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EXHIBIT NO. 116

CONFIDENTIAL

DOCKET NO:	20190001-EI
WITNESS:	Jeffrey Swartz
PARTY:	Duke
DESCRIPTION:	Duke Energy Bartow – Report of Telemetry Test
DOCUMENTS:	Bates DEF-19FUEL-000557-000583
PROFFERED BY:	Office of Public Counsel

Duke Energy Bartow
Report of Telemetry Test for 40” L-0

March 18, 2015

MITSUBISHI HITACHI POWER SYSTEMS

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Agenda

- Meeting Goal
- Background
- Mitigation
- Telemetry Test
- Telemetry Test Results
- Operational Limits
- Conclusion

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Goal of Meeting

- *Provide a technical understanding to Duke Energy of the telemetry test results and findings.*

- *Based on the telemetry test results, provide basis and definition of new guidelines for the steam turbine operation.*

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Background

- Unit COD was June 2009. From the time of commissioning until Spring 2012, ST operated up to 450MW.
- March 2012: Five governor end L-0 blades had fretting and cracking at mid-span stub.
- All governor end L-0 blades were replaced in March 2012.
- Mitsubishi estimated the cause of cracking was overloading of LP section based on 450MW operation which is over the design point of 420 MW.

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Background

- Mitsubishi recommended that Duke operate ST at or below 420MW to ensure proper loading on the L-0 blades.
- Mitsubishi evaluated modification of L-0 blades to increase output from 420MW up to 450MW and a proposal was presented to Duke in September 2013.
- Modified blades were tested in Air jet test facility in Takasago, Japan in August 2014 to ensure blade vibration frequencies have not been changed. Duke representative witnessed the test.
- New improved blades were installed on Bartow LP rotor and a telemetry test was performed in December 2014 to study blade response in actual steam turbine.

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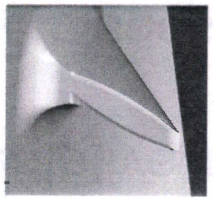
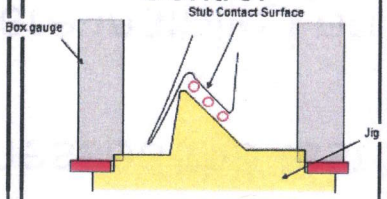
Mitigation Plan

Mitigation 1
Crowning



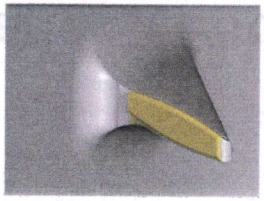
Edge of stub surface is rounded and chamfered.

Mitigation 2
Improved Gap Control



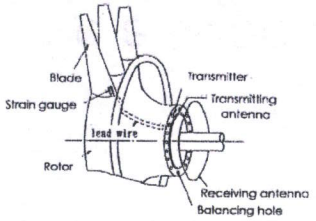
4-points measurement is performed.

Mitigation 3
Stellite coating



Stellite coating by HVOF is provided on stub surface.

Mitigation 4
Telemetry Test



Actual operation condition is measured.

- Stub Deformation and/or Tilting at higher load
- Vibratory Impact by Partial Latching
- Un-expected High Resonance Vibration
- Random Vibration

→ **Mitigated High Local Stress**

→ **High Durability against Fretting**

→ **Validation**

→ No Crack on Stub

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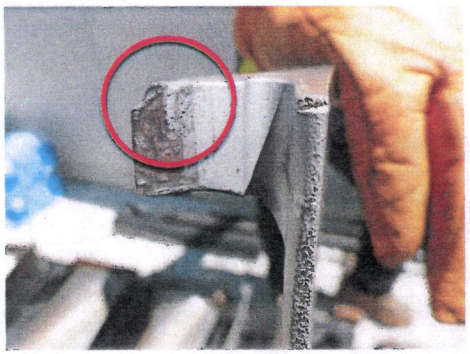
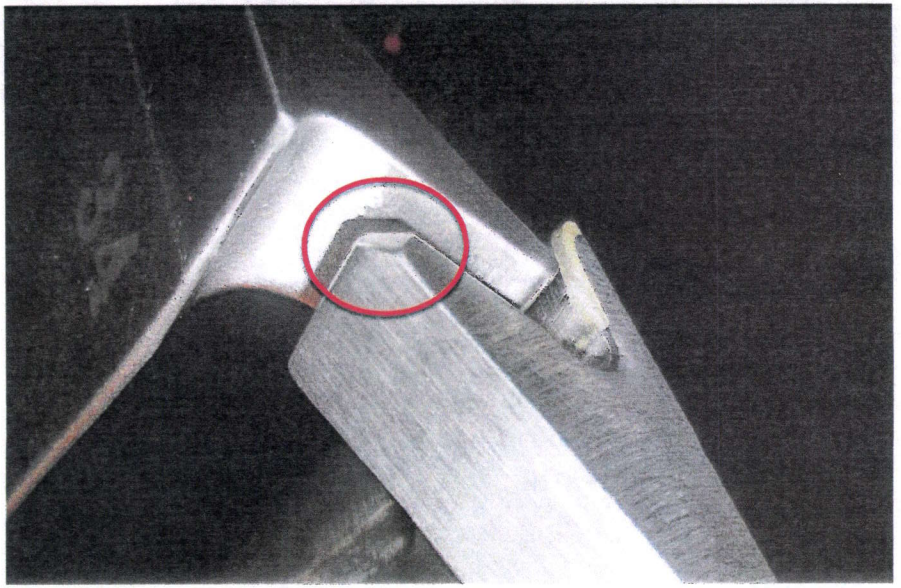
Shroud Chipping Resolution

- Along with mid span damage, Edge chipping on the shroud was observed on Bartow blades.



- As a countermeasure, a chamfer is applied to reduce stress concentration cased by blade twist and contact pressure.



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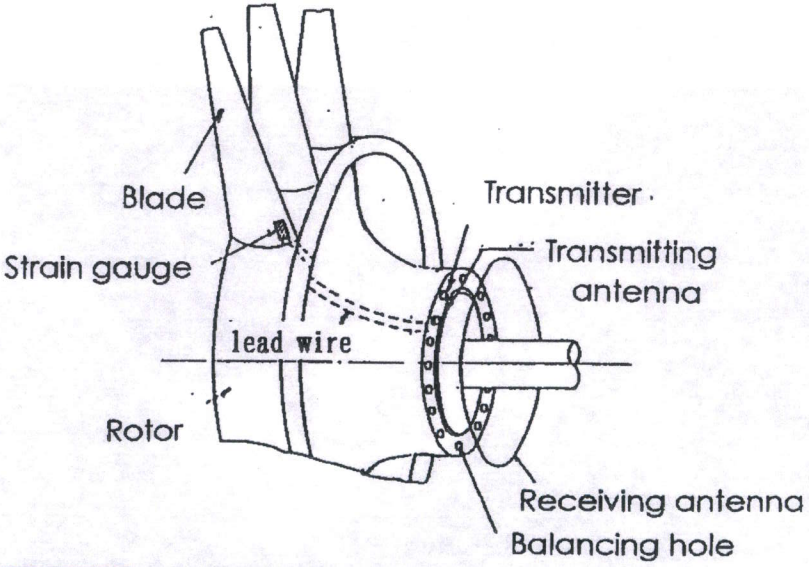
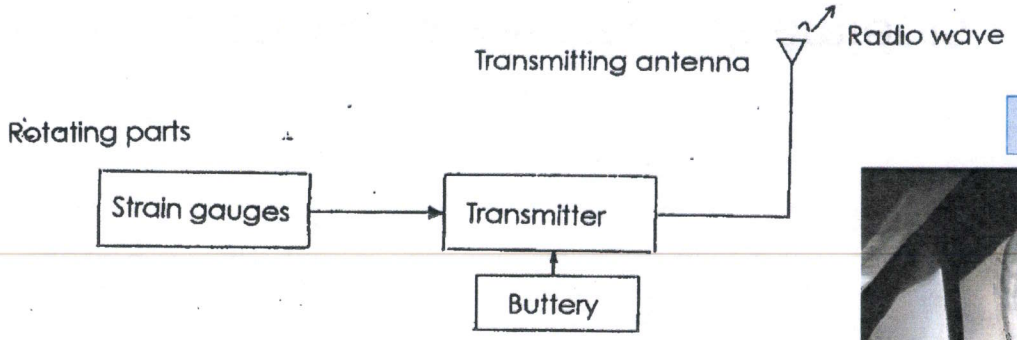
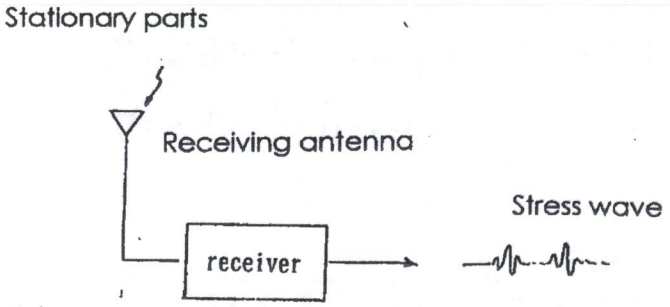
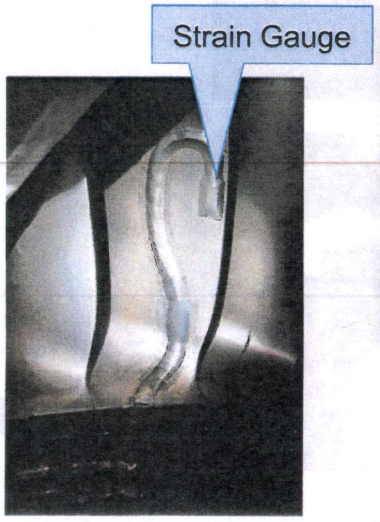
Telemetry Test of Last Stage Blades

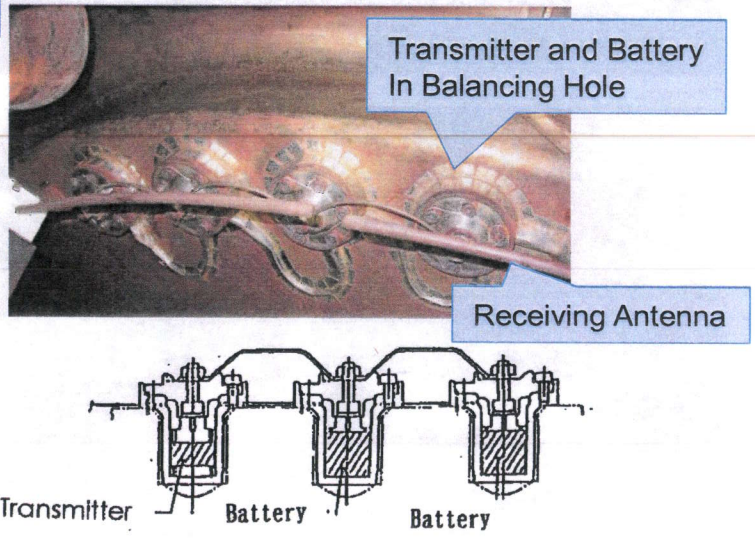
- Vibratory stress of moving blades are measured by telemetry system.
- Strain gauges and transmitters are mounted on blades and rotor.











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Purpose of Telemetry Test

- Air jet test performed in Takasago validated the natural frequencies of the blades.
- The purpose of the telemetry test in Bartow unit is to study blade response in actual steam environment.
- As the steam turbine operates at various operating conditions, hence blade response was studied at different combinations of load and condenser pressure.

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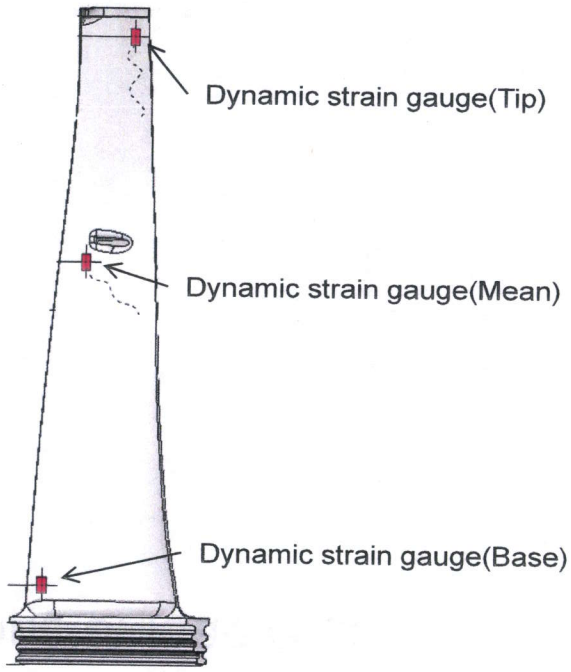
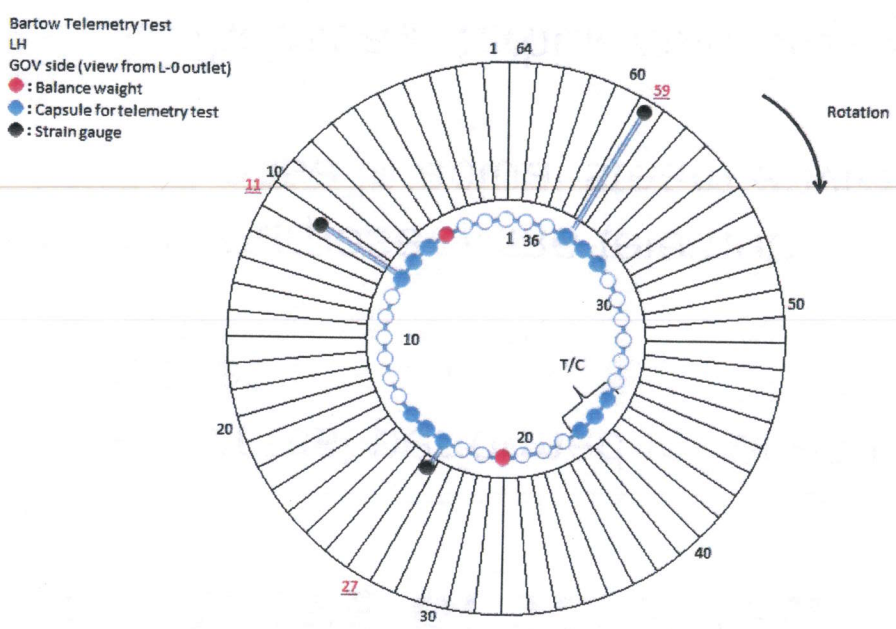
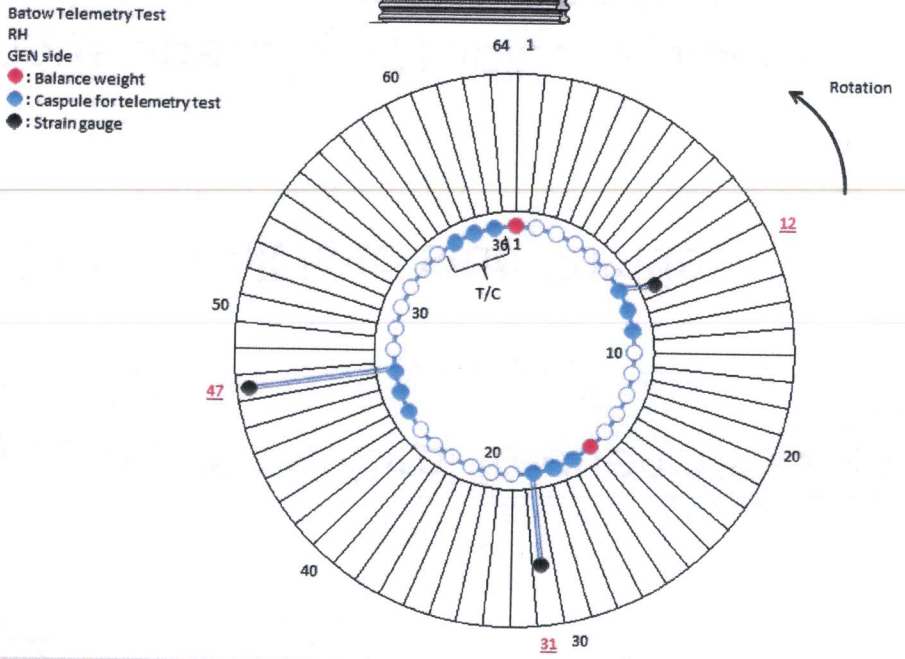
Strain Gage Locations

- Six strain gage were installed on LH and RH blades.

- Strain gage locations were selected
  - ➢ High response sensitivity for vibration modes.
  - ➢ Based on MHPS Experience







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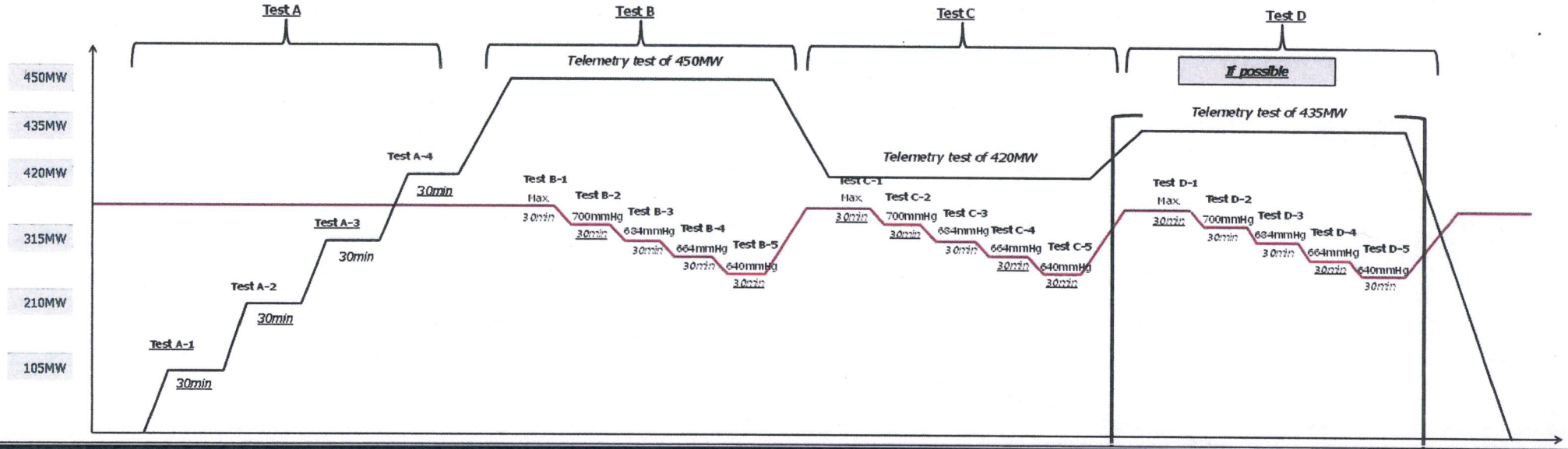
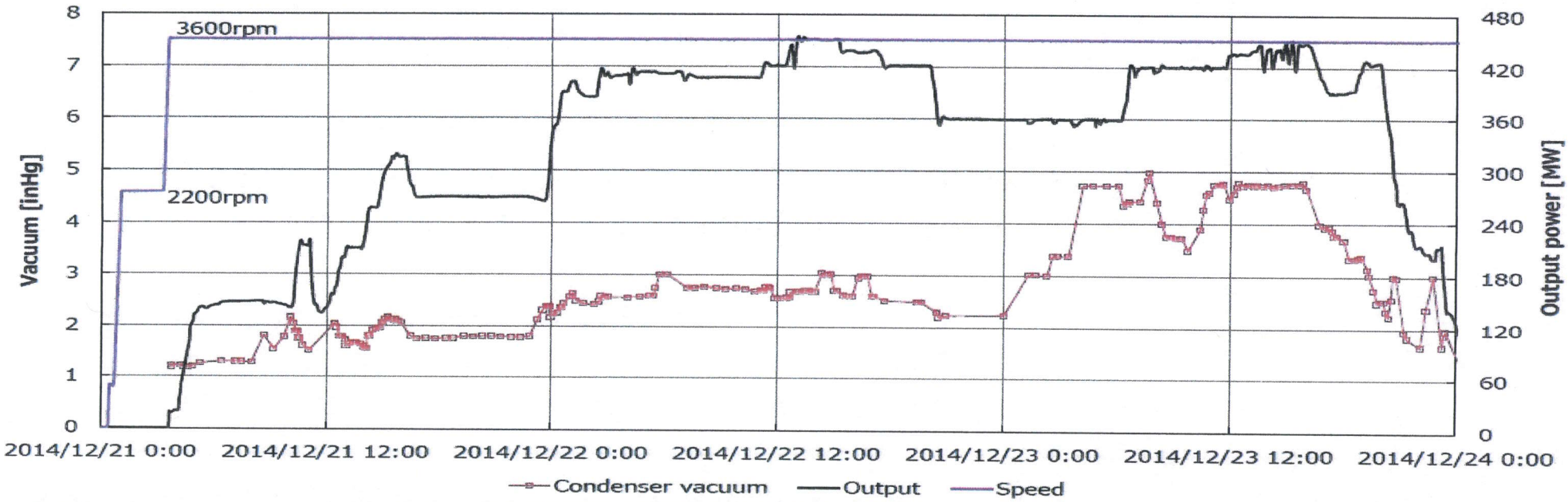
Test Plan



The telemetry test was executed from 0:00Hrs on 21st to 0:00Hrs on 24th December 2014.



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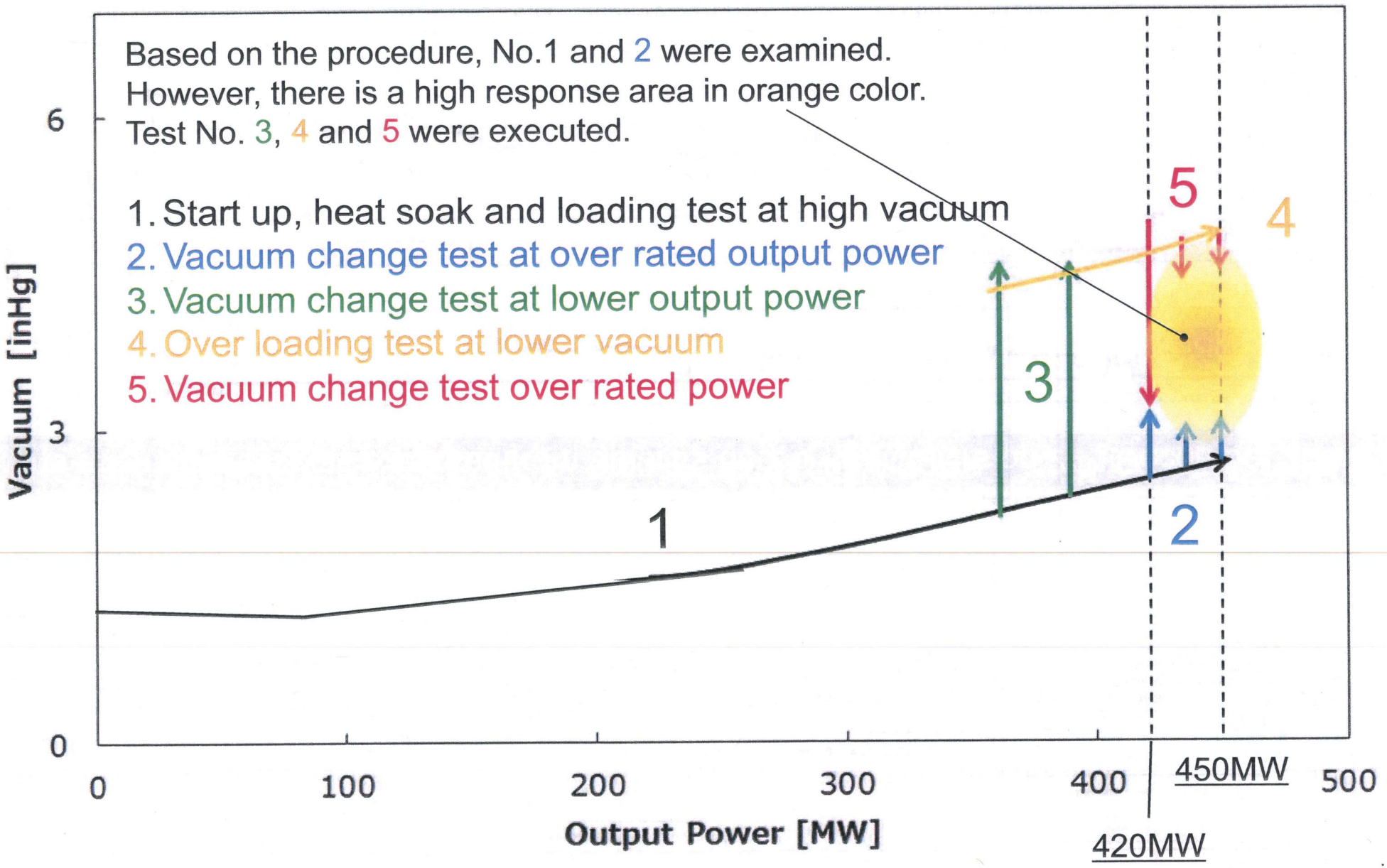
Telemetry Test Operation Area



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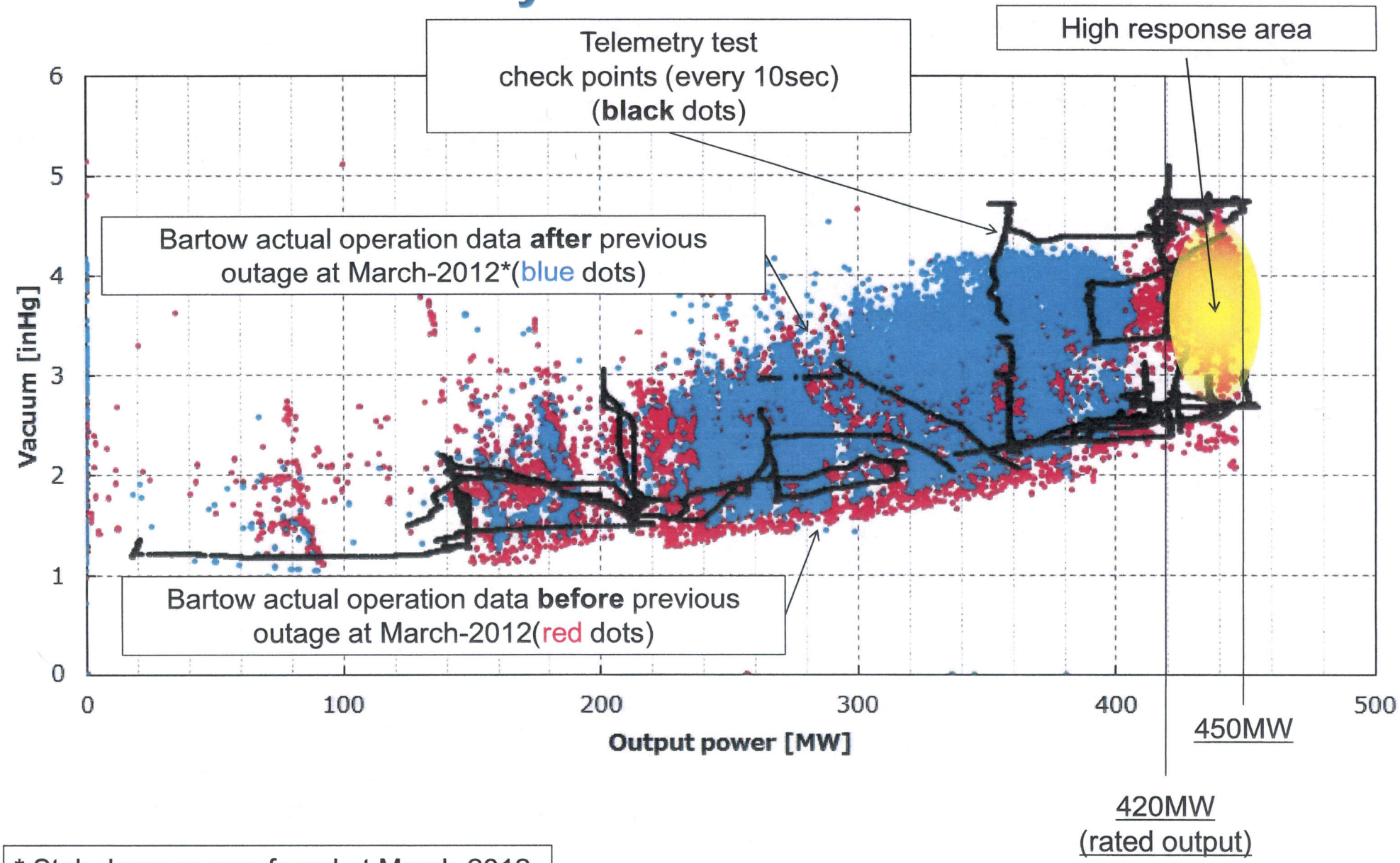
Outline of Telemetry Test



* Stub damage was found at March-2012

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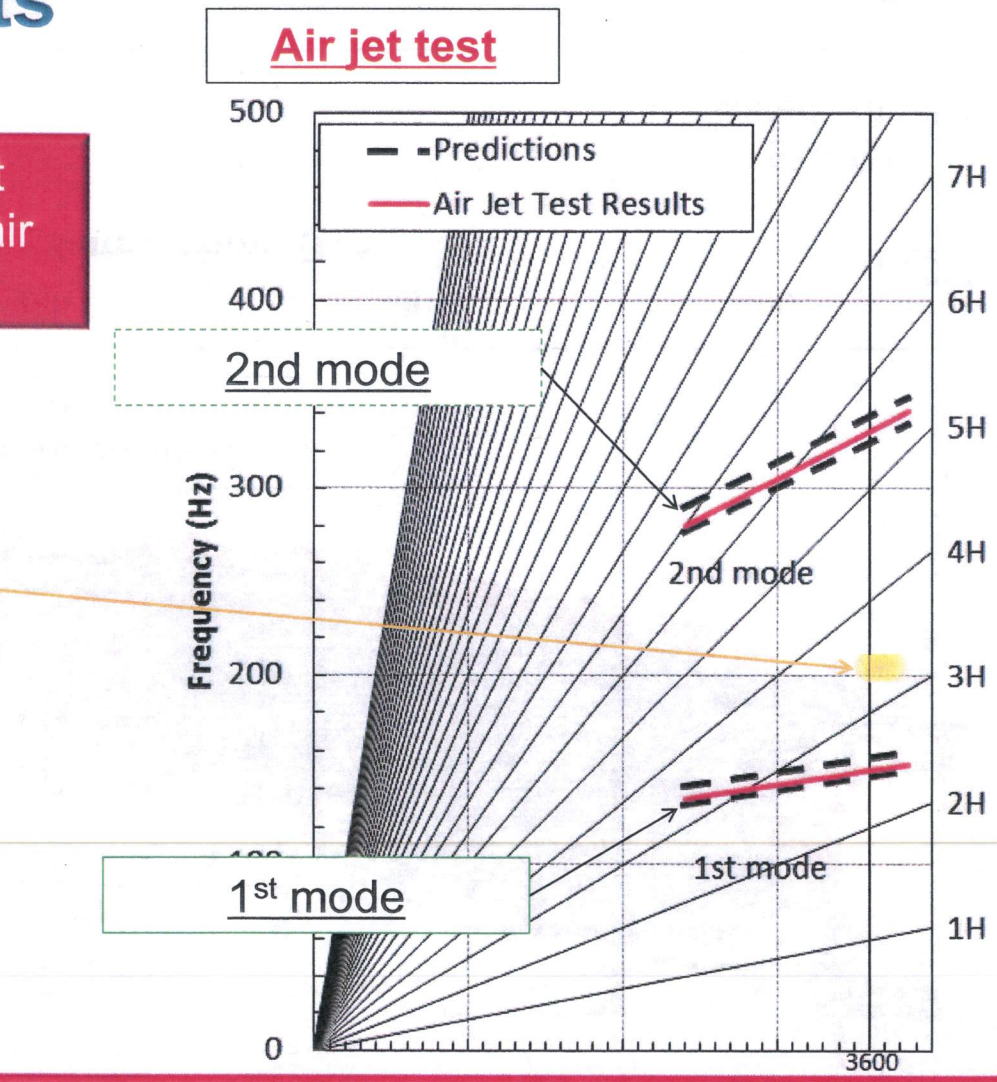
Telemetry Test Results

- Vibration modes of telemetry test are good in agreement with the air jet test results.



Non-synchronous vibration (Random vibration)

- There is no abnormal response in the start up process including heat soak.
- Small responses of non-synchronous vibration (random vibration) are observed at rated speed. Some of them have high response at specific loading and vacuum.

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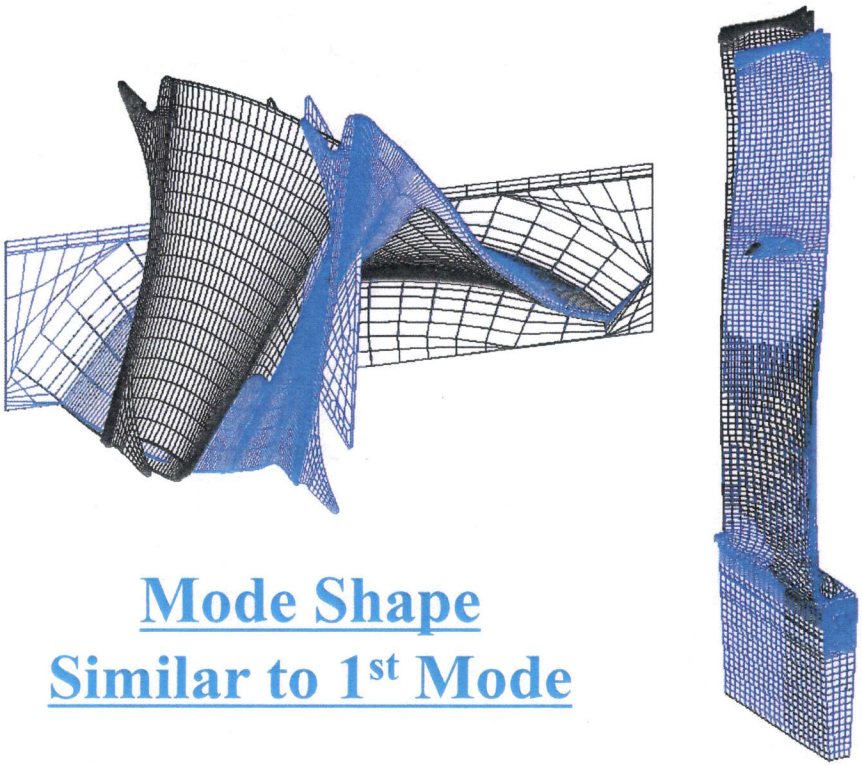
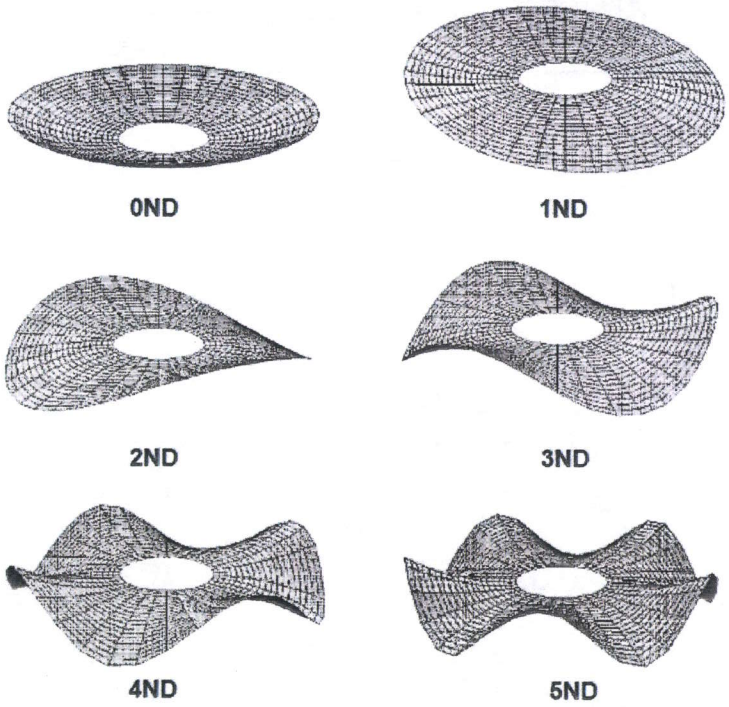
Test Results

- Analysis of Non-synchronous response show frequencies close to 200Hz region and composed of axial mode shape with higher nodal diameter.

- Fretting at stubs was evaluated with the telemeter test results.



Mode Shape
Similar to 1st Mode



Nodal Diameters

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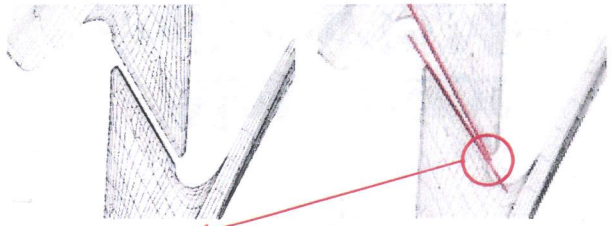
Procedure for Fretting Fatigue Evaluation

Stub contact situation



Higher local contact stress causes higher local vibration stress

Vibratory stress evaluated with the telemeter test

$\sigma_{v,measured}$

Fretting fatigue limit

$\sigma_{allowable}$

Coating affect is Evaluated

Vibration stress on stub for fretting fatigue

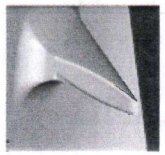
σ_D

Safety factor

$= \sigma_{allowable} / \sigma_D$

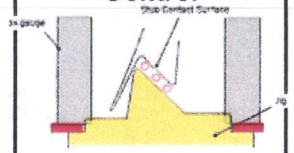
Mitigation 1 & 2 decrease local contact stress

Mitigation 1
Crowning



Edge of stub surface is rounded and chamfered.

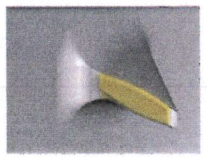
Mitigation 2
Improved Gap Control



4-points measurement is performed.

Coating on stub increase fretting fatigue limit

Mitigation 3
Stellite coating



Stellite coating by HVOF is provided on stub surface.

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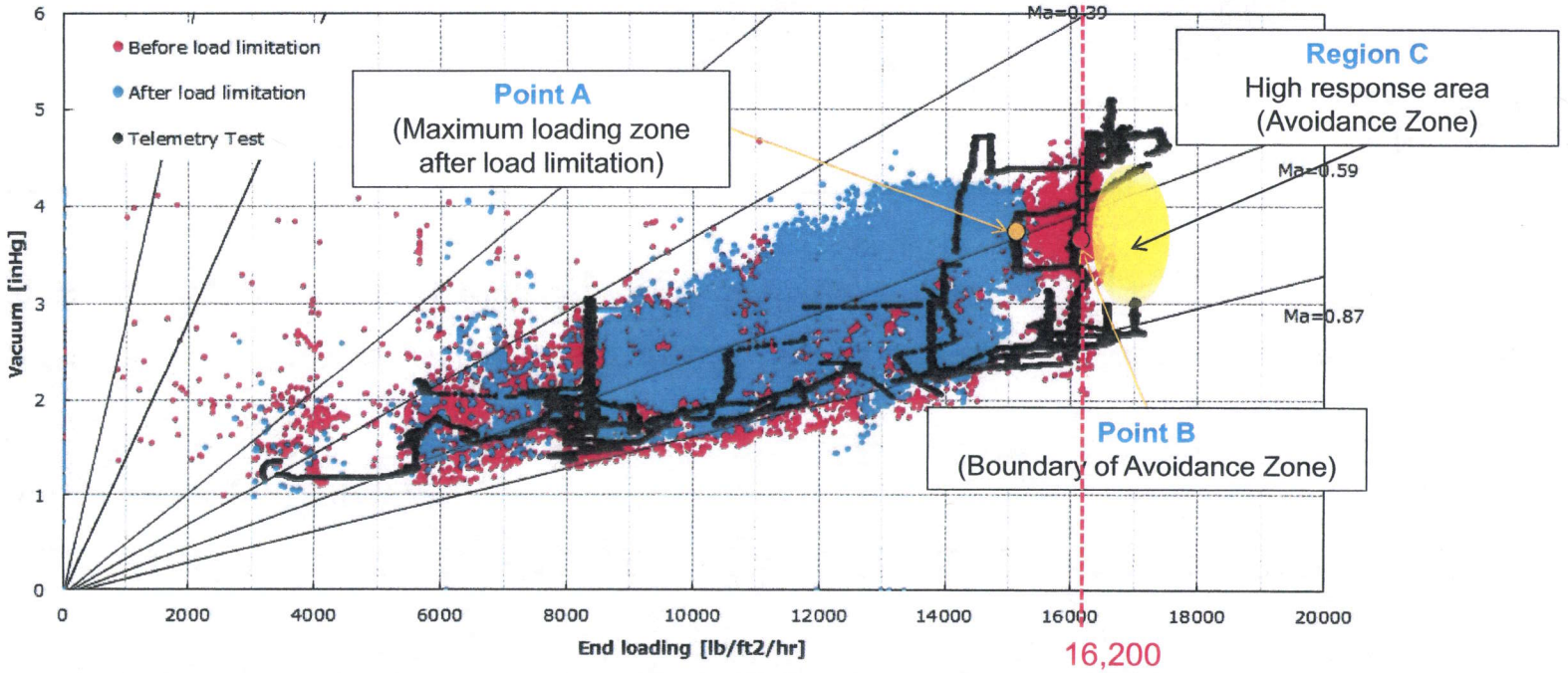
Test Results

Stub fretting evaluation at all tested region was conducted.
3 key evaluation points are shown :

- Point A : Max loading after 2012 load limitation.
- Point B : Minimum safety factor point during the telemetry test.
- Region C : Unexamined area due to high vibratory response observed during the telemetry test.

Point B achieved acceptable stress and safety margin after the stub coating.
Region C exceeds the stress limit and safety margin after the stub coating becoming the avoidance zone.



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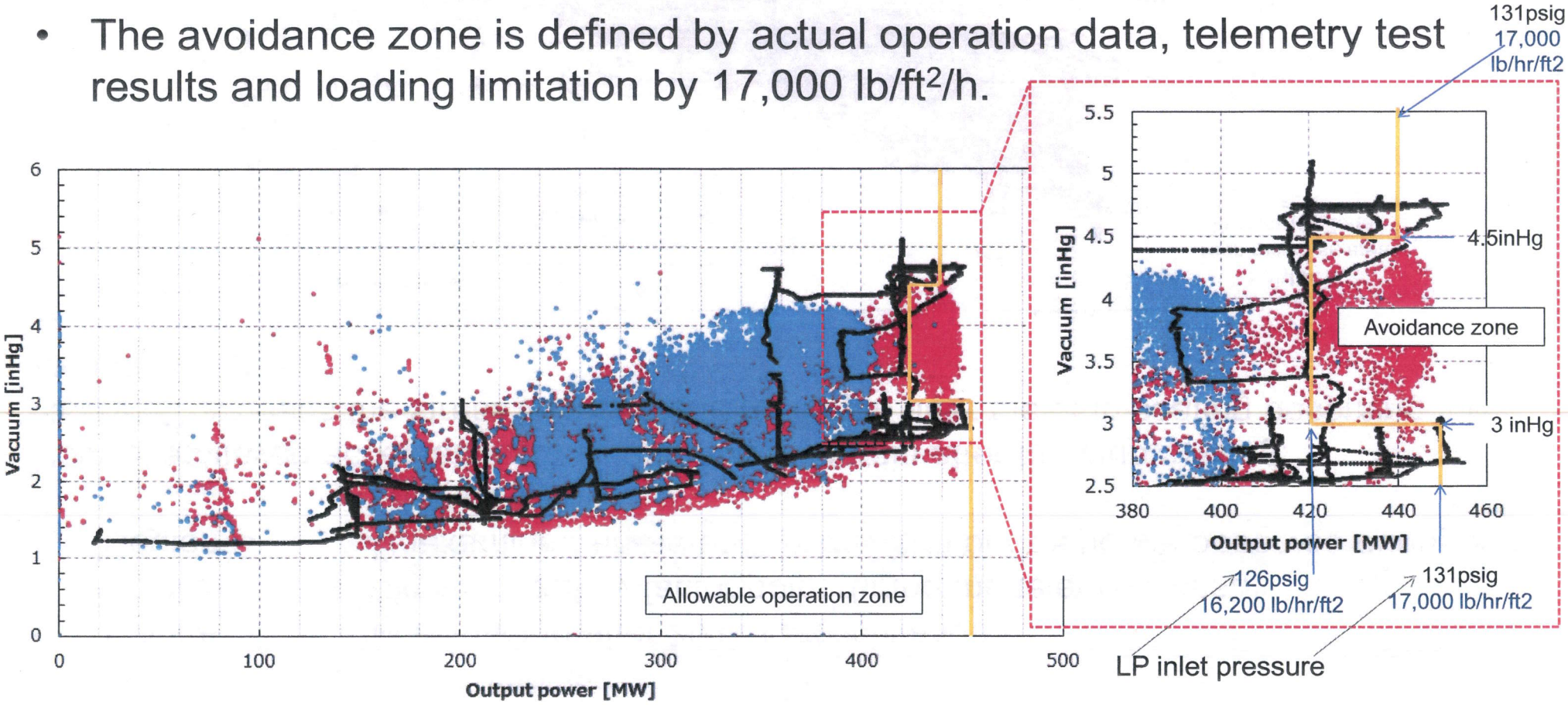
Results: Stub Fretting Fatigue Evaluation

- Based on Fretting Fatigue analysis, avoidance zone was created for safe operation of the L0 blades.

- The avoidance zone is defined by actual operation data, telemetry test results and loading limitation by 17,000 lb/ft^2/h.



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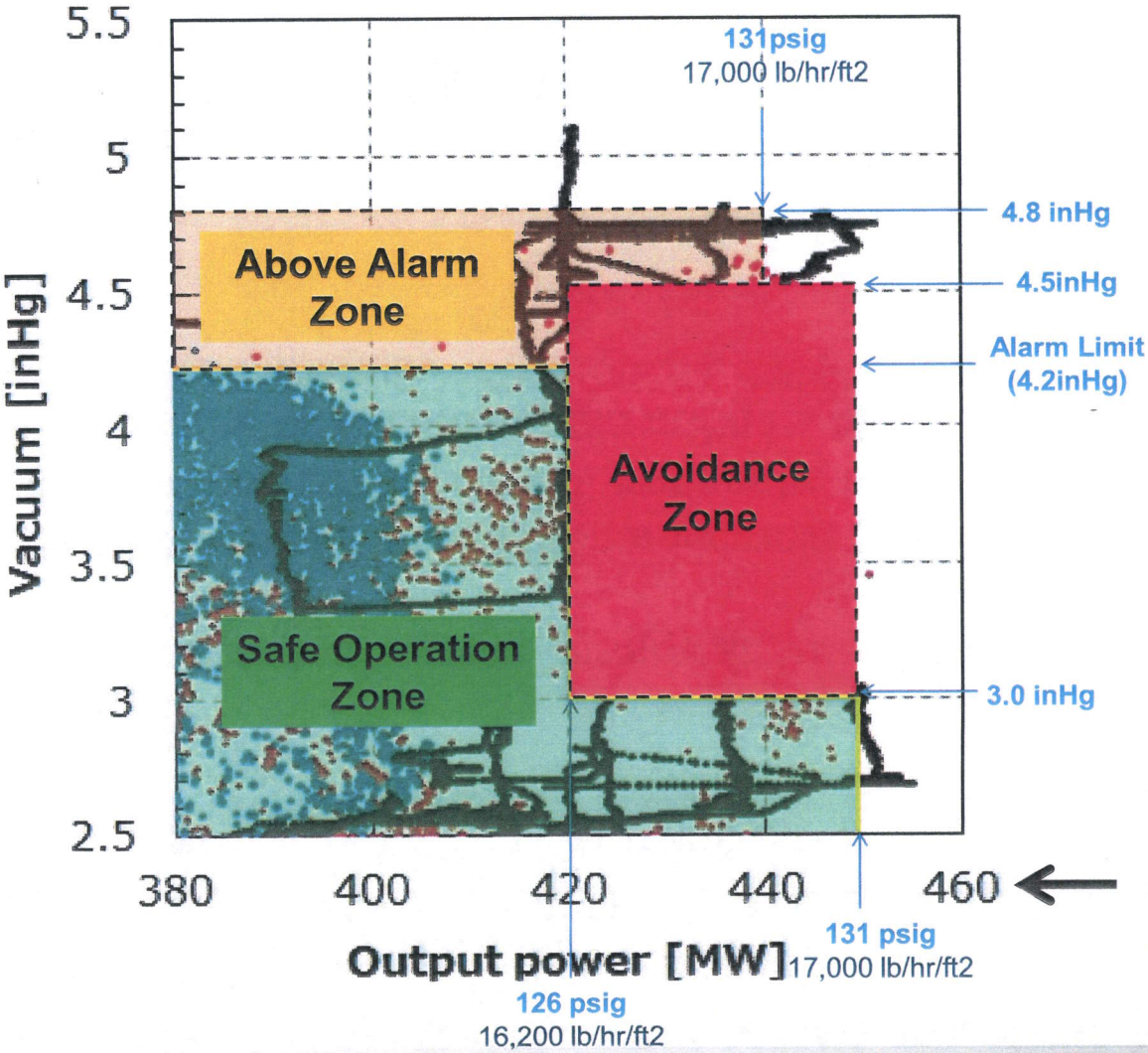
40” L0 Blade Limits

- Based on Fretting fatigue and HCF evaluation of the blade below “Avoidance Zone” is established



Safe Operation Zone:
Continuous operation permitted.

Avoidance Zone:
Operation is not recommended.

Above Alarm Zone:
Short term operation is permitted between 4.5 inHg and 4.8inHg with LP inlet pressure limit of 131psig during peak power seasons in summer.

Note : Output can be increased through higher HP Section Loading (Discussed Later)

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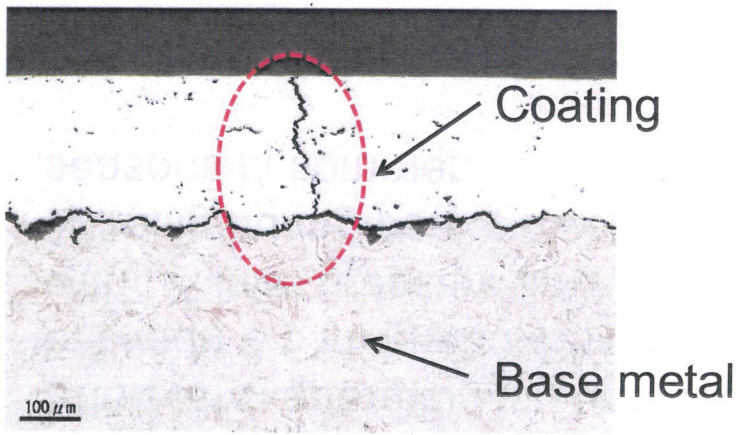
Plan of blade inspection at the next outage

Annual visual inspection of shroud and stub is recommended. This can be performed by access through man-way.

[Stub]

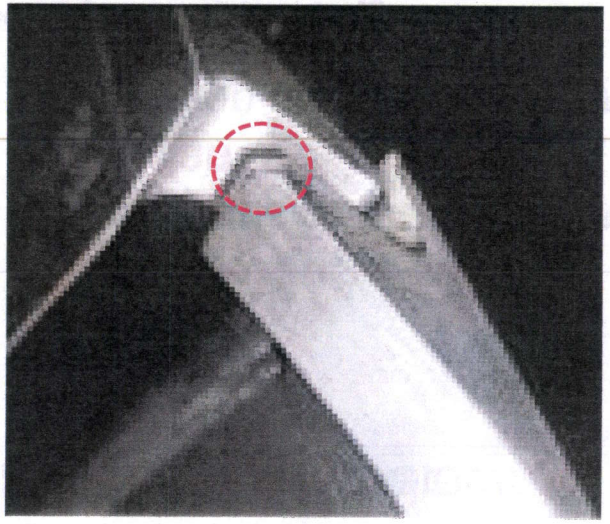
Inspect the coated surface for any abnormalities.

Bending test have proved that any crack that initiates in the coating will not propagate into base metal. So any cracks observed on the surface should be acceptable.



[Shroud]

Confirm the condition of shroud.



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Operational Limits – Background

- Bartow Steam turbine was designed to operate at 420MW.
- A Heat Balance diagram providing max operation (420MW) thermal conditions was provided as a part of the thermal kit.
- During the performance test in 2009, using the 420MW thermal conditions, the unit was able to reach ~402MW.
- The investigation pointed to larger discrepancy between pressure and flow measurements.
- It was concluded that the flow measurements were incorrect by up to 5%.
- As pressure measurement accuracy is much better than flow measurement, hence pressure data was used and flows were calculated using design pressure-flow curves.

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Operational Limits– Background

- The purpose of the Telemetry Test is to find a safe range of last stage blade loading.
- An experience based limit for 40" last stage blade loading is 15,000 lb/hr/ft2.
- Design limits for the steam turbine interface points are provided to Bartow via document T4-A6891.
- Total output from the steam turbine is the sum of power from HP, IP and LP sections.
- Same power output can be achieved with different loading on HP, IP and LP sections but interface limits listed in T4-A6891 should be followed to keep BoP operation within design limits.

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Operational Limits

- Bartow informed MHPSA that following the limits on 420MW HBD, the unit can not achieve more than ~400MW.

- MHPSA re-evaluated the HP, IP and LP steam path against the limits specified in T4-A6891.

- 420MW HBD steam conditions are lower than T4-A6891 limits.

- The conclusion of the study was that it is ok to operate the HP, IP and LP sections up to the limits specified in T4-A6891.

		420 MW HBD	Limits per T4-A6891
HP	Flow [lb/hr]	2,195,420	-
	Temperature [F]	1027.5	1056
	Pressure [psig]	2241	2375
IP	Flow [lb/hr]	2,255,203	-
	Temperature [F]	1035	1056
	Pressure [psig]	532	569
LP	Flow [lb/hr]	2,384,300	-
	Temperature [F]	676.5	680
	Pressure [psig]	112	128

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Operational Limits

Based on the study MHPSA relaxed the IP and LP inlet pressure conditions

HP Admission Pressure	2240 PSIG
IP Admission Pressure	569 PSIG [Was 532 PSIG]
LP Admission Pressure	128 PSIG (Note 1) [Was 118 PSIG]
LP Steam Flow	2690 KPPH (Was 2582 KPPH based on LP Condensate Flow)
Condenser Backpressure Alarm	4.20 inHgA
Generator Megawatt Output	**420 MW**

Note 1: LP Admission Pressure shall be measured using 0RCAODSE1101, IP Exhaust Pressure

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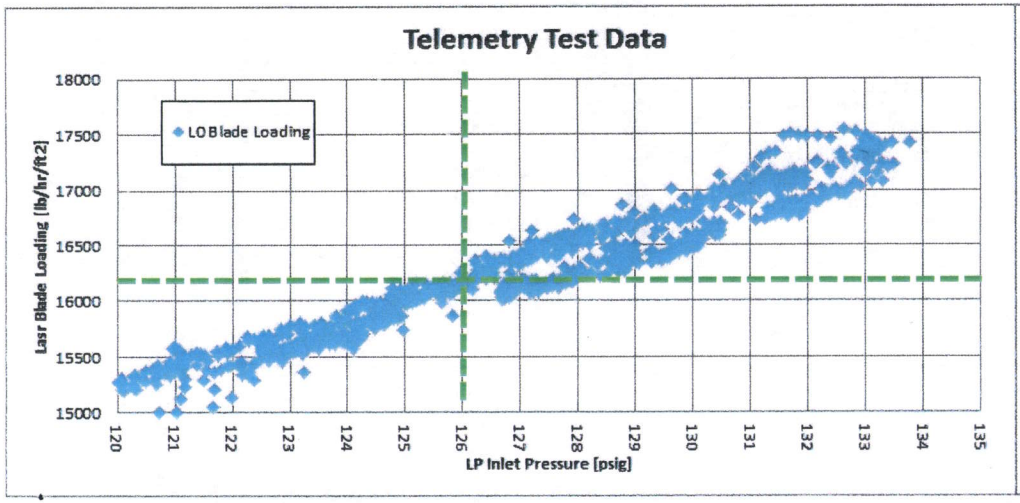
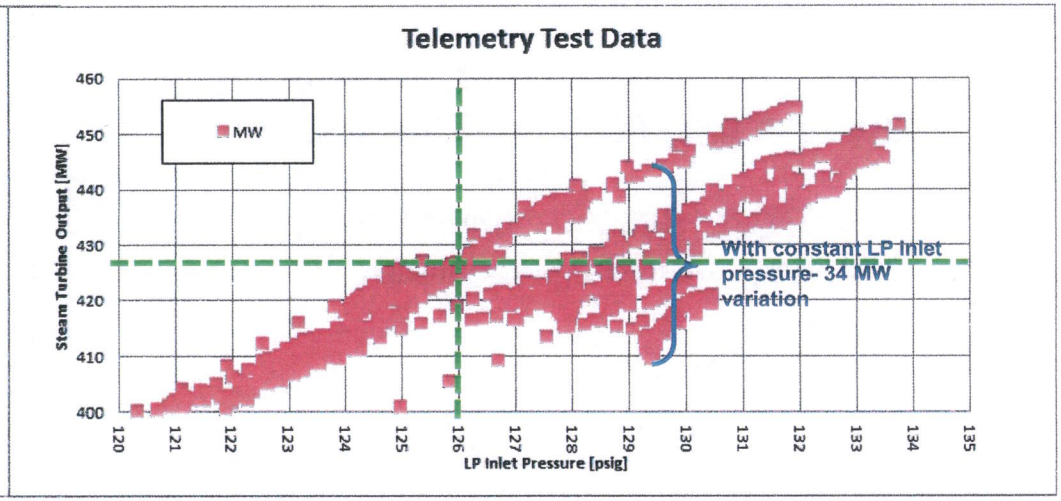
Operational Limits

- Based on L0 blade review for operation above 3 inHg, maximum allowed load on L0 blade is set at 16,200 lb/hr/ft^2.
- Review of test data shows that 16,200 lb/hr/ft^2 can be achieved with LP inlet pressure of 126psig and unit output as 426.7MW. (12/22 17:30Hrs)
- With constant LP inlet pressure, variation of power output is observed. This is largely related to loading change in HP and IP sections.
- If more steam is put through HP section, higher output greater than 426MW can be achieved by keeping LP inlet pressure under 126psig or L0 blade loading under 16,200 lb/hr/ft^2 .





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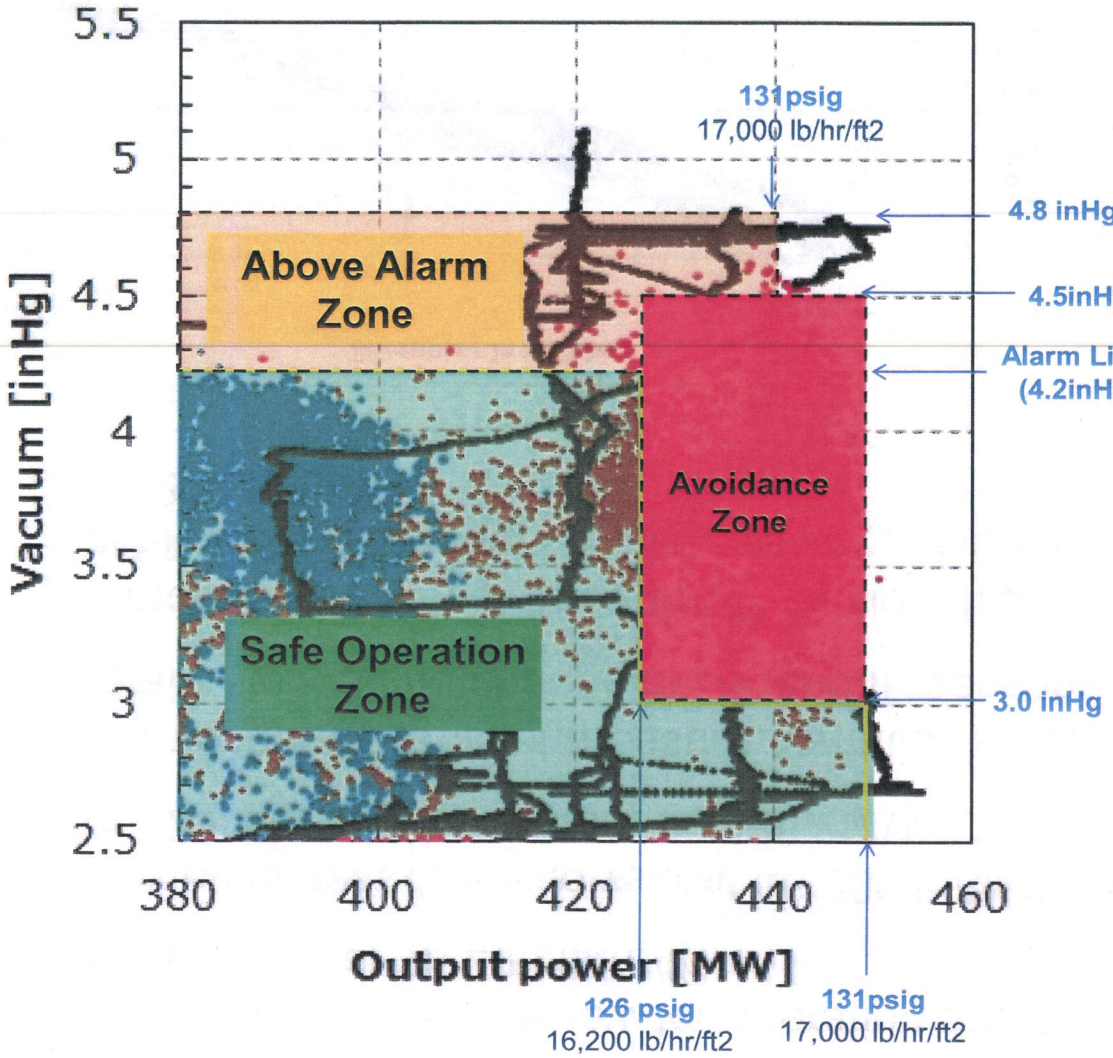
Operational Limits



- HP Admission Pressure : 2240 psig
- IP Admission Pressure : 569 psig
- **LP Admission : Max 126 psig for exhaust pressure up to 4.3 inHg**
- **LP Admission : Max 131 psig for exhaust pressure < 3 inHg**
  (Customer to confirm BOP capability for 131 psig LP Inlet System.)
- Exhaust Pressure Alarm: 4.2 in.Hg
- Max Gen Output : 450MW

Above Alarm Zone:
Short term operation is permitted between 4.5 inHg and 4.8inHg with LP inlet pressure limit of 131 psig during peak power seasons in summer.

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Conclusion

- Duke Energy and MHPSA have successfully completed the telemetry test to study the 40" L0 blade response in actual steam environment.
- High stresses have been observed with blade loading above 16,200 lb/hr/ft2 combined with condenser pressure between 3 inHg and 4.5 inHg.
- MHPSA has worked to allow steam turbine to produce 450MW at maximum possible operation ranges and keep the steam turbine components safe.
- New operation conditions in terms of HP, IP and LP steam turbine inlet conditions are provided to Bartow for safe operation of the steam turbine.
- MHPSA is thankful to Bartow Power Plant team for their extraordinary support during the test.

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