DESIGN AND SPECIFICATION OF A 10MW-CLASS sCO2 COMPRESSOR TEST FACILITY

The 4th European sCO2 Conference for Energy Systems

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❑ sCO2 Compressors – Type, Flowrate, Efficiency

Main Author	Year	Institution	Compressor Type	Compressor Driving Power
Steven A. Wright	2009	Sandia National Laboratories	Centrifugal	50 kWe
Masanori Aritomi	2011	Tokyo Institute of Technology	Centrifugal	
Jeff S. Noall	2014	Barber Nichols Inc., Sandia National Laboratories	Centrifugal	55 kW
Jekyoung Lee	2014	Korea Advanced Institute of Science and Technology	Centrifugal	
Timothy Held	2014	Echogen Power Systems	Centrifugal	2.7MW
Eric M. Clementoni	2016	Bechtel Marine Propulsion Corporation	Centrifugal	36.8 - 15.8 kW
Jae Eun Cha	2016	Korea Advanced Institute of Science and Technology	Centrifugal	
Junhyun Cho	2016	Korea Institute of Energy Research	Centrifugal	90 kW
Eric M. Clementoni	2017	Naval Nuclear Laboratory	Centrifugal	
Timothy C. Allison	2018	Southwest Research Institute	Centrifugal	
Eric M. Clementoni	2018	Naval Nuclear Laboratory	Centrifugal	
Jacqueline Lewis	2018	Naval Nuclear Laboratory	Centrifugal	
Alexander Hacks	2018	University of Duisburg-Essen, Research Center Rez	Centrifugal	7 kW
Seungjoon Baik	2018	Korea Advanced Institute of Science and Technology	Centrifugal	26 kW
Stefan D. Cich	2018	Southwest Research Institute, GE Global Research	Centrifugal	4.9 MW
Bongsu Choi	2019	Korea Institute of Energy Research	Centrifugal	90 kW
Yann Le Moullec	2019	EDF R&D China, Shouhang IHW		2.4 MW
Junhyun Cho	2019	Korea Institute of Energy Research	Centrifugal	90 kW
Eduardo Anselmi	2019	Cranfield University	Centrifugal	45 kW
Logan Rapp	2019	Sandia National Laboratories		1MW

Capacity of Test Facility

OBJECTIVE

I 10MW sCO2 Compressor Test Facility

OBJECTIVE

I 10MW sCO2 Compressor Test Facility

II Axial and Centrifugal Compressors

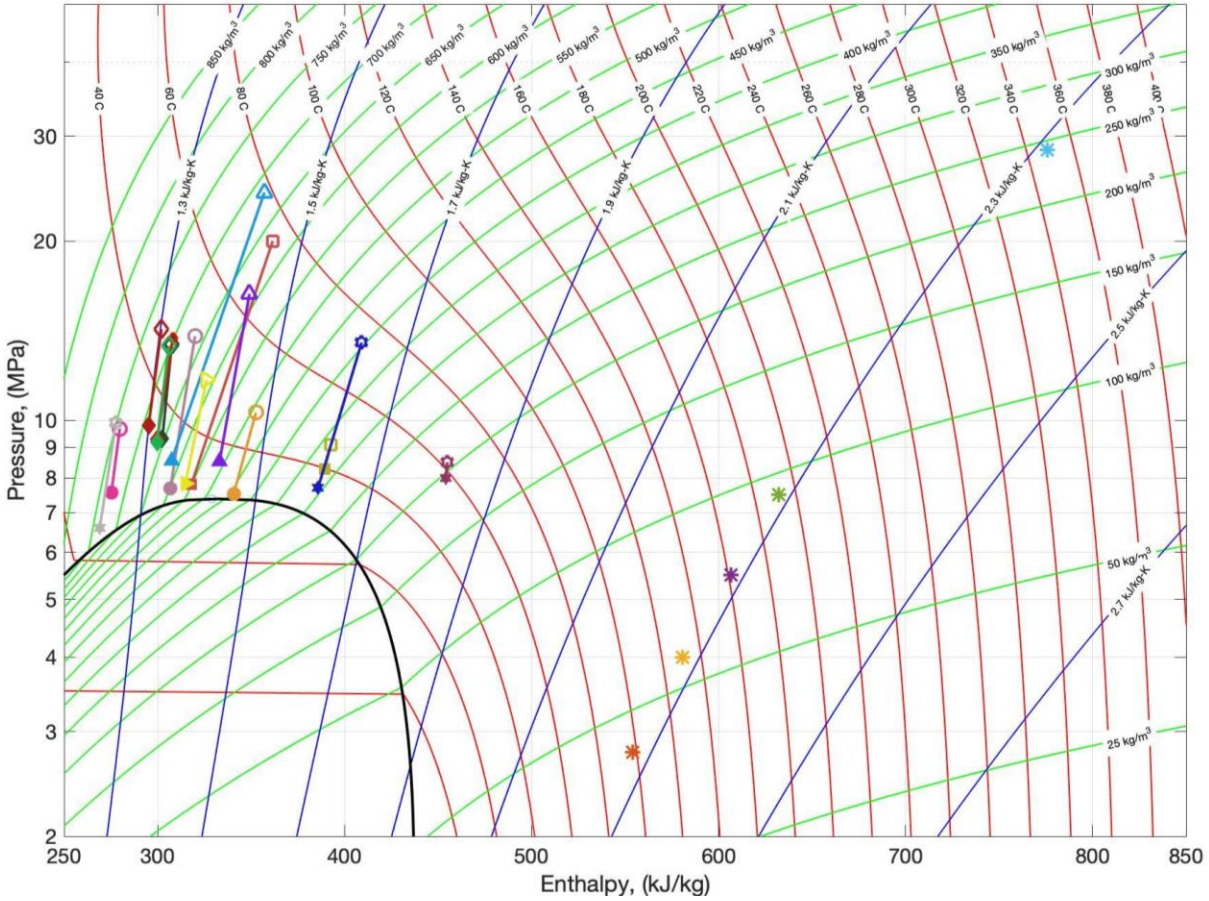
OBJECTIVE

I 10MW sCO2 Compressor Test Facility

II Axial and Centrifugal Compressors

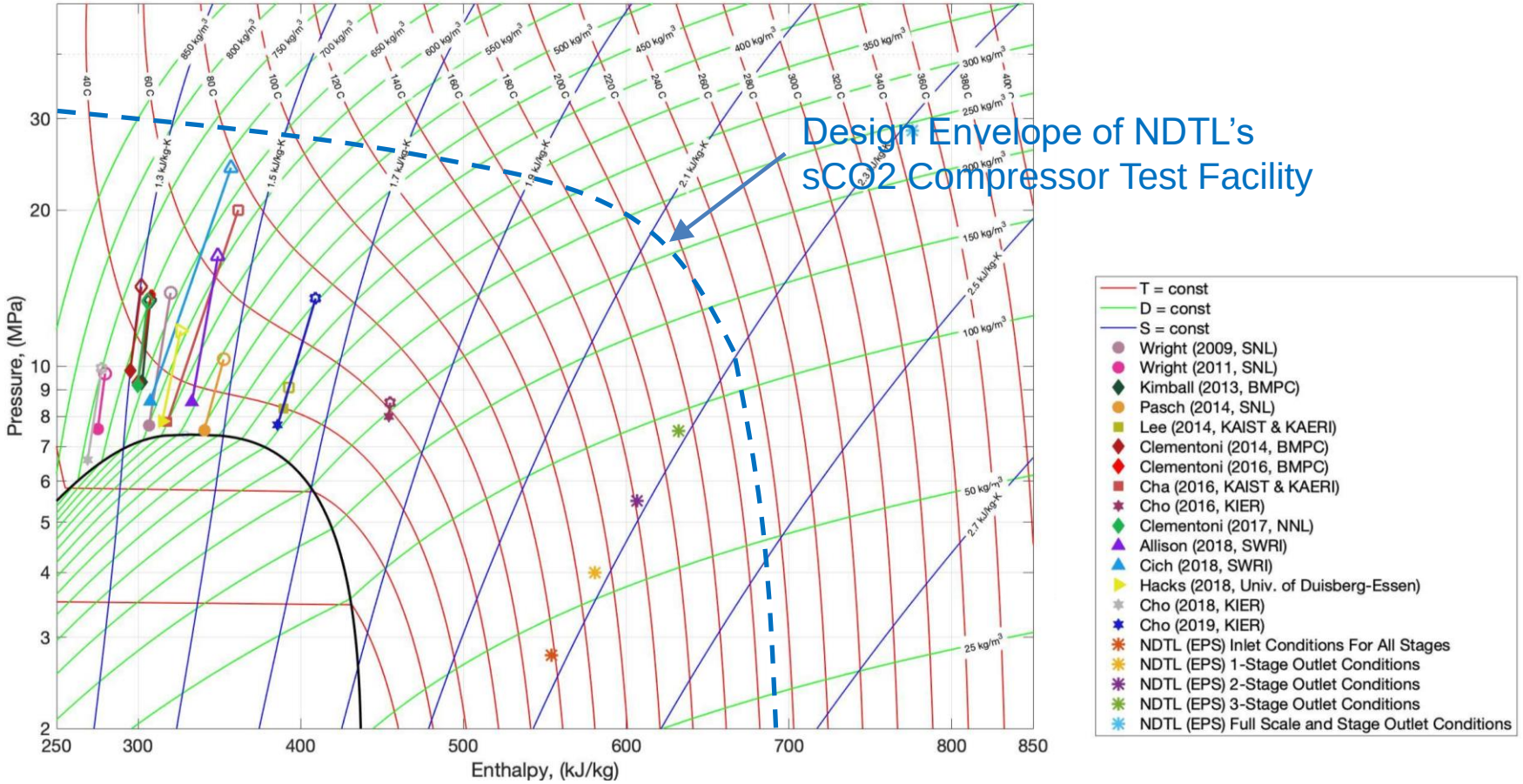
III Detail Aerodynamics and Aeromechanics Study

Cases of sCO2 Compressor

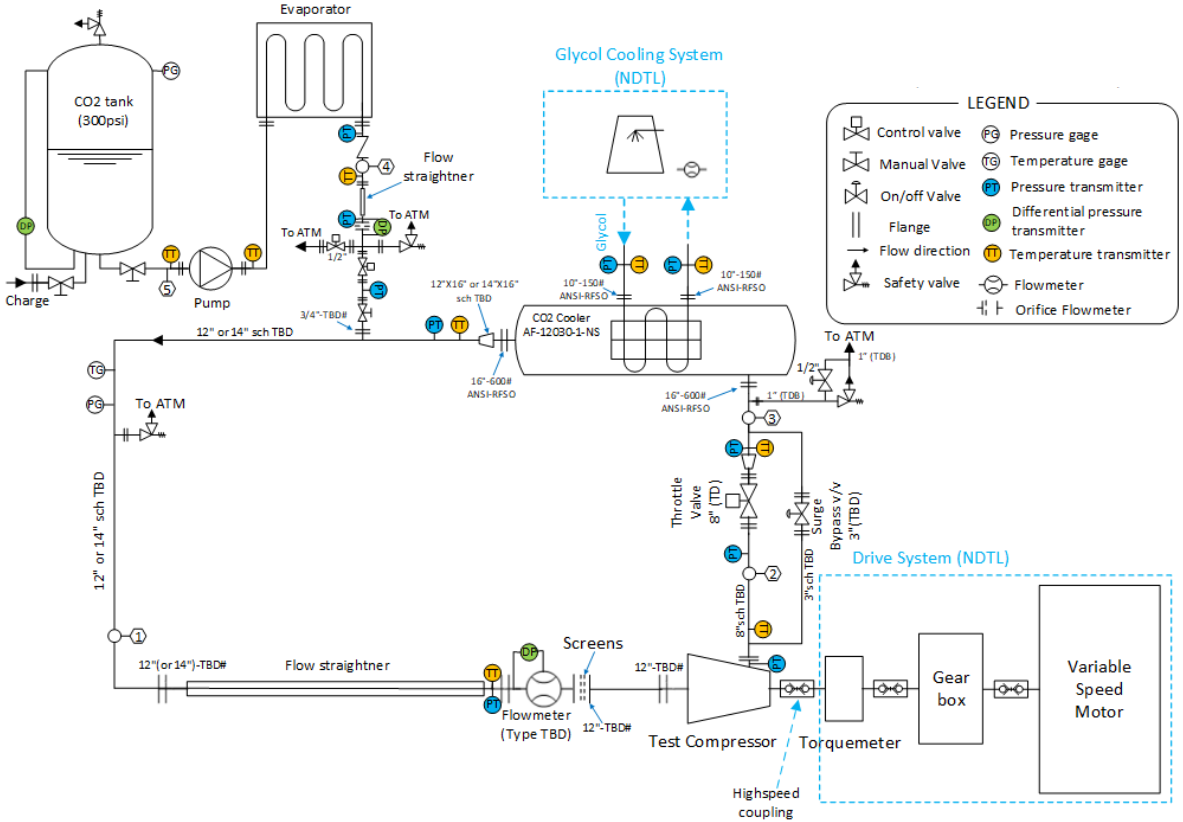


- Wright (2009, SNL)
- Wright (2011, SNL)
- Kimball (2013, BMPC)
- Pasch (2014, SNL)
- Lee (2014, KAIST & KAERI)
- Clementoni (2014, BMPC)
- Clementoni (2016, BMPC)
- Cha (2016, KAIST & KAERI)
- Cho (2016, KIER)
- Clementoni (2017, NNL)
- Allison (2018, SWRI)
- Cich (2018, SWRI)
- Hacks (2018, Univ. of Duisberg-Essen)
- Cho (2018, KIER)
- Cho (2019, KIER)

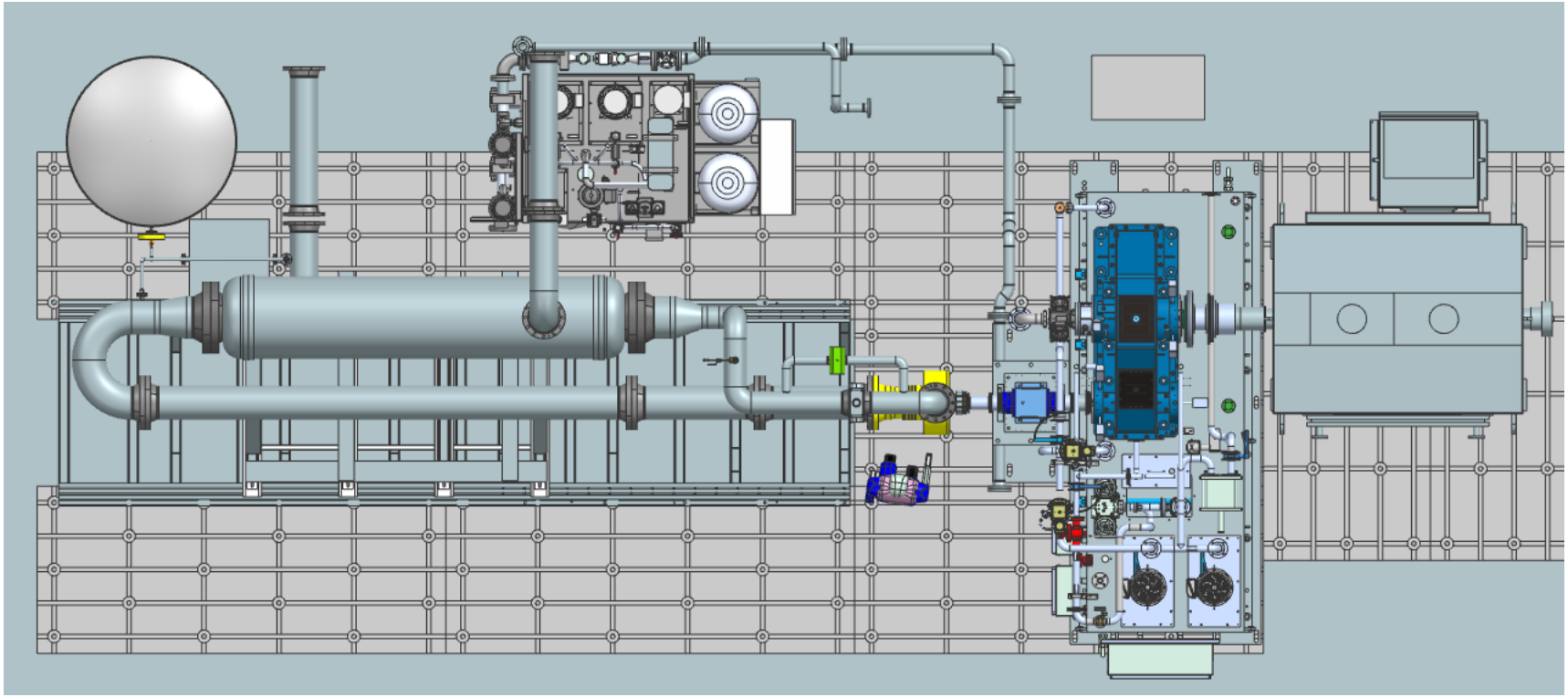
Design Envelope of NDTL sCO2 Compressor Test facility



Piping and Instrumentation Diagram of Test Facility

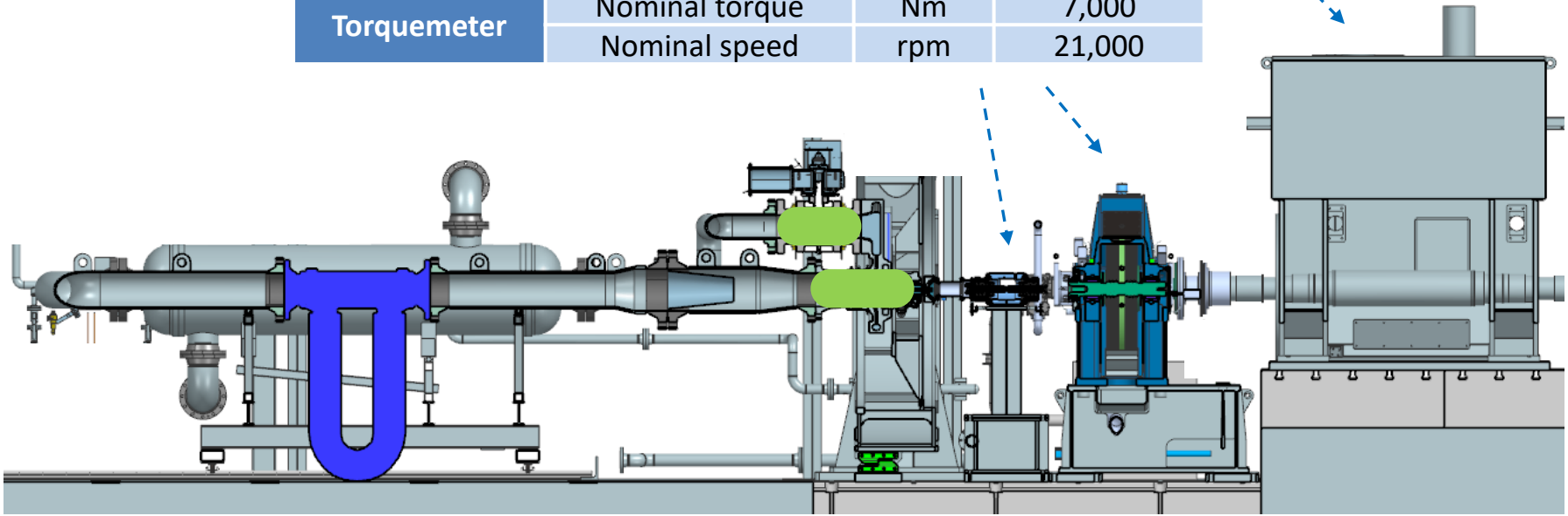


sCO2 Compressor Test Facility (Top view)



sCO2 Compressor Test Facility – Specification of Drive System

Motor	Max. power	MW	10
	Full load speed	kg/s	116
Gear Box	Max. output speed	rpm	19,945
	Rated power	MW	10
Torquemeter	Nominal torque	Nm	7,000
	Nominal speed	rpm	21,000

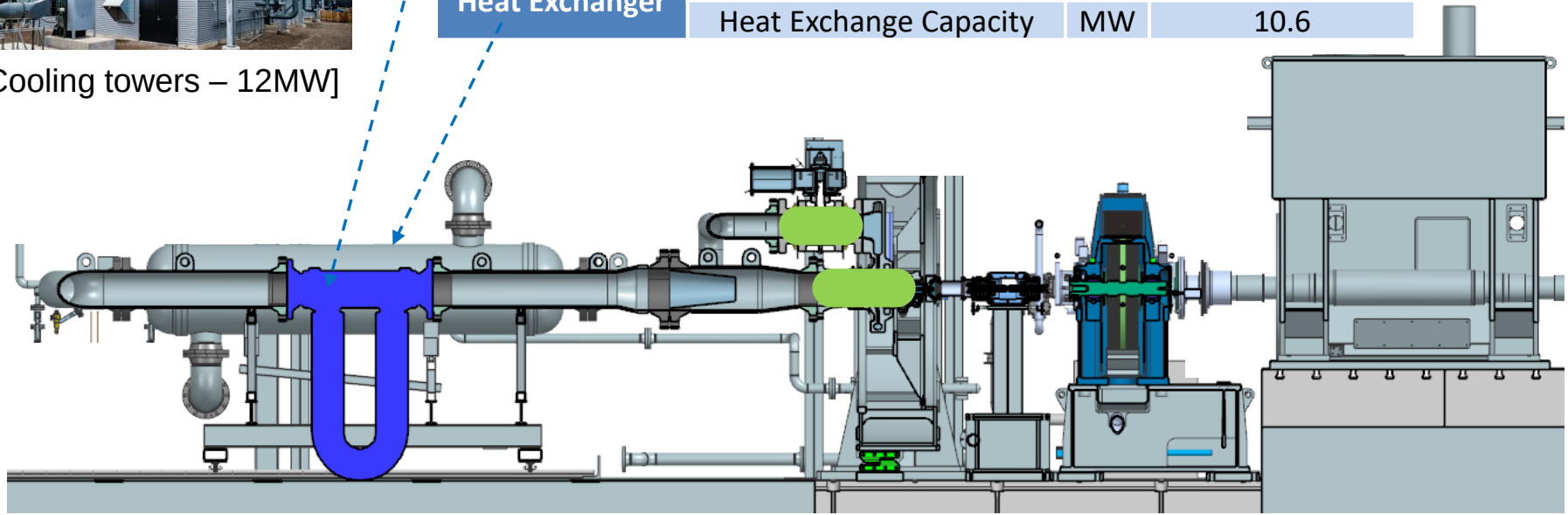


sCO2 Compressor Test Facility – Specification of Main Loop

[Specification of a main CO2 Loop]

[Cooling towers – 12MW]

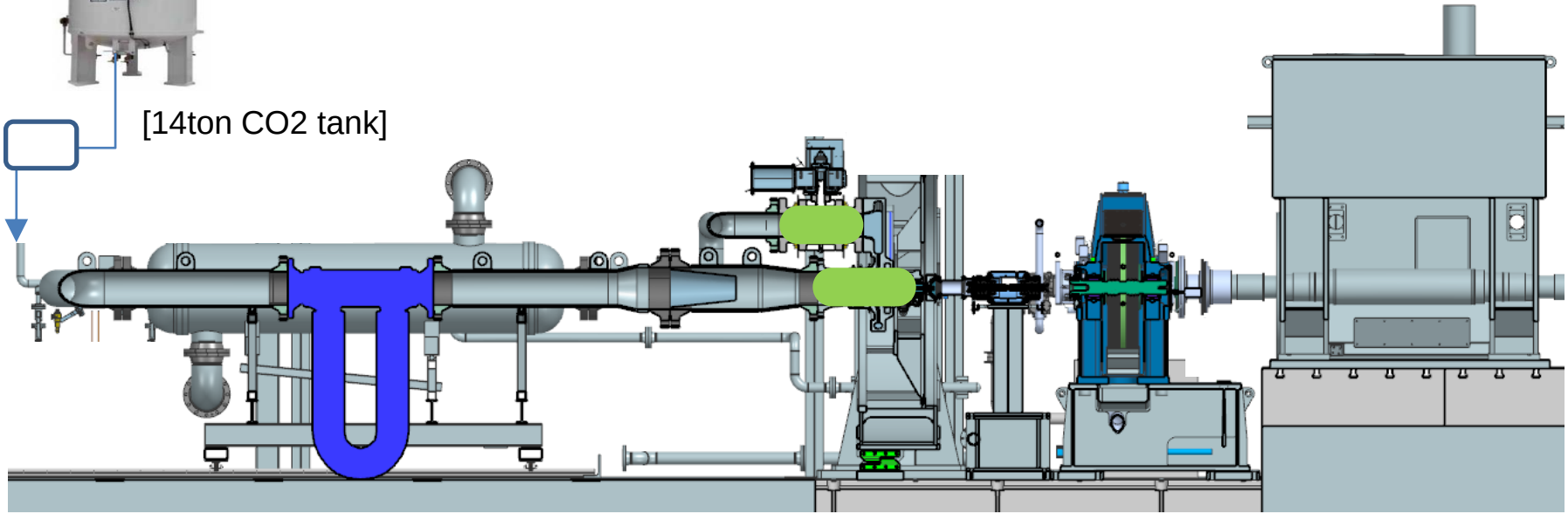
Flowmeter	Type	-	Coriolis
	Size	in	12
	Mass flow rate accuracy	%	0.10
	Max. flowrate	kg/s	907
Heat Exchanger	Type	-	Shell and tube
	Heat Exchange Capacity	MW	10.6



sCO2 Compressor Test Facility – CO2 Inventory System

CO2 Tank	Size	ton	14
	Reserve pressure	MPa	2.4

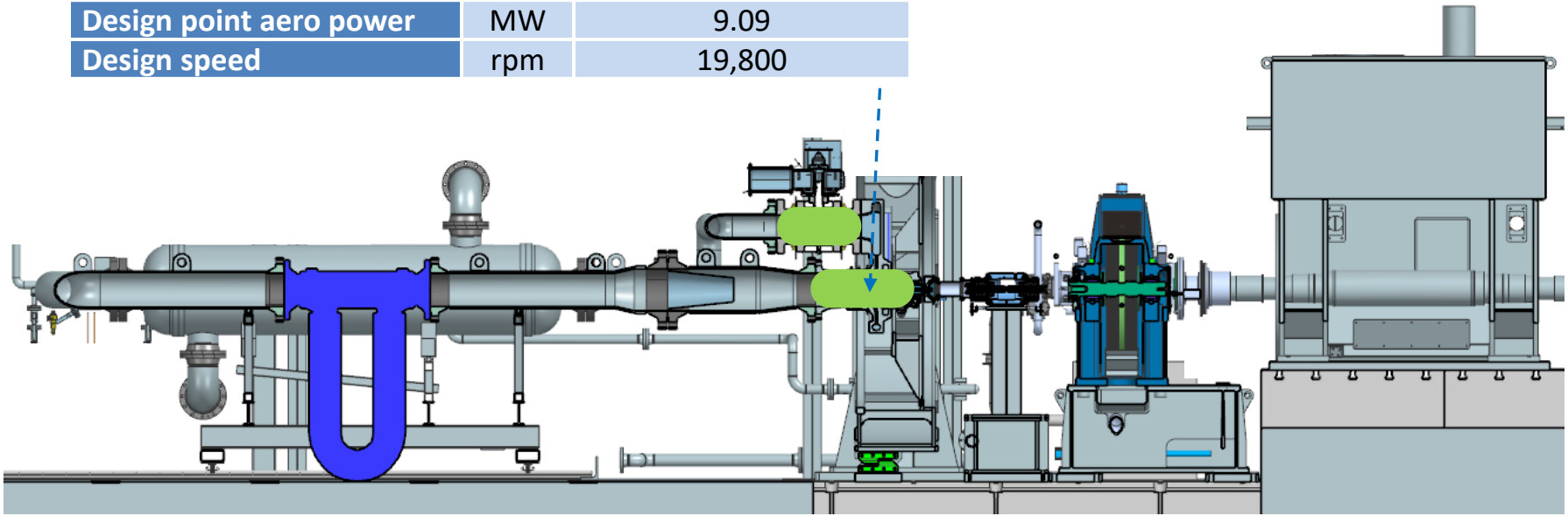
[14ton CO2 tank]



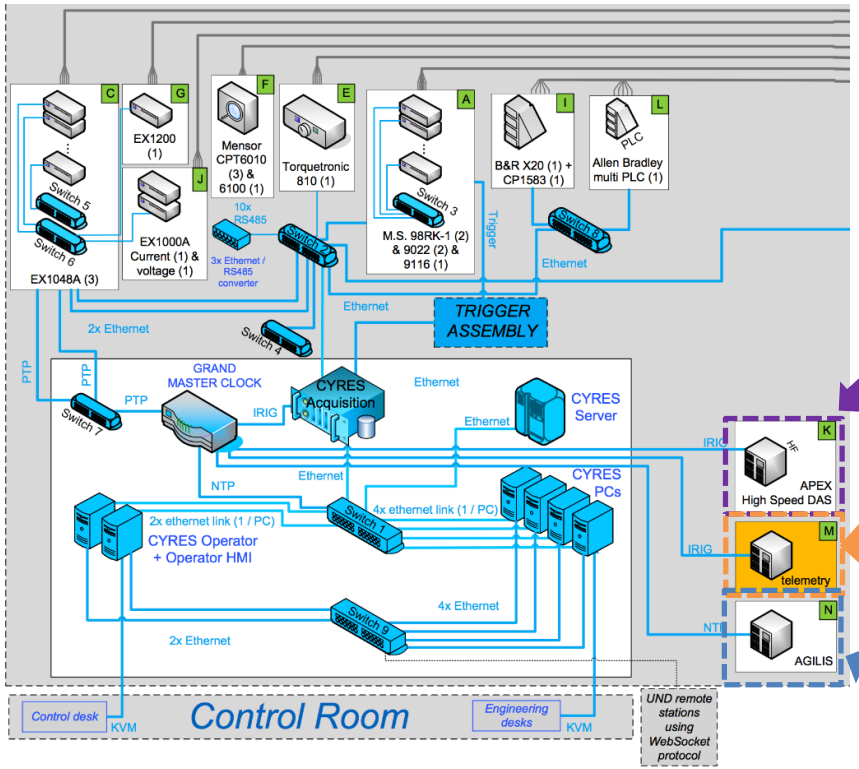
First Compressor to Test

Compressor type		Axial compressor
# of compressor stages	-	1 / 2 / 3
Inlet total pressure	MPa	2.77
Inlet total temperature	˚C	97.94
Mass flow rate	kg/s	116
Pressure ratio	-	2.706
Design point aero power	MW	9.09
Design speed	rpm	19,800

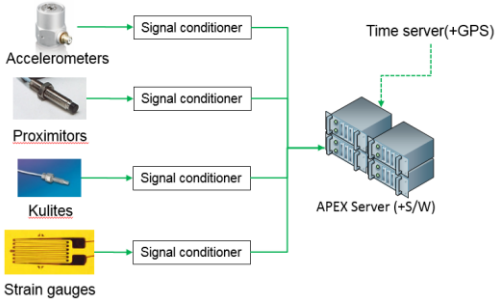
- Aerodynamic performance
- Aeromechanic characteristics
- Detail Flow survey



Architecture of Instrumentation & Data Acquisition System

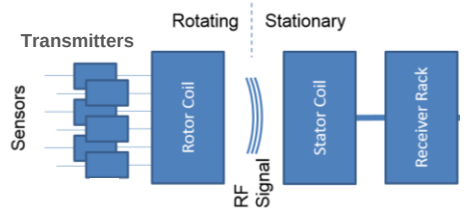


Dynamic Data Acquisition



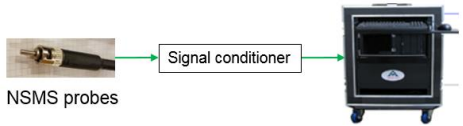
- 4 Dynamic DAQ systems
- 300 Channels
- Precision Filters
- Time stamped data

Telemetry



- 3 Telemetry systems
- Used with strain gages, Kulites, RTDs, TCs, etc.
- Fixed Sampling Frequency at ~100KHz

NSMS



- 2 NSMS systems
- 16 light probes and channels

CONCLUSION

I. A 10 MW-class sCO2 compressor test facility has been designed.

II. The 10MW scale allows sCO2 compressor testing of both **axial and centrifugal compressor** types with flow passages large enough to enable advanced experimental studies of CO2 compressors, including **detailed flow survey**, **steady and unsteady performance** measurement, and **aeromechanical research** on vanes or blades including blade vibrations and flutter.

III. The facility is to be built at the University of Notre Dame in 2021 with a schedule to test the first CO2 axial compressor in 2021.