

# Blade leading edge erosion: damage limitation, containment and prevention

Following the recent news, widely published in the industry and national press regarding a number of offshore wind farms, it seems that last year's end of warranty inspections highlighted unprecedented amounts of offshore wind turbine, blade leading edge erosion, across several offshore wind farms in Europe. As the offshore wind industry enters the 2018 season blade repair campaigns, there is much to be considered. Early intervention is imperative for the quality and longevity of repairs. PES asked WTG to give us their view on this problem.



*‘If the expected lifetime of the surface coating is less than the lifetime of the blade, suitable inspection and maintenance intervals should be specified.’*

It is an issue the industry has long been aware of and there are many initiatives in place looking to tackle the issue, such as the Offshore Renewable Energy (ORE) Catapult’s Blade Leading Edge Erosion Programme. Is this the Benchmark for future blade inspection and Integrity management during warranty?

The following extract applies:

If the expected lifetime of the surface coating is less than the lifetime of the blade, suitable inspection and maintenance intervals should be specified.

Inspection and maintenance intervals shall be planned to provide adequate assurance that no significant deterioration in the condition of the installation may arise in the interval. The design should take into account the practicability of carrying out inspections of relevant components or systems. Where inspection is not practicable, the component or system shall be designed and manufactured in a way that adequate durability for the entire operating life of the wind turbine is assured.

However, the following questions may be critical in ensuring the successful, efficient and effective execution of these leading edge repair campaigns.

- Are your minor blade erosion damages currently getting bigger?
- Are programmed repairs taking longer than expected due to further degradation?
- Would the ability to change from reactive to preventative repairs enable you to plan and prepare resources for the repair campaign better.
- Are your assets blades affected by leading edge erosion continuing to further degrade whilst awaiting repairs?

How can/will OEM’s and Asset owners:

1. Manage damage category limitation and containment of further leading edge erosion, specifically in the period before and during the blades are scheduled for repair. Whilst awaiting repair the affected blades will certainly have a continued exposure to further and more aggressive erosion damage and degradation of the substrate.

2. Ensure the correct levels of repairs and upgrades are carried out in response to existing leading edge erosion. Attention must be paid to the levels of erosion and the preparation of each repair will depend on the extent of the damage to the substrate.

During recent tests conducted by WTG Offshore using ORE Catapult’s rain erosion test rig facility in Blyth, some important discoveries came to light:

When testing a new TRI-Coat (temporary repair and Inspection coating), which was aimed at containing existing damages and the prevention of further erosion, the speed in containing and stabilising any further leading edge erosion has a direct bearing on the future durability of repairs.

Two separate tests were carried out under rain erosion conditions.

1. New test samples were coated with the WTG Offshore Biim TRI-Coat, our innovative temporary protective coating. (4.25hrs durability)
2. New perfect test samples where coated with the WTG Offshore Biim LEP coat, our innovative and possibly Aep increasing, LEP Protection solution. (7.25hrs durability)

For the tests it was clear that the Biim Coatings, should be applied directly to the laminate substrate of the ORE Catapult blade samples with no filler or gel coat layers.

Although under normal circumstances this would not be recommend for coatings on wind turbine blades, due to the nature and intended use of the coating; a temporary repair solution to stop and stabilise existing damages, it was important to test under these difficult and not ideal parameters.

Each coating had three individual samples that were each tested to failure.

The individual samples produced various levels of erosion damage.

- |           |   |
|-----------|---|
| Tricoat 1 | Two hours medium erosion damage.                    |
| Tricoat 2 | One hour light erosion damage.                      |
| Tricoat 3 | Four and a quarter hours very light erosion damage. |

Following this first stage test, the eroded samples were sanded back to a 320-grit finish, recoated with the Biim TRI-Coat under field conditions and retested as though applied over an erosion damaged leading edge.

The erosion damaged samples were then subjected to the same test parameters as the original undamaged samples. The tests, using four separate samples, showed strong evidence that when coatings are applied over a damaged substrate, failure of the new coating will occur at a far quicker rate with a decrease in durability of the newly applied coating by as much as 70%.

Also, even newly coated samples, showed far reduced durability when applied in field conditions.



Tri Coat 1 Two hours Photo 1

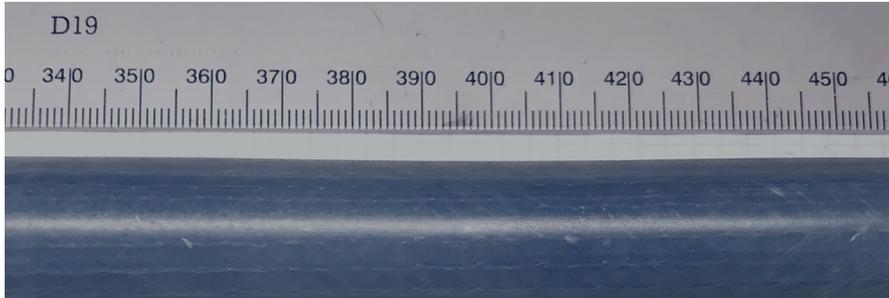


Tri coat 2 first test failure 1hr photo 2

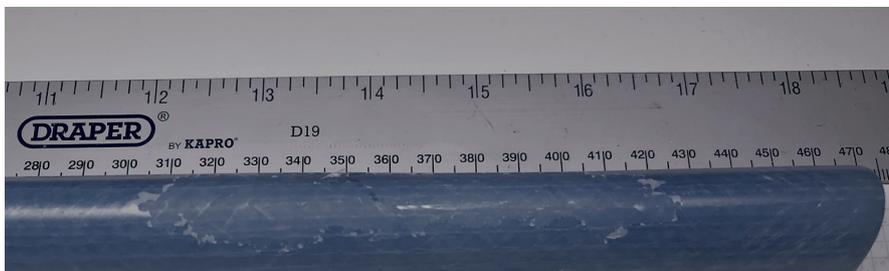


Tri coat 3 Four hours Photo 3

Due to the coatings clear nature and the 15 minute inspection intervals, the actual point of failure could be seen under the coating prior to actual failure, as can be seen in the following photographs.



Coating applied over erosion damage (Prefailure 3hrs)



Coating Failure (3.25hrs)

The milk white spots at 357/412cm indicate areas of delamination starting. These areas look to have started above the stitch line of the biax fabric

Once these areas of delamination occur, failure of the coatings is rapid and aggressive in nature.

Where areas of erosion have removed part of the substrate resin and possibly broken some glass stands, even though minimal and not through the outer layer of the fibreglass, failures will occur at these resin poor exposed/broken fibre glass areas.

After the eroded sample tests conducted at ORE Catapult, it was found that the replacement coatings failed three times faster than the original, when applied over erosion damage affecting the substrate resin and fibreglass. However, the replacement coatings applied over erosion damage to the original coating proved more durable.

This is fundamental proof that early intervention is critical to not only the repair requirements, but also the ongoing durability of the replace coatings. This also highlights the need to carry out laminate repairs even when only slight resin damage has happened to the substrate. Even a single broken glass fibre stand or simply thin resin area could present a future failure point.

With the emergence of some great new products and technologies over the last year, asset owners and OEM's have at their

disposal innovative solutions for protecting the blade leading edges including:

- Polytechs Elle. – Robust and durable soft shell system.

- 3M's new Version 2 Tape. – Revised version of the much used 3M tape.
- Basf Relest. – 3 process protection putty/ coating combination.

With new technology now available enabling QA/QC Inspections of the repair coatings and critical adhesion testing by NDT, of the chosen leading edge upgrade solutions, finally the industry has some robust quality options to address problems of leading edge erosion.

With many blades across numerous offshore sites, currently requiring repair after only five years, if these blades are left in operation (without any temporary protection) whilst awaiting scheduled repairs, we can certainly expect an escalation of these erosion damages from possible Category 3 damages to more critical Category 4 & 5 damages resulting in protracted repair programs.

Simply by acting quickly to contain and protect existing damages, asset owners and OEM's can dramatically reduce the magnitude of repair campaigns. These coatings serve to stabilise and seal in the affected area. Thus halting any further erosion or deterioration in the coated area for a period of up to two years. The aim is to provide the client with an extremely cost effective and simple way to eliminate the risk of further damages while allowing time

for permanent repairs to be budgeted for, planned and scheduled to meet the clients preferred time frame.

By using a combination of frequent preventative inspections and the WTG Offshore Biim products, technologies and processes, asset owners can now proactively control every stage of blade leading edge erosion and the associated repair programs, with complete piece of mind.

Procedures and products are now available to address, assist and ensure the quality levels required to achieve this much required industry solution during this period of unprecedented repairs.

Although often asset owners have no costs to consider, the earlier their blades degradation is arrested the better the condition the blades will be in the long run. Minor repairs must surely be preferred and limiting further erosion damages in a planned manner will result in a proactive and effective solution.

Kirsten Dyer, Senior Materials Research Engineer at ORE Catapult said: 'At the Catapult, our combination of world-leading testing assets and industry expertise means we are uniquely placed to support innovative UK SMEs like WTG Offshore in developing new products and services, which can solve some of the challenges faced by the offshore wind industry. Our rain erosion test rig and expertise in materials research is leading to a better understanding of the fundamental physics of erosion, and how it can be mitigated, leading to the development of new protective coatings and materials for blades.'

**EARLY INTERVENTION OF EROSION DAMAGES, IS IMPERATIVE FOR THE QUALITY AND LONGEVITY OF REPAIRS.**

[www.wtg-offshore.com](http://www.wtg-offshore.com)

**WTG Offshore's Biim® TRI-Coat™**  
(Temporary Repair and Inspection coating)

Innovative and efficient, providing a quality cost effective and competent offering.

A transparent single part coating, providing complete protection of existing damages by:

- Extreme UV resistance
- Highest Scratch resistance
- Extreme abrasion resistance
- Highest chemical resistance
- Excellent Hydrophobic properties
- Reduced surface debris

Applied in minutes whilst providing protection for up to 2 Years....