Bechtel Marine Propulsion Corporation
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Initial Transient Power Operation of a Supercritical Carbon Dioxide Brayton Cycle with Thermal-Hydraulic Control

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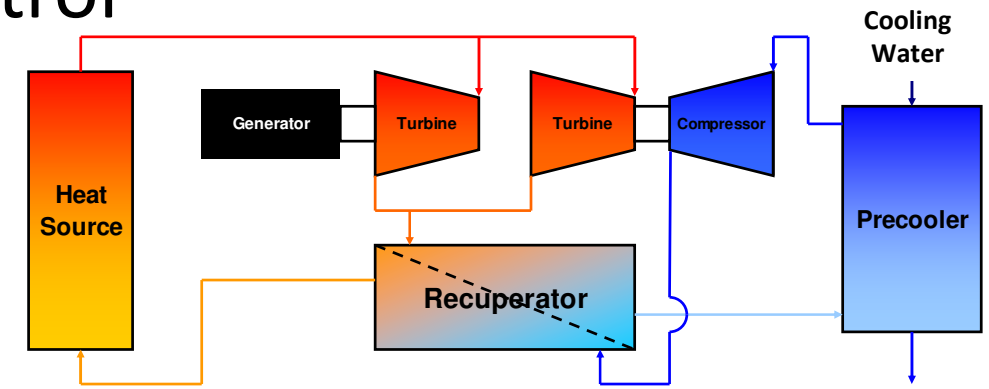
Presentation Summary

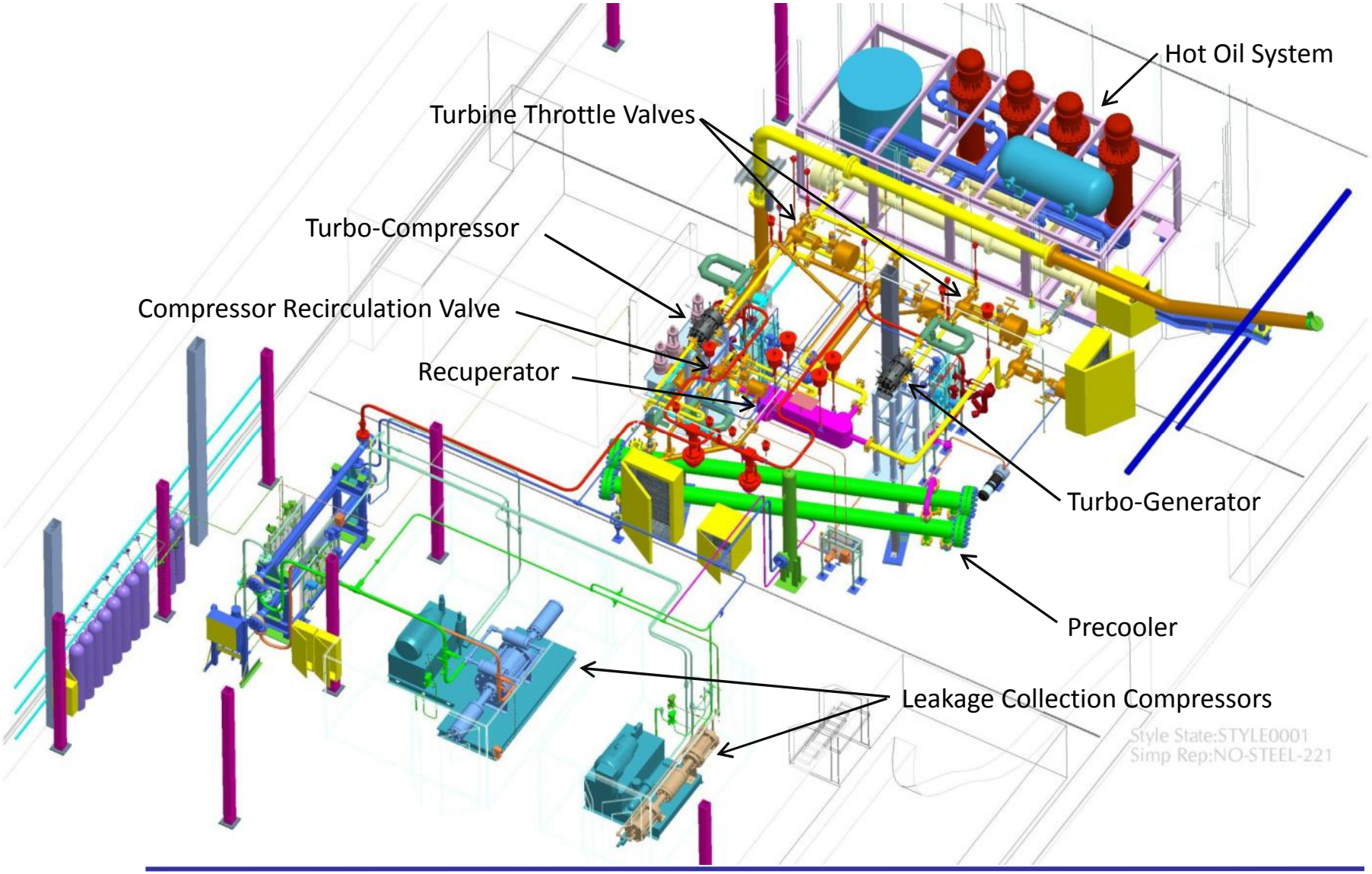
- sCO_2 Brayton Cycle Integrated Systems Test (IST) Overview
- System Control
- System Operating Conditions
- Operational Test Results

IST Overview

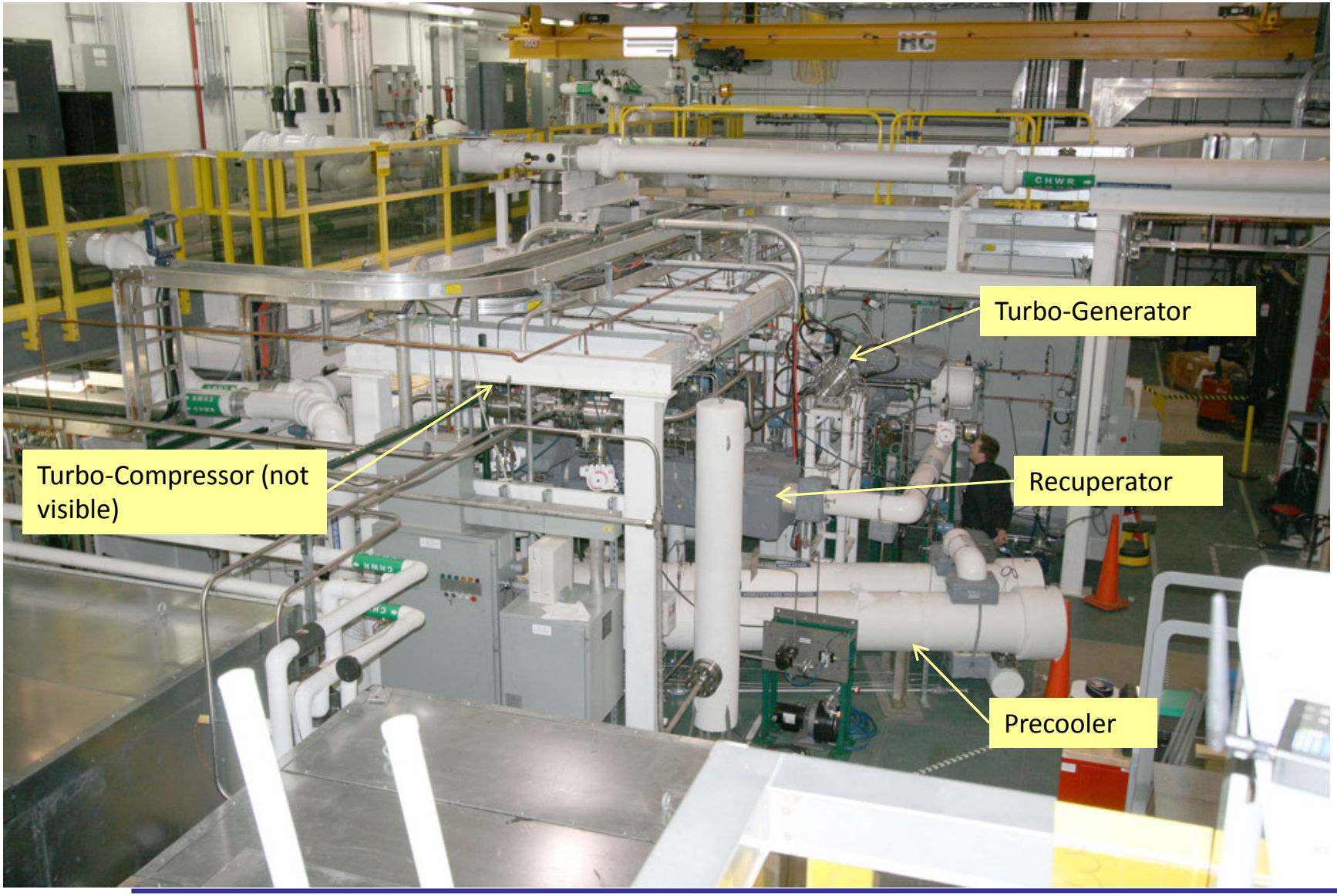
- 100 kWe IST has been main sCO_2 development focus of BMPC
- Simple Brayton cycle
  - Single variable speed turbine-compressor
  - Single constant speed turbine-generator
  - Single recuperator
- Focus on system control
  - Rapid startup
  - Power changes
  - Shutdown



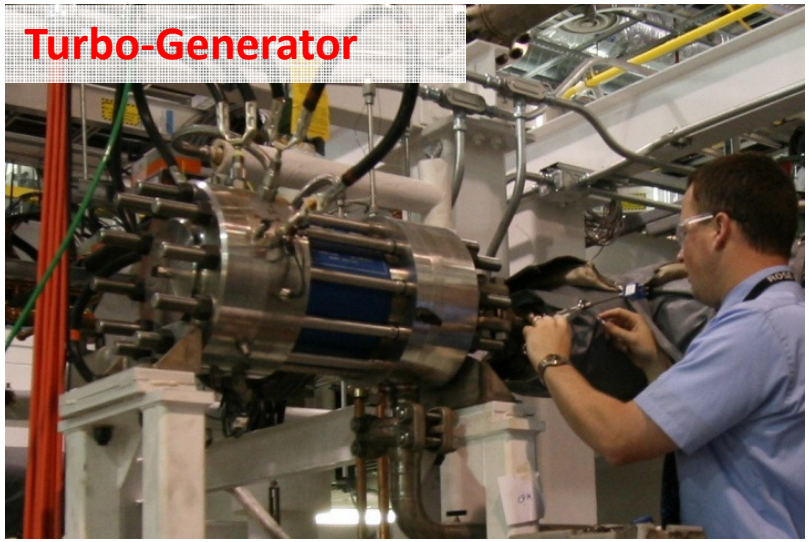
IST Physical Layout



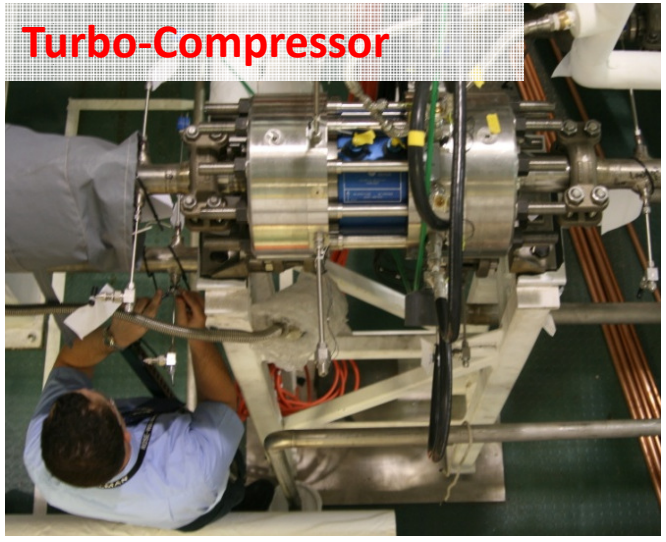
IST Physical Layout

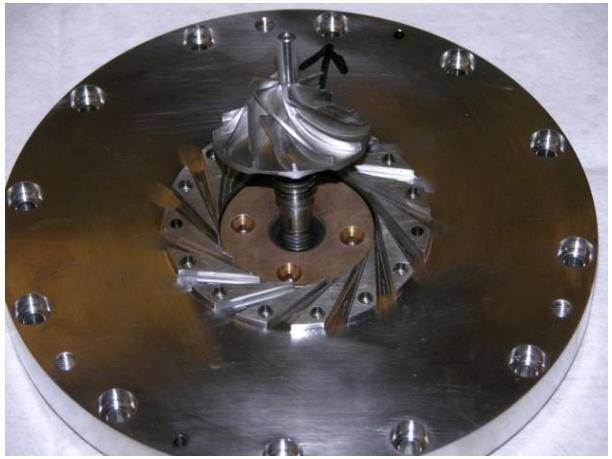


IST Turbomachinery

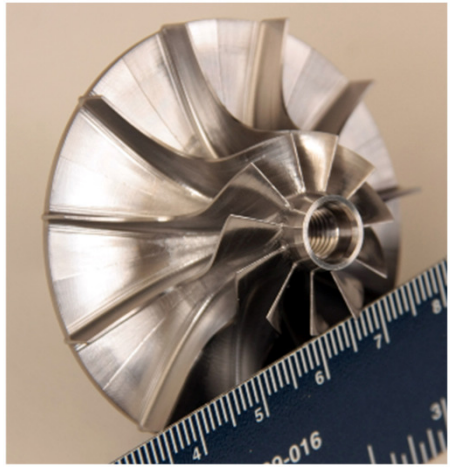


Thrust Bearing





Compressor/Diffuser

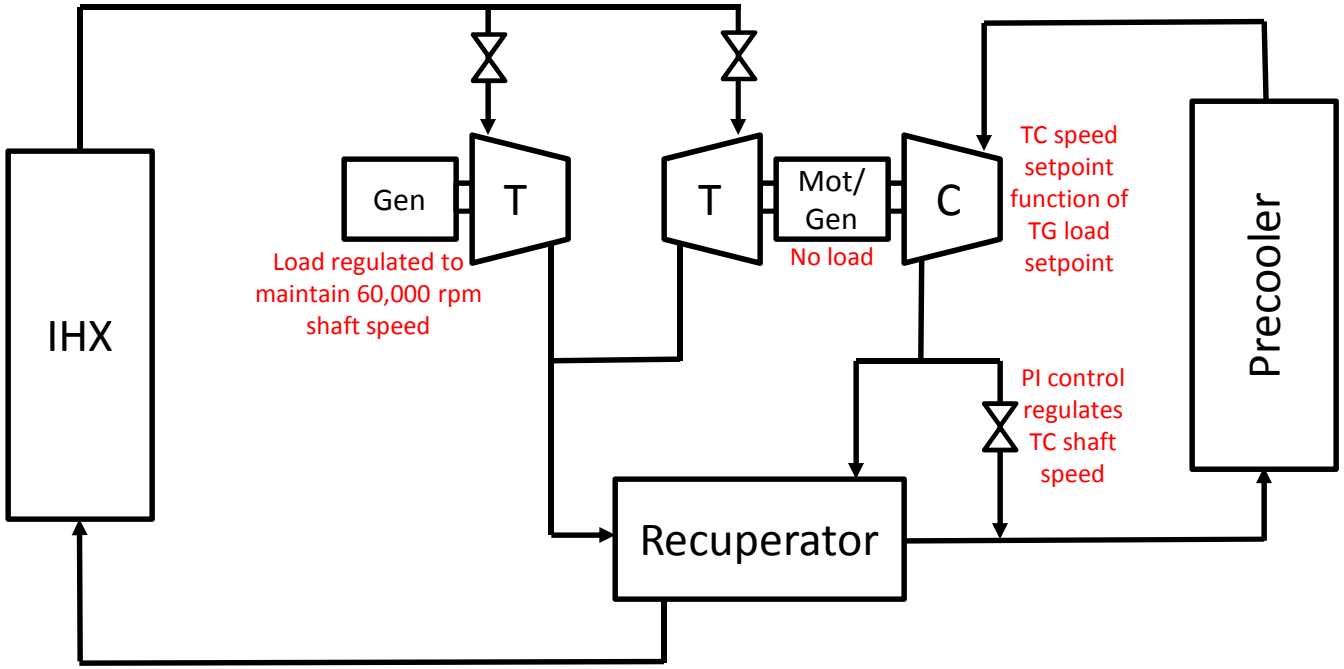


Turbine

Cycle Control Overview

- Turbine-generator speed fixed (60,000 rpm)
- Power level controlled via turbine-compressor speed
  - Speed setpoint via lookup table
- Compressor recirculation valve position also function of system power level
  - More open at low power, nearly closed at max power
  - Maintains adequate surge margin
- IHX outlet temperature and compressor inlet temperature controlled via PI control of heater power and cooling water flow, respectively

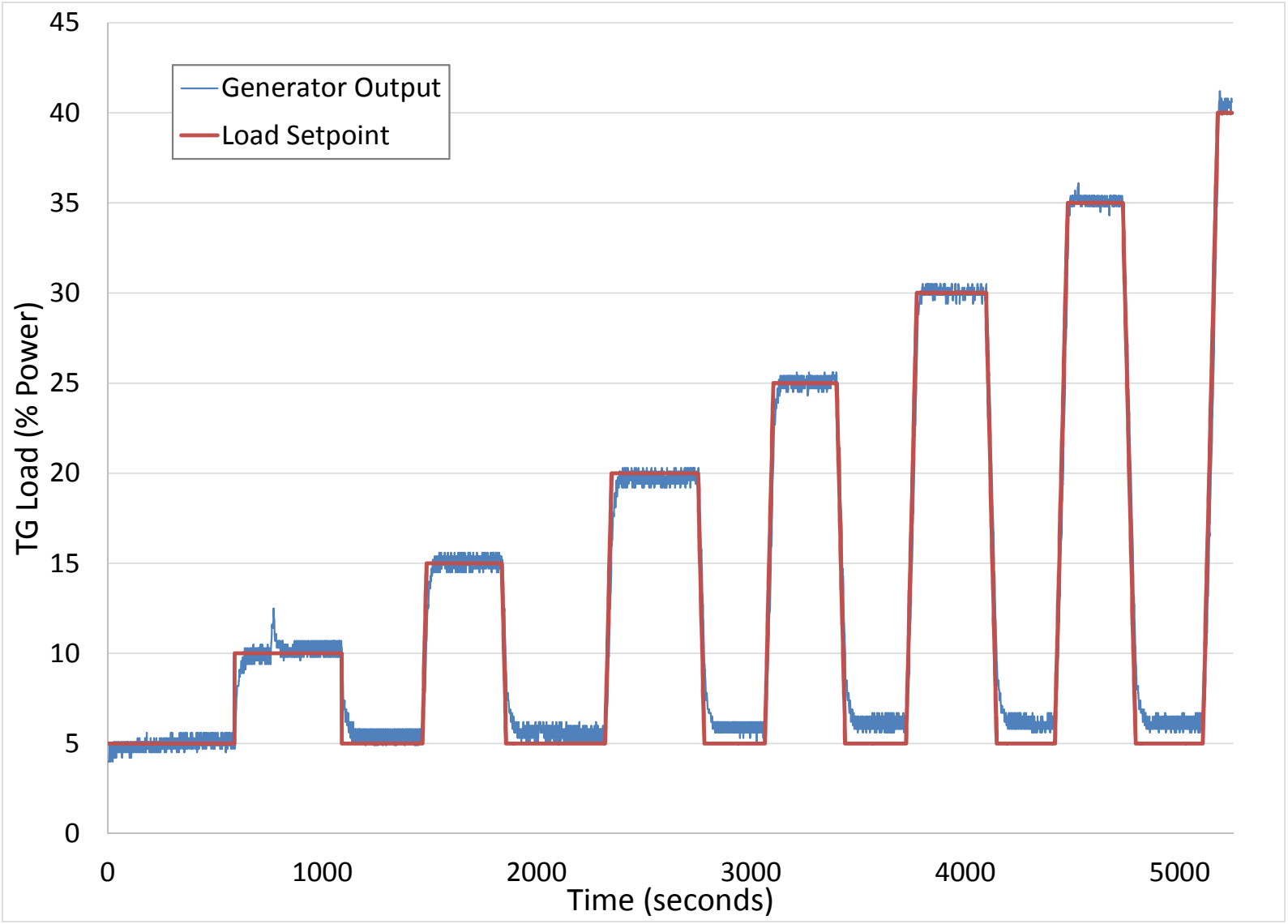
Thermal-Hydraulic Control



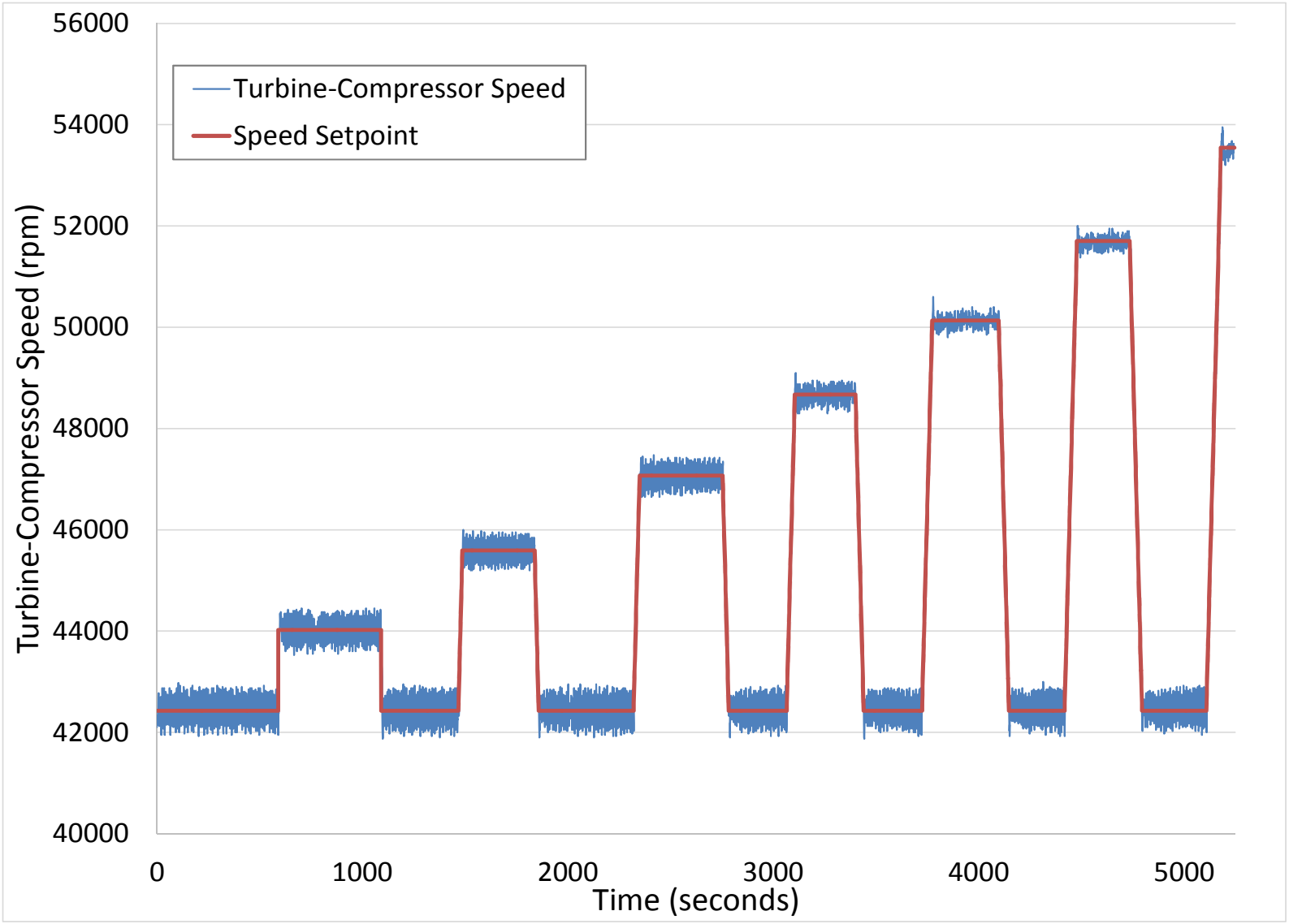
IST Operating Conditions

- Maximum power limited to 40 kWe by motor-generator controller performance
- Turbine inlet temperature reduced to 440°F
  - Achieve max power with CCV4 nearly closed
- Compressor inlet of 96°F and ~1310 psia
  - Stable compressor inlet density for small changes in parameters
  - Fixed total system mass → small changes in pressure with power level due to cavity conditions

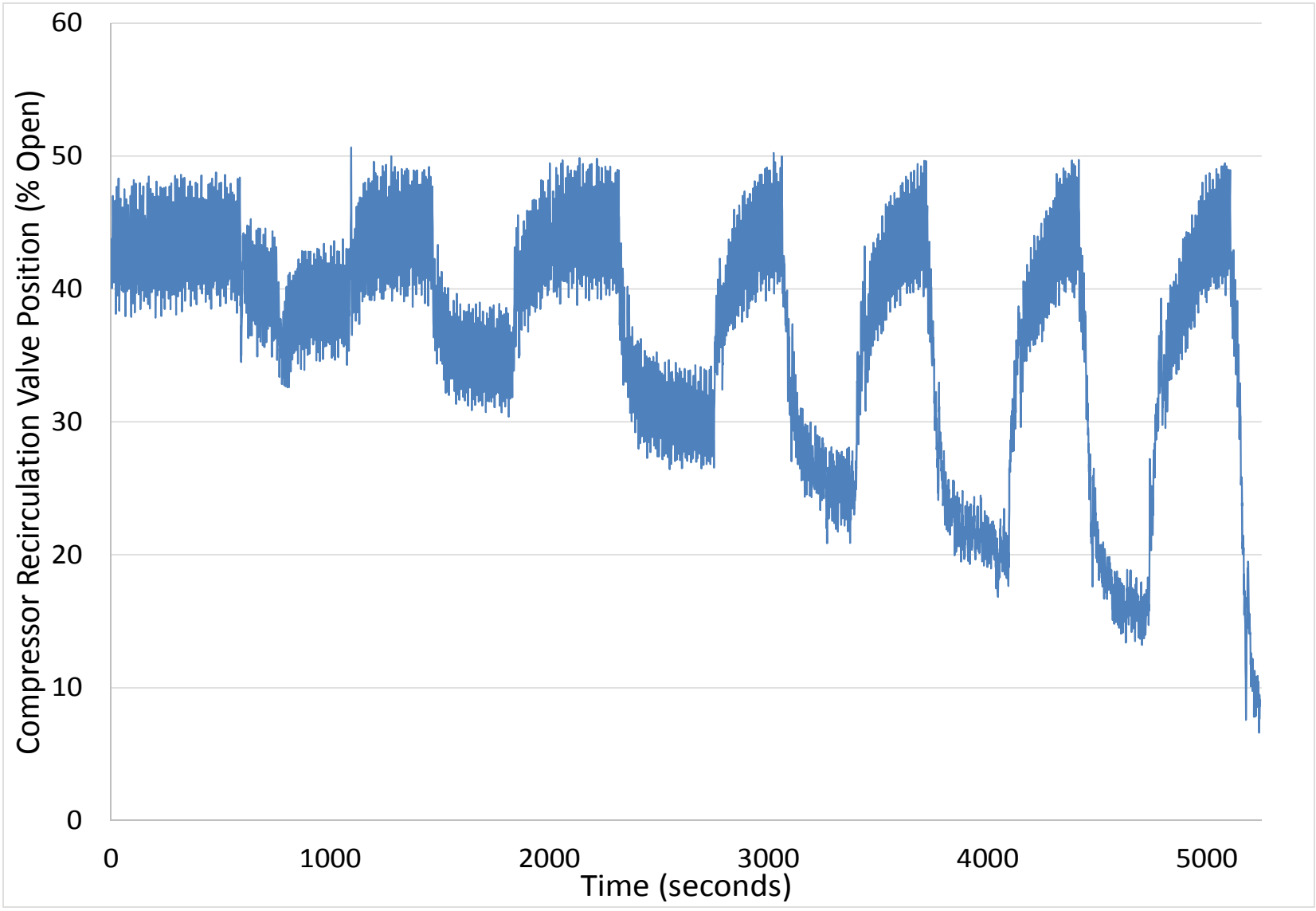
System Power Transients



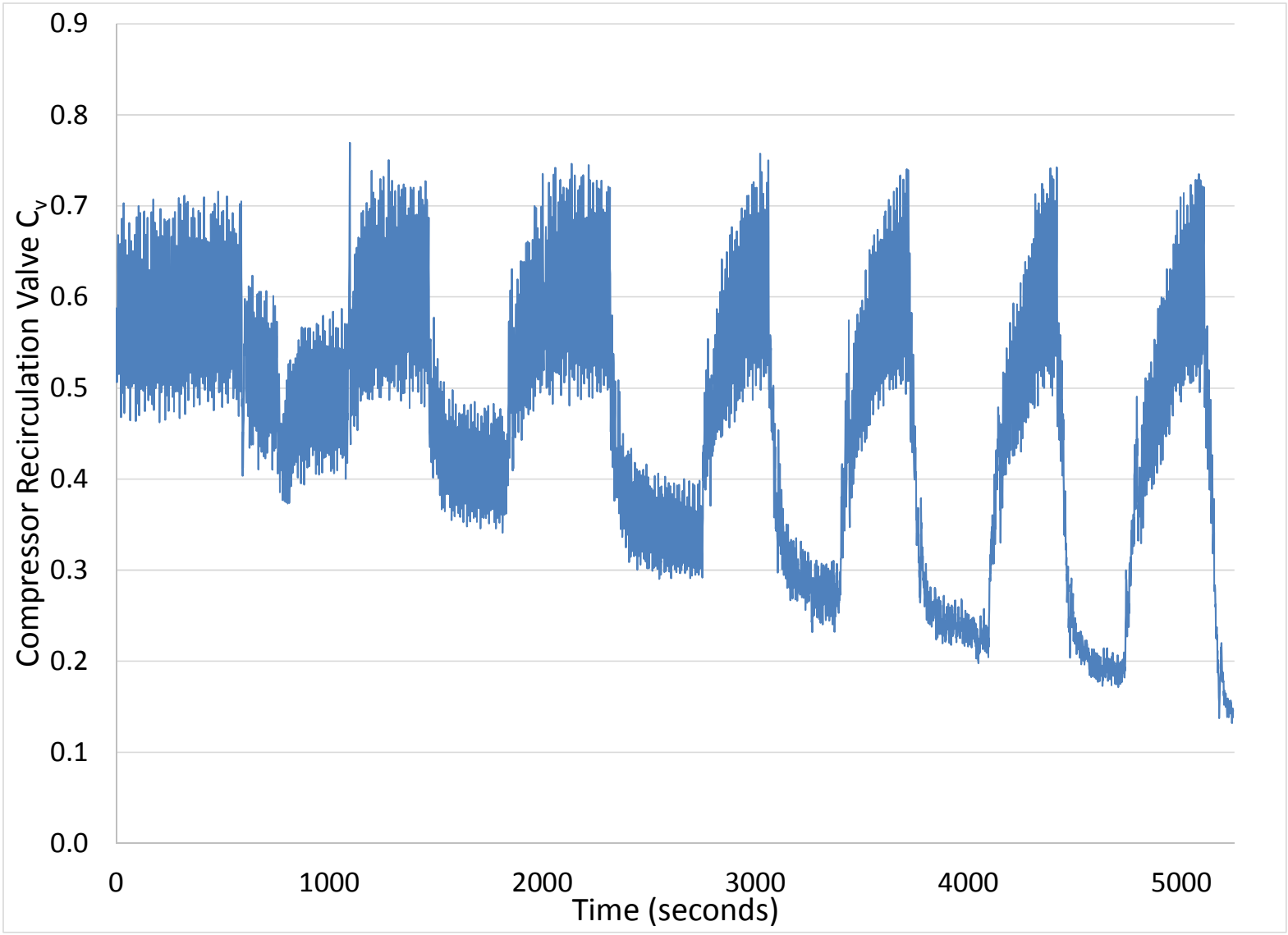
Turbine-Compressor Speed Control



Compressor Recirculation Valve Response



Compressor Recirculation Valve Resistance



Summary

- IST operated over range of power transients between 5% and 40% of design rating
- Thermal-hydraulic control strategy works very well for transients evaluated to date
- Overall system response is very stable despite large oscillations in compressor recirculation valve position

Acknowledgements

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