NDT Case Studies – and Quick Wins

Workshop on NDT and SHM requirements for wind turbines
13th -14th February 2019

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Uniper Technologies Ltd

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We are Uniper

Our operations:

- Power Generation
- Commodity Trading
- Energy Storage
- Energy Sales
- Energy Services

Where we operate:

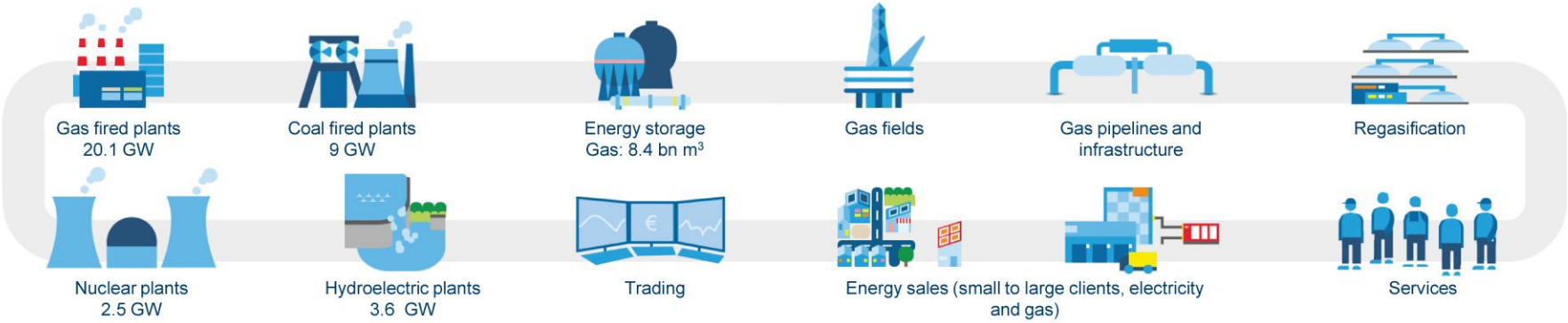
40+ countries around the world
4th largest generator in Europe

Employees: 13,000

- Power generation, Storage, Services - Europe
- Power generation - International
- Commodity Trading, Energy Sales

€1.71bn	100 years	40 GW
EBITDA	Experience	Total generation

Main activities:



Employee data December 31, 2015.
Capacity figures April 26, 2016.

Uniper Technologies - Non-Destructive Testing

- Uniper's Inspection Management (NDT) has always worked closely with Materials, Structural Assessment and Plant Specialists to provide a one-stop shop for Integrity services.

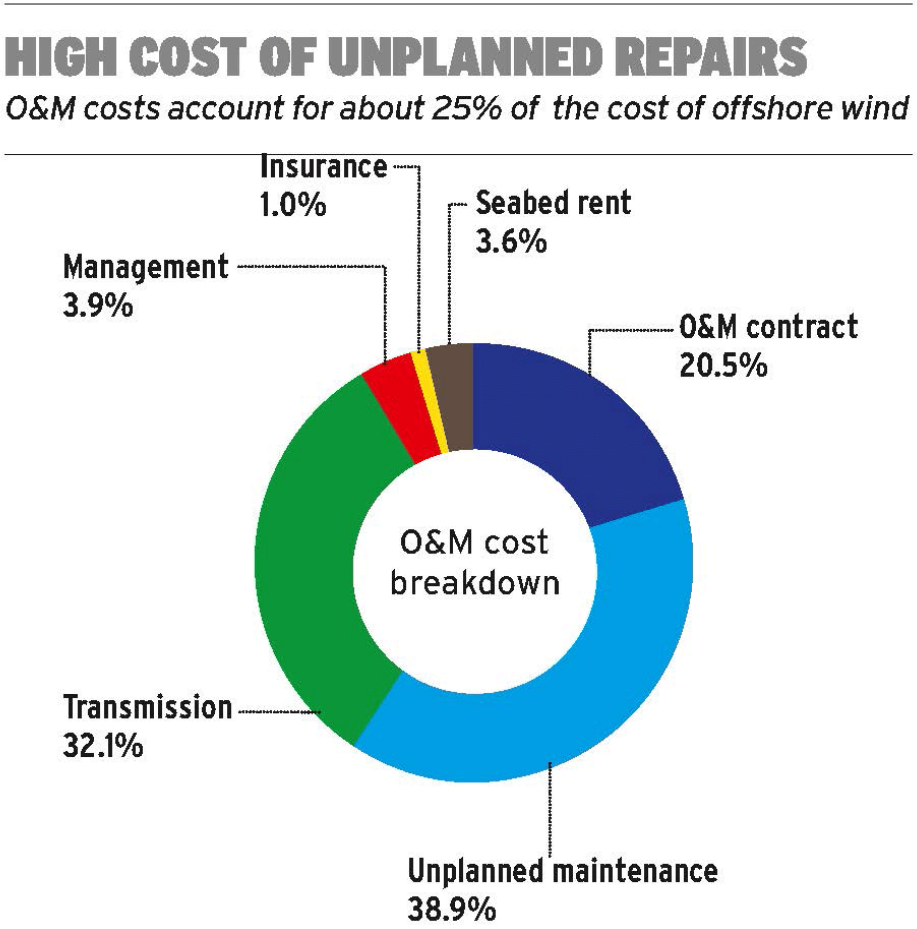
- NDT is not an end in itself, but it is the source of reliable data on the condition of a component so that informed decisions can be made on whether to Run, Repair or Replace a component/asset.

- Our heritage is "traditional" power stations (coal, oil, gas) but the growth areas are Renewables and Energy-from-Waste.

- This presentation will show a few case studies from work performed in the last ten years supporting Wind Generation.

- Based at Uniper Technologies, Ratcliffe-on-Soar, Nottingham.

NDT Case Studies



- Focus of presentation will be on response to “incidents”,

  i.e. unplanned events (often component failures) that require an investigation, usually followed up by some form of inspection.

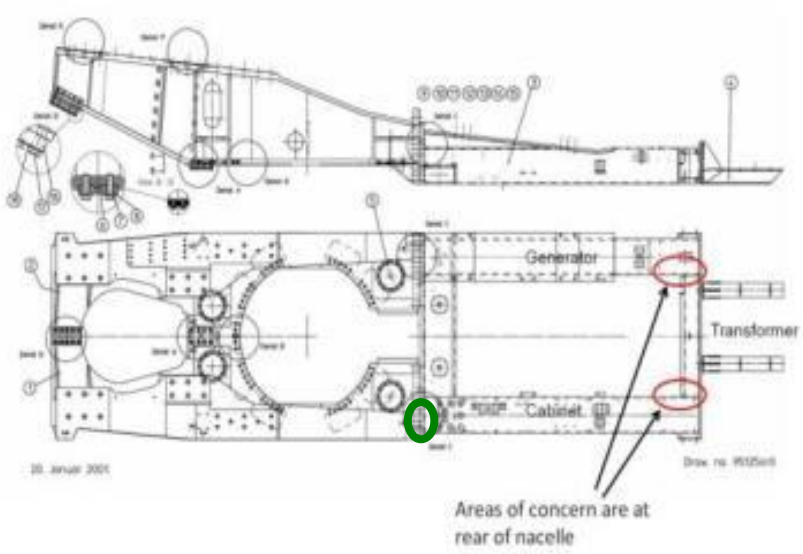
- 38.9% of O&M costs are due to unplanned maintenance.

  Ref: David Milborrow, WINDPOWER Monthly, 5 June 2017.

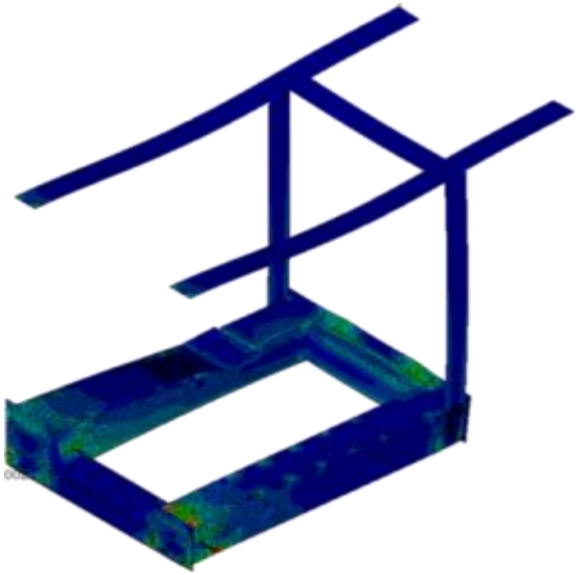
Case Study 1

Nacelle Cracking and Repair

Case Study 1 - Nacelle Cracks



Case Study 1 - Nacelle Cracks



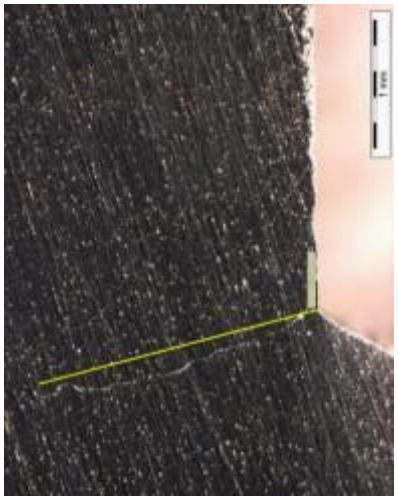
- Cracking in nacelle bedplate identified by visual examination
- MPI and ACPD undertaken to measure crack dimensions
- Finite element analysis to assess the integrity of the nacelle frame and to determine bolt loads during proposed repair to determine unbolting sequence
- Post-repair inspection schedule developed and implemented

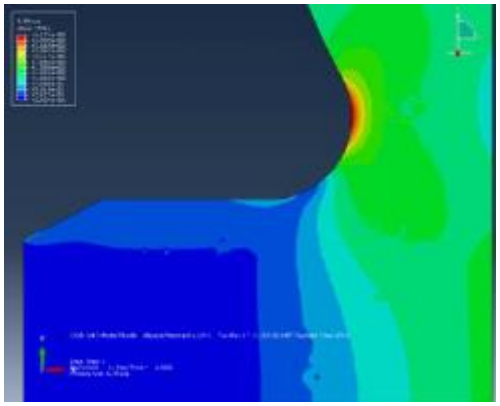
Problem subsequently identified at another wind farm, but poor NDT (penetrant) *by client* has led to cracks being under-sized or missed. Now a major repair programme underway in every turbine on farm.

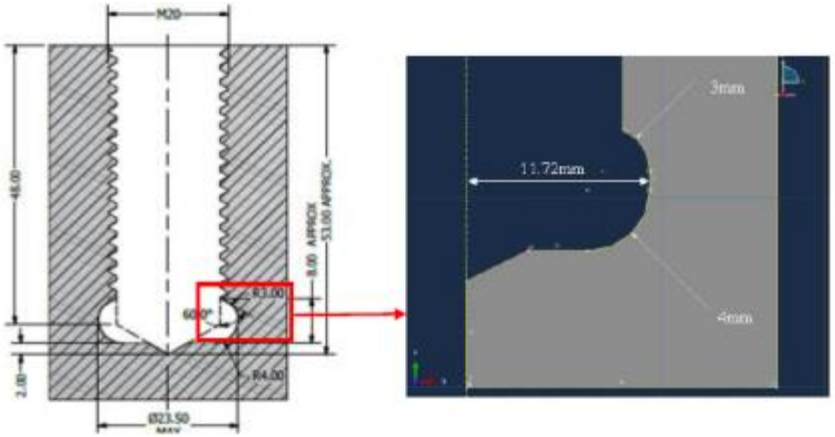
Case Study 2

Blade-to-Hub Mating Cans

Case Study 2 - Inspection of Blade-to-Hub Mating Cans

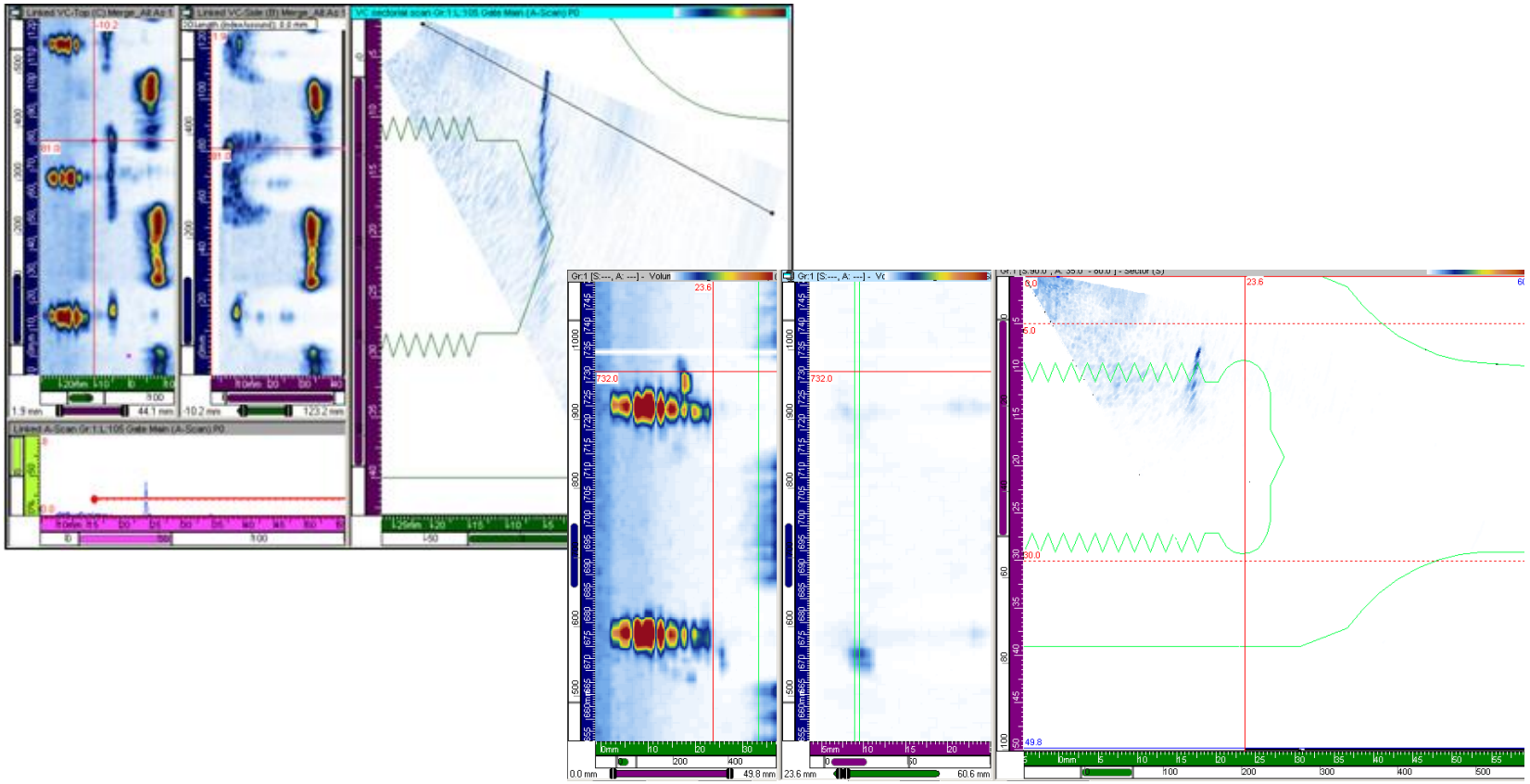






- Blades had been shed at two wind farms in New Zealand and another in Scotland
- Detailed materials investigation identified cracks at bottom of mating can bolt holes
- Fitness for service of the OEM-proposed modification was assessed
- Design review was extended to determine an improved modification

Case Study 2 - Inspection of Blade-to-Hub Mating Cans



- Initial inspections carried out from the nose-cone using ultrasonic phased arrays
- This produced a risk-ranking to establish priority for modification.

Modifications at Wind Farm

Case Study 2 - Inspection of Blade to Hub Mating Cans

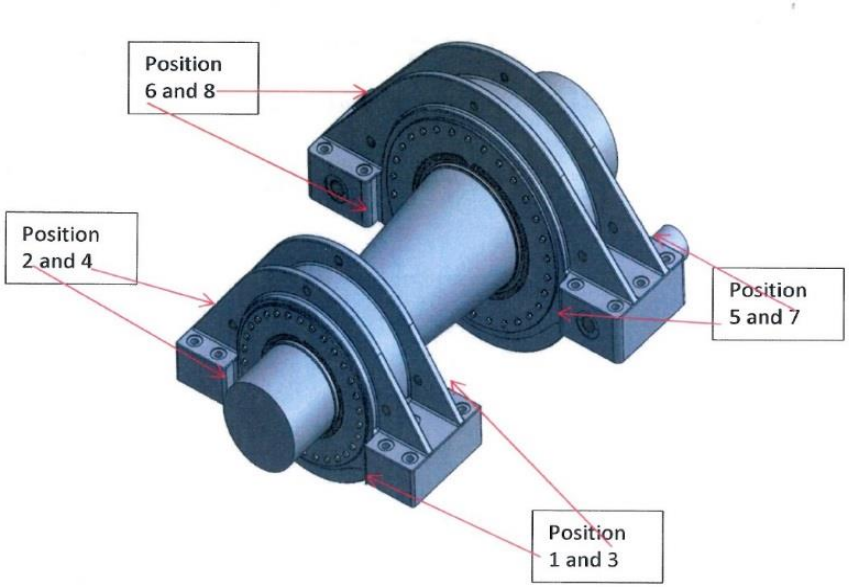
- Bespoke Eddy Current Inspection solution developed and implemented to detect and size 0.2mm deep cracks.
- Pneumatic tool designed by Uniper Workshops to cut the new profile(s).
- Re-profiling and NDT carried out in the field.

- Uniper design modification resulted in significantly lower stresses and longer predicted lifetimes.

What other stress raisers are out there?

Bearing Case Corners

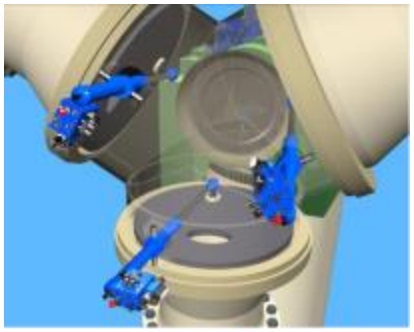
- Generator bearing case corners
- Cast component casings
- Many corners are “not smooth” and promote cracking.
- 24 out of 30 turbines have cracks at one site

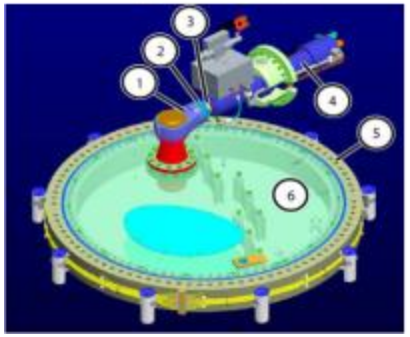


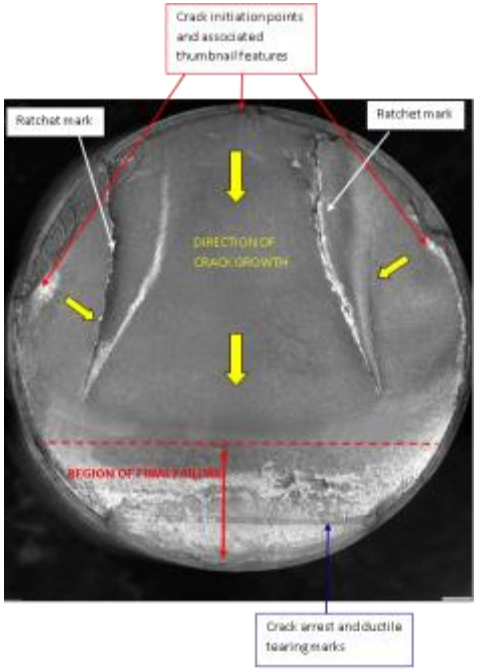
Case Study 3

Blade Pitch-Ram Cracking

Case Study 3 - Pitch Ram Failure

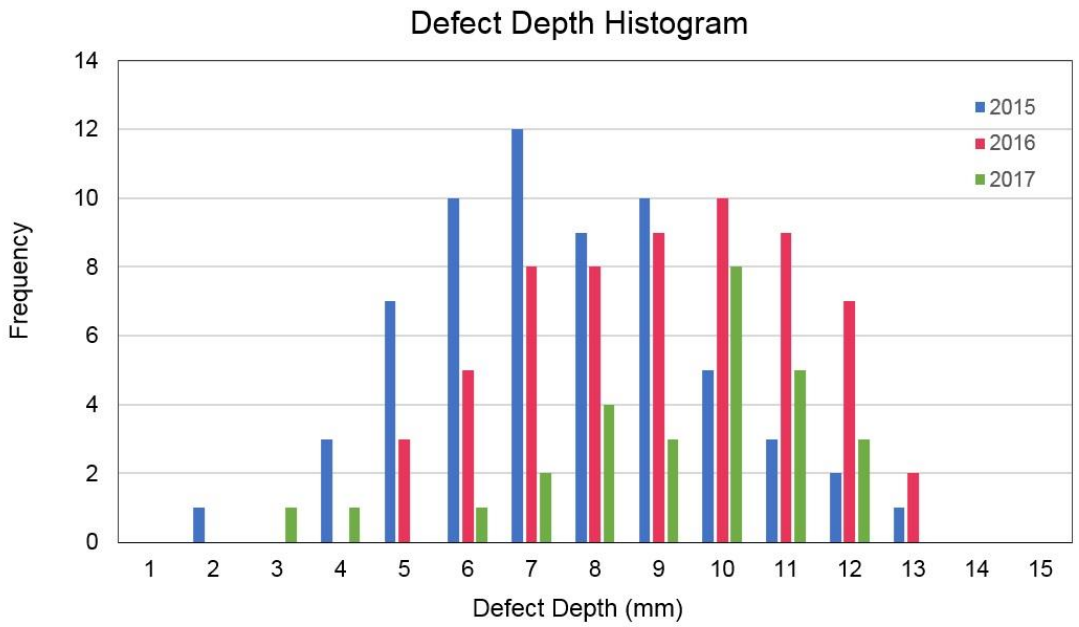






- Investigation identified poor design rendering hydraulic ram susceptible to failure
- Practical ultrasonic inspection technique determined and implemented
- Third of all rams on the offshore wind farm contained a crack

Case Study 3 - Pitch Ram Failure



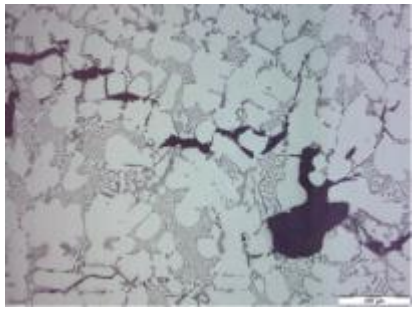
- Pitch rams at most risk targeted for replacement, but like for like.
- Solution is to replace faster than they are failing!
- Tide turned in 2017: failure rate decreasing and population of cracks diminishing.

- But, in 2018, found that some replacement rams are now cracking!

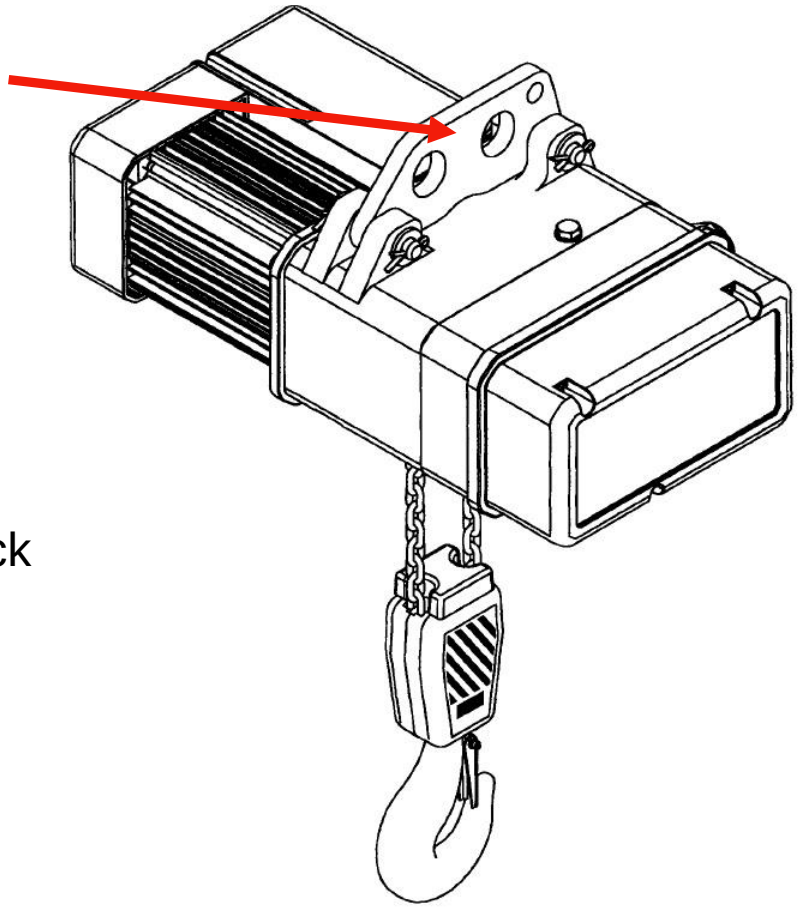
Case Study 4

Lift Hoist Failures

Lift Hoist Eyes



- Load splitter plate had been removed so that loads could be raised slightly higher.
- Plate not reinstated, and eventually the aluminium hoist eyes fatigued.
- Now carrying out penetrant and eddy current inspections on other units to check for cracking.

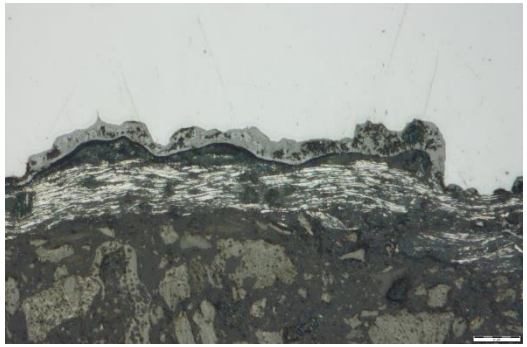


Case Study 5

Bolts

Bolts

- Axial cracks in bolts found at the blades to shaft flange. Full length of bolts.
- Zn/Al paint found inside crack
- So, missed at manufacturing, coating and installation stages?
- Client trying to trace other installed bolts through the QA and construction records



Case Study 6

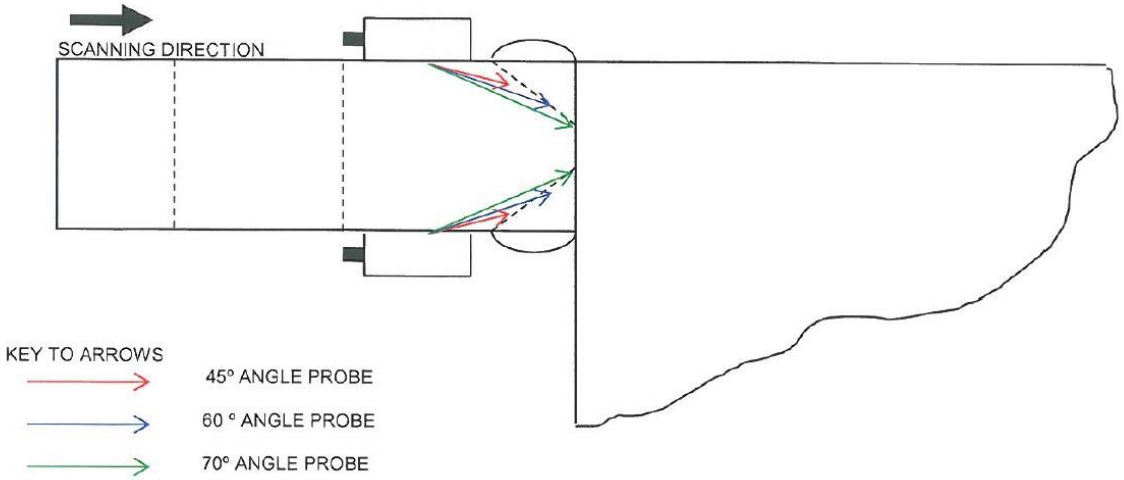
Supply Chain NDT

Supply Chain NDT

- Alerted to an issue when a visible crack was found at a weld in a new part destined for an offshore foundation reinforcement.

- NDT had been done by the supplier's in-house NDT, and all components passed.

- Investigation revealed a number of issues: no Level 3 authorisation, very limited ultrasonic calibration blocks, and misconceptions about how to carry out a weld inspection.



Conclusions / Observations

The views expressed below are personal and informed by over thirty years of managing and delivering NDT solutions to all types of power generating assets:

- There is a high proportion of unwanted O&M activities in wind.

- Some O&M is due to:
  - poor design requiring corrective action, e.g. stress raisers
  - inadequate inspection after manufacturing and/or before installation
  - component modification on site creating a new problem
  - NDT solutions being inappropriate and creating a bigger problem
  - Limited vetting of NDT in supply chain

- This leads to reactive NDT, and often high maintenance costs for the operator.

- All the above apply to other forms of generation (and other industries), but it seems especially frequent in wind.

Quick Wins

- Greatest benefit, and quickest win, is to perform systematic and documented inspections.
- Visual inspection is important, and usually cheap.
- Do inspections as early as possible when access is simpler, and costs lower.
- If NDT is needed, then do it well.
  - Ensure that the NDT supplier is competent for the specific task.
  - Don’t use the cheapest supplier as you will probably be doing it again.
- Share information between wind farms in same utility, and between utilities?

Many other examples…

- Meteorological mast base weld – poor weld, no NDT > mast collapse
- Blade balancing weights – parallel sided rod glued in place > blade failure
- Missing bolts in tower flanges > eventual tower collapse
- Ultrasonic load measurements in bolts – unskilled staff making measurements
- Nose cone struts
- Undocumented weld repair in main shaft > shaft breaking

Thank you!

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