

sCO₂ Test Loop and Heat Transfer Facility

A 1 MW_{th}-scale sCO₂ system for any Gen3CSP heat transfer pathway

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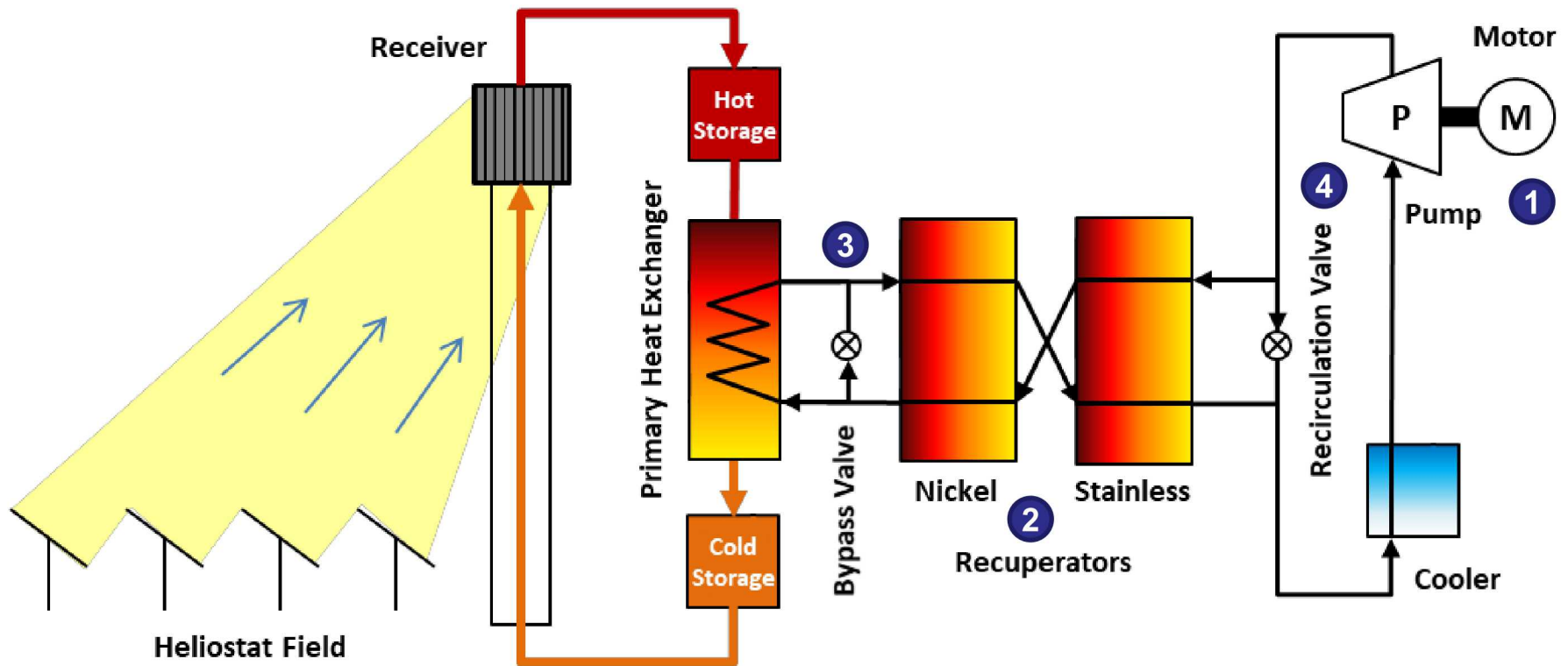


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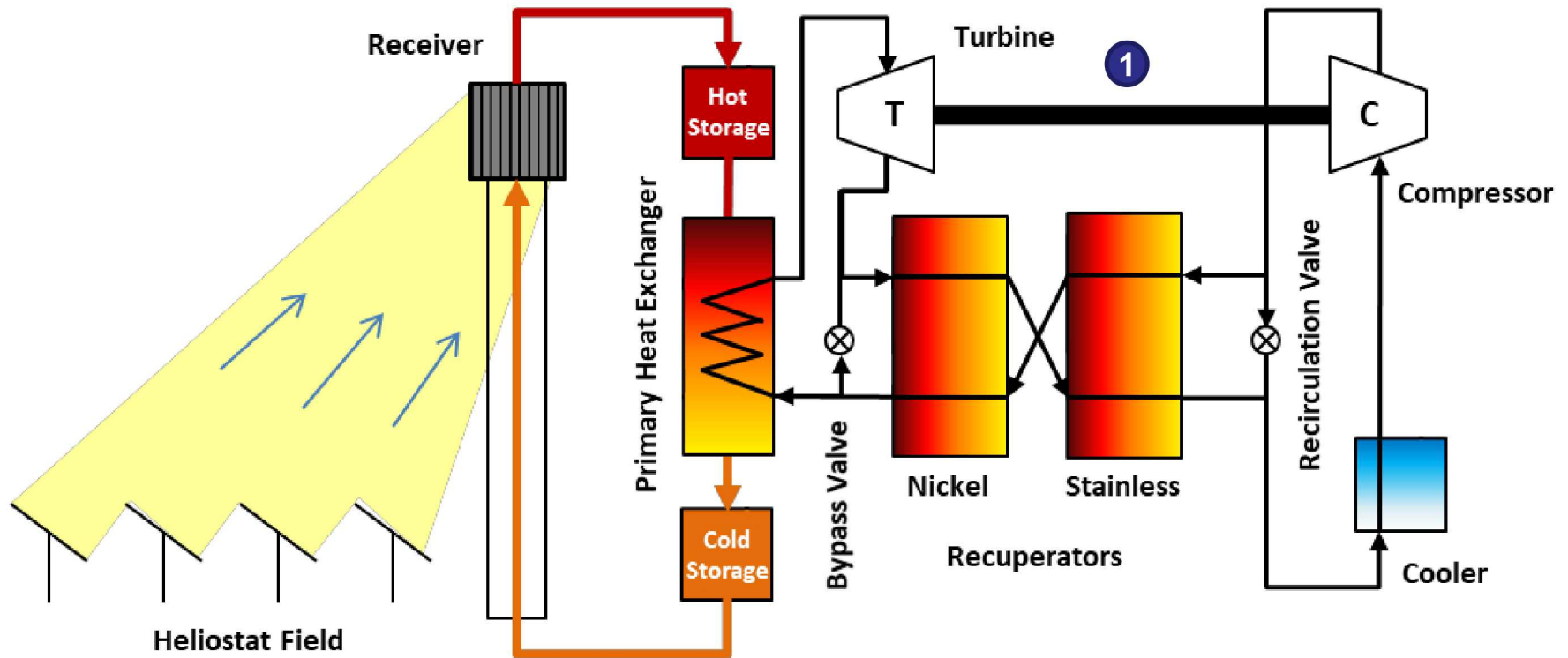


sCO₂ Flow System Design - Primary



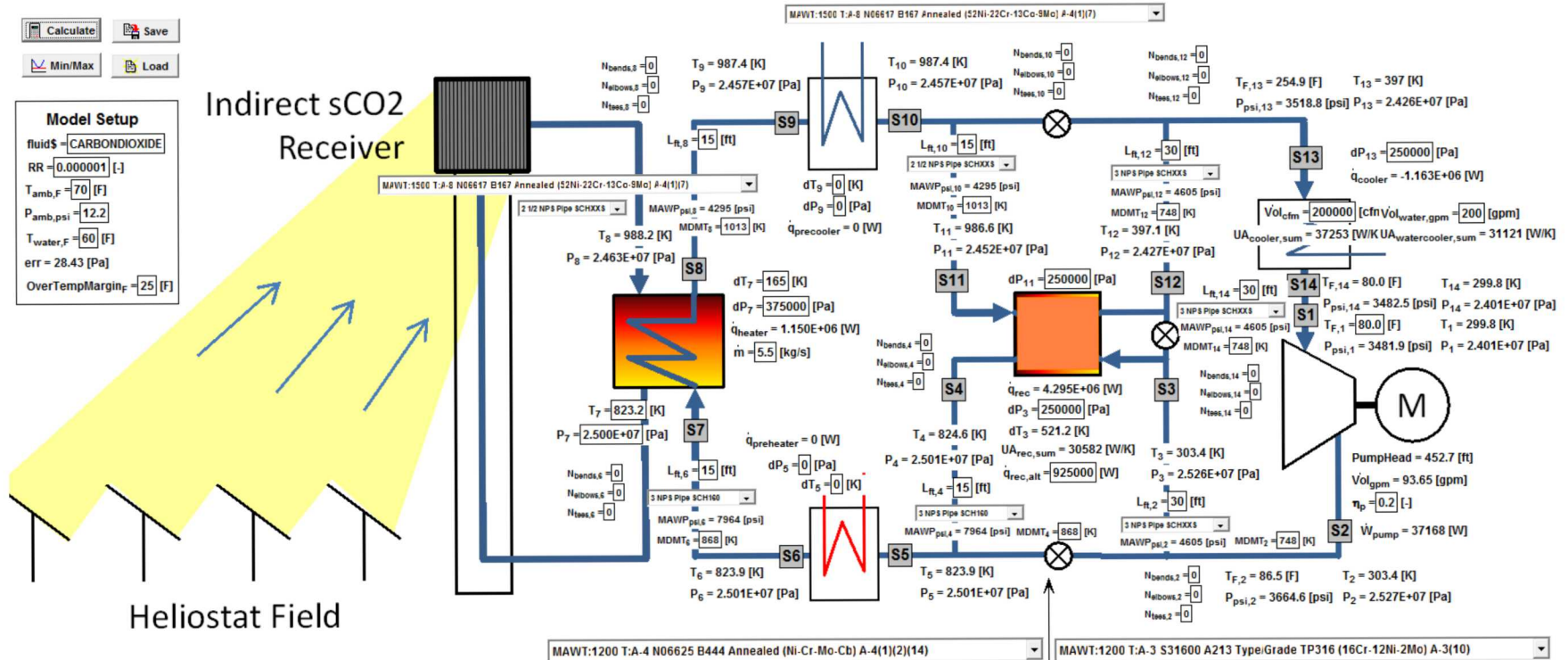
1. The primary loop design uses an industrial canned motor pump for reliability.
2. The recuperator is split into nickel and steel sections to reduce cost.
3. Particle/sCO₂ HXer bypass flow for turn-down operation.
4. Pump/Compressor recirculation avoids dead-head/surge conditions.

sCO₂ Flow System Design - Secondary



1. The secondary design allows for the use of a turbine and compressor. One option is a 420 bar, 750 °C, 5.5 kg/s Peregrine turbocompressor under test.

sCO2 Flow System Design - Detailed



	Pump	Cooler	Recuperators	Piping & Instr.	System
Cost / k\$	300	60	80	150	740 (total)
Lead Time / wks.	35	24	30	2 to 12	35 (max)
MAWP / bar	275	275	275	296	275 (min)
MDMT / °C	90	450	600	450 to 735	735 (max)
Material UNS#	S31600	S31600	S31600	N06230	Various
Weight / lbf	2500	550	650	250	4450 total

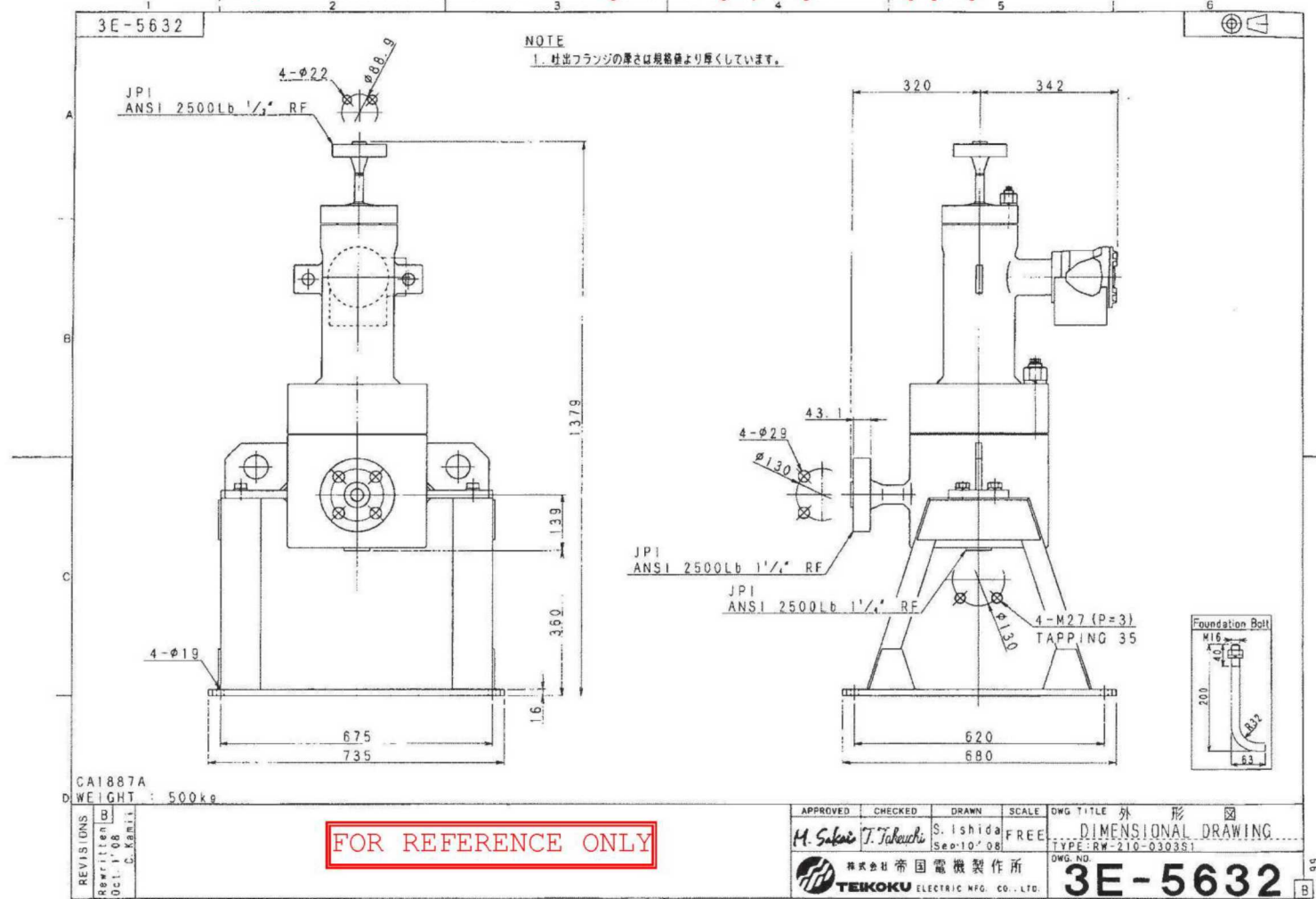
Relative Sizing of the Canned Motor Pump

	Teikoku RW49-518C4L-0405U1Z1V-A	This Estimate	Teikoku RW49-2919J4BL-1015WZ1V-G
Cost / k\$	184	300	732
Lead Time / wks.	26-28	35	53
Inlet Temp. / °F	100	100	100
Max Head / ft	450	450	684
Max Flow / gpm	117	100	1380
MAWP / psi	4000	>4000	5000
MDMT / °F	200	200	200
Impeller Type	Centrifugal	Centrifugal	Centrifugal
Drive Type	Canned Motor	Canned Motor	Canned Motor
Weight / lbf	1600	2500	22050
Motor Size / hp	35	50	268

- 1. Teikoku model RW49-518C4L-0405U1Z1V-A requires a higher design pressure.**
- 2. Information from the direct quote provides confidence in cost and lead-time.**
- 3. Canned motor design avoids the need for a dry-gas seal and make-up gas.**
- 4. Process fluid provides cooling of the motor windings.**
- 5. Silicon carbide bearings are more suitable than graphite for dry gas operation.**

Teikoku Canned Motor Pump

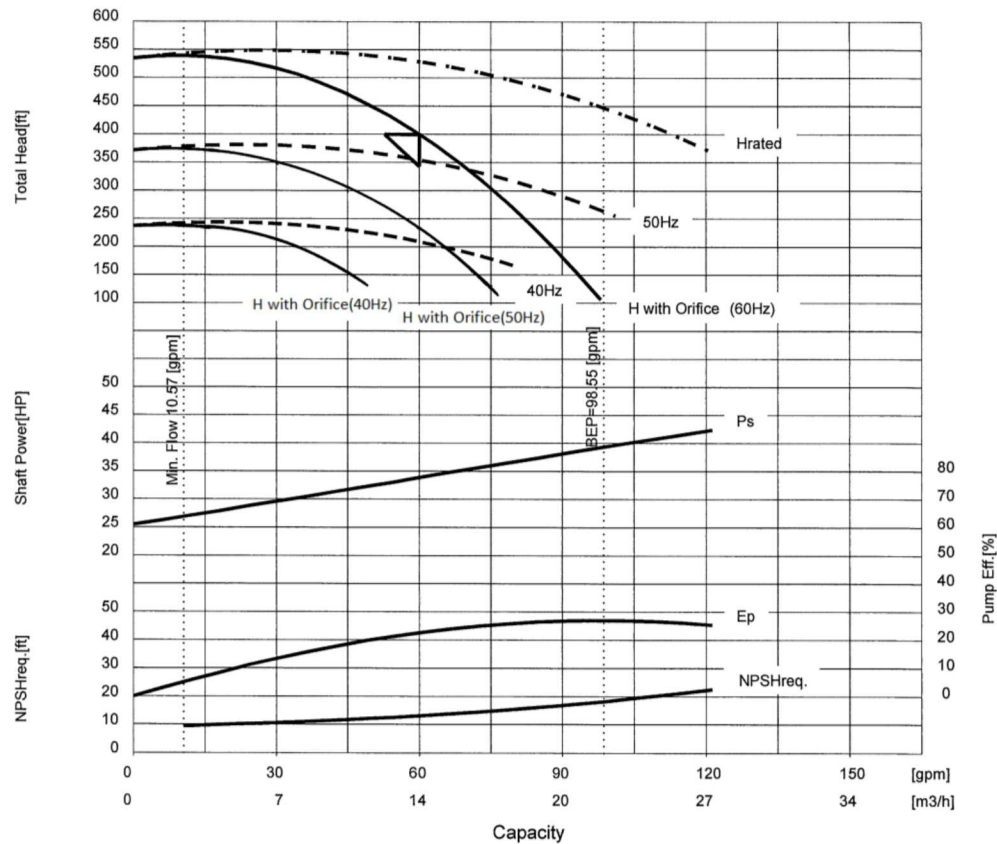
Quote TUS1600775 for Sandia N. L. -- drawing of similar high system pressure design pump



FOR REFERENCE ONLY

Teikoku Canned Motor Pump

Item No.	1 - Revised Selection RFQ 760475		Item Name	(Liquid) Supercritical CO2		
Model	RW49-518C4BL-0405U1z1V-G					
Frequency	60	Hz	Total Head	400	ft	
Voltage	460	V	Capacity	60	gpm	13.63 m3/h
Phase	3		Min.Flow	10.57	gpm	2.401 m3/h
Pole	2		Liquid	Supercritical CO2		
Output	38.9	HP	Temp.	100	degF	
Current	55	A	S.G.	0.96	Vis.	0.11 mPas
Ex-proof	d2G3		NPSHavail.	Advise	ft	NPSHreq. 13.1 ft



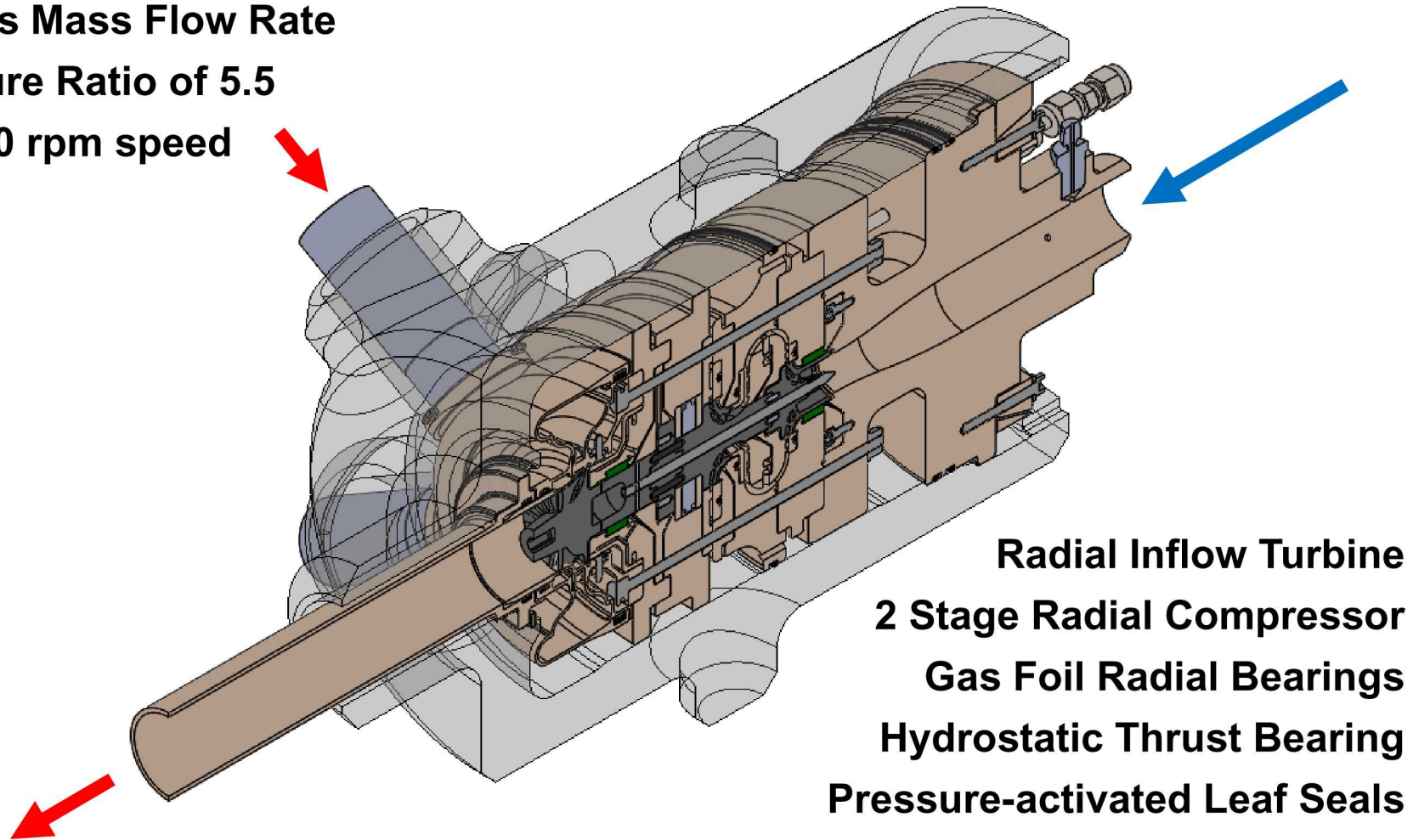
Peregrine Turbo-Compressor Option

750 °C Turbine Inlet Temperature

5.5 kg/s Mass Flow Rate

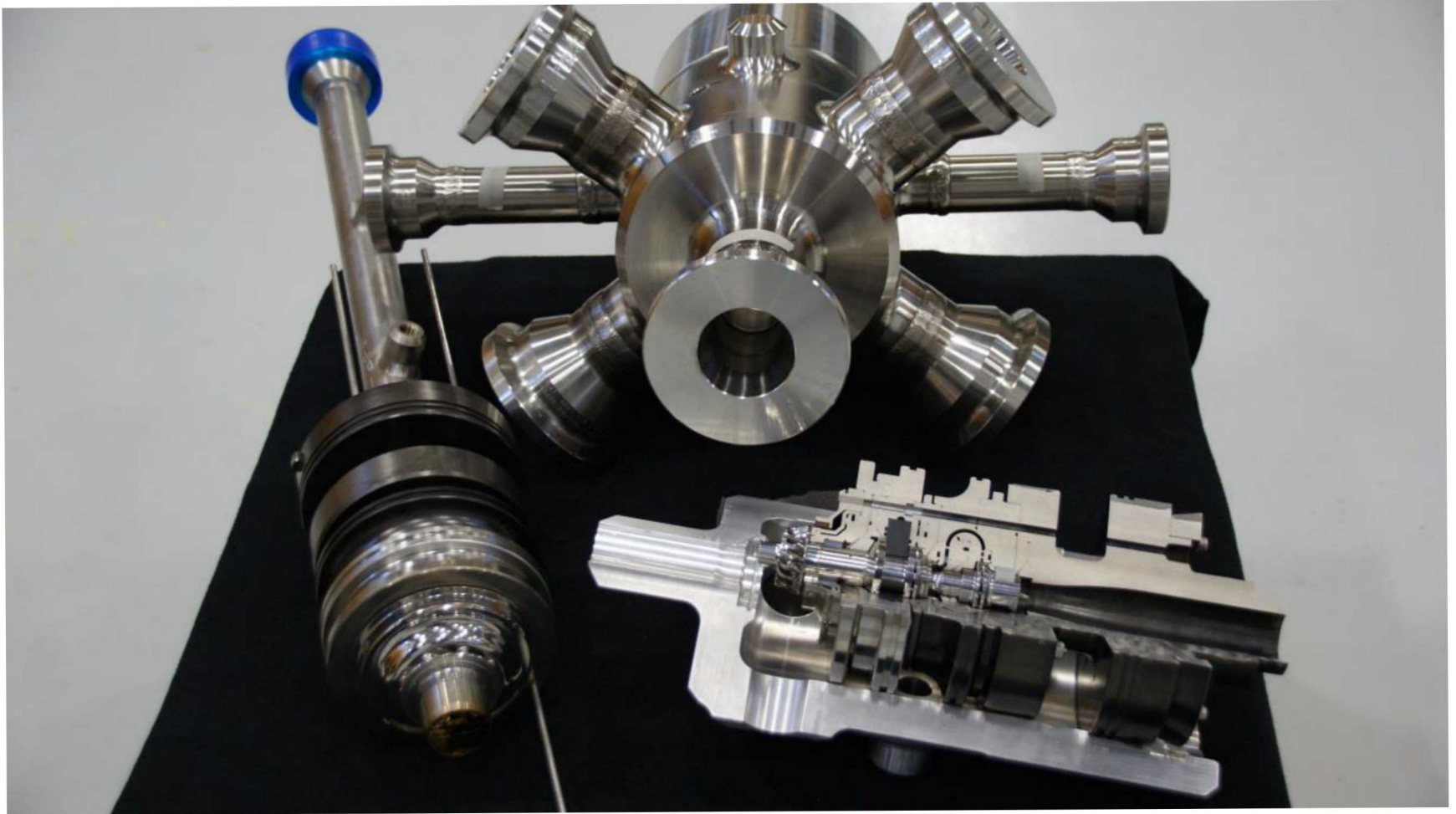
Pressure Ratio of 5.5

118,350 rpm speed



Radial Inflow Turbine
2 Stage Radial Compressor
Gas Foil Radial Bearings
Hydrostatic Thrust Bearing
Pressure-activated Leaf Seals

Peregrine Turbo-Compressor Option

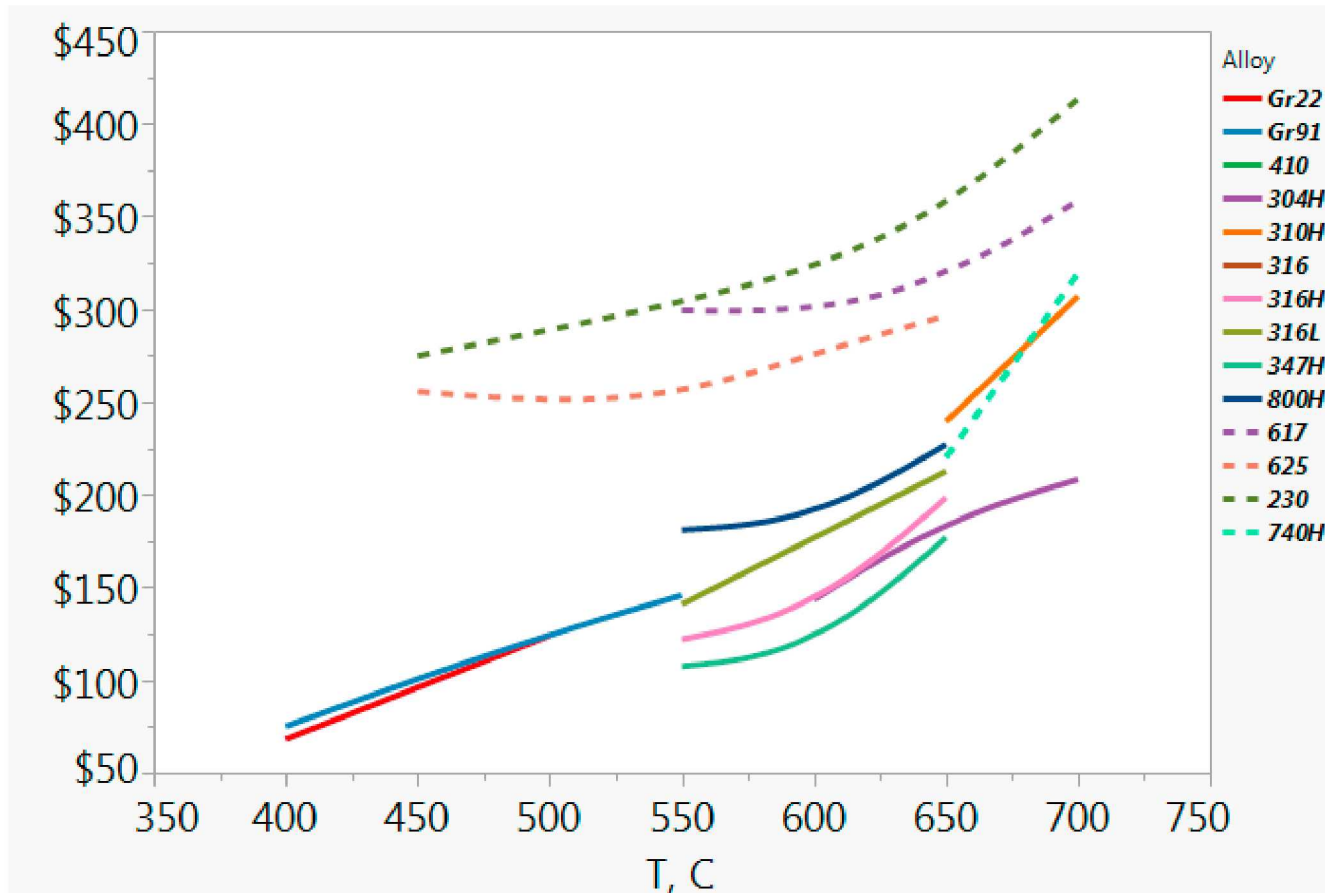


Preliminary Sizing of Heat Exchangers

	Water Cooler	Low-Temp Recup	High-Temp Recup
Cost / k\$	60	80	150
Lead Time / wks.	24	30	22
Max Inlet Temp. / °C	400	550	710
UA / W/K	34000	31000	10600
Surface Area / m ²	16	17	6
MAWP / psi	4000	4000	4000
MDMT / °C	450	600	735
Material UNS#	S31600/S31603	S31600/S31603	N06230 or N08810
Exchanger Type	PCHE	PCHE	PCHE
Duty / MW	1.2	3.9	1.3
Weight / lbf	550	650	250

1. Printed circuit heat exchangers (PCHEs) used for all applications.
2. The recuperator is split into high- and low-temperature sections to save cost.
3. Haynes 230 or 800H will be used for the high-temperature recuperator depending on the maturity of diffusion bonding processes.
4. Split recuperator also allows for future re-use in alternative cycle configurations (i.e. partial cooling) with additional turbomachinery.

Economical Piping Costs



Quotes from SuNLaMP are consistent; 2 NPS SCH XXS piping costs approximately 500 \$/ft for Inconel 617, 300 \$/ft for Inconel 625, 120 \$/ft for Inconel 800H, and 35 \$/ft for austenitic stainless steels satisfying high-temperature requirements.

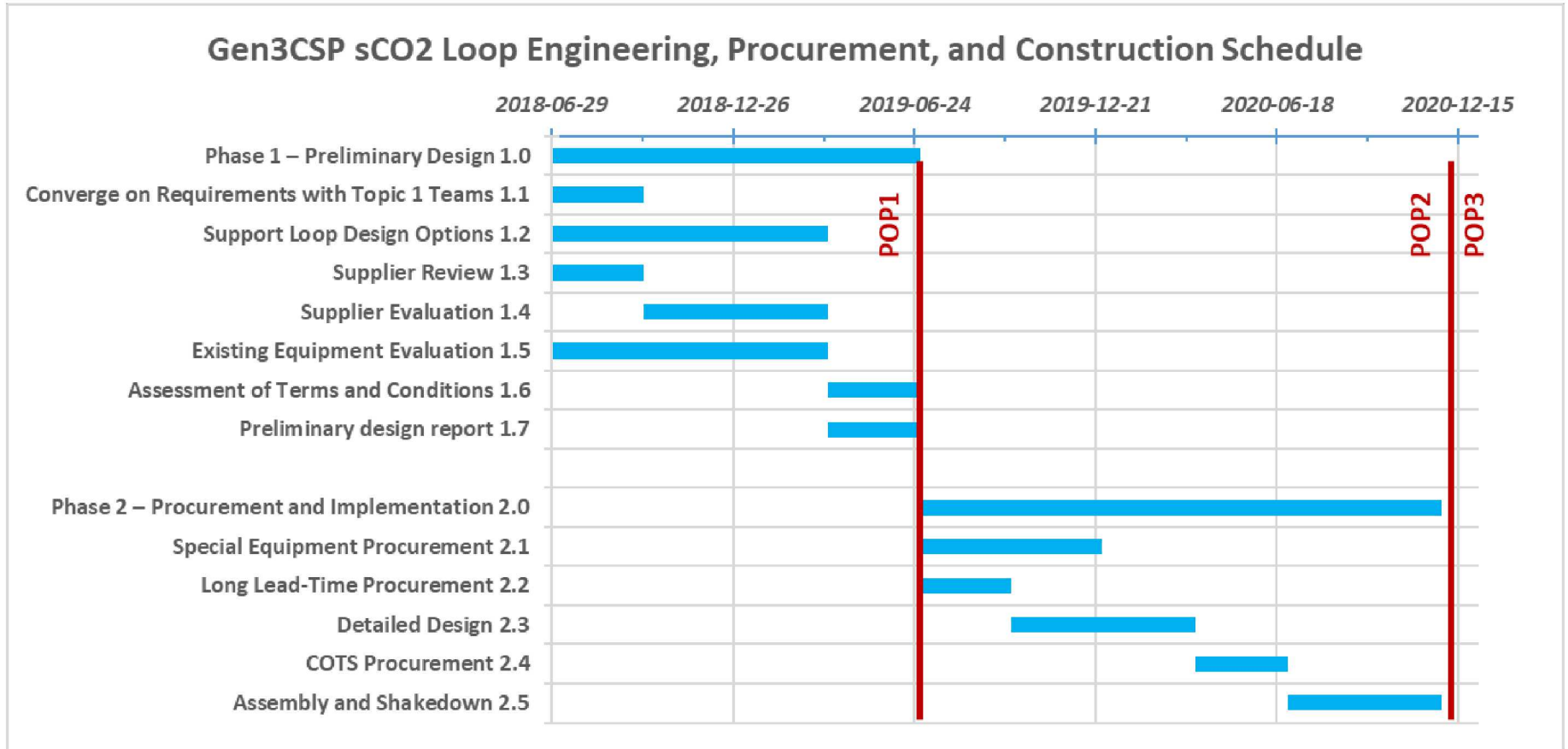
Economical Piping Costs

Piping	Above 595 °C	595 °C to 450 °C	Below 450 °C
MAWP / psi	4300	5650	4600
MDMT / °C	740	595	475
Velocity / ft/s	60	40	<30
Material UNS#	N06617	N06625	S31600/S31603
Pipe Size	2.5 NPS SCHXXS	3 NPS SCH80	3 NPS SCHXXS
Cost / \$/ft	500	300	35
Total Length / ft	30	30	90
Total Cost / \$	15000	9000	3150

1. Piping materials were chosen considering:

- Pressure containment requirements of the ASME B31.1 power piping code
- Flow resistance for sCO₂ at conditions appropriate to each section of pipe
- Experience with availability without a dedicated mill run (<1000 ft or 50 k\$)
- Corrosion allowances based on available sCO₂ data

Engineering, Procurement, and Construction



Requirements Needed from Topic 1 Teams

	Best Case	Most Likely	Worst Case
MAWP / bar	275		248
Flow Rate / kg/s			5.5
Inlet Temp / °C			
Outlet Temp / °C	735		
Inlet Pressure / psi			
Pressure Drop / psi			
Thermal Duty / MW_{th}	2		1
Inlet Connection	Clamp Connectors		Welded
Outlet Connection	Clamp Connectors		Welded
Ramp Rate / °C/s			
Turndown Ratio			
Air/Water Cooling	Air	Air	Water
Footprint / ft²			
Height / ft			
Weight / lbf		4450	
?			

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G3P3 sCO₂ System

