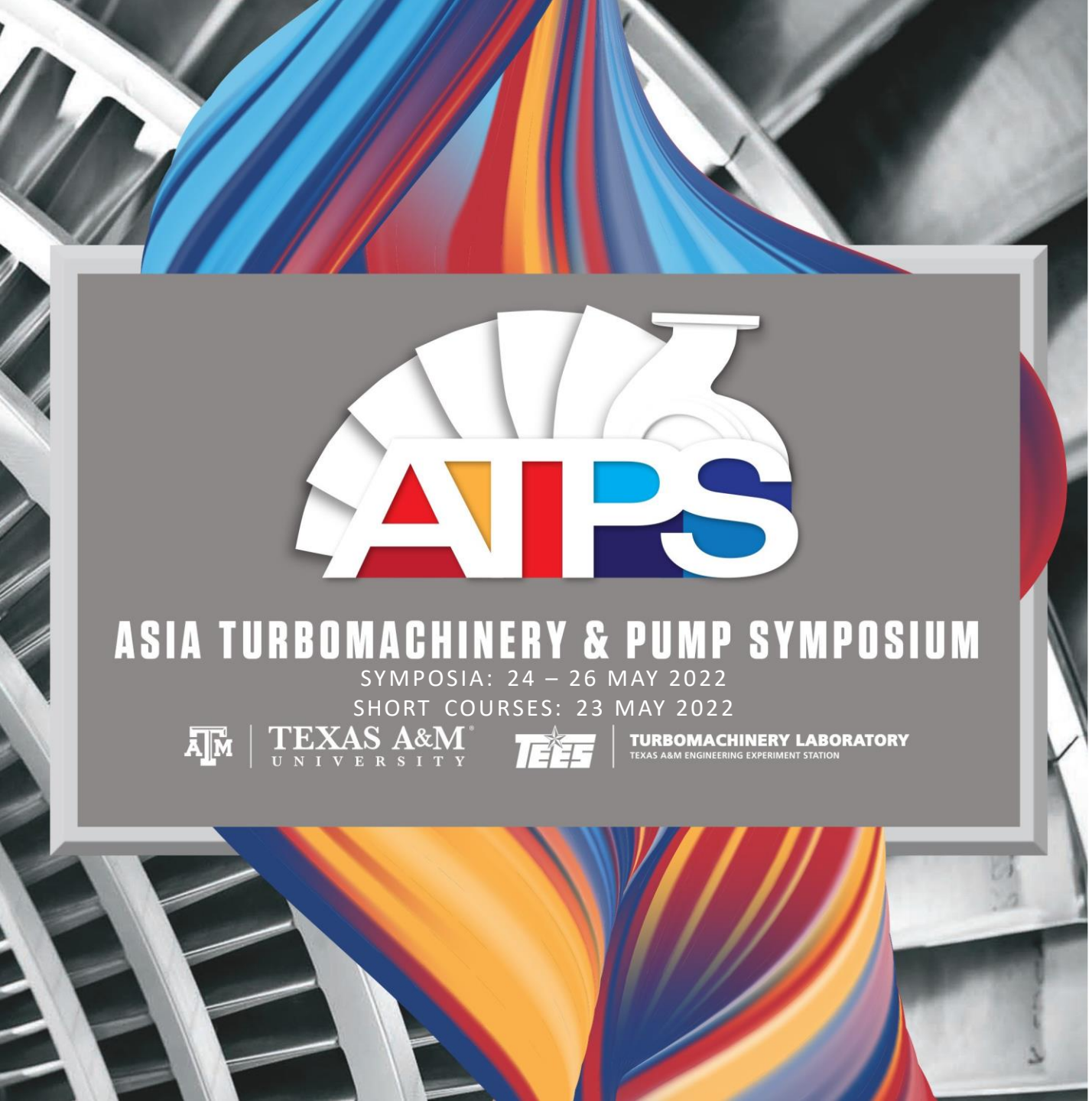

Chronic high vibration issue of a Condensate Pump

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engrofertilizers

Presenter/Author Bios:

Muneeb A. Sheikh is working as a Maintenance Engineer at Engro Fertilizers, Ammonia Plant. His responsibilities include planning and execution of maintenance for rotary and static equipment of the plant along with investigation of reliability issues of the plant. He is a certified Vibration Analyst Category II & Machinery Lubricant Analyst Level II.

Muneeb received his BSc Mechanical Engg. degree from UET Lahore in 2016.

Syed M. Haseeb Bukhari is currently working as Manager Ammonia Plant at Engro Fertilizers. Haseeb has over 10 years of experience in rotary equipment maintenance and troubleshooting. He has worked on several chronic reliability issues and his work has been published in many international forums including Syn Gas Conference in 2015 and ATPS in 2017.

Haseeb received his BSc Mechanical Engg. degree from NUST EME in 2010.

Abstract:

Chronic high vibration issue was being observed on a critical condensate pump. Although this motor driven pump is a standby unit, however, in case the running pump has a breakdown and the motor pump is unavailable, the Ammonia Plant will trip. This is a horizontal overhung, centerline mounted, single stage pump. The pump was relocated to current site in 1992 and the problem of high vibration was observed after ~10 years of operation. The issue was observed around the timeframe when locally manufactured spares were used since OEM had discontinued offering its spares. The pump was overhauled 03 times in past 10 years, but the high vibration issue remained as such.

Background:

At our Ammonia Plant, 02 condensate extraction, horizontal overhung, centerline mounted, single stage pumps are installed to maintain level of a surface condenser. The surface condenser is maintaining vacuum for critical plant turbines hence these pump are considered very critical to the plant operation. These pumps were originally commissioned in Pascagoula USA in 1968, however, they were relocated to the current site along with the rest of the Ammonia Plant back in 1992. As per philosophy, the turbine driven pump remains in service while the motor driven pump remains on Auto Cut-in.

Problem Statement:

The vendor of the pump had obsoleted this design and offered no spares, therefore some of the spares required for the maintenance of these pumps were being fabricated in-house (Shaft, locknuts etc) while rest were being sourced from Non-OEMs.

- ✓ The motor driven pump had chronic high vibration issue **(0.5ips - 0.6ips)** for **past 8~10 years**
- ✓ Multiple efforts were done in the past to resolve this issue, like modification / addition of piping supports and overhauling the pump, but the issue persisted.
- ✓ Therefore, the turbine driven pump was always kept in operation and motor driven pump was kept as a standby

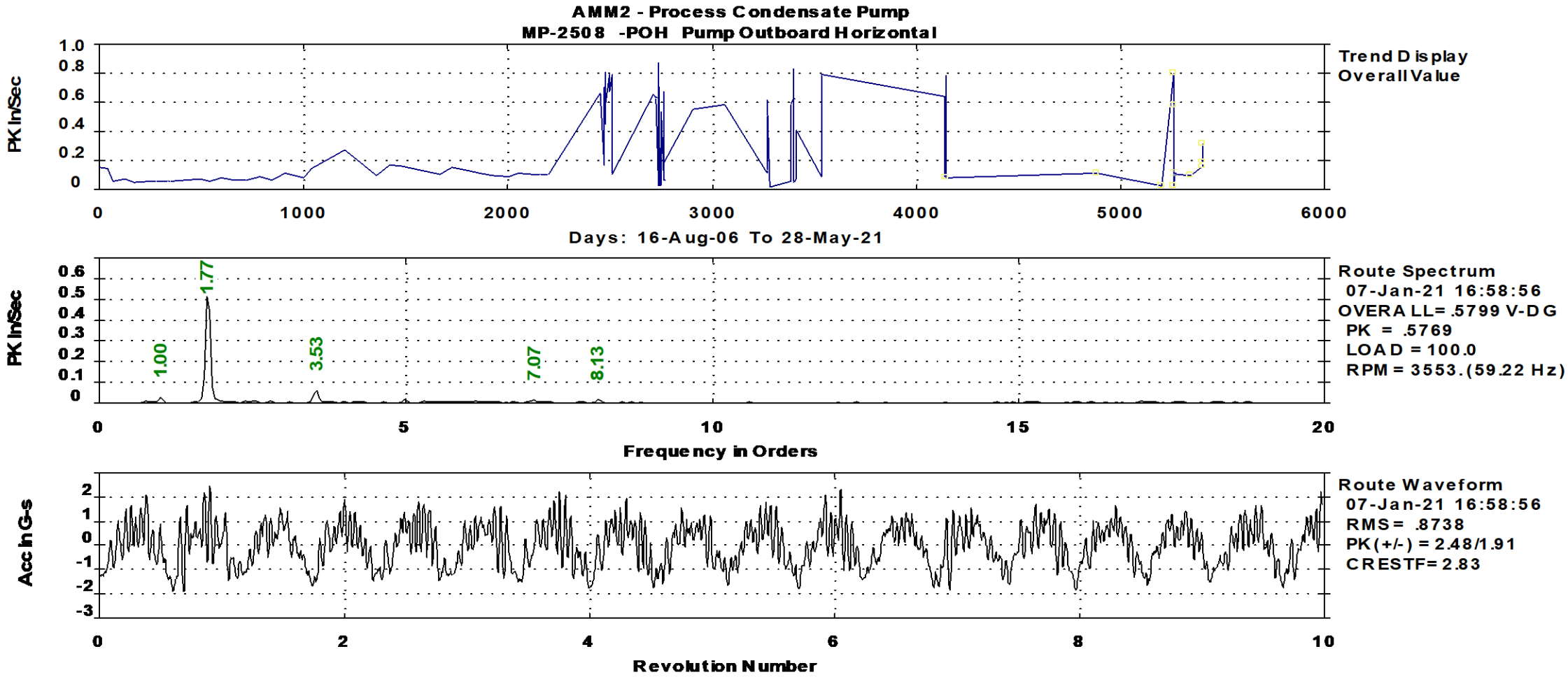
Recently, the motor driven pump was taken in service due to a Turbine bearing high temperature issue but the vibration on the motor driven pump was so high (0.54ips) that the turbine had to be returned to service asap.

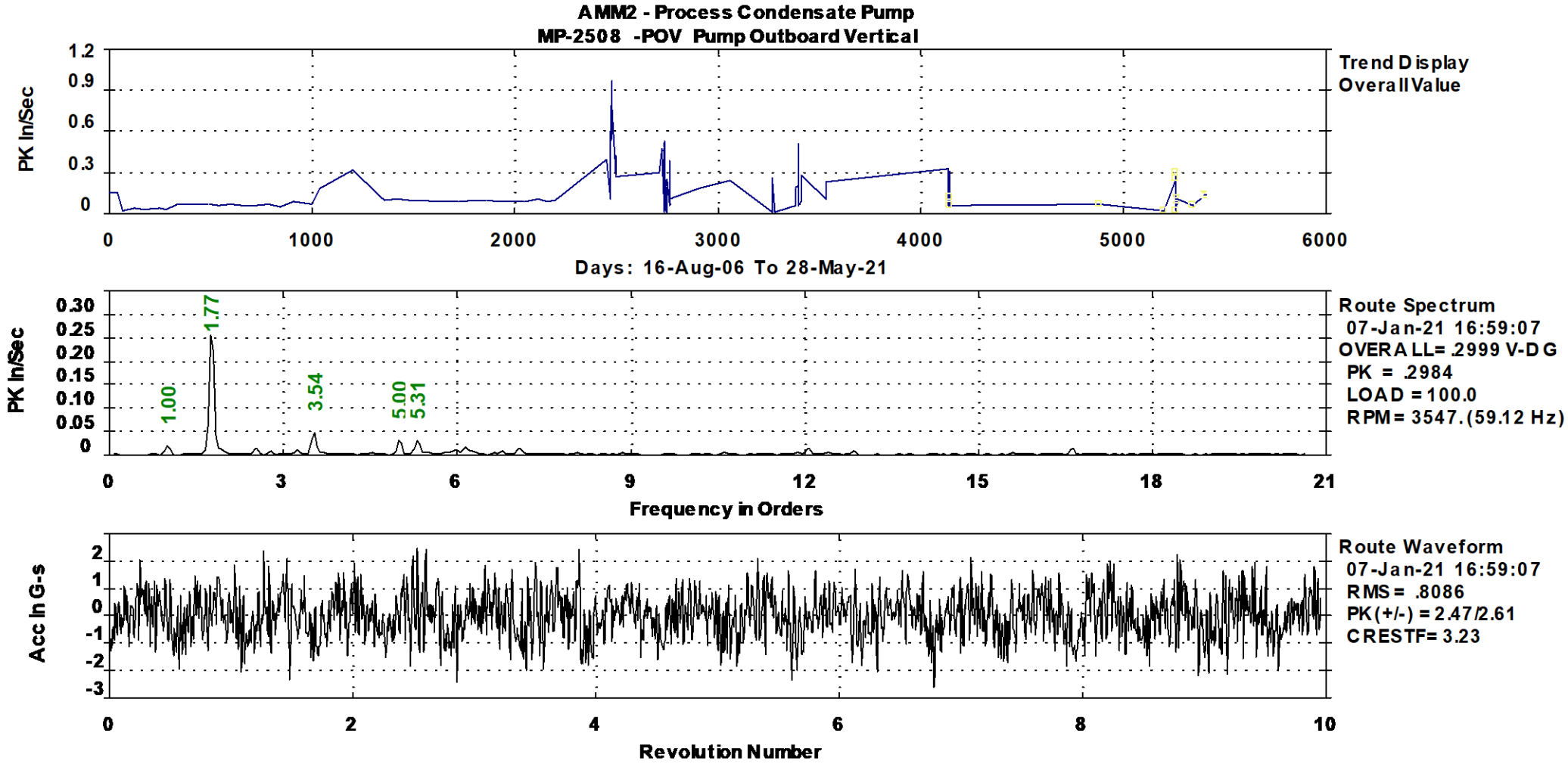
Trouble Shooting:

Vibrational analysis of was carried out using Emerson CSI 2140 to identify the root cause of the issue. The Spectrum revealed peak vibrations at 1.7X (Spectrum is appended below). Based on this analysis, the pump was overhauled 03 times in past 10 years however there were no abnormalities observed and the high vibration issue remained as such. A lot of efforts were put in, like piping supports modifications, installation of stiffeners but the issue persisted.

In January 2021, the turbine driven pump had to be shutdown owing to high turbine bearing temperature and MP-2508 was taken in service. The pump still exhibited the high vibration and the turbine was taken back in service within next 2-3 hours.

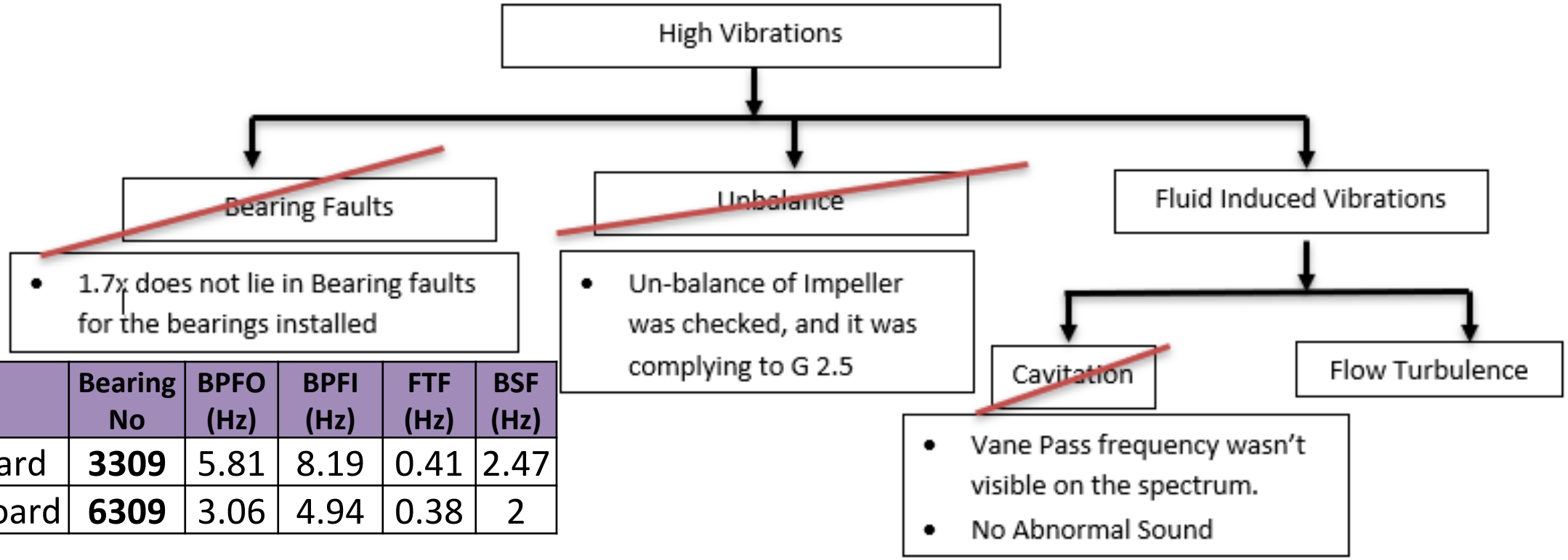
Vibration spectrum are appended on the next slide.





Fault Tree Analysis (FTA):

It was decided to overhaul this pump again to identify and resolve the issue. Based on the vibration data, following course of action was taken to identify the root cause. Once observations were taken, the below Fault Tree Analysis was carried out to narrow down the issue,



Location	Bearing No	BPFO (Hz)	BPFI (Hz)	FTF (Hz)	BSF (Hz)
Pump Inboard	**3309**	5.81	8.19	0.41	2.47
Pump Outboard	**6309**	3.06	4.94	0.38	2

Observations & Rectification:

Upon dismantling bearings, impeller, wear ring and throat bush clearances and fits were checked. However, except for minor rubbing on wear rings, no significant mechanical issue was observed in this pump. The pump was assembled back with new bearings and mechanical seal.

Once the pump was assembled and final checks were done, following glaring observations were noted which were suspected of contributing to this fluid induced vibrations,

View from Discharge Nozzle: Impeller not centered in the opening

View from Inlet of the Pump: Impeller eye and Nozzle are not concentric

Sr. No	Issue	Rectification
1	The impeller was not aligned with the discharge nozzle which could have caused **hydraulic imbalance.**	The impeller eye was aligned with the outlet nozzle by machining the face of gasket seating area of the adaptor
2	The suction eye of impeller & casing inlet was not concentric; a portion of the impeller was facing the casing wall causing **flow restriction.**	Casing was fixed on 4 jaw chuck lathe machine and casing was centered w.r.t to adaptor guide collar. Machining of inlet nozzle bore was carried out so that the impeller eye is not blocked by the portion of the casing.

Hydraulic Unbalance:

Hydraulic unbalance is a result of asymmetrically acting hydraulic forces and moments on each vane or on each vane channel. Following are some of its causes,

- ✓Uneven action of vanes or channels caused by geometrical unevenness (shape, roughness)
- ✓Uneven energy transmission caused by vanes with differing cavitation behavior
- ✓Hydraulic unbalance occurring with single-vane impellers (due to their design principle)

https://www.ksb.com/centrifugal-pump-lexicon/unbalance/191250/

Root Cause Analysis:

Based on the issues observed in this overhaul, further investigation was done internally, maintenance personals of 2007-2008 timeframe were reached out (since problem was suspected to be initiated at that time). The interviews revealed that, owing to erosion on the casing a new casing was locally cast and machined and replaced in that time frame. This fact positively concluded that the issue was caused due to locally casted & Machined pump casing.

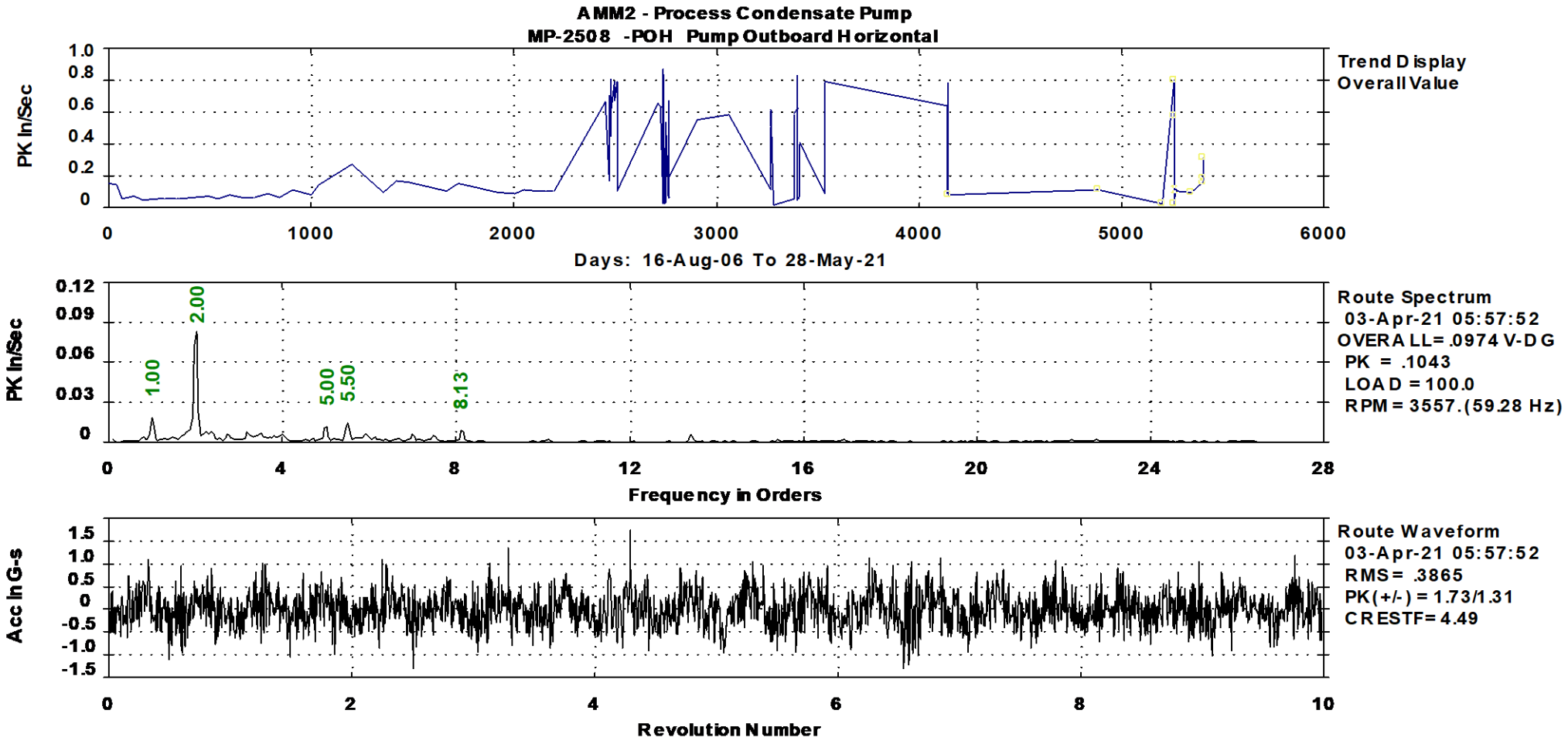
We explored all possibilities which can manifested into non-synchronous but higher 1X and Lower than 2X Vibration .

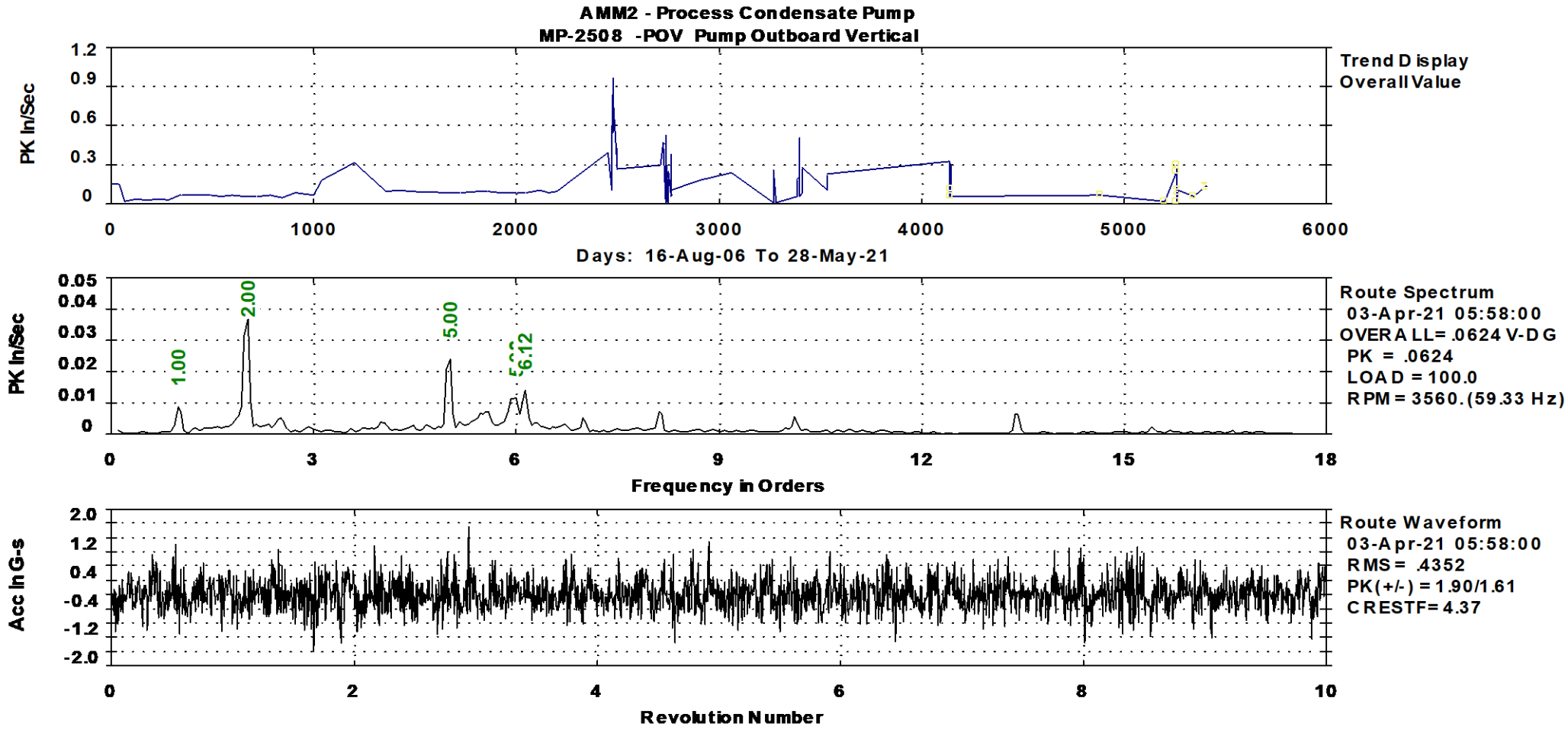
Upon deeper investigation of all assembly based on general installation guidelines of pump we found that pump impeller non- concentricity with casing center resulted in flow induced vibration

Root Cause:

The pump was started post the overhaul and the earlier mentioned rectifications. The high vibration issue was resolved and the 1.7x component of the spectrum was also not there anymore.

The vibration spectrums are attached below,





Lesson Learnt:

- ✓ If local manufacturing of the machinery components is to be carried out, a very stringent QA / QC plan should be developed
- ✓ Special care needs to be taken for concentricity checks for casted parts like pump housings and bearing housings
- ✓ Manufacturing related issues have significant affect on long term reliability and operability of machine

Thank You

ASIA TURBOMACHINERY & PUMP SYMPOSIUM