


Intelligent energy for a greener planet

NORTH BATTLEFORD ENERGY CENTRE

Air Cooled Condenser Maintenance and Vibration Issues and Solutions

Plant History and Background

- 1 x 1 GE 7FA.04 CCGT with Air Cooled Condenser, STG and HRSG
- COD June 3 2013
- Performance test passed successfully and historical plant thermal performance has been above expectations
- Site is in Saskatchewan, Canada
- Ambient temperature avg. 40F, Range (-)40F to (+)100F, low humidity
- Wind speed on site 0-40 miles/hour
- Design point 100F, 6in Hg @ 11 mph
- Average Wind 8-12 mph From W-NW
- Base load facility: load range 50-100% CTG > 8000h per year

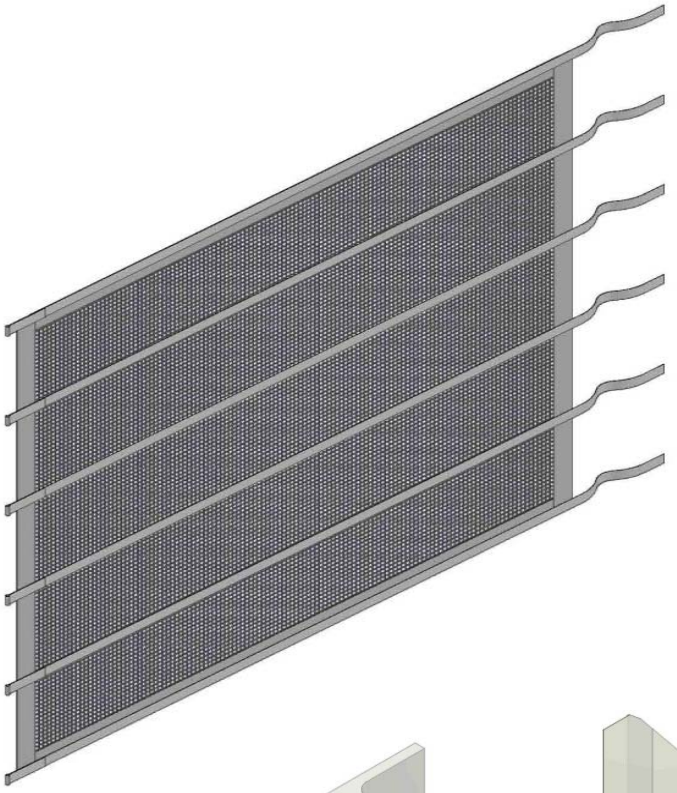
Air Cooled Condenser Design

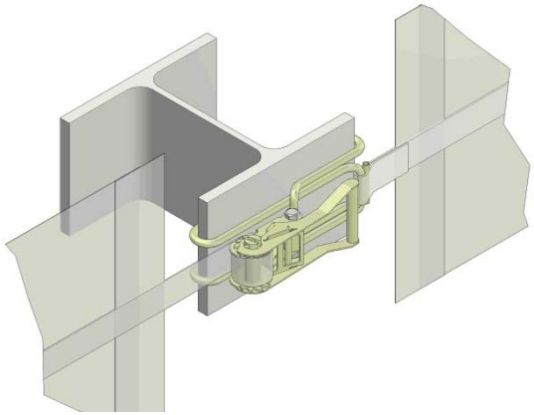
- ACC specified with features due to past NPI history and expertise in cold weather applications/freeze protection
- VFD fan drives specified by NPI for all 10 fans, all for freeze protection reasons
- In winter, half of condenser can be isolated for freeze protection, fans speed reduced and reversed if necessary
- ACC supplier freeze protection logic implemented
- Wind design for performance was for 11 mph@100F
- Bentley Nevada vibration (velocity) probes and logging specified and installed on gear boxes after recommendations from other users
- Fibreglass fan blades
- Gearboxes with integral gear driven oil pump and desiccant breathers
- Synthetic gear oil used (due to cold temperature)

ACC Operation Experience To Date at North Battleford

- hundreds of fan trips (up to 20 / day / fan) on vibration (Alarm Level set at 0.4 in/sec RMS, trip is triggered if level gets to 0.5 in/sec RMS and sustained above 0.45 in/sec for >5 seconds
- Early anecdotal indication that wind was a contributing factor in vibration trips
- Gear oil viscosity degradation and accumulation of coking material causing seal (input and output end), bearing and pump failures
- Water accumulation in gear oil
- High vibration is obvious on access platform adjacent to motor/gear boxes. “teeth rattling vibration”
- No substantial freezing issues to date
- **Decision made by NPI to Install Galebreaker Windshields and permanent wind monitoring equipment**

Galebreaker Wind Shield Specification





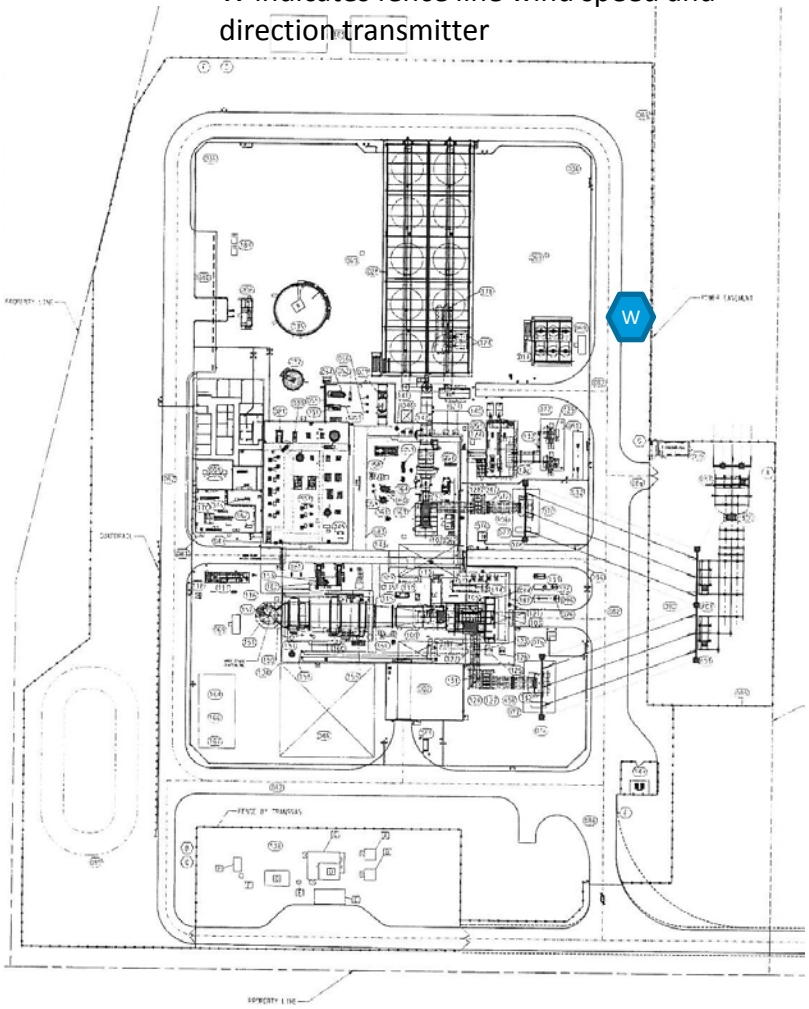
- 40% Permeable Mesh Wind Shield
- Able to withstand 90mph winds
- Hooking on to current ACC structure
- To be located on North, East and West elevations *(not fitted to South which is sheltered by turbine hall building)*
- Wind shield design to extend down 6.5m from bottom of Wind Wall *(~50% of Fan Deck height)*

Galebreaker® INDUSTRIAL

NBEC Site Layout

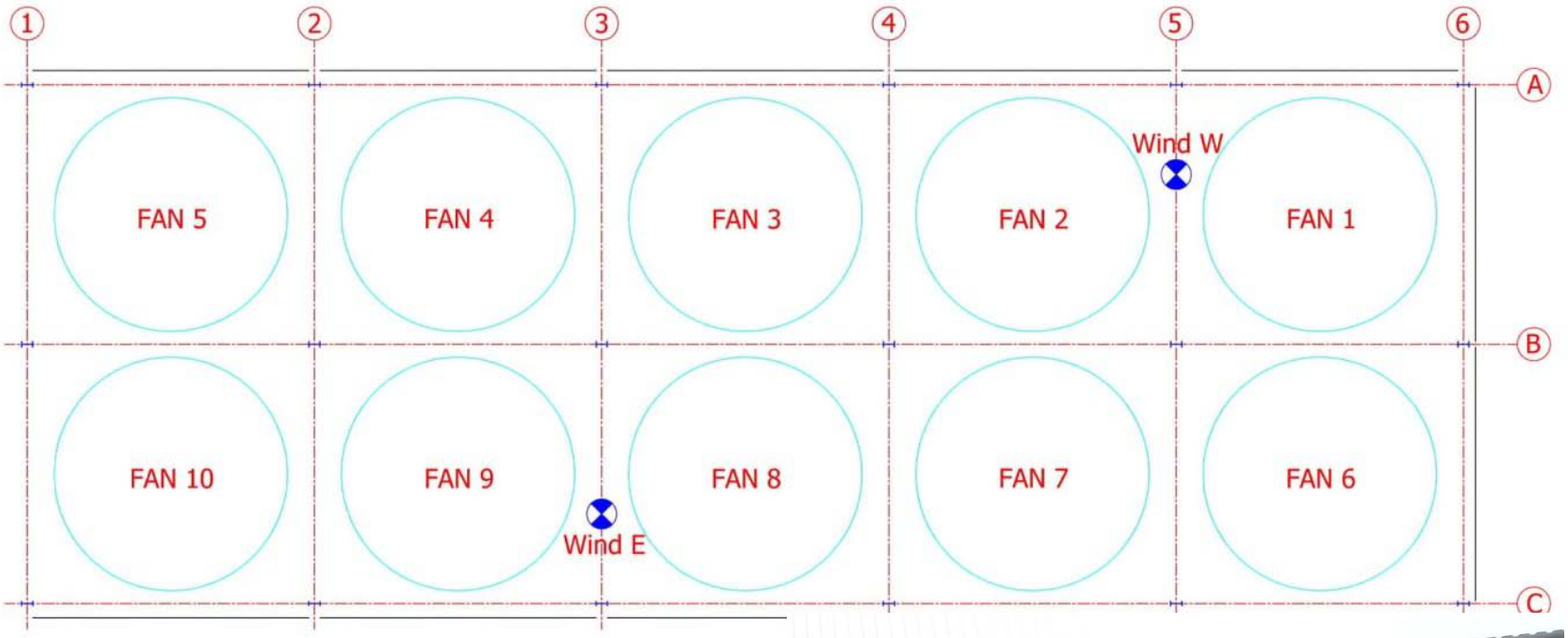
W indicates fence line wind speed and direction transmitter

Site North



ACC at NBEC with Galebreaker Wind Shields Installed

NBEC Ultrasonic Wind Sensor Locations



S

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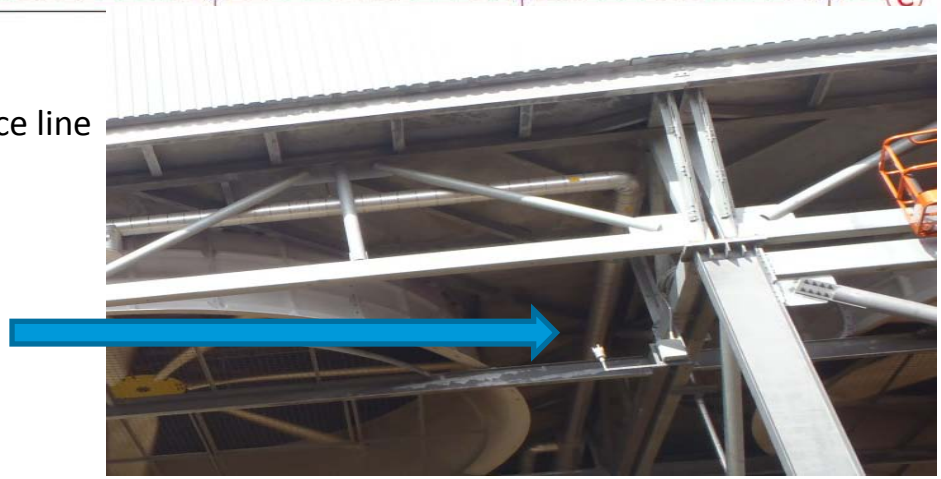
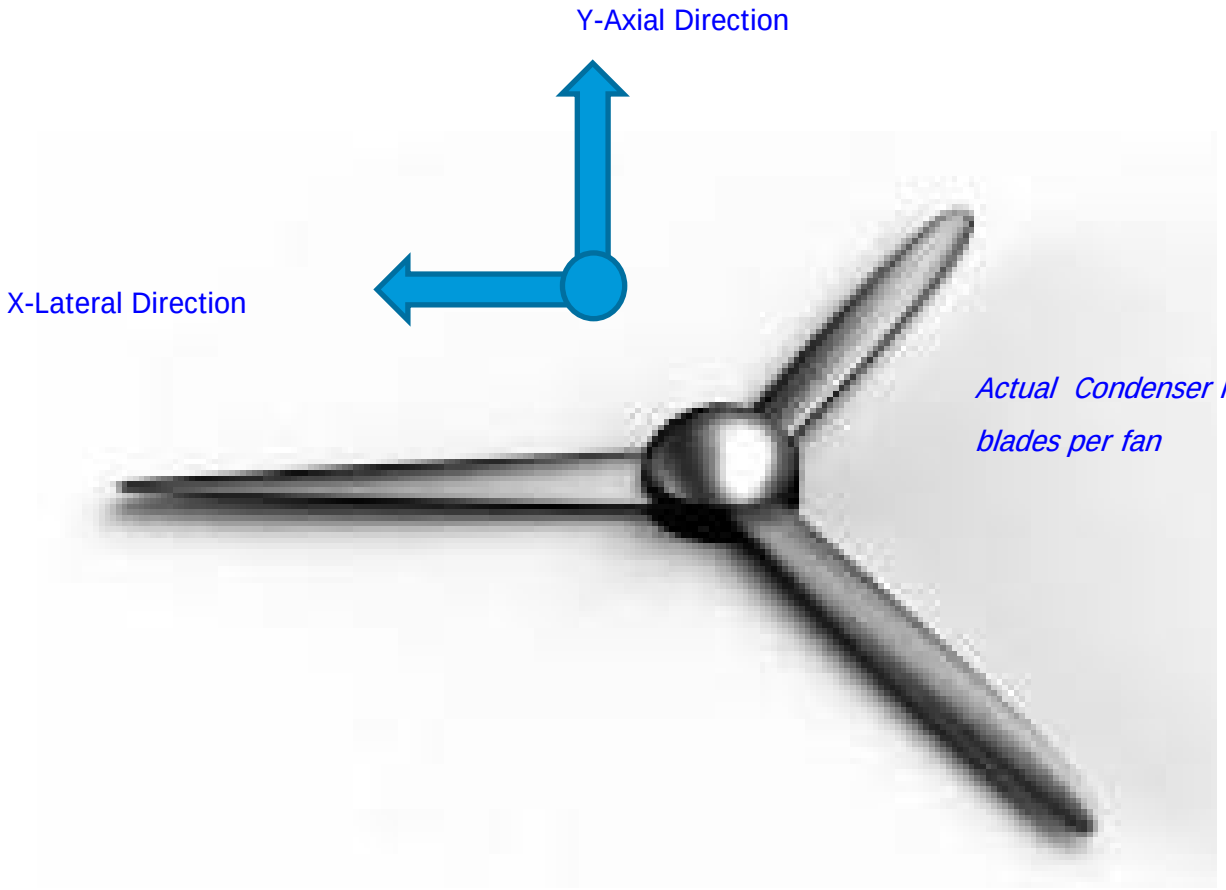
- Additional Sensor Installed at Perimeter Fence line
- Sensors are Vaisala Heated Ultrasonic
- NPI uses same sensors on its wind farms



NBEC Vibration (B-N) Probe Locations

- Probe Mounted on Gear Box

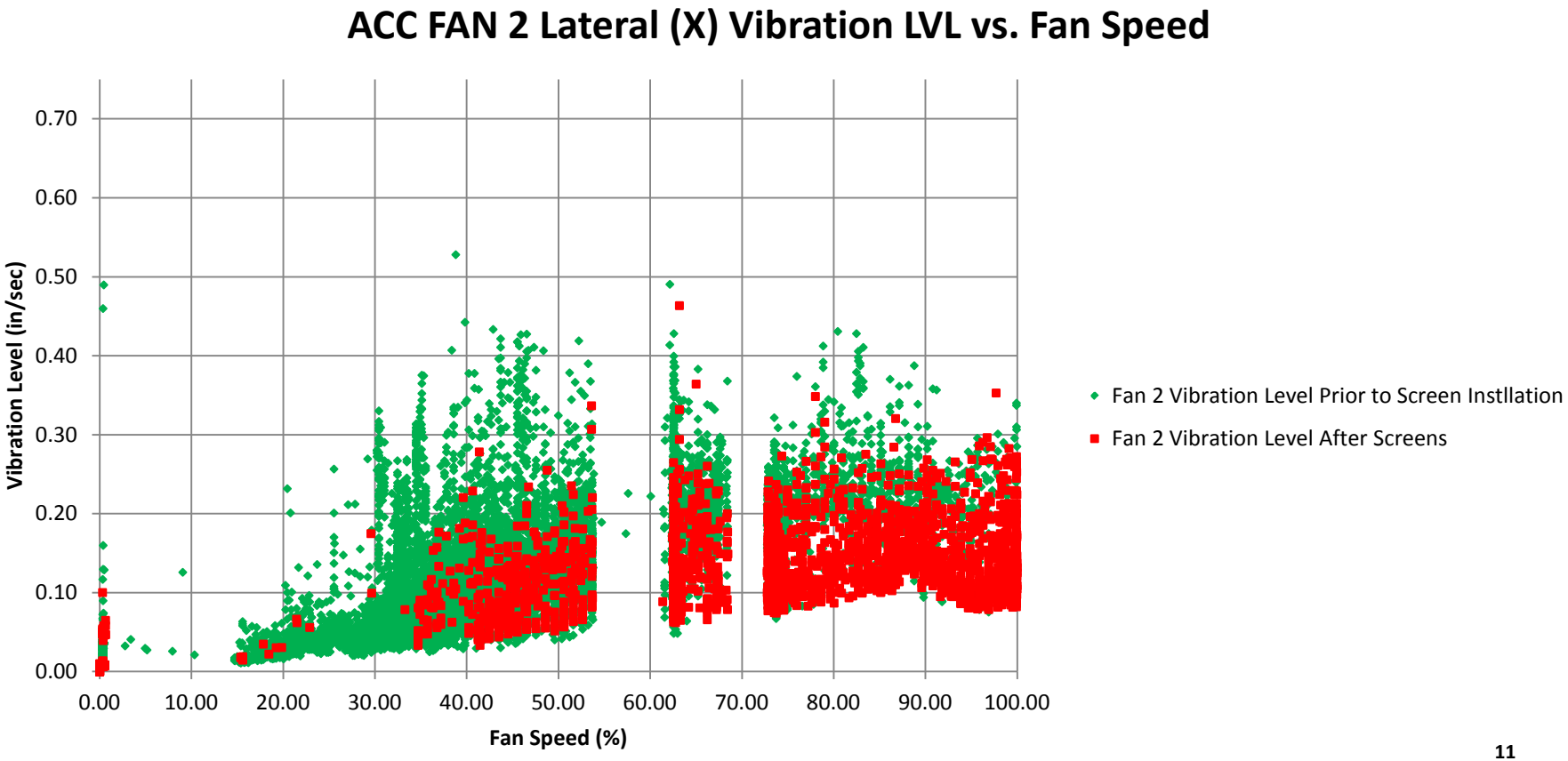


Vibration and Wind Data collection

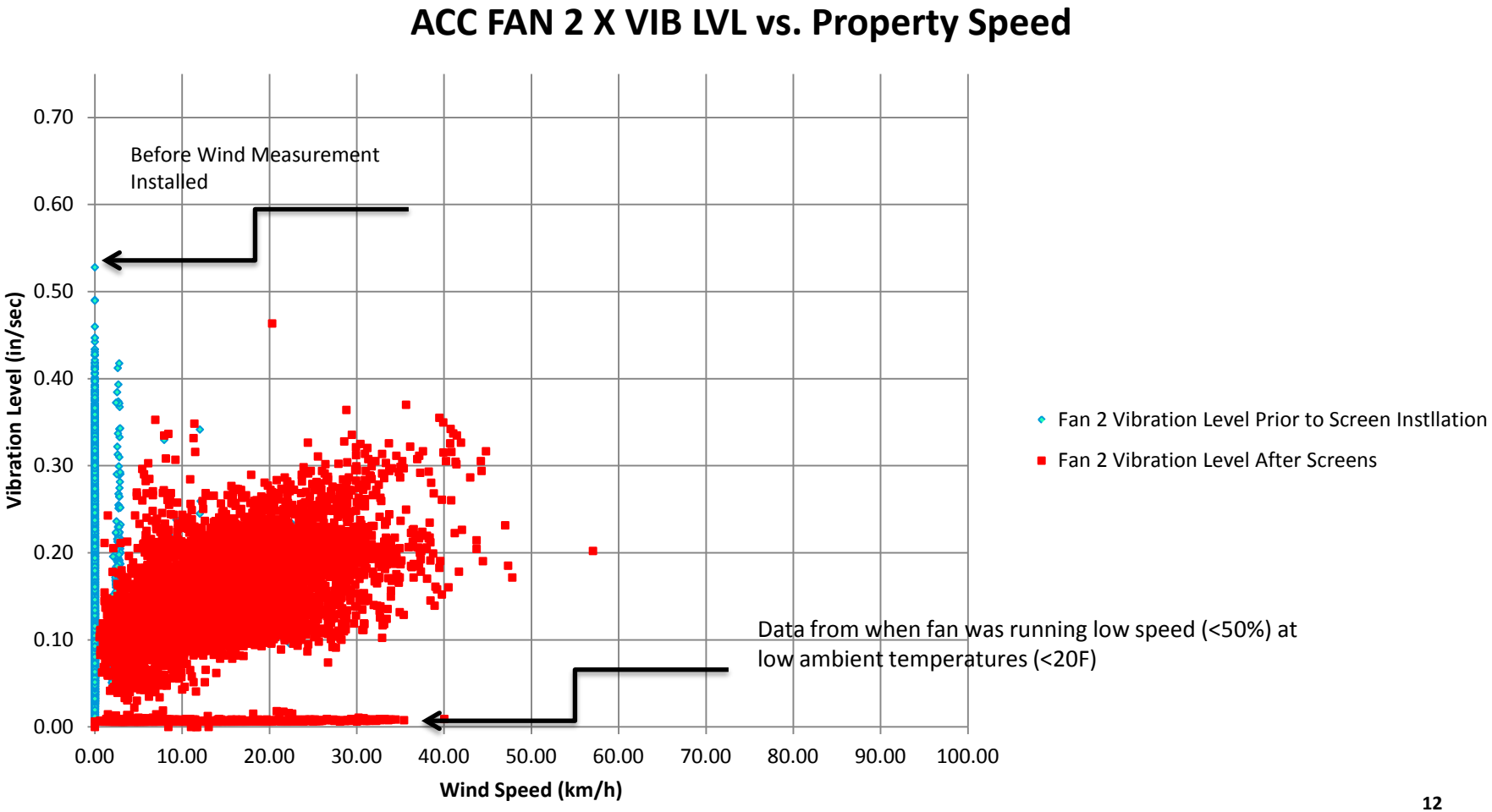
DCS Data polled every 15 minutes
(Every 1-5 minutes would have been better but data set size exceed capacity of MS Excel)
RESULT: We Don't see all the high vibration spikes and trips in the data capture, but we catch enough to get a picture)

Before Screens Jan 1 2014 – 3 May 2014
Wind Measurement Installed April 2014
After Screens May 12 2014 – 23 July 2014

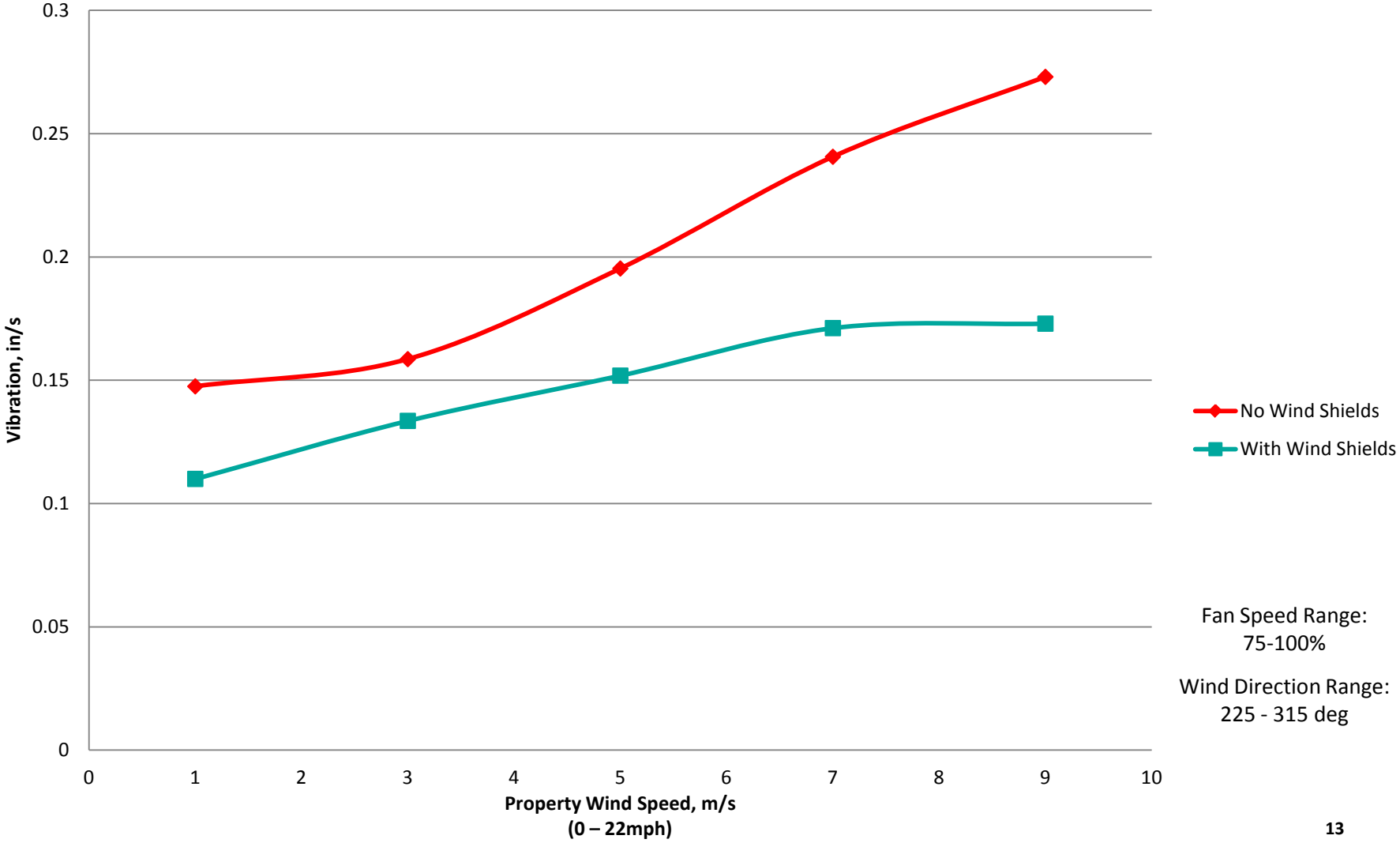
Vibration vs. Fan Speed



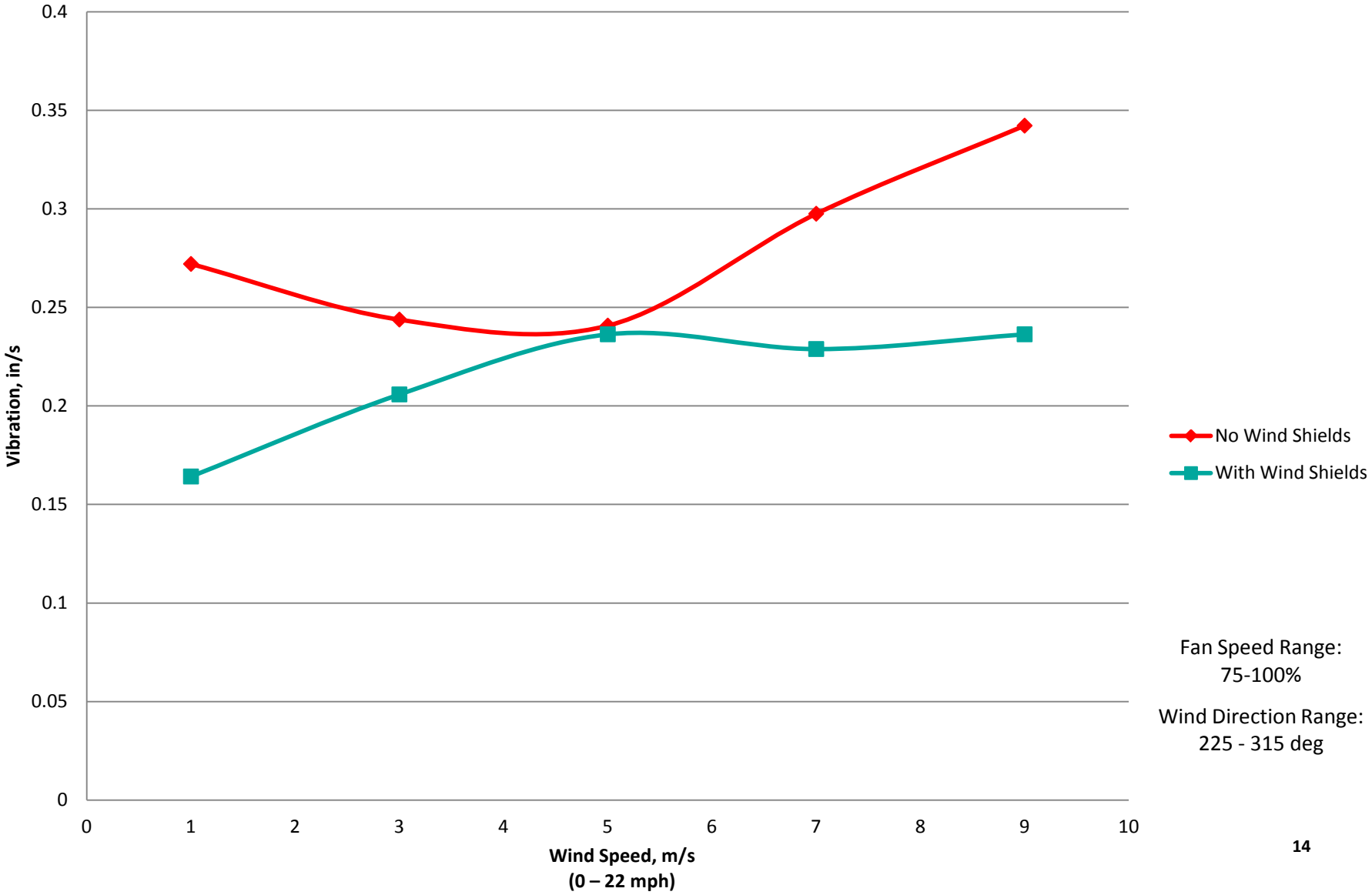
Vibration Vs. Wind Speed



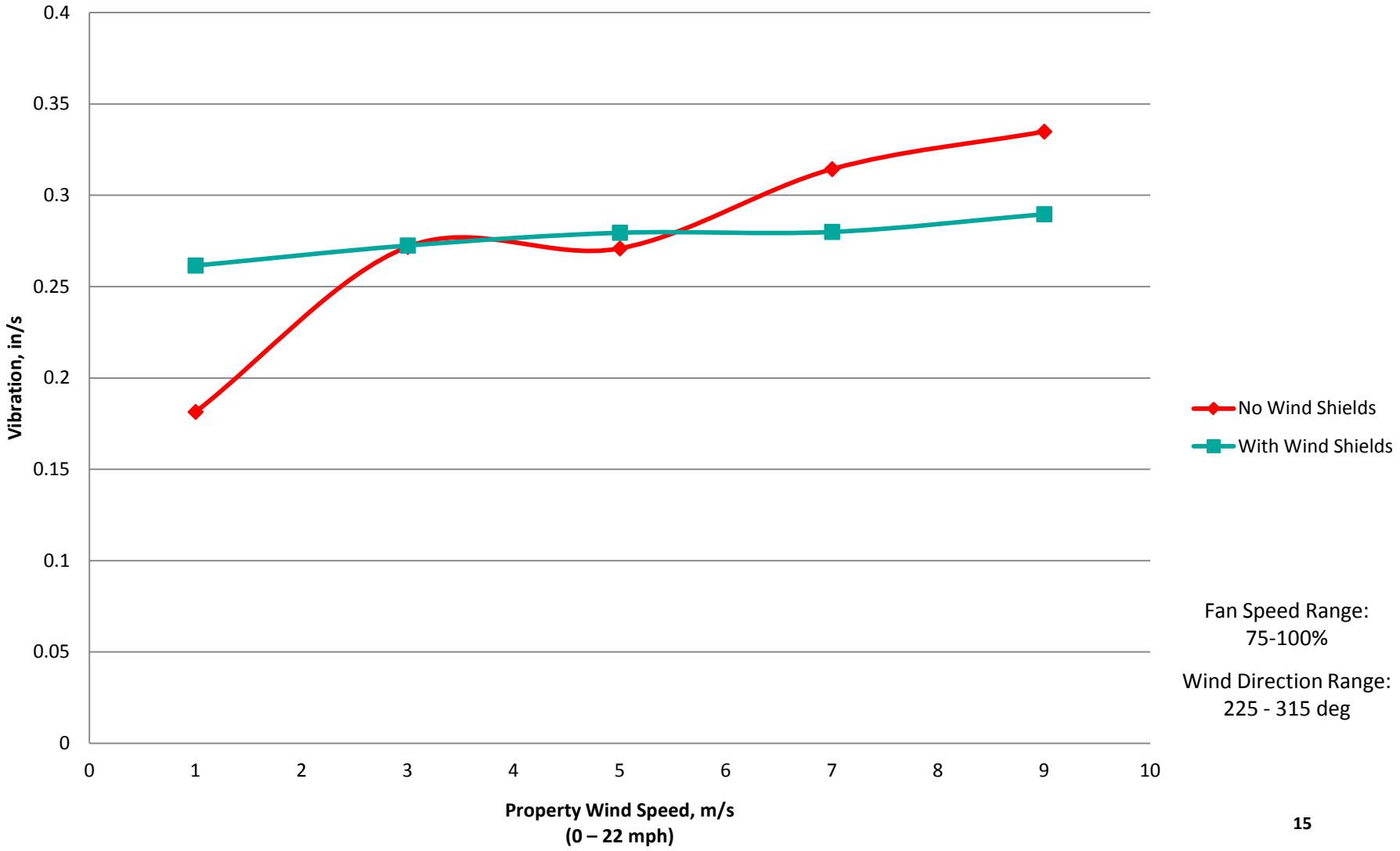
Fan 2: Mean Lateral (X) Vibration vs Wind Speed



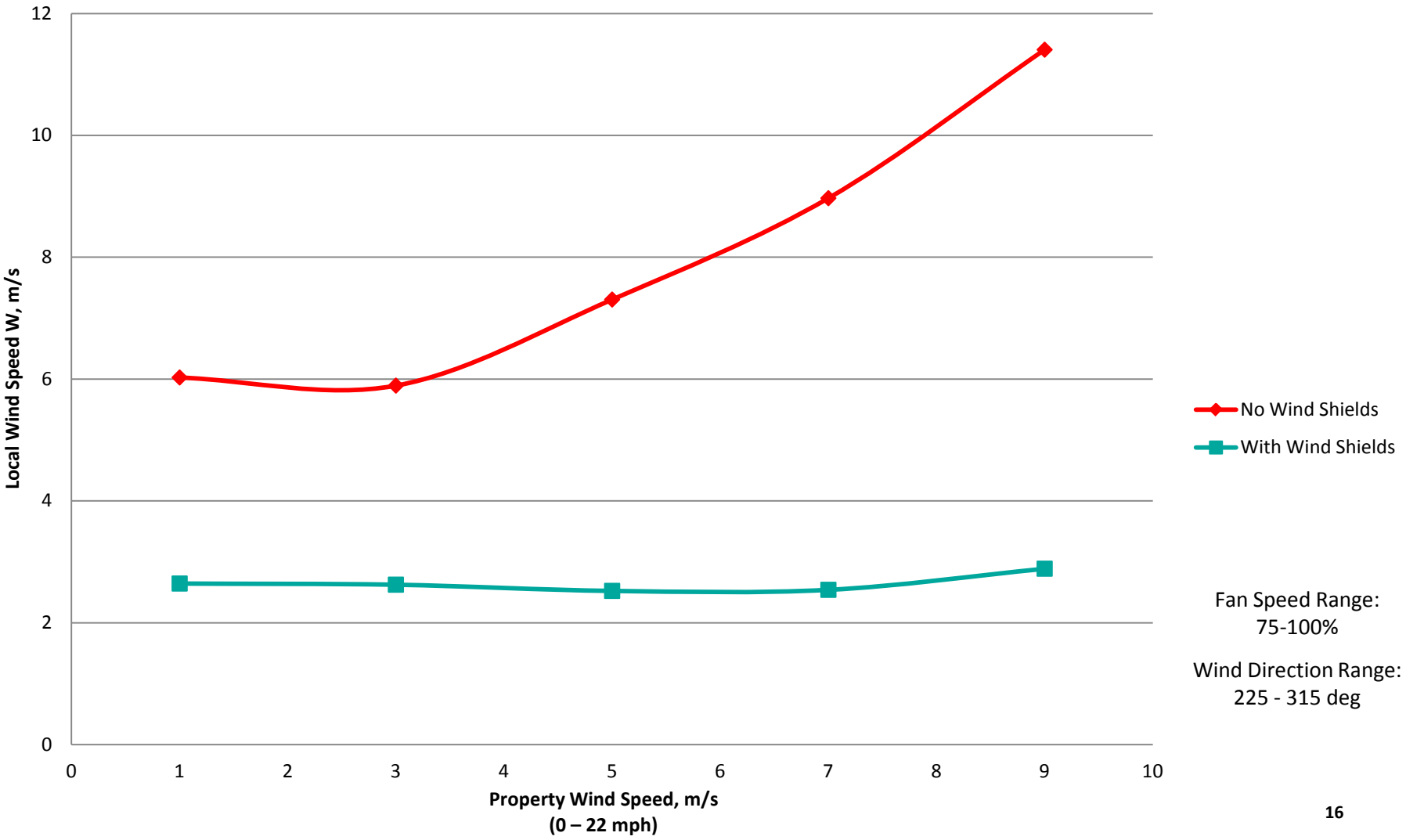
Fan 3: Max Lateral Vibration vs Wind Speed



Fan 2: Mean Axial (Y) Vibration vs Wind Speed



Influence of Wind Shield on Air Flow Speed under ACC



Summary Results of Wind Screen Installation

- **ZERO** fan trips since installing wind screen
- Horizontal vibration levels have been reduced approximately 25% and spikes reduced dramatically
- Axial vibration levels have increased slightly on average, likely due to changes in axial loading
- Axial vibration is now closely correlated to fan loading
- Negligible thermal performance impact observed

Other Design/Maintenance Issues and Actions Taken

Gear Oil Heaters

- Gear oil heaters were not designed to provide heat flux in the range recommended by gear oil providers
- Supplied flux was >15W/sqin
- Heat Flux recommended by oil suppliers <5W/sqin
- Gearboxes removed by supplier and cleaned, replaced all seals and bearings
- New heaters installed going from 1 to 6 per unit with flux density ~5W/sqin

Moisture

- Larger desiccant breathers installed with guard bed to protect desiccant from oil fouling

Gear Box Seals

- No change in seal design has been performed at this time (and seals continue to leak from input and output shaft seals), no bearing or pump failures have occurred since the overhaul of gear boxes but root cause of this was carbon coke caused by excessive heat flux

Other Vibration Related Actions Taken

- Blocked speed ranges have been implemented to stay away from observed resonant frequencies (this prior to wind screen as seen in data)
- It has been observed and measured that the fan blades have a natural frequency corresponding to operating conditions at several speeds and that blades delivered do not match supplier's desired/specified natural frequency range (ie. desired was above operating speed)

Further Actions To Be Done or Under Consideration by NPI

- Assess New Vibration Levels over Winter 2014/15 when Fan Speeds are reduced when winds are higher
- Re-perform On-site Vibration Assessment for further improvement ideas including a gear box vibration dampener and redesigned motor support between motor and gear box
- Retain a Structural Engineer to model the entire structure for vibration sensitivity, especially fan deck and support for fans, motors and boxes
- Review and consider changing seals to different design
- Moisture removing desiccant breathers upsized to last longer or supplied with dry air supply
- In future, ensure that vacuum design pressure is clearly stated on drawings to sub-vendors (this related to expansion joint buckling failure on start-up)

Discussion

- Should ACC's always have means to minimize AIR FLOW INDUCED VIBRATION?
- Should vibration be a specified/guaranteed parameter for ACC design?
- Given that wind screens have also improved performance (ref. ACCUG 2013), should they be used on all ACCs?
- What do ACC fan suppliers (Howden, Tecsys, etc) think about the use of wind screens?