ACC Users Group Annual Meeting 2017

Ivanpah Solar Thermal Facility ACC Review

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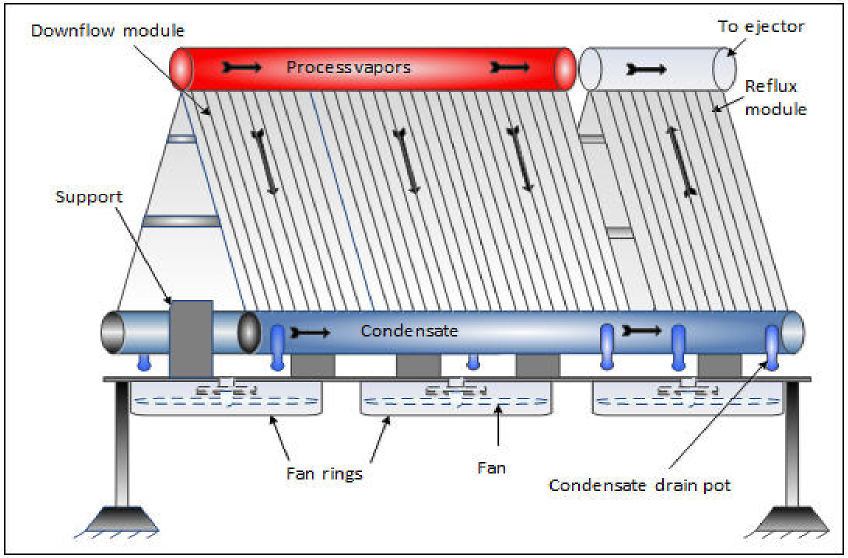
Ivanpah ACC SPX

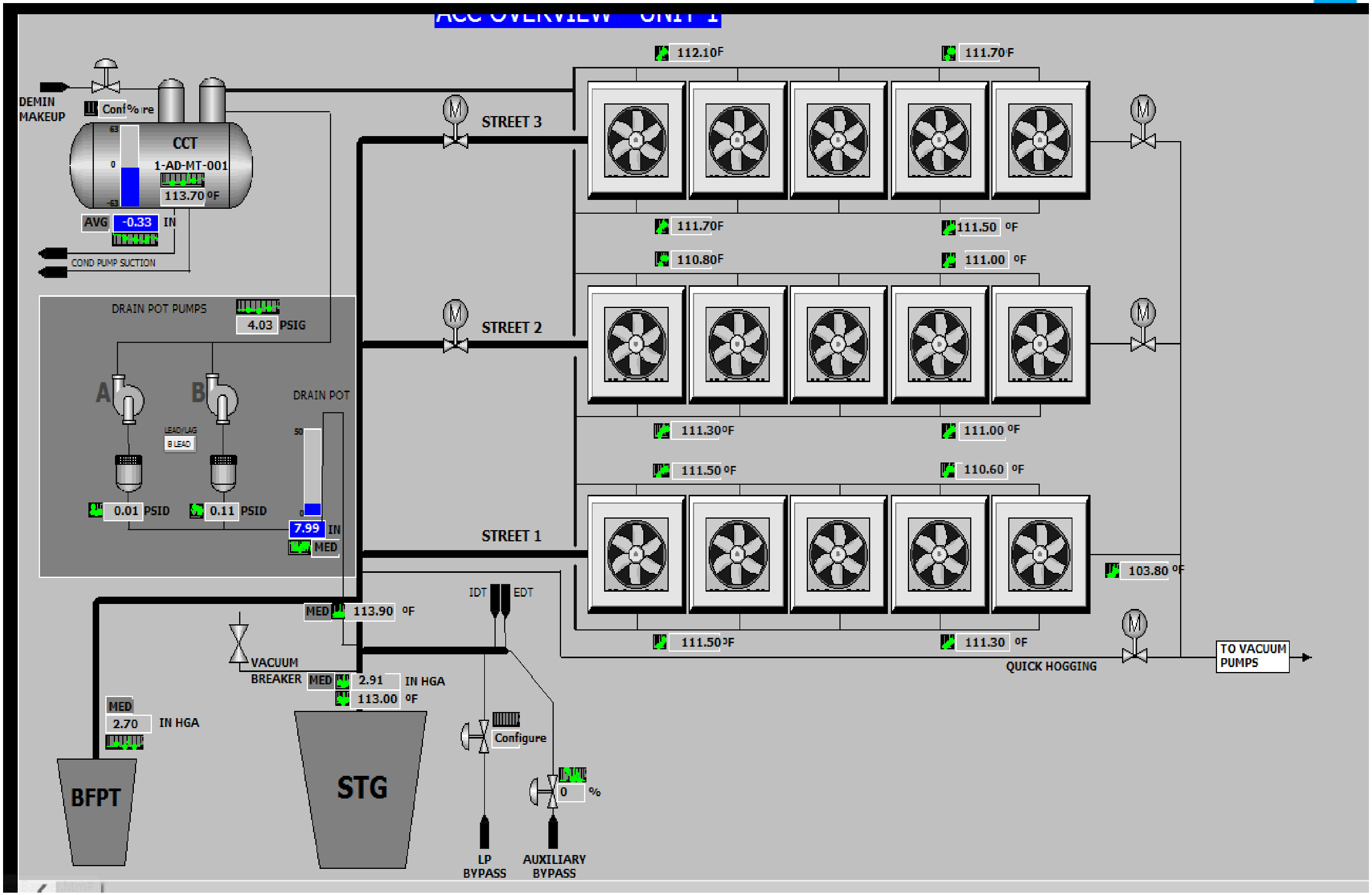
- Design specifications
- Steam flow 702,147 lb/hr
- Turbine back pressure 3.52 inHga at ambient temp 83F
  - 26.9 in Hga at an altitude of 3,182 ft above sea level
- Total volume of 125,541 cuft
- 3 streets/ACC 57 primary tube bundles and 6 secondary tube bundles
- 5 fans per street (max 85 rpm)
  - 36' diameter
  - 9 blades each
- Gear box reduction ratio 20.9 to 1



Ivanpah Solar Thermal Facility

Nipton, California

Operating Conditions



Maintenance-Internal Inspection

- TED, steam distribution manifolds
  - System surfaces looked good-*chemistry program effective*!!
- Steam bypass diffusor had a support that was dislodged from the ACC duct

Maintenance-He Leak Testing

All units have been showing a reduction in vacuum, causing a decrease in Megawatt production. In efforts to maximize the vacuum on the systems, systems were checked for air in leakage.

- Found the main boiler feed pump (MBFP) had the largest leak at the gland steam seals and trip/throttle value
- Turbine bearings—only through gland steam condenser
- Aux steam supply line (small leak)
- Several areas in the vacuum pump skids

**VS Agilent Leak Portable leak detector with He gas supply

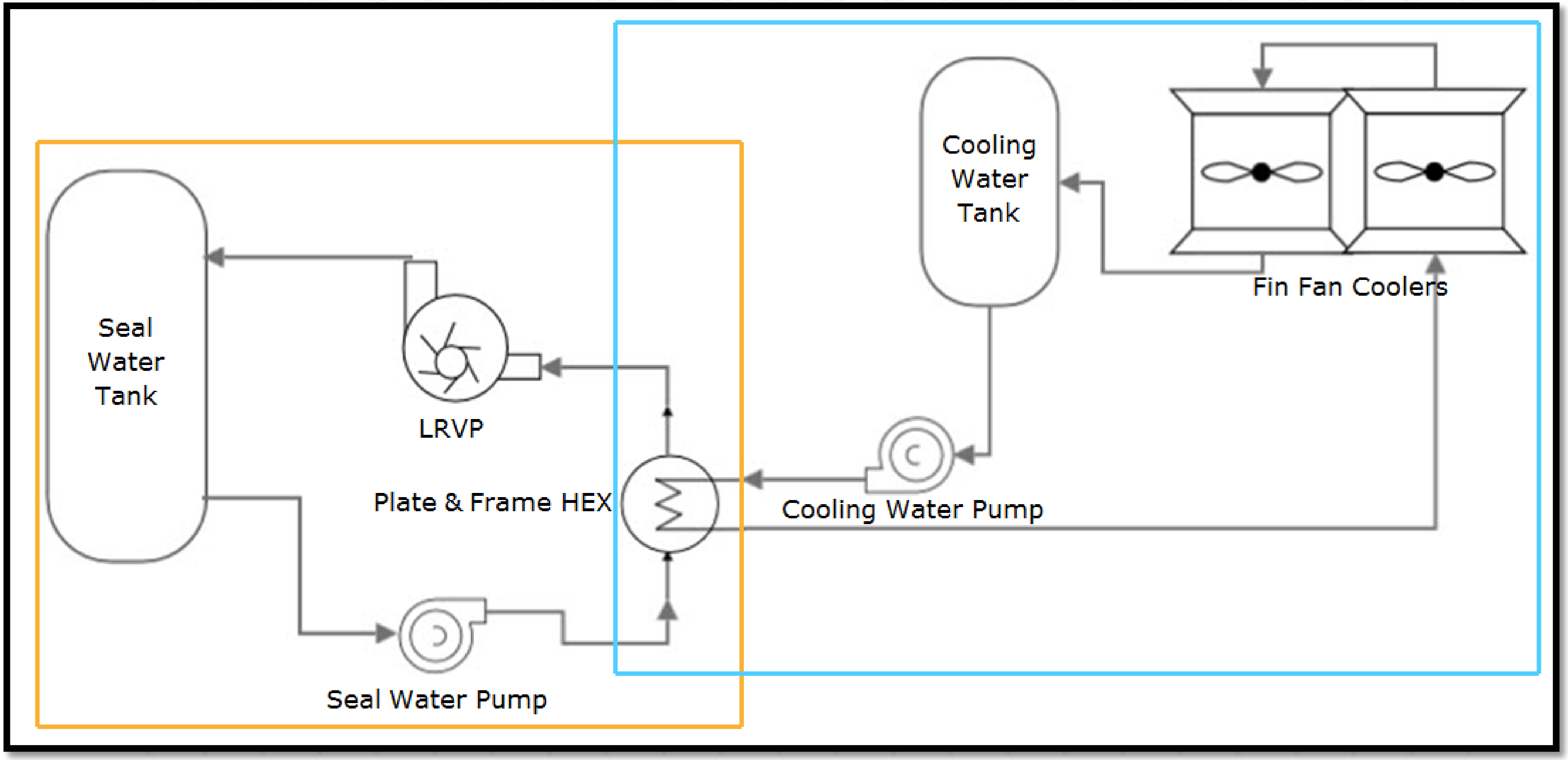
Ivanpah Liquid Ring Vacuum Pump Optimization and Maintenance Project

First…A Little About Me

- South Jersey native
- Graduated from Lafayette College, PA in 2016 with a B.S. in Chemical Engineering
- Moved to the Las Vegas area in February 2017 for a job opportunity at Ivanpah

- ***First big job assignment:***
  - Lead the optimization efforts surrounding Ivanpah's liquid ring vacuum pumps (LRVPs)

LRVP System at Ivanpah

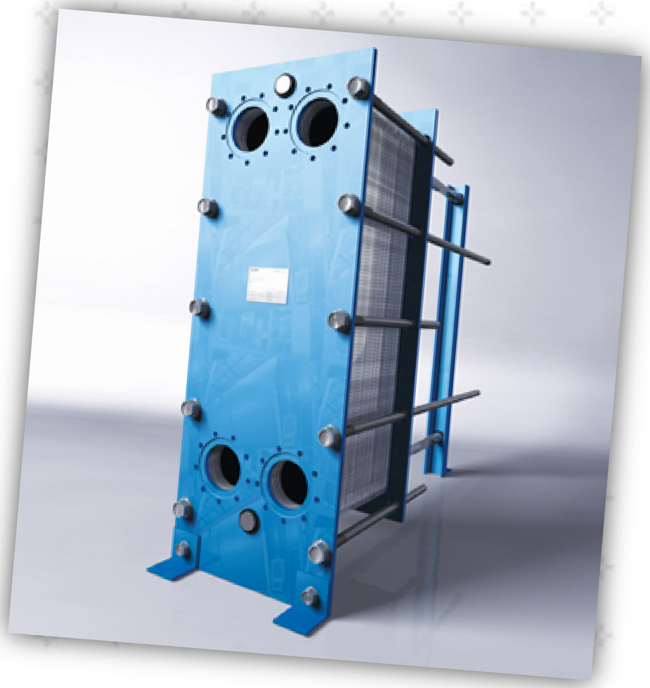


Seal Water Side

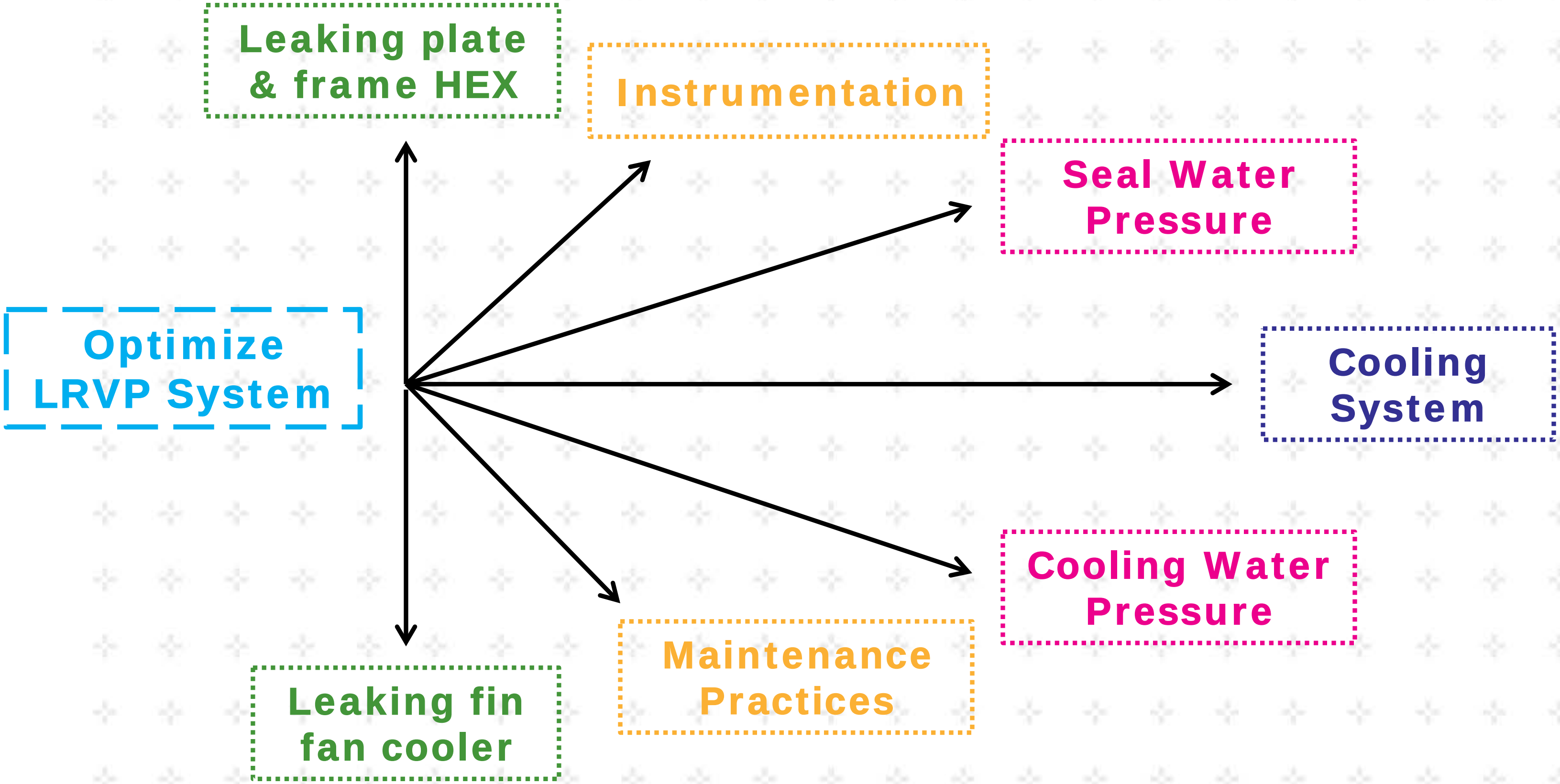
Cooling Water Side

Initial Task…

- Improve LRVP cooling system to reduce temperature alarms and increase pump efficiency, particularly in the summer months



Opening Up Pandora's Box



Although all six vacuum pump skids were designed identically, each exhibit different behavior, making troubleshooting challenging.

LRVP Action Items List

1. Install evaporative swamp coolers on fin fan coolers
2. Expand and clean plate & frame heat exchanger
3. Determine appropriate cooling medium in cooling water loop for summer and winter seasons
4. Install critical instrumentation throughout system (i.e. – pressure gauges, flow meter)
5. Reposition and/or replace existing instrumentation (e.g. – level gauge on cooling water tank)
6. Clean fin fan coolers
7. Add isolation valves to plate & frame heat exchanger
8. Develop “Equipment Health Plan” for vacuum pump system

Completed Items

1. Install evaporative swamp coolers on fin fan coolers
2. Expand and clean plate & frame heat exchanger
3. Determine appropriate cooling medium in cooling water loop for summer and winter seasons
4. Install critical instrumentation throughout system (i.e. – pressure gauges, flow meter)
5. Reposition and/or replace existing instrumentation (e.g. – level gauge on cooling water tank)
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Outstanding Items

1. Install evaporative swamp coolers on fin fan coolers
2. Expand and clean plate & frame heat exchanger
3. Determine appropriate cooling medium in cooling water loop for summer and winter seasons
4. Install critical instrumentation throughout system (i.e. – pressure gauges, flow meter)
5. Reposition and/or replace existing instrumentation (e.g. – level gauge on cooling water tank)
6. Clean fin fan coolers
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Performance Analysis: Evaporative Swamp Coolers

	Unit 1		Unit 3	
	LRVP A (swamp cooler)	**LRVP B (none)**	**LRVP A (swamp cooler)**	**LRVP B (none)**
Cooling water temperature **entering** fin fan cooler #1 (°F)	113	120	102	117
Cooling water temperature **entering** fin fan cooler #2 (°F)	108	118	98	116
Cooling water temperature **exiting** fin fan cooler #2 (°F)	102	114	95	112
Degree of cooling $(T_{cw,\ in} - T_{cw,\ out})$ (°F)	***11***	***6***	***7***	***5***

****Note:*** *No data available before swamp coolers were installed on LRVP A. Although minor differences in performance may exist between pumps A & B, data was collected at the same ambient conditions for the most direct comparison.*

Utilizing swamp coolers to deliver cooler air to the fin fan coolers significantly reduces the temperature of the cooling water.

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Performance Analysis:
Plate & Frame Heat Exchangers

	Unit 1		Unit 2		Unit 3	
	LRVP A	LRVP B	LRVP A	LRVP B	LRVP A	LRVP B
Seal water approach temperature ***before*** (°F)	5	2	4	2	4	2
Seal water approach temperature ***after*** (°F)	2	2	3	0	1	3

****Note:*** *Performance data was collected at similar operating conditions, however, slight variations in ambient temperature may affect the accuracy of results.*

All but Unit 3 B's plate & frame heat exchanger demonstrate a better seal water approach temperature—and therefore better performance—after expanding and cleaning them.

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Performance Analysis:
Cooling Water Tanks

After filling the cooling water tanks to maximum capacity, all of the cooling water pressures and flow rates are not only stable, but closer to their design parameters.

Conclusions

- Importance of instrumentation to properly diagnose problems
  - New additions (e.g. – pressure gauges, flow meter)
  - Modifications to existing instrumentation (e.g. – level gauge)
  - Replacing broken instrumentation (e.g. – temperature gauges)
- Routine maintenance equally vital to equipment success
- System headed in the right direction, but still requires enhancing to optimize its performance
- Largest on-going challenge: keeping the cooling water side as cool as possible during the summer months
- *Continuous LRVP improvement ultimately benefits ACC performance!

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Thank You!