51ST TURBOMACHINERY & 38TH PUMP SYMPOSIA

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Reciprocating Compressor Motor Vibration During Initial Start-up

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Robert C. Eisenmann, Jr.

Robert C. Eisenmann, Jr. is the bp Rotating Systems Advisor with Innovation & Engineering based in Houston, Texas. He provides technical advice to the bp global portfolio to support business delivery, company strategy, industry direction, and technical assurance to support business decisions. He also promotes technology solutions and development and implementation of best practices across the bp. He is currently the API 618 Chairman, API 692 Chairman, API Committee for Refining Equipment (CRE) Chairman serves as a SME for BP's Engineering Technical Practices and has been a member of the Texas A&M Turbomachinery Advisory Committee since 2012. Bob has over 30 years of experience in the industry. Bob graduated from Texas A&M University at Galveston in 1992 with a B.S. in Marine Engineering.

Yasser Nasef

- Is a Senior Rotating Equipment Engineer with bp Egypt based out of Cairo, Egypt. He provides technical support for west Nile Delta “WND” major gas plant with 800MSCFD of gas production and 25mobepd of condensates. This includes plant commissioning, start-up activities and setting up equipment operating strategies to achieve safe, efficient and reliable operation. Yasser has over 25 years of experience in the industry. Yasser was graduated from Helwan university south of Cairo in 1993 with an engineering degree in electrical power and machinery systems and completed his MEng., later in 2000 in Power electronics and drives systems from Cairo University.

Abstract

- Shortly after start-up of a new 4 throw 3 stage reciprocating compressor, high motor vibration was recorded on a machinery monitoring system. The single bearing motor vibration levels reached 260 microns (10.25 mils) during a run that dissipated to 25 microns (1 mil) after 20 minutes but repeated intermittently over following runs. An investigation identified several contributing factors that ultimately led to realignment of the motor and disassembly of the motor bearing seals, where damaged PTFE seals were discovered.

Flash Gas Compressors

- Commissioning of 2 new reciprocating compressors in Flash Gas Service
- 4 Throw/ 3 Stage – 2/1/1
- Motor
  - Induction Motor
  - 425 rpm
  - 1300 kW (1750 Hp)
  - Single Bearing/rigid coupling
- Monitoring and Protection System Aligned with API 670 5th Edition Annex P
  - Including X/Y displacement probes on motor bearing

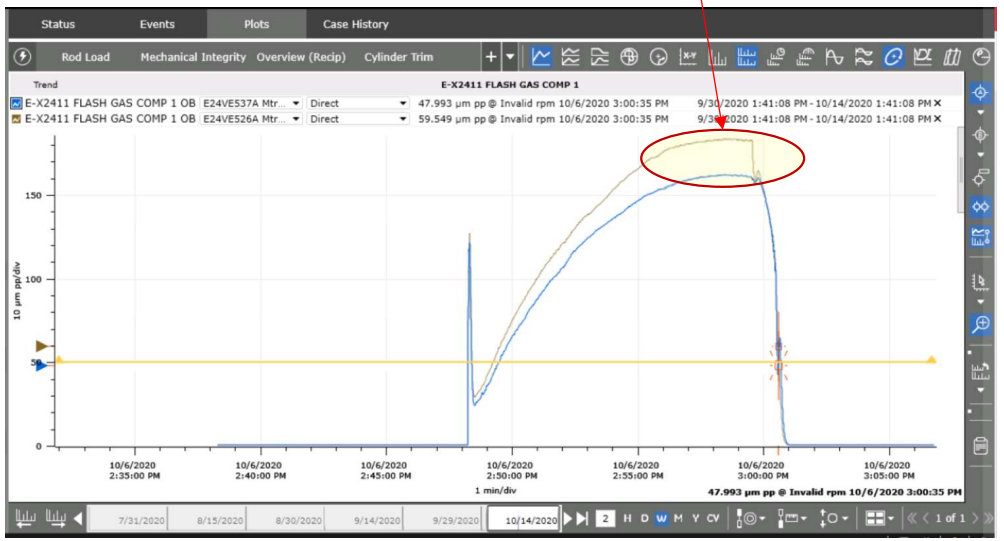
Summary of Events

- October 2019
  - Train 1 and 2 commissioning nitrogen runs.
  - Compressors preserved

- October 4th, 2020 – Train 2
  - Commissioning reconvened with 2nd nitrogen runs
    - No significant issues

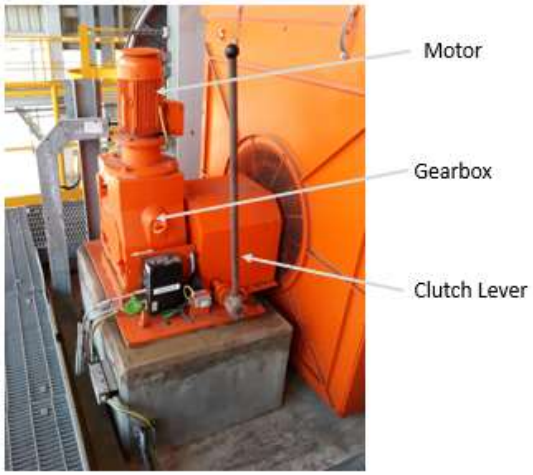
- October 6th, 2020 – Train 1
  - Alarm on motor vibration after 1 minute 15 seconds
  - Noise from the area of the motor bearing, motor fan and barring device
  - Vibration continued to climb
  - Shutdown after vibration reached 180 microns pp
  - Total run time 12 minutes

Vibration appears to have leveled and started to reduce



Potential Sources of Vibration

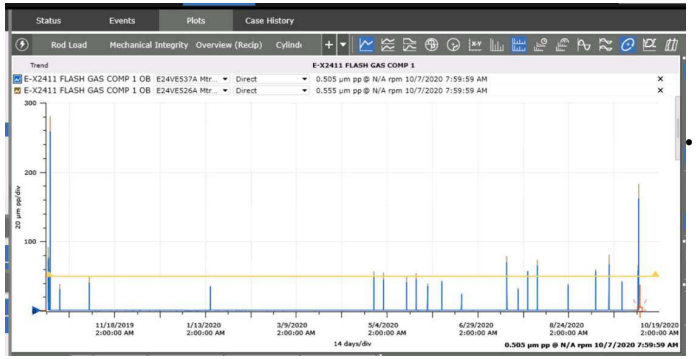
- Alignment
  - Single bearing motor and slight vibration response on compressor frame
  - Not supported by historical data
- Bearing Fault
  - No significant gap movement and no abnormal temperature increase
  - Gap did not return to post run position immediately following shutdown
  - Not supported by historical data
- Motor/Shaft Fault
  - Sinusoidal waveform where amplitude varies over time
  - Not supported by historical data
- Barring Device
  - Area of concern due to noise in area

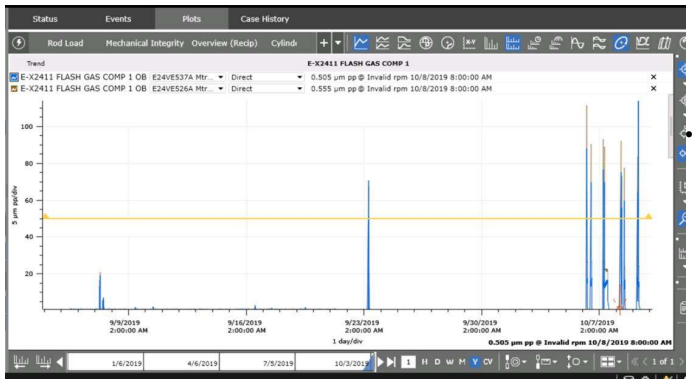


Motor driven barring device with reduction gearbox and clutch

Train 1 – Initial Commissioning and Preservation

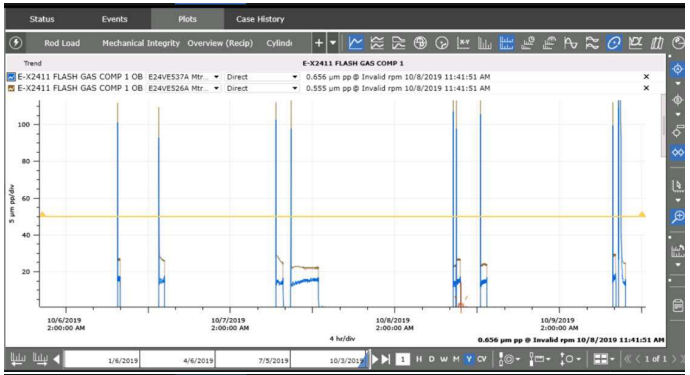
- Barring during 1 year of preservation, runout up to ~ 75 microns at times, higher than expected



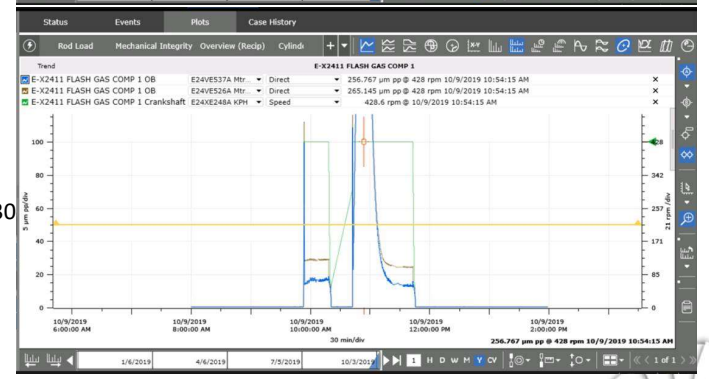


- Very high readings from October 2019

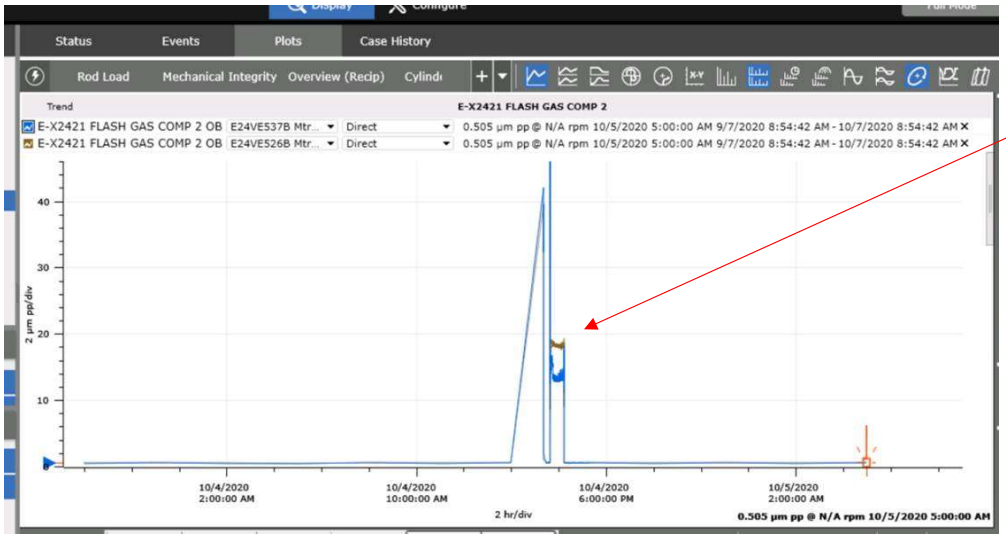
- Barring and runs in October 2019 with very high displacement during barring but semi acceptable runs with the exception of the run on October 9th



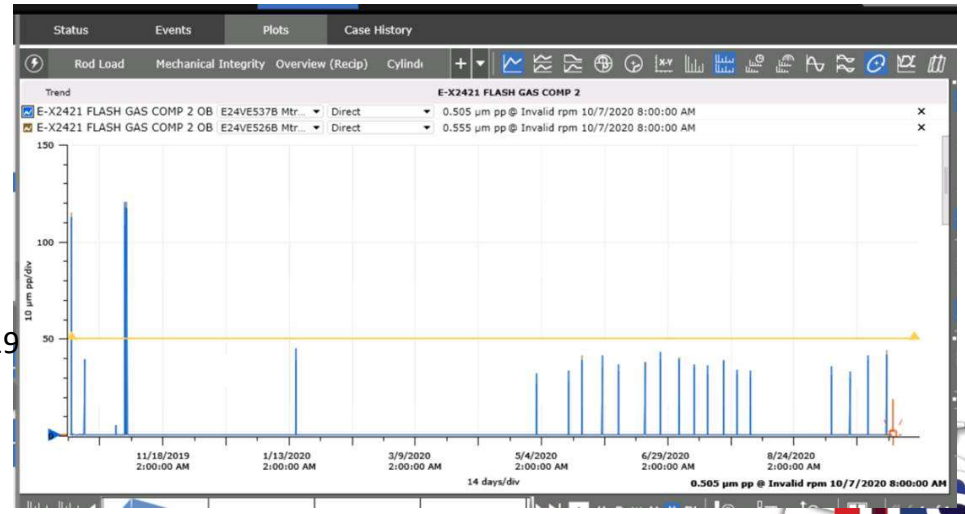
- October 9th , 2019 run test. Running state with ~ 260 microns that dropped to ~20 to 30 microns after 20 minutes.



Train 2 – History



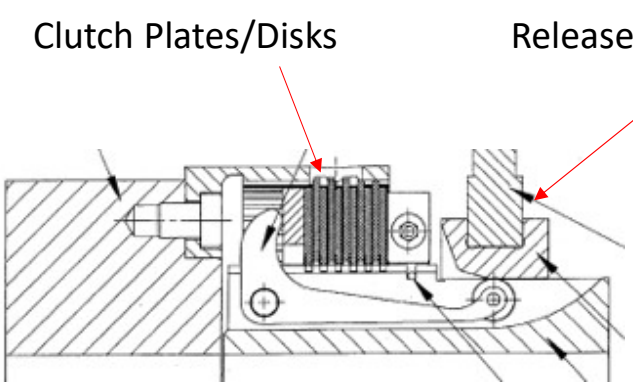
- Run on October 6th, 2020, where the barring and run are at acceptable levels of about 45 microns during barring and less than 20 microns during the run.



- Barring events in 2020. All are at acceptable levels, but 2019 shows very high levels during barring. This indicates some influence from the barring device.

Findings – Round 1

- History indicates clutch was adjusted due to slipping
- Significantly harder to engage clutch on Train 1 verse Train 2
- History shows that vibration decreases after some run time
- Elevated response during barring
- Vertical, horizontal and angular misalignment identified
- Clutch plate wear



Restart – Nov/Dec 2020

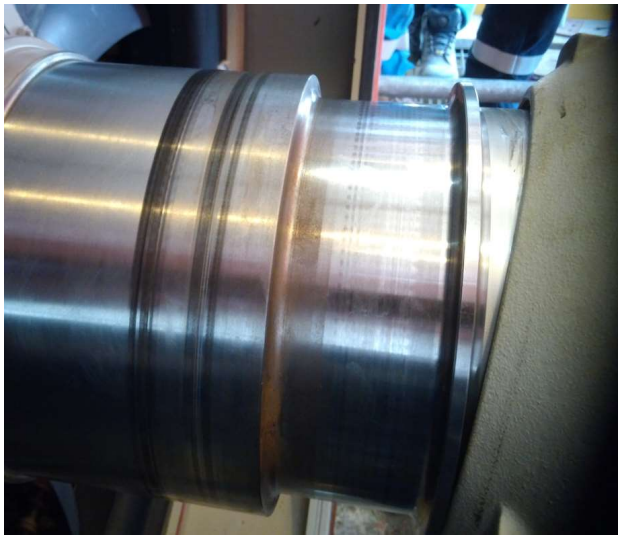
- Attempted to resolve the vibration issue by:
  - Adjusting the clutch
  - Aligning the clutch
  - Then removing the clutch completely
- All resulted in no significant changes in response
- Re-evaluated the options and decided to inspect motor shaft, bearing and alignment

Motor Details

- The motor data supplied was only an outline drawing showing external details
- Bearing was a 3rd party supplied bearing assembly
- During bearing inspection, inner seal was identified
  - Motor OEM identified inner PTFE air seal.
- Inconsistencies on motor stator alignment/movement data

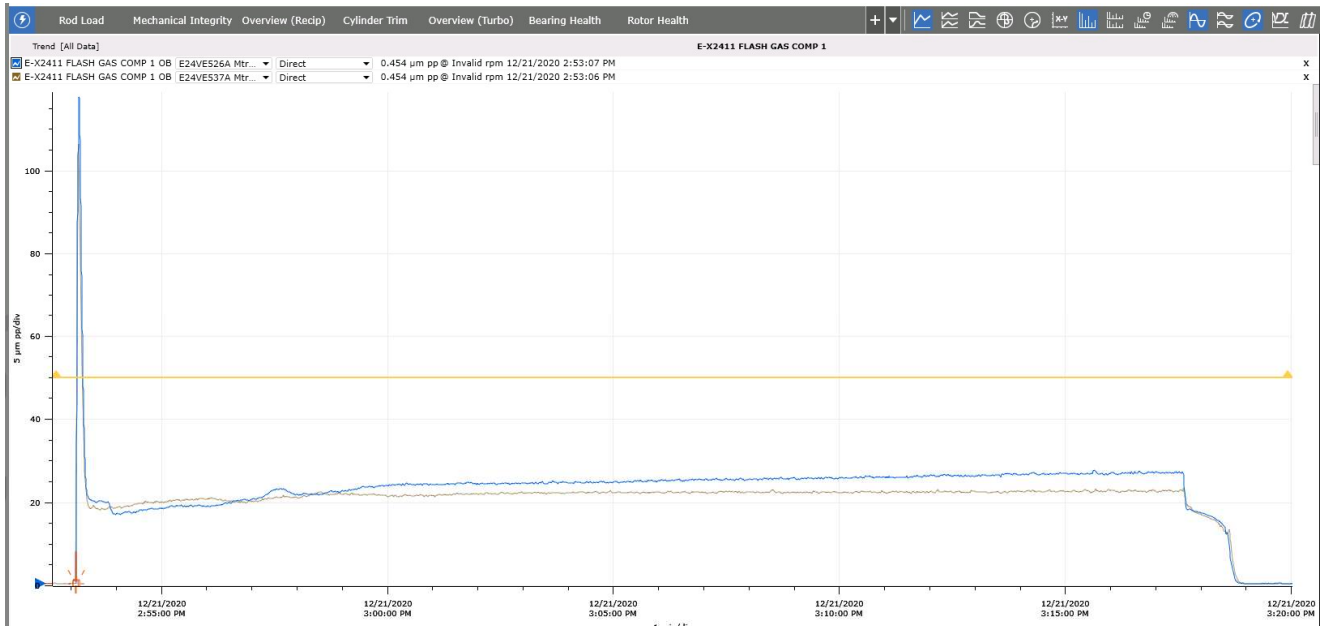
Inner Air Seal

- PTFE seal “rub tolerant”
  - Heavy rub
  - Material pulled from grooves and balled up



Start-up – Dec 2020

- After PTFE material was removed from the inner air seal and alignment was verified, there was a successful start-up.



Conclusions

- Application of displacement probes on low speed reciprocating compressor motors is not common, and site team did not notice high values during initial runs and preservation activities.
- Initial fault tree conclusions were based on incomplete data, given the lack of detailed motor and motor bearing drawings.
- Application of “rub tolerant” or “wear in” type PTFE seals are common and thought to have little influence on rotor dynamics
- Actual influence of these seals can be significant and lead to vibration issues if not correctly installed.

Lessons Learned

- Machinery protection/monitoring systems must be active during commissioning
- Review test data to identify anomalies from expected results
- Historical designs such as “wear in” seals are viewed to have little to no impact on rotors due to lack of information. These seals should be treated no differently than any other contacting seal when properly commissioned.
- Drawings with sufficient details are required for troubleshooting