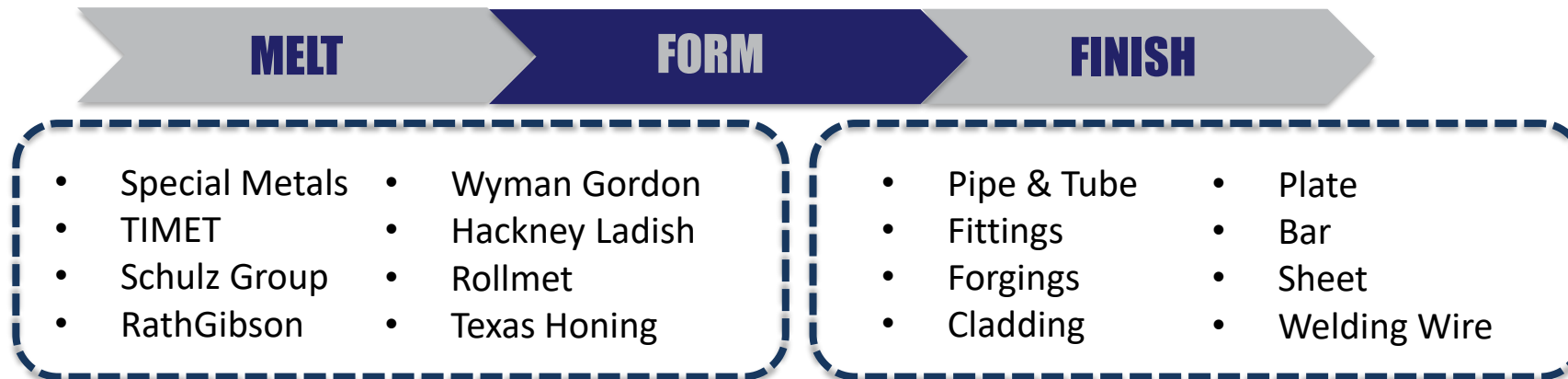
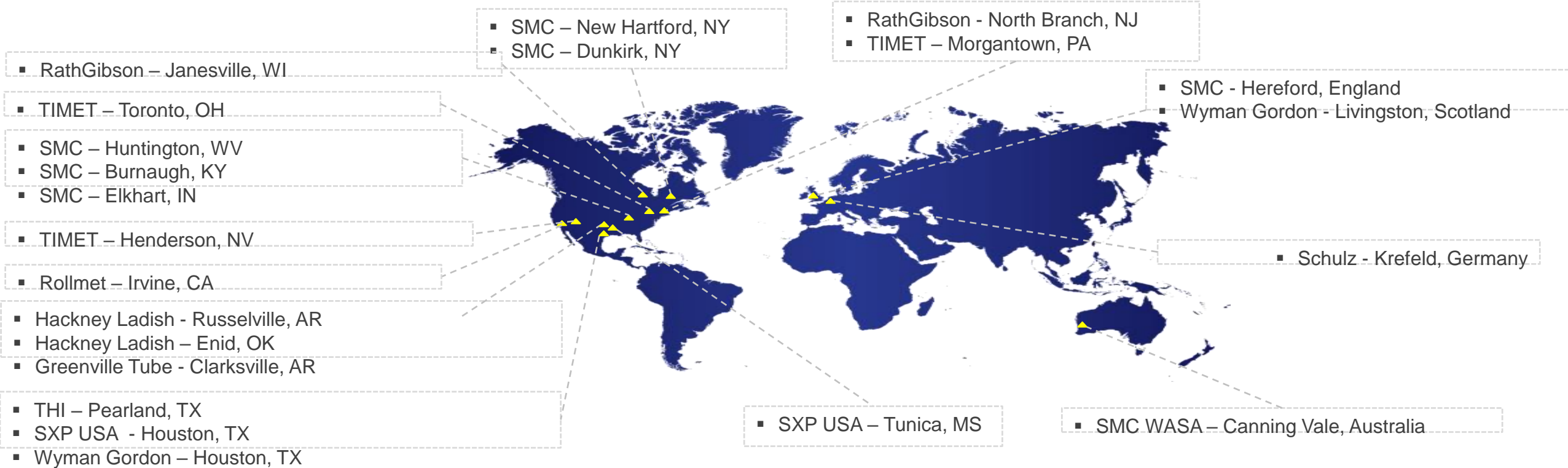


PCC

**SPECIAL
METALS**

Application INCONEL alloy 740H for CSP & sCO₂ power

PCC Metals & Energy Locations



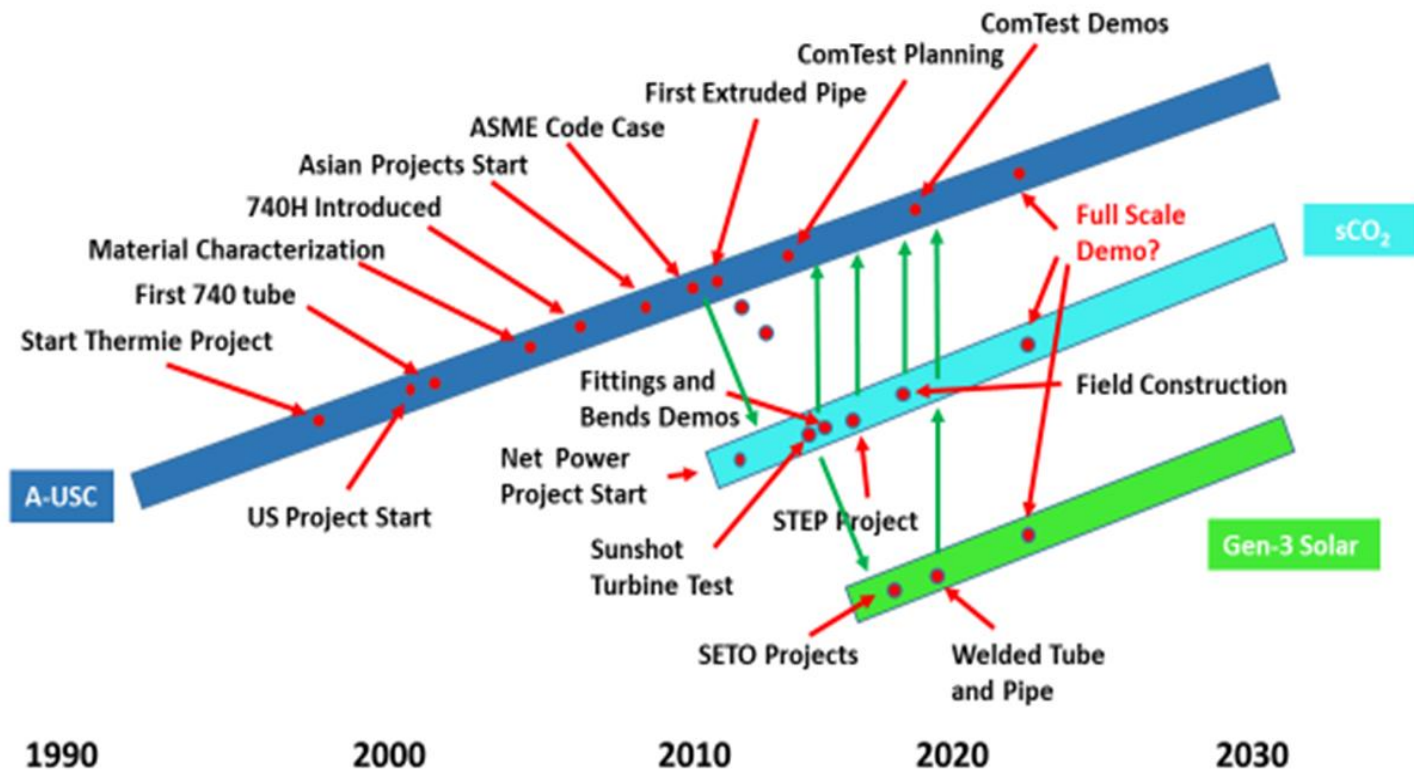
Introduction

INCONEL Alloy	Ni	Co	Mo	Cr	C	Al	Ti	Other
740H	50	20	0.5	25	0.04	1.4	1.4	1.5 Nb

- Comtest steam A-USC 760C boiler & turbine
- sCO₂ power systems
 - High efficiency – low emission
 - Low cost electricity
 - Low water consumption
 - Small footprint
 - Coal, gas, nuclear and solar
- SETO CSP Projects
- INCONEL 740H – designed for 760C & 300bar
- ASME code approval in 2011
- Pilot & Demonstration projects



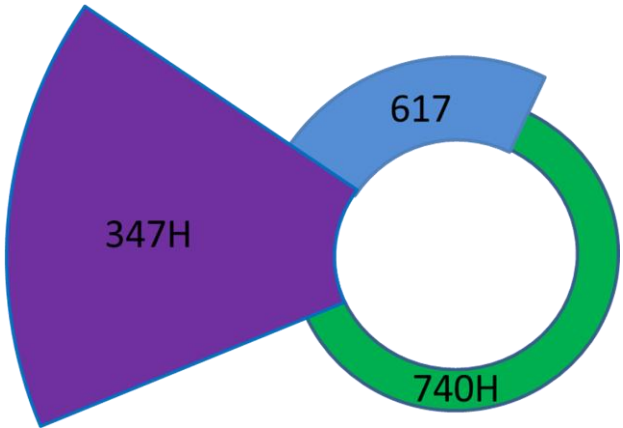
First fired sCO₂ system using 740H Sun Shot Turbine Test Heater (Thar/SwRI)



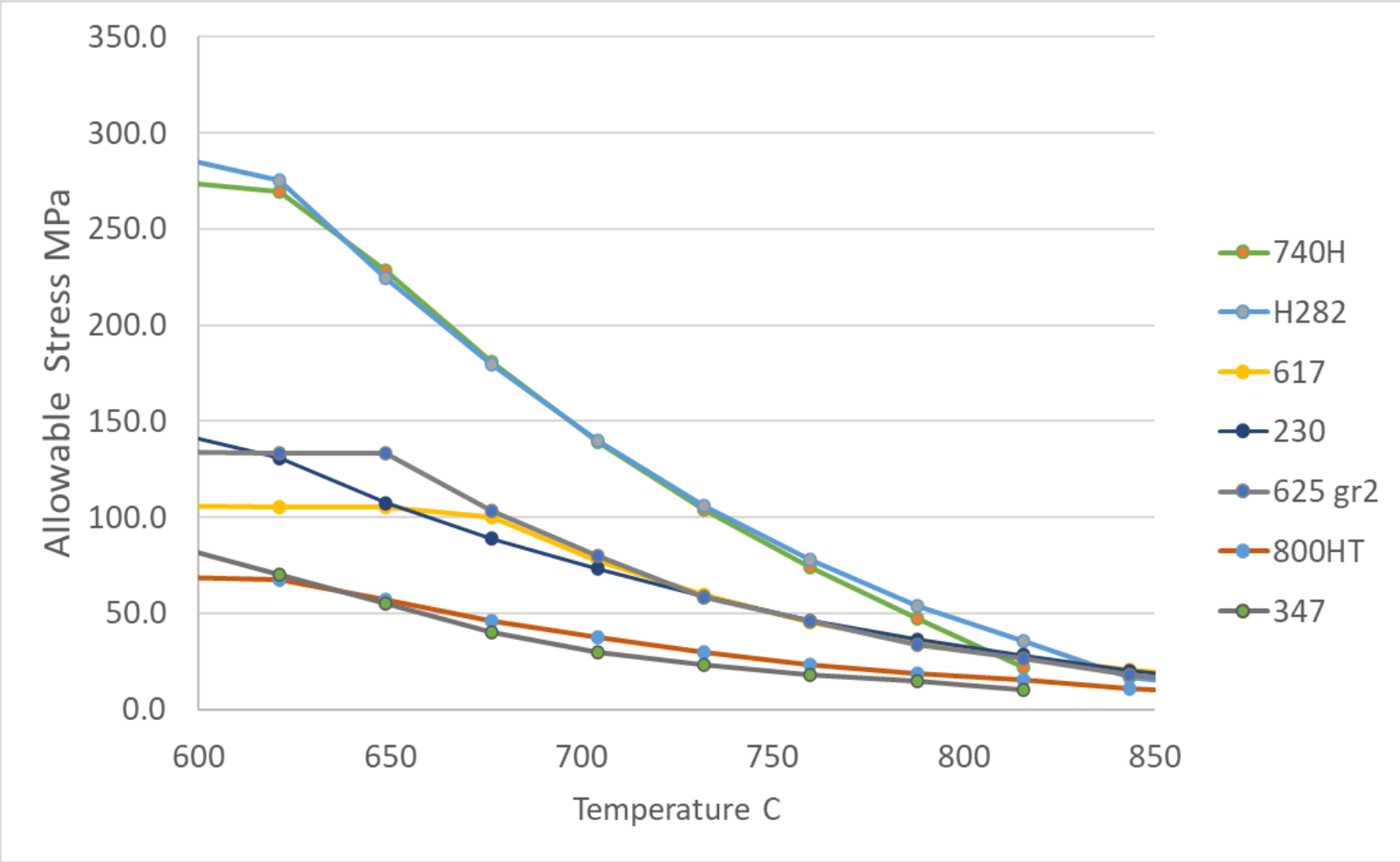
Specifications: ASME Code Stress Allowables

- ASME BPVC Code Stress Allowables
- PH Grades included sect 1 & VIII
- 740H creep data up to 100k hrs
- 740H Strength & Cost advantage

Relative pipe wall thickness at 700C, ASME allowable stress for 350 bar



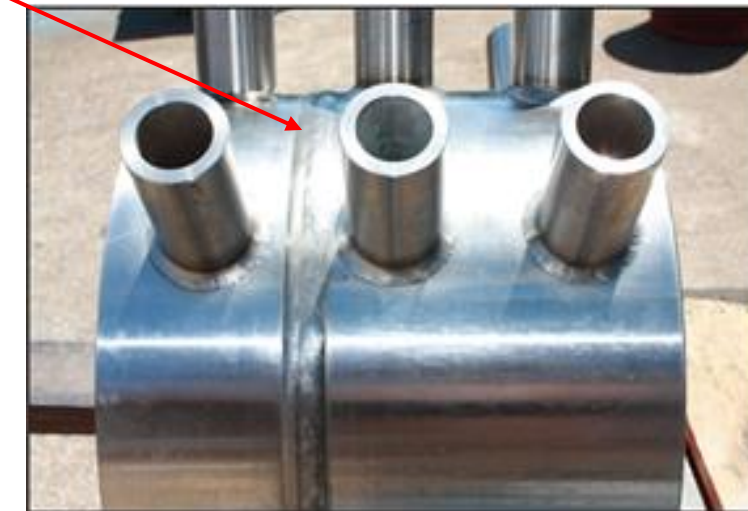
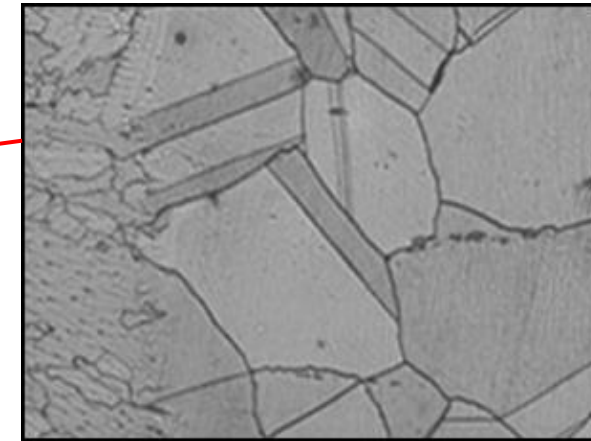
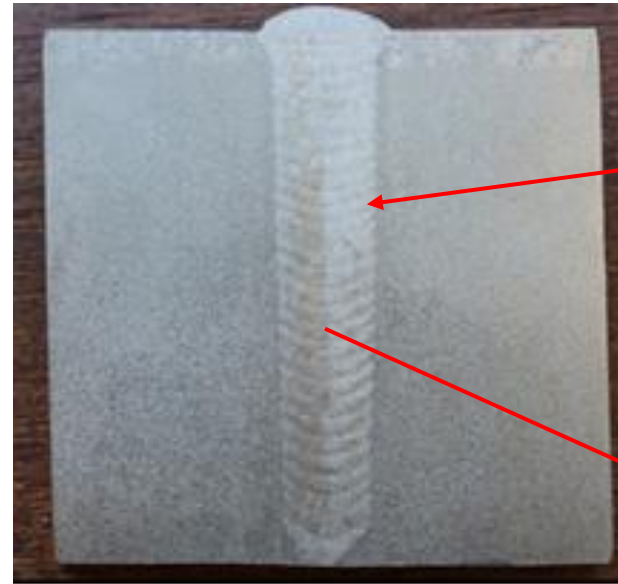
ASME Code Stress Allowables



740H is a registered tradename of Special Metals Corporation
 282® is a registered tradename of Haynes International

Welding: INCONEL alloy 740H

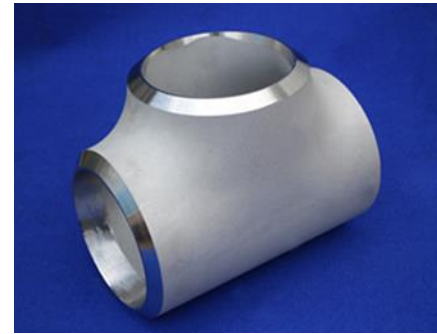
- Nickel alloy Welding Parameters
 - Low heat input, bead shape, avoid oxide buildup, Ar + He gas, interpass < 175C
 - Weld in soln ann or soln ann & aged
- Applicable Methods
 - GTAW, GMAW with matching filler
- Heat treatment
 - PWHT same as 740H aging treatment
- Properties
 - Mechanicals similar to base, 4T Bend
 - Good microstructure stability of weld metal
 - No Stress relief or liquation cracking in 740H 3" thick weldments



**Header Mockup,
Girth Welding**

Products: Fittings, Rings, Valves and Turbine Parts

- Manufacture of fittings
 - Flange hammer forged
 - Elbow by press forging
 - Concentric reducer by cold pressing
 - Tee by cold hydroforming
- Heavy wall rolled ring
 - Application for gas and sCO₂ turbine components
 - Upset press forged from bar
 - Roll to 864mm OD x 635mm ID x 165mm wt



Tee

Hydro
formed



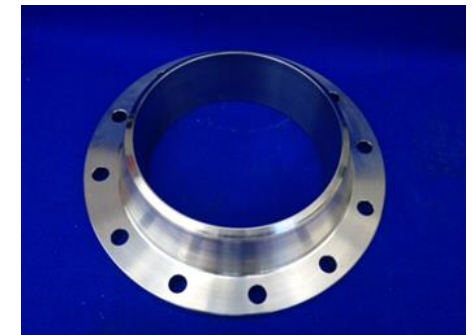
Reducer

Elbow



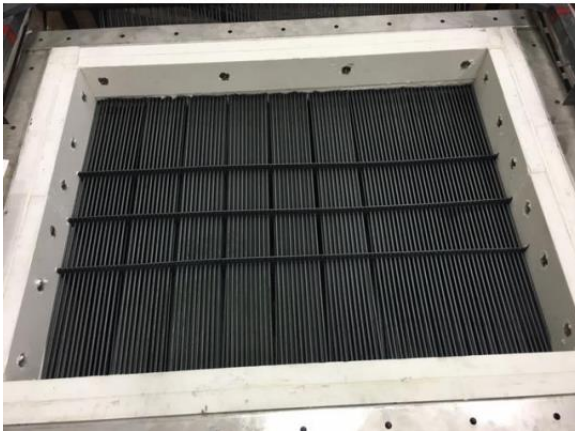
Rolled
Ring

Flange



INCONEL 740H sCO₂ Application: 2.5MW uSCO₂ Heater

- **SUNSHOT sCO₂ 2.5MW microtube heater**
 - Thar Energy & SWRI designed
 - Recuperated Brayton Cycle
 - Heater air –sCO₂ HX – air @ 715C, 250bar
 - 1830m of 7.37mm OD x 1.14mm wt 740H tube
 - 2.5" sch XXS manifold piping & 90° elbows in 740H
 - 1.5D cold bending tube in the solution annealed condition

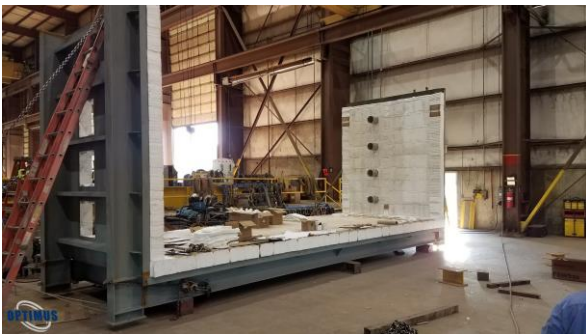
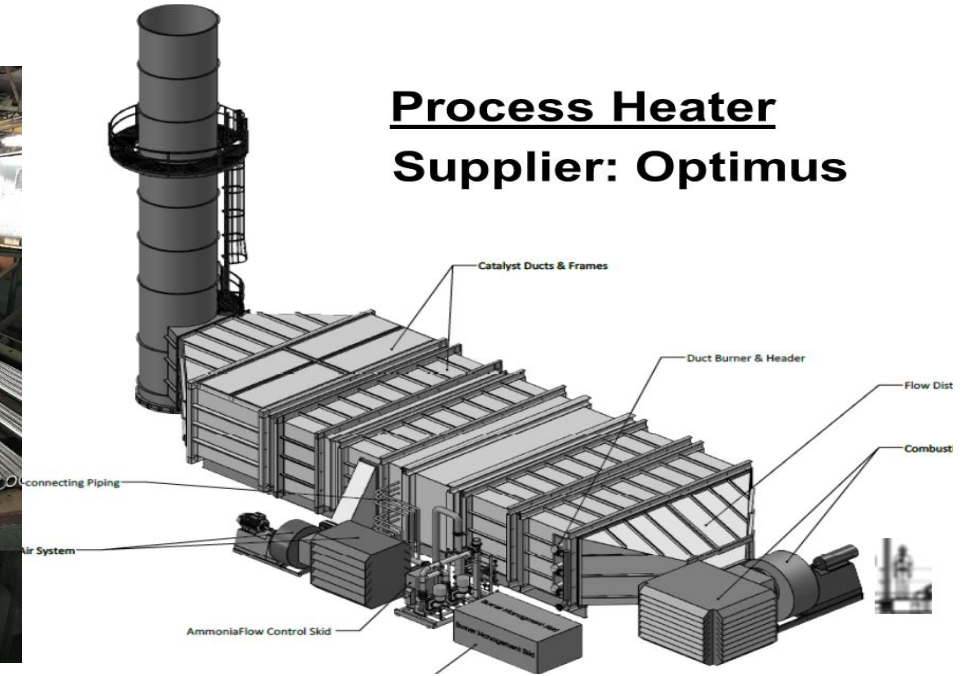


INCONEL 740H



Application: Supercritical Transformational Electric Power (STEP)

- STEP - \$120M 6yr project demo sCO₂
- Turbomachinery, compressors, recuperators
- Process Heater - HSRG style “boiler”
 - Multi-pass IN740H heat exchanger
 - Designed to ASME BPV Section 1
 - Designed for 100 kg/s CO₂
 - at 276 bar, 715°C
 - Size: 4.2m W x 40m L x 5.5m H
- SMC 4440ft 1.5”OD tube alloy 740H
- Provided by Optimus Industries, LLC



Burner Section module
being fabricated



IN740H header pipe 11.25” OD, 7.5”
ID with holes for tubing drilled



Cast tube sheet



IN740H tubing bends



IN740H tubing with 304S fins

INCONEL 740H Supply Chain & Product Forms



Valves
Fasteners



Valves,
Turbine Rings



Large bore pipe



Small bore tube



Pipe spools
Fittings



Headers,
Manifolds



Thin sheet &
Plates



Specification	Product	Date
ASME section 1, code case 2702-07	All product forms	2011
ASME B31.1 code case 190,	Pipe	2012
ASME B16.24	Valves	2016
ASME VIII, Division 1, VIII code case 3056	All product forms	2022
ASTM B983-16	Seamless Tube & pipe	2016
ASTM B637	Forgings, forging stock and bars	2016
ASTM B1007-17	Welded PH Nickel tube alloys	2017
ASTM B670	Strip, Sheet & Plate	2021
AWS A5. 14-ERNiCrCo-1	Welding products	2012

Summary: INCONEL alloy 740H

- INCONEL 740H applied in sCO₂ pressure applications
- Characterised mechanical and corrosion properties
- Developed welding & fabrication techniques for aged material
- Used in Pilot & Demo scale plants
- GEN 3 solar & sCO₂ welded tube and pipe



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