SAFCO/IBB

RUBBING DETECTION IN A SYNTHESIS GAS COMPRESSOR

NOV 2015

By: Dr. Chinmaya Kar & Mr. Waleed J. Al-Sallom

CHEMISTRY THAT MATTERS™

PROBLEM STATEMENT

Large shaft vibration of

- 52µm persisting for last 1 year at HP DE in one proximity probe, and
- 40µm persisting for last 1 year at Turbine LP End for both proximity probes

HISTORICAL FAILURE

- The rotor had silica deposit at 5th , 6th and 7th stages and large unbalance
- HP gland at 5th stage was worn out
- Rotor and gland were replaced

- Gear coupling failure at HP-Turbine side as oil supply nozzle is not directed towards lubricating zone
- Seal rings have been scored and HP DE side oil seals were replaced
- Parallel and angular misalignment found and corrected
- Thrust bearing of turbine replaced

TA 2007 — TA 2011 — May 2011 — Oct 2011

- Slight sludge observed on seal housings at oil seal assemblies of both ends .
- Both ends of inner and outer seal rings are found scoring - replaced.
- NDE tilting pad seal clearance found out of tolerance.
- Parallel misalignment observed and corrected

- Wiping of journal bearing bottom pads on both DE & NDE noticed.
- Sludge noticed on the inner seal rings on both DE & NDE.
- Parallel and angular misalignment found and corrected

HISTORY OF THE IBB SYNTHESIS GAS COMPRESSOR

2011 TA

- Slight sludge observed on seal housings at oil seal assemblies of both ends .
- Both ends of inner and outer seal rings are found scoring - replaced.
- NDE tilting pad seal clearance found out of tolerance.
- Parallel misalignment observed and corrected

May 2012 Shut down:

- Gear coupling failure at HP-Turbine side as oil supply nozzle is not directed towards lubricating zone
- Seal rings have been scored and HP DE side oil seals were replaced
- Parallel and angular misalignment found and corrected
- Thrust bearing of turbine replaced

Oct 2012 Shut down

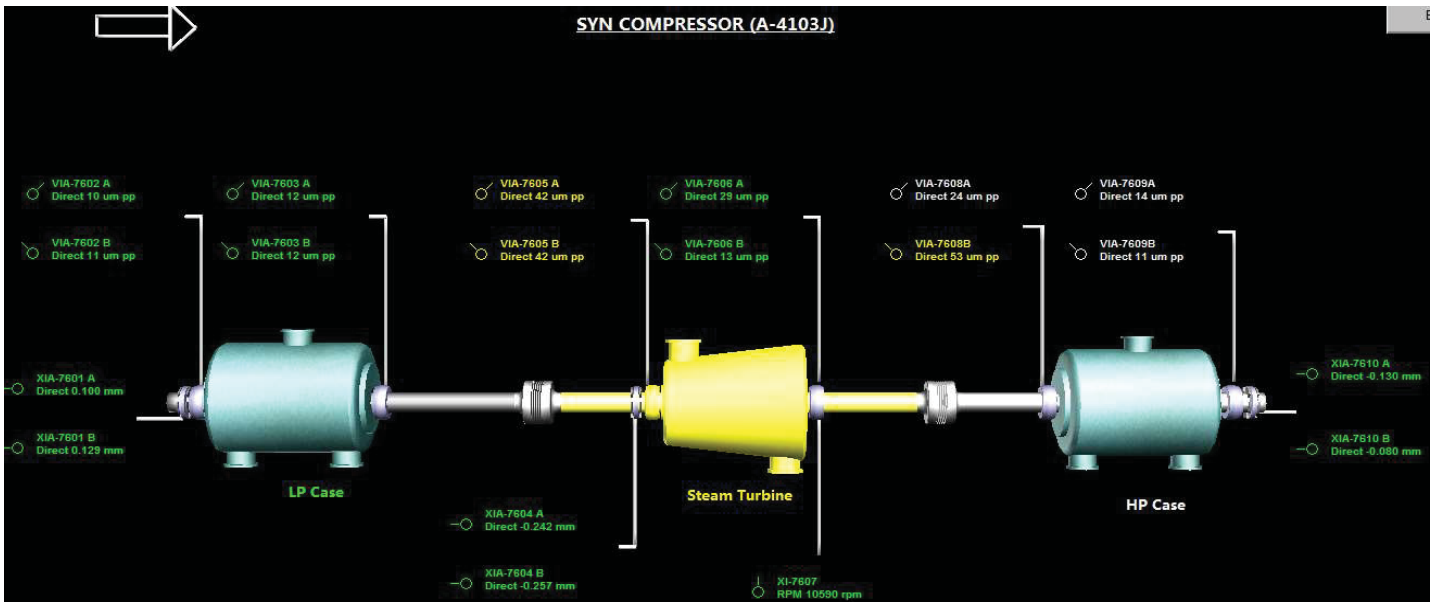
- Wiping of journal bearing bottom pads on both DE & NDE noticed.
- Sludge noticed on the inner seal rings on both DE & NDE.
- Parallel and angular misalignment found and corrected

Summary of the maintenance history:

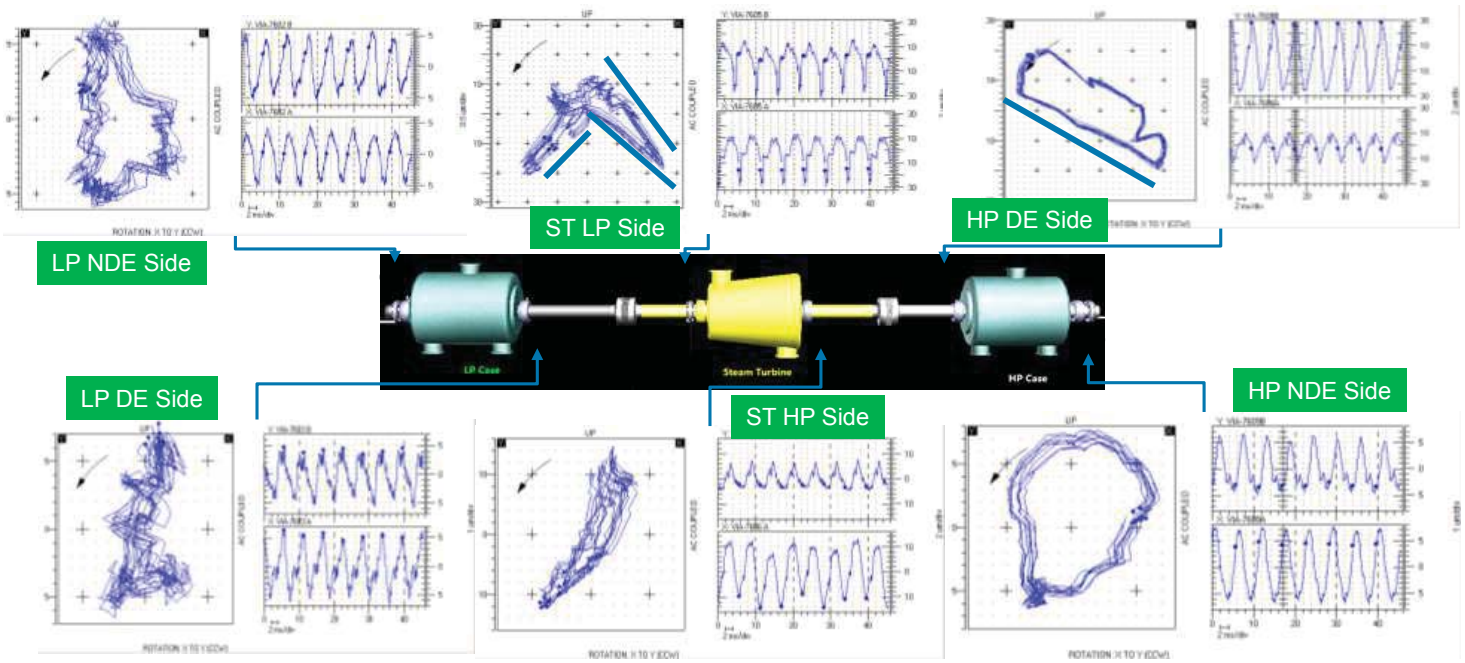
- A repeated parallel and angular misalignment is observed – Coupling can be the reason as evident in the coupling failure in May 2012
- Scoring of seal rings with sludge – One of the main reason is misalignment

OVERALL SHAFT VIBRATION IN MARCH 2014

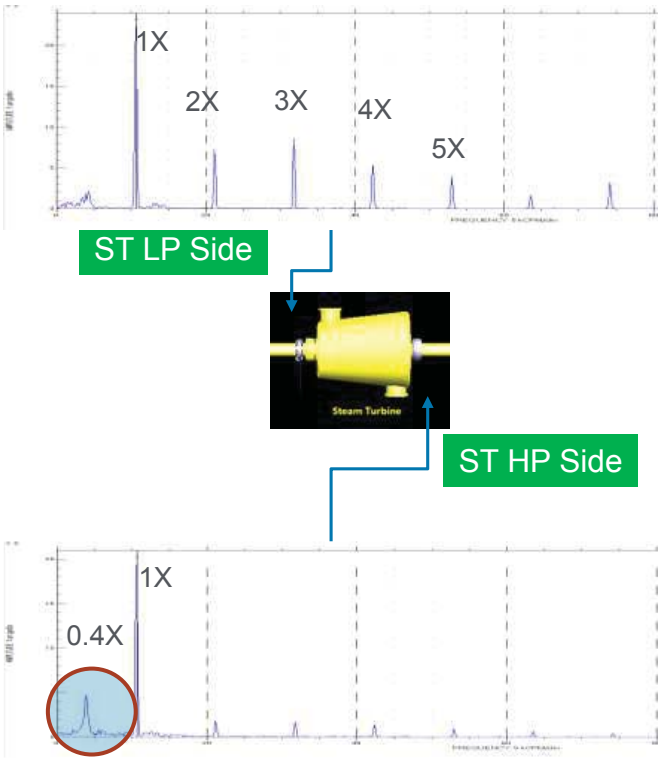
- The LP side of steam turbine vibration shows a large amplitude of 42µm pp in both the direction
- One of the HP side probe of the steam turbine shows 53µm pp



VIBRATION ANALYSIS – ORBIT PLOTS



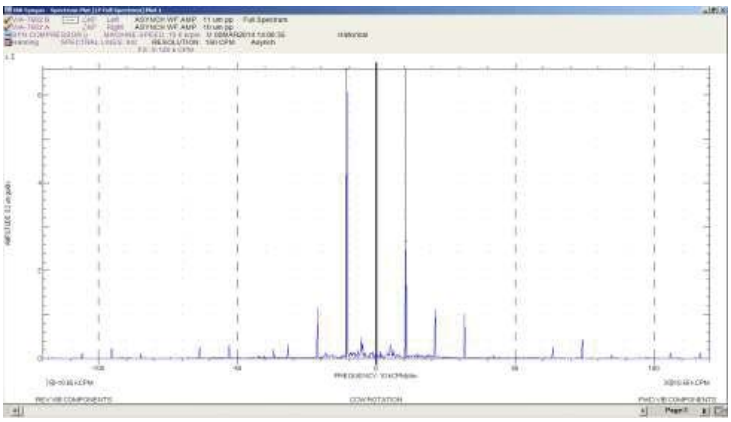
VIBRATION ANALYSIS – SPECTRUM PLOTS



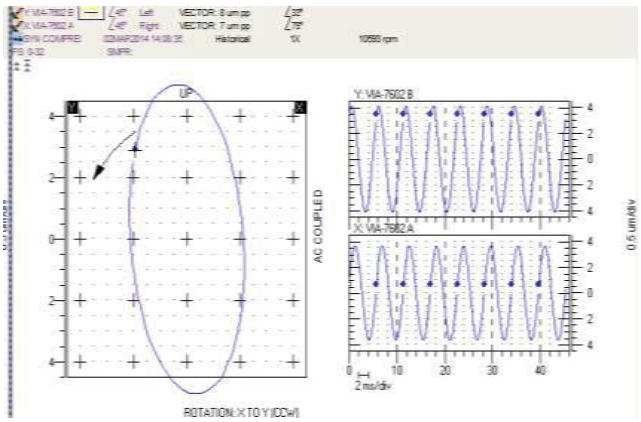
SHAFT VIBRATION AT LP COMPRESSOR

- The LP compressor's NDE probes indicate normal vibration
- There is a reverse precession observed (may be detrimental in future with large fatigue of the shaft) – this may be the reason of probe and key phasor placement as well

Full Spectrum



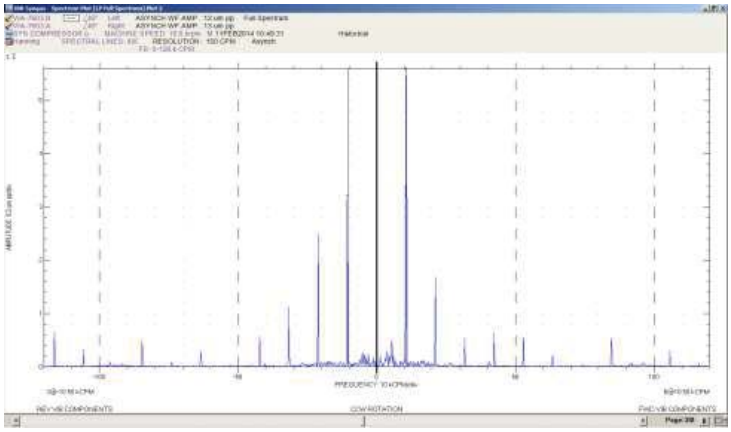
Filtered 1X Orbit plot



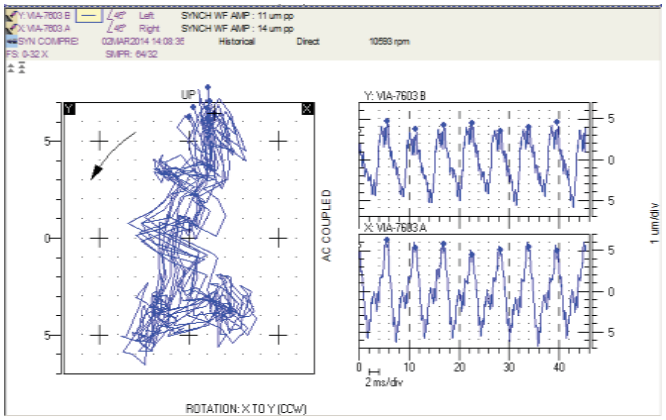
SHAFT VIBRATION AT LP COMPRESSOR

- The LP compressor's DE probes indicate normal vibration
- There are a number of 1X, 2X, 3X components shows either looseness or rubbing
  - The mild looseness / rubbing indicates that it may be in the journal / seal / coupling
- Though the orbit plot is very irregular, doesn't show rubbing (impact – with straight lines) – may be an effect of steam turbine's LP side vibration

Full Spectrum



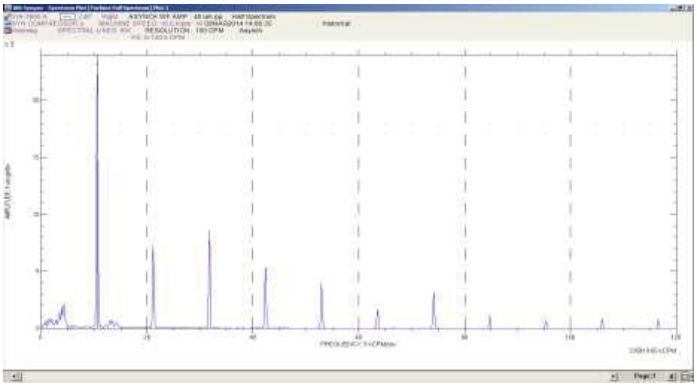
Orbit plot



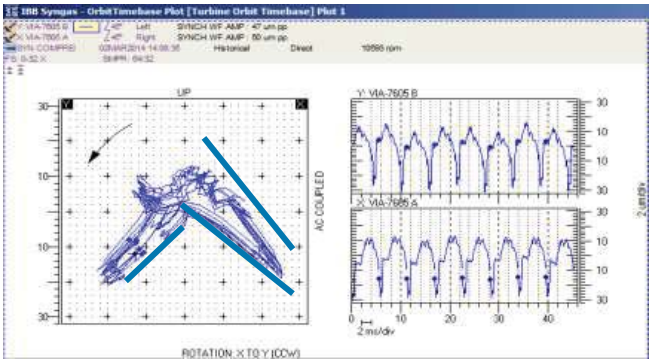
SHAFT VIBRATION AT STEAM TURBINE

- The Steam turbine's LP Side probes indicate large vibration of 42µm pp in both the direction
- There are 1X, 2X, 3X components and also sub-harmonic component (near rotor natural frequency of 4000rpm) - either looseness or rubbing at bearing / seal / coupling
- The orbit plot is very irregular with some impact and straight lines and hence shows some mild rubbing

Half Spectrum



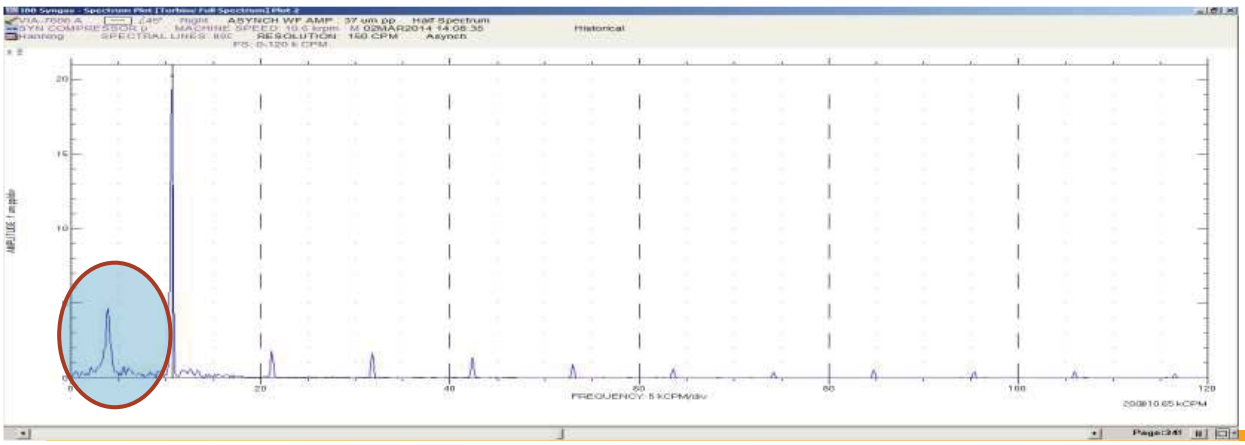
Orbit plot



SHAFT VIBRATION AT STEAM TURBINE

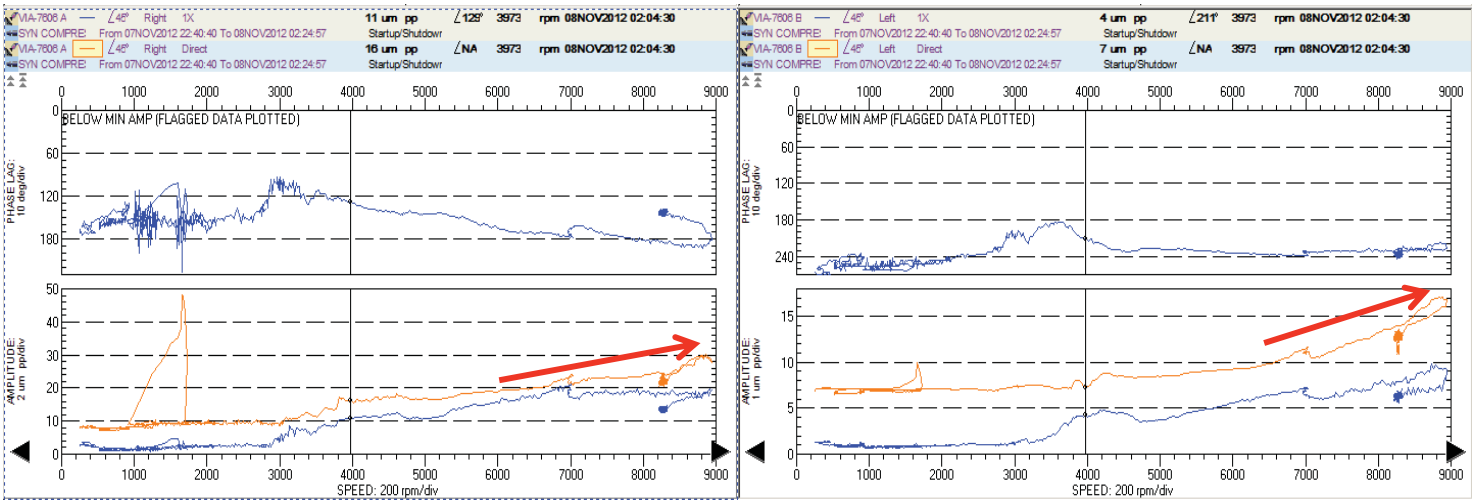
- The Steam turbine's HP Side probes indicate normal vibration
- However, large sub-harmonic components (particularly at exciting the rotor natural frequency is a concern
  - The sub-harmonic component even showing an amplitude of 5µm which is very large

Half Spectrum



BODE PLOTS

- The Bode plot reveals large unbalance only at turbine HP side end as seen in the trend below
  - The amplitude increases with speed and phase between the probes is nearly 90˚
- The other Bode plot have
  - Either large amplitude for some RPM range and then decreases with speed
  - Or have less amplitude

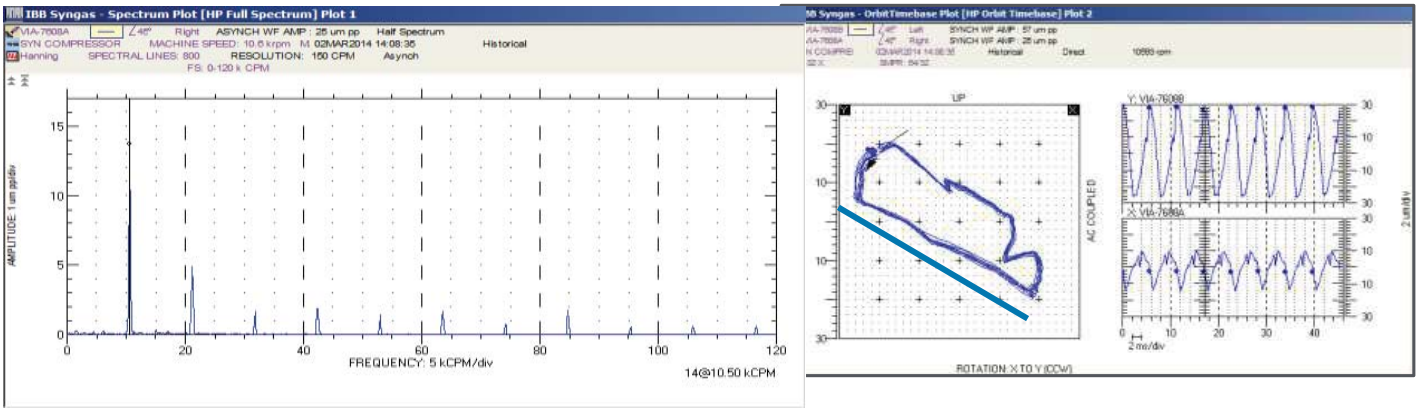


SHAFT VIBRATION AT HP COMPRESSOR

- The HP Compressor's DE Side probes indicate large vibration of 53µm pp in one direction (7608B)
- There are a number of 1X, 2X, 3X components shows either looseness or rubbing
- The orbit plot is very irregular with some impact and straight lines and hence shows some mild rubbing

Half Spectrum

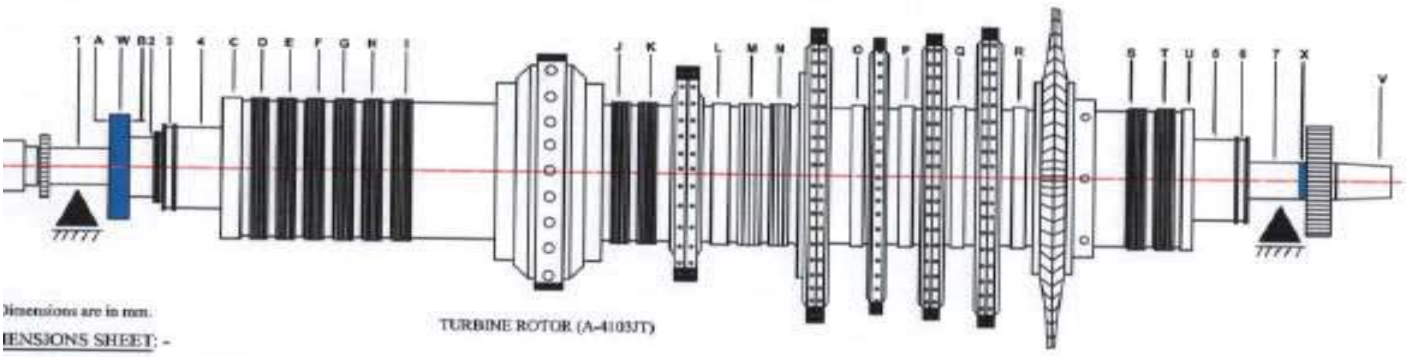
Orbit plot



FIELD OBSERVATIONS: RUBBING AT STEAM TURBINE

FIELD OBSERVATIONS: RUN-OUT OF STEAM TURBINE ROTOR

FINAL DIMENSIONS & RUN OUT REPORT



TURBINE ROTOR (A-4103JT)

Dimensions are in mm.

DIMENSIONS SHEET: -

	1	2	3	4	5	6	7
Ø	119.85	200.01	200.01	200.02	200.10	160.05	119.84

RUN OUT SHEET: -

	1	2	3	4	5	6	7	A	B	C	D	E	F	G	H	I	J	K
	0.000	0.02	0.01	0.01	0.01	0.01	0.002	0.01	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.03	0.00	0.03

	L	M	N	O	P	Q	R	S	T	U	V	W	X
	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.00	0.00	0.01	0.0015	0.0015

Marks: Nil.

FIELD OBSERVATION: HP JOURNAL BEARING

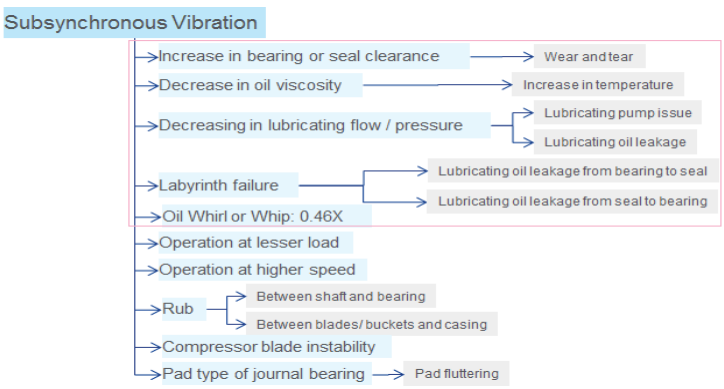
CONCLUSION

There was evidence of rubbing from the vibration analysis
- Either at bearing or seals or gear coupling

Some looseness has also been noted
- The subsynchronous components and other 2X, 3X etc. components were found

There is an unbalance particularly near the turbine's HP side end only
- Only one side unbalance may indicate that the turbine's HP side coupling may have caused this effect as there is no unbalance effect in turbine's LP side

The sub-synchronous vibration with signs of rubbing may also be the effect of
- Either rubbing at the seal
- Or rubbing at the gear coupling



CONCLUSION

Benefits of this analysis are

- Rubbing could be detected prior to Turnaround leading to
  - Proper planning in maintenance of the turbine
- FMEA analysis could determine all the probable faults and proper fault detection