

sCO₂ Test Loop and Heat Transfer Facility

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

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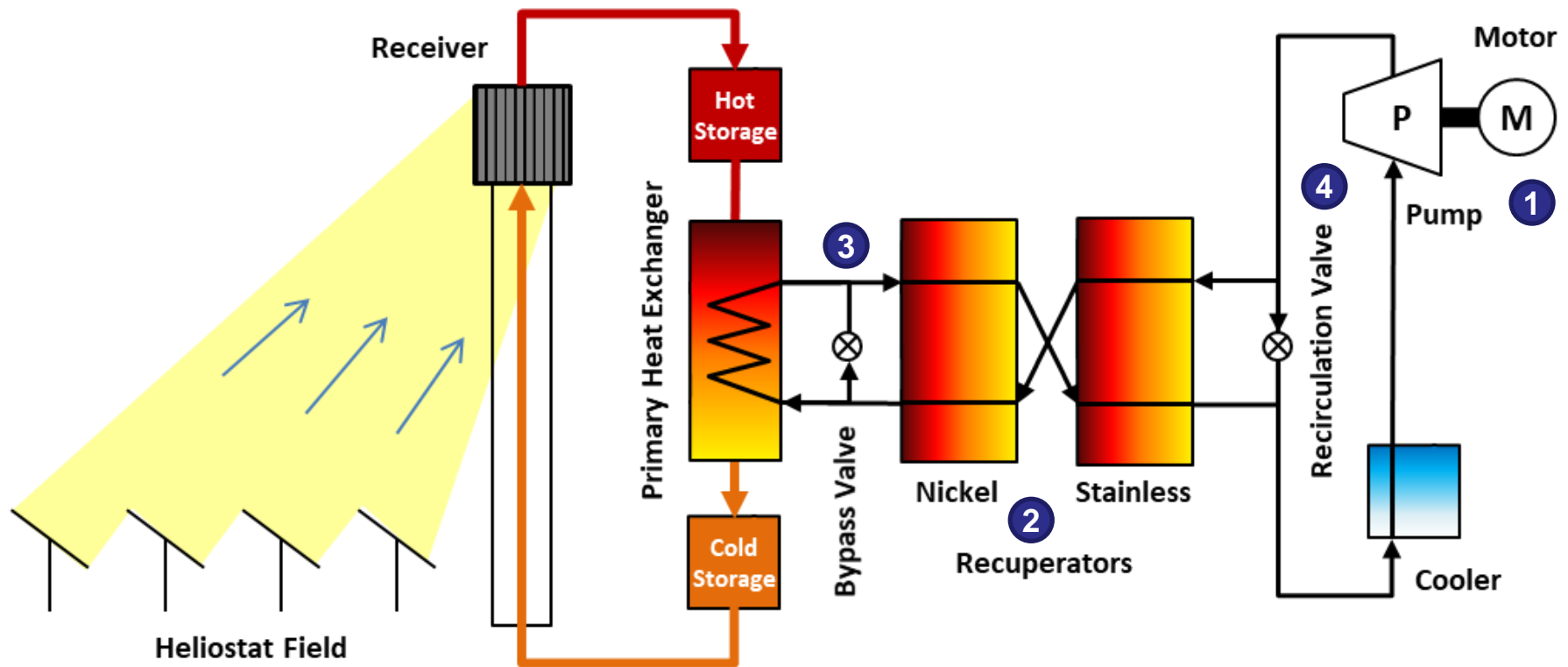


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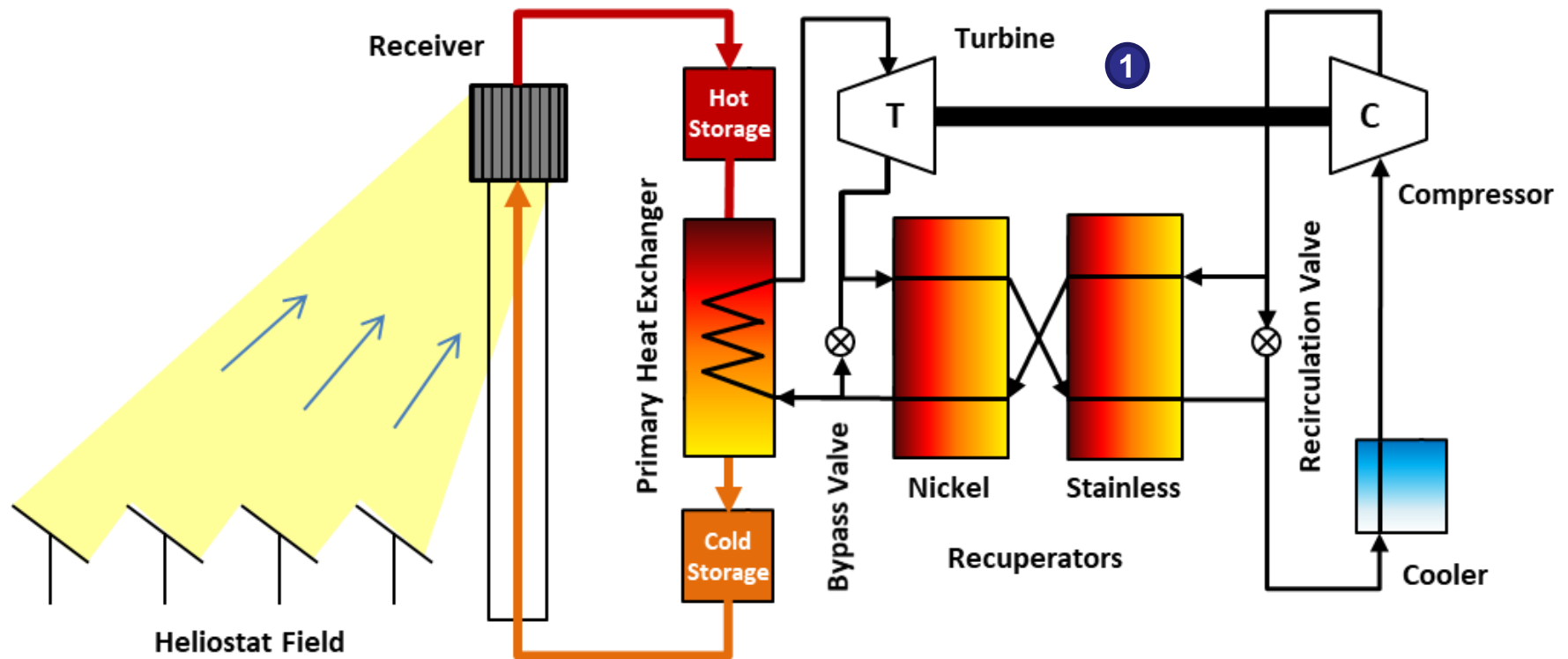


sCO₂ Flow System Design - Primary



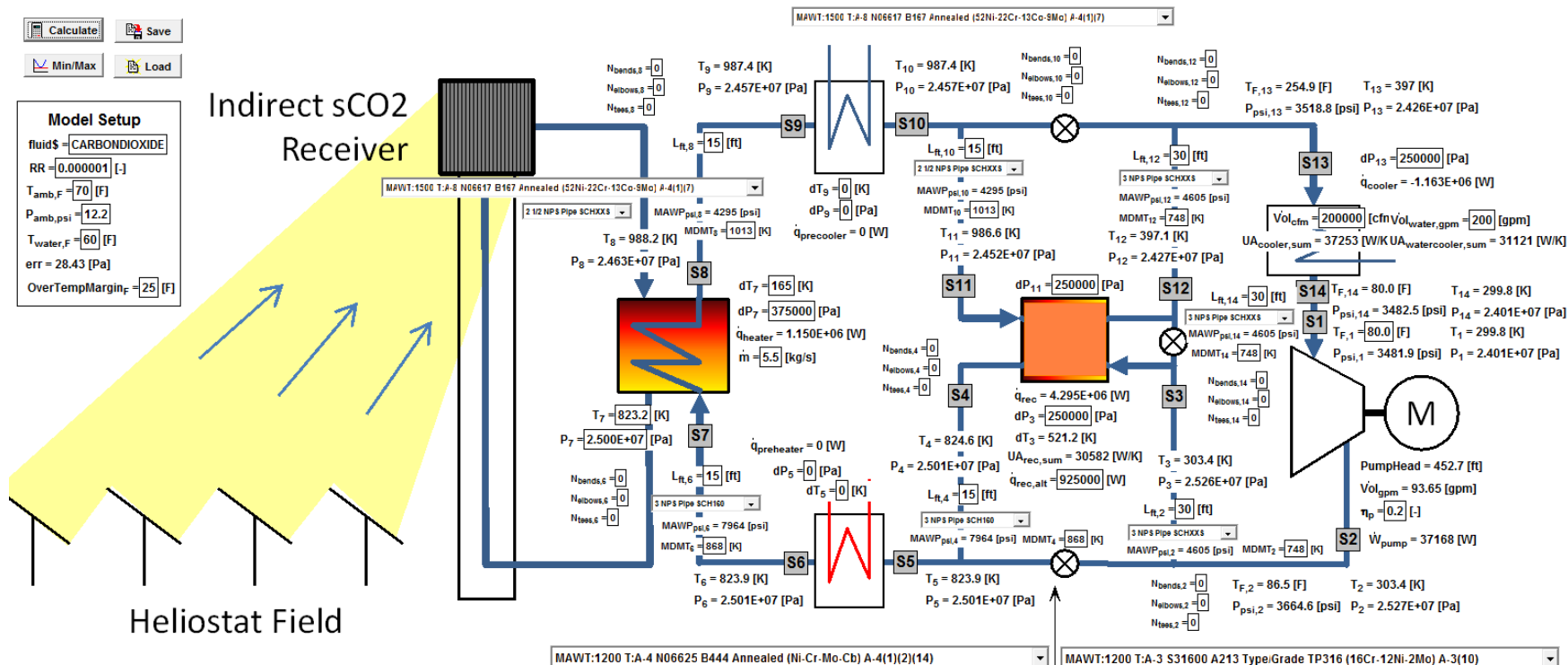
1. The primary loop design uses an industrial canned motor pump for reliability.
2. The recuperator is split into nickel and steel sections to reduce cost.
3. Particle/sCO₂ HXer bypass flow for turn-down operation.
4. Pump/Compressor recirculation avoids dead-head/surge conditions.

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	22	35 (max)
MAWP / bar	275	275	275	296	275 (min)
MDMT / °C	90	450	600	735	735 (max)
Material UNS#	S31600	S31600	S31600	N06230	Various
Weight / lbf	2500	550	650	250	4450 total

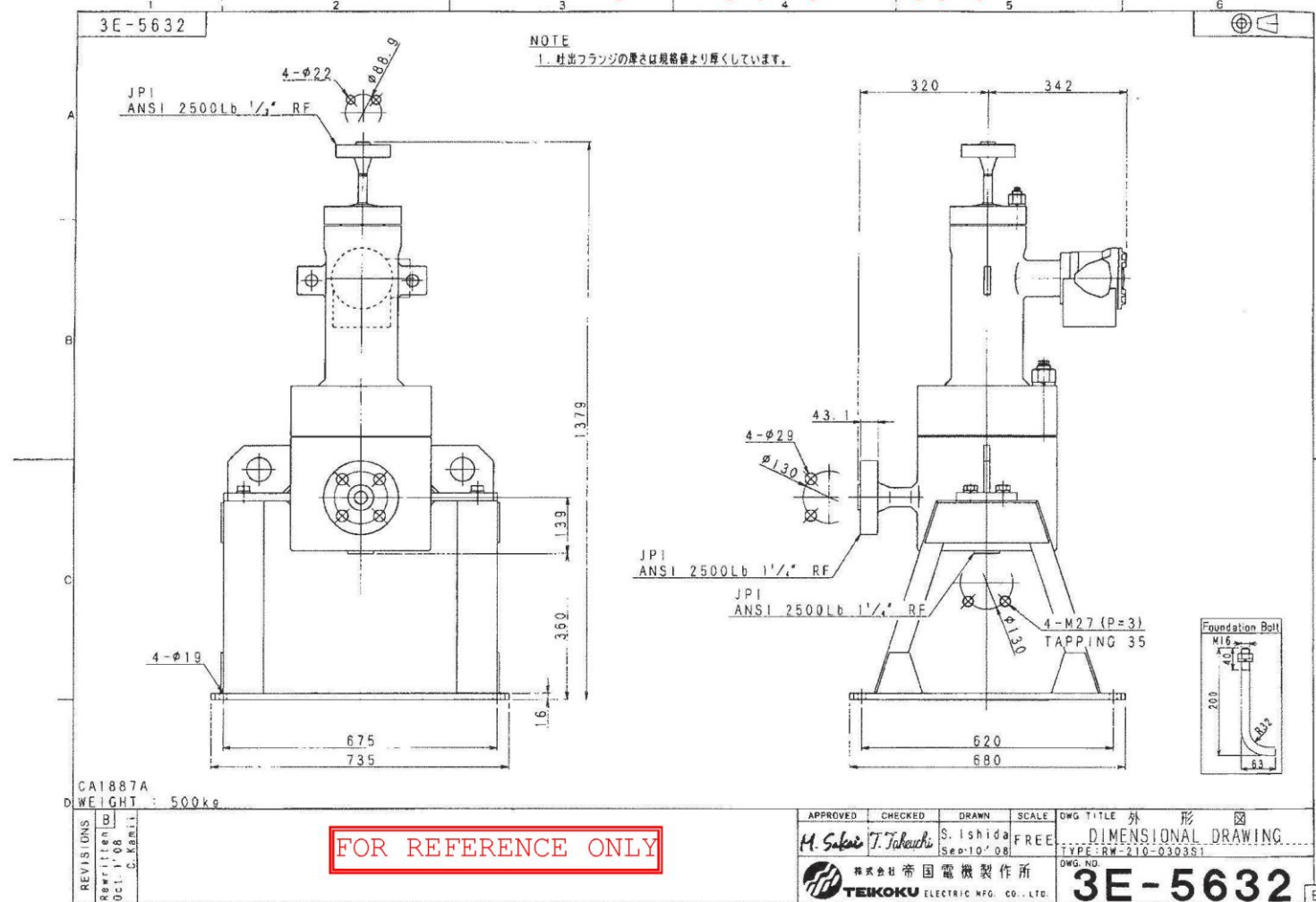
Relative Sizing of the Canned Motor Pump

	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.

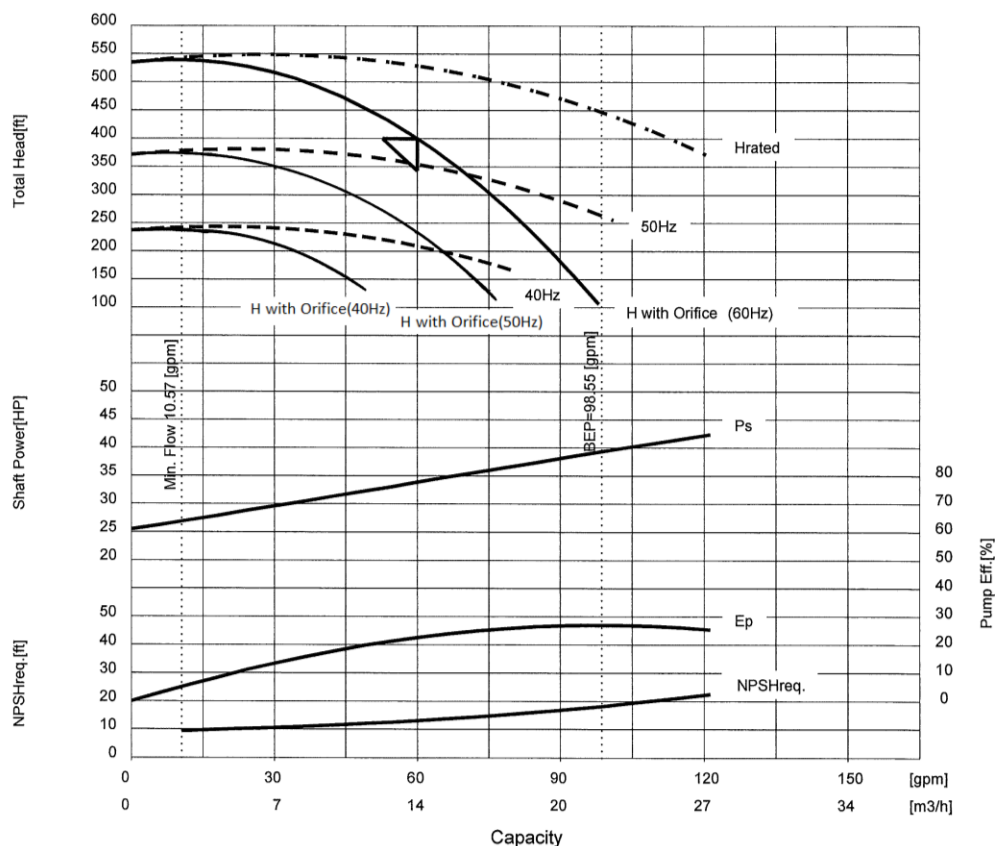
Teikoku Canned Motor Pump

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



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



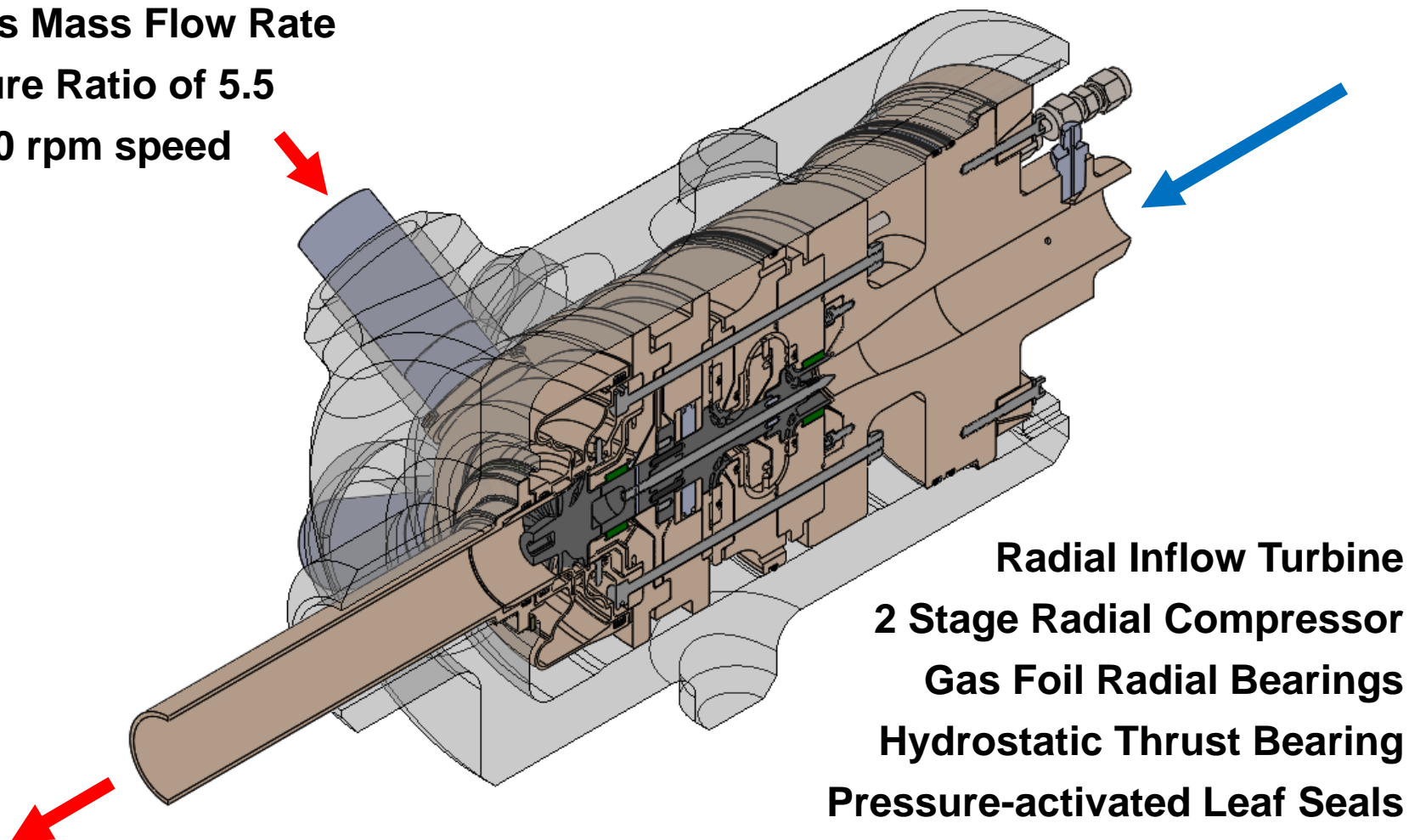
Peregrine Turbo-Compressor Option

750 °C Turbine Inlet Temperature

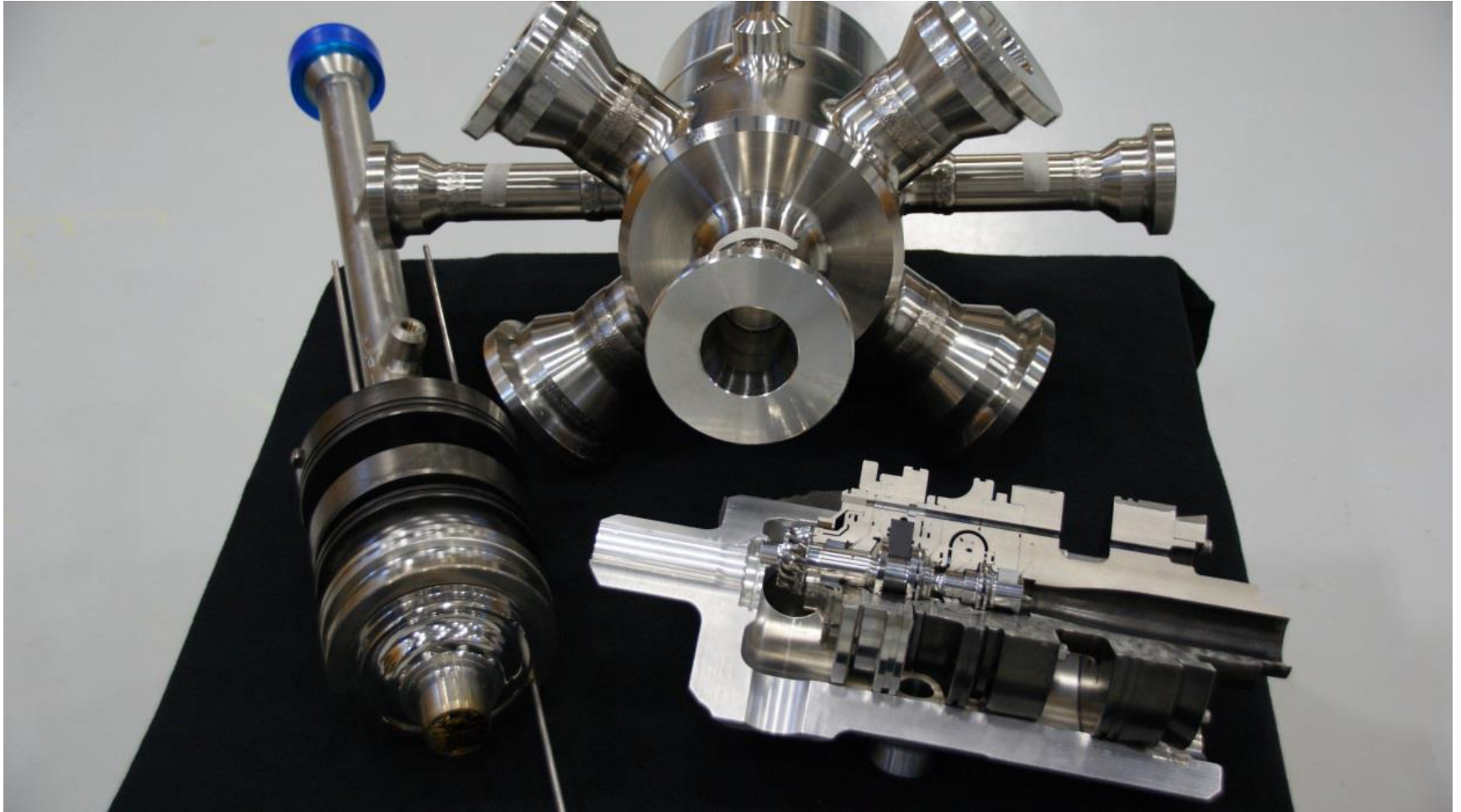
5.5 kg/s Mass Flow Rate

Pressure Ratio of 5.5

118,350 rpm speed



Peregrine Turbo-Compressor Option

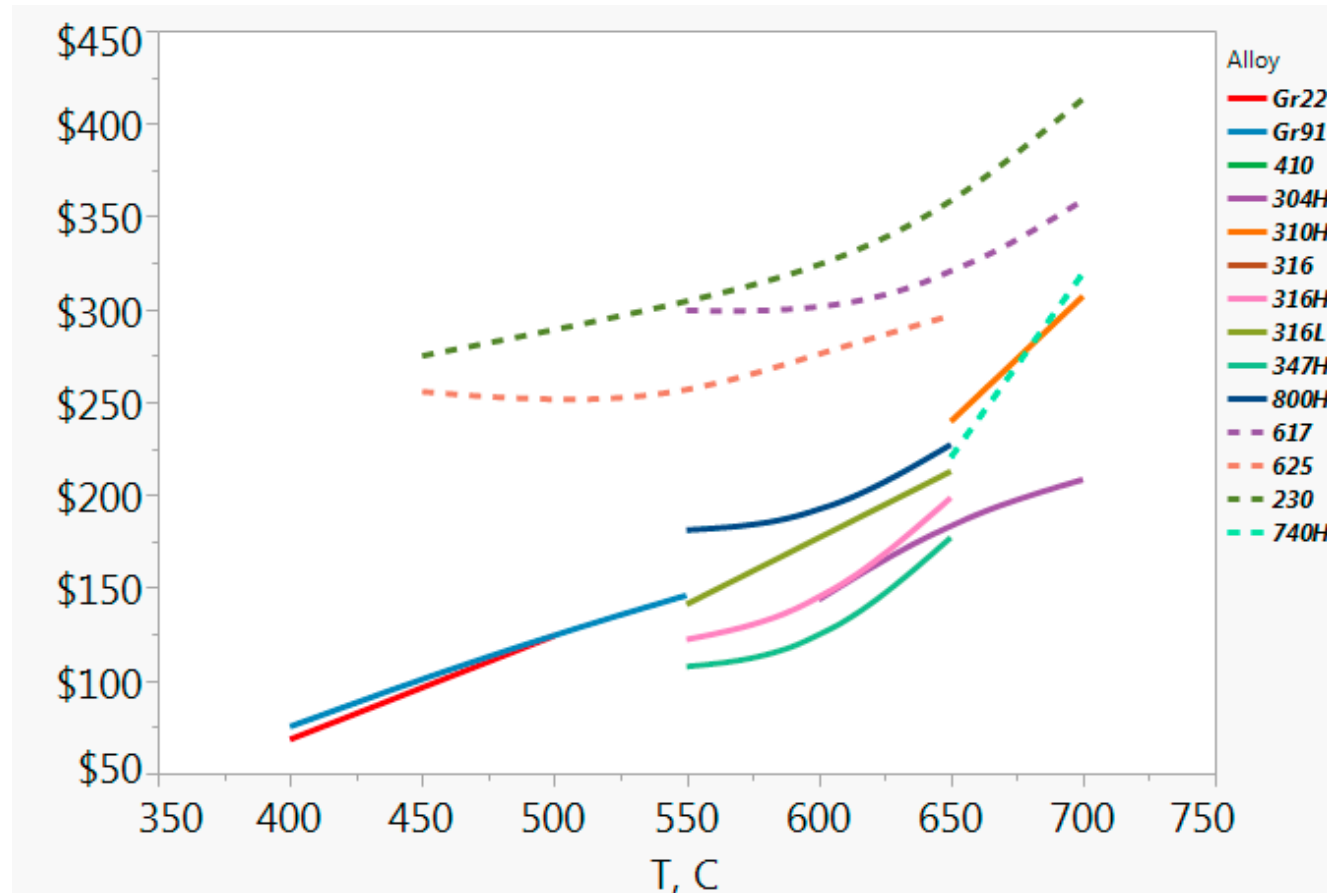


Preliminary Sizing of Heat Exchangers

	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.

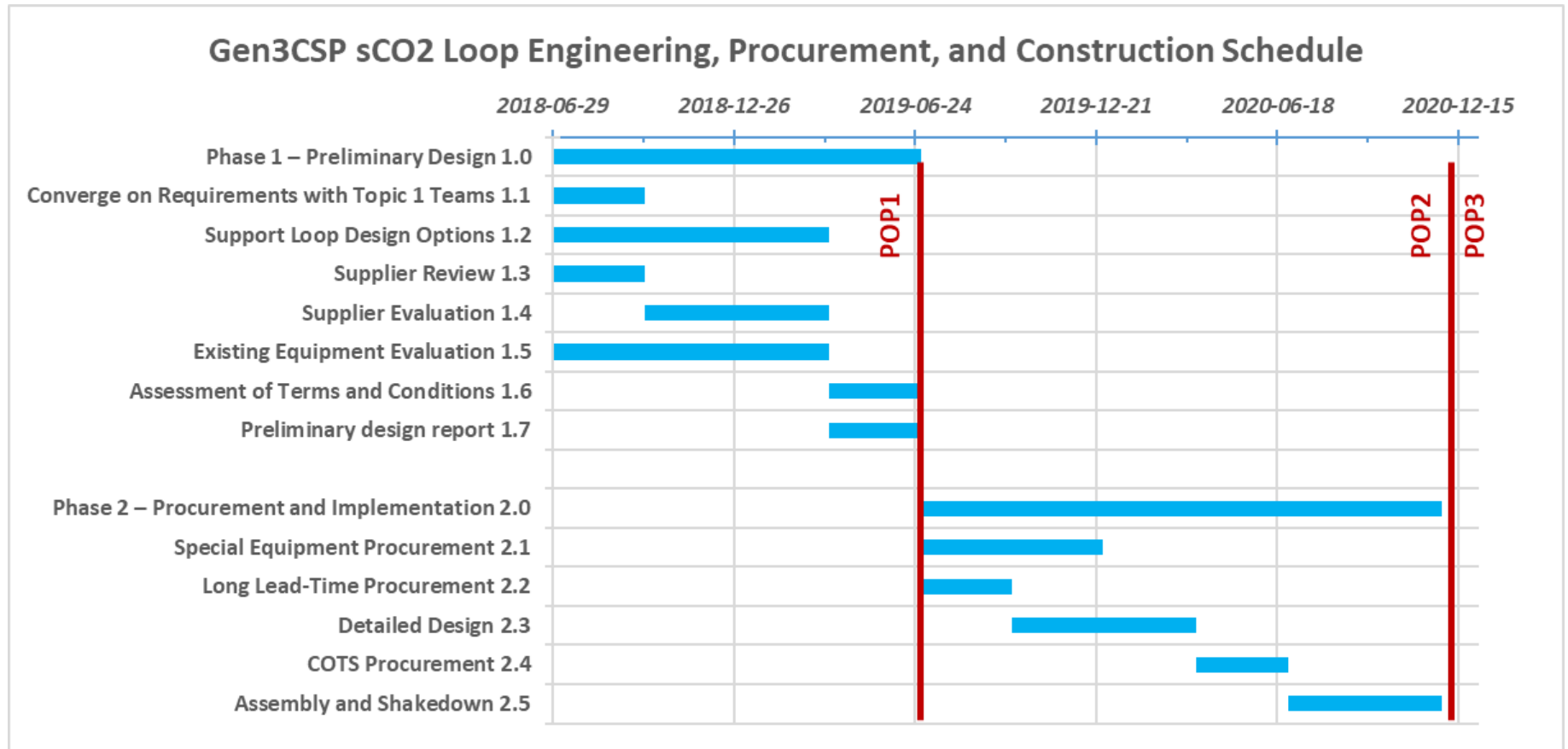
Economical Piping Costs

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 / ft ²			
Height / ft			
Weight / lbf		4450	
?			

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G3P3 sCO₂ System

