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

Continuous Control of Lube Oil Water Contamination – Never get Surprised Again

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Biography

Steve Locke is a Principle Consultant in Rotating Machinery for The Chemours Company, a 2015 spin-off of DuPont. He retired from DuPont in 2015, his career focusing on turbomachinery reliability, safety and other machinery in DuPont. An active Turbomachinery Advisory Committee member since 2005, he is now an Emeritus Member. Steve authored several papers, case studies, and represented DuPont for the Texas A&M Turbomachinery Research Consortium.

Acknowledgement

Thanks to Mick Hovanec for demonstrating DuPont's first use of an oil moisture sensor after a compressor failure. One year later, the new sensor prevented a repeat compressor failure .

Problem:

High water contamination of lube oil damaged a turbine driven process blower on multiple occasions

Traditional solution:

- Monitor oil for milky appearance – only **qualitative**
- Drain free water from reservoir, but oil stays **saturated**
- Periodic samples are **slow** – *like periodic vibration!*

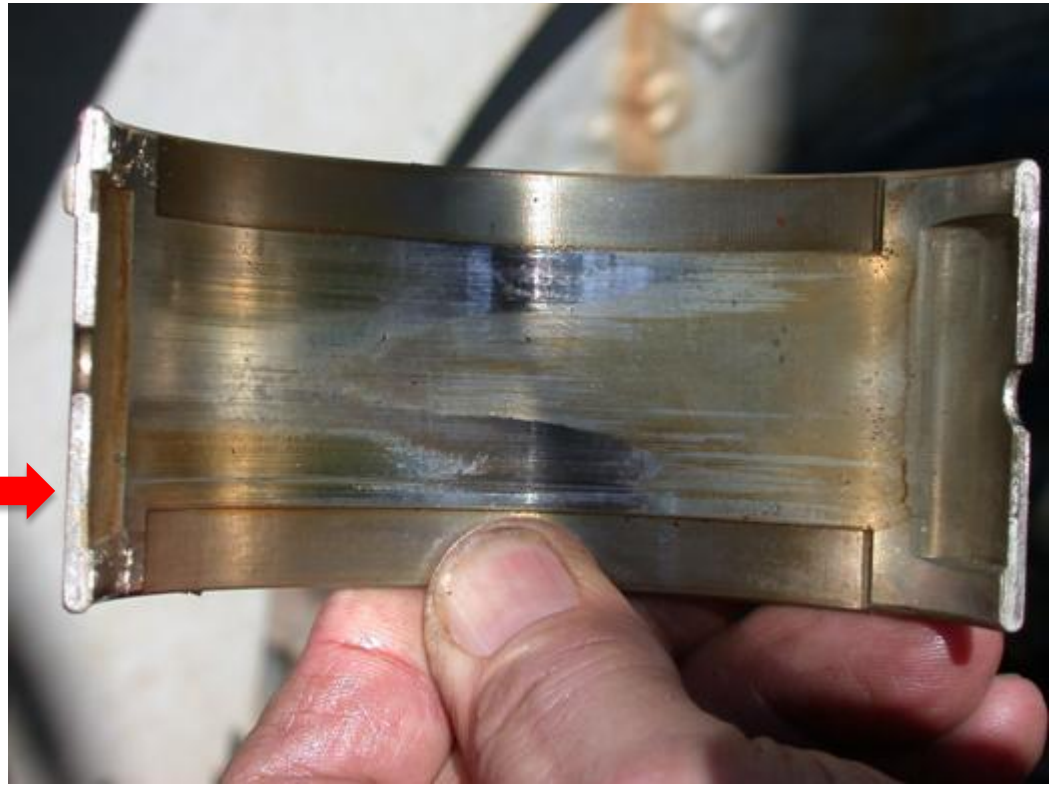
Better solution: 4-20 mA on-line Humidity + Dry Gas purge

- Humidity sensors give **numbers** to alarm & troubleshoot
- Dry gas purges vent moisture, oil stays below saturation
- Operators can **control** humidity to prevent damage

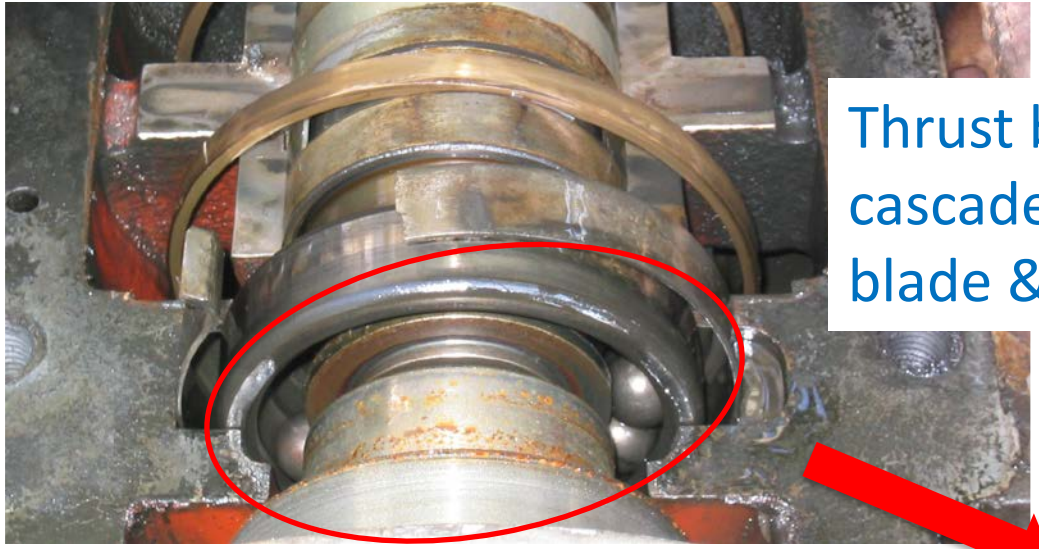
Turbine Driven Blower

Multiple failures showed traditional approaches were not fast enough to protect this machine from damage due to high water in the lube oil

High Water Oil Contamination Bearing Damage



High Water in Oil caused Ball Bearing Thrust Failure



Thrust bearing failure cascaded into turbine blade & nozzle damage

Life Extension Table - Moisture

New Moisture Level (ppm)

Current Moisture Level (ppm)	10,000		5,000		2,500		1,000		500		250		100		50	
	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal
50,000	2.3	1.6	3.3	1.9	4.8	2.3	7.8	2.9	11.2	3.5	16.2	4.3	26.2	5.5	37.8	6.7
25,000	1.6	1.3	2.3	1.6	3.3	1.9	5.4	2.4	7.8	2.9	11.2	3.5	18.2	4.6	26.2	5.5
10,000			1.4	1.2	2.0	1.5	3.3	1.9	4.8	2.3	6.9	2.8	11.2	3.5	16.2	4.3
5,000					1.4	1.2	2.3	1.6	3.3	1.9	4.8	2.3	7.8	2.9	11.2	3.5
2,500							1.6	1.3	2.3	1.6	3.3	1.9	5.4	2.4	7.8	2.9
1,000												1.5	3.3	1.9	4.8	2.3
500												1.2	2.3	1.6	3.3	1.9
250													1.5	1.3	2.3	1.6
100															1.4	1.2

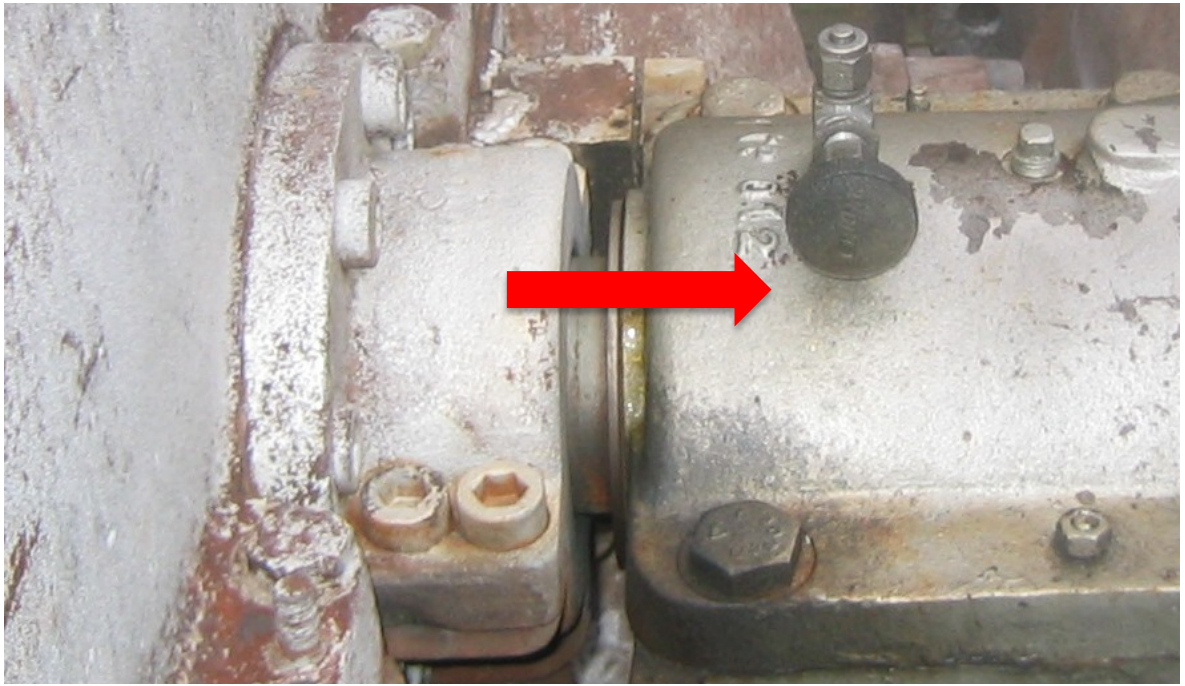
Rolling Element Bearings are more sensitive to Water Contamination than Journal Bearings.

 Ref: SKF, OSU, DT

Sources of Water Contamination of Oil

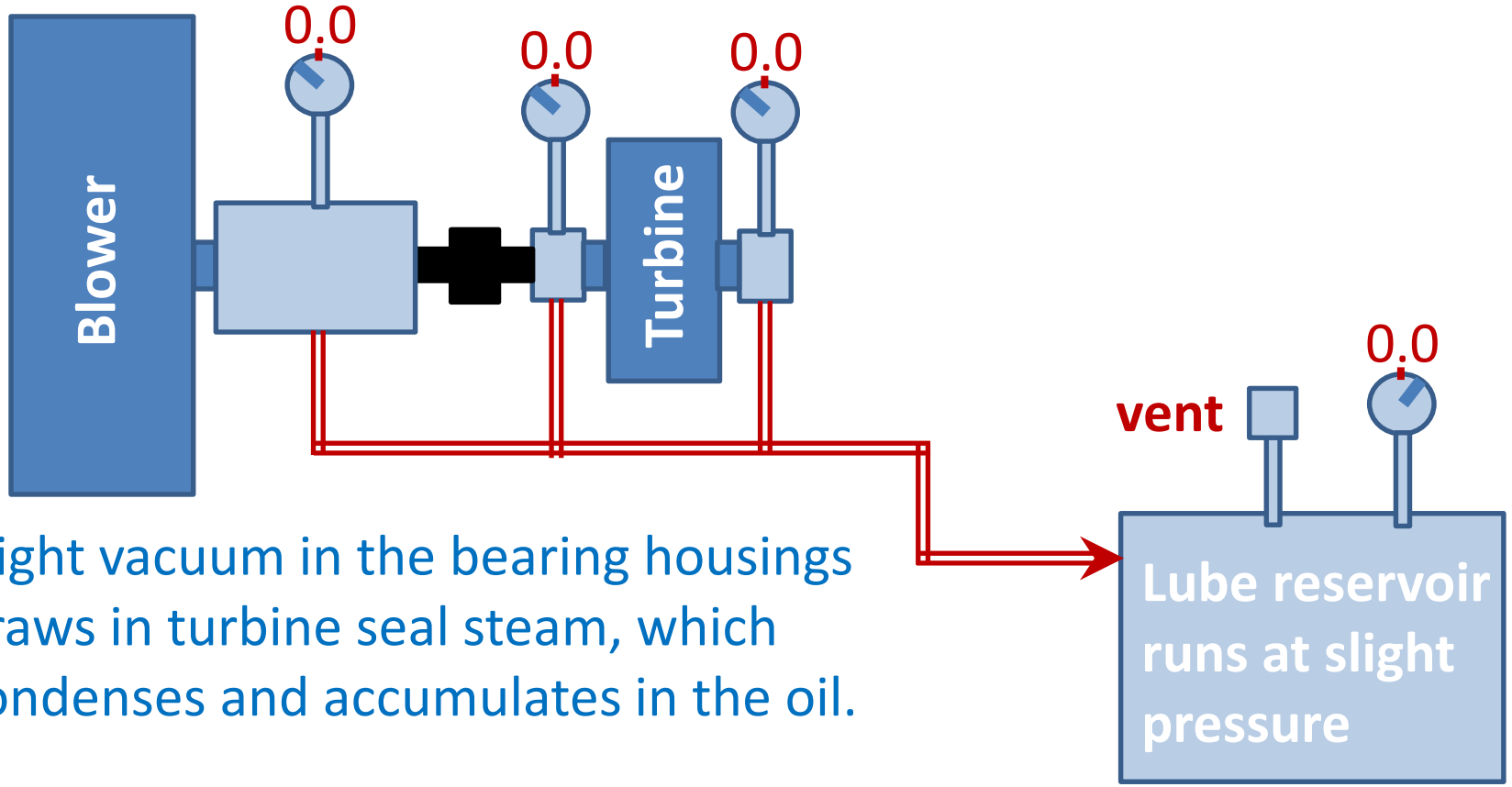
- Turbine steam seals are a continuous source of water contamination in bearings and lube oil system.
- Bearing housings normally run at a slight vacuum due to oil drainage flow which pulls seal steam in & accumulates condensate. Lube reservoir vent runs slightly positive.
- This blower had two episodes of severe Lube Cooler leaks.
- The outdoor installation also has Rain Exposure risks.

Turbine Seals vent Steam above 212^{0}F



Bearing housings run slightly negative due to oil drainage.
Some steam gets pulled in and condenses in the cooler oil.

Oil drainage flow pulls a Slight Vacuum on Bearings

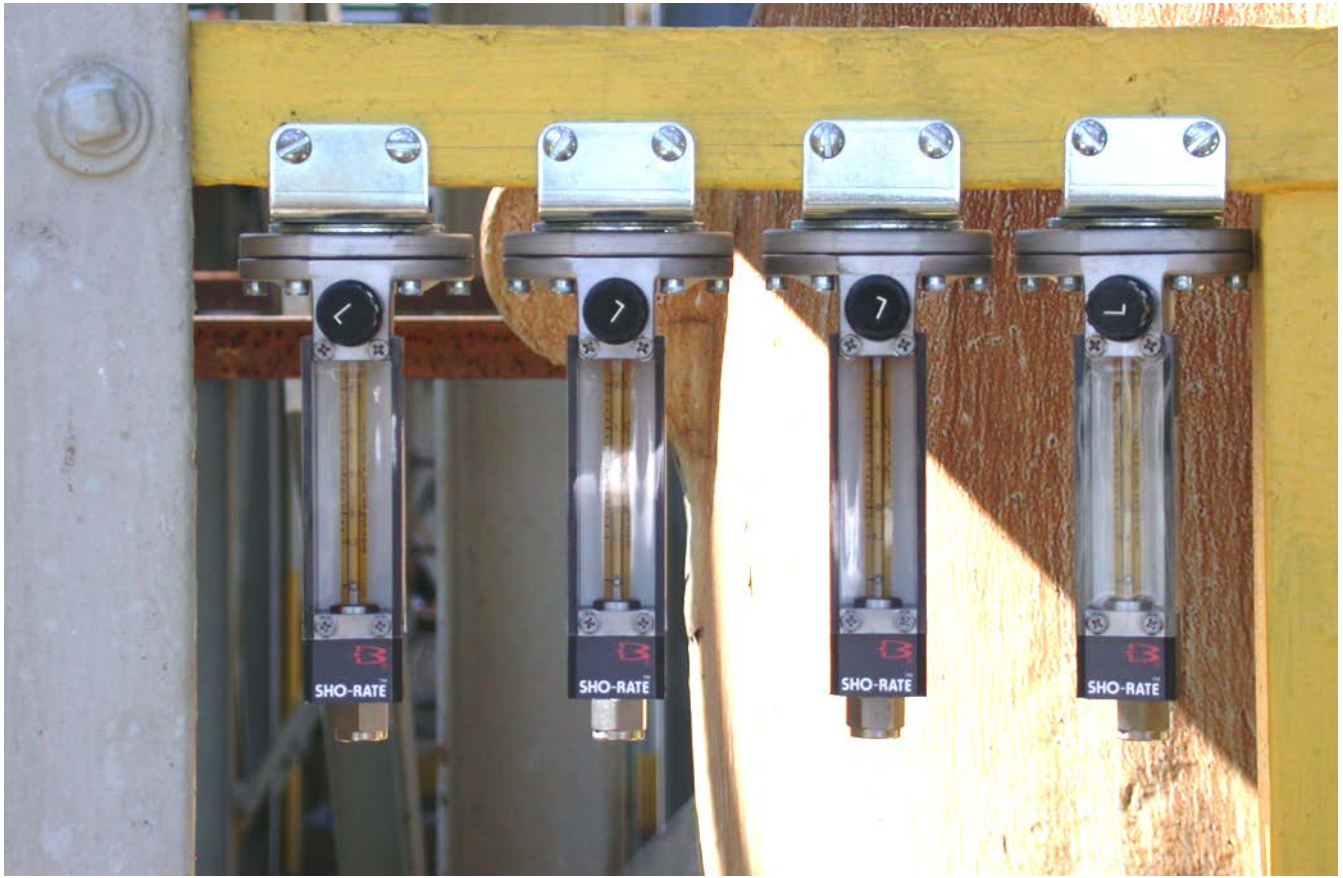


Slight vacuum in the bearing housings draws in turbine seal steam, which condenses and accumulates in the oil.

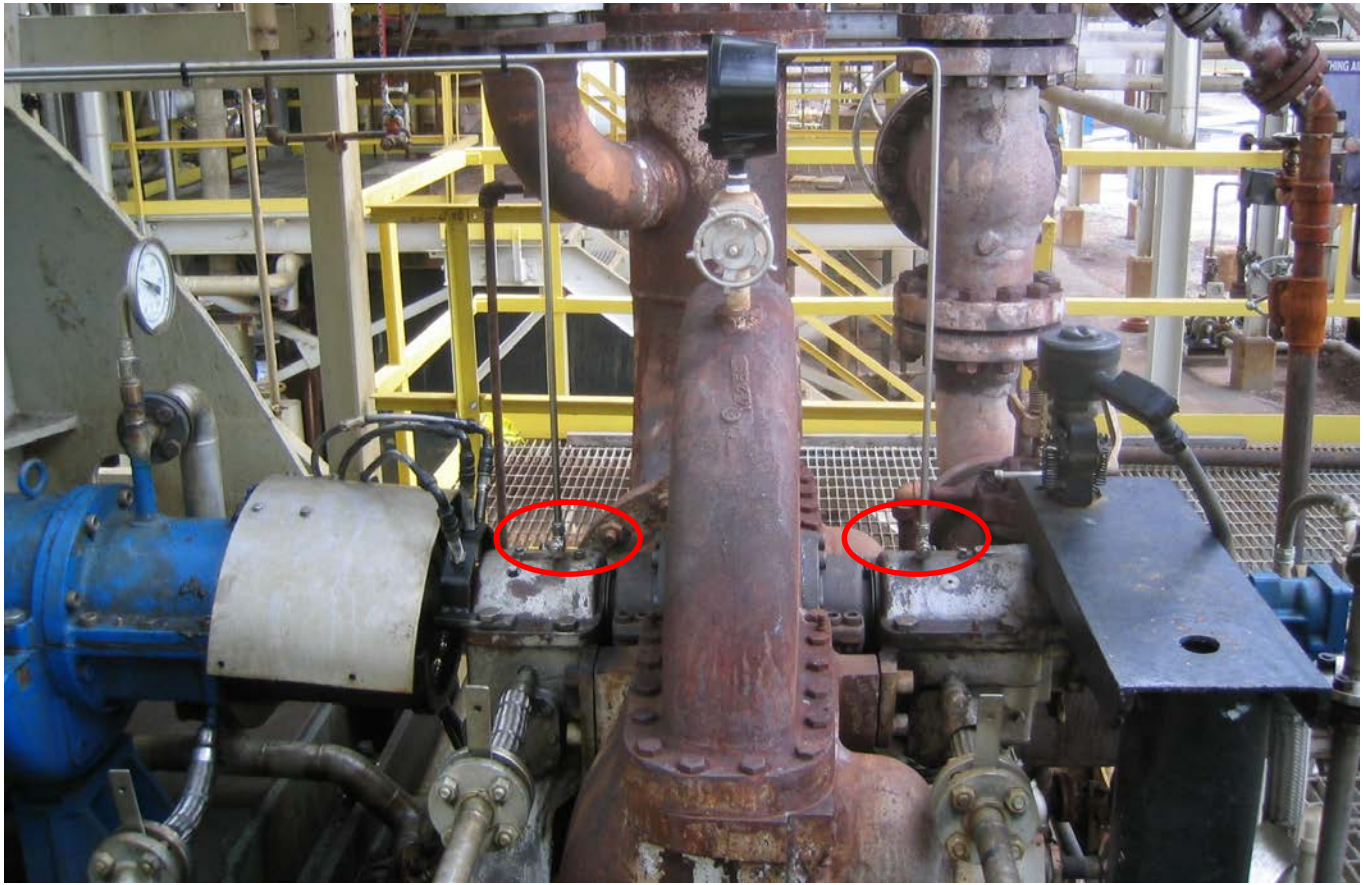
Bearing Housing Purge Addition

- Dry air purges were added to the middle of each of the bearing housings on the turbine and the blower.
- We usually purge into the center of bearing laby seals, but time & resources did permit this extra step on this blower.
- Rotameters were provided to control purge rate. These rotameters are sized for a peak flow of 6 SCFM.

Dry Air Rotameters for Bearing Purges

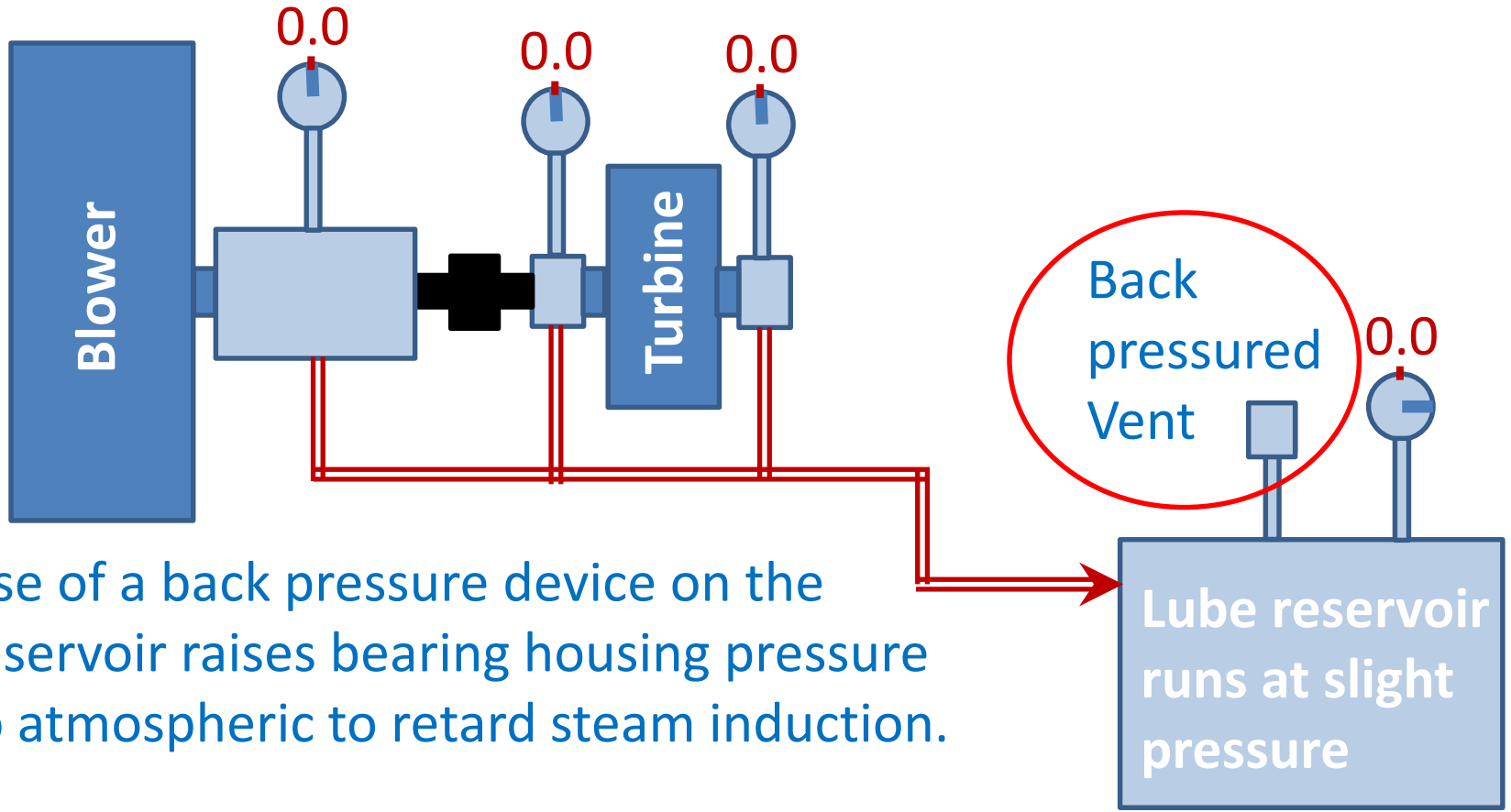


Bearing Dry Air Purge Injection on Turbine



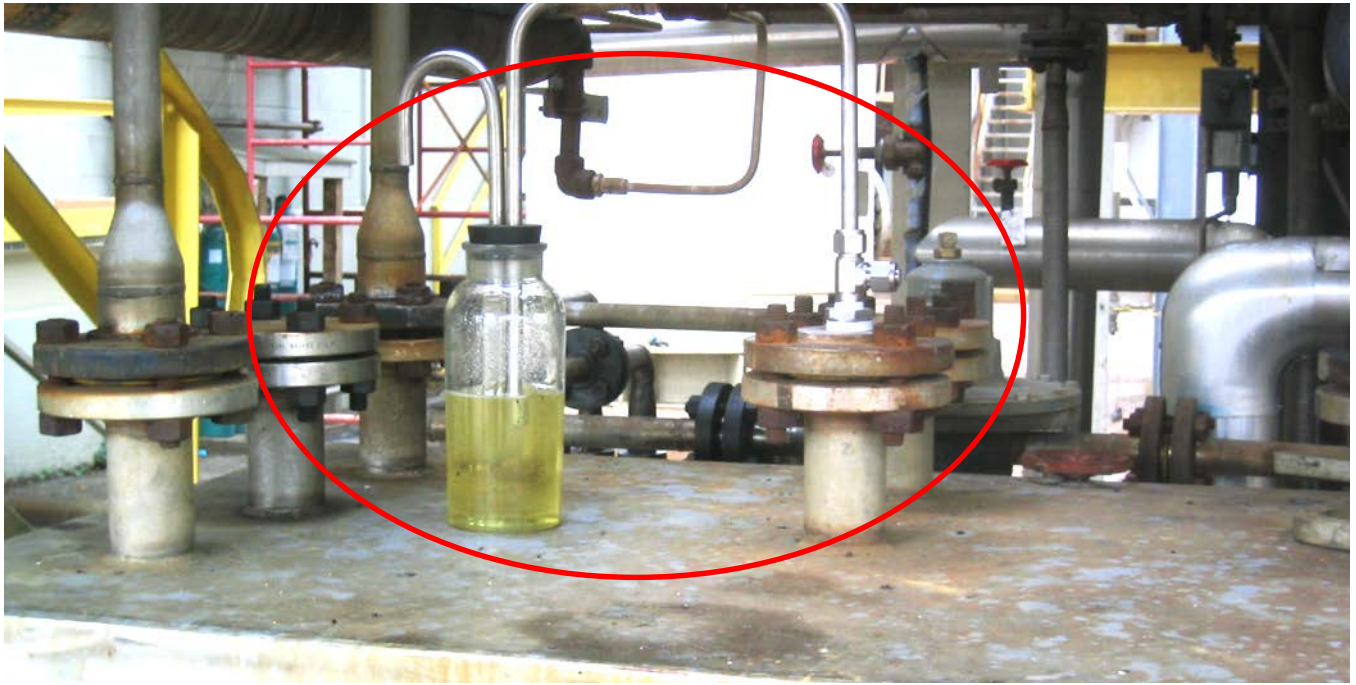
Bearing Dry Air Purge Injection on Blower

Reservoir back pressure raises Bearings to Atmospheric



Use of a back pressure device on the reservoir raises bearing housing pressure to atmospheric to retard steam induction.

Reservoir back pressure raises Bearings to Atmospheric

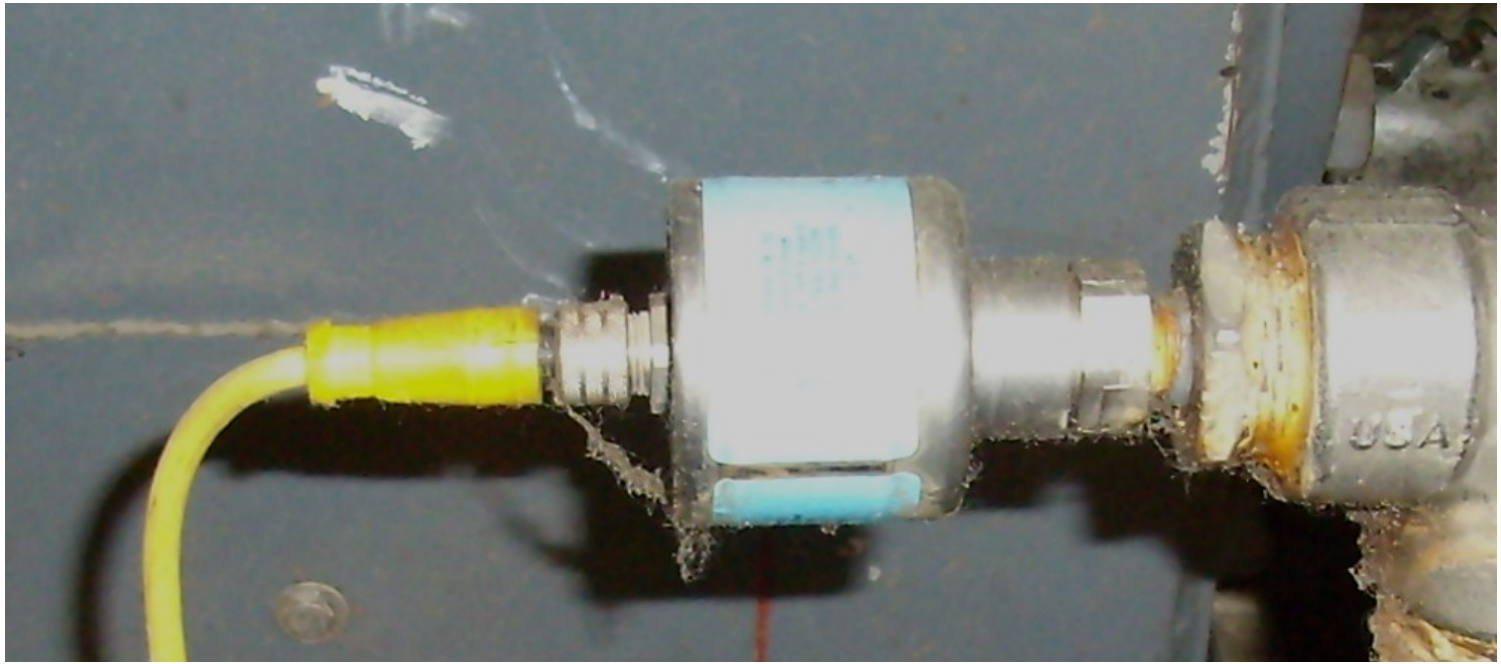


A clever instrument tech used a small hydrostatic head to raise bearing housing pressure to atmospheric.

Oil Humidity Sensor

- An Oil Humidity Sensor was added to continuously monitor the water concentration in DCS with high alarm set at 80%
- Trend history can be valuable in troubleshooting to correlate any high water events with changes in process or other conditions such as weather.
- Several suppliers sell industrial strength, modestly priced 4-20 mA sensors.

On Line 4-20 mA Oil Humidity Sensor



Sensors can be installed in the reservoir or the cooler oil flow to the bearings, which has a lower saturation level.

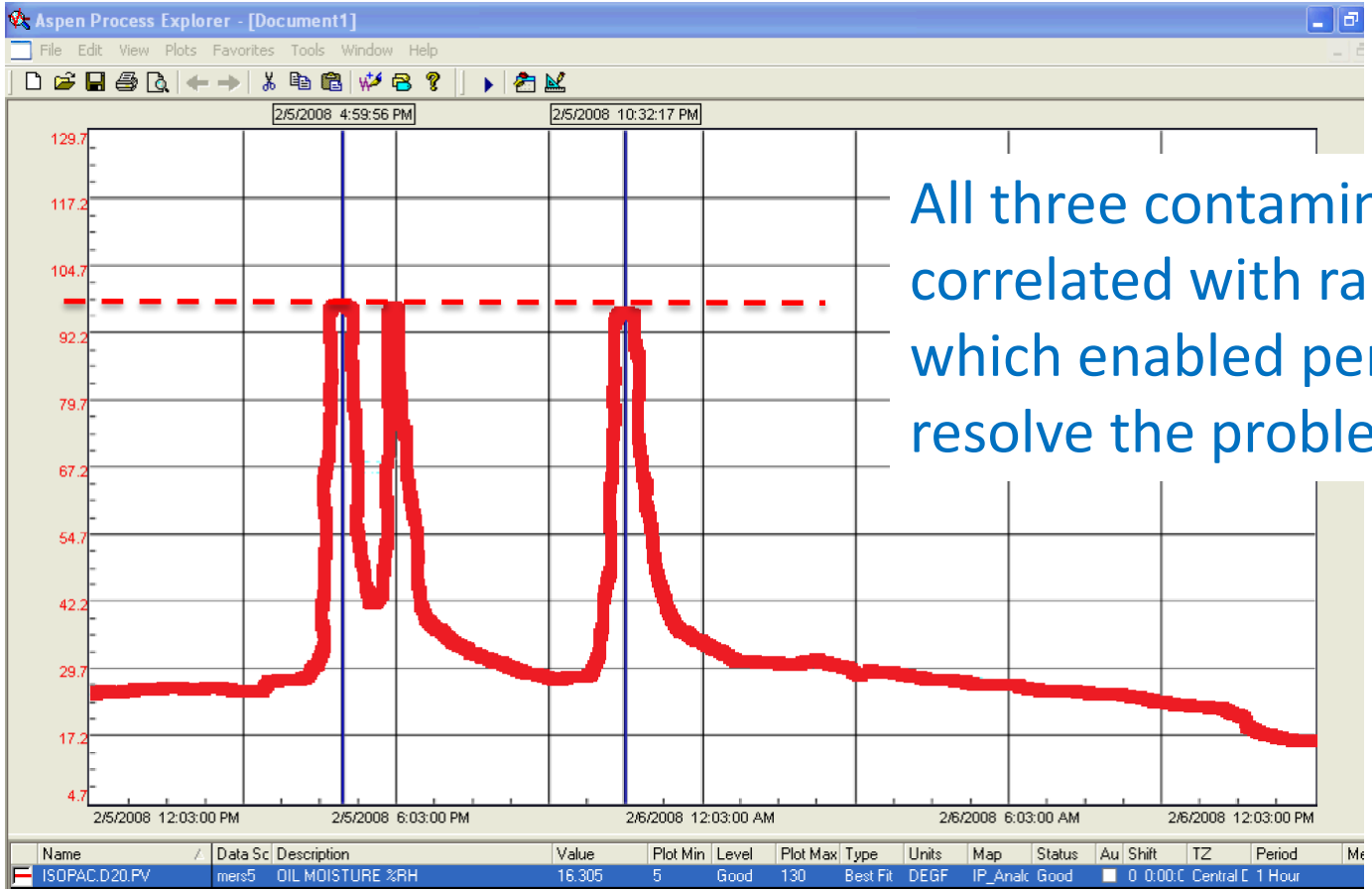
Oil Water Contamination Control Steps

- Use of dry gas (instrument air) absorbs water entry from the turbine steam seals and any other sources.
- A 4-20 mA oil humidity sensor provides continuous DCS history to alarm & troubleshoot before reaching 100% saturation in the oil.
- Rotameter air purges allow operators to add more air if needed to help arrest water entry.
- Back pressuring the bearing housings retards steam flow into the turbine and blower bearing housings.

Results

- The above combination of control steps has stopped water entry into the lube oil system of this turbine driven blower.
- The turbine driven blower has run for over seven years with no repeat failures from water contaminated oil.
- The humidity sensor output from this machine draws nearly straight lines and is almost boring!

Humidity sensor alarm on another machine



All three contamination events correlated with rain showers, which enabled personnel to resolve the problem.

Lessons Learned and Recommendations

- High water contamination need not be an ugly surprise with oil humidity sensors. Just as the Turbomachinery community saw benefits for continuous vibration monitoring, we can now **continuously monitor oil humidity and get numbers.**
- DCS history and alarms enable troubleshooting to **resolve contamination sources before machines get damaged.**
- DuPont and now Chemours have used oil humidity sensors on most new machine and retrofits for over five years. We normally inject dry air in the middle of bearing laby seals.