



**RESTORE, ENHANCE,
EXTEND & PROTECT**

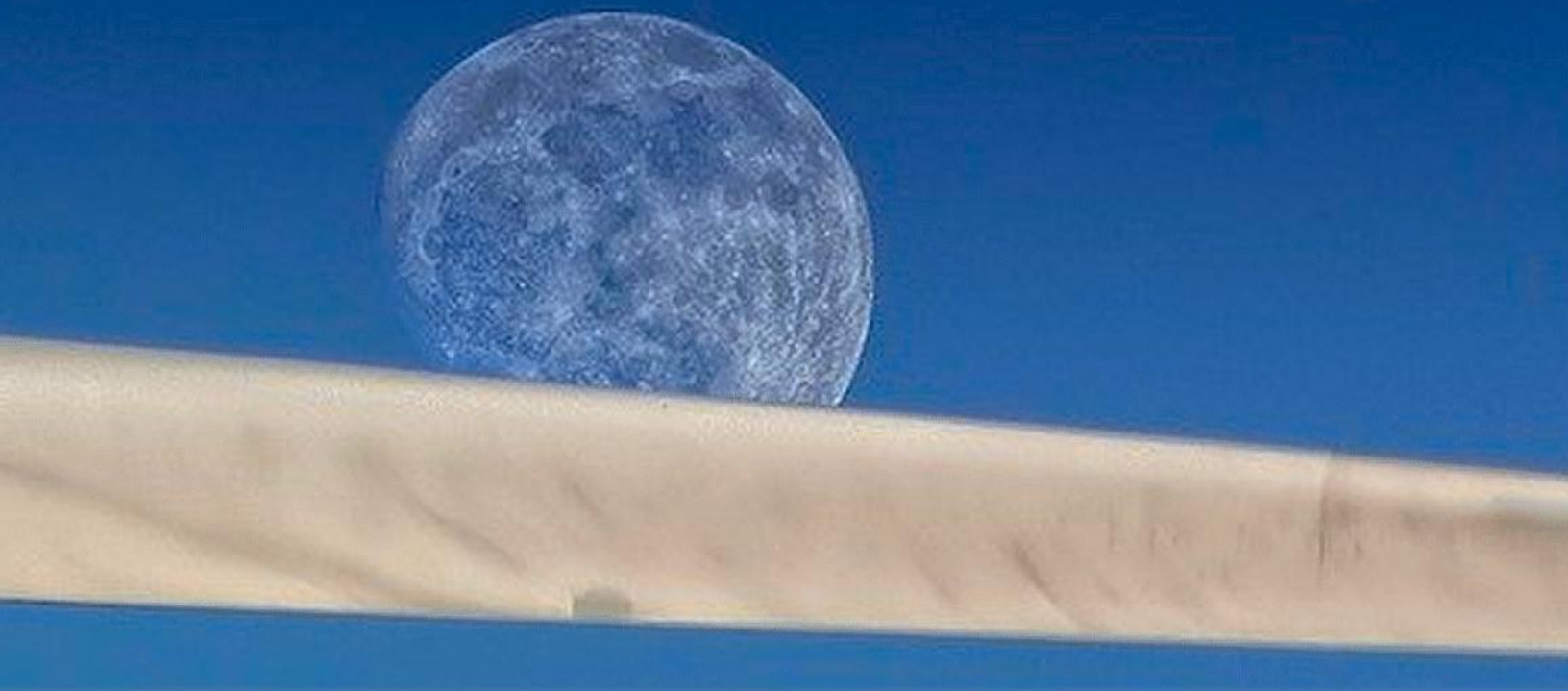
NANO-CLEAR[®] **FOR WIND TURBINE BLADES**

- ❖ Industry Award Winning, Eco-Friendly Coatings Guaranteed to Extend the Service Life of Valuable Assets
- ❖ 23x (2,300%) More Scratch Resistant Compared To A Leading Aerospace Grade Coating for Fibreglass
- ❖ Unmatched Durability, Even in the Harshest Environments

(For Oxidized or Freshly Painted Surfaces)



v-2021.12.13-1



WIND TURBINE OPERATIONS

700,000 blades in operation growing by 50,000+ blades annually. Fiberglass turbine blades and their supporting structures are subjected to conditions that lead to extreme erosion, corrosion and material fatigue. 1/3 of downtime is caused by blade failures.

TCO & ROI Impact:

- Reduced performance **5 - 8%**
- Shortened service lifespan **5 - 10 yrs**
- Increased maintenance **25%**

50,000 tons / year of wind blades are landfilled.

Nano-Clear[®]

Nano-Clear[®] dramatically increases service lifespan, reduces surface maintenance costs and increases ROI.

COATINGS FOR WIND TURBINE BLADES

"To protect your investment in the future, you need wind turbine coatings which protect against the erosion and corrosion of the entire structure due to the harsh environmental conditions it faces daily."
CoatingPaint.com

Nano-Clear[®] reduces erosion-caused drag resistance to improve performance.

Nano-Clear[®] is **23x (2,300%) more scratch resistant** as compared to a leading aerospace grade coating for fiberglass. (independently tested / validated - * see test results: pg 8, Table 2)

FOR NEWLY MANUFACTURED ASSETS OR IN-FIELD REPAIR WORK

Applied During Manufacturing Process

Nano-Clear® - can be integrated into current manufacturing processes.



During Maintenance Procedures

Nano-Clear® - can be incorporated into regular maintenance routines.



LEADING EDGE EROSION (LEE)

The front edge of a turbine blade is subjected to constant impact from airborne projectiles such as rain, ice, salt, and sand.

"The impact of liquid droplets on rigid surfaces generates water hammer pressure of several gigapascals. Later, the droplet depressurizes through lateral jets that can move two (2) to six (6) times faster than the impact velocity. Lateral jetting and water hammer pressure can exert stress beyond the solid surface's endurance limit, resulting in failure mechanisms like increased roughness, fatigue cracks, delamination, spalling, and pitting." Ducom Water Droplet Erosion Tester.

It's well known that Leading Edge Erosion is one of the largest and most costly maintenance, repair, and overhaul (MRO) issues for wind turbine blades.

NOTE - Nano-Clear® is the optimum solution for *entire blade surfaces*, not just leading edges.

Impact On Performance

Testing has shown a drag increase of **80 - 500%** due to leading edge erosion (light-to-heavy erosion cases).

Erosion also caused a substantial reduction in lift coefficient, especially at the higher angles of attack that are experienced by wind turbines during their operation.

Aerodynamic Characteristic	Impact	Energy Capture Losses
Leading Edge Erosion	TBD	5 - 8%
Drag	80% (Low) 400 - 500% (High)	5% 25%



Nano-Clear®

REDUCE CARBON FOOTPRINT / ENHANCE BRAND REPUTATION



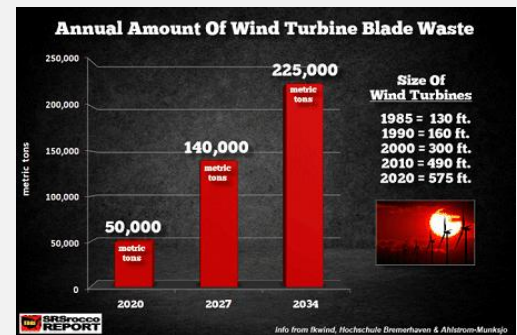
These unrecyclable blades will lie in the ground essentially forever (or at best for many hundreds of years), as they don't degrade over time.



Operations and Maintenance (O&M) costs can total 30% of a turbine's overall annual price tag and continues to be a burden for operators.

Accelerated replacement of turbines becomes expensive: up to **2% to 4%** of the value of all wind-generated power is lost as a result of this problem.

"50,000 tons of blade waste in 2020 ... will quadruple to 225,000 tons by 2034."



IMPROVING BLADE MANUFACTURING QUALITY AND THE MITIGATION OF ENVIRONMENTAL DAMAGE

"Unplanned maintenance and component failures are concern to both wind plant owners-operator and wind turbine manufacturers." Sandia Energy

NANO-CLEAR® PERFORMANCE FEATURES

- ✓ Reduces blade vibration / noise levels
- ✓ Increases impact resistance (superior water droplet shock absorption)
- ✓ Exceptional substrate delamination prevention
- ✓ Hydrophobic surface increases water and ice repellency
- ✓ Improves airflow (less drag)

Nano-Clear® is 23x (2,300%) more scratch resistant as compared to a leading aerospace grade coating for fiberglass. (independently tested / validated - * see test results: pg 8, Table 2)

NANO-CLEAR® - THE SUSTAINABLE OPTION

- ❖ Eco-innovative / Eco-responsible, Low VOC, Green Solution
- ❖ Unmatched Durability, Even in the Harshesht Environments



NANO-CLEAR® - A NEW & BETTER OPTION

Nano-Clear® is a unique technology that uses proprietary 3D nano-structured polymers with extreme crosslink (xxLink™) density.

Nano-Clear® Dramatically Improves Resistance To:

- ✓ Erosion
- ✓ Weathering
- ✓ Abrasion
- ✓ Scratching
- ✓ Chipping
- ✓ Marring
- ✓ Chemical Attack
- ✓ UV Degradation

Client Testimonial 1

MarAd Fleet

BEFORE Application of Nano-Clear®



AFTER Application of Nano-Clear®



Note: Original colour and gloss was restored with Nano-Clear®. Fiberglass lifeboats were **not** repainted.

"The results are stunning. I have a meticulous bosun who rolled and back brushed the product onto the boat, and despite having far from ideal circumstances (outdoors, wind, dust) the improvement to my lifeboats is remarkable."

Master/Chief Mate - MarAd Fleet

Nano-Clear®

Client Testimonial 2

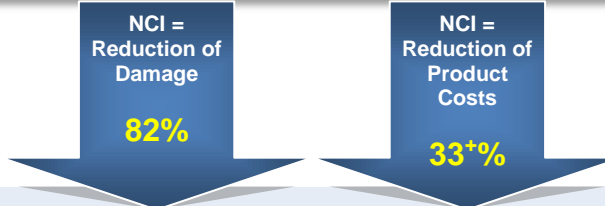
Metrolinx / GO Transit

After a demanding 3 year field evaluation, the contrasting images below of the entire front fiberglass sections (including light & accessory panels) of these buses clearly demonstrate the extreme protective capabilities of **Nano-Clear® (NCI)**.



✗ (8304) Conventional Clearcoat

✓ (8305) Nano-Clear®



According to Metrolinx Engineering,

"As shown above, 2 layers of Nano-Clear® has outperformed 6 layers of the (current) stone guard ... As Nano-Clear® has significantly reduced the number of stone chips to the front bumper, and has proven to be a more resilient stone guard, Engineering recommends that future bus deliveries, and buses that go out for refurbishment have the NCI stone guard applied."

Michael Battiston, Equipment Engineering Officer
GO Transit - Metrolink

A comprehensive System Evaluation Report from Metrolinx Engineering is available upon request.



INDUSTRIAL USERS OF NANO-CLEAR®



INDUSTRY RECOGNITION

Nano-Clear® has been recognized for its innovative engineering by:

- ❖ **NACE MP 2019 / 2020 Corrosion Innovation of the Year Award**
NACE (the National Association of Corrosion Engineers) sets the standards for surface preparation, coating selection, coating application, painting contractor certification, and testing.
- ❖ **Frost & Sullivan Technology Leadership Award 2020**
Frost & Sullivan is the premiere business consulting firm to the Paints and Coatings Industry.
- ❖ **PaintSquare Prestige Award 2020 (Top Product: Coatings for Steel)**
PaintSquare is the premier industry publication to the Paints & Coatings Industry.



To arrange a Nano-Clear® application demonstration, contact **Assero** at:

888.588.6986
or
info@assero.co



ASSERO COATING TECHNOLOGIES

Assero Coating Technologies delivers **Exceptional Surface Protection™** which extends the useful service life of valuable assets that operate in harsh environments. Assero is built around an ethos of delivering eco-innovative / eco-responsible, sustainable, green chemistry solutions with a line of **Protective Clearcoats™** that reduce damage to the environment.

Nano-Clear®

Recommended Uses: For Oxidized or Freshly Painted Surfaces
Chemistry: 3D Nano-Structured Polyurethane / Polyurea Hybrid

TABLE 1		NANO-CLEAR [®] WITHOUT PERFORMANCE UPGRADES	
TEST PROPERTIES		TEST METHOD	RESULTS
1	Crosslink Density	DMA (Dynamic Mechanical Analysis)	2.17 (x 10 ³ mol/m ³)
2	VOC	ASTM D3960	1.25 lb/gal (150 g/l)
3	Recommended Dry Film Thickness	ASTM D5796	1.0 mil to 2.0 mils (25.4µm to 50.8µm)
4	Coverage	Nanovere Inhouse	1,122 ft ² /gal @ 1.0mil
5	Gloss 20° / 60°	ASTM D523	86.0 / 92.2
ABUSE RESISTANCE			
6	Abrasion Resistance (CS-17, 1 kg, 1000 cycles)	ASTM D4060	8.4 mg loss
7	Pencil Hardness, Scratch	ASTM D3363	4H
8	Scratch Hardness	SASO 2833	2500 gm
9	Pencil Hardness, Gouge	ASTM D3363	5H
10	Pendulum Hardness (Persoz)	ASTM D4366	> 250 oscillations
11	Impact Resistance 18°C Direct in/lbs	ASTM D2794	50 Pass / 60 Fail
12	Impact Resistance 18°C Reverse in/lbs	ASTM D2794	10 Pass / 20 Fail
13	Impact Resistance	SASO ISO 3248	1 kg - 160cm
14	Impact Strength	ASTM D2794	145 kg - cm
15	Chip Resistance 23°C / 73.4°F (2.0 mils)	ASTM D3170	7A
16	Chip Resistance -29°C / -9.4°F (2.0 mils)	ASTM D3170	7B
17	Falling Sand Abrasion 100 liters	ASTM D968	Pass
18	Mar Resistance	ASTM D5178	5.0 kg
ENVIRONMENTAL RESISTANCE			
19	Xenon WOM Resistance 4,000 hrs	SAE J1960 / ASTM G155	100% Gloss Retention 99% Gloss Retention
20	QUV 313, >1,500 hrs	ASTM D4587	100% Gloss Retention
21	Water Immersion Test 240 hrs @ 50°C/122°F	ISO 2812-2	Pass
22	Salt Spray, 6,360 hrs	ASTM B117 / 2018	No corrosion points - Approved
23	Humidity, 100% RH, 100°F / 37.8°C - 240 hrs	ASTM D1735-02	No loss of adhesion - No change
24	CASS 240 hrs @ 50°C / 122°F	JIS H8502	Pass
25	Thermal Shock (Heat: 100°F / 37.8°C: 3 hrs, Freeze: 3 hrs, Steam)	GM9525P	No loss of adhesion - No Change
CHEMICAL RESISTANCE			
26	10% Sulfuric Acid	ASTM D 1308	No effect
27	10% Hydrochloric Acid	ASTM D 1308	No effect
28	10% Sodium Hydroxide	ASTM D 1308	No effect
29	10% Ammonium Hydroxide	ASTM D 1308	No effect
30	Isopropyl Alcohol	ASTM D 1308	No effect
31	Xylene	ASTM D 1308	No effect
32	Skvdrol [®] 500 Fluid	ASTM D6943-A	No effect
33	MEK Resistance - 1,500 Double Rubs	ASTM D4752	No effect
FLAMMABILITY			
34	Flammability: Fire Retardant & Flame Spread	ASTM E84 / BS476	Class 1 (Excellent)

TABLE 2		COMPARISON TEST FOR COMPOSITE MATERIALS (FIBREGLASS WITH GEL-COAT) BASF VS NANO-CLEAR [®] WITHOUT PERFORMANCE UPGRADES				
TEST PROPERTIES	TEST METHOD	CLEAR TOP COAT (1K or 2K)	DRY FILM THICKNESS (DFT)	ACETONE PRE-CLEAN	RESULTS	
35	Mechanical Scratch Ambient Temperature	ASTM D7027	BASF DC92 (2K)	2.0 - 3.0 mil	43.853 Mean	
36	Mechanical Scratch Ambient Temperature	ASTM D7027	Nano-Clear [®] (1K)	2.0 mil	38.129 Mean	
37	Mechanical Scratch After 7 Day 8 hr Heat Cycling @ 50°C/122°F, Ambient Cool down Temperature	ASTM D7027	BASF DC92 (2K)	2.0 - 3.0 mil	1.532 Mean	
38	Mechanical Scratch After 7 Day 8 hr Heat Cycling @ 50°C/122°F, Ambient Cool down Temperature	ASTM D7027	Nano-Clear [®] (1K)	2.0 mil	35.99 Mean	

TABLE 3		TESTING OF CHEMICAL AGENT RESISTANT COATINGS - CARC NANO-CLEAR [®] WITH MATTING ADDITIVE (NCI+MA)		
TEST PROPERTIES		TEST METHOD	CONVENTIONAL COATING RESULTS	NCI +MA RESULTS
OPTICAL PROPERTIES				
39	Gloss 20° 60° 85°	ASTM D234 ASTM D234 ASTM D234	0.7 3.6 7.4	0.6 1.3 7.8
40	Color L a b	ASTM D2244 ASTM D2244 ASTM D2244	66.66 6.02 20.71	66.66 6.02 20.71
41	Infrared Reflectance	ASTM E-903	PASS	PASS
PHYSICAL PROPERTIES				
42	Adhesion	ASTM D3359	5B	5B
43	Pencil Hardness	ASTM D3363	2B	>6H
RESISTANCE				
44	Acid Spot Resistance	MIL-DTL-53039E Sec 4.6.24	No Effect	No Effect
45	MEK Resistance: Double Rubs to Substrate Double Rubs to Start of Coating Dissolution	ASTM D4752 ASTM D4752	>200 20	>1,500 >1,500
46	Water Immersion Test: Visual Observation Pencil Harness Adhesion	MIL-DTL-53039 Sec 4.6.22	No Effect 4B 5B	No Effect >6H 5B

TABLE 4		CONTACT ANGLE AND ICE DE-BONDING (SHEDDING) TEST	
COATING INFORMATION		CONTACT ANGLE RESULTS (%)	
CONTACT ANGLE RESULTS OF FROZEN DI WATER ICE DROPLETS (%)			
47	Control	43.12	
48	NCI +EC @5%	102.41	
49	NCI +MA @30% +EC @5%	101.07	
SHEDDING TIME RESULTS OF FROZEN DI WATER ICE DROPLETS (Seconds)			
50	Control	58.0	
51	NCI +EC @5%	32.0	
52	NCI +MA @30% +EC @5%	40.05	



Sample of Ice De-bonding Test on Aluminum Substrate (NCI +MA +EC: 40 seconds)

TABLE 5		ANTI-MICROBIAL (LOG ₁₀ REDUCTION) TEST NANO-CLEAR [®] WITH ANTI-MICROBIAL ADDITIVE (NCI+AM)		
TEST PROPERTIES	TEST METHOD	AVERAGE CFU/CARRIER	RESULTS (Log ₁₀ Reduction / % Efficacy)	
53	Control	JIS Z 2801	3.97E+05	NA
54	NCI +AM	JIS Z 2801	1.53E+01	6.87 / 99.99998%



Sample Log Reduction Test (Comparing CFU (Colony Forming Units), Before & After)



Assero Coating Technologies
20 De Boers Drive, Suite 202
Toronto, Ontario, M3J 0H1, Canada

info@assero.co | www.assero.co



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