Nexgen Carbon Flex Laboratory Testing Results

Introduction

Nexgen Carbon Flex was tested at ATI for:

Adhesion thickness
Surface porosity at 100% and 55% degradation
pH Degradation
Durability against 5 common metals
Advanced weathering durability
Sensitivity to rapid changes in temperature

A total of 12 test panels were used in this testing procedure. All panels were properly gauged and assigned certified scan codes before any testing proceeded.

All testing panels were properly decontaminated and prepared to allow maximum adherence of Carbon Flex. Application and curing of the product was performed according to the manufacturer recommendations.

All prep, application, and curing processes were in accordance with the IATF regulations on repeatable conditions and installation procedures. An ISO3 installation area is utilized with air contamination regulation not exceeding 200ppm @ .2μm with 600 air exchanges per hour.

Note: For each test, 2 panels with extreme high or low results were disregarded, and only 10 panels' data were recorded. This was to obtain a more accurate view of averages and maximum/minimum variance.

Summary of Data

Adhesion Thickness: 0.89µm
Surface Porosity:
- Open Cell Count: 27
- Open Cell Structure: 0.05µm
- 45% Open Cell Count: 45
- 45% Open Cell Structure: 0.06µm

pH Degradation
- Alkaline: 13
- Acid: 1.5

pH Degradation 100% Failure:
- Alkaline: 13
- Acid: 1.25

Scratch Resistance:
- LCS: 0.23µm
- AL 6061: 0.15µm
- AL 3003: 0.17µm
- CU: 0.11µm
- FE: 0.25µm

Advanced Weathering Durability:
- 12 months: 0.06µm
- 24 months: 0.08µm
- 36 months: 0.08µm
- 48 months: 0.08µm
- 60 months: 0.08µm
- 72 months: 0.14µm (end of test)

Temperature Sensitivity (Max: Δ10°F)
- Declining: 8°F
- Inclining: 10°F

Adhesion Thickness Test

This test determines the amount of product added to a surface after application. In this case, the thickness of the adhered layer deposited by Carbon Flex, measured in micrometers (μm).

After prep, application, and curing (see Introduction), a Marposs Aeroel XLX scan Micrometer was used to measure the thickness of product. The instrument is certified at a 0.2μm repeatability and is calibrated weekly to ensure accuracy and precision. A total of 200 scan points are made per panel and readings are averaged with maximum/minimum values shown.

10 panels with centralized data were selected to record. Based on the results of these 10 panels with 200 sample points each, the adhesion thickness results were averaged and presented as follows.

Results: 0.89μm
- Min: 0.79μm
- Max: 0.94μm

Surface Porosity

This test measures surface regularity and smoothness by measuring the number and structure of naturally-occurring pores in the surface technology.

After prep, application, and curing (see Introduction), a Leica HM6R was used to scan the panel surface and digital software determined the number of pores in 10 1mm x 1mm scan areas per panel. Only pores measuring > 0.01μm were counted.

The same digital software was also used to measure and determine the average diameter in μm of pores in the surface technology. This measurement presents a probability account of contaminants' ability to embed into the surface. Larger pores/openings increase the likelihood that contaminants will embed. The software presents a maximum/minimum and average for each sample area.

Both measurement processes were replicated when the coating had degraded at least 55% of the original adhered thickness.

10 panels with centralized data were selected to record. Based on the results of these 10 panels with 10 sample areas each, the surface porosity results were averaged and presented as follows.

Results at Just-After Curing:
- Open Cell Count: 27
- Open Cell Structure: 0.05μm
  - Min: 0.04μm
  - Max: 0.07μm

Results at 45% Remaining Adhered Thickness:
- 45% Open Cell Count: 45
- 45% Open Cell Structure: 0.06μm
  - Min: 0.06μm
  - Max: 0.08μm

% Change:
- 100% vs 45% Open Cell Count: 66% increase
- 100% vs 45% Open Cell Structure: 20% increase

Notes: At 45% remaining, the coating still maintains most of its physical integrity, continuing to display hydrophobicity and enhanced gloss, while also providing valuable information about degradation patterns on the microscopic level. Coating performance would begin to deteriorate at any less than 45% remaining.

pH Sensitivity

This test measures the ability of the Carbon Flex surface technology to resist the penetration of chemical substances at varying pH levels for a sustained 10 minutes.

After prep, application, and curing (see Introduction), a specialized injection pod system loaded with 10 tubes of an alkaline pH solution was applied to the panel surface to test direct contact resistance. After 10 minutes, the tubes were removed, and a new set of 10 tubes containing a solution of a different alkaline pH were applied to a fresh area of the panel. This was repeated until all 10 tube surfaces had reached the failure point. The entire process was replicated to test resistance to acidic solutions, assessing resistance at up to 25 different pH levels in total.

After each contact test, a Leica HM6R was used to scan the panel surface, and digital software determined the surface degradation of each sample area and recorded the failure points. A sample area was considered “failed” when the surface technology was fully penetrated, leaving the panel exposed to the air. The pH measure of these failure points was recorded.

The 100% failure pH was simply the stopping point for each of the alkaline/acid tests, as this is the measure of the pH at which all 10 tube surfaces had reached the failure point.

10 panels with centralized data were selected to record. Based on the results of these 10 panels with up to 25 sample areas each, the pH sensitivity results were averaged and presented as follows.

pH Degradation Alkaline: 13
pH Degradation Acid: 1.5
pH Degradation 100% Failure:

- Alkaline: 13
- Acid: 1.25

Notes: Proprietary alkaline/acidic formulas are used in favor of generic alkaline/acidic formulas for the purpose of precision. “Pre-preparing” generic solutions, like $NaOH$ for example, presents many opportunities for error, which can be avoided by using formulas known to measure the same pH consistently.

Scratch Resistance

This test measures the durability and scratch resistance of Carbon Flex surface technology against common metals by performing a drag test and measuring the damage.

After prep, application, and curing (see Introduction), a specialized mechanism was used to perform the drag test. A 1.5mm contact surface is applied with 250g of regulated pressure moved across the panel in 25mm areas at a speed of 1cm/sec. This was repeated several times per metal material to establish an accurate average and variance result.

Level of damage was determined by using a Terras Surface M, which uses a probe to measure surface variation in micrometers (μm).

10 panels with centralized data were selected to record. Based on the results of these 10 panels with several sample drags for each metal, the durability and scratch resistance results were averaged and presented as follows.

LCS: 0.23μm
- Min: 0.18μm
- Max: 0.30μm

AL 6061: 0.15μm
- Min: 0.13μm
- Max: 0.15μm

AL 3003: 0.17μm
- Min: 0.14μm
- Max: 0.19μm

CU: 0.11μm
- Min: 0.09μm
- Max: 0.19μm

FE: 0.25μm
- Min: 0.21μm
- Max: 0.29μm

Notes: These metals were selected because of their abundance in everyday life. By using metals found in common items like belts, zippers, and keys, the test provides a more comprehensive and accurate summary of how the Carbon Flex coating will endure in the average setting. Results are not listed in order of hardness.

LCS: Low Carbon steel.
AL 6061: 6061 Aluminum alloy.
AL 3003: 3003 Aluminum alloy.
CU: Copper.
FE: Iron.

Advanced Weathering

This test determines the durability of Carbon Flex surface technology against simulated weathering events and timeframes.

Weathering was simulated in 12-month cycles using a purpose-built chamber module with a 12-panel capacity. After prep, application, and curing (see Introduction), the 12-panel table was moved throughout each chamber mimicking 30 days of weathering per chamber. Exposure to UV, wind and temperature variations, and rain content were simulated with exacted data from NOAA and other reporting agencies. After each 12-month cycle was complete, surface degradation by erosion or removal was measured on 25 distinct points of the panel using a Marposs Aeroel XLX.

The test was ended when the surface technology fell below 45% of its original thickness and was then marked “SF”, meaning the surface’s abilities and performance would begin to deteriorate.

10 panels with centralized data were selected to record. Based on the results of these 10 panels, the advanced weathering results were presented as follows.

12 Months: 0.06μm
24 Months: 0.08μm
36 Months: 0.08μm
48 Months: 0.08μm
60 Months: 0.08μm
72 Months: 0.14μm (SF/End of Test)

Sensitivity to Temperature Change

This test determines the ability of the Carbon Flex surface technology to withstand expansion and contraction caused by rapid changes in temperature, both decreasing and increasing.

After prep, application, and curing (see Introduction), the panel underwent a test designed to mimic surface temperature fluctuations. The first half of the test starts with a 1°F decline in 1 second, and ends with a 10°F decline in 1 second. Between each temperature decline, the panel is scanned with a Leica HM6R and a digital program highlights any fractures that occurred in the coating. The test is considered "failed" when the length of 1 or more fractures measures > 0.3μm. The entire process was repeated to measured the coating's sensitivity to increasing temperatures.

10 panels with centralized data were selected to record. Based on the results of these 10 panels, the sensitivity to temperature change results were presented as follows.

Fractures > 0.3μm (Max: Δ10°F)

- Declining: 8°F
- Inclining: 10°F