ACC 360

SPG DRY COOLING

2024 ACC Users Group

Unlocking Efficiency:

Overcoming Subcooling Challenges in Air-Cooled Condensers

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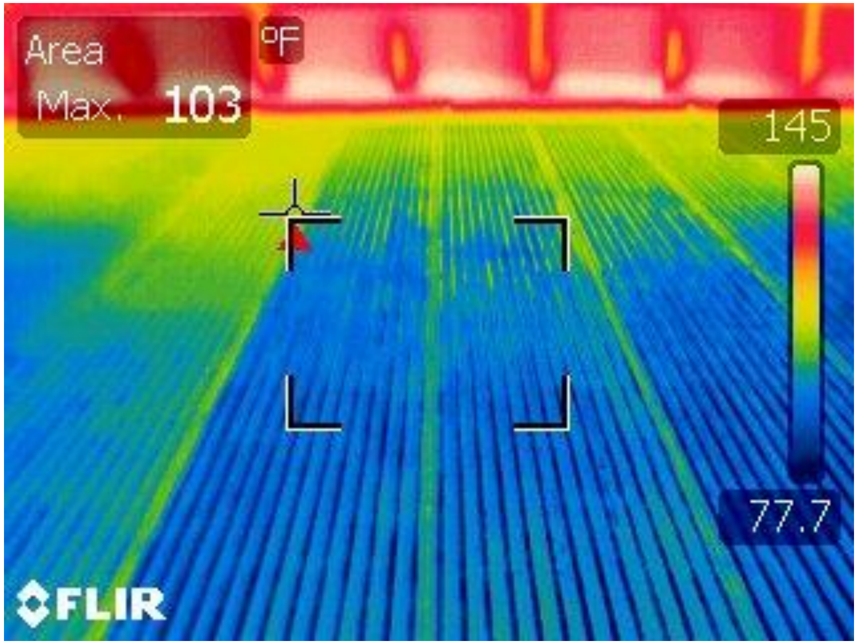
Purpose

- Discuss the phenomenon of Subcooling with ACCs
  - What is it and what are the impacts to efficiency
  - What causes it
- How can we mitigate it
- Case Studies
- ACC360



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ModuleAir®

W-Style ACC®

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www.spgdrycooling.com

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SPG DRY COOLING
WORLDWIDE DRY COOLING INSTALLATIONS

BELGIUM	1.150 MW
FRANCE	450 MW
GREECE	1.210 MW
IRELAND	790 MW
ITALY	7.332 MW
LUXEMBURG	360 MW
NETHERLANDS	570 MW
RUSSIA	300 MW
SPAIN	1.100 MW
UK	5.037 MW
EUROPE	**18.229 MW**

9,3 %

GANSU	2.910 MW
HEBEI	2.460 MW
HENAN	2.010 MW
INNER MONGOLIA	22.500 MW
JILIN	2.400 MW
NINGXIA	2.400 MW
SHANXI	26.445 MW
SHAANXI	12.580 MW
SHANDONG	2.800 MW
QINGHAI	200 MW
XINIANG	14.270 MW
CHINA	**90.975 MW**

46,4 %

CANADA	2.720 MW
MEXICO	9.918 MW
USA	21.339 MW
ARGENTINA	1.840 MW
PERU	1.630 MW
VENEZUELA	1.000 MW
COLOMBIA	560 MW
AMERICANAS	**39.007 MW**

19,9 %

ALGERIA	6.150 MW
BARHAIN	2.592 MW
IRAQ	2.700 MW
ISRAEL	1.720 MW
JORDAN	1.827 MW
MOROCCO	470 MW
OMAN	1.503 MW
SOUTH AFRICA	8.980 MW
SYRIA	660 MW
U.A EMIRATES	4.729 MW
GHANA	200 MW
IVORY COAST	280 MW
SENEGAL	300 MW
MOZAMBIQUE	4.50 MW
AFRICA & MIDDLE EAST	**34.542 MW**

17,6 %

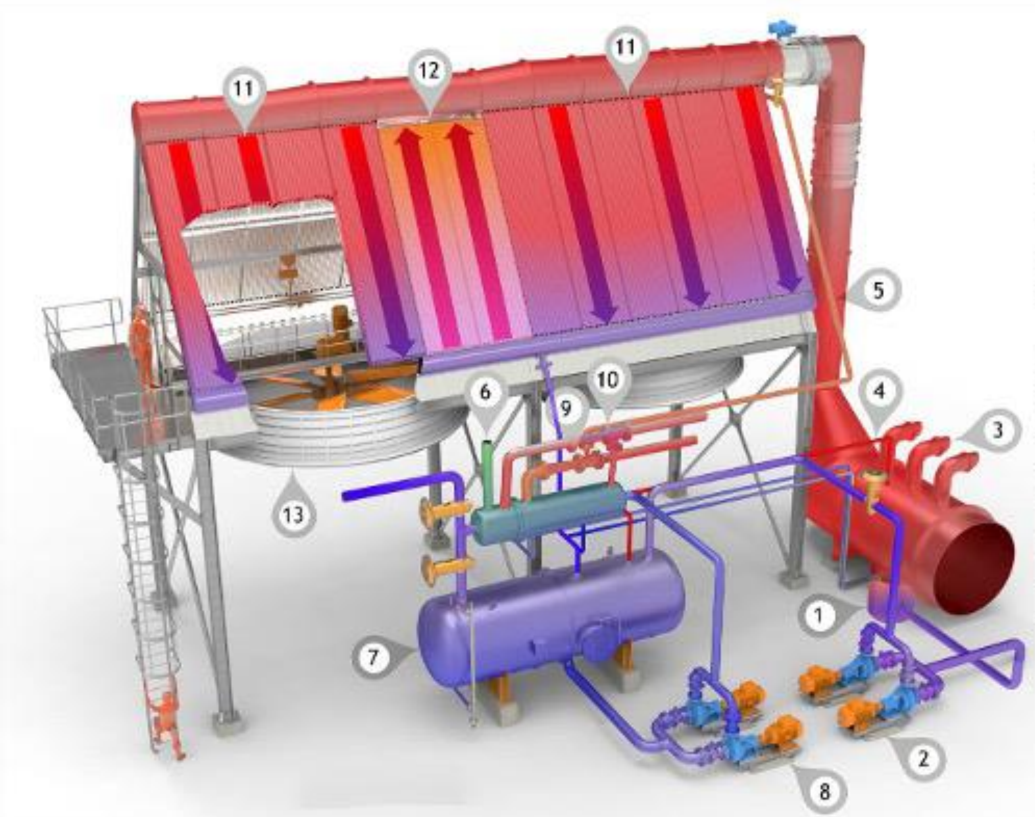
BANGLADESH	1800 MW
INDIA	5.05 MW
INDONESIA	420 MW
IRAN	600 MW
JAPAN	730 MW
KOREA	105 MW
MALAYSIA	300 MW
PAKISTAN	130 MW
TAIWAN	3.105 MW
VIETNAM	250 MW
THAILAND	240 MW
INDIA/APAC	**12.731 MW**
AUSTRALIA	**705 MW**

6,5 %

1 %

MORE THAN
196.000 MW
INSTALLED

ACC Fundamentals
Process



Basics of Operation

- Cold Air travels up through fan and passes over finned tubes
- Steam arrives through ducting and condenses in tubes as heat is transferred to air
- Condensate at bottom of tubes returns to system by gravity

Module/Cell overview

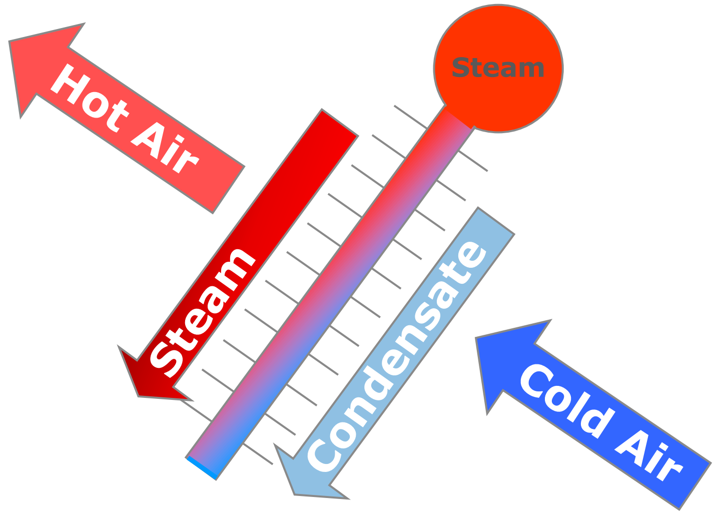
Two stage condensing process

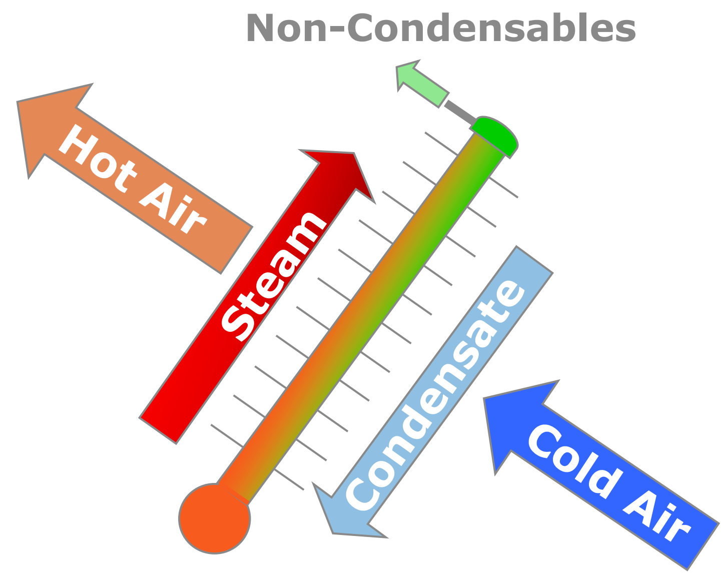
- Primary Bundles: First stage or primary bundles with parallel flow
- Secondary Bundles: Second stage or secondary bundles with counter flow

⇒ non-condensable gases are pushed toward the air removal system and evacuated from the ACC.

ACC Fundamentals

Process - Bundles





Primary Section

- Cocurrent Flow
- Only 70 – 80% of the steam condensed here

Secondary Section

- Counter-Current flow
- Condensate is re-heated
- Non-Condensables removed from the top

ACC Fundamentals

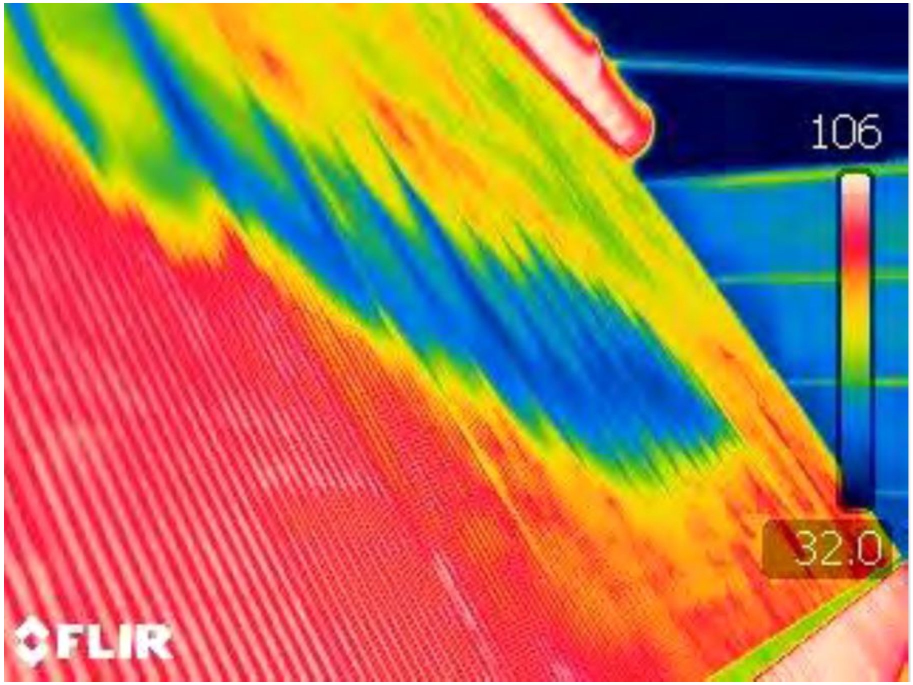
Subcooling

subcool (sʌbˈkuːl)

the difference between the *calculated* saturation temperature and the *actual* condensate or non condensable temperature

Sources of subcooling

1. Uneven steam distribution
2. Airflow (too much from fan or wind)
3. Steam surface availability
4. Vacuum system issues
5. Air Ingress

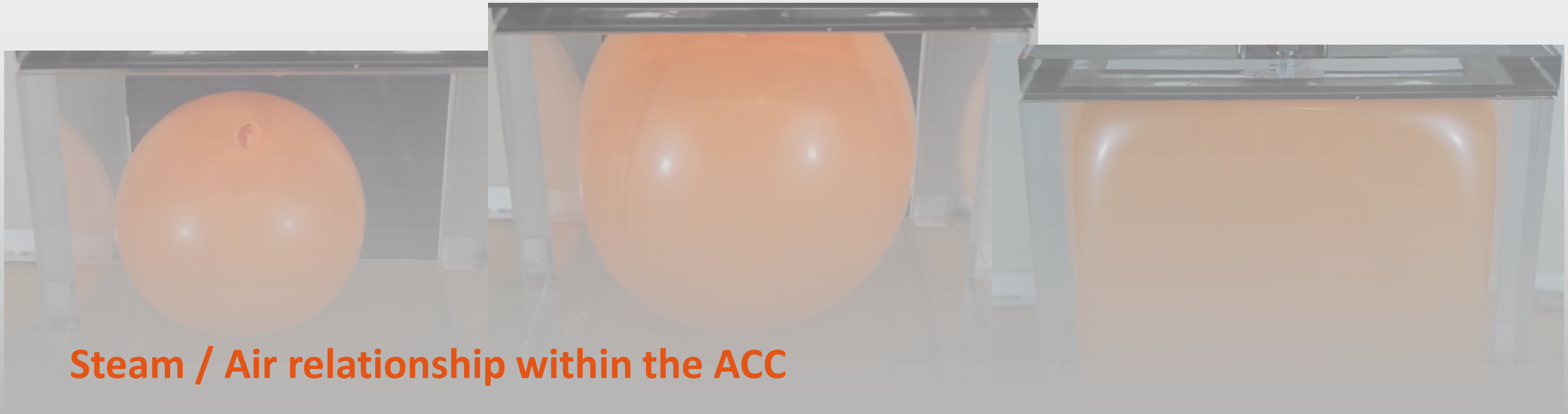


Subcooling

Impacts

Subcooling is inherent in all ACCs, but can be indicative of potential problems:

- Lead to Freezing and a loss of efficiency
  - Subcooling drives freeze protection
- Air Ingress
- Higher backpressure, greater fuel consumption, greater auxiliary load



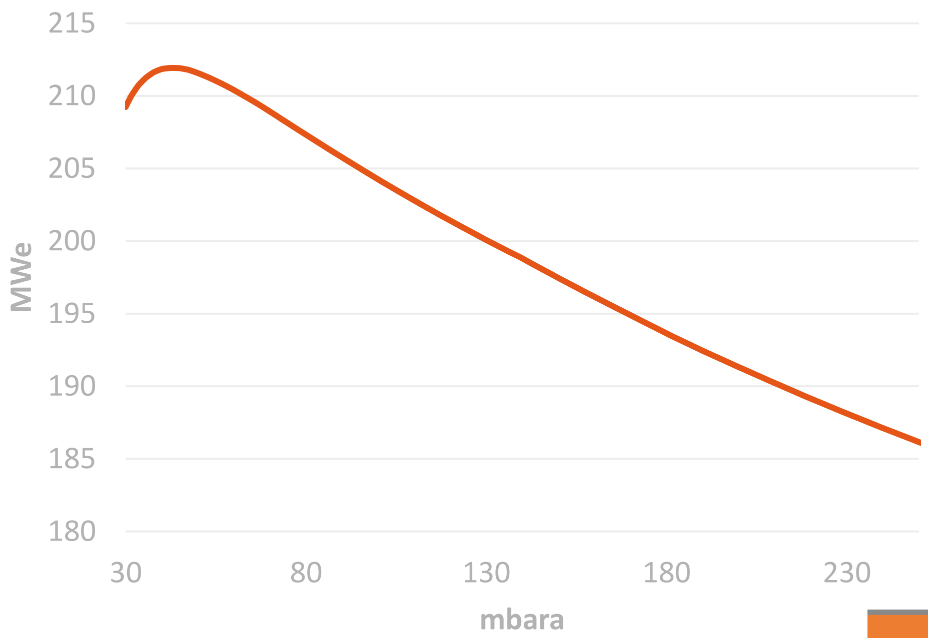
Steam / Air relationship within the ACC

- Where there is air there is not steam
- Where there is steam there is not air

⟹ Condensate subcooling increases when the condensate passes through air within the heat exchanger

ACC Fundamentals

Typical Steam Turbine Curve (200 MW)



What if my ACC underperforms by 15 mbar (0.45inHg) for a 250MW turbine?

- → 1 % steam turbine output lost
- → ~ 2.5 MWe lost in generation
- → 17,500 MWh lost in a year @100 EUR / MWh

1,750,000 EUR lost / year

ACC Under performance	Steam Turbine Capacity (MW) 10	25	50	100	200	500
10 mbar	46,720 €	116,800 €	233,600 €	467,200 €	934,400 €	2,336,000 €
15 mbar	70,080 €	175,200 €	350,400 €	700,800 €	1,401,600 €	3,504,000 €
20 mbar	93,440 €	233,600 €	467,200 €	934,400 €	1,868,800 €	4,672,000 €
25 mbar	116,800 €	292,000 €	584,000 €	1,168,000 €	2,336,000 €	5,840,000 €
30 mbar	140,160 €	350,400 €	700,800 €	1,401,600 €	2,803,200 €	7,008,000 €

ACC performance matters

Subcooling
What is it?

HEI: Standards for Air Cooled Condensers

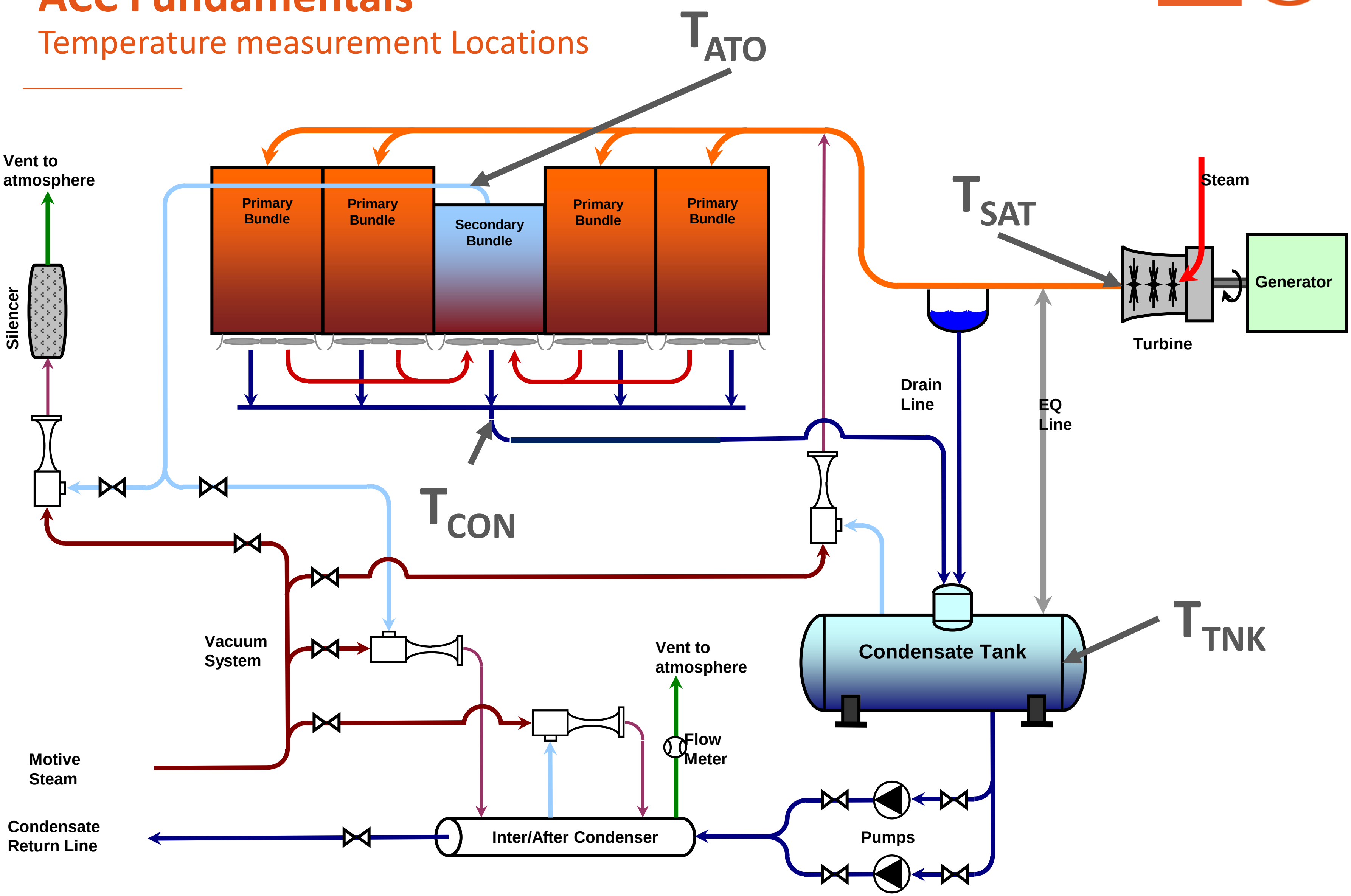
6.4 Condensate Subcooling

6.4.1 Condensate subcooling is casually defined as the difference between the saturation temperature of the steam at the **steam turbine exhaust** and the temperature of the condensate at the outlet of the **condensate tank**. This is not to be confused with the conventional subcooling definition, which is the local temperature difference at a given location between the steam and the condensate.

Anytime the condensate temperature is lower than the inlet steam temperature within the ACC => Subcooling

ACC Fundamentals

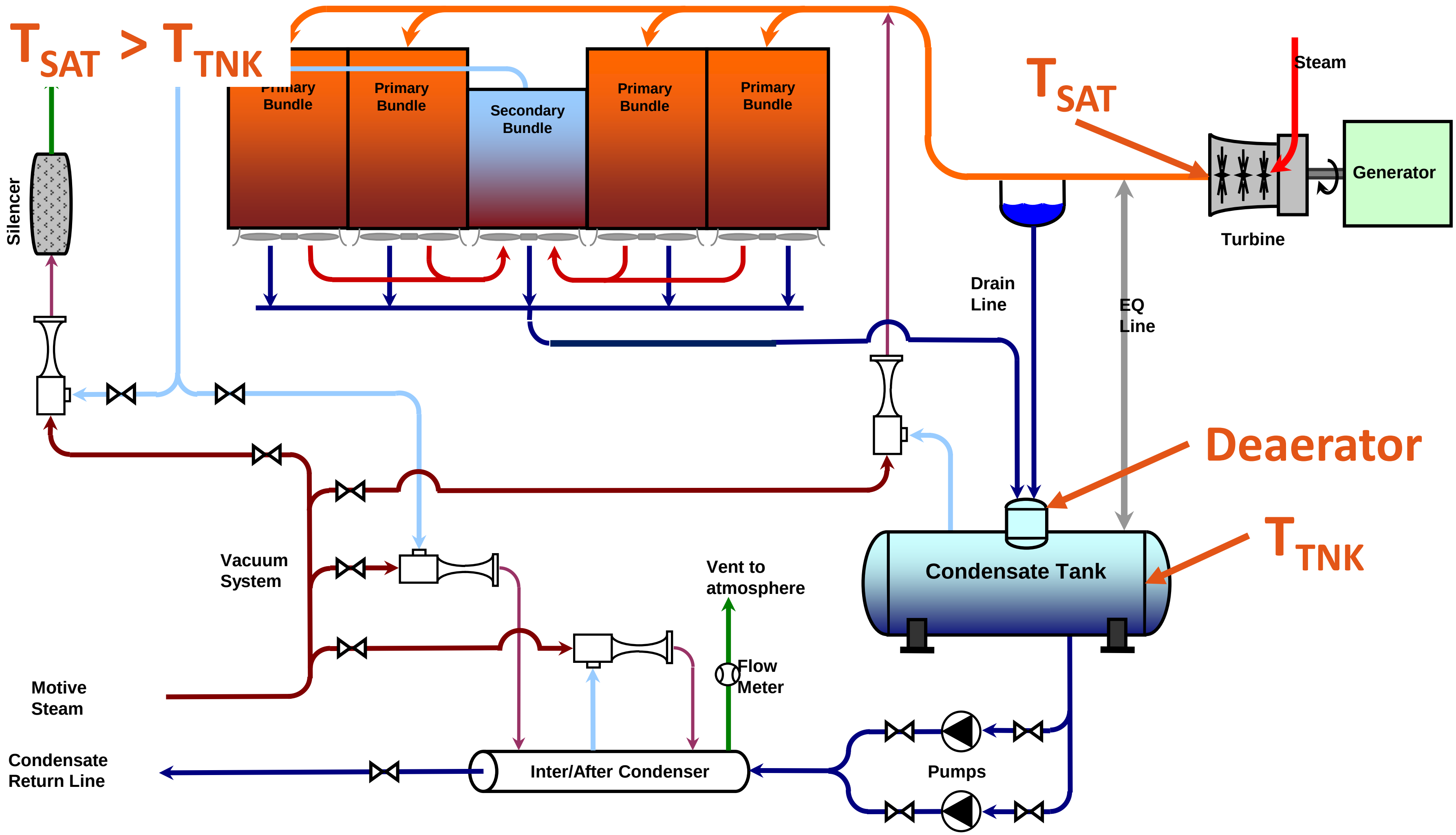
Temperature measurement Locations



ACC Fundamentals

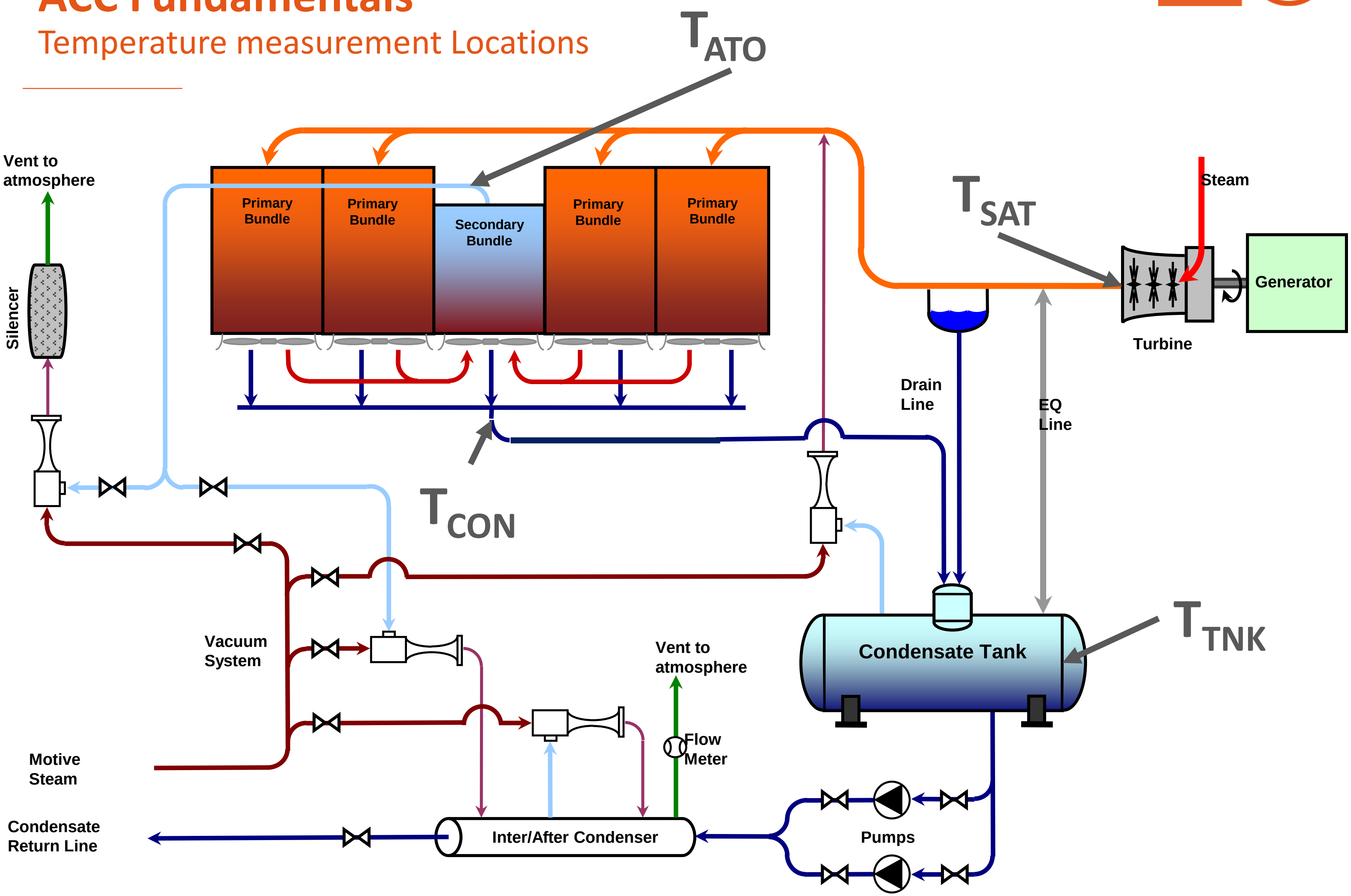
Subcooling in the Condensate Tank

$T_{SAT} > T_{TNK}$



ACC Fundamentals

Temperature measurement Locations

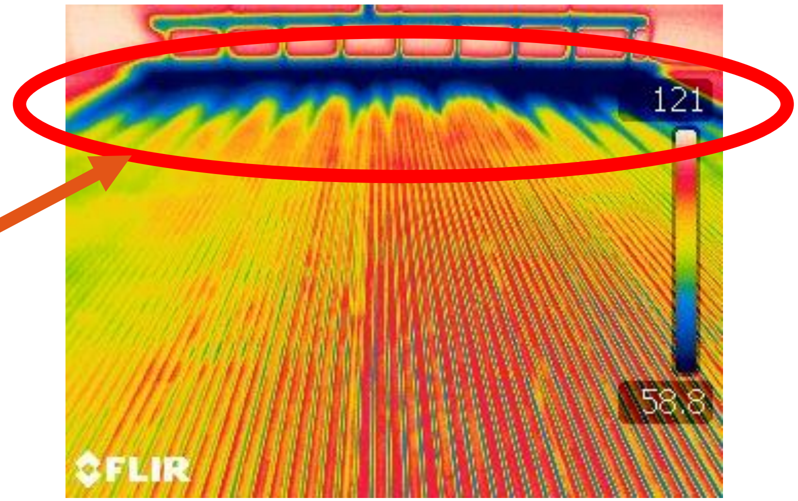


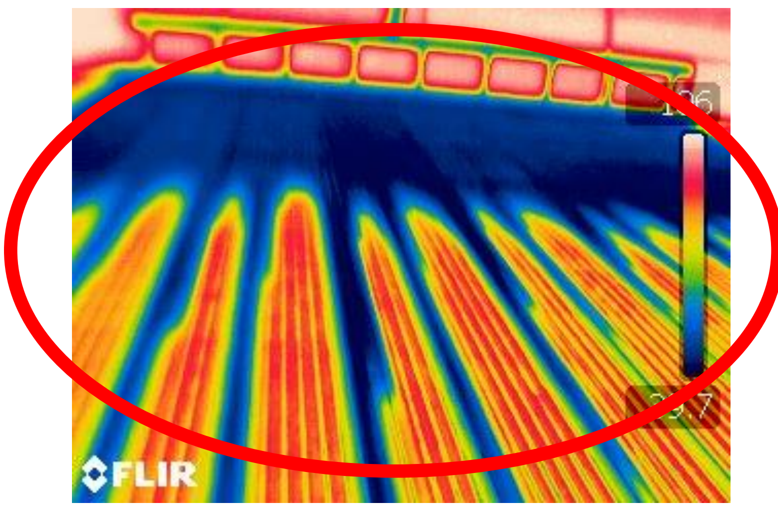
Subcooling

Subcooling in the Air Take-Off Piping

$T_{SAT} > T_{ATO}$

Subcooling: <2°C





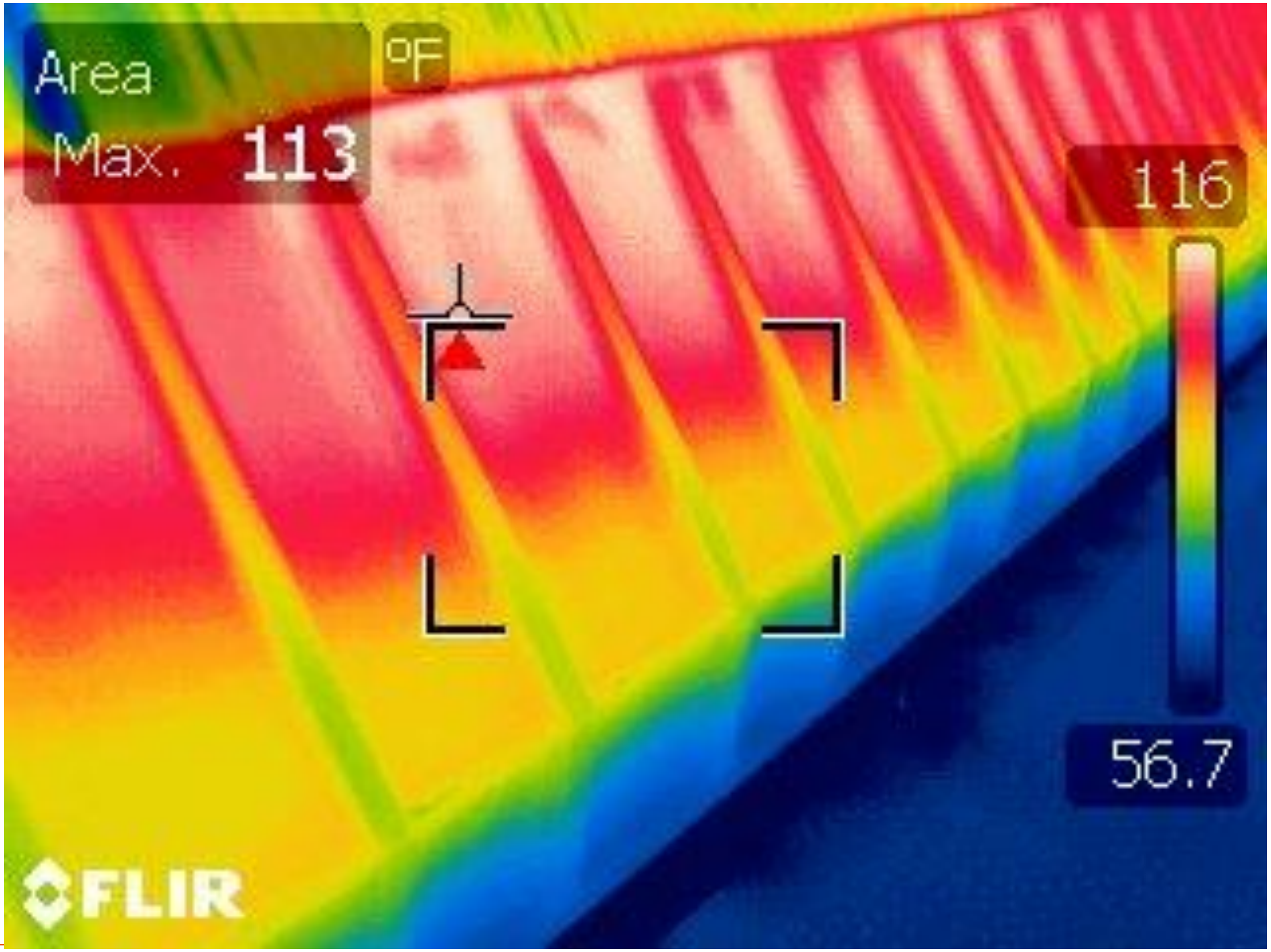
Subcooling: 2° - 5°C

$T_{SAT} - T_{ATO}$ > 8-10°C => freeze protection measures

Subcooling

Subcooling in the Condensate Manifold

$T_{SAT} > T_{CON}$

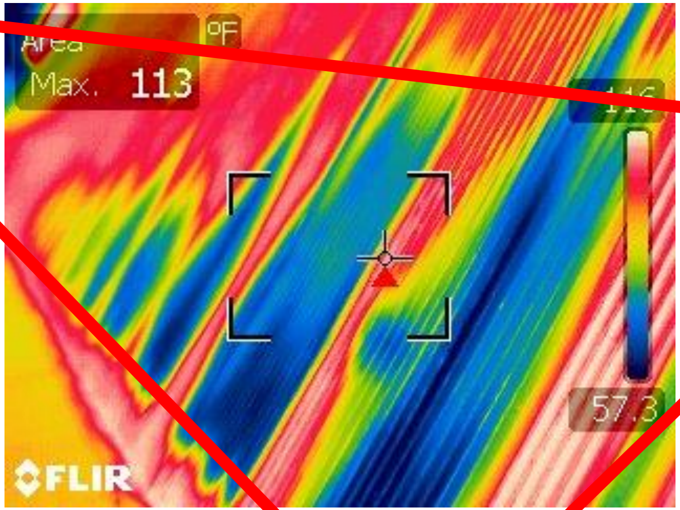


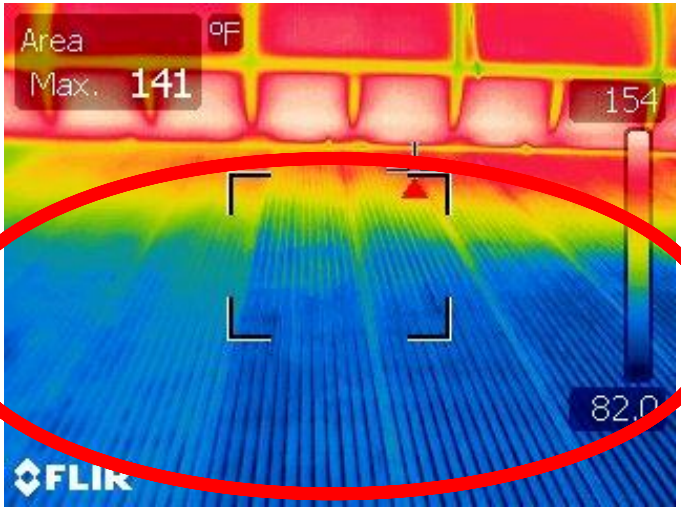
Subcooling

Subcooling in the Condensate Manifold

$T_{SAT} > T_{CON}$

Subcooling: <2°C





Subcooling: 2° - 5°C

$T_{SAT} - T_{CON}$ > 5 - 8°C => freeze protection measures

Case Study

ACC and H20 Best Practices from CPV Valley Energy Center – Combined Cycle Journal (ccj-online.com)

Challenge: The site observed continuous subcooling. Working with SPG, identified several leaks and remedied – problem persisted

Problem: Continued air flow across the heat-exchanger bundles, paired with slight air ingress, was driving the subcooling anomaly. the DCS logic prevented the fans from turning off to counteract the subcooling.

Solution: made minor adjustments to the deadband and setpoint and reduced parasitic power by ~3 MW while maintaining the required backpressure.

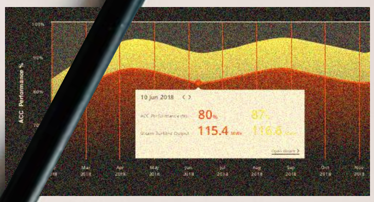
Note: The subcooling issue was unique to the season and location, ambient temperatures between 35F and 75F, operating ~5000 hours within this range. Prior to identifying a resulting loss of approximately 15,000 MWh/yr prior to the new ACC logic implementation.

Method: The improvement was achieved by turning multiple fans from full speed to half speed (reducing the required power per fan by seven-eighths) and eliminating the need to run a second vacuum pump.

Results: The experience highlights the importance of investigating all aspects of ACC performance to optimize efficiency. As a result of this improvement, VEC will implement SPG's remote performance monitoring system (**ACC360**) to maintain the realized results and continually improve the ACC system.

Further information found in Combined Cycle Journal article

ACC 360



Historical Data
Real-Time Data
Fleet Data
Mathematical Model
Machine Learning

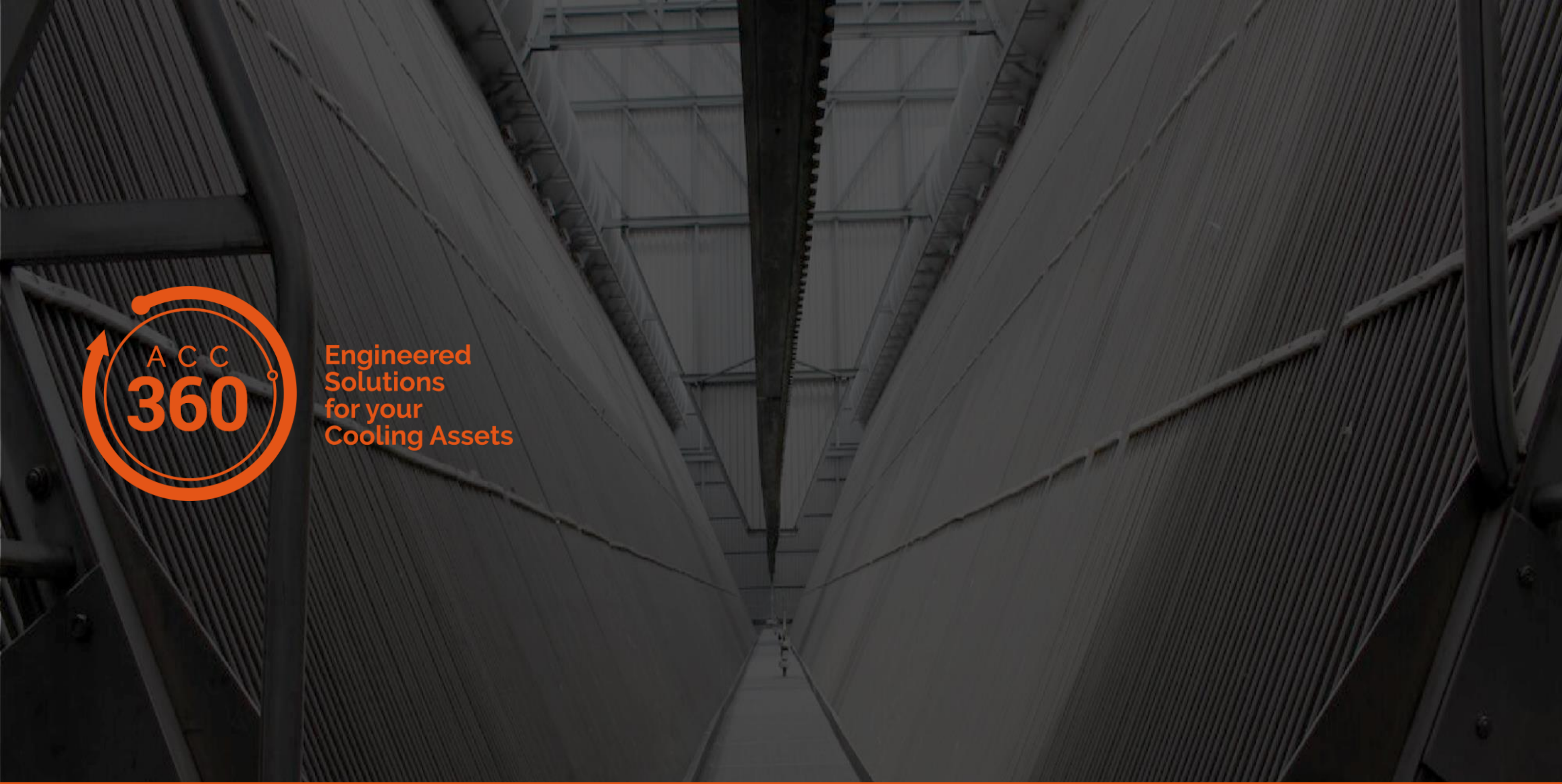
Actionable Feedback

REAL-TIME PERFORMANCE OPTIMIZATION

ACC360

ACC360 is an intelligent, purpose-built, ***cloud-based solution that provides unprecedented insight into the performance and health of any Air Cooled Condenser (ACC)****.*

ACC360 relies upon the fastest computational modeling and analysis. We've partnered with several other industry leaders to help provide the necessary expertise in modeling and data analytics. We create a digital twin of each unit, continuously feed data to the model, and constantly search for better, more optimized operating methods, i.e., machine learning. As a result, we allow the customer to minimize any internal margin and capitalize on a more accurate forecast"



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