



Centrifugal Compressor Over Speed Trip Case Study

Authors: Thota Praveen Kumar

&

Ali Abdullah



Qatar Shell GTL Limited-Doha Qatar.

Problem Statement

The compressor was tripped on over speed after running less than 200 hrs since commissioning. The compressor was running on Max. Continuous (9278 rpm) speed before it trips on over speed (10206rpm)

COMPRESSOR DETAILS

Type / Size / Model :- STC- SV (10-1-A)

(Single stage – Barrel type compressor)

Driven by :- Steam Turbine

Rated Power:- 14487 KW

Rated capacity :- 2866 m³ / hr

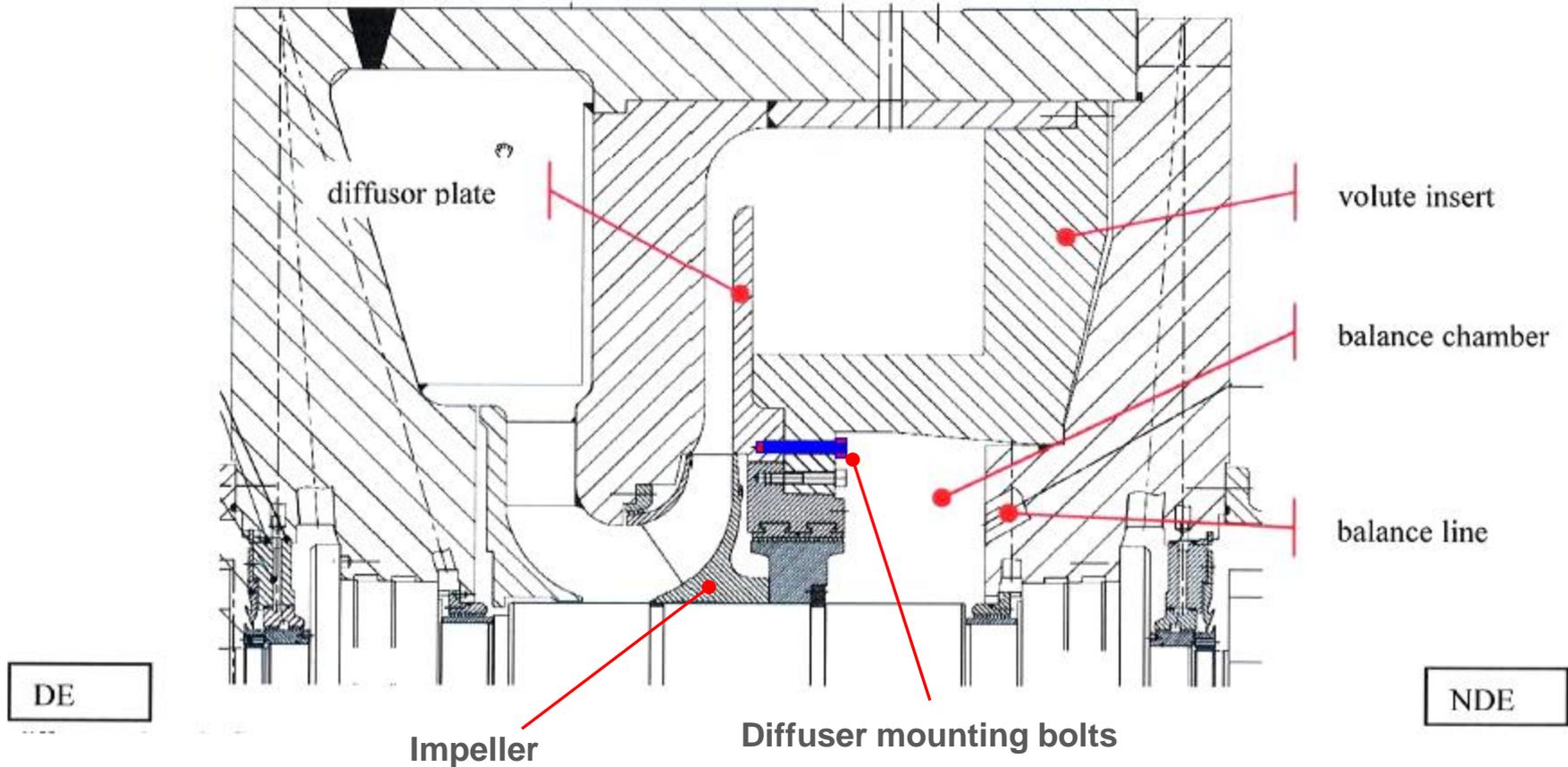
Max continuous speed :- 9278 RPM

Trip Speed :- 10206 RPM

Observations

- ❖ Barring operation started automatically as per logic after trip the compressor however there was no barring of rotor even though barring pump is running and barring actuator could not able to rotate the rotor.
- ❖ Decoupled the turbine to compressor for check the free rotation of the turbine and compressor as there was no barring operation.
- ❖ After decoupling it was found that compressor rotor was hard to rotate and stuck, where as turbine rotor was free to rotate.

Compressor construction



Removed the compressor end cover found:

- ❖ Seven of the eight Allen head bolts holding diffuser plate in position were broken. One bolt was completely missing.
- ❖ Seven of the bolt heads were found sitting in the bottom of the balance chamber.
- ❖ One bolt broken had backed out and was found in balance chamber.
- ❖ 5 of bolts had been elongated.

Findings



After opening Casing end cover- Balance chamber area



Broken bolt found the section of discharge cover



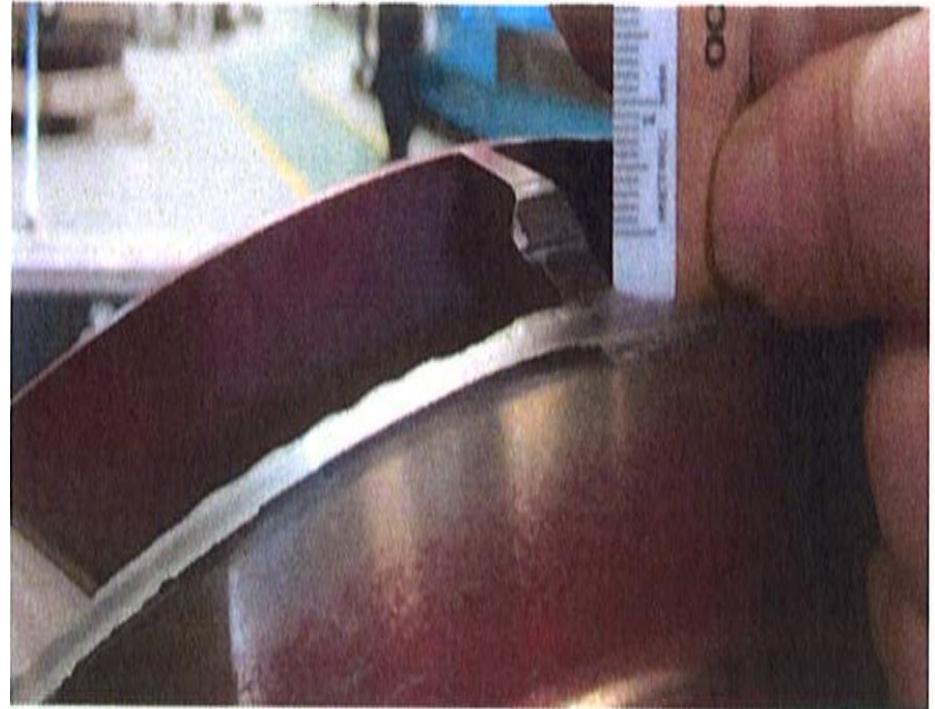
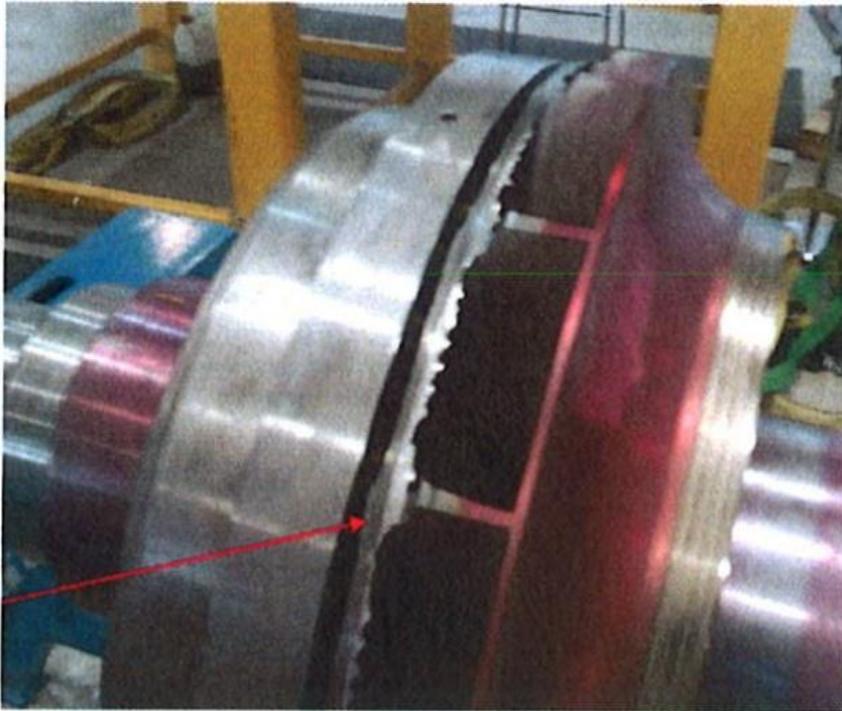
Broken bolts after remove



Allen head back side

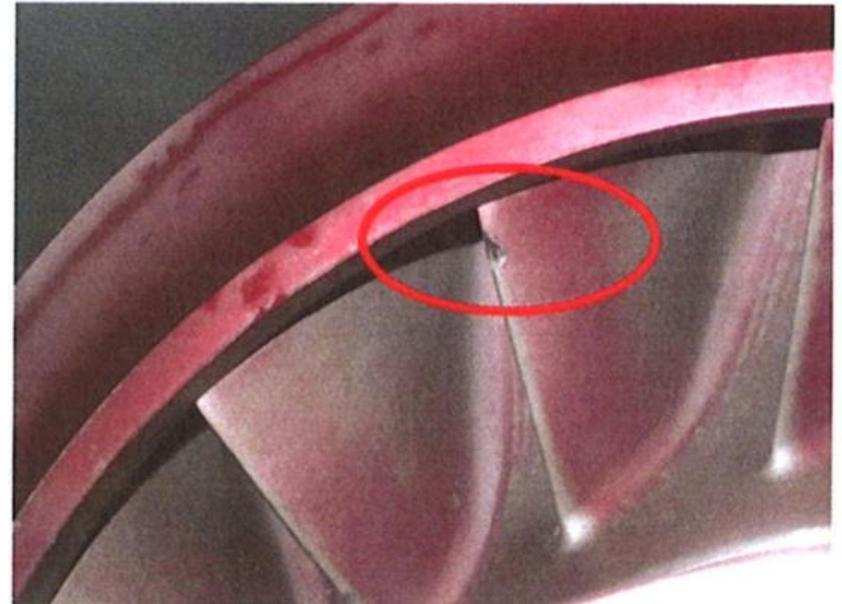
Findings

- ❖ The compressor was dismantled and found that outer diameter of the impeller was cut axially 18mm by the diffuser. The cut removed 16 mm from the impeller OD.



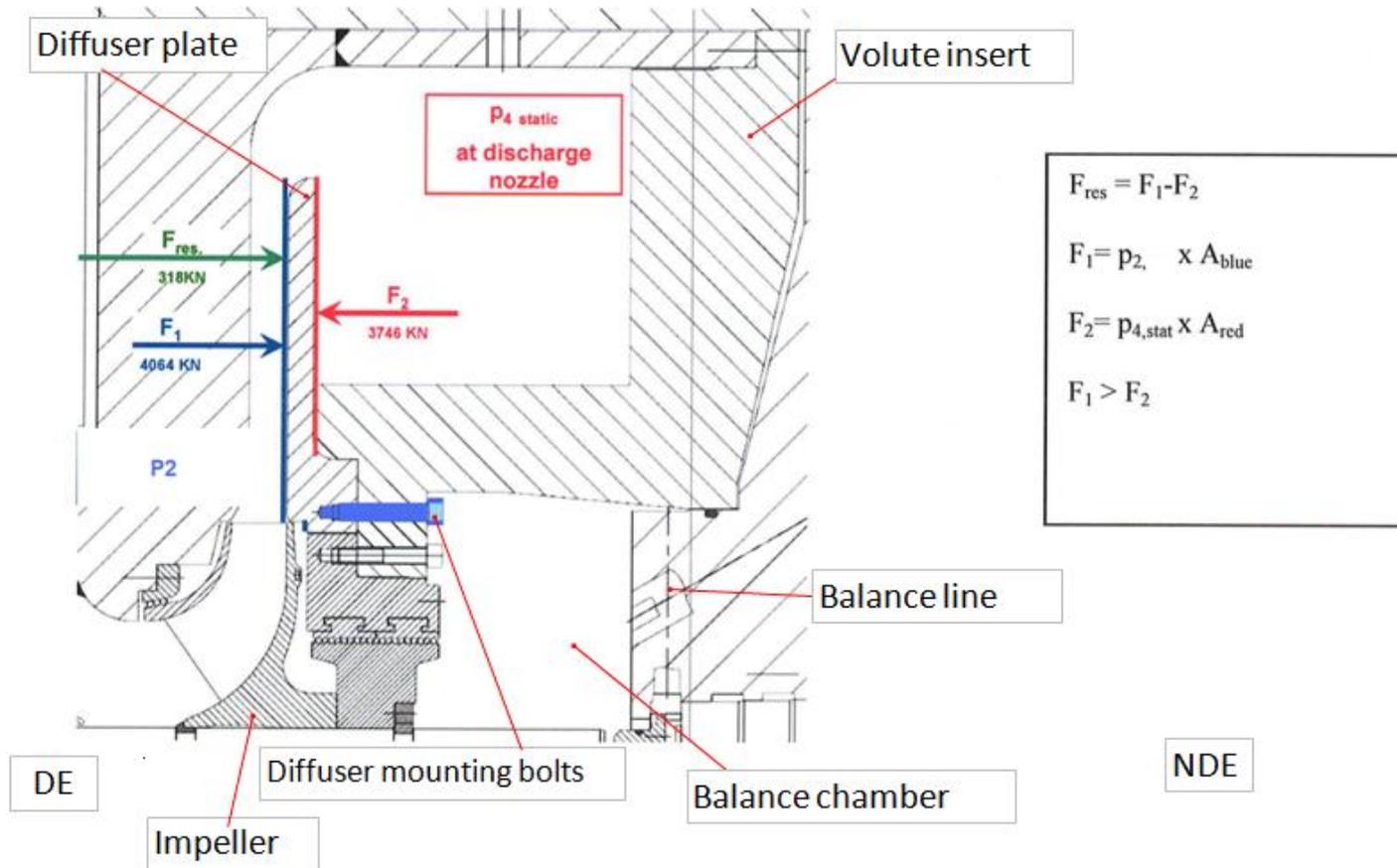
Findings

- ❖ At the impeller inlet one blade was found in significant damage and another 2 blades were with minor dents.
- ❖ Balance piston and all labyrinths are found in good condition
- ❖ The both radial and axial bearings were found in good condition.
- ❖ The missing bolt passed through the balancing line to the compressor suction and hit the impeller vane.



Diffuser Design

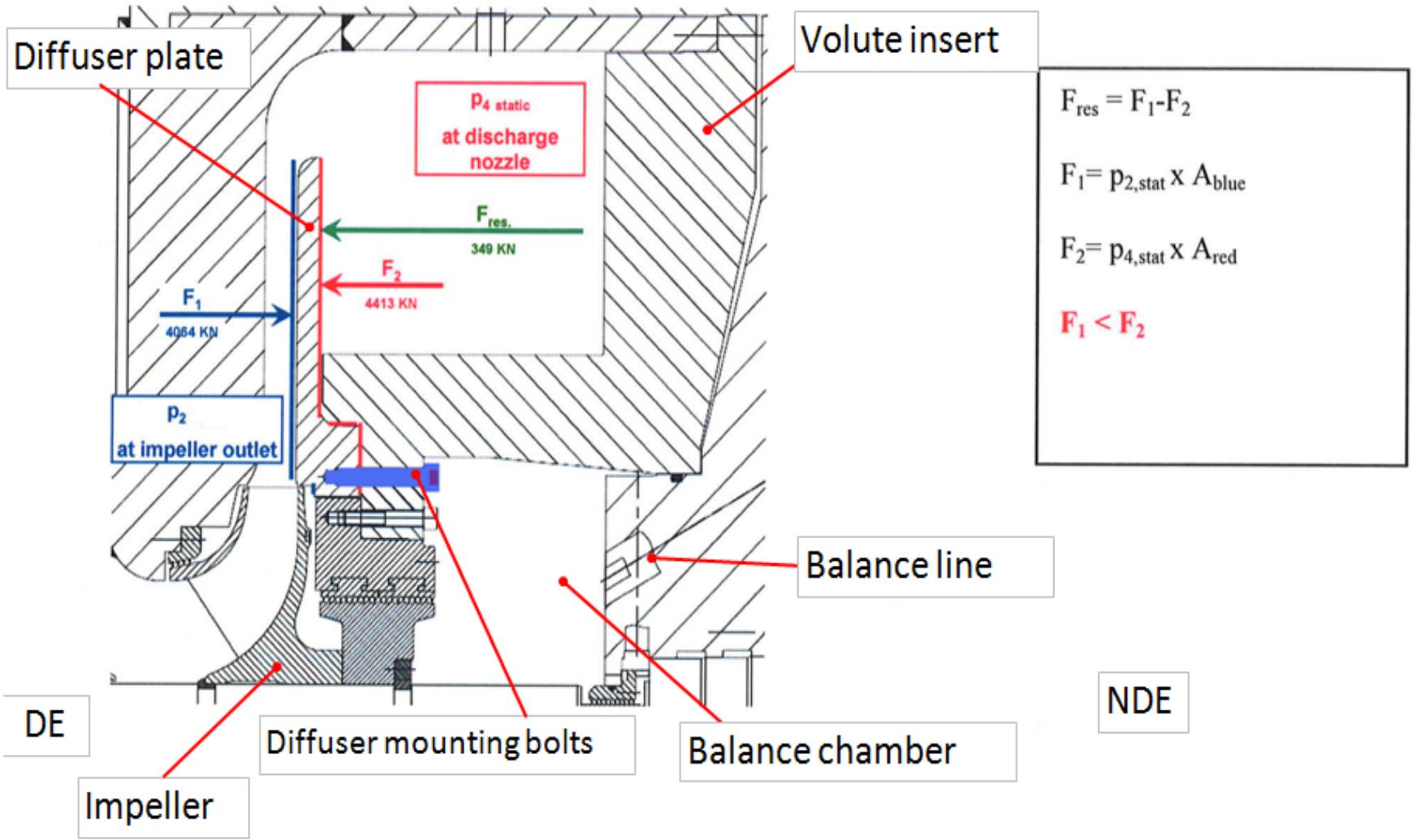
- The diffuser plate is fixed with 8 bolts. The resultant force during operation pushes the diffuser plate towards the NDE side of the compressor.



Sequence of failure

- ❖ The bolts holding the diffuser plate in position were not tightened properly.
- ❖ Additional area behind the diffuser was eventually exposed to discharge pressure (P4) effecting forces on the diffuser.
- ❖ The orientation of the resultant force on the diffuser changed to opposite direction (towards Drive End).
- ❖ The new resultant force exceeds the yield strength of the bolts.

Root cause analysis –cont,



Root cause analysis

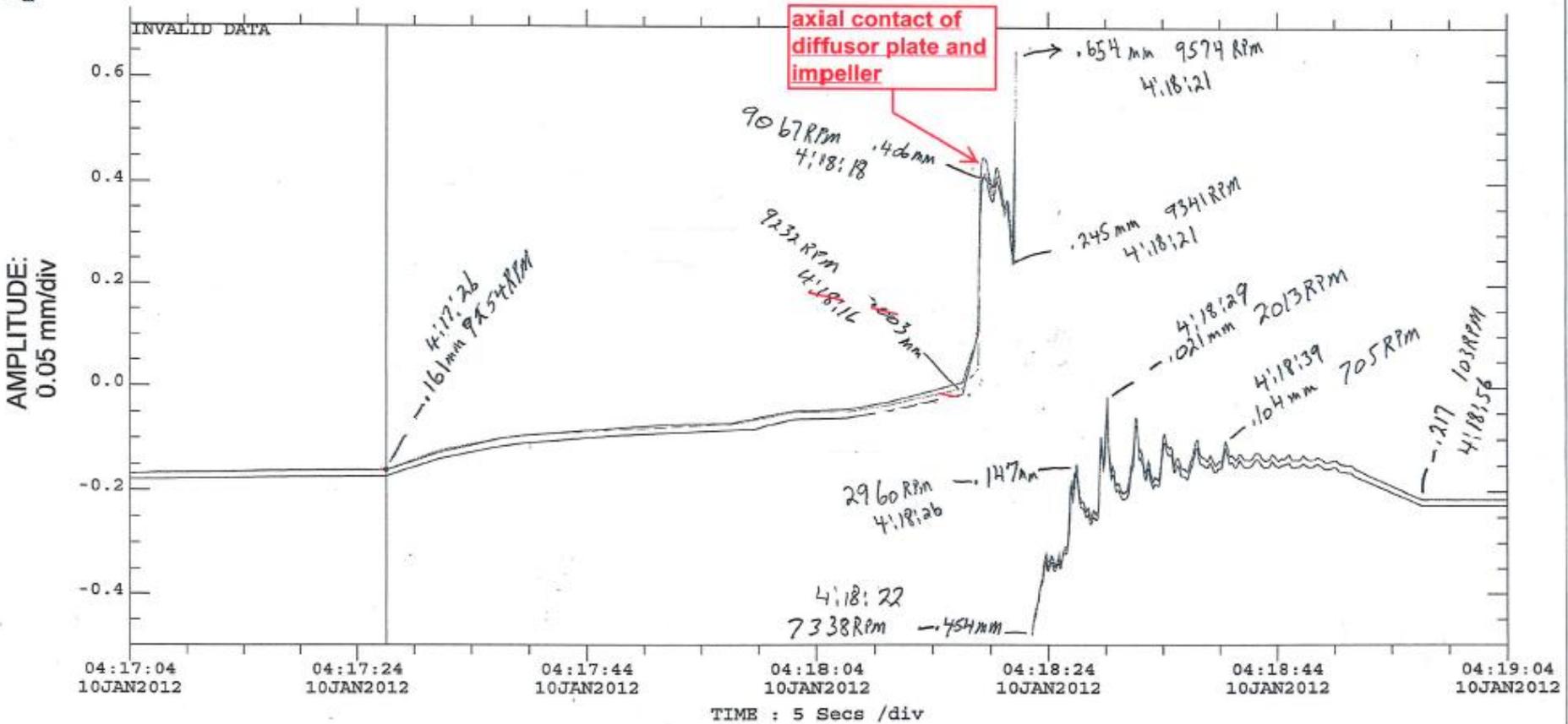
- ❖ The pressure in the balance chamber increased due to a bypass at location of missing bolt head and changed the axial position of the rotor.
- ❖ The diffuser plate pushed towards the impeller and caused the damage of the Rotor

Evidence in Trend display

shaft displacement monitoring

231GIZA-10703/TX $\angle 90^\circ$ Left Direct
 2K-3141 SeconC From 10JAN2012 04:17:04 To 10JAN2012 04:19:04
 231GIZA-10704/TX $\angle 90^\circ$ Left Direct
 2K-3141 SeconC From 10JAN2012 04:17:04 To 10JAN2012 04:19:04
 231GIZA-10705/TX $\angle 90^\circ$ Left Direct
 2K-3141 SeconC From 10JAN2012 04:17:04 To 10JAN2012 04:19:04

Historical 10JAN2012 04:17:26 -0.161 mm 9254 rpm
 Historical
 Historical



Job carried out

- ❖ Rotor sent back to vendor for repair. Used the spare Rotor for assembly.
- ❖ The threads of the diffuser plate increased from M12 to M16 as they were found loose, and holes in the volute also increased to match.
- ❖ Diffuser plate Dye penetrant test carried out and found that there were no crack caused by the contact.
- ❖ All bolts were tightened with 130NM torque as per vendor recommendation and found no gap between diffuser plate and volute insert.
- ❖ Thrust and Radial bearings were reused.

Conclusion

- ❖ As per the trends analyzed, the failure is due to the bolts improper tightening.
- ❖ Metallurgical failure analysis also concludes that one bolt is fractured by fatigue and others are due to tensile over load.
- ❖ The OEM did not have as QC step for ensuring the diffuser bolts were properly tightened.
- ❖ There are no other evidences that could lead to this failure other than improper tightening.

