



45TH TURBOMACHINERY & 32ND PUMP SYMPOSIA
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GEORGE R. BROWN CONVENTION CENTER

Integral Gear Compressor Gearbox Flooding Issue

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Presenter Background

- ▶ Sr. Principal Machinery Engineer with 12 years at Air Products
- ▶ Currently responsible for troubleshooting, repair, and reliability/efficiency upgrades of rotating equipment supporting primarily air separation units.
- ▶ Past responsibilities at Air Products include the specification, selection, installation, and commissioning of rotating equipment for hydrogen facilities world wide.
- ▶ M.Eng in Mechanical Engineering from Lehigh University (2002)



Abstract

- ▶ This case study discusses a series of integral gear compressor trips and machine damage that resulted from a sudden increase in motor power not related to process changes. After testing it was determined that the increase in power was the result of oil accumulation in the gearbox. Interestingly the oil accumulation was not in the bottom of the gearbox but in the top. After modifications to the gearbox were made the flooding phenomenon was prevented from occurring.
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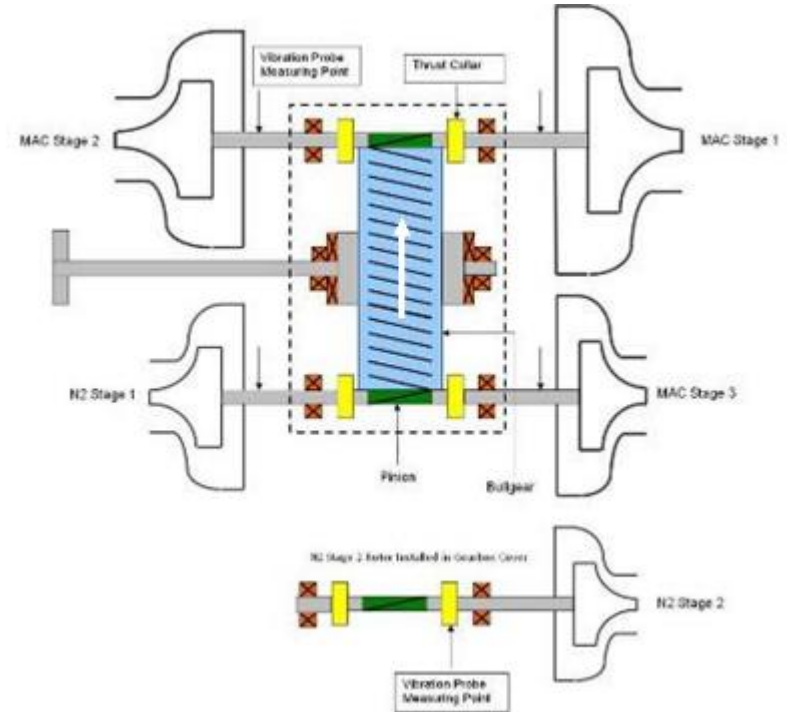


Problem Statement

- ▶ Three “identical” compressors located at an owned and operated facility have experienced trips related to high motor power that are unrelated to process conditions
- ▶ Events have resulted plant trips and damage to gearing components and replacement components
- ▶ Compressors unable to keep operating if main oil pump and aux oil pump operating.

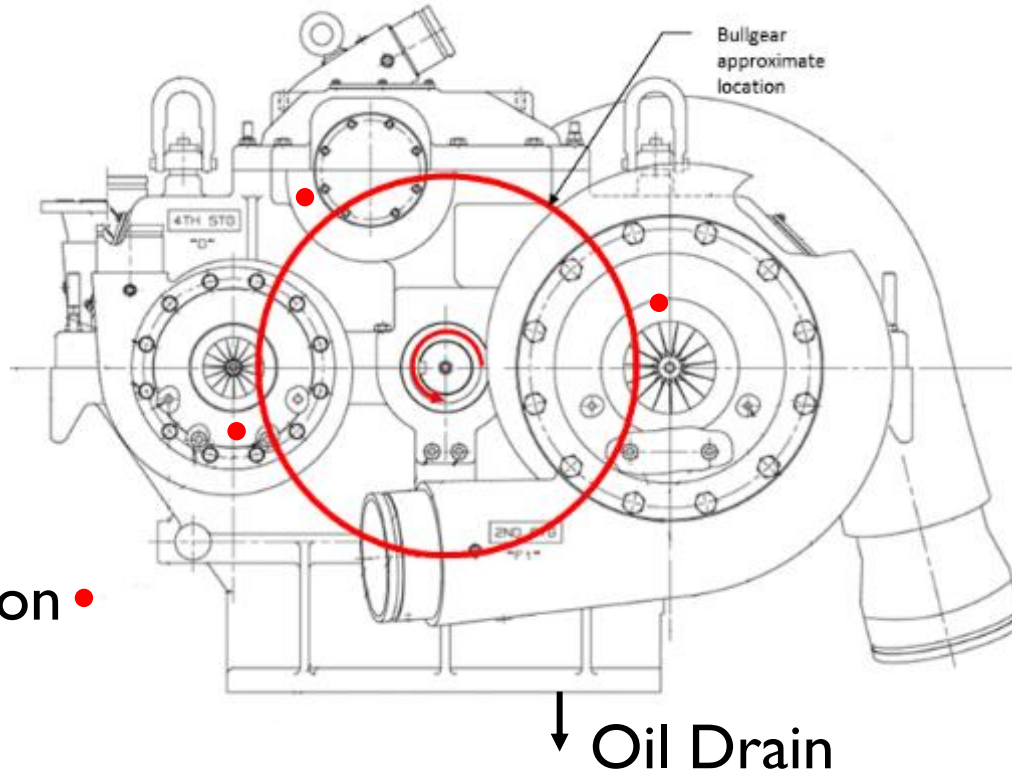


Physical Arrangement



Driven by 4000 hp (2983 kW) two pole induction motor

Physical Arrangement

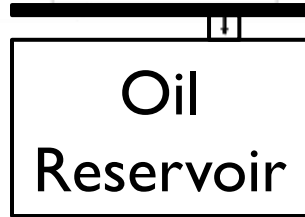
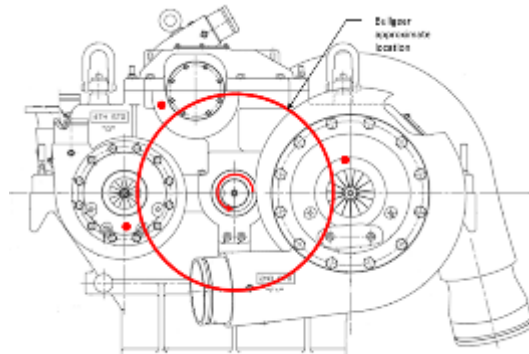


Spray Location •

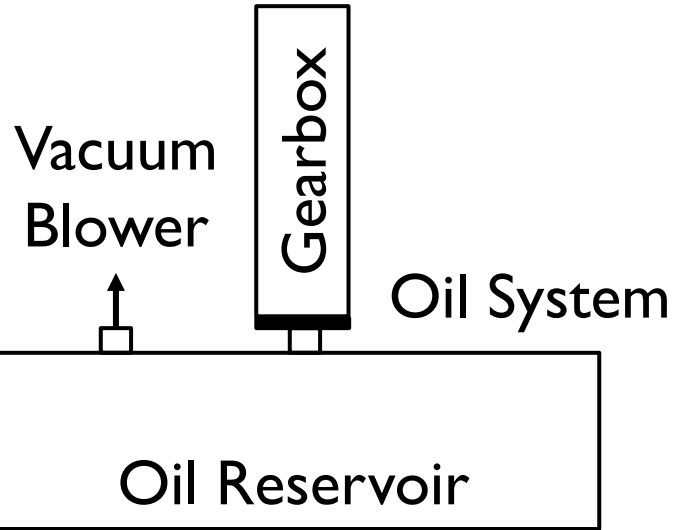
↓ Oil Drain



Physical Arrangement



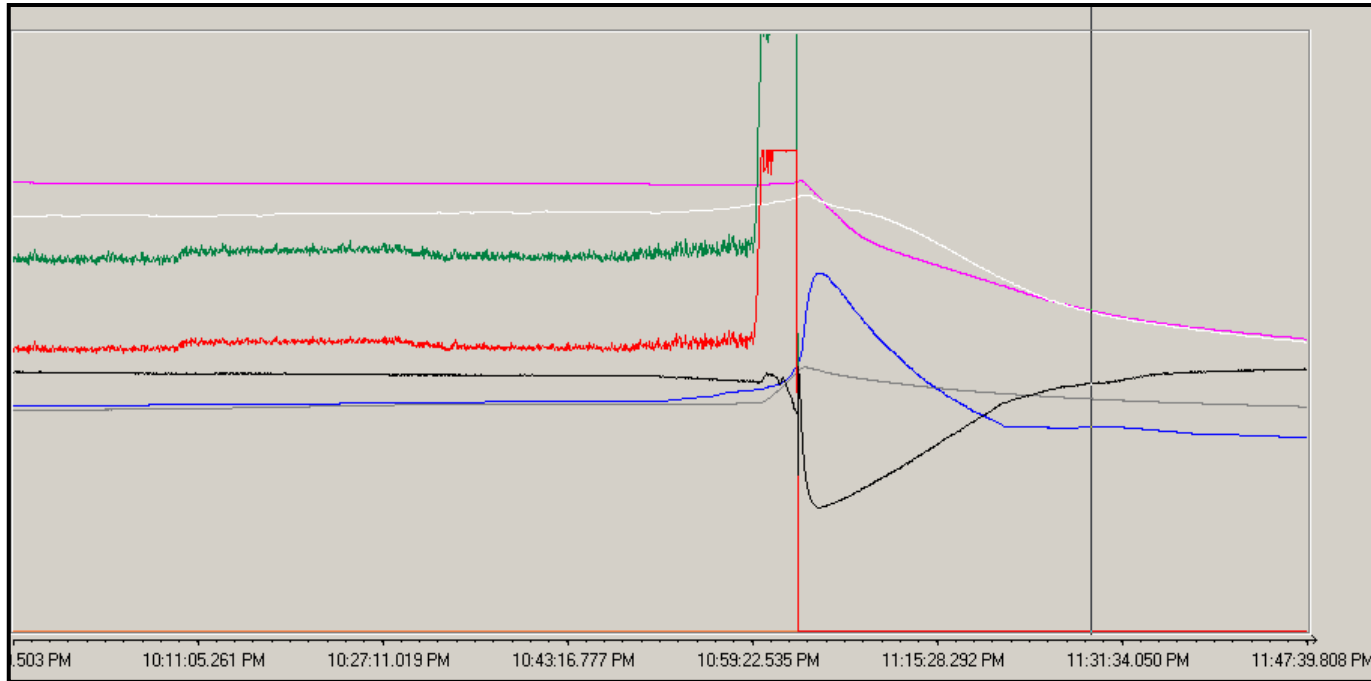
End View



Side View



Compressor Trip Trend



Red = Motor Amps

Green = Motor kW

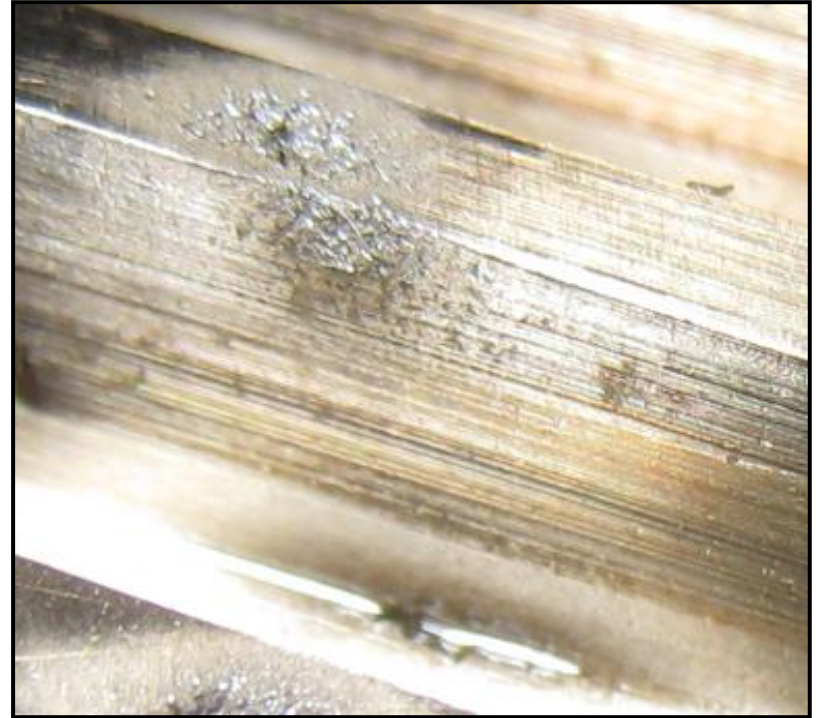
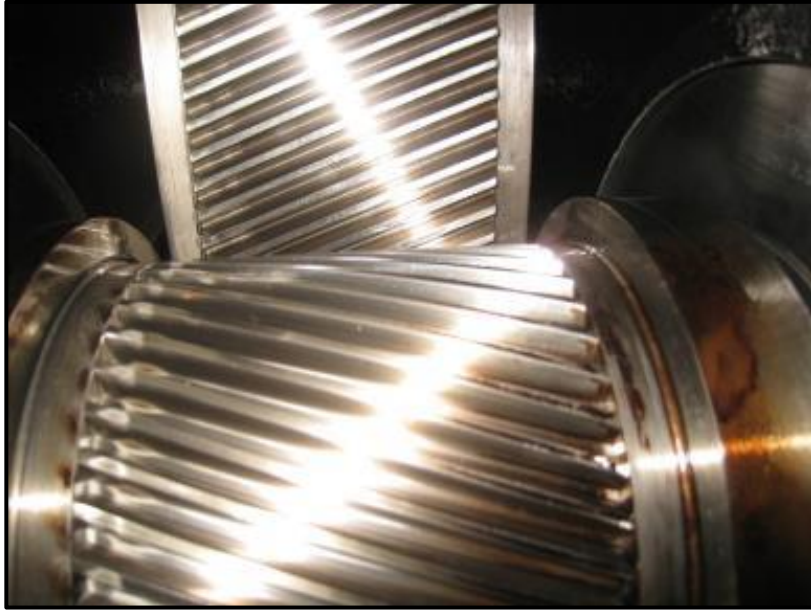
Pink = OB Motor Bearing Temp

Black = Lube Oil Pressure

Blue = Lube Oil Temperature

Grey = Motor Stator Winding Temp

Gearing Damage



Trip Event Observations

- ▶ No apparent process or lube oil related instigation of event
- ▶ Gearbox vacuum is lost on the cover pinion but not on the high speed pinion area or on the reservoir
- ▶ Process pressures and lube oil pressure drops as amps increase
- ▶ Oil forced through gaskets around cover pinion and low speed pinion inspection covers
- ▶ Trip events can be forced by running auxiliary oil pump



System Modifications

- ▶ Added additional instrumentation to diagnose problem
- ▶ Lowered setting for high amps trip

- ▶ Oil viscosity changed
- ▶ Oil pressure reduced to absolute minimum
- ▶ Water flow through oil cooler increased



Compressor Modifications

- ▶ Additional oil drains added to the compressor to get oil out of the gearbox
 - ▶ Drain added in side of gearbox
 - ▶ Drain added from low speed pinion cover
 - ▶ Drain added from cover pinion cover



Compressor Modifications



Modification Testing

- ▶ On compressor start oil seen flowing from side drain and low speed drain
- ▶ Side and low speed drains closed, oil begins to flow out of cover pinion drain
- ▶ Oil no longer flows from low speed drain through remainder of testing
- ▶ All drains closed except side drain and AOP started, no trip characteristics seen in 15 minutes of operation



Conclusions

- ▶ Oil flooding in the gearbox in the cover pinion area is the cause of the high amps trips
- ▶ Root cause of what initiates the flooding has not been identified but the following are likely contributors
 - ▶ Cover pinion offset, Windage, Gearbox internal design, Oil spray amount
- ▶ The additional oil drain area allows enough of the oil to leave the gearbox to run at higher oil flows into the gearbox without flooding



Conclusions

- ▶ Gear spray arrangements and oil flow requirements are based upon supplier experience.
- ▶ Well referenced frame size including at Air Products.
- ▶ Testing done on a sister machine at another facility with no similar high power event occurring.



Current Status

- ▶ Permanent hard piped side drain added to Plant 2 and Plant 3
- ▶ Testing drains removed and permanent hard piped side drain installed on Plant 4

