

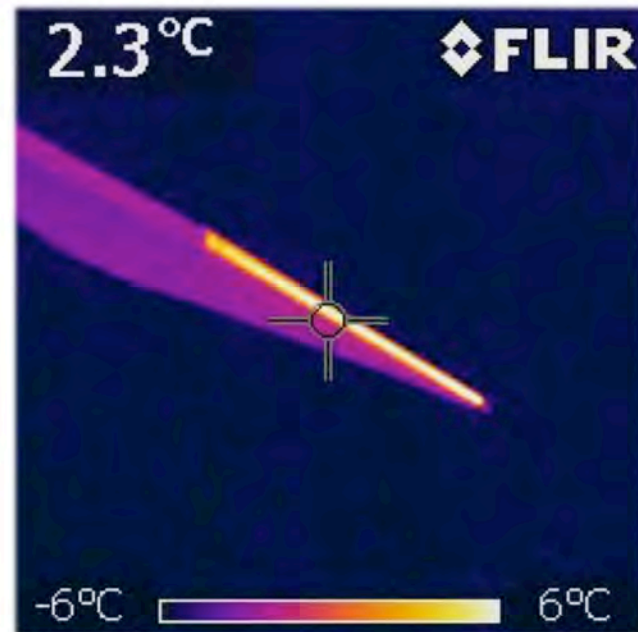
Blade Heat System Repair



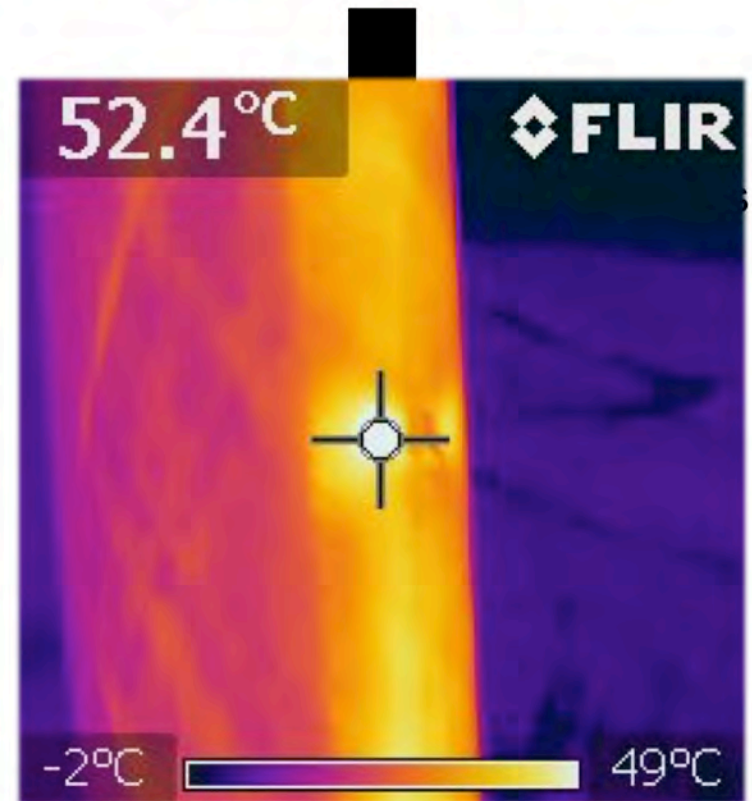
Greger Nilsson

Blade heat systems

- Hot air – Enercon, Vestas, Gamesa
- Carbon heat mat, VTT, Nordex, Simens
- Combination, Dongfang

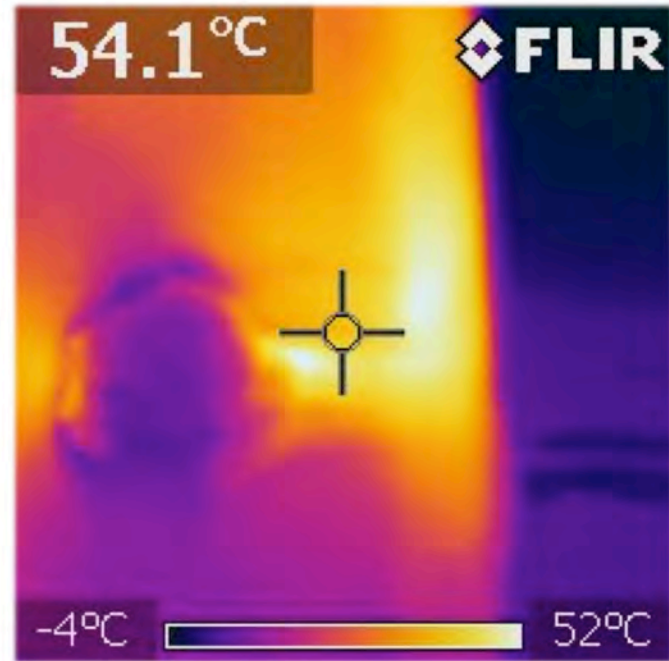


Carbon heat mat inspections



Impact

Carbon heat mat inspections



Lightning

Carbon heat mat inspections



Lightning

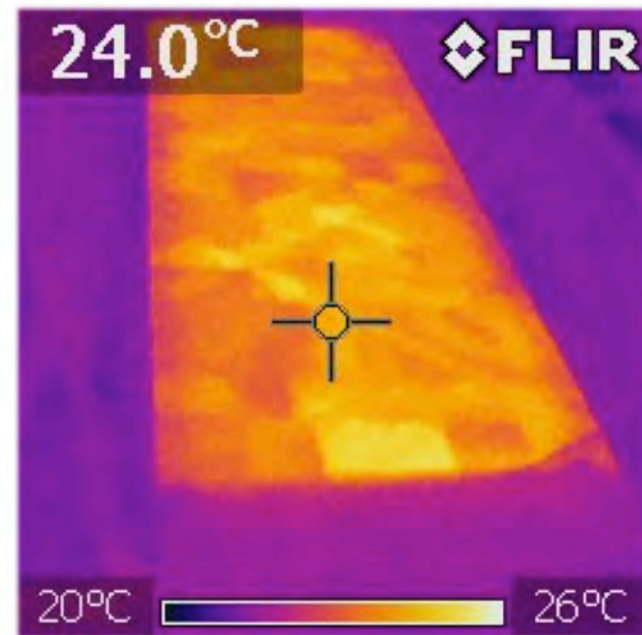
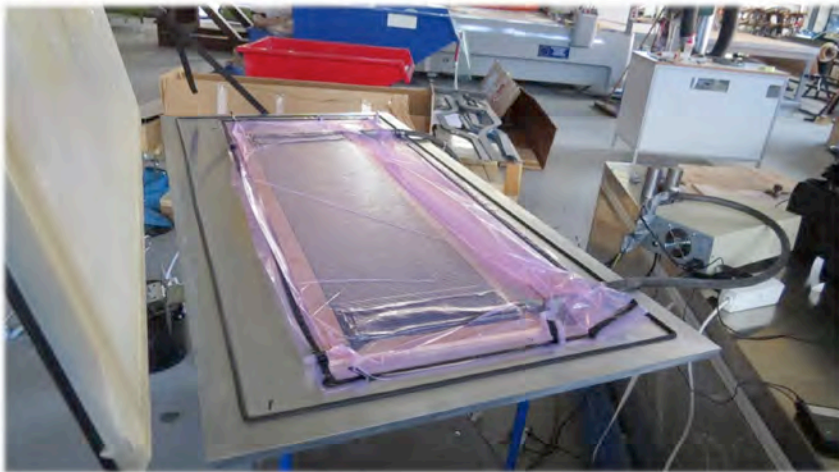
Work to develop repair methods for hot spots on blade heat systems

- Laboratory experiments
- Field specimen repairs
- Blade heat system repairs

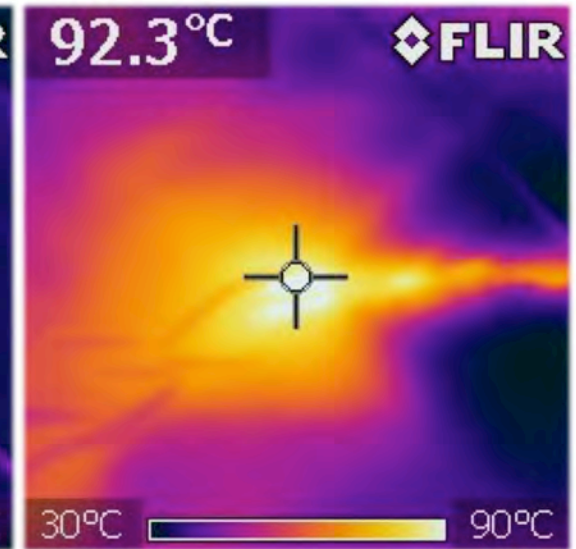
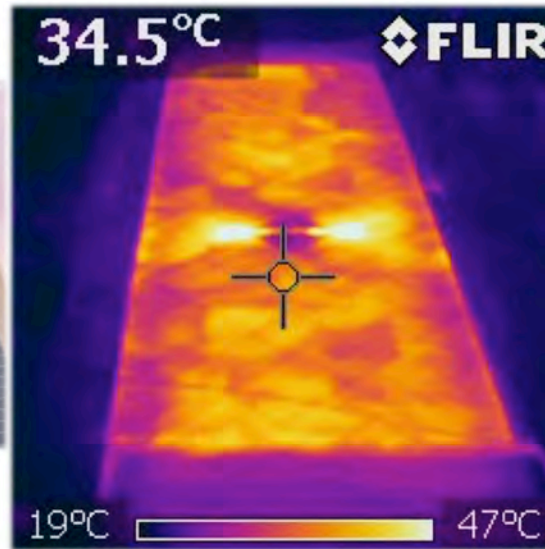
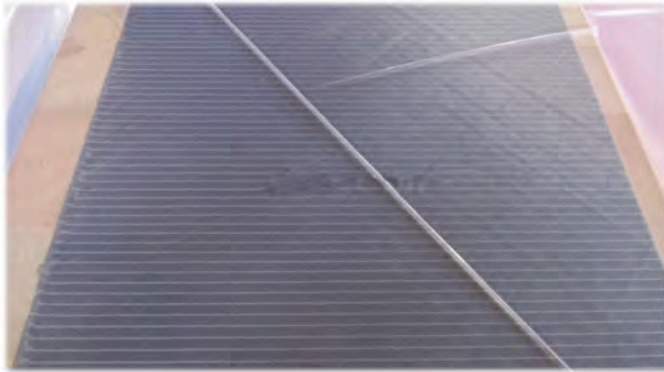
Experimental setup

1. Initial dry fabric blade heat damage and repair
2. Blade heat specimens manufacturing
3. Thermographs
4. Blade heat damages (impact/lightning damage)
5. Thermographs
6. Blade heat repairs (three methods, one winter and two summer solutions)
7. Thermographs
8. Fatigue testing
9. Thermographs
10. Results
11. Field specimen repairs

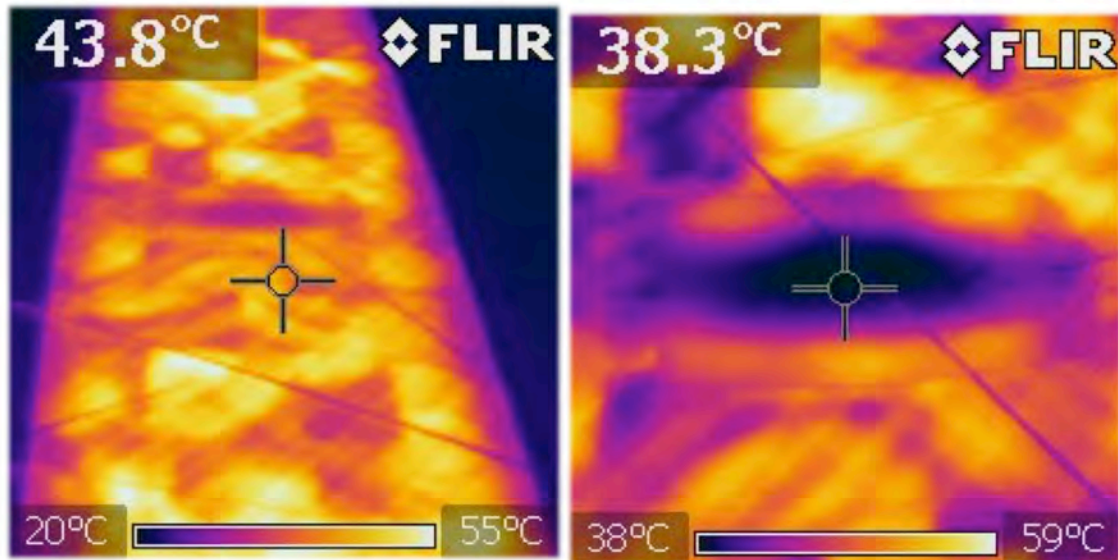
Initial experiments, dry fibres



Damage on carbon fibre mat, Hot Spot



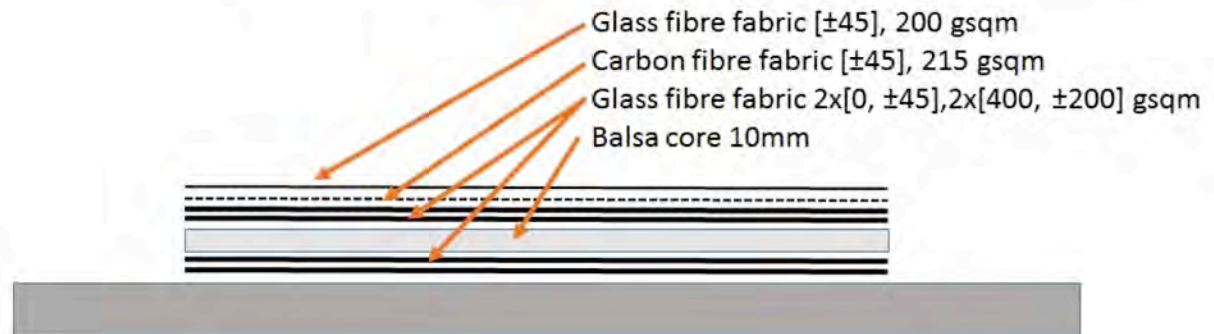
Initial repairs



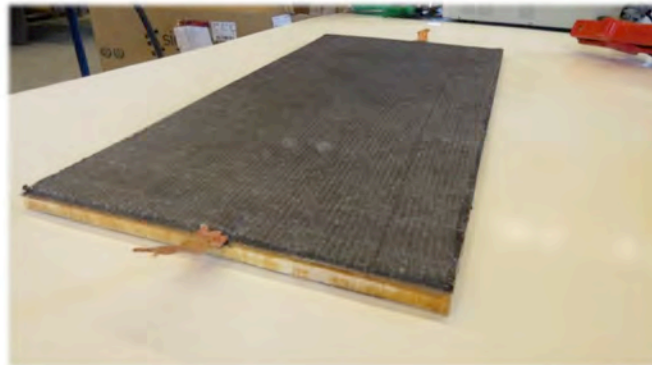
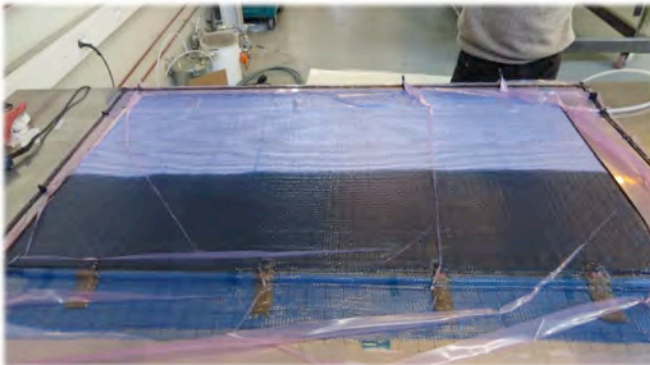
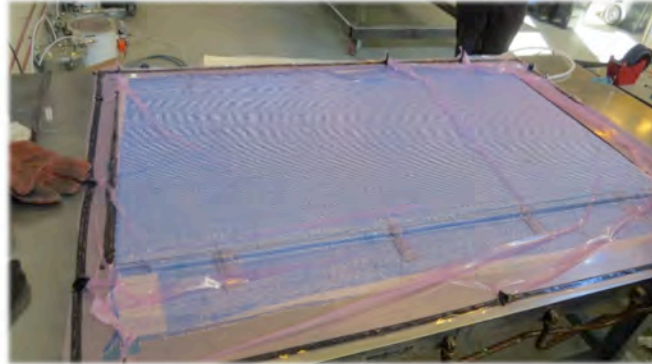
Blade heat project

Manufacturing of 16 specimens dimension 300 x 600mm

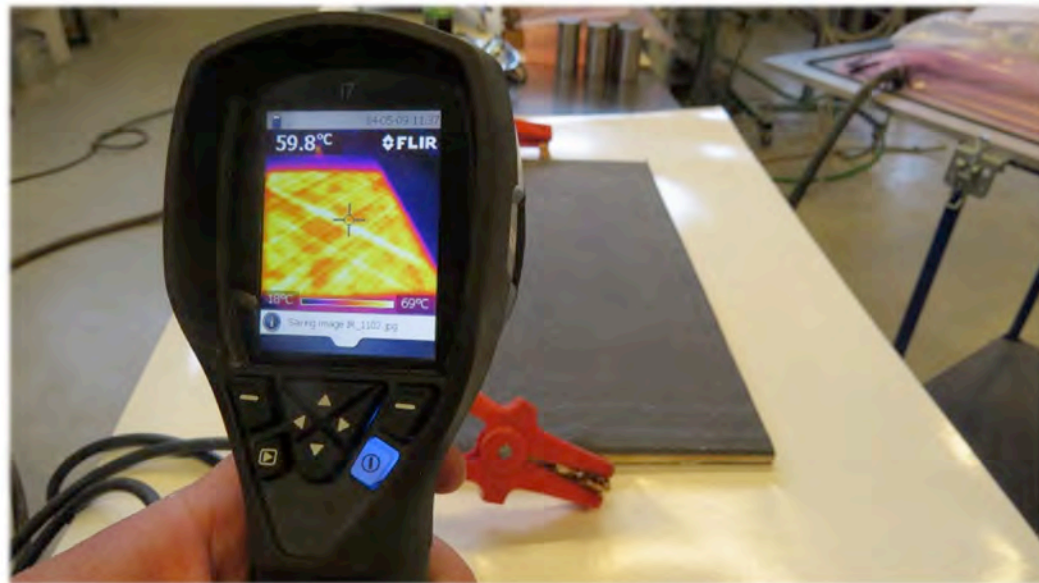
- Heat material: Carbon fibre fabric [± 45], (215g)
- Structural material: Glass fibre fabric [0, ± 45], (400g, ± 200 g)
- Protection material: Glass fibre fabric [± 45], (200g)
- Core materials: Balsa 10mm
- Resin: Araldite LY1568CH/Aradur 3489BD (100/28)



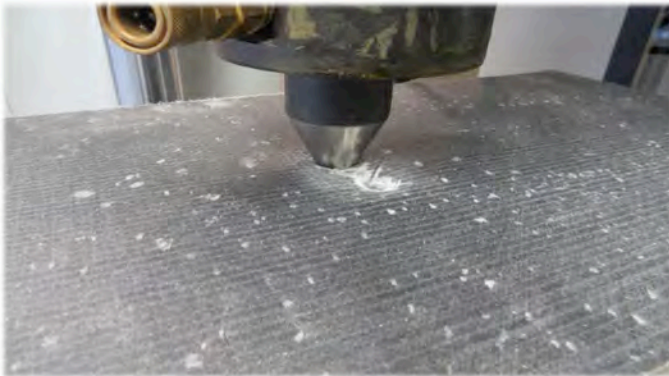
Specimen manufacturing



Thermography



Impact and lightning damage

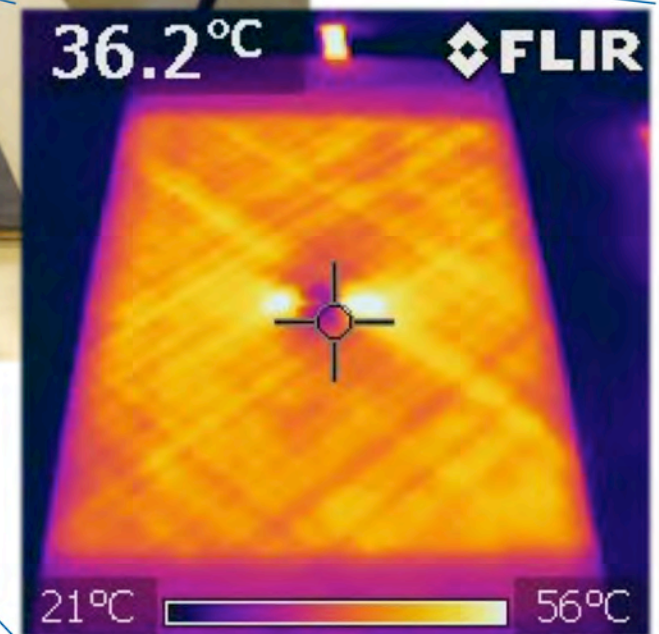


Impact



Lightning

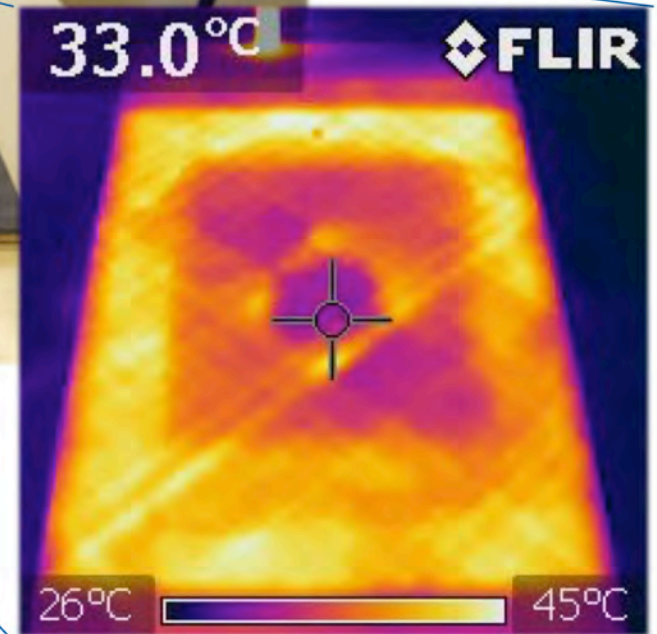
Thermography



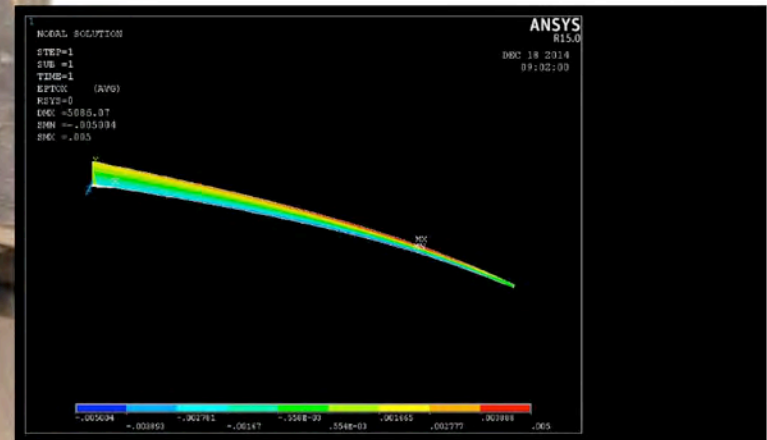
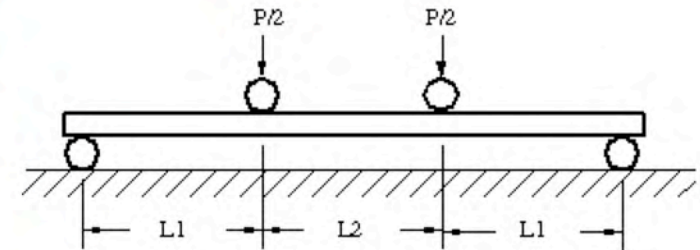
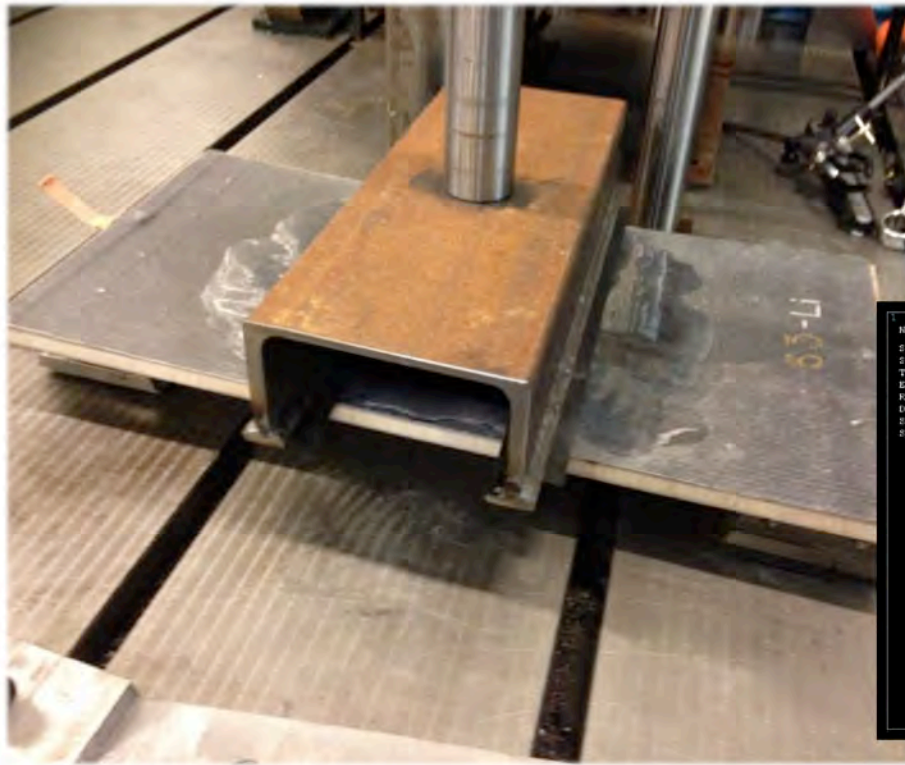
Hot spot repairs



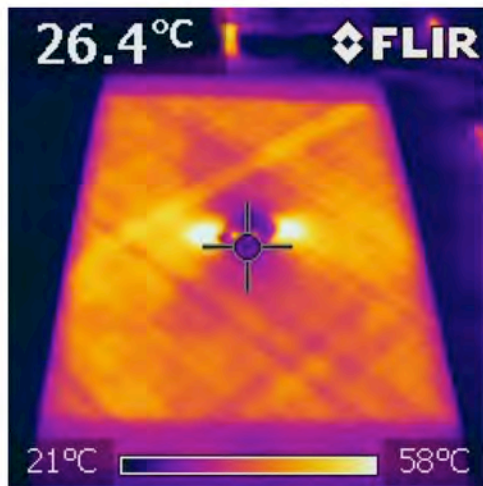
Thermography



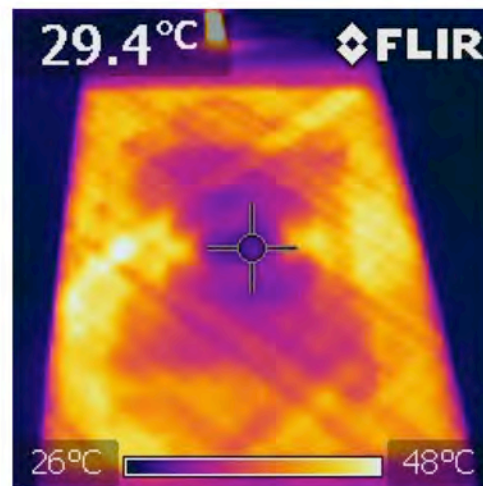
Fatigue testing of repairs



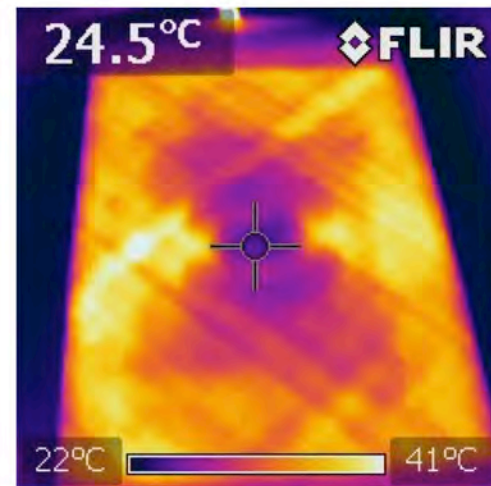
Impact damage



Before repair

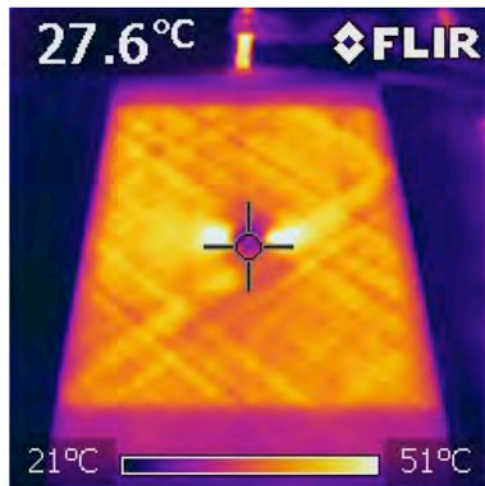


After repair

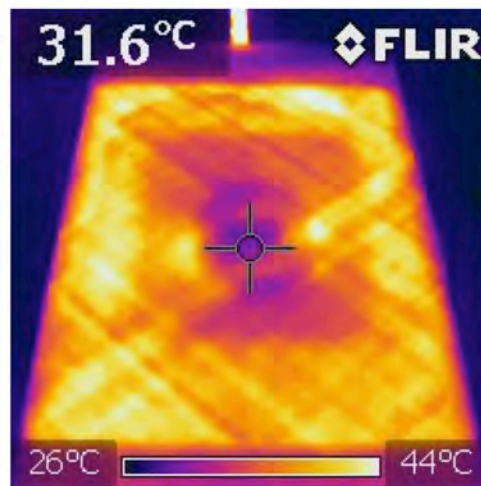


After fatigue testing

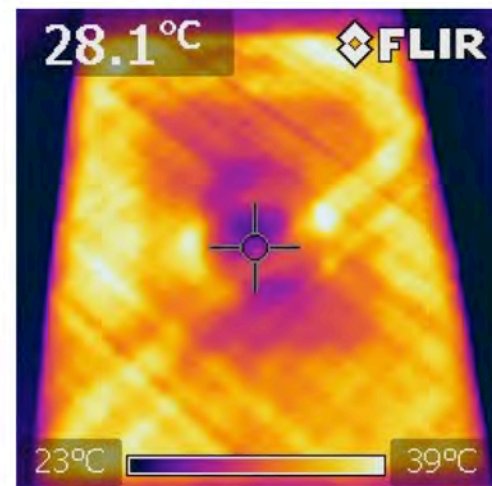
Lightning damage



Before repair



After repair

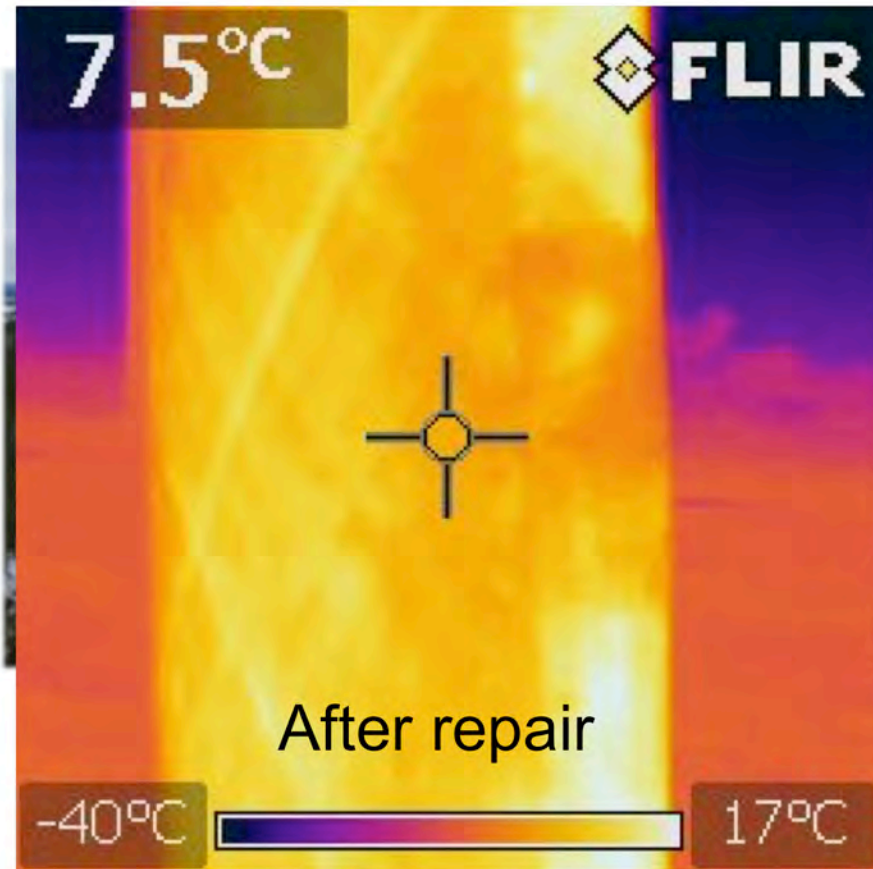


After fatigue testing

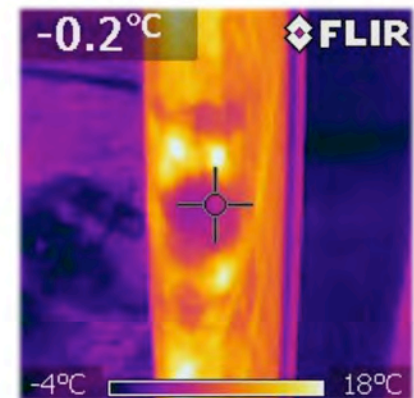
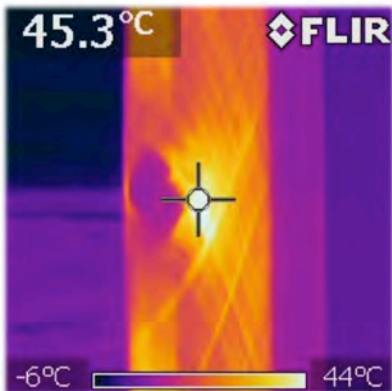
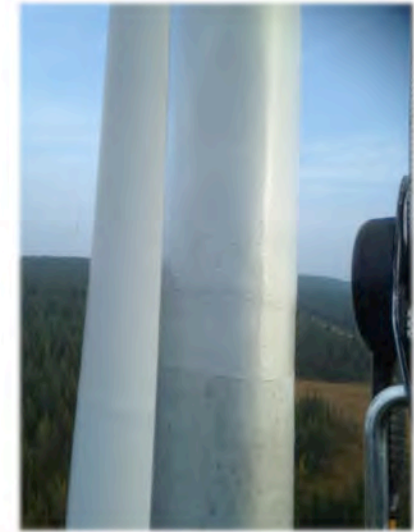
Results

	Winter solution	Summer solution 1	Summer solution 2
Impact damage	Perfect results	Perfect results	Perfect results
Lightning damage	Perfect results	Perfect results	Perfect results
Field repairs	Perfect results		

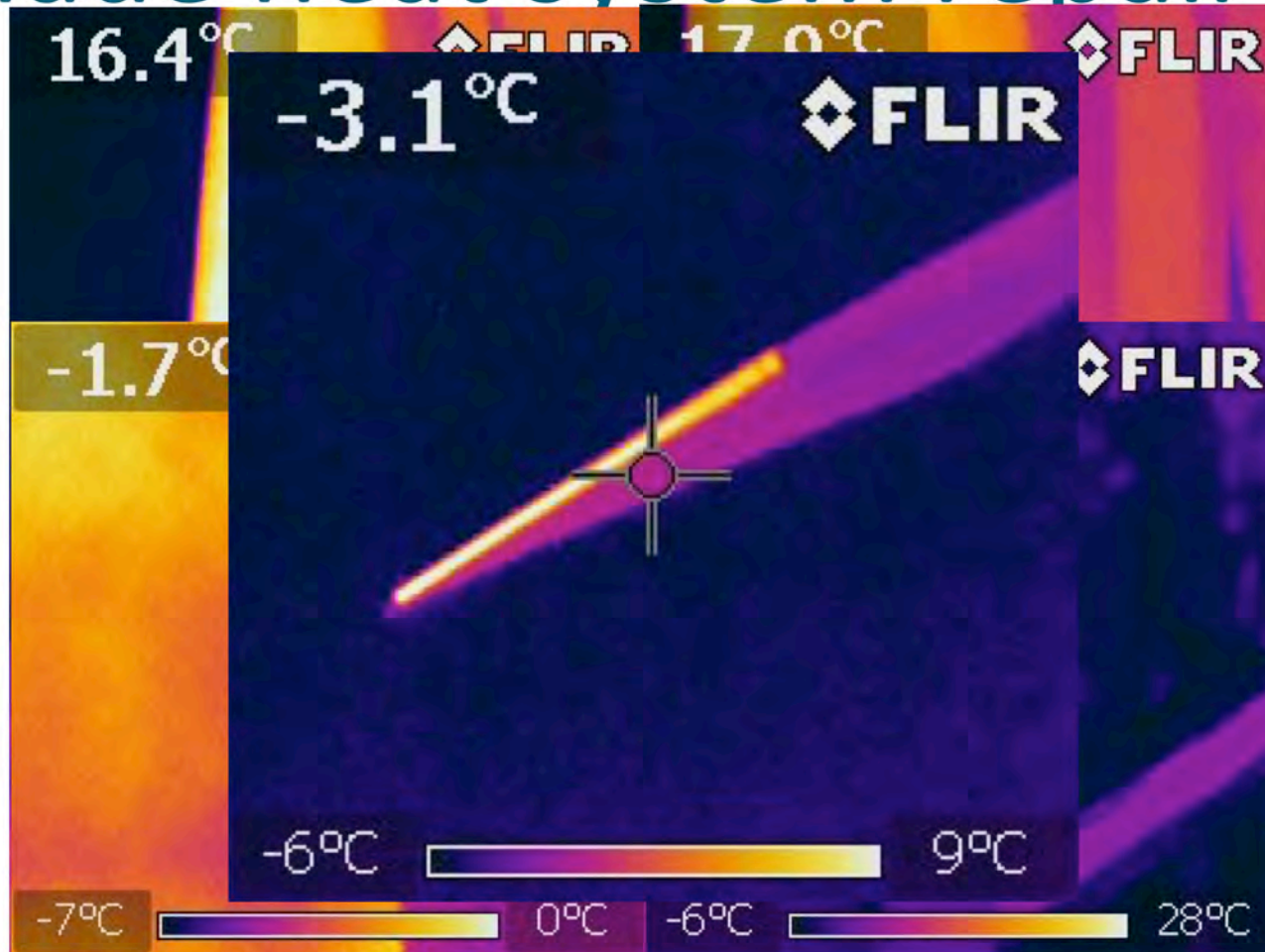
Field repairs



Field hot spot repairs



Blade heat system repair



Recommendation to owners

Inspect, inspect and inspect!

At least one thermal inspection every year. This is by far the most important blade inspection.

Install some lightning record system, inspect after lightning

Small hotspots are repaired in hours
Large hotspots takes weeks to repair, if possible!

Disconnect the blade heat system during lightning season

Thermal inspection

- Cherry picker
- Rope access
- Drone
- Long range thermal camera



Recommendation to suppliers

Blade heat system must be design to be repaired.

There are several blade heat system designs that are very hard to repair





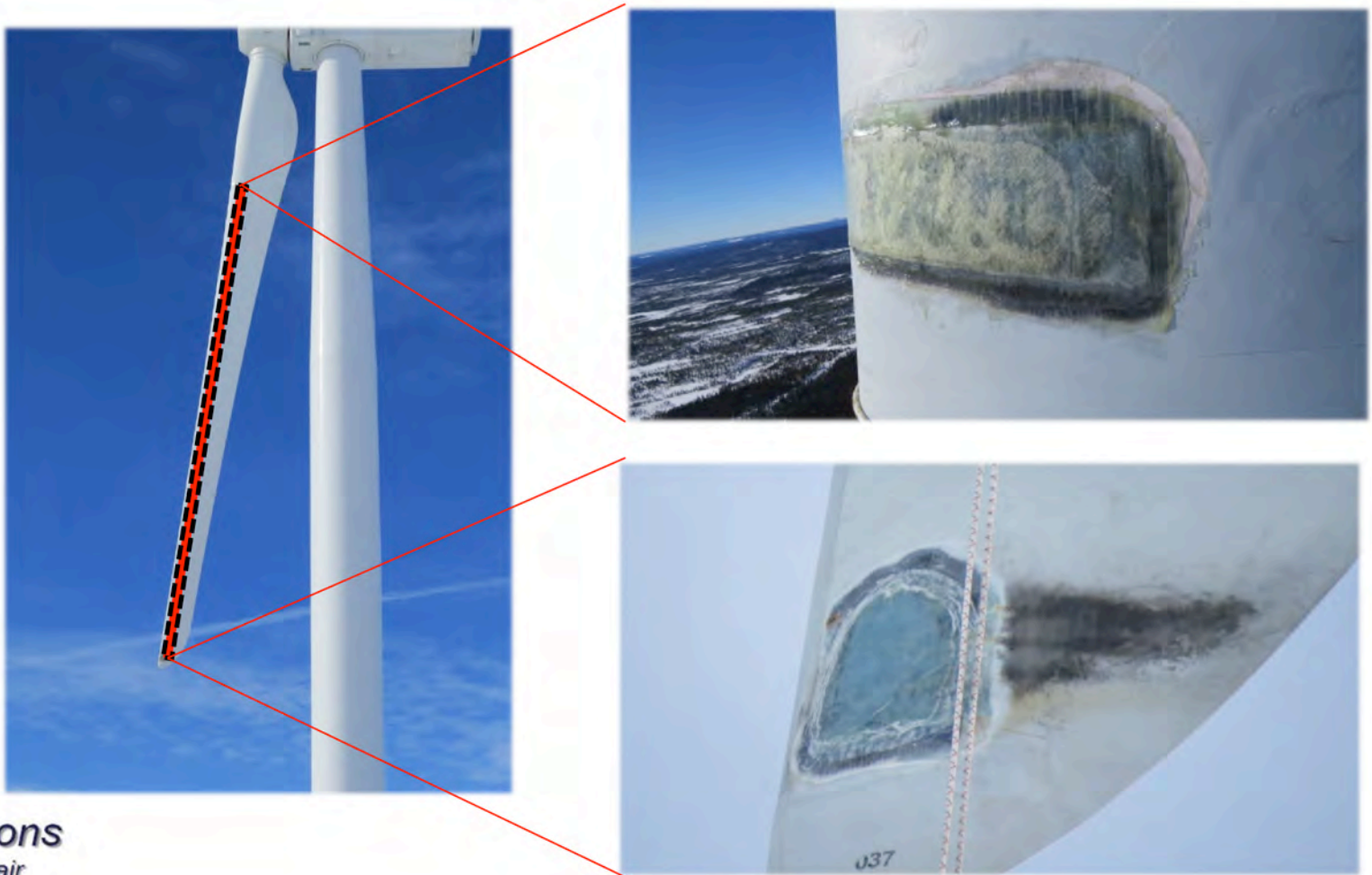
Blade Solutions

inspection & repair

Blade Heat repair



Winter repair



Blade heat repair

