liquids. According to research from IDC (International Data Corporation), more than 900,000 smartphones are damaged by liquids every day globally[1]. IDC's research revealed that liquid damage is the second-largest cause of damaged smartphones (the primary source of damage being broken screens) with the impact estimated to be worth nearly $100 billion each year. IDC claims that by 2020, more than 1.7 billion smartphones will be shipped at a market value of $398 billion, with the problem of liquid damage only becoming more widespread if not addressed.

The need for waterproofing PCBs goes way beyond smartphones. There has been tremendous interest from producers of tablets, IoT devices, and appliances as well as automated component manufacturers. Because of their delicate nature, electronics manufacturers are challenged to find reliable, economical and high-performance materials that minimizes or mitigates the damage that compromises safety and operation of electronic devices. Increasingly, designers want to build fluid protection into the design to improve product reliability and reduce device failures. As a result of claims by several leading mobile phone brands, consumers are now looking for water resistance and protection as a feature of new improved devices.

Until recently, thick encapsulating coatings or enclosure gasketing have been used to try remedy the situation. Gaskets are very difficult to incorporate on devices with complex shapes (*e.g.* mobile phones), take up a lot of real estate, and encapsulation eliminates the possibility of reworking a board which creates massive yield losses during manufacturing. Due to these issues, manufacturers turned to conformal coatings, a class of surface treatments that were used for many years to protect circuitry from foreign contaminants like dust, flux residues, etc. Unfortunately, these coatings were not designed to protect devices from direct contact with water. That level of board protection required multiple coats (it can take 10+ successive applications of conformal coating), a process not feasible for high volume manufacturing. Further complicating the process was the introduction of flex connections and press-fit connectors, as well as the use of sensitive devices such as microphones which made masking of these small electronics very time consuming and costly for traditional conformal coating applications.

Using the fundamentals of molecular self-assembly, the Aculon® Inc. team was able to resolve many of those issues, and the Aculon NanoProof® Series of coating chemistries provides IPX8 level protection to devices by manipulation of these phenomena.

Previously, water-resistant products fell into two distinct categories: conformal solution-based coatings and vacuum-deposited coatings. Both surface treatment options protected circuitry from contamination and exposure to humid environments, yet neither method was capable of achieving high levels of water protection (IPX7: full water immersion for 30 minutes while powered on at 1-meter depth[2,3]) to electronic devices being produced in mass manufacturing environments (*e.g.* mobile phones, tablets, e-readers, etc.). Aculon's new class of coating chemistry, NanoProof 7, achieves IPX7 and beyond as well as providing a water and oil repellent surface to circuitry even within the tight constraints imposed by high volume manufacturing lines. It can be readily applied by high speed jetting or dispense equipment (such as those manufactured by Nordson Asymtek or PVA) onto all the sensitive component areas, there is no need to mask or dam and fill with this treatment. This coating chemistry also contains no volatile organic compounds, so it is highly desirable for applications in regions where tight atmospheric controls are in place for the industrial sector.

In the ever-evolving PCB market, a "no mask" category of surface treatment emerged as a result of some recent discoveries made in research and development in the chemistry of conformal coatings. These surface treatments are capable of forming a 'true' conformal coating that maintains consistent thicknesses across complex parts which provides much greater water resistance when compared with traditional conformal coatings. While previous chemistries required masking of connector hubs so other parts could be electrically connected after coating these new surface treatments are applied directly onto connectors which prevents these points from becoming the point of failure upon water immersion. These new hydrophobic coatings are economical and can be applied inline via straightforward processes at the manufacturer. They also eliminate the need for costly capital investments and mitigate the bottlenecking batch process of vacuum-based manufacturing or masking operations.

Aculon's NanoProof 8® Series is a hydrophobic coating which provides IPX8 protection and can also be applied to push-pin connectors without impeding their performance. While this treatment does not provide oleophobic properties, its ability to coat circuitry with consideration for connectors, test points, etc. is an incredibly valuable attribute.

To demonstrate the effectiveness of some of the NanoProof Series, several IPC-B-25A multipurpose test boards were treated with two coatings from the NanoProof Series: NanoProof 7.0 and NanoProof 8.4 using two different methods – rod, and dip coating. IPC-B-25A Multipurpose Test Boards were selected as per recommendation from the guidelines for testing solder masks (IPC-SM-804C) and for testing conformal coatings (IPC-CC-830B). Populated devices (light emitting diode strips) were also tested to illustrate the issues with using the industry standard conformal coating test procedures to approximate water ingress testing. This paper focuses on the IPX7 and IPX8 qualification of devices coated with the NanoProof 7 and 8.4 Series using rod and dip coating. Data for Moisture and Insulation Resistance (IPC-TM-650 2.6.3.4 Rev A) testing are also evaluated.

Experimental Overview

https://www.youtube.com/watch?v=0tGVAiIOKF4

Aculon NanoProof 7.0 and 8.4 were applied to general multipurpose test boards manufactured in compliance with the IPC-Association Connecting Electronics Industries. The coated boards were then submerged underwater following a modified stress test of the IPX7[2,3] testing standard which essentially mimics removal of the enclosure and immersion in a conductive aqueous media, making it an IPX8 level test. The boards were immersed in “Instant Ocean”[4] which was used to mimic seawater while being forward biased for an extended period and while measuring the leakage current between the conductive paths of the comb pattern on the multipurpose test board. The test boards’ leakage current was plotted to demonstrate the overall insulation of NanoProof 7.0 and 8.4 while being stress tested in salt water. Fluctuations in current measured is attributed to either the development of minor conductive paths due to polarization of molecules in the NanoProof 7.0 and 8.4 coating or due to extraneous effects on the circuit such as line noise, floating ground, etc. since the test setup was not placed inside a Faraday cage nor was the ground circuit isolated.

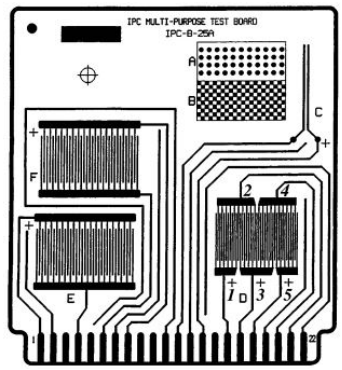
In a separate test, NanoProof 7.0 and 8.4 were subject to Moisture and Insulation Resistance testing in accordance to IPC-TM-650 number 2.6.3.4 (Rev A), where the coatings were subject to a variety of temperature and humidity over a period of 178 hours as well as large biasing loads while monitoring current and insulation resistance. Similar to the modified IPX7 testing, fluctuations in current are attributed to the development of conductive paths under or through the coating, which is typically due to mobilization of flux residues left from soldering on the contact wires.

In a final test, NanoProof7.0 and 8.4 were subject to the same IPX8 level test outlined previously but on live LED light strips immersed in the same saltwater over 60 minutes. The LEDs were assessed pre and post immersion testing for corrosion and functionality. This was performed as a ‘reality check’ to compare the results observed with the IPC-B-25A boards.

Test Boards

For the purposes of these tests, IPC-B-25A Multipurpose Test Board test boards manufactured in compliance with the IPC-Association Connecting Electronics Industries were used, as per recommendation from the guidelines for testing solder masks (IPC-SM-804C) and conformal coatings (IPC-CC-830B); and as per recommendation for Moisture and Insulation Resistance Testing in accordance to IPC-TM-650 number 2.6.3.4 (Rev A). The schematic is shown in Figure 1.

Figure 1



For the last test, some LED light strips from Inspired LED were used to mimic a live board conducting underwater. LED strips were selected for their straightforward design and because their visual indicators (byproducts of electrochemical reactions are clearly visible on the resistors) for protective properties of the coatings being tested. For the last test, some LED light strips from Inspired LED, shown in Figure 2, were used to mimic a live board conducting underwater.

Board Preparation and Coating Application

Figure 2

The IPC-B-25A test boards were cut vertically to isolate the D and C patterns. To increase the rigor of testing, the D-pattern was solely used for its narrower and condensed paths allowing for increased possibility of formation of conductive paths and parasitic capacitances between the copper traces. The test method for Moisture and Insulation Resistance testing also required the use of the D comb pattern.

Prior to testing, all boards were wiped with polyester Berkshire MicroSeal SuperSorb® microfiber cloth moistened with isopropanol to clean them and then the surfaces were blow dried with oil-free compressed air. This preparation method removed outside contaminants such as dust, dirt and other particles thereby eliminating coating deformities as well as conductive pathways between the copper comb leads which could affect conductivity and leakage current and overall results.

For application of the NanoProof Series, Aculon employed its recommended rod/slot coating dip coating or dispensing. To deposit homogenous coatings, Meyer bar coating was selected for the application of NanoProof 7.0 and dip coating was used for the application of NanoProof 8.4.

To increase layer uniformity of dispensing, a RDS 50, R.D. Specialties drawn down bar was used. Once the first layer was dry, an additional layer of NanoProof 7.0 was applied and the board dried at room temperature. This ensured that the final film thickness was on par with the other coatings evaluated.

To dip coat, the test board was slowly lowered into a reservoir containing NanoProof 8.4 and extracted at 10 cm a minute. To properly coat the board while mitigating coating defects such as bubble formation and other inconsistencies in the coating the board was slowly inserted and extracted from the waterproofing solutoin. Once the board was fully extracted from the coating, it was left to hang dry in a ventilation hood at room temperature before testing. Dip coating was solely used for all treatments for the LED test.

Aculon® IPX8 Test Method

The Aculon IPX8 test methodology was developed in adherence to the standard test method developed by the International Electrotechnical Commission with a few modifications. The IP Code, also referred to as the Ingress Protection Rating, determines how well the given electronic device is protected from environmental hazards such as water and dust. Typically, IP ratings are given by two numbers, with the first digit referring to the solid hazards the coating protects and the second indicates the protection level from liquids. In this test, an X served as the first digit to indicate that the coating had not been evaluated for solid hazards, and the second digit an eight to indicate full liquid insertion protection to the coated IPC-B-25A board in saltwater for 60 minutes at 18V bias.

The general IPX7 standard calls for an unpowered finished electronic device to be immersed in water for a period of 30 minutes. Following the 30 minutes, the device is removed and evaluated for functionality. Should the device remain functional as intended, the device meets the IPX7 classification standard. This test is typically done on fully assembled finished electronics such as a mobile phone. This test was modified by removing the variable of the exterior casing.

This modification to the IPX7 test procedure was necessary to eliminate the varying complexities of electronic devices, to include case design, presence or absence of external ports, circuit board layering, element size, etc. Using full immersion of the IPC-B-25A boards removes variability in the enclosure type and allows for direct comparison between conformal coatings on flat surfaces.

Rather than regular water, salt water with an approximate ratio of 3.8% per 39.7g per liter was used. Salt water was used to mimic harsh ‘real world’ conditions, such as exposure to sea water which has roughly a 3.5% salinity level, and to remove interference from the resistivity of the water and any interfering electrochemical reactions that could confound results, like the formation of insulating copper oxides.

Due to the high resistivities of the coatings, the boards were powered with 18 VDC forward bias. This is referred to as Test A. In an additional separate test with newly coated boards, a 50VDC forward bias is referred to as Test B. A summary for the IPX7/8 testing is shown in Table 1.

Table 1

Test Method	Liquid Media	Time (Min)	Bias
IEC IPX7	Water	30	Varies
Aculon IPX8 A	Salt Water	60	18 VDC
Aculon IPX8 B	Salt Water	60	50 VDC

Once the test board was submerged under water, the board's leakage current was measured using a Keithley 6487 Picoammeter over a period of 60 minutes. The picoammeter was programmed to gather 1800 data points or a new data point every two seconds to ensure the test board was properly insulated. The Keithley 6487 also served as the power supply to directly bias the test points on the IPC-B-25A D-comb pattern.

Moisture and Insulation Resistance Testing

Prior to the application method of NanoProof for Moisture and Insulation Resistance Testing, 22 AWG wire with polytetrafluoroethylene insulation was hand soldered onto the mounting pads of the IPC-B-25A multipurpose test board using a white-water rosin flux as specified in the IPC-TM-650 number 2.6.3.4 (Rev A). Once the wire was soldered into place, the test boards were coated as previously described. Flux residues were intentionally not removed prior to testing. Prior to testing, the boards were conditioned at 50°C for a period of 24 hours with no additional humidity prior. Initial resistance measurements were made, and then testing began.

Once the boards were fully coated and prepared, they were inserted and hung from internal racks of a temperature humidity chamber in a near vertical position. The boards were subject to 20 cycles of various temperatures and humidity while being polarized by 50 VDC along the D-comb pattern in accordance to IPC-TM-650 number 2.6.3.4 (Rev A). One cycle was implemented under the following conditions: The temperature was set at 25°C for the first 1.75 ± 0.75 hours and ramped up to 65°C. For the high phase of the cycle, the temperature was maintained at 65°C for three hours, +0.5, -0 hours, and then ramped down from 65°C to 25°C over a 1.75 ± 0.75 hours period. Humidity was maintained at a minimum of 85% throughout the test until the cooldown phase where the boards were subject to 25°C with 50% humidity for 24 hours.

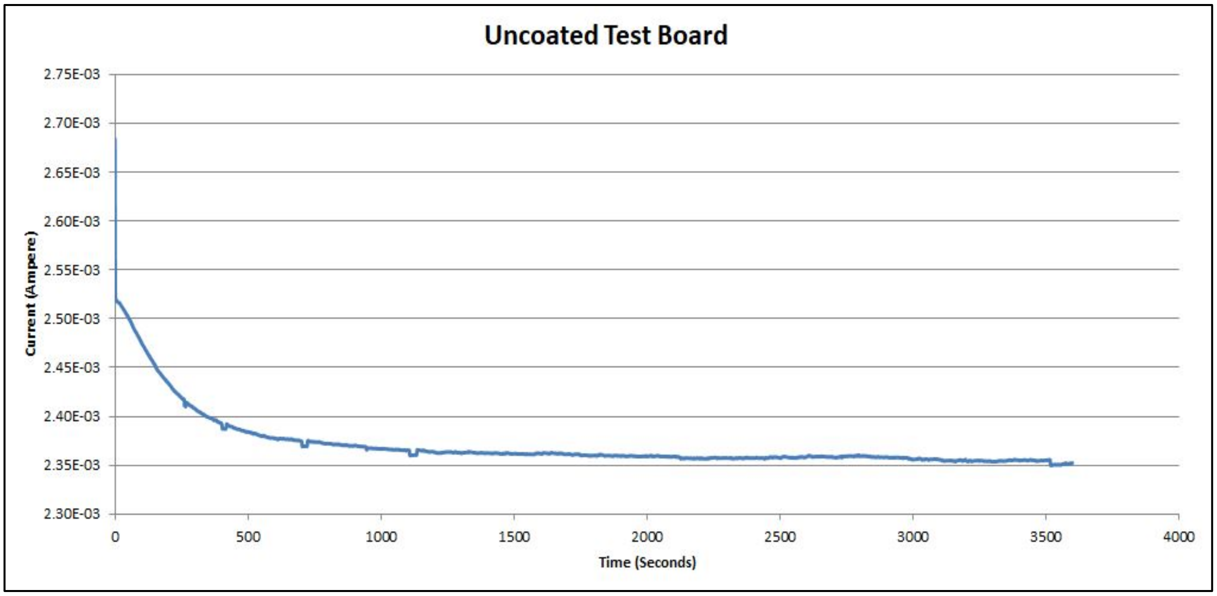
To calculate Resistance, current was measured with a 100 VDC polarizing voltage applied to the D-Pattern's test points as outlined in IPC-TM-650 number 2.6.3.4 (Rev A). Five measurements were taken per test point after one minute of polarizing. Current measurements were taken during the high phase of multiple cycles rather than just the 1st, 4th, 7th, and 10th cycles. The current measurements were taken using a Keithley 6487 picoammeter along with the 100 VDC polarizing voltage. The general 50 VDC biasing maintained throughout the test was provided by a Jameco 50 VDC power supply.

Test Results Aculon® IPX8

The general IPX7 immersion testing standards call for the immersion of finished devices in regular water for 30 minutes. After immersion, the finished electronic device was evaluated for functionality. The Aculon IPX8 modified testing was more strenuous in that an exposed board was being directly submerged and polarized in salt water with 18 volts of direct current over a period of 60 minutes. To further stress the insulation, the test was rerun at 50 VDC with newly coated boards following the same manner previously described.

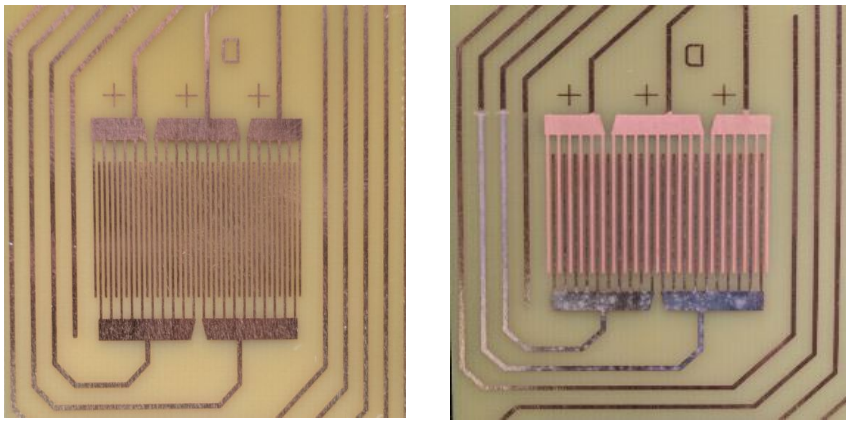
Test A Results (18 VDC Bias)

Figure 3A



Test Board	Average Current (A)	Maximum Current (A)	Minimum Current (A)	Average Resistance (Ω)	Voltage Bias (V)
Uncoated	2.37E-3	2.68E-3	2.35E-3	7.59E+3	18 VDC

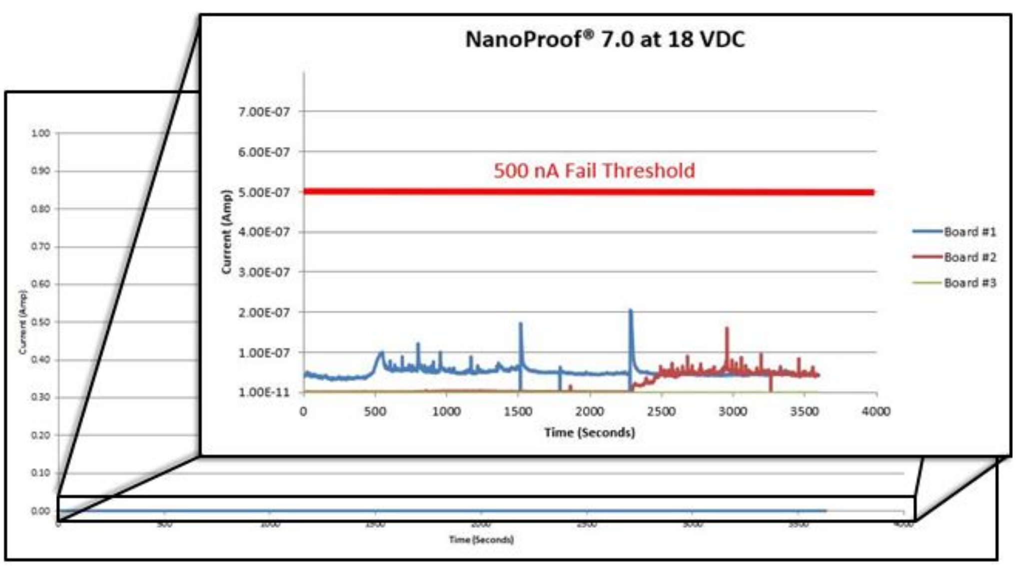
Figure 3B



Uncoated Before Immersion vs Uncoated Post Immersion

As illustrated in Figure 3A, it is quite apparent that an exposed uncoated test boar were severely damaged if powered up while immersed in salt water. The current ranges around 2.5 mA was internally limited to 2.5 mA to protect the ammeter. Upon closer inspection of the boards, it was evident post immersion that the testing the board had become extremely corroded. After coating with the NanoProof chemistries the results are completely different; the results of NanoProof 7.0 and NanoProof 8.4 are outlined below. Upon closer inspection of the boards post immersion, they had become extremely corroded. After coating with the NanoProof chemistries the results were completely different. The results of NanoProof 7.0 and NanoProof 8.4 are outlined in Figure aA.

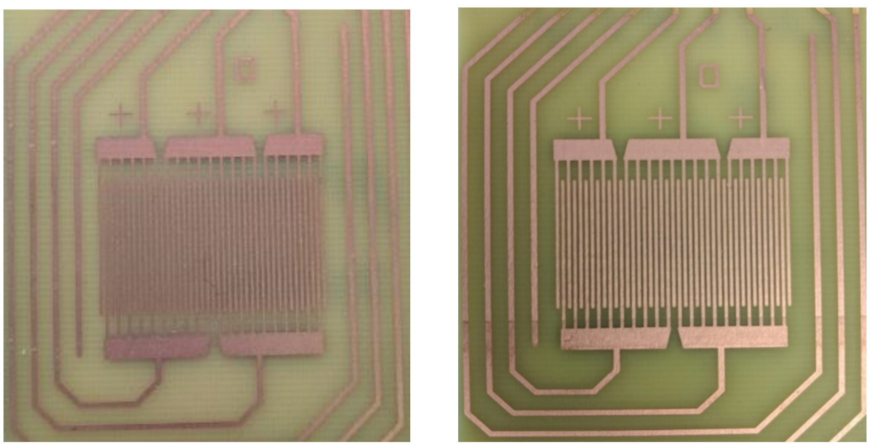
Figure 4A



As indicated by Figure 4A, on average current did not exceed 100 nA. Test board 1 and 2 spiked over 100 nA, which is most likely due to line noise or interference from other electrical equipment that the picoammeter is detecting as a result of the scale at which the current is measured. In general, the safety standards for electrical devices such as handheld devices can leak on a larger scale (up to 250 uA allowed) than the current being detected[5]. The development of negative currents can be attributed to line noise due to the scale at which current is being measured. Since the boards have such low leakage currents, ion migration is minimal and the coating provides a high amount of insulation.

On average, the amount of insulation resistance for NanoProof 7.0 applied in this manner is in the Gigaohm range as can be viewed in Table 3. When compared to an uncoated IPC board, the leakage current has been scaled down by a factor of nearly one hundred thousand. Even at its highest amount of leakage as per Table 3, 204 nA, and the lowest amount of leakage for the uncoated board as per Figure 3A, around 2 mA, the amount of current leakage is still lowered by a factor of ten thousand for NanoProof 7.0 when applied in this manner.

Figure 4B



NanoProof 7.0 Pre-Test vs NanoProof 7.0 Post Test

In the case of NanoProof 8.4, the current did not exceed 250 nA. Indicating on average NanoProof 8.4 applied in this manner provides around a Gigaohm range of insulation. All these leakage rates are exponentially smaller than that of an uncoated board, as indicated in Figure 2A. There is a decrease in leakage current by a factor of forty thousand on average for NanoProof 8.4 and when compared to the lowest leakage rate for the uncoated board and the highest leakage rate of one of the NanoProof 8.4 boards, the decrease is still by a factor of ten thousand.

Figure 5A

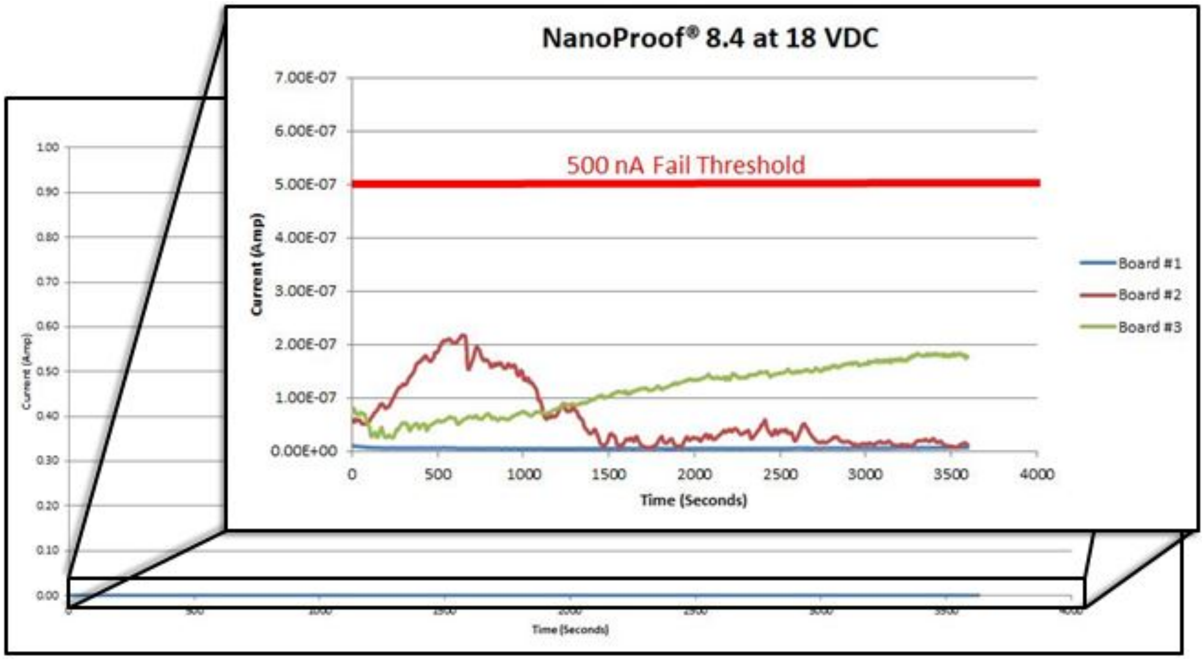
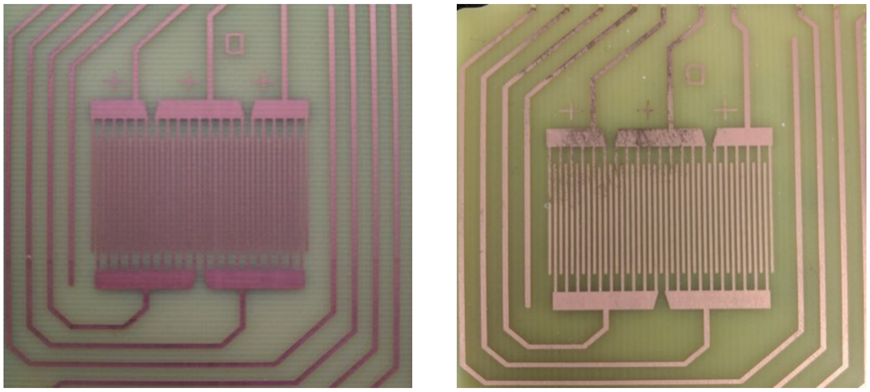


Figure 5B



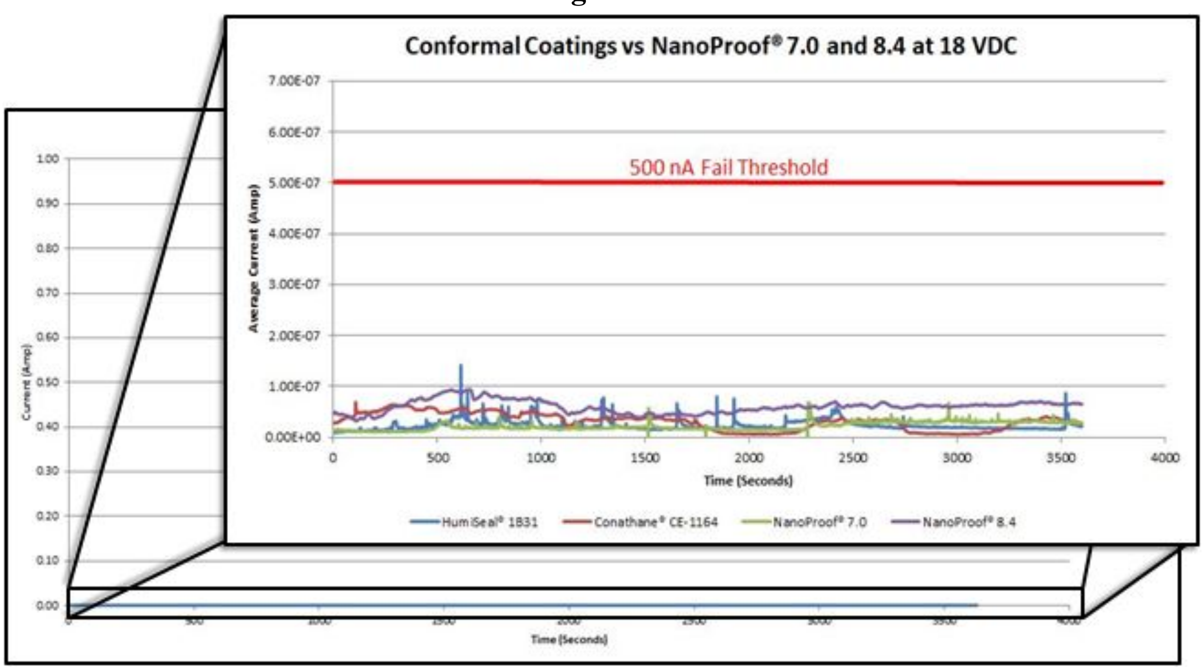
NanoProof 8.4 Pre-Test vs NanoProof 8.4 Post Test

Table 3

Test Number	Average Current (Amp)	Max Current (Amp)	Min Current (Amp)	Average Resistance (Ω)	DC Voltage (Volt)
NanoProof 7.0 #1	4.89E-08	2.04E-07	2.96E-08	3.68E+08	18
NanoProof 7.0 #2	1.69E-08	1.59E-07	-9.31E-10	1.06E+09	18
NanoProof 7.0 #3	3.36E-11	2.99E-10	-1.24E-10	5.36E+11	18
NanoProof 8.4 #1	5.35E-09	9.99E-09	4.24E-09	3.36E+9	18
NanoProof 8.4 #2	6.27E-08	2.18E-07	5.96E-09	2.87E+8	18
NanoProof 8.4 #3	1.13E-07	1.84E-07	2.50E-08	1.59E+8	18

Summary of Electrical Data for Test A

Figure 5



Average Current vs Time for 2 conformal coatings against NanoProof® 7.0 & 8.4

NanoProof coatings were compared to two traditional notable conformal coatings, acrylic-based Humiseal 1B315 and polyurethane-based Conathane CE-1164 were chosen for electrical testing. As evidenced from the data above, all four coatings exhibited the same performance on the IPC-

B-25A test boards. Spikes in the data were attributed to line noise detection as well as potential coating defects like pinholes.

Test B Results

The standard Aculon IPX8 modified test calls for the IPC-B-25A board to be polarized with 18 Volts. To demonstrate the insulation properties provided by the NanoProof 7 and 8 Series, the boards were also biased with 50 VDC. The data is shown in Figure 6.

Figure 6

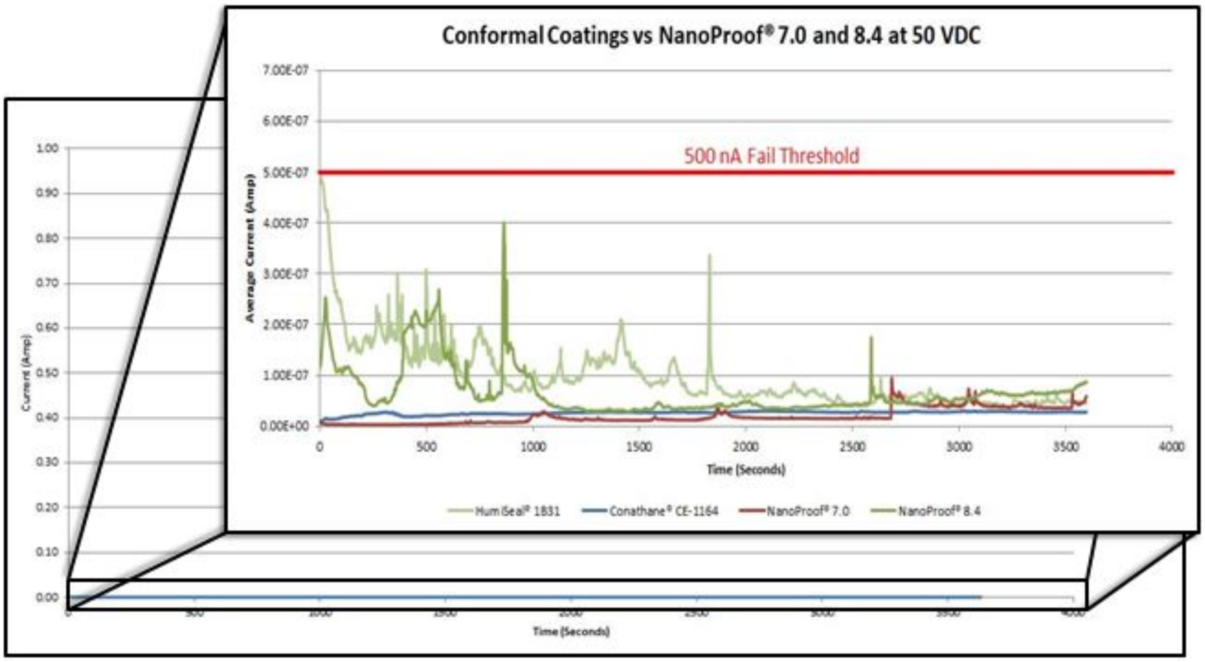


Table 4

Test Number	Average Current (Amp)	Maximum Current (Amp)	Minimum Current (Amp)	Average Resistance (Ω)	DC Voltage Bias (V)
NanoProof 8.4 #1	1.10E-07	5.70E-07	4.14E-08	1.63E+08	50
NanoProof 8.4 #2	8.96E-08	1.11E-06	2.62E-08	2.01E+08	50
NanoProof 8.4 #3	6.22E-11	4.23E-10	-1.18E-10	2.89E+11	50
NanoProof 7.0 #1	5.52E-08	2.78E-07	4.72E-09	3.26E+08	50
NanoProof 7.0 #2	1.83E-09	8.92E-09	1.07E-09	9.83E+09	50
NanoProof 7.0 #3	1.56E-09	2.86E-09	8.72E-10	1.16E+10	50

Summary of Electrical Data at 50 VDC

Again, all four coatings performed well even at high bias indicating that they can all adequately protect two-dimensional circuitry.

Moisture and Insulation Resistance Test Results

The criteria for passing Moisture and Insulation Resistance as specified in the IPC-CC-830 standard is for the test points of the D-comb pattern remain greater than 500 MΩ or 5E+8Ω. Aculon's NanoProof 7.0 and NanoProof 8.4 results are outlined in Table 5 and Table 6.

Table 5

Test Number	Average Resistance Points +1/-2	Average Resistance Points +3/-2	Average Resistance Points +3/-4	Average Resistance Points +5/-4
NanoProof 7.0 #1	5.12E+12 Ω	5.35E+12 Ω	3.14E+12 Ω	2.39E+12 Ω
NanoProof 7.0 #2	2.01E+12 Ω	1.68E+12 Ω	1.59E+12 Ω	2.56E+12 Ω
NanoProof 7.0 #3	2.26E+12 Ω	2.22E+12 Ω	1.95E+12 Ω	1.61E+12 Ω
NanoProof 8.4 #1	3.28E+12 Ω	3.90E+12 Ω	1.96E+12 Ω	3.55E+12 Ω
NanoProof 8.4 #2	1.21E+12 Ω	1.83E+12 Ω	5.48E+11 Ω	1.23E+12 Ω
NanoProof 8.4 #3	9.27E+11 Ω	6.22E+11 Ω	7.95E+11 Ω	7.19E+11 Ω

Summary of Average Resistance per Test Points

Table 6

Average Resistance (Ω)						
Time in chamber (Hours)	**NanoProof 7.0 Test Board #1**	**NanoProof 7.0 Test Board #2**	**NanoProof 7.0 Test Board #3**	**NanoProof 8.4 Test Board #1**	**NanoProof 8.4 Test Board #2**	**NanoProof 8.4 Test Board #3**
Initial	8.45E+12	8.03E+12	3.06E+12	2.81E+12	7.30E+12	1.19E+12
1.75	2.58E+10	3.52E+10	1.24E+11	8.40E+11	3.08E+11	1.20E+11
21.25	5.65E+10	7.43E+10	1.86E+11	7.52E+11	1.19E+11	6.10E+10
40.75	7.74E+10	1.08E+11	2.01E+11	9.45E+11	1.70E+11	6.19E+10
60.25	7.29E+10	1.13E+11	2.04E+11	6.87E+11	1.82E+11	6.14E+10
66.75	8.73E+10	1.31E+11	2.09E+11	1.31E+12	1.26E+11	6.35E+10
86.25	1.19E+11	4.89E+11	3.51E+11	6.39E+11	1.40E+11	7.05E+10
95.75	1.21E+11	3.41E+11	3.97E+11	1.96E+12	3.16E+11	6.99E+10
105.75	4.12E+11	3.46E+11	1.96E+11	1.06E+12	1.97E+11	1.98E+11
112.25	1.14E+12	4.09E+11	3.03E+11	7.75E+11	2.21E+11	9.42E+10
125.25	4.52E+11	6.29E+11	2.33E+11	4.28E+11	3.32E+11	2.18E+11
Final	3.70E+13	1.28E+13	1.87E+13	2.84E+13	6.13E+12	7.59E+12

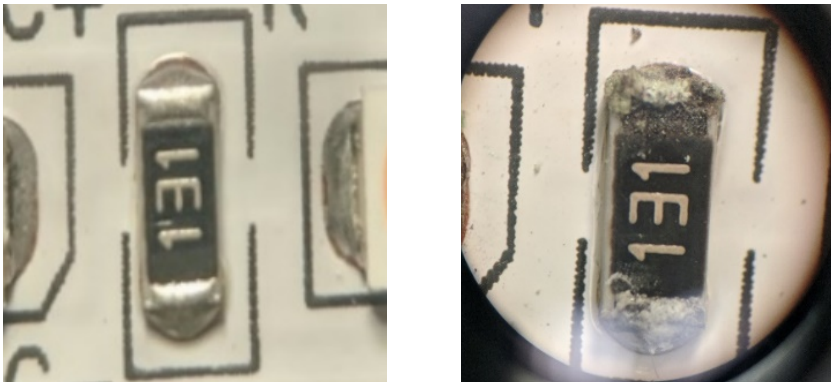
Summary of Average Resistance per Time Interval Measured

Also indicated in Tables 5 and 6, NanoProof 7.0 and NanoProof 8.4 exceed the criteria for moisture and insulation resistance. The moisture and Insulation resistance testing is designed to stress the applied coating through exposure to various temperatures and humidities and expose any contaminants present on the board or in/on the coating may react with water over time and form conductive traces. Conathane® CE-1164 and HumiSeal 1B31 have resistance values of 1.3E+10 and 6E+10 (values listed by the mfgs.) after MIR testing, respectively, which are similar to the aforementioned values for NanoProof 7 and NanoProof 8.4. This indicates that all the coatings are appropriate for insulation of conductive surfaces.

IPX8 Functional Board Test

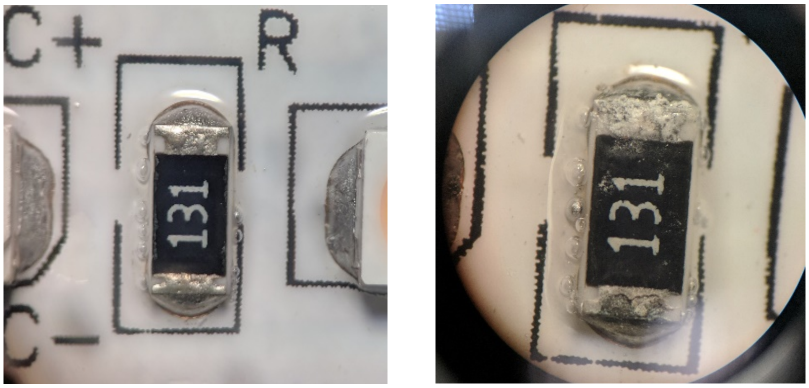
The IPC-B-25A multipurpose test board is a well-regarded process qualification vehicle to test coatings, but the complexities of printed circuit boards vary in element size, design and purpose. As a true functional test, some flexible LED strips were coated and performed a very similar test to the Aculon IPX8 test but the strips were powered with 12 VDC, rather than 18 VDC. The deviation was due to the inherent design of the strips. The circuitry was still immersed in the same “Instant Ocean” salt water mix for 60 minutes and evaluated for corrosion/functionality post testing. The results are illustrated in Figures 7A through 7E:

Figure 7A



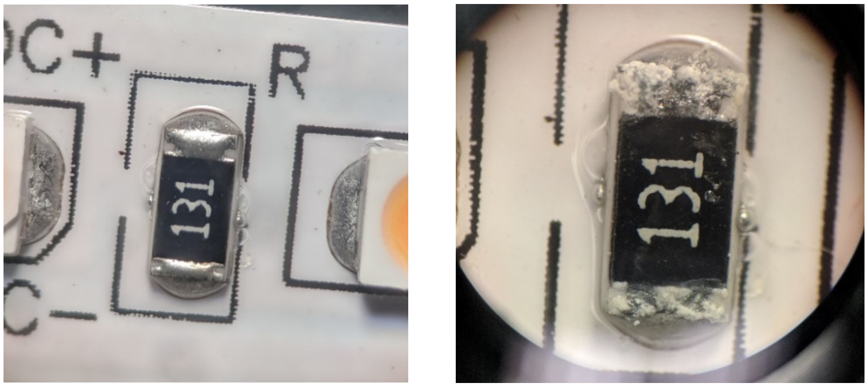
Uncoated LED strip Pre-Immersion vs Post Immersion (Corrosion visible)

Figure 7B



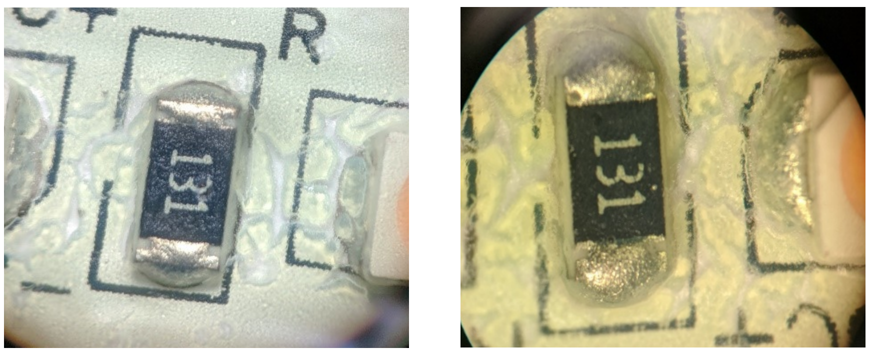
Conathane® CE-1164 coated LED strip Pre-Immersion vs Post Immersion (Corrosion visible)

Figure 7C



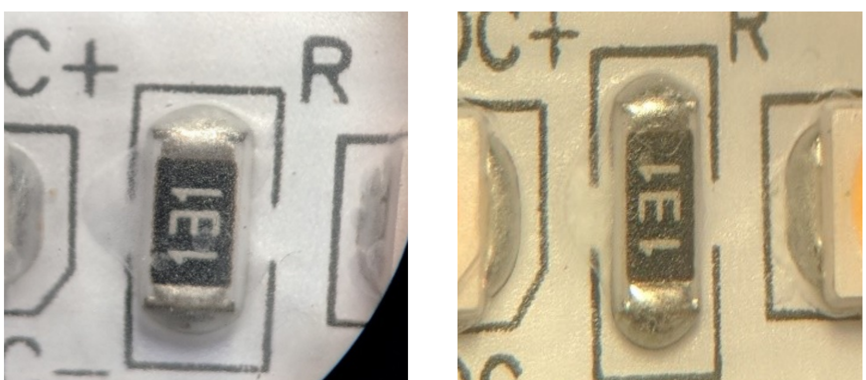
HumiSeal® 1B31 coated LED strip Pre-Immersion vs Post Immersion (Corrosion visible)

Figure 7D



NanoProof 7.0 coated LED board Pre-Immersion vs Post Immersion (No corrosion visible)

Figure 7E



NanoProof 8.4 coated LED board Pre-Immersion vs Post Immersion (No corrosion visible)

From the IPX8 testing data on the IPC-25A boards it could be surmised that all four coatings would have performed similarly with insulating materials providing adequate protection from water damage. Further examination of the LED boards after the 60 min immersion in salt water test indicated that the uncoated strip and the HumiSeal® and Conathane® coated strips still developed corrosion, whereas the boards coated with NanoProof 7.0 and 8.4 showed no corrosion. Although the traditional conformal coatings have very high resistivities and excellent MIR performance, they rapidly fail water immersion testing on a test part with three-dimensional structure. While this may seem counterintuitive, note that the former conformal coatings were not designed to provide IPX7 protection, rather they were intended to protect the circuitry from corrosion, current leakage, and component damage due to contaminants present on the board or those present in their operating environment. So, while the traditional conformal coating chemistries have excellent insulating properties, they are not capable of achieving the desired level of thickness required for direct contact with liquid water without multiple successive applications, a process not feasible for high volume manufacturing. In contrast, NanoProof 7 and 8 Series chemistries were specifically designed to be deposited in high volume production with a single coating pass being sufficient to pass IPX7 and above. NanoProof 8.4 also has an added benefit of being able to coat connectors without concern for loss of continuity.

Summary and Conclusions

Superficially, indicators show that two-dimensional test circuity of the four tested coatings (HumiSeal®, Conathane®, NanoProof 7.0 and NanoProof 8.4) would demonstrate similar circuit protection from water. However, when actual functional 3-D circuitry devices were tested with HumiSeal® and Conathane® coatings, they exhibited corrosion and device failure in under 60 minutes of saltwater immersion testing. The devices coated with NanoProof 7.0 and NanoProof 8.4 did not. Aculon NanoProof 7 and 8 Series of coating chemistries create an insulation barrier for electronics protecting them from liquid media such as water and prevents liquid induced damage during operation.

In today's competitive marketplace where the value of electronic devices, particularly smartphones is constantly rising (and therefore the risk of water damage rises concurrently), not having some kind of water resistance to the device is becoming a serious problem for device designers/manufacturers. Application of the latest generation of hydro/oleophobic coatings provide longevity to devices under 'real-use' circumstances when exposed to liquids.

However, application of the latest generation of hydro/oleophobic coatings can help these devices achieve longer lifetimes under 'real-use' circumstances where they are going to be subject to exposure to liquids.

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References

[1] IDC research: http://blog-idcuk.com/a-problem-with-mobile-phones-that-is-no-longer-acceptable-part-i/

[2] The IP Code is a test standard published by the International Electrotechncal Commission (IEC) and describes the level of protection provided by an enclosure. For an explanation of the IP code see: http://www.ce-mag.com/archive/06/ARG/bisenius.htm

[3] IP Code Defined: https://www.engineeringtoolbox.com/ip-ingress-protection-d_452.html

[4] Sea salt information: http://www.instantocean.com/

[5] Safety Standards for leakage: http://www.marcspages.co.uk/pq/3333.htm