

Appendix A – Coupling Images

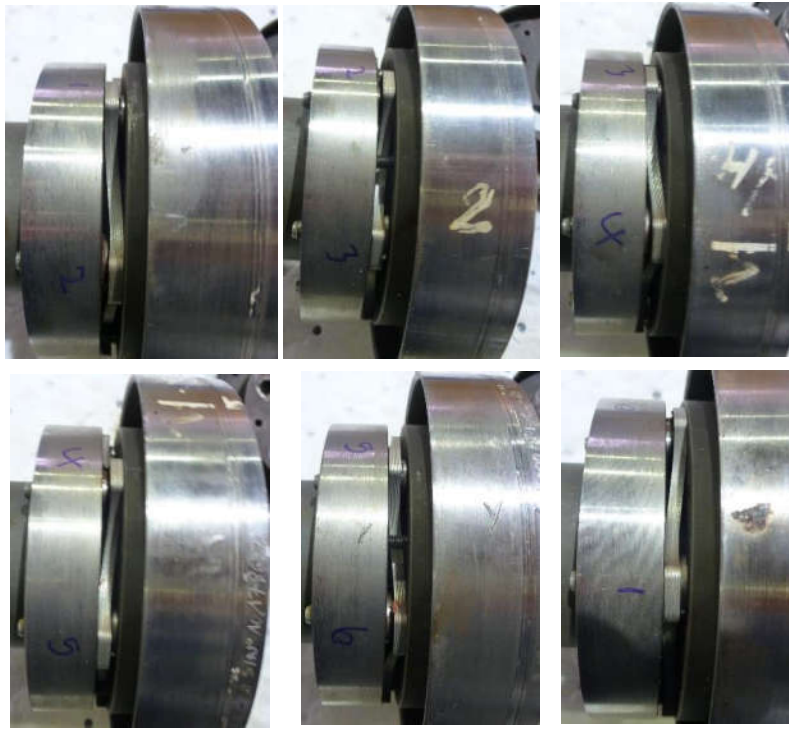


Figure 1 - HPC Guard ring as received

membrane pack was found to be overtightened using gagging bolts

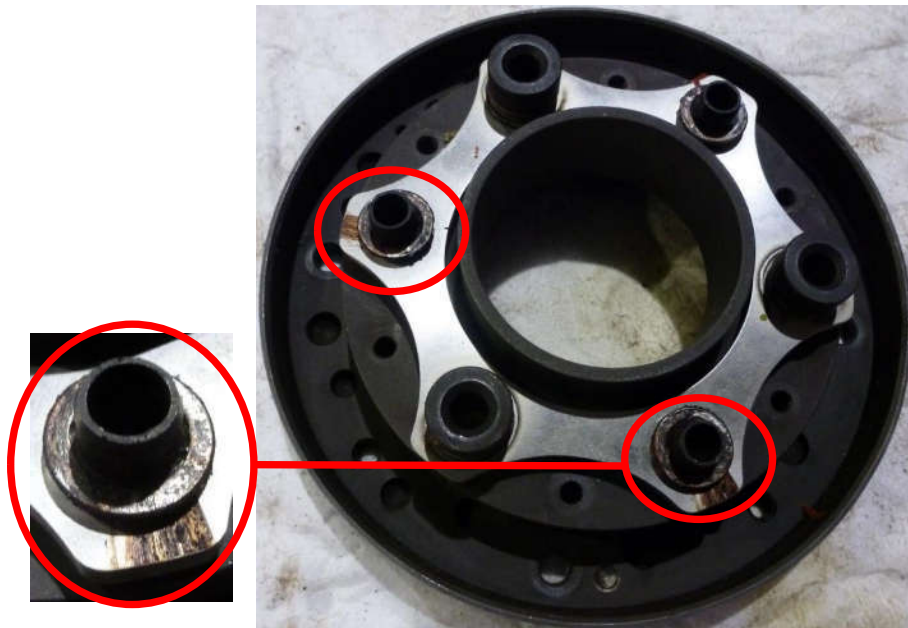


Figure 2 - HPC side membranes still attached to guard ring, fretting residue is seen on the two marked positions and the washers are worn



Figure 3 - membrane pack showing fretting residue around the membrane pack but with an overall good condition and no noticeable bowing



Figure 4 - Guard ring showing signs of wear around the bolt hole washers which grooved the surface



Figure 5 - Spacer HPC side condition with damage around the bolt holes



Figure 6 - HPC side bolts with an overall good condition with minor fretting on some of the bolts shank

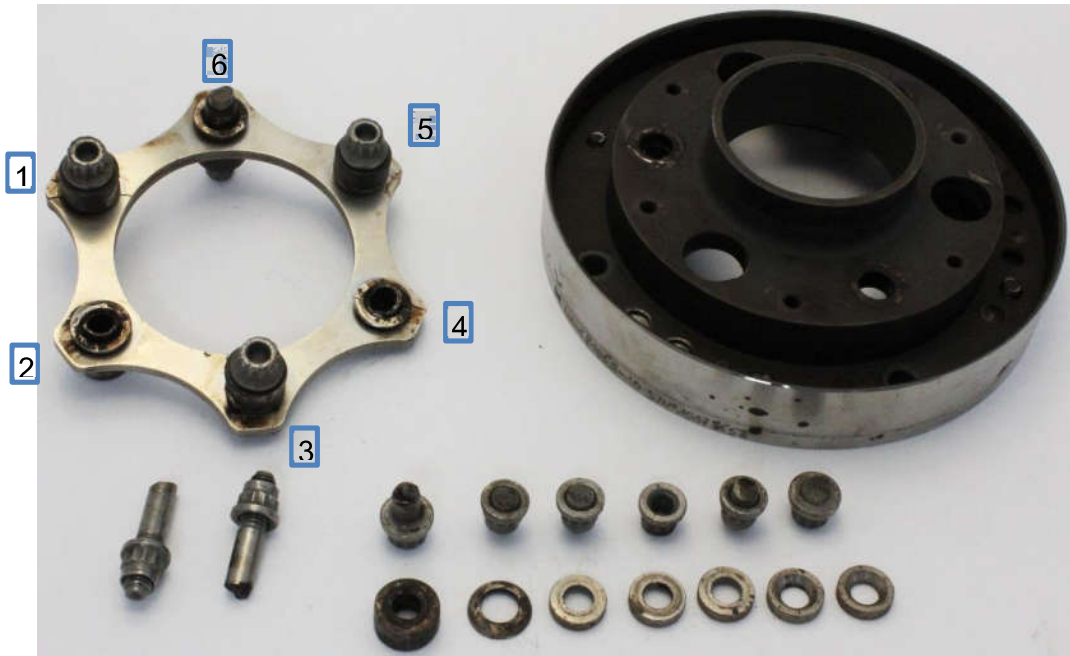


Figure 7 - Driver side with damaged components as received from



Figure 8 - LP compressor side Guard ring

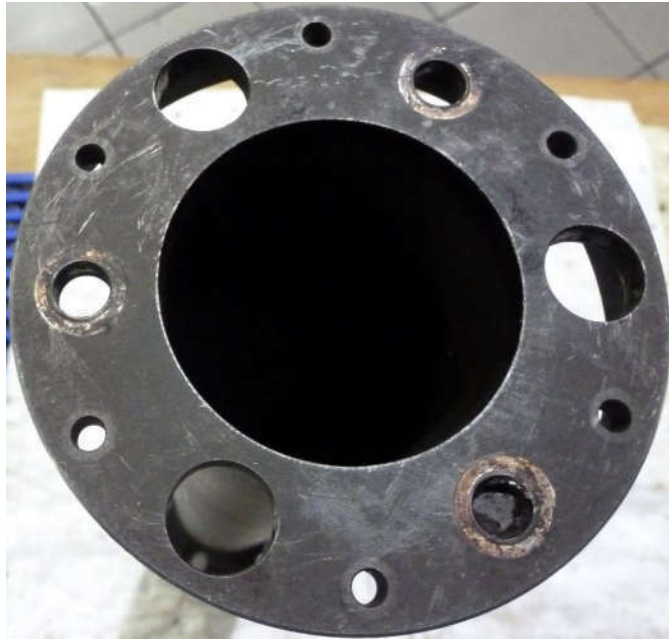


Figure 9 - Spacer from LP compressor side, with damage at the bolt holes

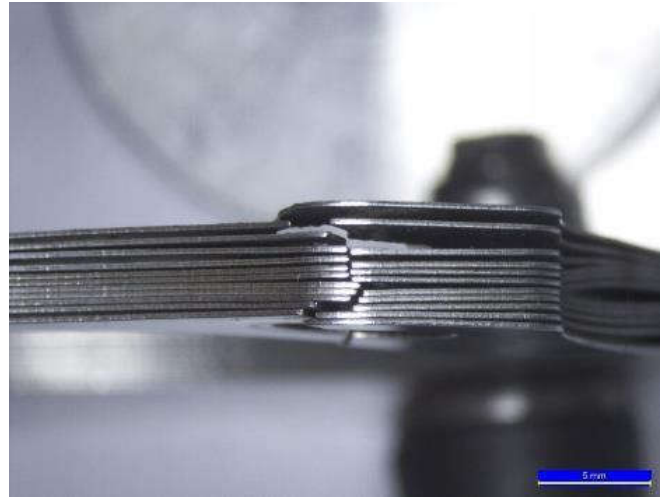


Figure 10 - membrane hole with fretting damage around the hole and crack propagating from the bolt hole and failure across of the membranes



Figure 11 - LPC membrane pack with wear damage on overload collars

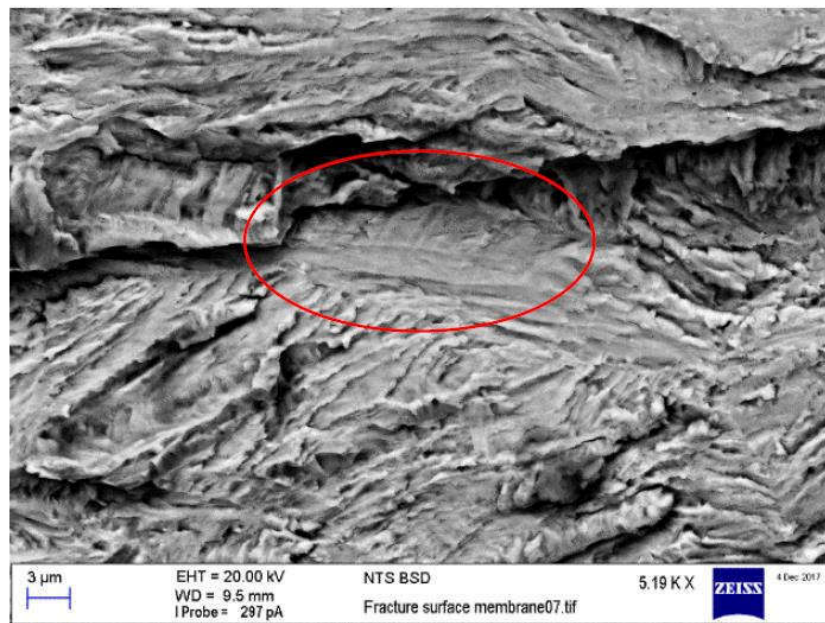


Figure 12 - SEM BSD micrograph showing general view of fracture surfaces from membranes, highlighting fatigue striations (red circle) within the microstructure



Figure 13 - Mechanical damage and cracking of the bolt collar (left) and fretting damage along the shank of the bolt (right)



Figure 14 - Failed bolts, highlighting the location of failure i.e. fillet radius (left), threads (middle) and shank (right)

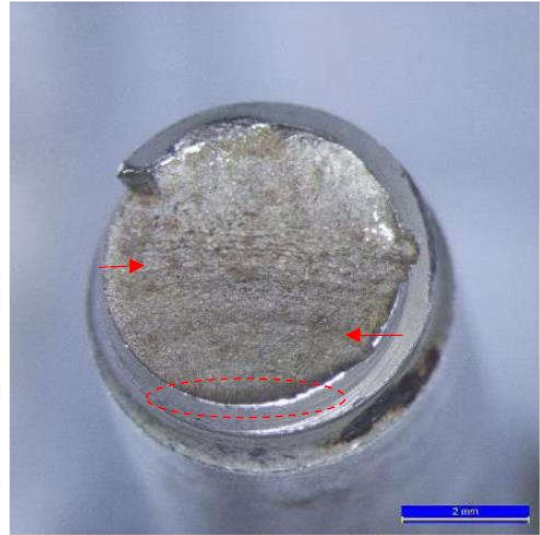
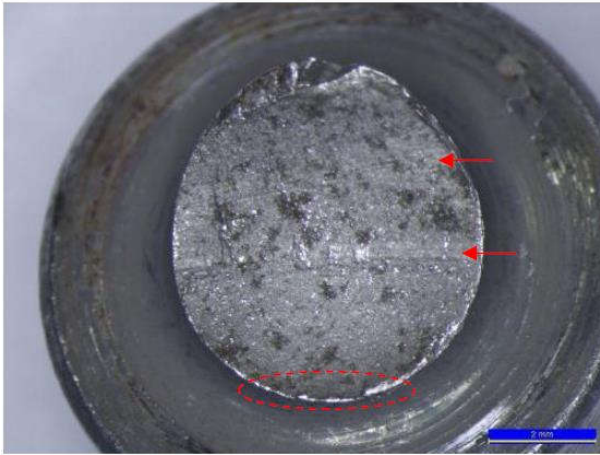


Figure 15 - Drive bolts located at no. 1 and 3 on the membrane pack, highlighting clamshell marks (red arrows) and the area of initiation (red circle).

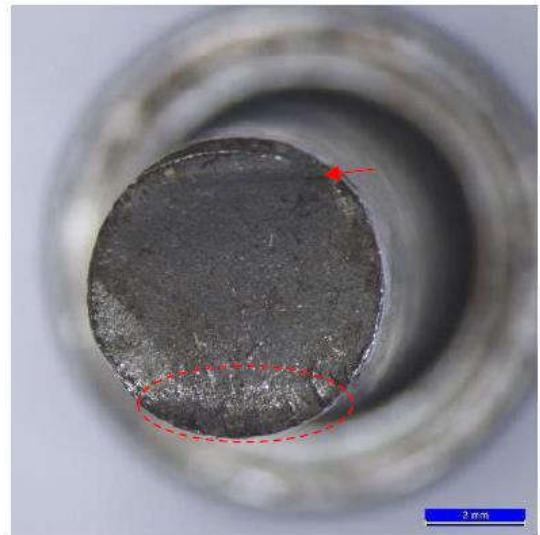
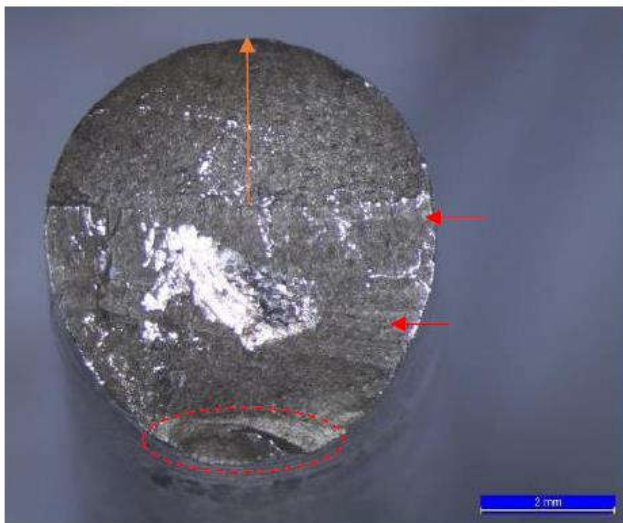


Figure 16 - drive bolts located at no. 2 and 5 on the membrane pack, highlighting the area of crack initiation (red circle) and clamshell marks (red arrows) which indicate fatigue crack propagation.

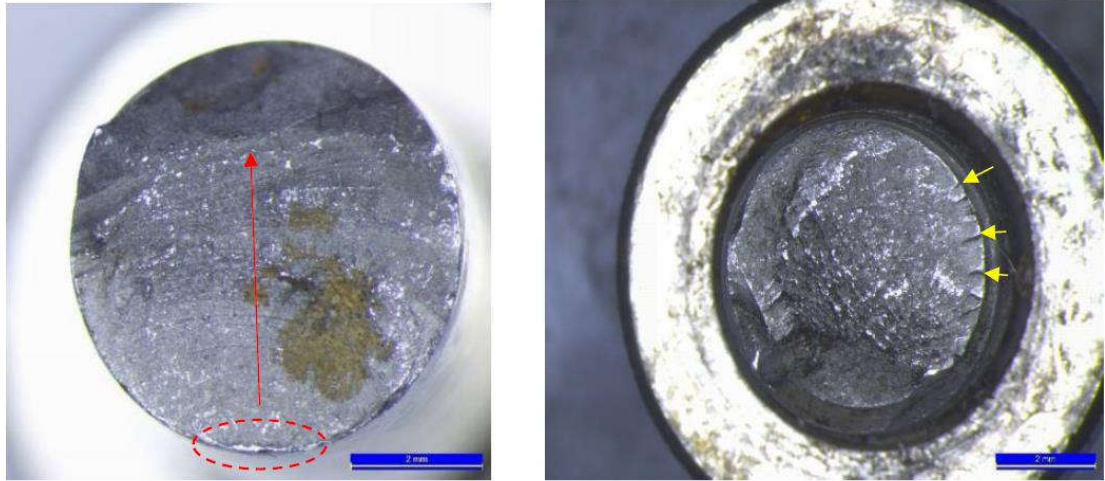


Figure 17 - Fracture surfaces of the failed bolts, highlighting i) fatigue crack propagation across the fracture surface and initiation area (red circle) and ii) ratchet marks (yellow arrows) indicative of high stresses at time of failure lab]