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EXHIBIT NO. 107

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WITNESS: Jeffrey Swartz

PARTY: Duke

DESCRIPTION: Harry Carbone spreadsheet

DOCUMENTS: Bates DEF-19FUEL-000430-433

PROFFERED BY: Office of Public Counsel

Bartow Combined Cycle steam turbine (or BCC aka BRR) Sequence of time, by year and blade run periods vs issues

	Year	Month	Significant event / Comment	Blade Type
	2007			
	2008			
Period 1	2009	Jan	Unit went in commercial operation CC	Type 1
	2010			
	2011			
	2012	Feb	Damage found on 1 row & replaced 1 row	Type 1?
Period 2	2012	April	1 row original 1 row new	
	2013			
	2013	Nov	No significant additional damage found Scheduled outage for redesigned blade install with strain gages (10 x life expected from fretting fatigue with redesign)	
Period 3	2014	Dec	1st redesigned blades installed, both rows	Type 3 w/ snub hard face
	2015			
	2016	April	Found damage and installed 2nd redesign	
Period 4	2016	June	2nd Redesign installed both rows	Type 3 w/ snub & tip hard face
	2016	July	Experienced 1st Vibration step changes	
	2016	Oct	Found 3 missing air foil section, while inspecting for source of possible mass loss. Installed Period 1 style blades	
Period 5	2016	Dec	Since redesigns were driving shorter intervals with less high flows operations, Decision was made to return to blade type used in period 1 that gave ~ 3+ yrs. service	Type 1
	2017	Jan	Experienced Blend event and projectile damage to burst diaphragm	
Period 6	2017	April	Found snubbers missing on one end. Like damage found Feb '12 (that was un-noticed when it happened) because liberated material penetrated burst disk this event. Source of projectile to burst disk was liberated snubber tip. Removed L-0 blades ran with pressure plate.	No L-0
	2018		Experienced Cracks in LP inner case supports caused by pressure plates	
	2019			
Period 7	2019	~ Oct	Outage planned to remove press. plate and install Type 1 blade upgraded for 80% stress reduction (20% stress w/ same loadings). With Blade Vibration Monitoring System, to alert high blade motions and possible high stresses.	Upgraded Type 1
	2019	~		

HMC 3-27-19 rev

	Most Likely Failure Mechanisms	Contributor(s)	Failed rows/ replaced
Period 1 Jan 09 Feb 12	**Inadequate design margins** for intended application. High steam flows may have contributed to contact face motion and subsequent fretting. Blends or transients likely spiked the snubber contact stresses and started cracks at the fretted contact surfaces. Cracks then grew with running stress, or a combination of high cycle and low cycle events until the sharp toes of snubber ends were liberate without incident or notice. Damaged snubbers were discovered during outage related visual inspection.	• High energy blends • Longest run period • Longest time with high steam flows • Rotor vibration was very low	• 1 failed / 1 replaced
Period 2 Apr 12 Nov 14	No failures occurred during Period 2, RCA not applicable.	• High energy blends • Very few hrs at high steam flows • Poor hood spray pressure • Curtain sprays on long periods • Rotor vibration was not as good as Period 1.	• 0 failed/2 replaced • Both rows were replaced with design improvement #1. • Theory indicated 20% less stress because of contact shape changes and 10X life from hard-face coating.
Period 3 Dec 14 Apr 16	**Inadequate design margins** for intended application and the 1st OEM design improvements (hard-face on snubbers) caused even less design margin without the OEM realizing what was happening. OEM indicated high steam flows significantly contribute to fretting of contact surfaces, but snubbers **did not** fail. High steam flow may have accelerated fretting on tip z-lock contact surfaces. Blends or transients may have spiked stresses and started a contact surface corner crack that grew with run stress, then liberated tip corners without notice while running. Damage was unknown until visual inspection found the unexpected conditions.	• High energy blends • Very few hrs at high steam flow • Poor hood spray pressure • Rotor vibration required field balance, but rotor did not run as well as Period 1	• 1 failed/2 replaced • 1 failed z-lock contact on one blade forced row replacement. Both rows were replaced with design improvement #2. • Since it appeared snubbers were improved hard-face was added to z-lock tips as well.

HMC 3-27-19 rev

	Most Likely Failure Mechanisms	Contributor(s)	Failed rows/ replaced
Period 4 Jun 16 Nov 16	**Inadequate design margins** for intended application and the 2nd OEM design improvement (hard-face on the z-lock as well as snubber surfaces) allowed significantly less contact area and reduced vibration damping. High steam flows **did not** contribute to contact face fretting of snubbers or tip z-lock contact surfaces. Blends or transients may have spiked stress and started a crack that grew with run stress. The life limiting crack started in the trailing edge of the air foil inches from the end of the blade. This crack initiated and grew within 30 days and liberated a large section of the air foil that caused a vibration step change. An inspection to find a possible cause of mass loss discovered three blades with similar airfoil sections missing. Two step changes in vibration were observed so two sections may have liberated together, or one section was in a position that did not significantly change the residual unbalance vector.	• High energy blends • Very few hours at high steam flow. Zero hours at high steam flow before first mass loss. • Poor hood spray pressure • Rotor vibration was high	• 2 failed /2 replaced • 2 missing airfoil sections at the tip on one row and 1 missing section on the other side forced replacement of both rows.
Period 5 Dec 16 Feb 17	**Inadequate design margins** for intended application. High steam flows did not contribute to contact face motion. A high energy blend likely spiked the contact stresses and started snubber cracks. These then grew with running stress, via high cycle fatigue until the sharp toes of snubber ends liberated. Less than 1 hr after the significant blend incident, the condenser back pressure started to increase. A small hole was subsequently found in one of the burst disk relief diaphragms. Once the disk was removed, it showed a projectile like penetration from the inside. Snubber damage was then discovered as the likely cause of disk penetration. 10 to 12 snubber toes on one end were found missing. These failures were like Period 1 but in this case one liberated toe exited through the diaphragm. Had that random damage not occurred, the incident would have gone unnoticed like Period 1.	• High energy blend, failure happened < 1hr after a high energy blend incident. • No hours above steam flow limit.	• 1 / removed both L-0 rows, • added pressure plates.
Period 6 Apr 17 (current period) Fall 19	L-0 blades replaced by Pressure Plate. Sonic velocity steam thru Pressure Plate holes caused exit area acoustic energy and likely shock waves that cracked hood spray piping, ladders. And cracked four corners support plates ~ 1 ½" thick.	• High sonic energy that induced high cycle fatigue cracks in support plates, hood spray piping, instrumentation piping, and access ladders.	• 0/ 2 (no L-0 blades had to add two rows) • Blend logic improved and automated. • All unnecessary hood spray piping, instrumentation piping, and access ladders were removed. Reinforcements added to cracked support plates.

	Most Likely Failure Mechanisms	Contributor(s)	Failed rows/ replaced
Period 7 Fall 19 - (TBD)	Upgraded 40" blade with 80% dynamic stress reduction (20% of previous stress). Cold at rest contact clearance geometry that allow faces to have flat contact in operation. This results in better surface contact and more damping. Beefed up snubber and z-lock structure to prevent surface cracks from propagating if they occur. Continuous Blade Vibration Monitoring system to ensure blades operate within design deflection limits with steam flow loading and unit blending.		

We did believe that the 1st OEM design improvement with a 20% stress reduction and hard-faced snubbers (which was backed by bench tests at 10x life improvement) were adequate design improvements to accept this solution. We achieved about a 3-year life in Period 1, and 10x on that plus 20% less stress would likely provide the intended life. This was also followed by field strain gage testing that showed acceptable stress and frequencies as found in the shop testing. The stress exception was the excitation of 16th nodal diameter frequency (about 200 hz) that was evident in the field data at higher steam flows, but not excited in the shop test. The risk mitigation for this was to limit condenser back pressure at higher steam flows.

The 2nd OEM design improvement included hard-facing the z-lock tip contacts and geometry changes since the previous improvements worked well on the snubbers. What was overlooked on both design improvements was that these addressed the symptoms, but not the cause. The cause was inadequate stress design margins in the snubbers and z-locks. While the paper studies would show lower stresses, field experience was showing the contact surfaces having misalignment and point contact thus effectively lowering contact surface area and damping and increasing dynamic stresses. Very likely blade processing, welding, flame spraying hard-face etc. were slightly changing contact clearance geometries such that achieving the conditions assumed in calculations were not achievable in actual installations. This allowed higher dynamic stresses, less margins for fatigue and wear, shorter blade life (the time between blade changes decreased) even while operation at higher steam flows was greatly reduced. In other words, the more the design was "improved", the shorter the actual blade life was.

The spring 2018 proposal of 80% reduction in dynamic stress, or running at 20% of previous stress level, is consistent and appropriate for root causes that conclude inadequate design margins as the root cause. The caution is that the claimed dynamic stress reduction is only supported by calculations, computer models, and experience with blades for 50 hz units.

It is essential that we trust but verify the 80% reduction in dynamic stress with shop testing. The installed instrumentation, BVM (Blade Vibration Monitor), is our safety net and insurance that the blades are operated within design limits. If we get good correlation in the factory data between blade movement and actual blade life limiting stresses, we will be able to determine proactively if there are operating conditions that are subjecting the blades to conditions they were not designed for. If the test data are discovered to not be as expected, this needs to be investigated and resolved prior to installation of the blades in the unit in fall 2019.