AIR COOLED STEAM CONDENSER TEST LABORATORY

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Outline

- Why test the heat exchangers?
- Small scale water testing
- Small scale steam testing
- Large scale steam testing
- Product improvements

Why Test the HX?

- The thermal performance of the ACC has a direct impact on the power generation.
- Temperatures and pressures inside the ACC must be predicted accurately to meet or exceed the forecast power generation.

Why Test the HX?

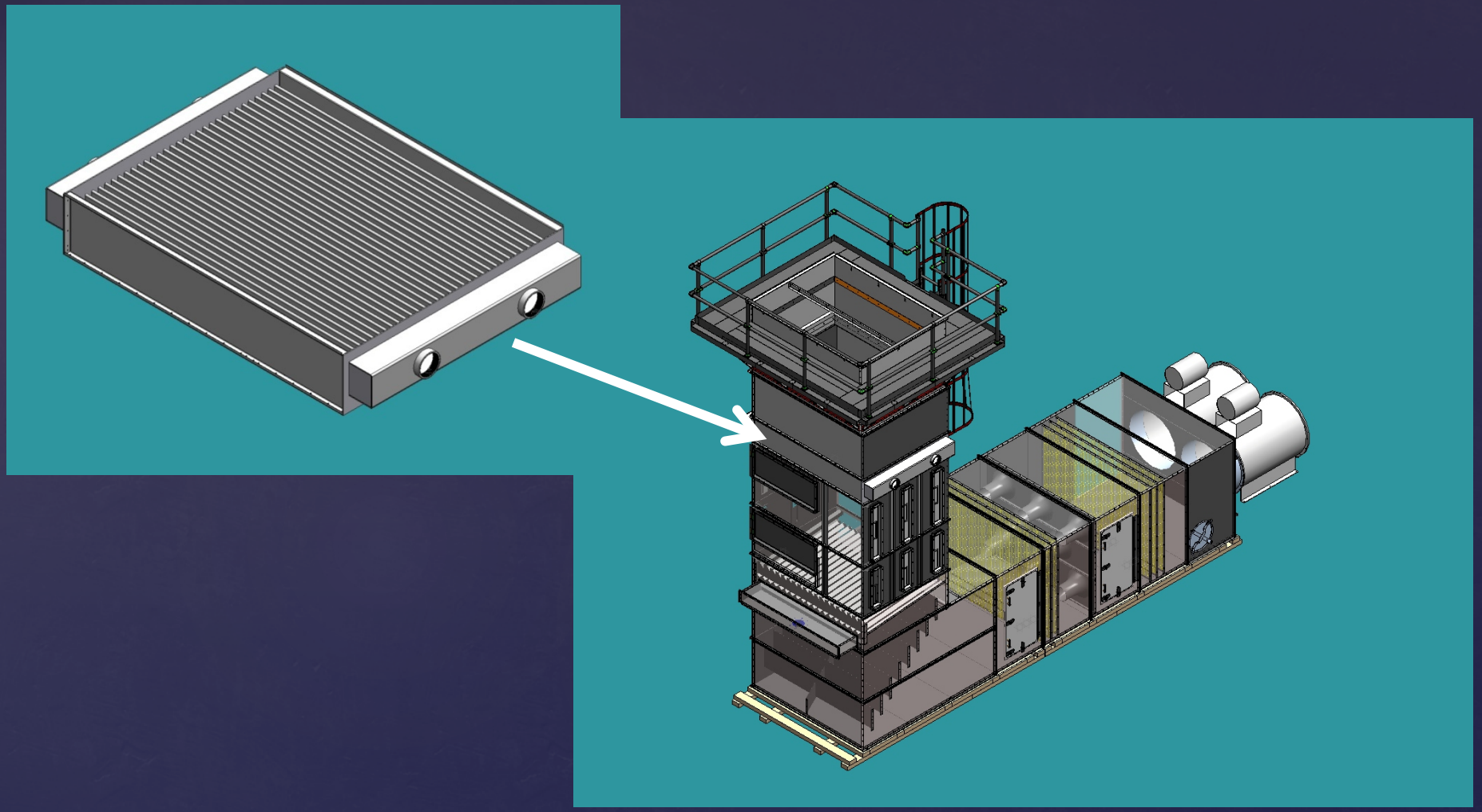
- ACC are the largest power consumers in a power plant.
- It is important to find ways to reduce the parasitic power losses due to the ACC.

Heat Transfer Knowledge

- Computation of heat transfer in the steam HX has 3 main components:
  1. Condensation inside the tube.
  2. Conduction through the tube wall and the fins.
  3. Convection between the fins and the cooling air.

Small Scale Water Test

- Relatively quick and easy method to find the air side heat transfer coefficient.
- Test small scale HX in a wind tunnel.
- Heated water flows inside the tubes.
- Measure water and air temperatures, flows, air-side pressure drop.



6′ x 8′ HX in Wind Tunnel

Water Test Shortcomings

- In a steam condenser the internal temperature is relatively constant along the length of the tube.
- The changing temperature of water along the tube length is not representative of ACC conditions.
- Provides no information on the condensation heat transfer inside the tube.

Small Scale Steam Testing

- Shorter tubes have less condensing capacity than longer tubes.
- Less condensing capacity equates to lower liquid and vapor flow rates in the shorter tubes.
- The internal heat transfer coefficient and the pressure drop are dependent upon the liquid and vapor flow rates.
- Small scale testing does not experimentally represent the heat transfer coefficients or the internal pressure drops that occur in full scale tubes.

Large Scale Air Cooled Steam Condenser Lab

Design Goals

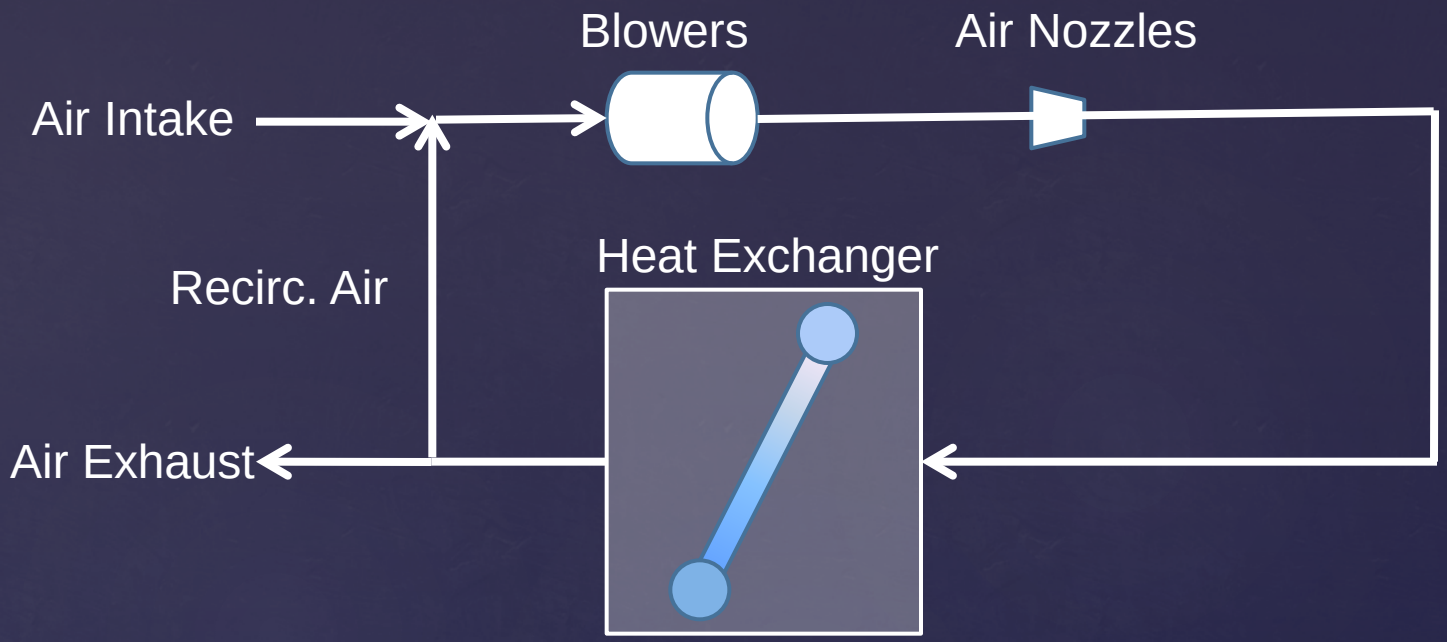
- Test large scale ACC HX condensing steam.
- A wide range of operating conditions.
- Configurations of interest.
- Accurately measure ACC thermal performance.

Test Large Scale ACC HX Condensing Steam

- HX Width up to 2.4 m (8 ft).
- HX Length up to 11 m (35 ft).
- Generation capability of over 1.3 kg/s (10,000 lb/hr) of saturated steam under vacuum at temperatures up to 65ºC (150ºF).

A Wide Range of Operating Conditions (Air Side)

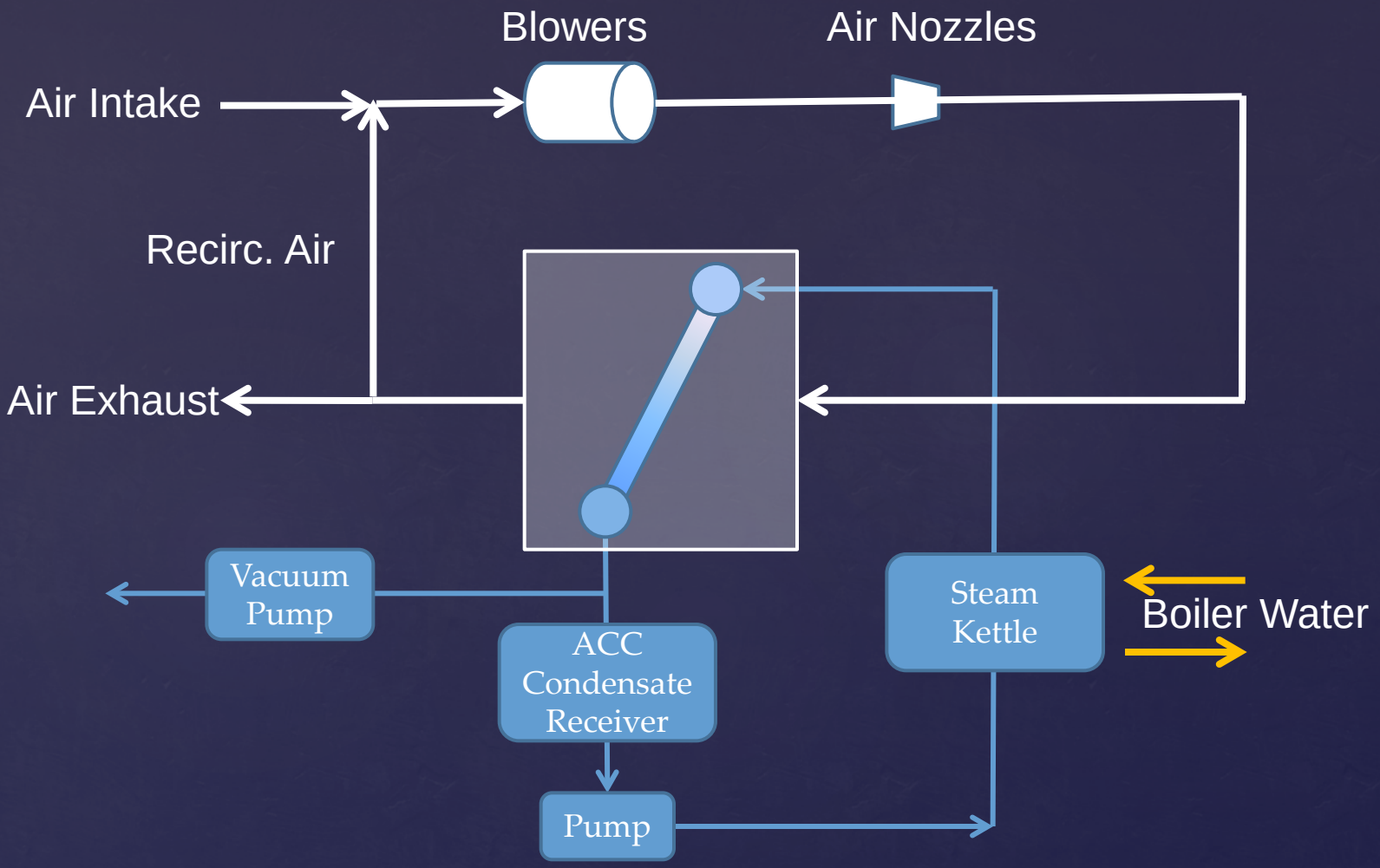
- Inlet air temperature: -12 to 49 °C (10 to 120 °F).
- Inlet air velocity: up to 4 m/s (800 FPM).



Wind Tunnel With Inlet Air Temperature Control

A Wide Range of Operating Conditions (Steam Side)

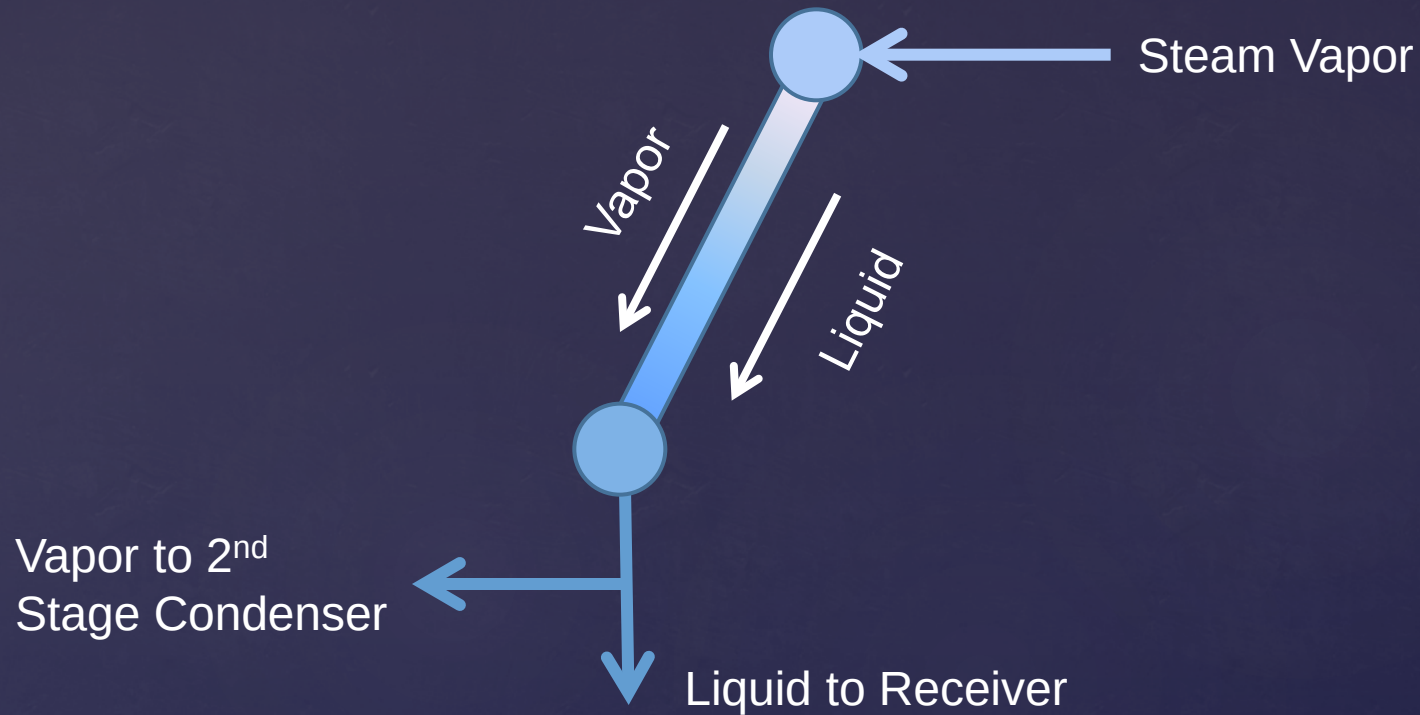
- Condensing Pressure: 50 to 260 mbara (1.5 to 7.7 inHga)
- Condensing Temperature: 33 to 65 °C (91 to 150 °F)
- Steam Load: 0.13 to 1.3 kg/s (1000 to 10000 lb/hr)



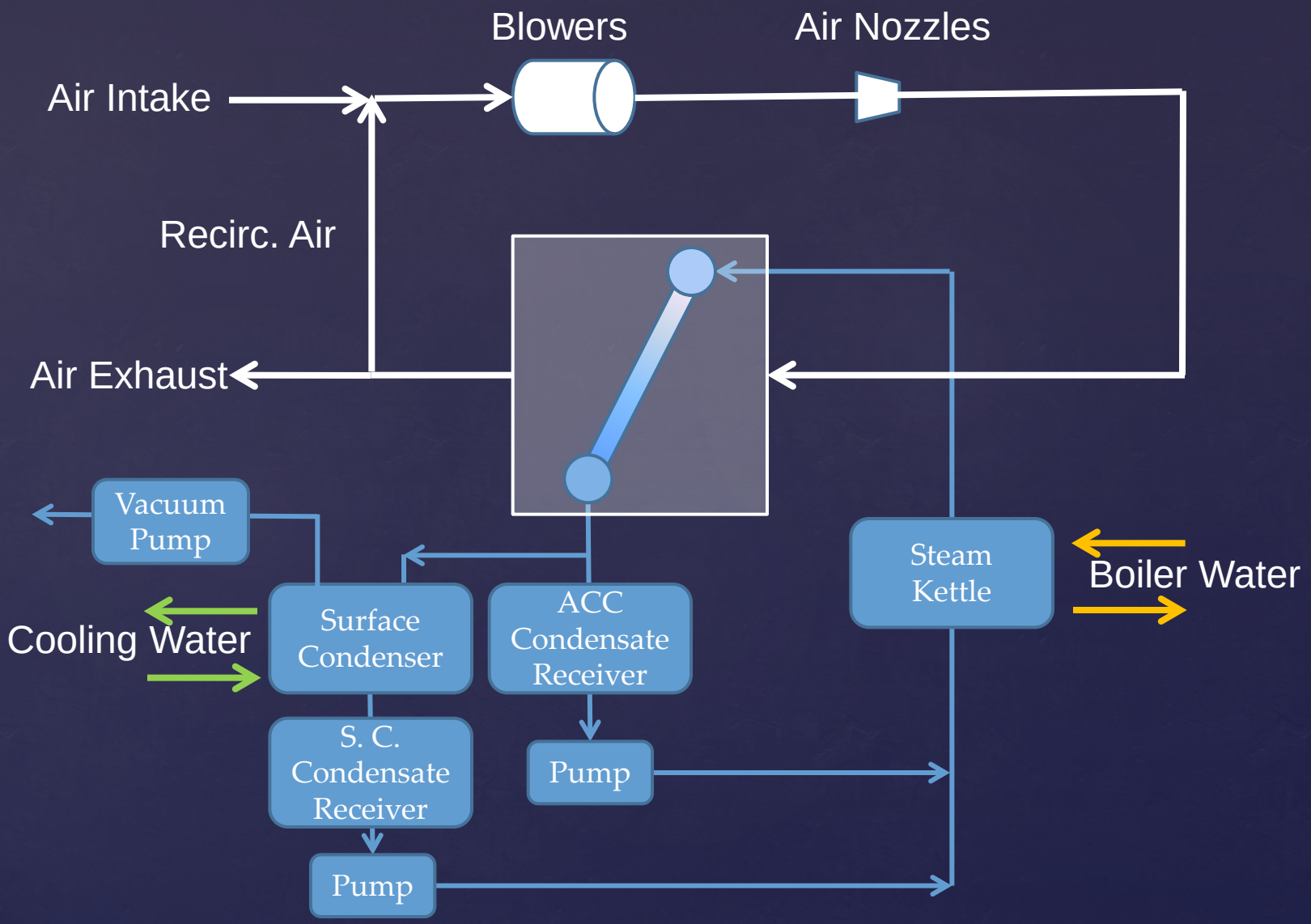
Steam Loop (Simplified)

Configurations of Interest

- 1st Stage Configuration (Concurrent Flow, K or condenser cell) with variable 2nd Stage capacity.



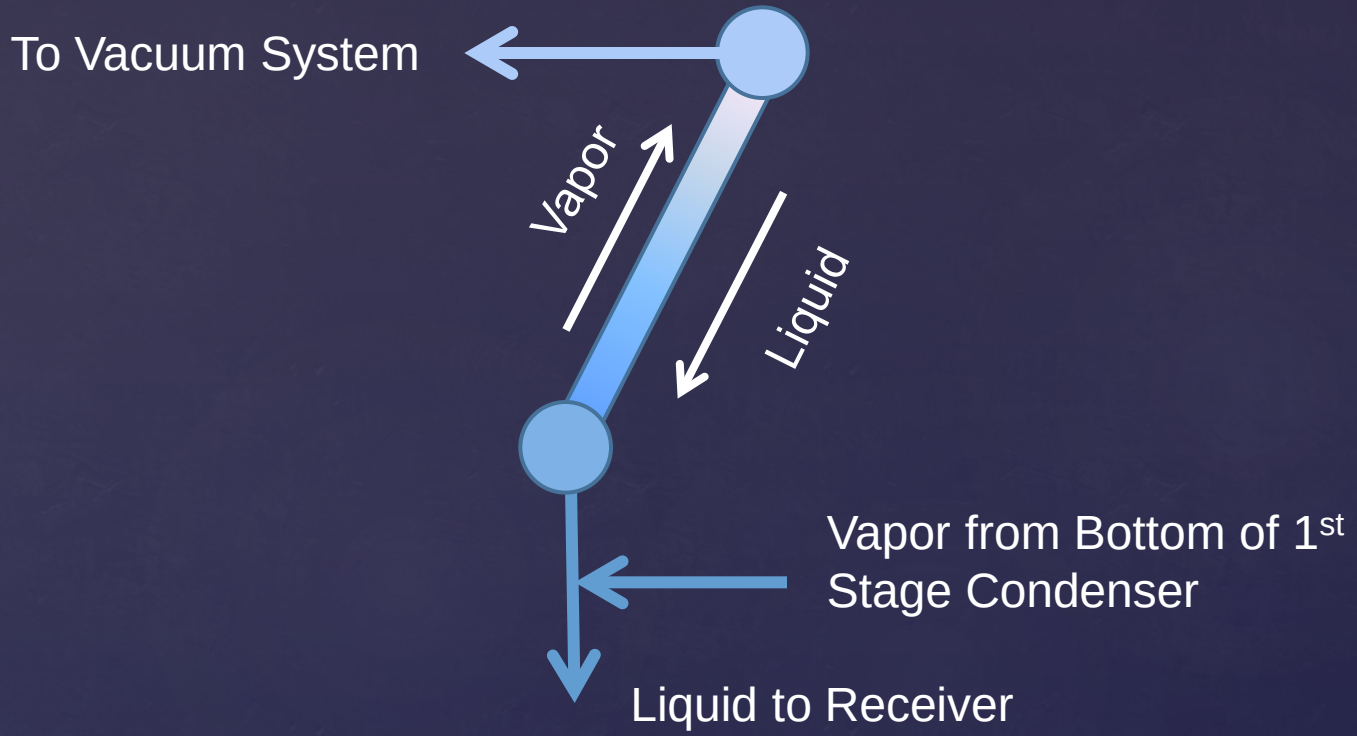
1st Stage Configuration: Concurrent Flow



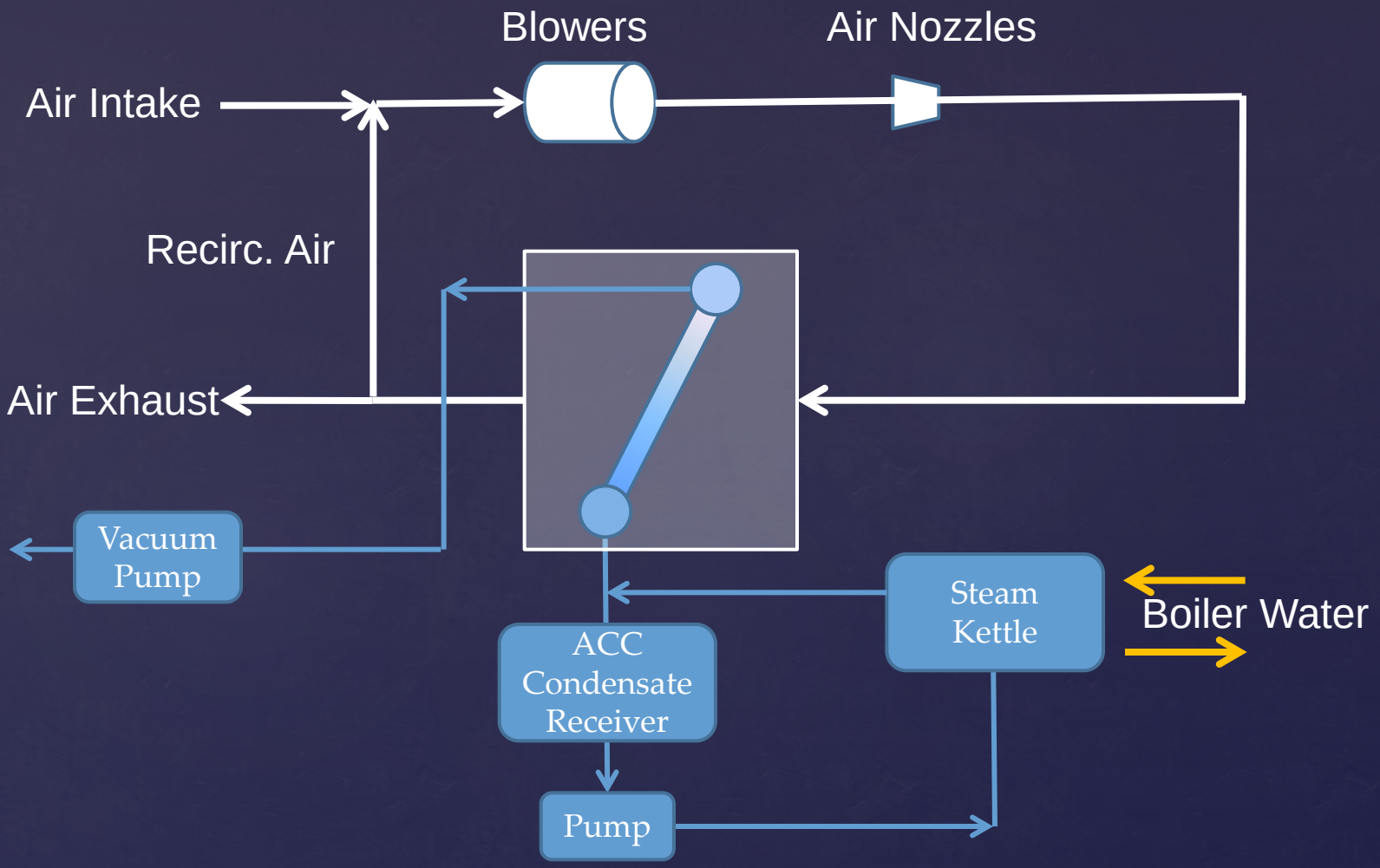
Steam Loop 1st Stage Config.

- 2nd Stage Configuration (Counter-Flow , dephlegmator or reflux cell)

Configurations of Interest



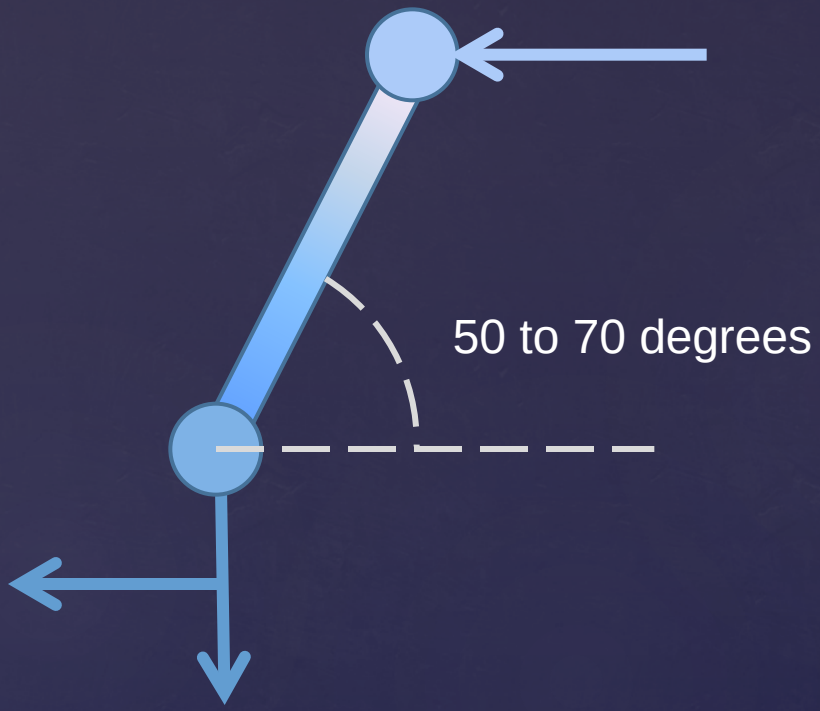
2nd Stage Configuration: Counter-Flow



Steam Loop 2nd Stage Config

- Installation Angle: 50 degrees to 70 degrees

Configurations of Interest



Installation Angle

Accurately Measure ACC Thermal Performance

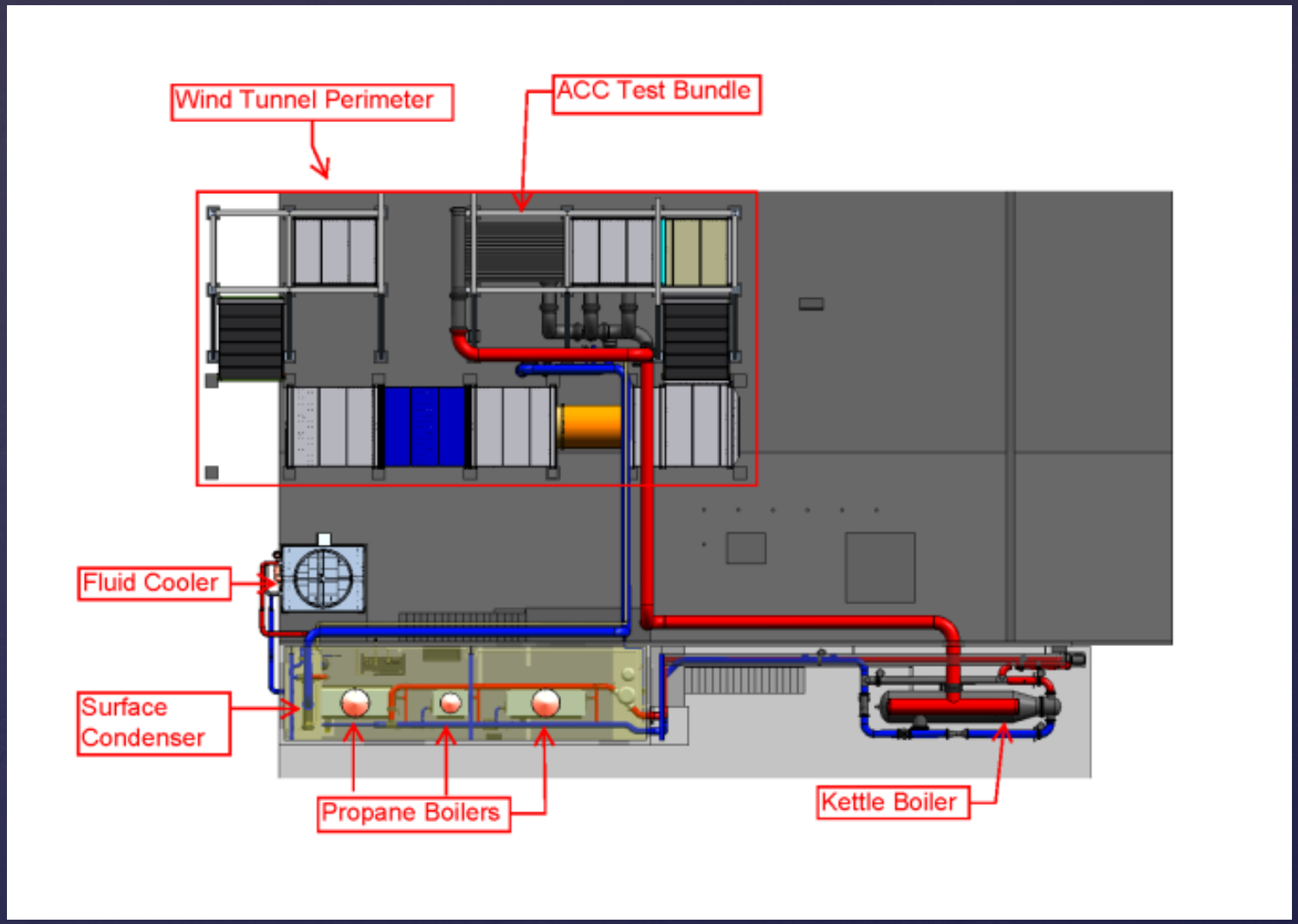
Measurements:

- Boiler Water Flow & Temperatures.
- Steam Temperature and Pressure (HX In & Out).
- Air Temperature and Pressure (HX In & Out).
- HX Condensate Flow Rate, Pressure, and Temperature.
- Surface Condenser (2nd Stage) Condensate Flow Rate, Pressure, and Temperature.
- Air Flow Rate and Velocity Profile.

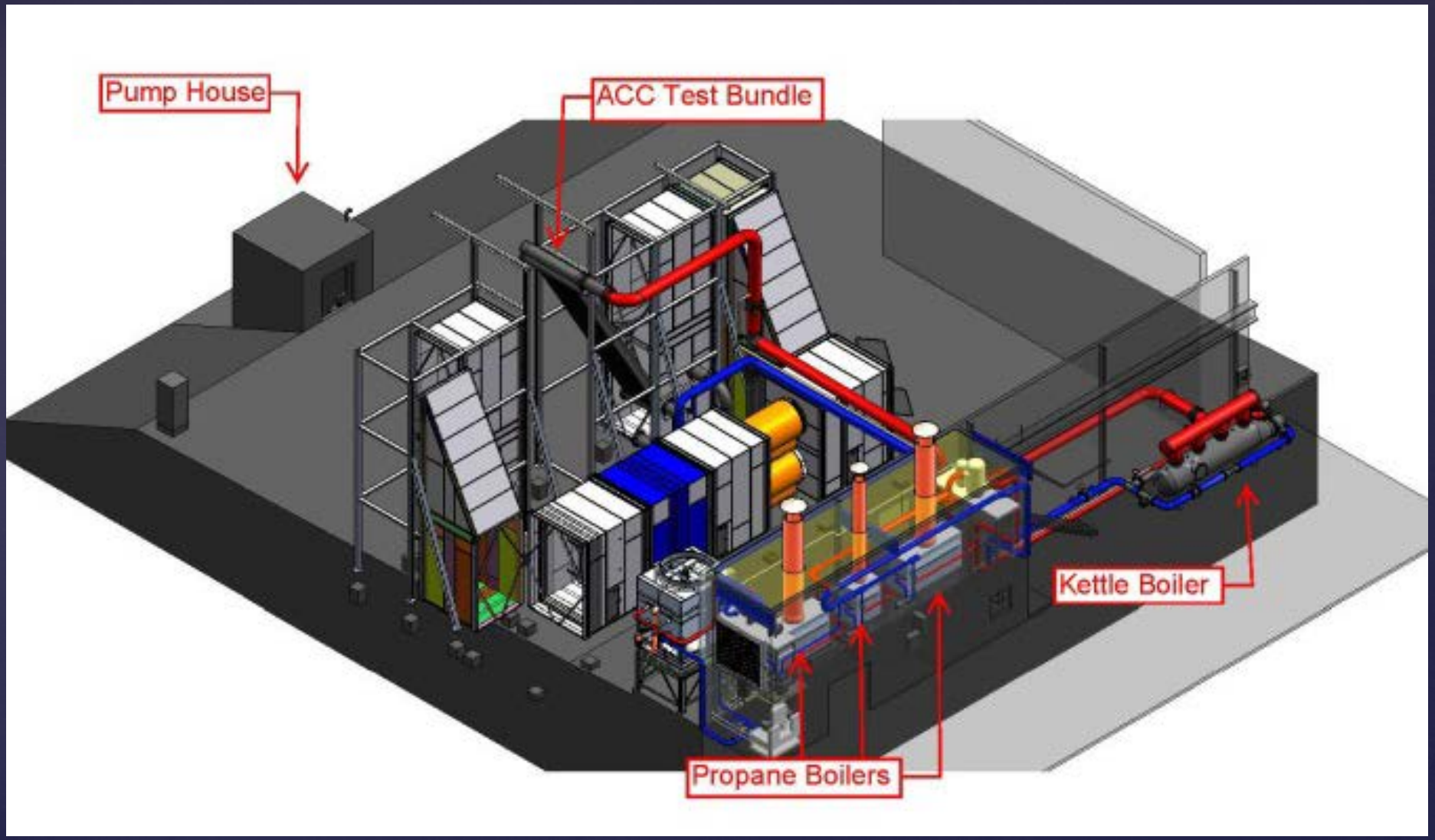
Accurately Measure ACC Thermal Performance

Analysis & Heat Balances:

- Boiler Load Calculation (Total Load)
- HX Steam Side Load Calculation
- HX Air Side Load Calculation
- Surface Condenser Steam Side Load Calculation (Steam vapor velocity at outlet of HX tubes).
- Surface Condenser Water Side Load Calculation.



Plan View of the Lab



3D View

Steam Lab Completed

Steam Kettle, ACC HX

Boiler & Control Rooms

- Tube Geometry
- Fin Geometry
- Materials of Construction

Product Improvements

Product Improvements

Air leakage and freeze prevention:

- Optimize the 1st stage /2nd stage ratio considering thermal performance and freeze prevention by studying the effects of injecting controlled flow rates of non-condensable gases.

Product Improvements

Erosion, corrosion:

- The lab is capable of generating low pressure high velocity steam under controlled conditions.
- Possible to study the causes of FAC and test solutions?

Conclusions

- Evapco has designed, built and commissioned a unique test lab to investigate ACC heat exchangers.
- One of a kind test lab with ability to test full size heat exchangers condensing steam under vacuum … conditions typically found in power plants.

Conclusions

- Ability to test and analyze multiple configurations.
- Ability to rate ACC heat exchangers with unprecedented precision and to guarantee performance.

Thank you!