ComTest "Superheater"
for
Advanced Ultrasupercritical (A-USC)
1400F (760C) Steam Conditions

increase temperature to improve efficiency

Pittsburgh Pennsylvania - 2015 April 29

DOE-FE-00242067

Paul Weitzel

Technology, New Product Development

Project title: COMPONENT TEST FACILITY (ComTest) PHASE 1 ENGINEERING FOR 760^{O}C (1400^{O}F) ADVANCED ULTRASUPERCRITICAL (A-USC) STEAM GENERATOR DEVELOPMENT

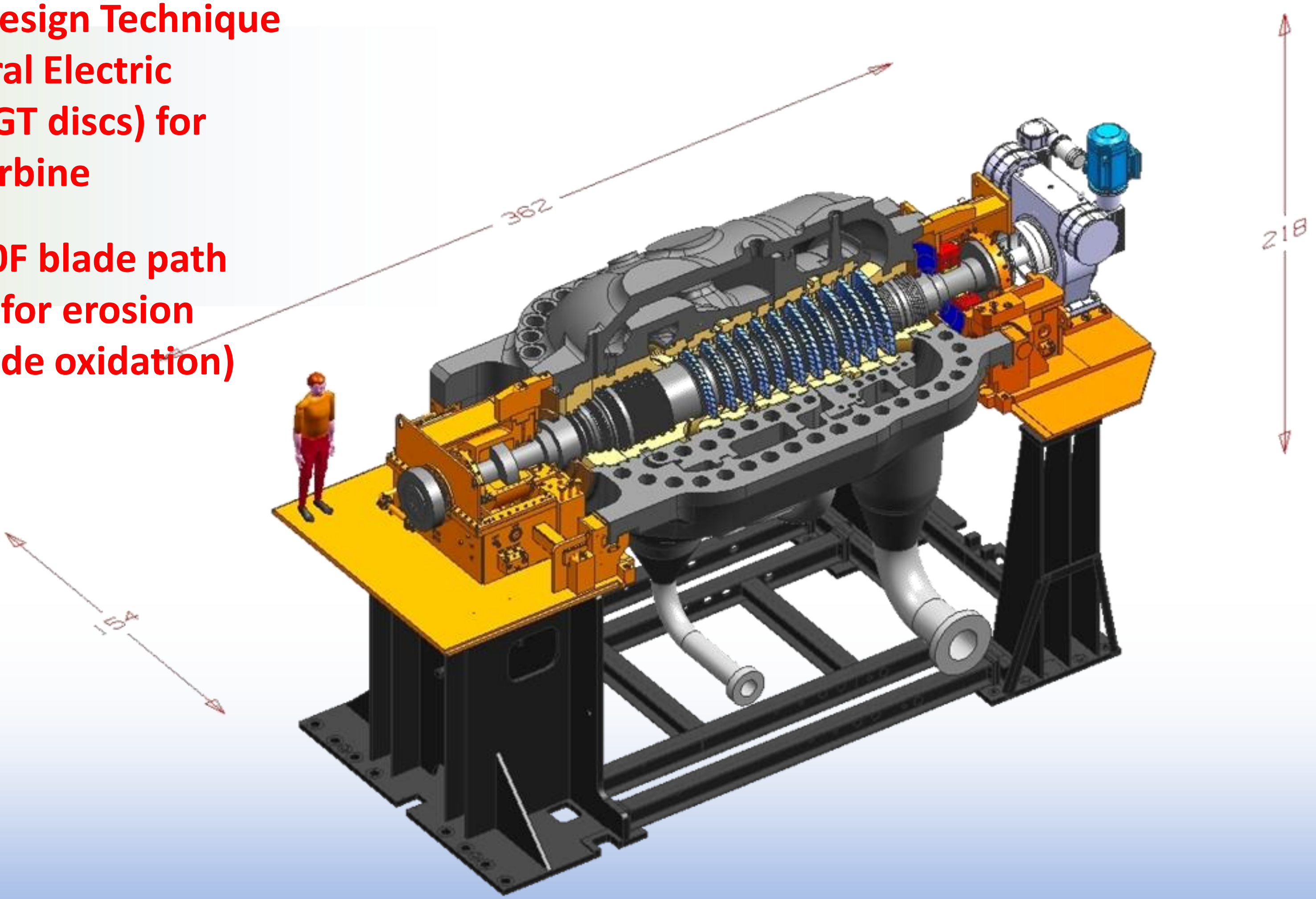
B&W will perform the pre-front end engineering design (Pre-FEED) of an A-USC steam superheater for a component test program achieving 760^{o}C (1400^{o}F) steam temperature. The steam generator superheater would subsequently supply the steam to an A-USC prototype scaled intermediate pressure steam turbine.

In the 3rd quarter of a 5 quarter project (15 months)

COMTEST Turbine Concept Design

"New" Design Technique by General Electric (bolted GT discs) for steam turbine

Test 1400F blade path integrity for erosion (steam side oxidation)



ComTest Youngstown Thermal

ComTest A-USC Superheater

OBJECTIVES

The technical goal of the project is to perform the pre-front end engineering design (Pre-FEED) of a gas fired A-USC steam superheater capable of operating at 760 deg C steam temperature.

-expected results: completed Pre-FEED package for design, procurement, manufacturing, construction, and installation.

ComTest A-USC Superheater

TASKS and SUBTASKS TO BE PERFORMED

Task 1.0 – Project Management and Planning

Task 2.0 – Scope Interface Engineering

Task 3.0 – Product Engineering

Subtask 3.1: Perform pre Front End Engineering Design Studies

Subtask 3.2: Develop Preliminary Commissioning and Testing Plan

Task 4.0 – Mechanical Design of the A-USC Steam Superheater
mechanical engineering design
stress analyses (ASME Code calculations by rule)
general arrangement and layout drawings.

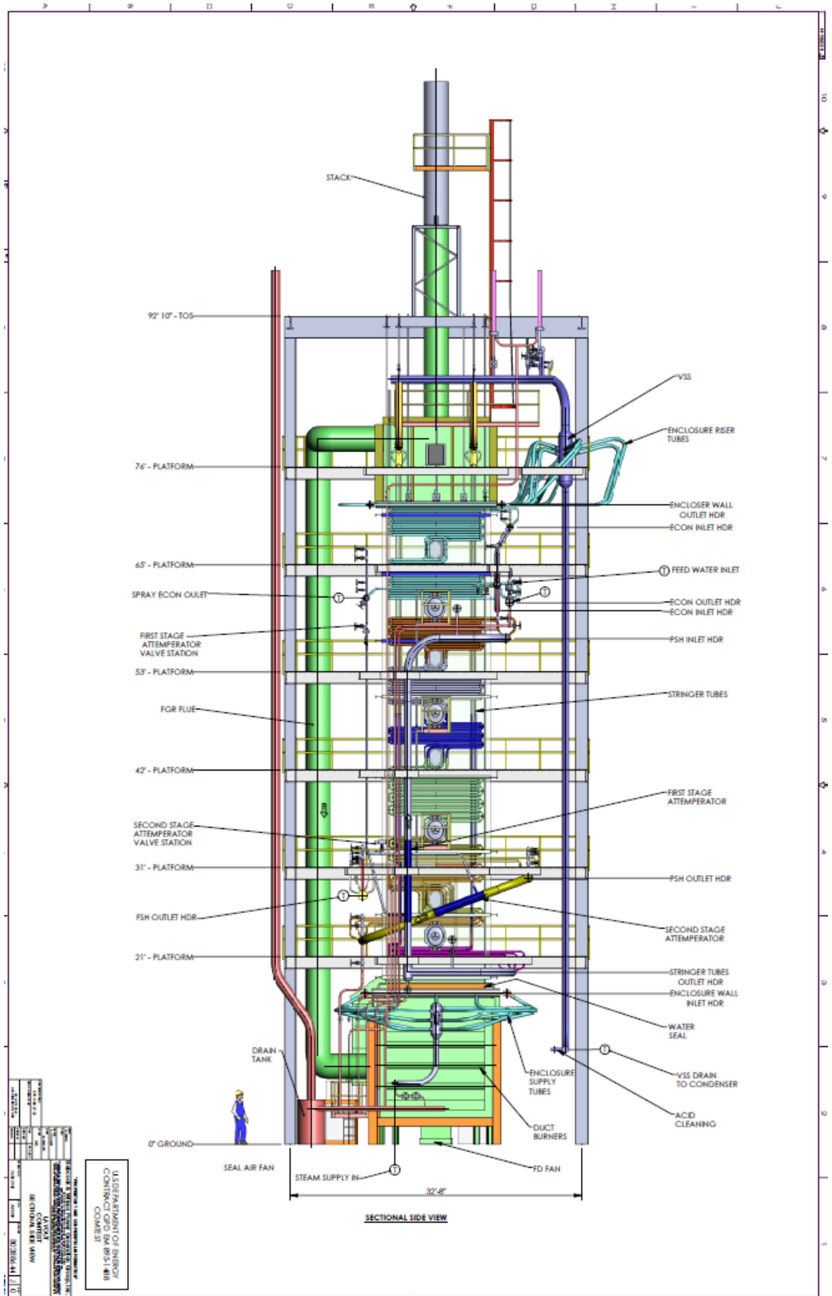
Task 5.0 – Manufacturing Engineering of the A-USC Steam Superheater

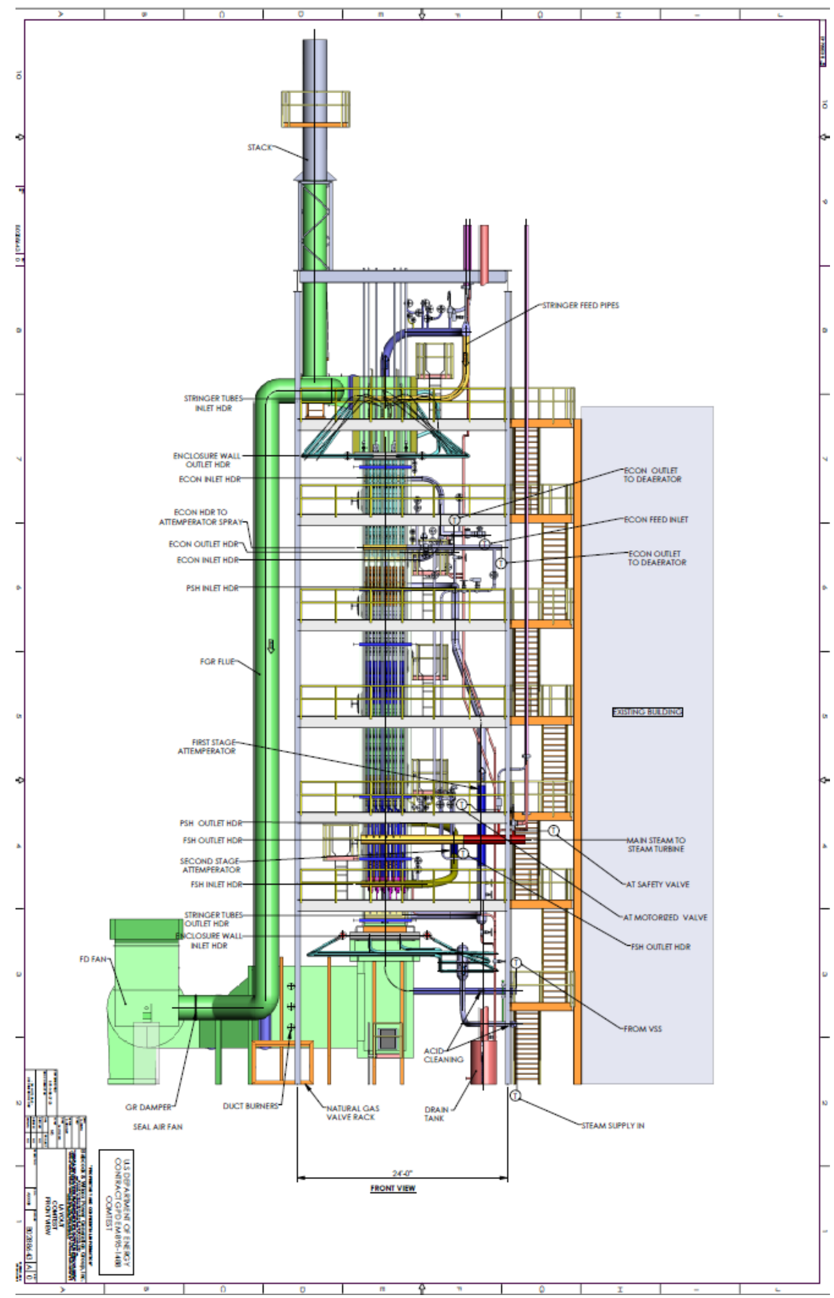
Task 6.0 – Construction Engineering of the A-USC Steam Superheater

Task 7.0 – Cost Estimate for A-USC Steam Superheater

A-USC ComTest Superheater Youngstown Thermal

A-USC ComTest Superheater Youngstown Thermal



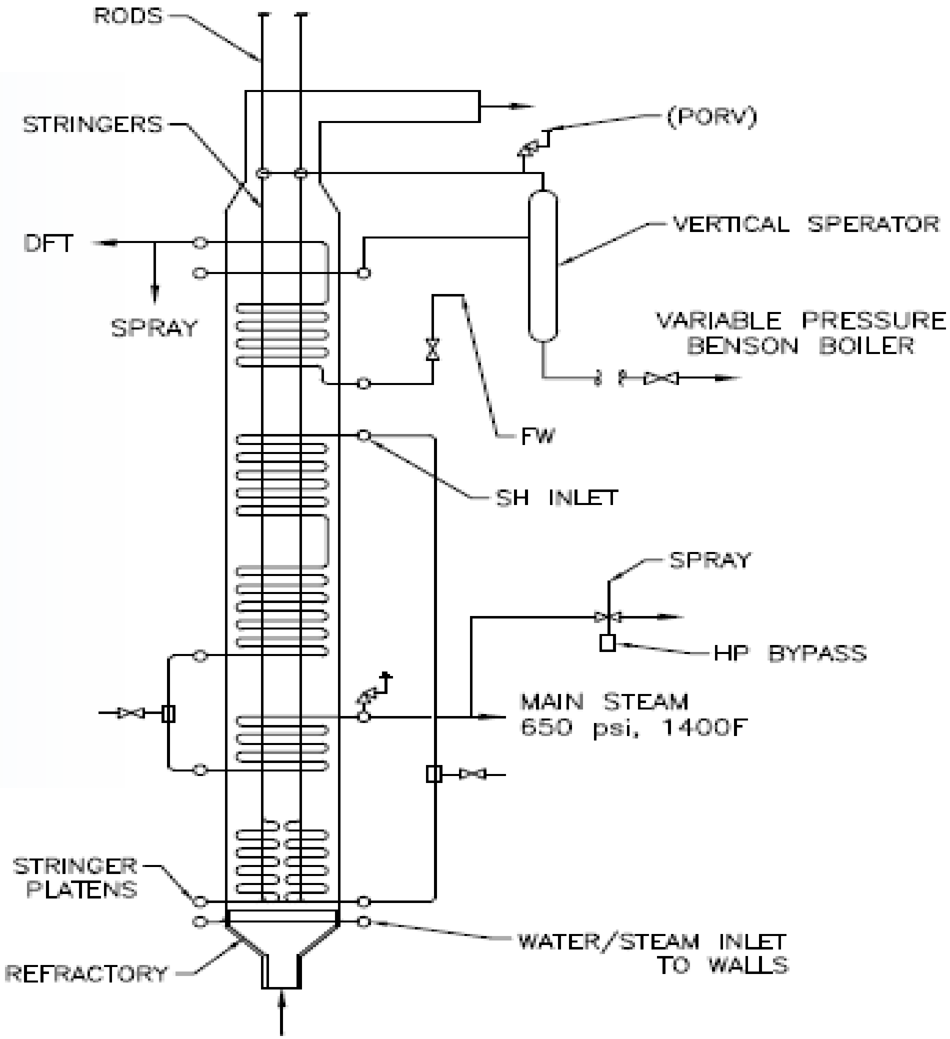


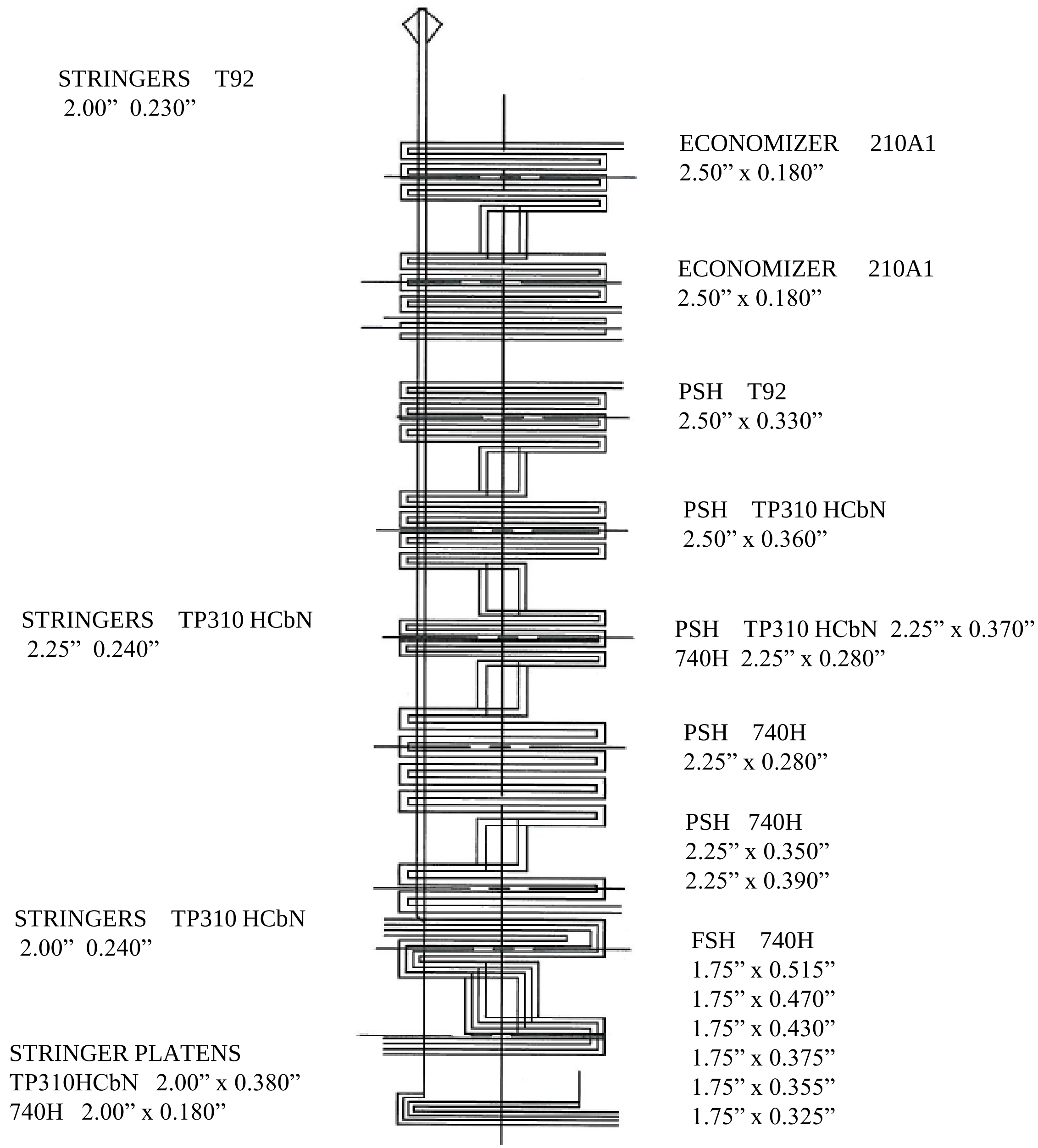
ComTest "Superheater"
@ Host Youngstown Thermal

T-92 Membrane Enclosure, field welding, PWHT, initial service, high temperature operation
2 walls 11ft x 60ft
2 walls 4 ft x 60ft

740H nickel tubes, header, thick piping

Supply chain- nickel valves, accessories




STRINGERS T92
2.00” 0.230”
ECONOMIZER 210A1
2.50” x 0.180”
ECONOMIZER 210A1
2.50” x 0.180”
PSH T92
2.50” x 0.330”
PSH TP310 HCbN
2.50” x 0.360”
STRINGERS TP310 HCbN
2.25” 0.240”
PSH TP310 HCbN 2.25” x 0.370”
740H 2.25” x 0.280”
PSH 740H
2.25” x 0.280”
PSH 740H
2.25” x 0.350”
2.25” x 0.390”
STRINGERS TP310 HCbN
2.00” 0.240”
FSH 740H
1.75” x 0.515”
1.75” x 0.470”
1.75” x 0.430”
1.75” x 0.375”
1.75” x 0.355”
1.75” x 0.325”
STRINGER PLATENS
TP310HCbN 2.00” x 0.380”
740H 2.00” x 0.180”

Fabricate install, PWHT, Repairs accomplished

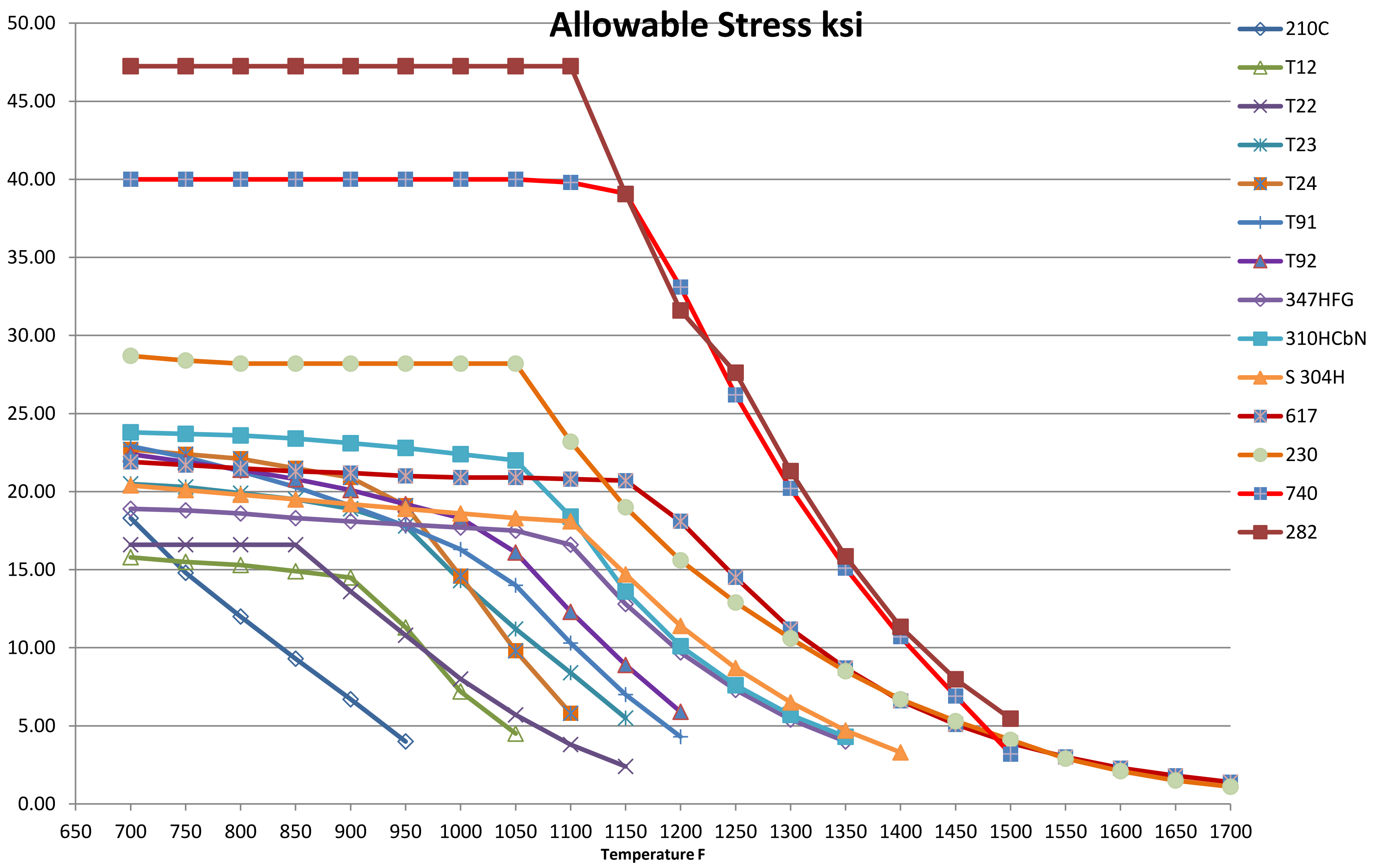
T-92 Test Wall Panel

Have not operated the T-92 panel. Can not weld panel into existing wall enclosure and operate at needed conditions. Need to do that in ComTest

Candidate Steam Generator Materials

Grade or Short Name	Specification	Composition	Application
Carbon Steel	SA-210C SA-106C	Carbon Steel	Economizer Tubes, Piping, Headers
T-12, P-12	SA-213 SA-335	1Cr-.5Mo	Enclosure Tubes, Piping, Headers
T-22, P-22	SA-213 SA-335	2.25Cr-1Mo	Enclosure Tubes, Piping, Headers Superheater Tubes, Piping, Headers
T-23, P-23	SA-213 SA-335	2.25Cr-1.6W-V-Nb	Enclosure Tubes, Piping, Headers, Superheater Tubes, Piping, Headers
T-91, P-91	SA-213 SA-335	9Cr-1Mo-V	Enclosure Tubes, Piping, Headers, Superheater Tubes, Piping, Headers
T-92, P-92	SA-213 SA-335	9Cr-2W	Enclosure Tubes, Piping, Headers Superheater Tubes, Piping, Headers
TP347 HFG	SA-213	18Cr-10Ni-Nb	Superheater Tubes
Super 304H	UNS 30432	18Cr-9Ni-.3Cu-Nb-N	Superheater Tubes
TP310 HCbN	SA-213	25Cr-20Ni-Nb-N	Superheater Tubes
617_	UNS N06617	55Ni-22Cr-9Mo-12Co-Al-Ti	Superheater Tubes, Piping, Headers
230_	UNS N06230	57Ni-22Cr-14W-2Mo-La	Superheater Tubes, Piping, Headers
740H	S/B N07740	50Ni-25Cr-20Co-2Ti-2Nb-V-Al	Superheater Tubes, Piping, Headers
282_	non-ASME	58Ni-10Cr-8.5Mo-2.1Ti-1.5-Al	Future Potential for Tubes, Piping, Headers

ASME I *Allowable Stress for Materials*



ComTest Demonstration Aspects

Validation of the supply chain for nickel components

4500 psi design pressure for fabrication at prototype component sizes

Design and fabrication of nickel (740H) superheater tubes, headers, connection piping and attemperator with nickel liner

Membrane panel (T92) shop welding, field welding and PWHT

Membrane panel corner and buckstay restrained loads at prototype temperature, 750F to 950F steam

Mitigate early life cracking of CSEF (T92) materials

Chemical cleaning and steam blowing start up operations of pressure parts

Thermal load cycling of the A-USC Superheater

A-USC ComTest Purpose

* reduce the economic risk of the first A-USC demonstration plant

* exercise the complete project execution process for placing into service the A-USC plant (the design, procurement through the supply chain, manufacturing, delivery, site construction and commissioning is contained in the ComTest project)

* smaller quantities of expensive materials will be tested in the ComTest phases rather than in a larger first of a kind power plant that must serve the electric grid while using components that have not been placed in first practice

The risk of sacrificing the expensive nickel alloy components in a plant that may not be able to shut down to protect the ComTest materials is averted by this form of test facility design.

ComTest A-USC Superheater

Project Status

Preliminary performance loads for up to 133,800 lb/hr and set tube metals for 1400F steam outlet – need higher pressure drop than initially desired

Final Superheater Outlet Header - 740H 12”OD x 2.875” thick

Determined that a duct burner can be used

Decision to not use an inlet steam heat exchanger from turbine exhaust

Using a two part economizer to provide hotter spray attemperation water & cool the flue gas

Developed initial control system functional process & P&ID’s

Started mechanical engineering design and developed 3D SolidWorks model of ComTest A-USC Superheater arrangement

Started sourcing materials, components and accessories

ComTest A-USC Superheater

Design and supply-chain exercise with a project that attracts response and participation by vendors

Follow-on phases would demonstrate the delivery steps in the same manner of US practice for power plant projects.

Why A-USC +1300F (704C) Operation

- **+11% reduction** in fuel consumption and CO_2 emissions vs. 600C plant heat rate
- **+29% reduction** vs. the current fleet average heat rate and CO_2 emissions – **could replace <u>existing units</u>** with new A-USC plants and meet EPA CO_2 goal without carbon capture

- Lower flue gas handling equipment size and fan power
- Lower plant fuel handling
- Lower fuel transportation system impact
- Lower water consumption and condenser heat duty

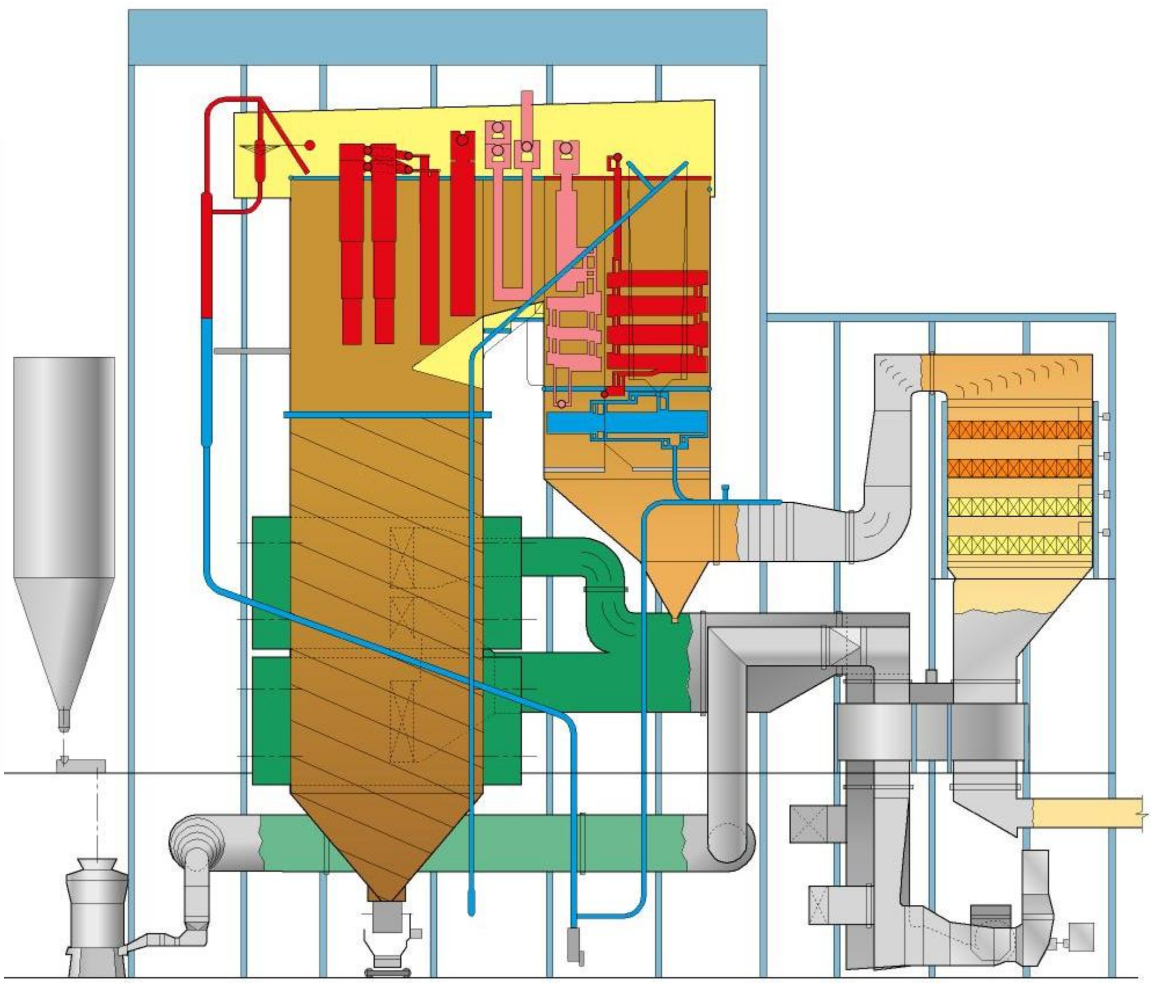
- **Lower CO_2 emitted and auxiliary power consumption for capture**

Current US State-of-the-Art – Ultrasupercritical (USC)
1115F (600C)
AEP John W. Turk Plant 2012

16% better heat rate and lower CO_2 emissions

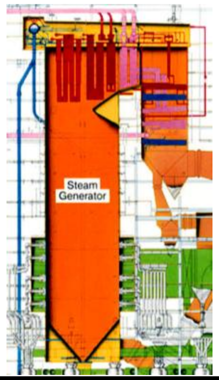
@ nominal 600 MW_{NET}
Average heat rate 8858 Btu/kWh in 2013

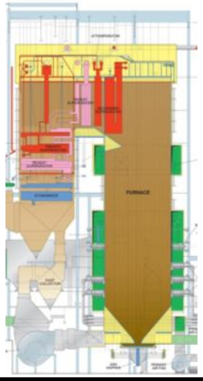
US Fleet Average
10,555 Btu/kWh

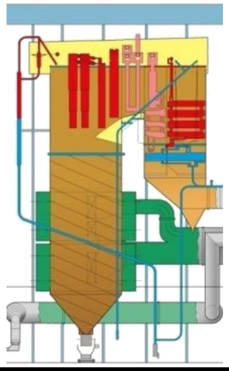


* Power Engineering July 2014

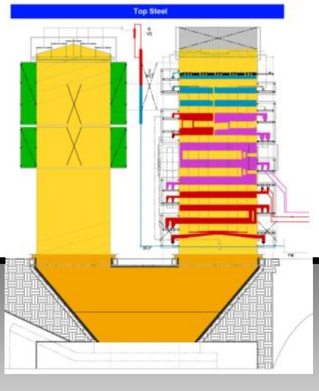
Steam Cycle Evolution







Future Consideration?



	Subcritical Xcel-Sherco 3	Supercritical FE-Sammis 7	Ultra Supercritical AEP-Turk	Advanced Ultrasupercritical
Steam Press/SH/RH	2640/1005/1005	3785/1005/1005	3789/1114/1126	5000/1356/1401
Heat Rate	10,700	9500	8860	7500
Net Efficiency	32	36	38	45.5
Relative CO_2 Reduction	Base	11.2	17.2	29.9

Thank You!

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