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20 YEARS STRONG
HydroVision INTERNATIONAL
JULY 22-25, 2014
Music City Center, Nashville, TN, USA
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WORLD'S LARGEST HYDRO EVENT
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MURPHY'S LAW OF BEARINGS AND SHAFT ALIGNMENTS
PRESENTATION
BY
DANY LESSARD, MSc
Hydro Expertise
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Bearing Failures

- Interesting subject.
- Normally not by choice.
- Solving a bearing failure can become priority # 1
- Imagine when multiple bearing failures occur.

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Bearing Failure Consequences

- Adding to project duration and costs
- Very expensive down time when unplanned event.
- Mess with personnel vacation plans
- Can create frustration

Cases Review

Project Fictive name	Type	# of bearings	Damaged bearing	Event year	Bearing life (years)	Power (MW)	Causes
Horse Creek	Suspended	3	LGB	1997	0	8	Bracket Assembly
Sea Falls	Overhang	3	TGB	2001	30	>300	Head cover flatness
Thundering	Suspended	3	Thrust	2000	0	30	Alignment, Bracket flatness
Beauchamp	Suspended	3	Thrust	2001 2005	0.5	>100	Design, Combination
South Plain	Overhang	3	Thrust TGB	2000 2006	0	>300	Design, Manufacturing Operation
Wolfgang	Suspended	2	Thrust	2000	5	<10	Alignment Verticality
Hope Bay	Overhang	2	Thrust	1996	0.5	>100	Runout, Balancing
Stone Falls	Suspended	3	Thrust	2013	0	15	Design, Manufacturing Assembly
Magnan	Suspended	2	UGB	2003	0	>300	Vibration, Resonance

Cases Review

Case #	Project Fictive name	Type	Damaged bearing	Bearing life (years)	Power (MW)	Causes
1 →	**Horse Creek**	**Suspended**	**LGB**	**0**	**8**	**Bracket Assembly**
2 →	**Sea Falls**	**Overhang**	**TGB**	**30**	**>300**	**Head cover flatness**
3 →	**Thundering**	**Suspended**	**Thrust**	**0**	**30**	**Alignment, Bracket flatness**
	Beauchamp	Suspended	Thrust	0.5	>100	Design, Combination
	South Plain	Overhang	Thrust TGB	0	>300	Design, Manufacturing Operation
4 →	**Wolfgang**	**Suspended**	**Thrust**	**5**	**<10**	**Alignment Verticality**
	Hope Bay	Overhang	Thrust	0.5	>100	Runout, Balancing
5 →	**Stone Falls**	**Suspended**	**Thrust**	**0**	**15**	**Design, Manufacturing Assembly**
	Magnan	Suspended	UGB	0	>300	Vibration, Resonance

Bearing Failures

Different types of bearing failures,

This presentation is mainly for wiped bearings…

…with causes related to assembly and alignment.

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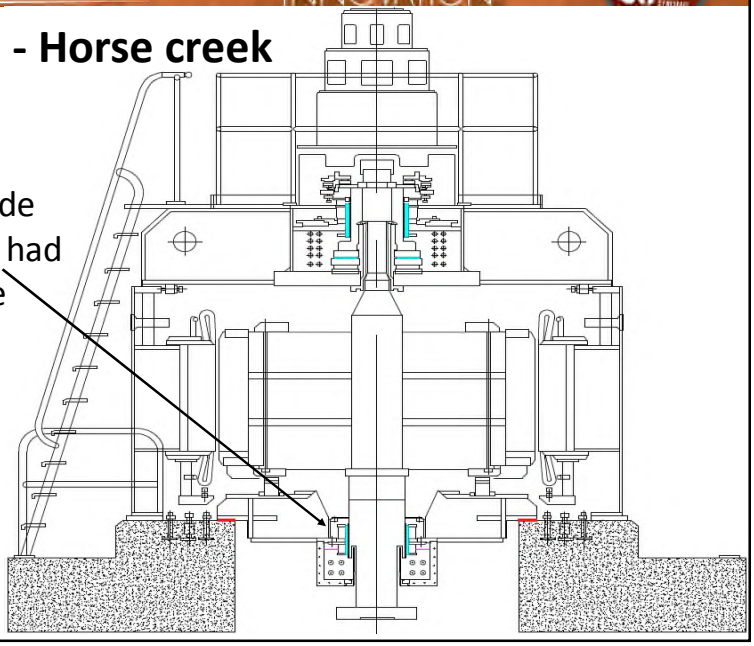
Case # 1 - Horse creek

This guide bearing had multiple failures.
Why?



Case # 1 - Horse creek

- 3 guide bearing failures at start-up
- Minor fixes had been done, but did not solve it
  - Bracket re-centering
  - Pole short-circuited turn fixed

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Case #1 - Horse creek

<u>Method used for diagnostic</u>

- Turbine bearing and shaft seal out
- Lower guide bearing out
- Rotational checks,
  - airgap sensors for rotor/stator sweeps
  - precision level on shaft
  - dial indicators and micrometer readings
  - runner seal clearances

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Case #1 - Horse creek

Alignment results

- Verticality deviation 23 mils/ft !! (1.9 mm/m)
  - Not sufficient cause for bearing failure
- Stator / rotor concentricity 50 mils (2X CEATI tol.)
  - Create additional radial force
  - Not fixed for not worsening runner clearances
- Runout at TGB 17 mils (within CEATI tolerance)
  - Reduced at 9 mils as additional precaution
- Seating flange for LGB with flatness error of 7 mils

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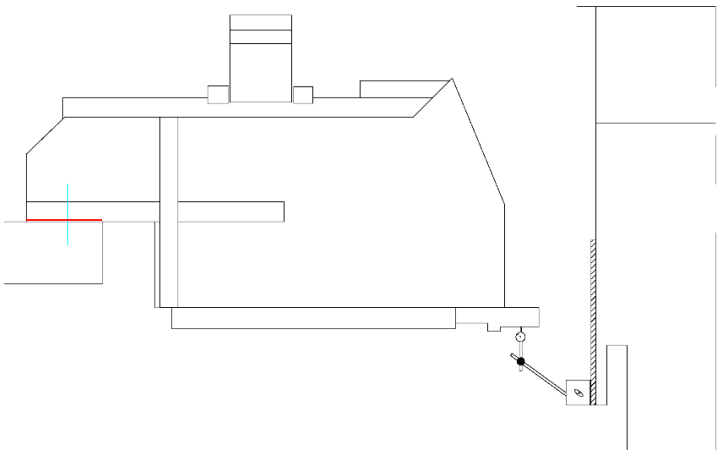
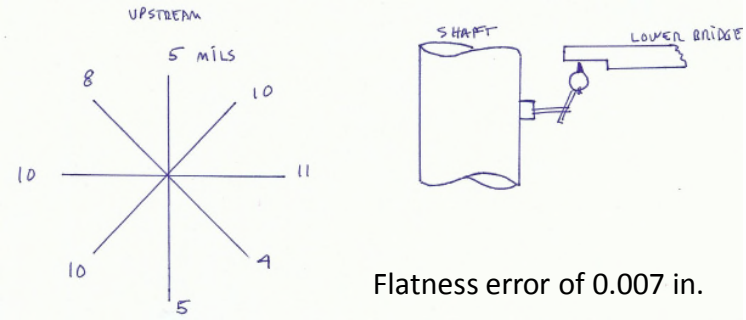
Case # 1 - Horse creek

Perpendicularity and flatness check



Case # 1 - Horse creek

Perpendicularity and flatness check



Flatness error of 0.007 in.

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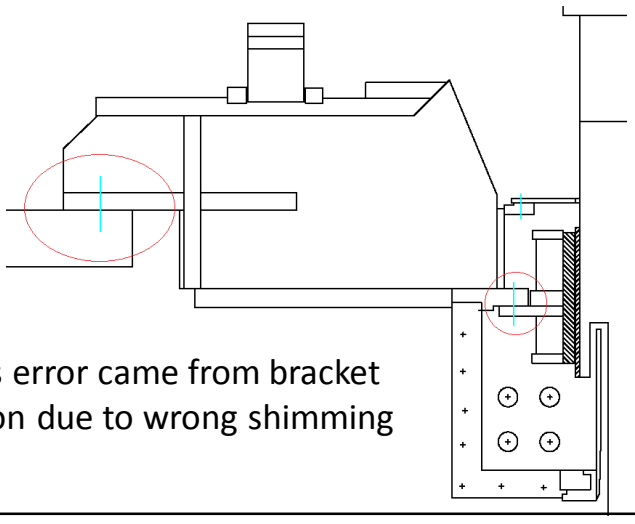
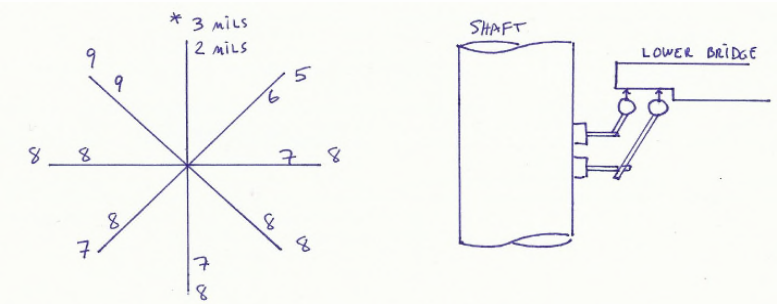
Case # 1 - Horse creek



Flatness error came from bracket distortion due to wrong shimming

Case # 1 - Horse creek

After correction of shims under bracket arms



Good perpendicularity and flatness within 3 mils

* Local surface defect corrected with a shim of 4 mils

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Case # 1 - Horse creek

Conclusion:

- The most important correction for that project was to fix the flatness of the seating surface where the guide bearing is bolted, preventing unwanted distortion of the bearing.
- The fixed bearing ran for 25 years until 2012 when the unit was stopped for a major overhaul.

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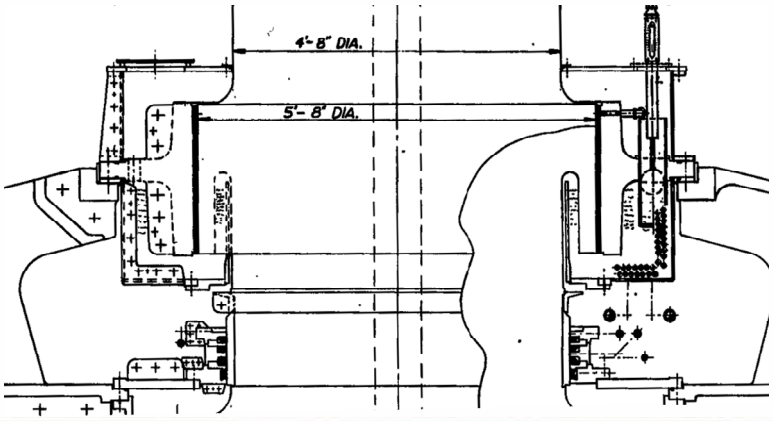
Case # 2 Sea Falls



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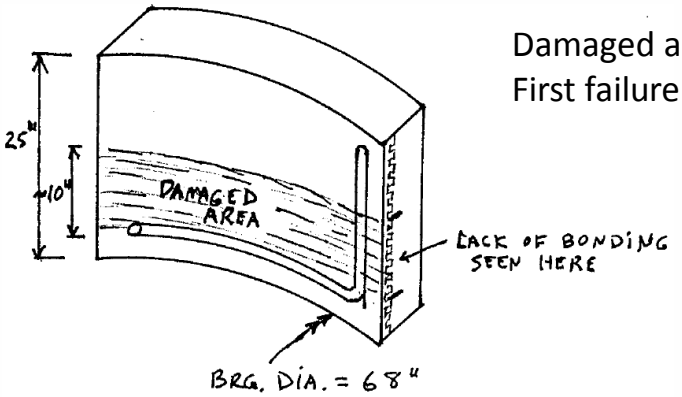

Damaged area all around
First failure in 30 years

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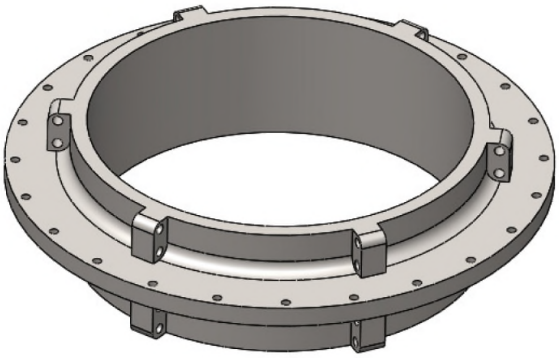
Case # 2 Sea Falls

Shell type bearing
68" Dia x 25" high
In 6 sections



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Case # 2 Sea Falls

DIAGNOSTIC

- Unit alignment checked and OK
  - ✓ Runout
  - ✓ Concentricity
  - ✓ Verticality
- Seating surface for Turbine Bearing, not OK
  - ✓ Flatness deviation of 0.014"

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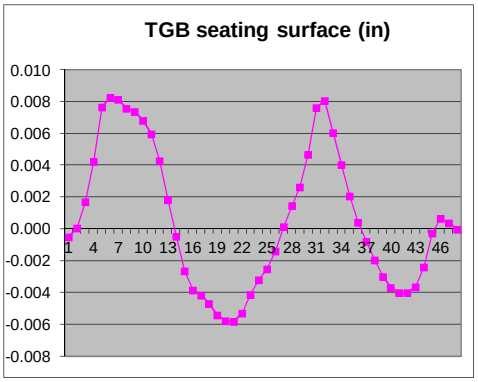
Case # 2 Sea Falls

Head cover surface, where TGB is seating, has flatness deviation of 0.014''.
Two high points and two low points, is typical of a bent surface.



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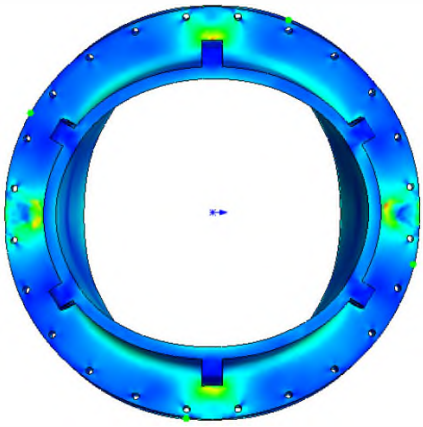
Case # 2 Sea Falls

Simulated deformation

Two oval shapes, at 90 deg.



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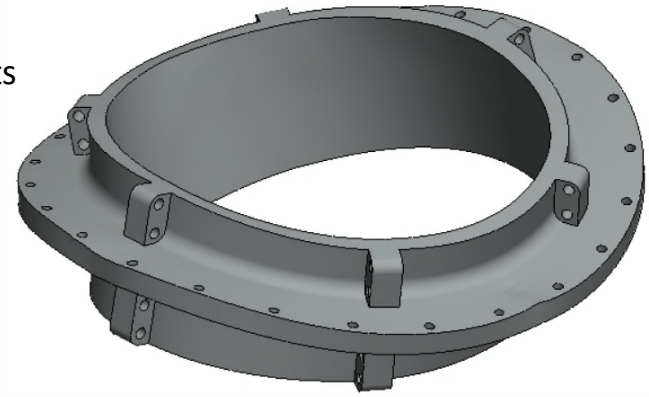
Case # 2 Sea Falls

Two high points and two low points around the circumference



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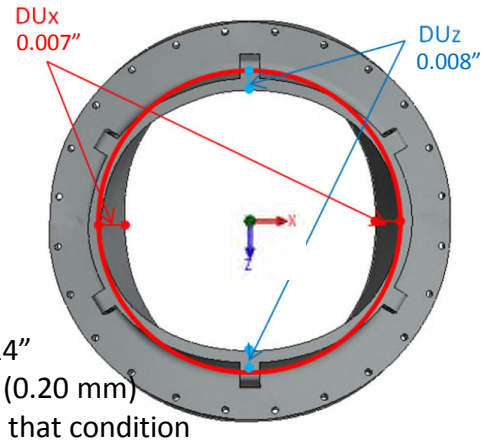
Case # 2 Sea Falls



- Under axial deformation of 0.014”
- Babbitt face varies up to 0.008” (0.20 mm)
- Bearing not designed to work in that condition
- It takes only 3 tons or 1 bolt on each side to deform it.

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Case # 2 Sea Falls

SOLUTIONS / CONCLUSION

- If major overhaul, machining of stationary components probably required.
- For a repair, we added shims of different thicknesses around the circumference of the seating flange, to make it flat (within 0.005")
- That repaired bearing may possibly live for 30 years, and already ran for 13 years.

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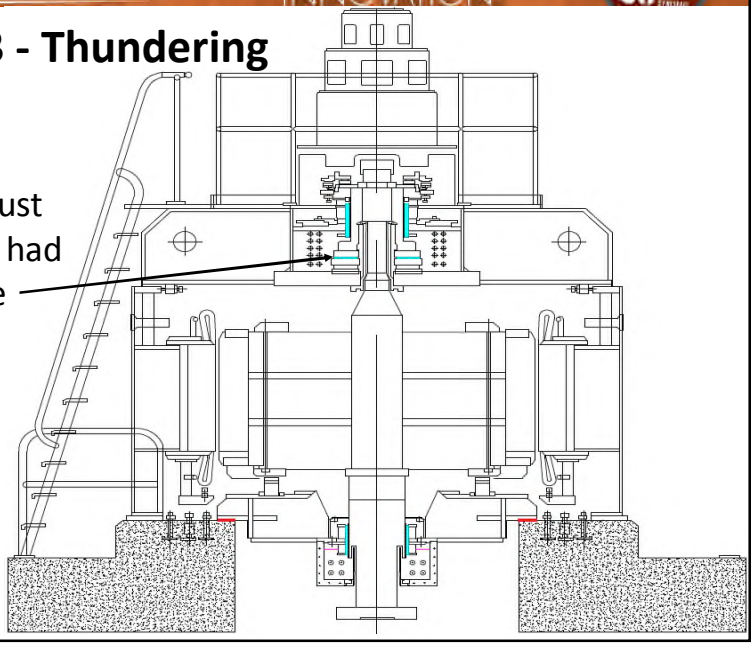
Case # 3 - Thundering

This thrust bearing had multiple failures.
Why?



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Case # 3 Thundering

SUMMARY

- Repetitive bearing failure at start-up
- Bent surface under the thrust bearing base ring plate
  - flatness error of the order of 0.40 mm (0.016")
  - Leading to non-uniform loading of the bearing
    - Visible on wiped bearing pattern
- Recommended solution was to readjust shimming of the upper bracket legs, and control surface flatness.

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Case # 4 Wolfgang

SUMMARY

- Small suspended machine similar to case no. 3
- Thrust bearing failure after 5 years.
- Upper bracket was misaligned, creating non-uniform load on the bearing. More load on one side.

<u>Interesting fact</u>

- Since start-up, the bearing temperature increased 2°C every year (same month) up to failure.

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Case # 5 Stone Falls

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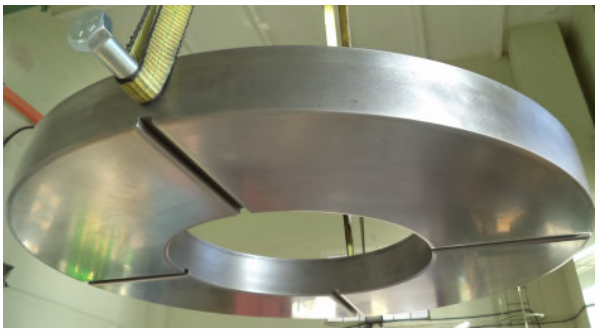
Case # 5 Stone Falls



Bottom side of the rotating ring has 4 radial grooves

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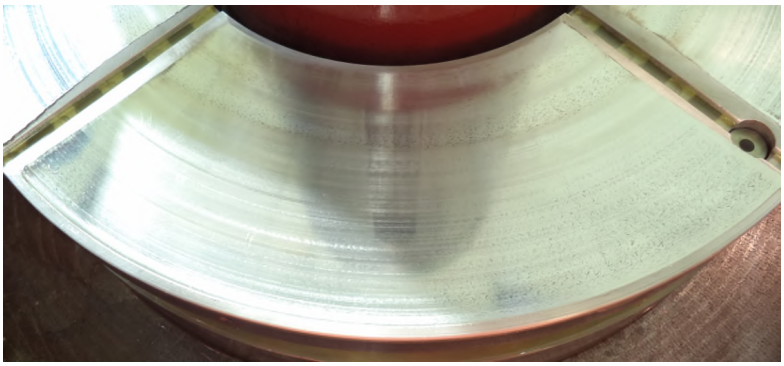
Case # 5 Stone Falls



Babbitt wiped

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Case # 5 Stone Falls

Solution for that unit

- No change on alignment
- Minimum cut in Babbit
- Hand scraping of the Babbit surface
  - Rubbing against actual thrust collar assembly for finding high spots, instead of flat marble
- Redistribution of springs, shorter springs near edges

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Case # 5 Stone Falls

Final result

- Thrust bearing temperature from 60s to 50s ^{o}C
- Inspection of bearing after commissioning revealed a Babbitt surface in perfect condition.

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Bearing Failures Prevention

Simple: good design, manufacturing, installation and commissioning ☺ … plus maintenance and monitoring.

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Bearing Failures Prevention

Installation tips

- Proper load distribution on bracket legs (no soft foot)
- Check surface flatness under thrust bearing (if applicable)
- Check flatness of seating surfaces for guide bearing
- Proper alignment with rotational checks
- Check bearings and shaft parallelism

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Bearing Failures Prevention

How To Check bearings and shaft parallelism?

- Check unit axis verticality and level of brg seating flange
- Dial on shaft to check seating flange perpendicularity
- Get top and bottom clearances when possible
  - ➢ Rule of thumb, 0.0015” maximum difference between top and bottom centers.

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Bearing Failures Prevention

Preventive maintenance & Monitoring

- Periodic inspection of thrust bearing in some cases.
- Periodic oil sampling
- Trending of temperature over consecutive years

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Presented
on July 24, 2014
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