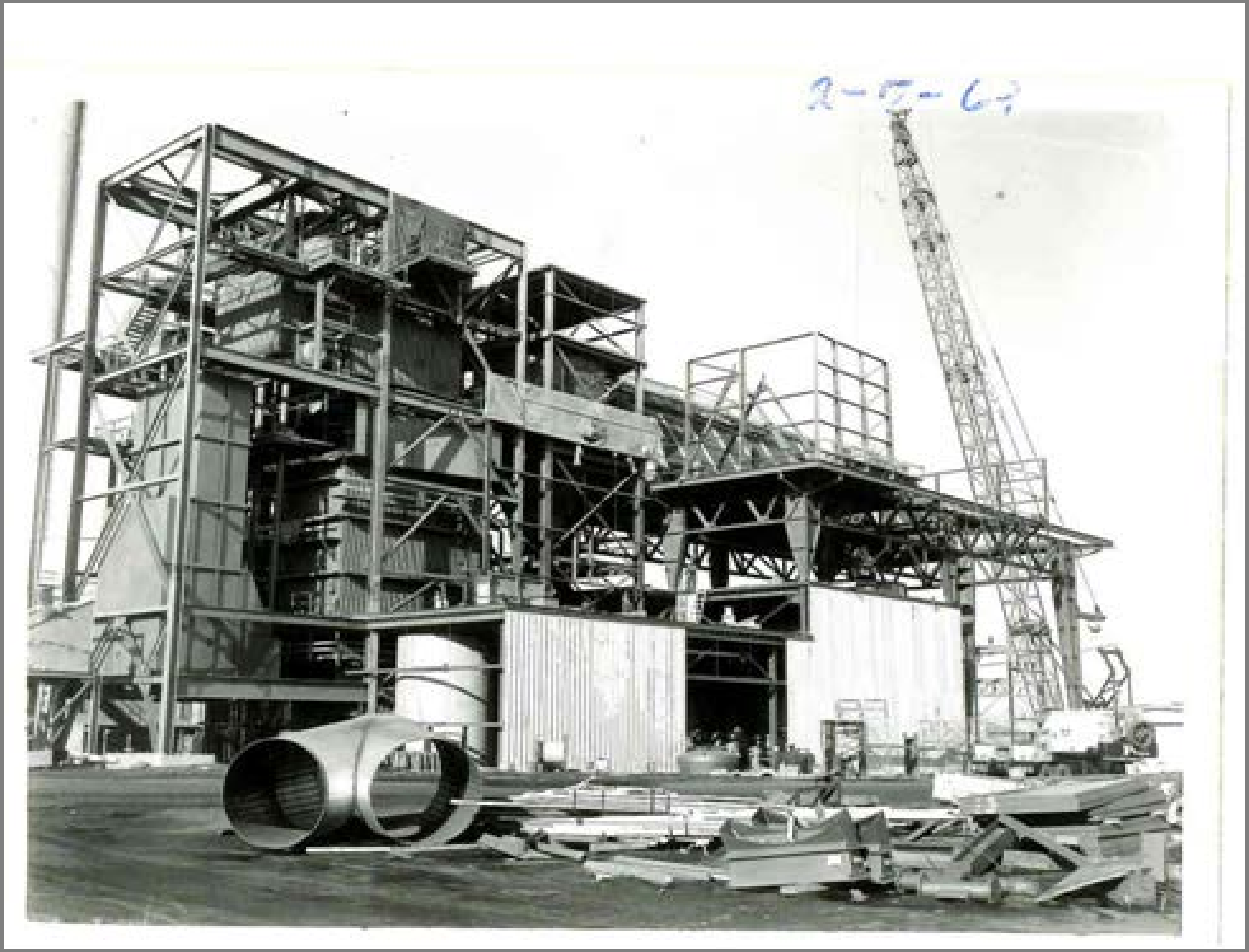
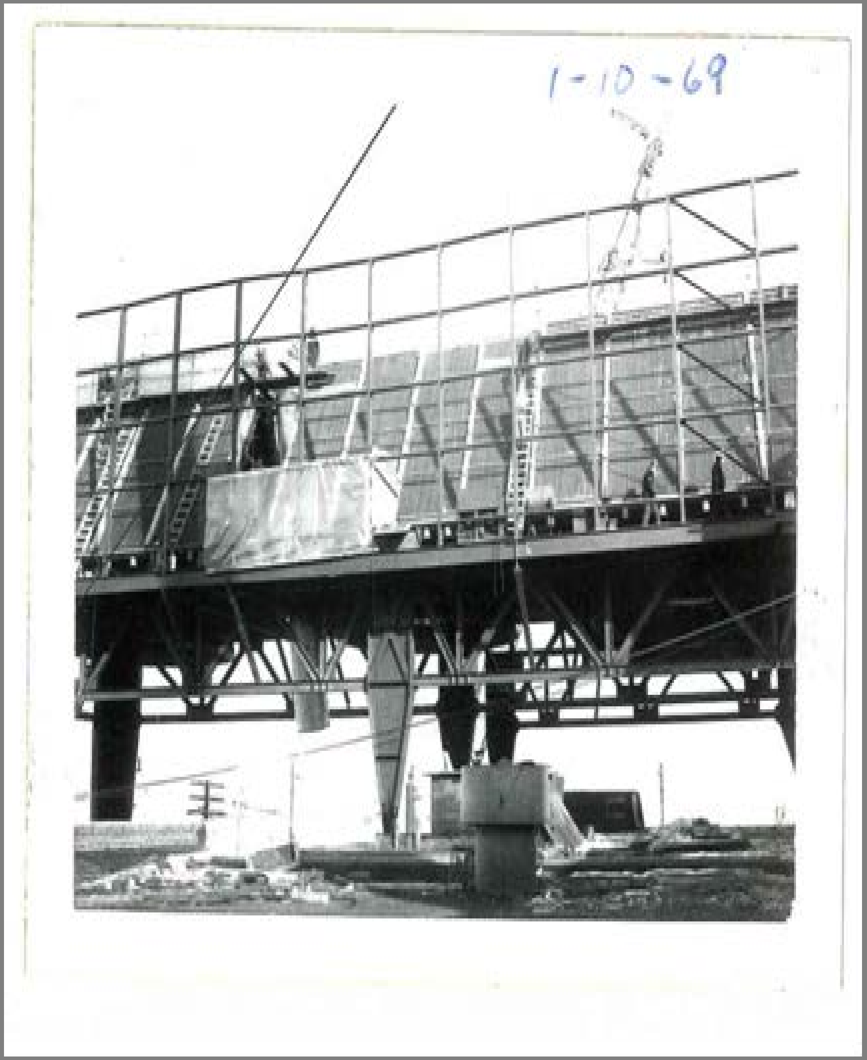
Black Hills Power – ACC's

AIR COOLED CONDENSER CONSTRUCTION

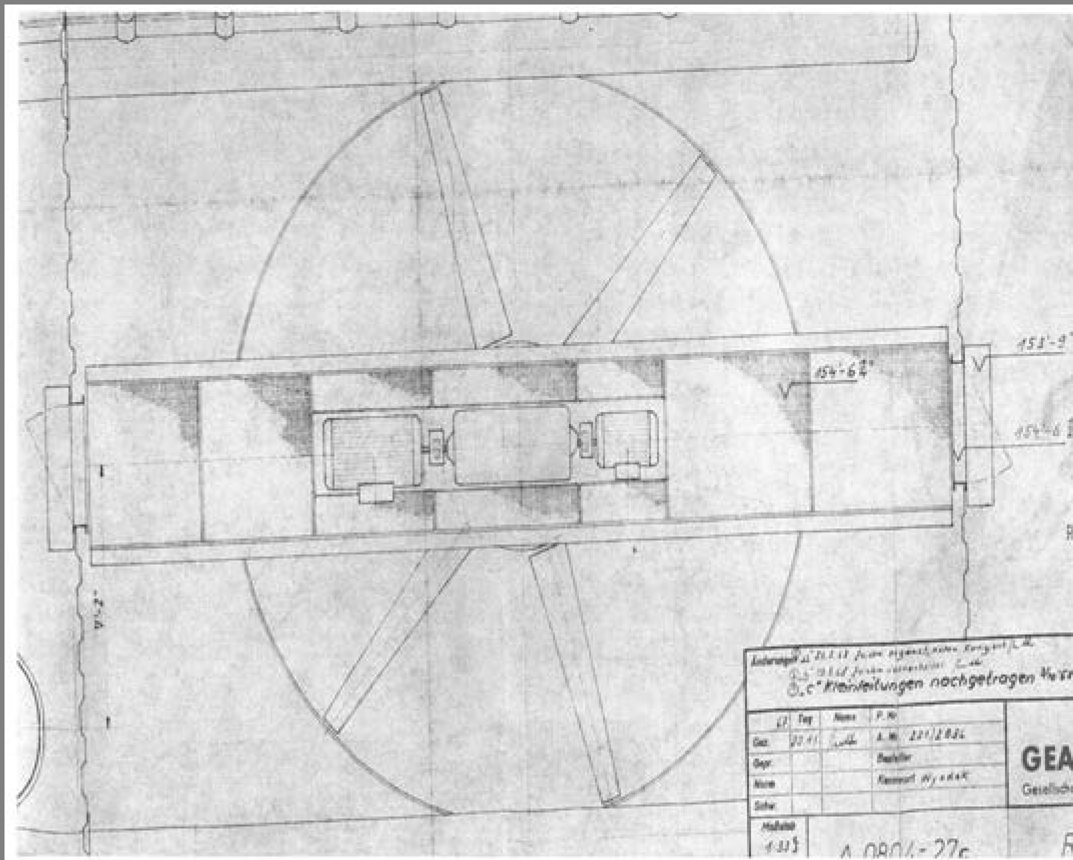


Neil Simpson Station Unit 1



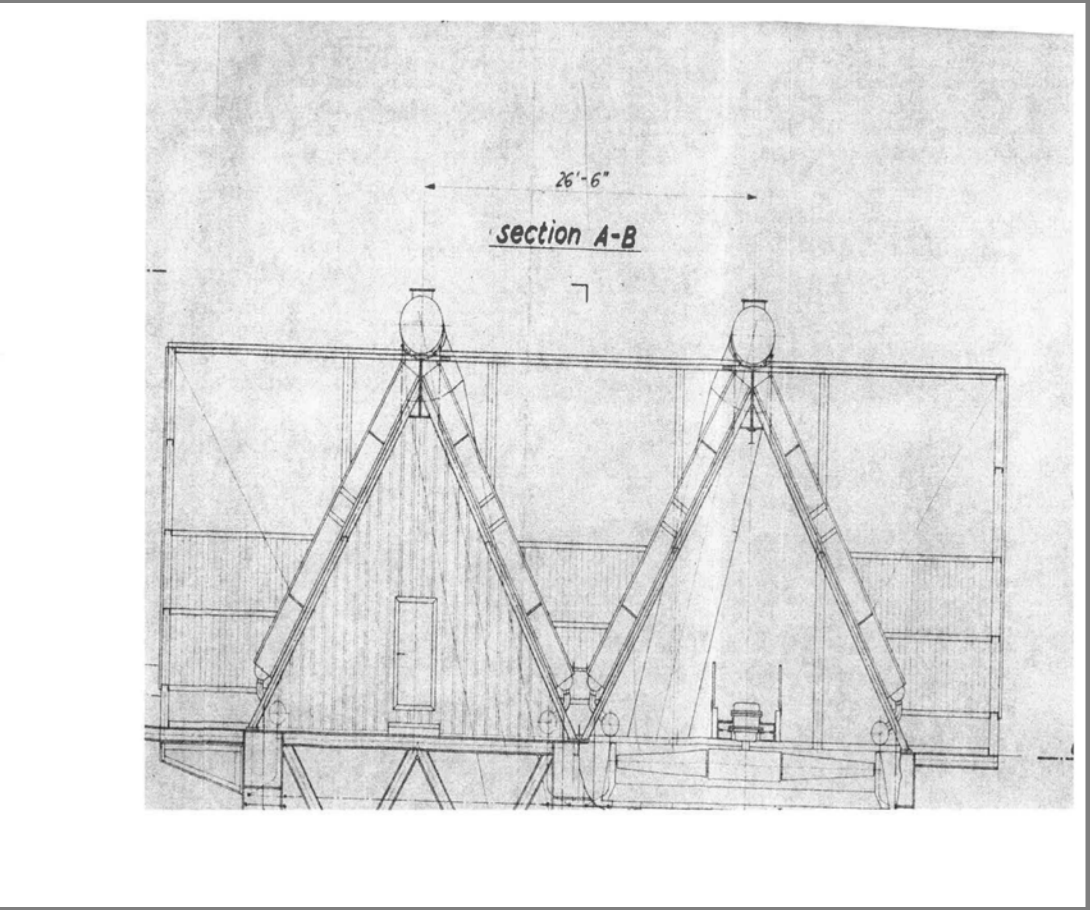
Air Cooled Condenser Fans

Neil Simpson 1 Condenser Design



- Axial fans 20.8 feet in diameter 6 blades 200rpm manual blade angle
- 150 HP motor 1800 rpm
- Two speed 45/10 HP motor 1800/900 rpm

Operating Design Conditions

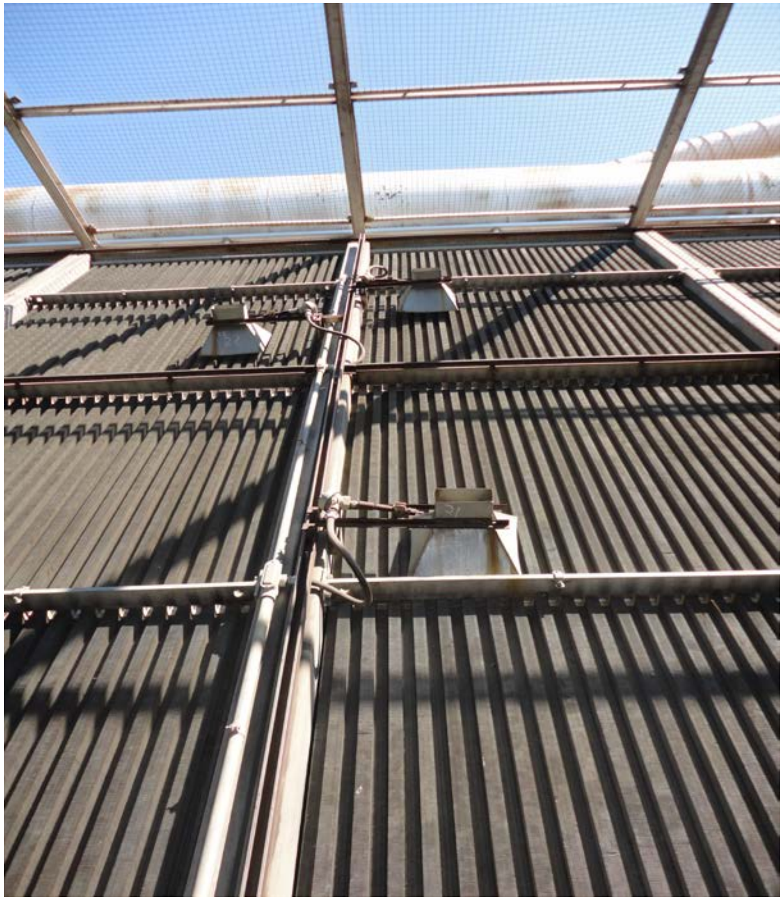


- Cooling air temp 110° F
- Relative humidity 10%
- Exhaust steam psi at turbine max 8in. Hg. Abs
- Spray water consumption 200 gpm
- Condensing capacity 169,518 Lbs./hr.
- Barometer 25.3 in Hg.
- Wind velocity 50mph at air temps down to -20° F

Early Lesson Learned NS-1 Condenser

- Unable to maintain consistent back pressure during low ambient temperatures due to limit of 3 speeds of fans
- Icing during ambient temperatures below freezing
  - Condenser warm-ups
- Wind speed and direction were a larger factor than anticipated in both hot and cold ambient temperatures
- Condenser cleaning
- Maintenance practices
- Added cooling capacity of water sprays created additional issues including:
  - Scaling on fins and tubes.
  - Moisture and water on motors and gearboxes
  - Wet fins wetted fugitive dust creating blockage of air flow

Early Lesson Learned NS-1 Condenser



- Air Temperature probe placement created problems
- Ice in condenser and warm-ups during cold ambient temps created hotwell & Misc. Drain tank level problems
- All valves on hogging steam and air ejectors are manual valves
- Gearbox oil temperature

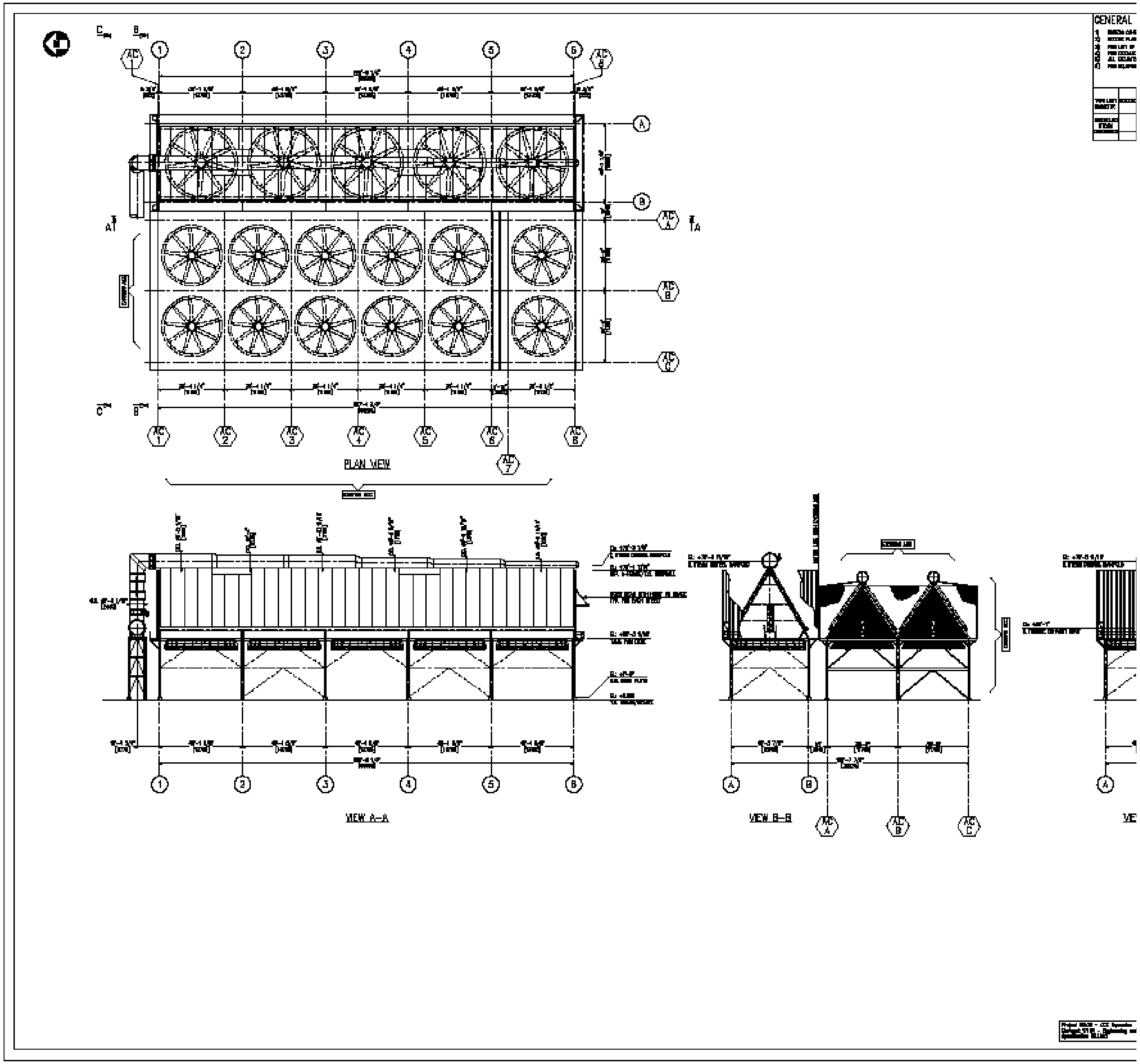
NS-1 Upgrades

NSC NS2 – Wygen 3 ACC's

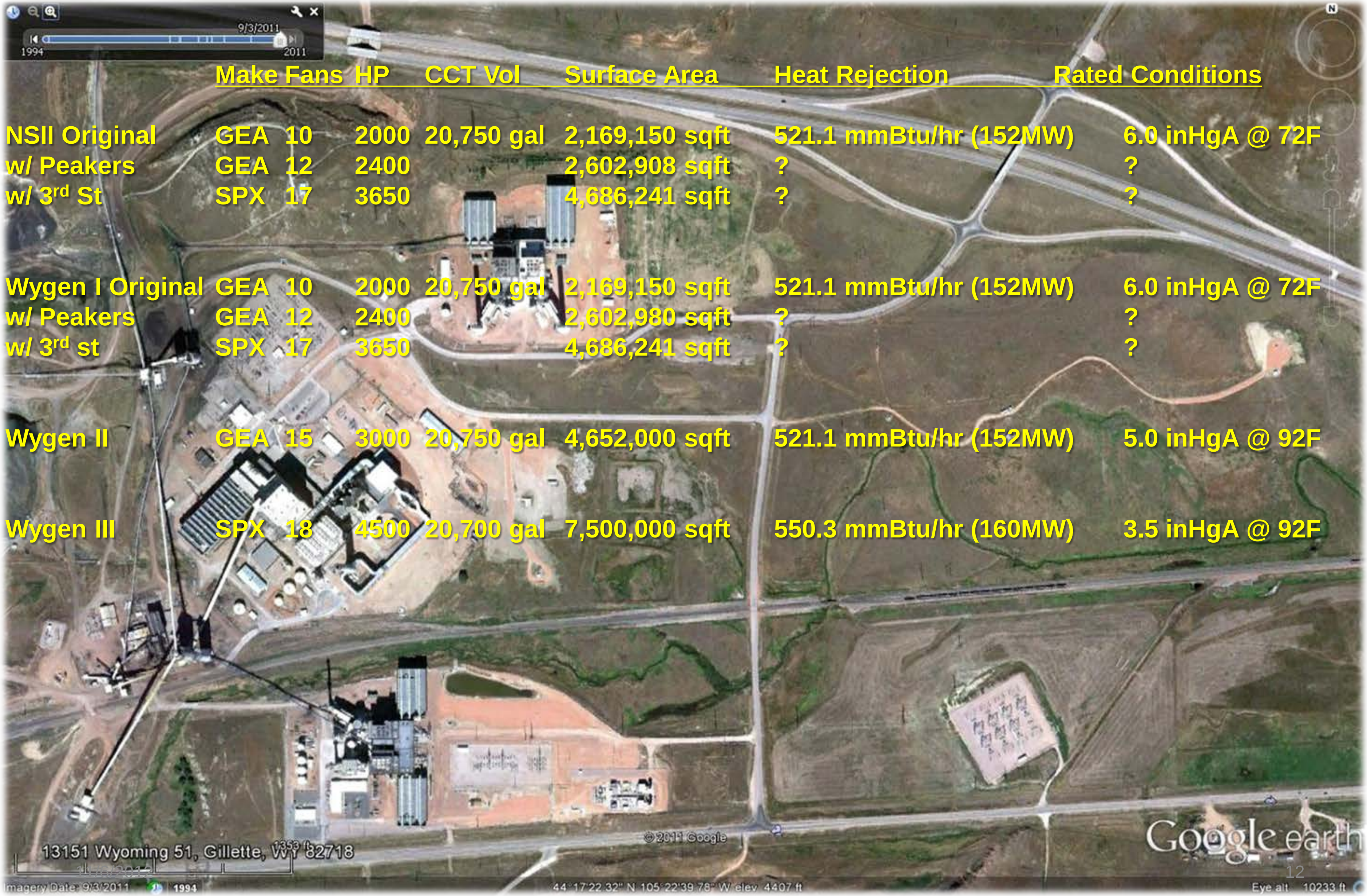
Unit - Name	Year Built	Rated Capacity (Gross MW)	Boiler MAWP (Psia)	Max Oper Press* (Psig)	Design Temp (° F)	Design Steam Flow (klb/hr)
2 – NS2	1995	90	1900	1520	1005	778
3 – Wyg 1	2003	90	1900	1520	1005	778
4 – Wyg 2	2007	100	1900	1777	1005	778
5 – Wyg 3	2010	110	2100	1829	1005	897

Max Oper Press* - maximum allowable operating pressure (being limited by turbine design or other limiting issues)

NSC NS2 – Wygen 1 ACC Expansion



NSC ACC Design



	Make	Fans	HP	CCT Vol	Surface Area	Heat Rejection	Rated Conditions
NSII Original	GEA	10	2000	20,750 gal	2,169,150 sqft	521.1 mmBtu/hr (152MW)	6.0 inHgA @ 72F
w/ Peakers	GEA	12	2400		2,602,908 sqft	?	?
w/ 3rd St	SPX	17	3650		4,686,241 sqft	?	?
Wygen I Original	GEA	10	2000	20,750 gal	2,169,150 sqft	521.1 mmBtu/hr (152MW)	6.0 inHgA @ 72F
w/ Peakers	GEA	12	2400		2,602,980 sqft	?	?
w/ 3rd st	SPX	17	3650		4,686,241 sqft	?	?
Wygen II	GEA	15	3000	20,750 gal	4,652,000 sqft	521.1 mmBtu/hr (152MW)	5.0 inHgA @ 92F
Wygen III	SPX	18	4500	20,700 gal	7,500,000 sqft	550.3 mmBtu/hr (160MW)	3.5 inHgA @ 92F

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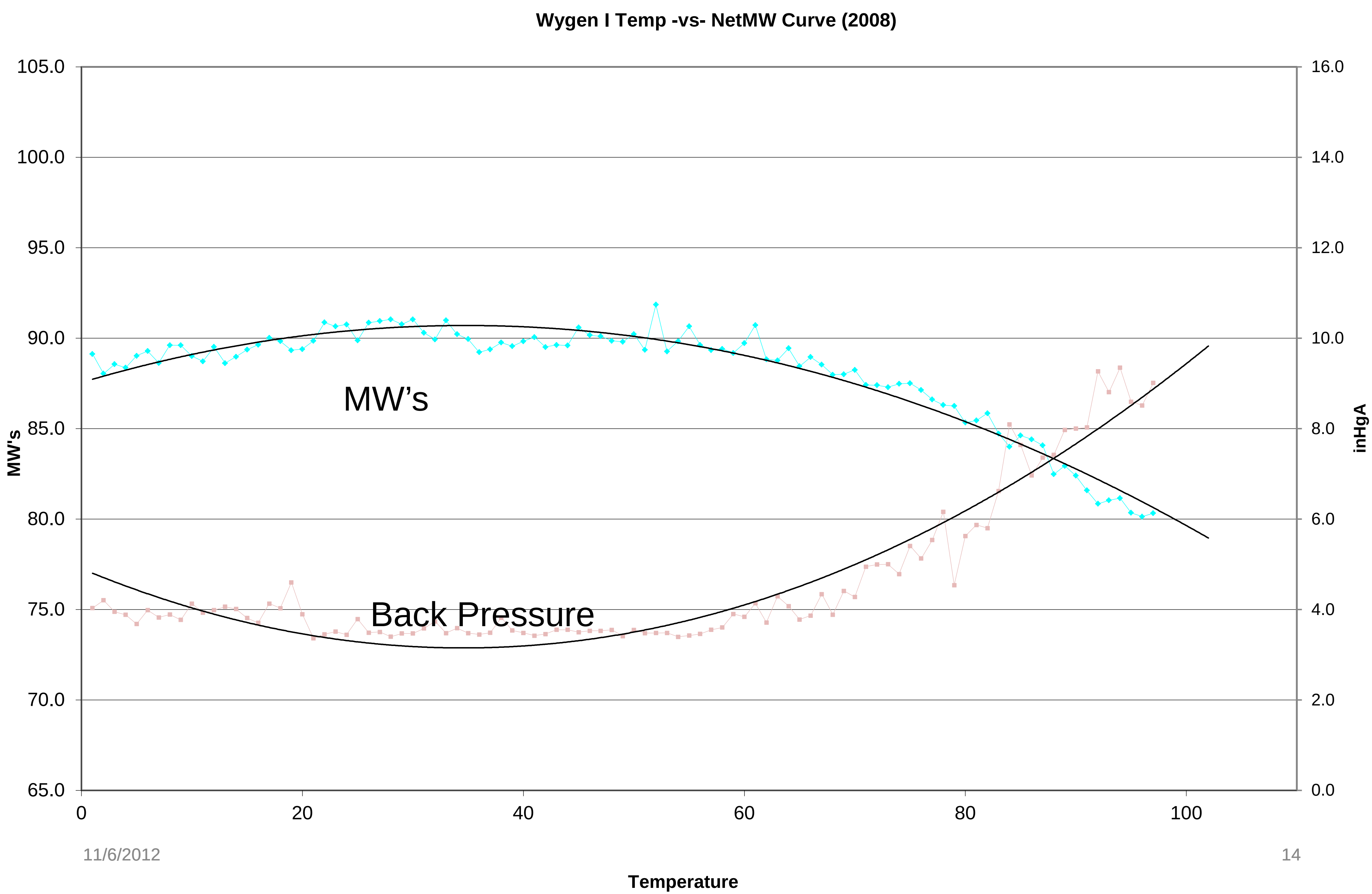
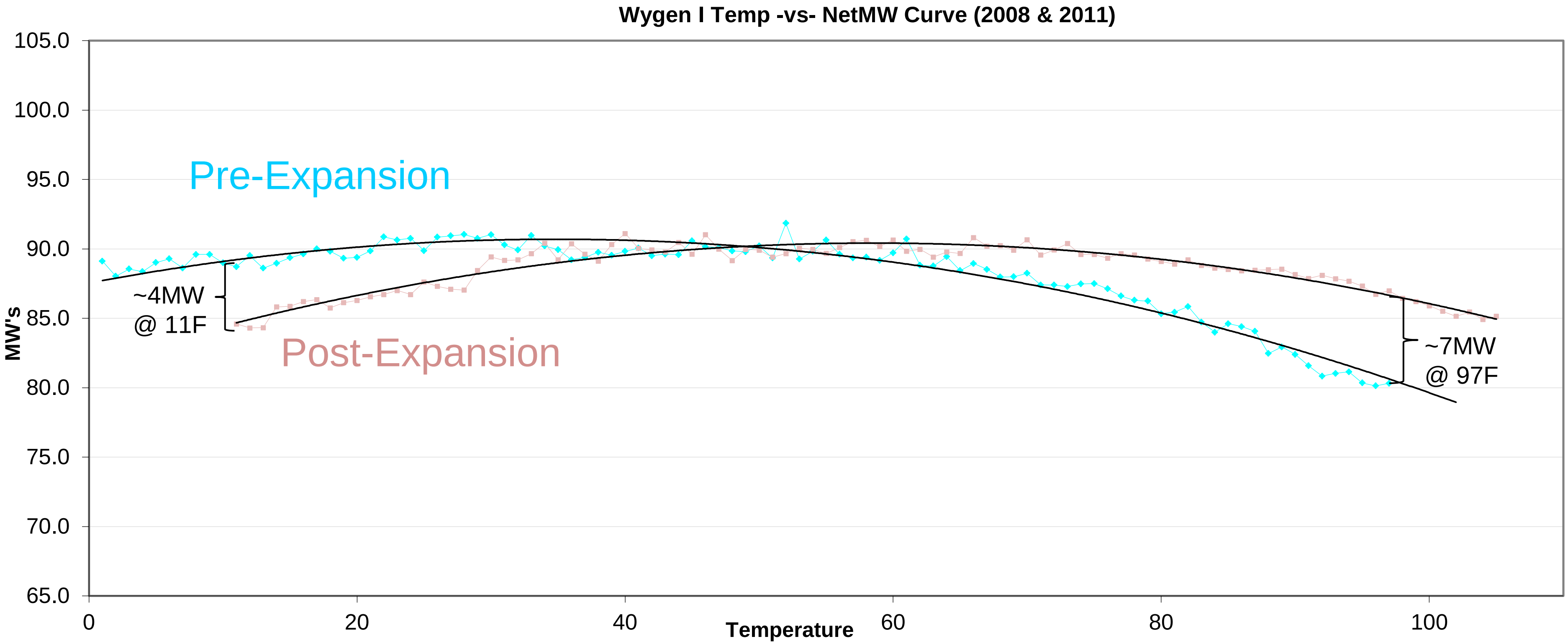
Hot Weather Effects on ACC's



Effects of ACC Expansion



Additional MW at Ambient Temperature >60F

- Measured Additional 7MW @ 97F Ambient Temp

Less MW Production at ambient Temperature <32F

- Measured Less 4MW @ 11F Ambient Temp
- More Conservative operation during cold weather.

Cold Weather Effects on ACC's

Additional attention required by Unit Operators

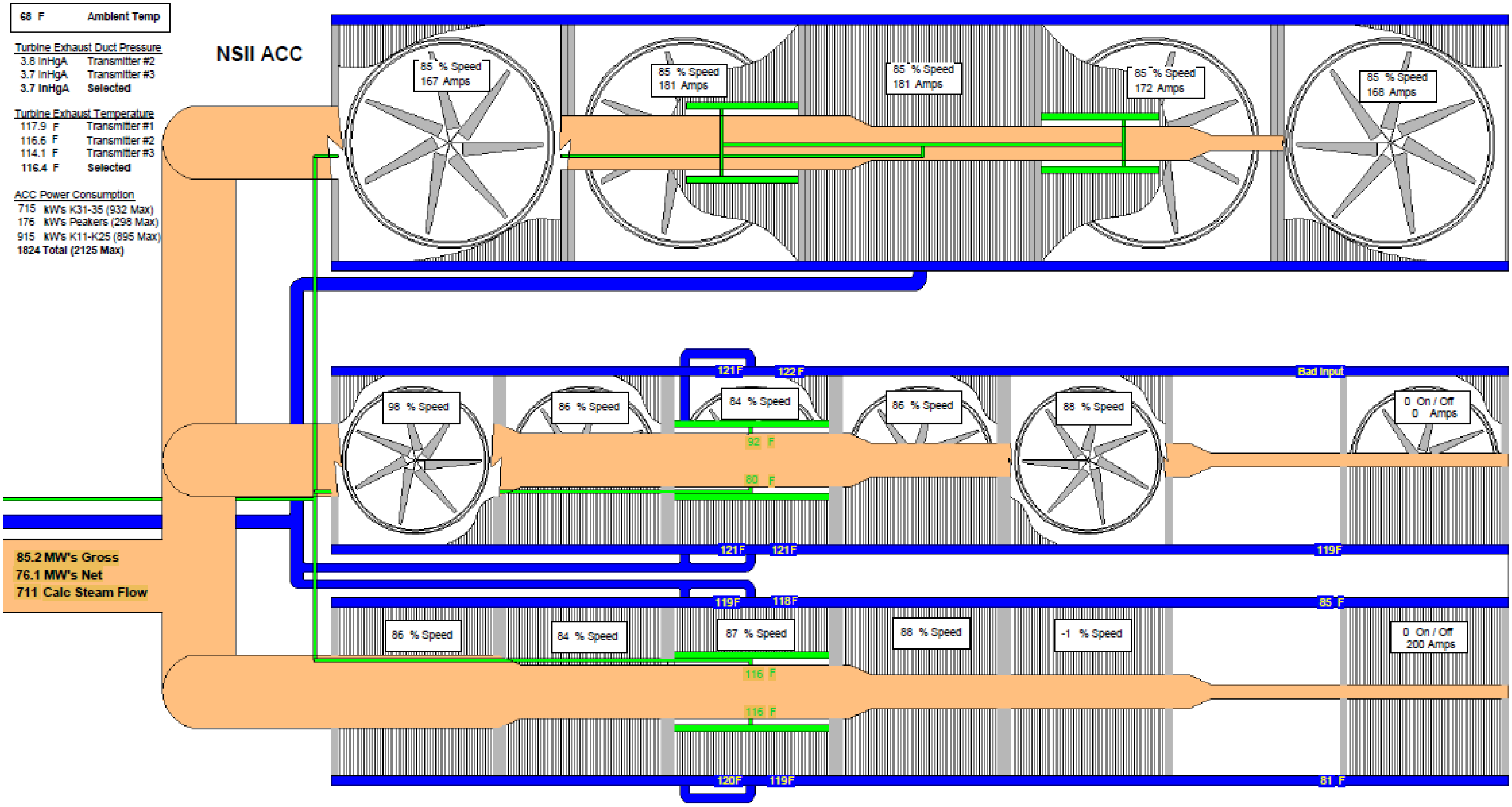
With minimal instrumentation, freeze prevention logic is 'Dumb,' operates by timing, not by instruments / data.

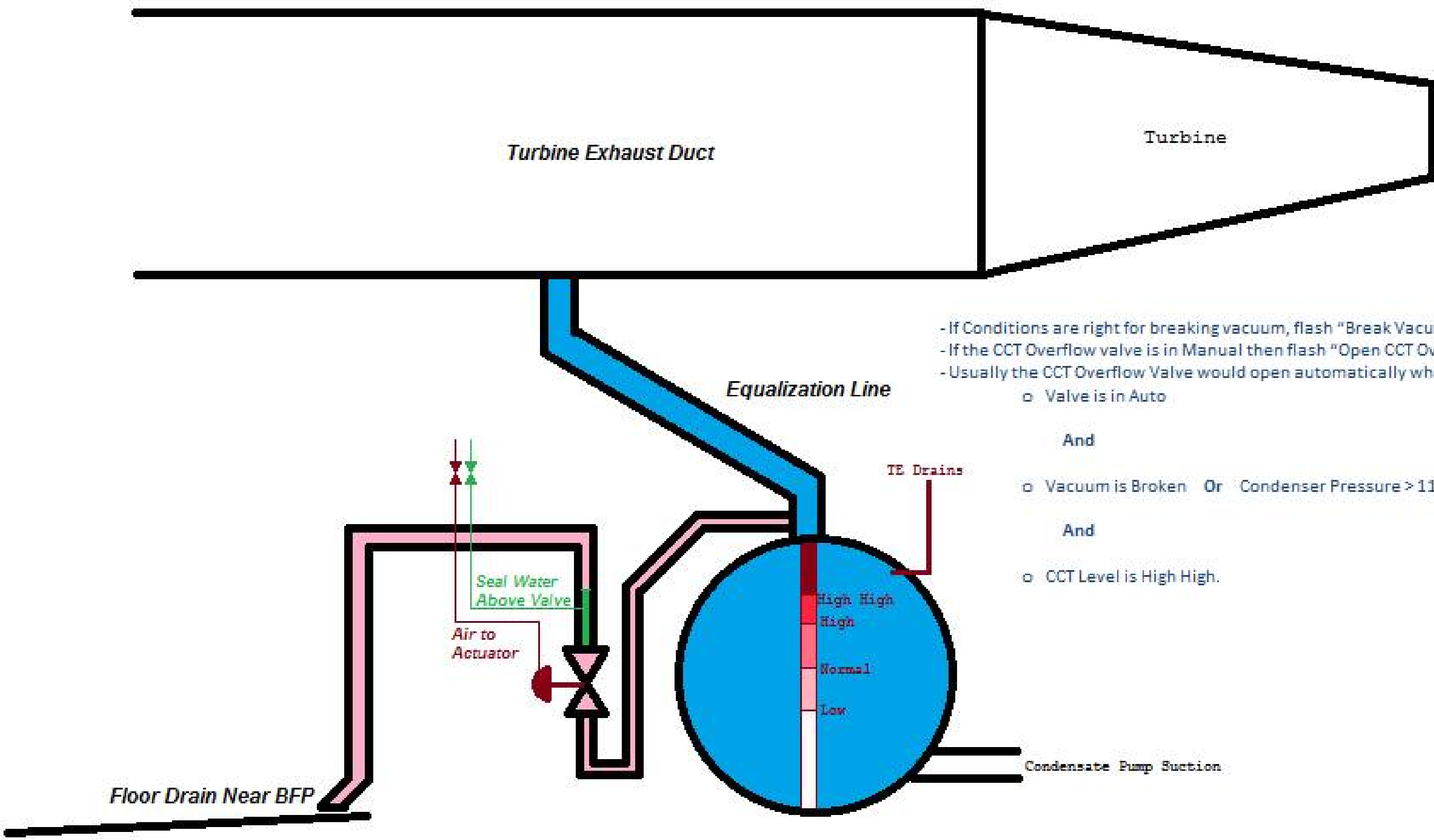
Introduction of Critical Speed block-outs for VFD's causes sub-cooling due to 'Dumb' Logic

Freeze-ups Consequences:

- Ruptured Tubes
  - Potential to trip unit
  - Leaks Hard to find
  - Repairs take away capacity
  - Repairs hide future leaks (Thermal Imaging)
- Ice Dams / Water Storage
  - Turbine Water Induction Risk
  - Swinging of Condensate Collection Tank Level
  - Not Designed to handle excess water

Cold Weather Effects on ACC's - Instrumentation





- If Conditions are right for breaking vacuum, flash "Break Vacuum" on the screen.
- If the CCT Overflow valve is in Manual then flash "Open CCT Overflow Valve" on the screen.
- Usually the CCT Overflow Valve would open automatically when:
  - o Valve is in Auto

    And
  - o Vacuum is Broken Or Condenser Pressure > 11psia

    And
  - o CCT Level is High High.


CLOSED
NICHOLS-GIVEN
ASSOCIATES, INC.
Bray
INDUSTRIAL CONTRACTORS

QUESTIONS?


9/3/2011
1994
2011
WYG2
WYG3
WYODAK
NS1
WYG1
NS2
13151 Wyoming 51, Gillette, WY 82718
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