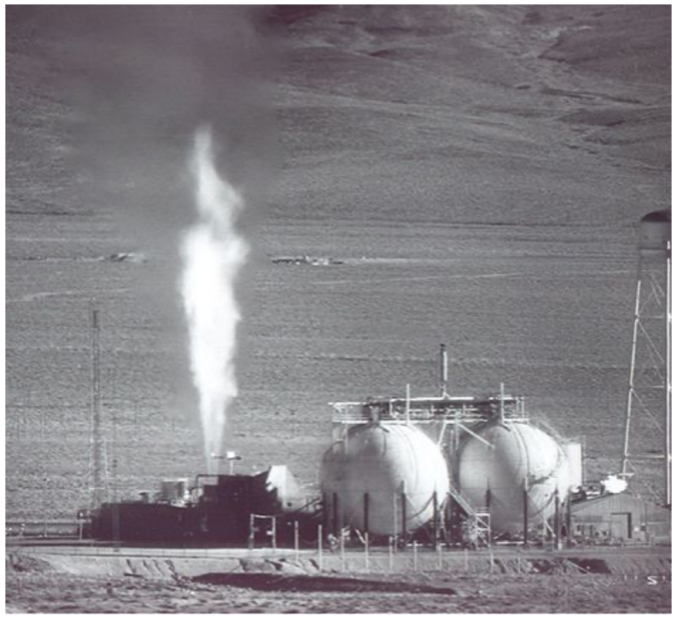
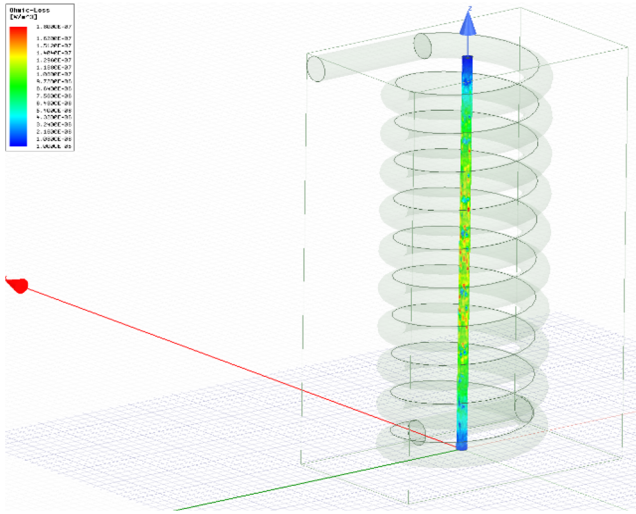
Contact: cdpowers@usc.edu

ASPEN

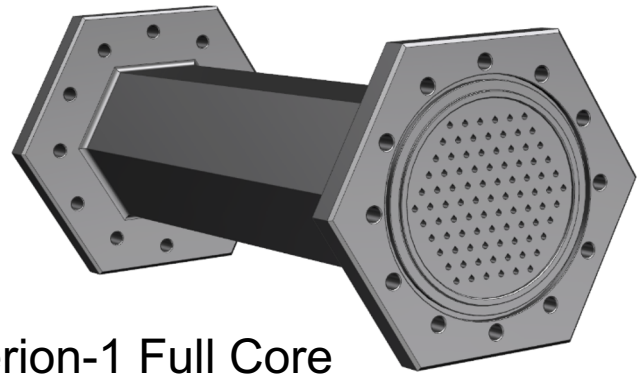
Development Campaign of an Additively Manufactured, Inductively-Heated Model of a Solid Core Nuclear Thermal Rocket Engine



NERVA Test Firing



Hyperion-1 Single Channel Ohmic Losses Map



Hyperion-1 Full Core

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Connor Powers | Spencer Powers | Samantha Cendro | Diego Ochoa-Cota | Branden Kretschmer | David Amaral | Kristen Pedersen | Trey Cranney

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Test Hardware

Single Channel

- 3/16” OD 316SS Tube
- $D_{hydraulic}$ = 0.090”
- T_{exit} < 350 K

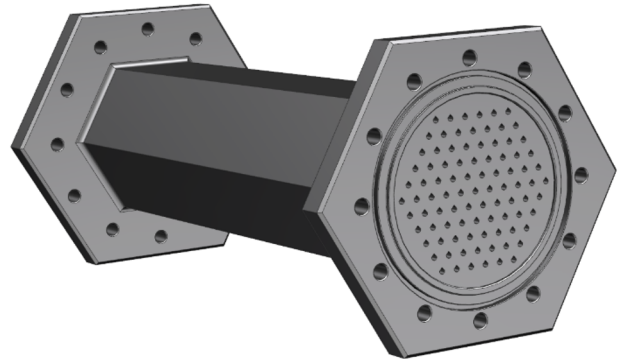
Single-Channel Model Validation

Mid-Scale

- 7 teardrop channels
- $D_{hydraulic}$ = 0.090”
- T_{exit} < 500 K

Multi-Channel Model Validation

Full Core



- 61 teardrop channels
- $D_{hydraulic}$ = 0.090”
- T_{exit} = 900 K

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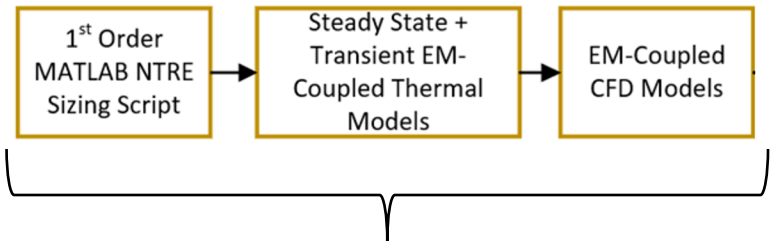
Hyperion-1 Development Campaign

Summary: Computational Simulation and Experimental Validation of a Series of Inductively Heated Test Articles as a Subscale Inert Test Bed for a Solid Core Axial-Channel Nuclear Thermal Rocket Engine



Phase 1: Modeling and Simulation

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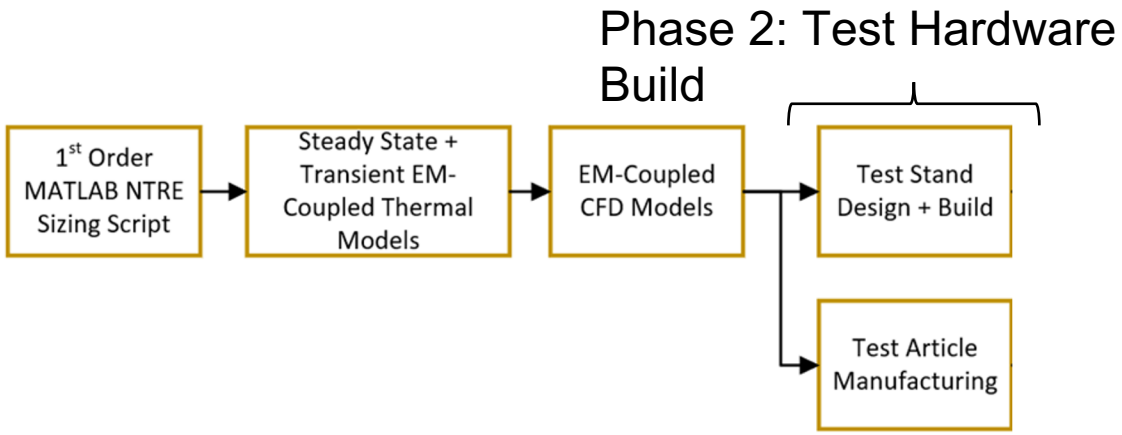

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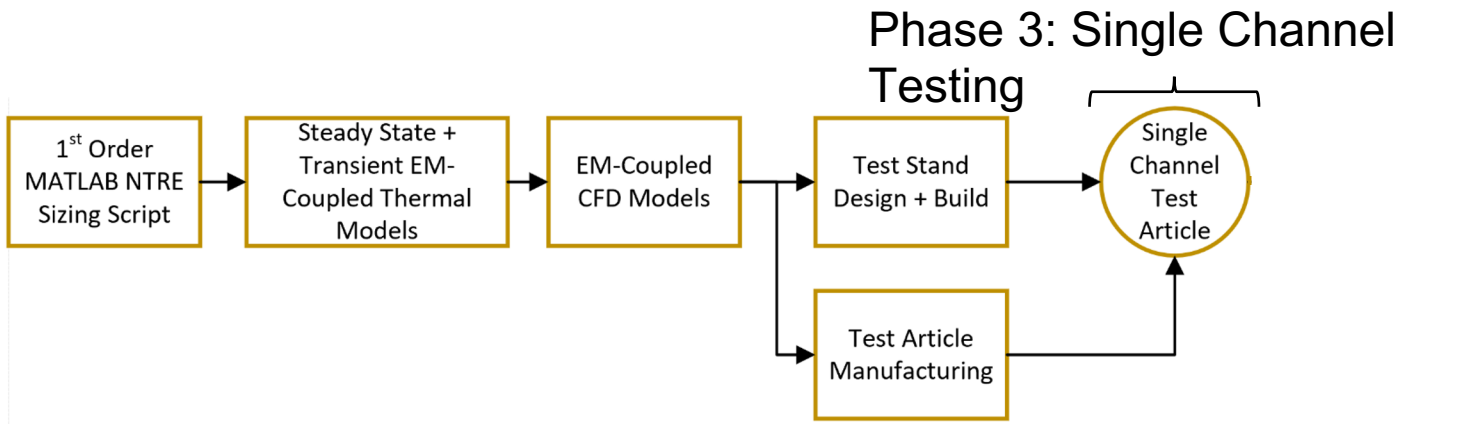
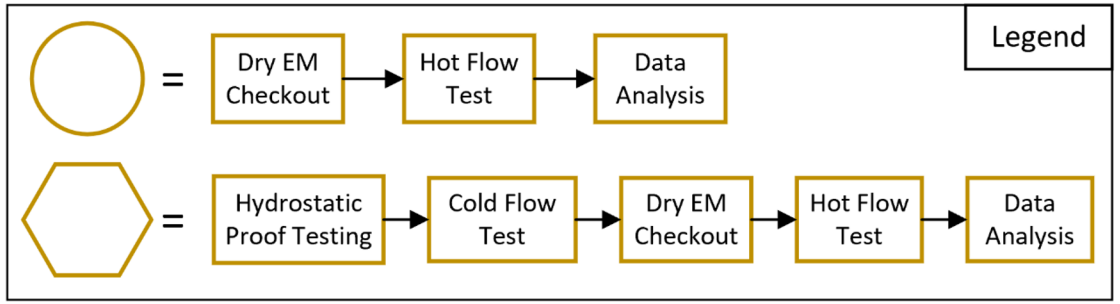


Single Channel



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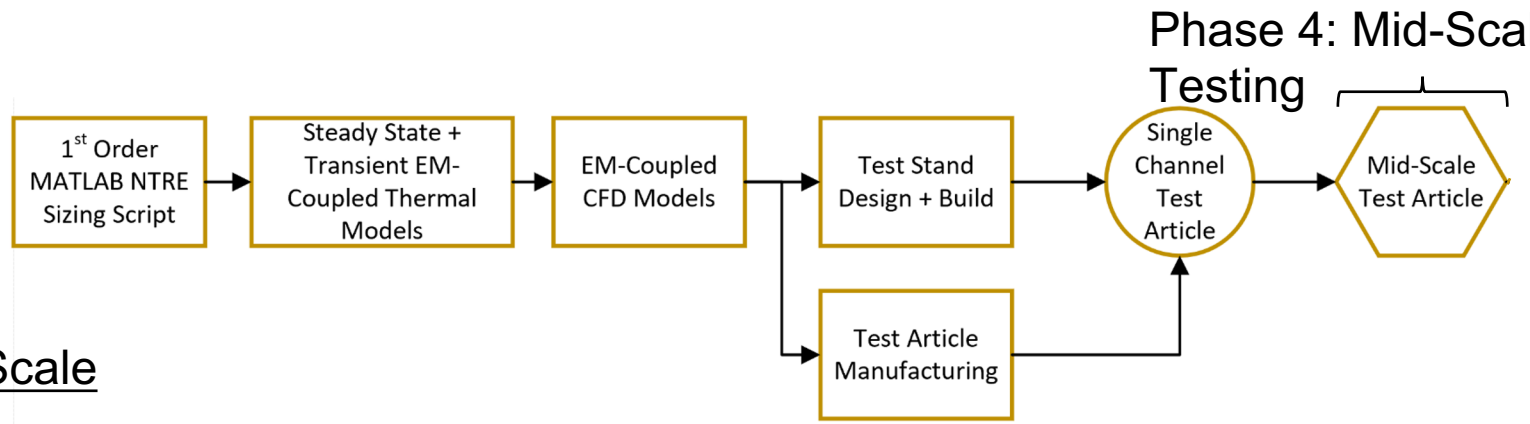
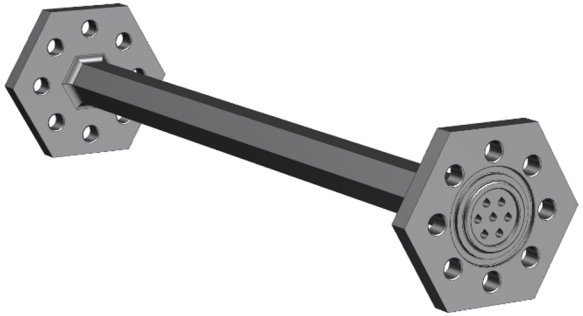
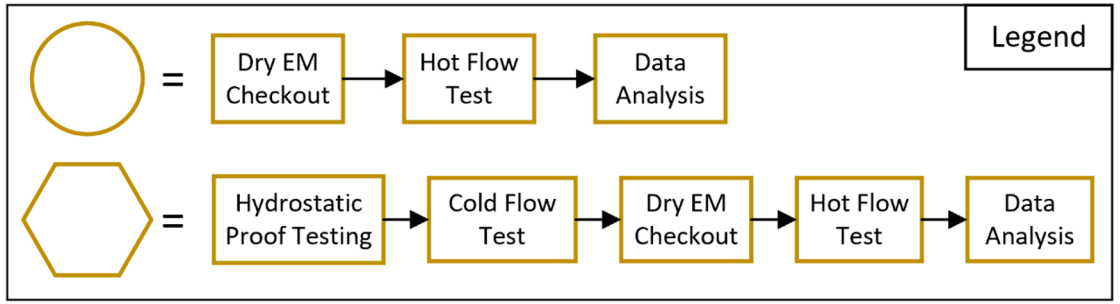


Mid-Scale





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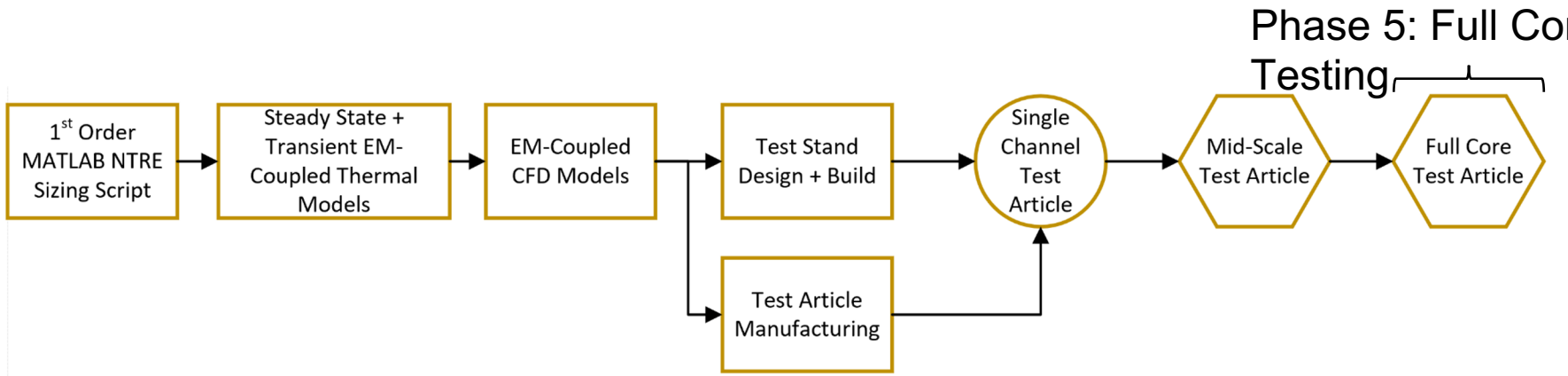
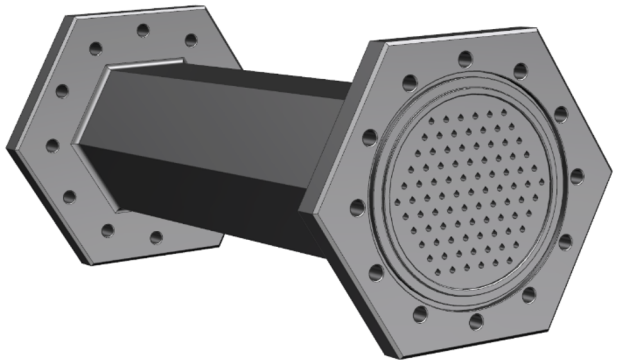
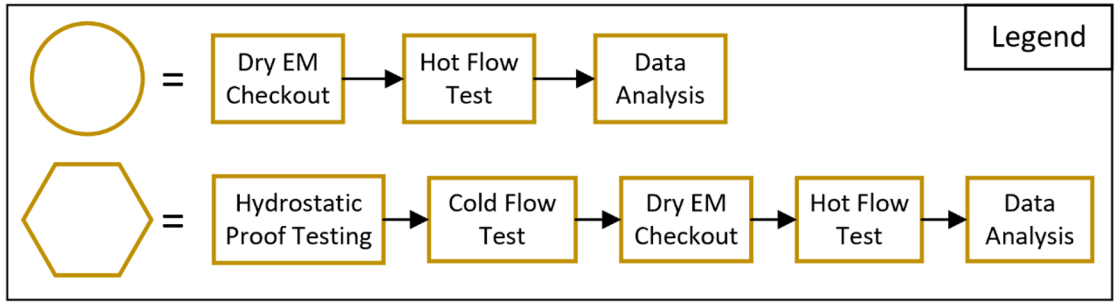


Full Core





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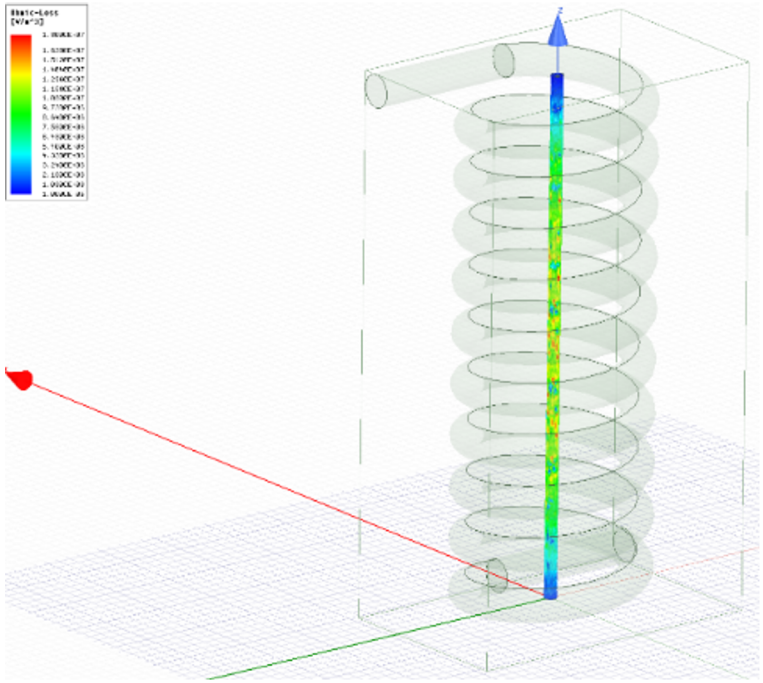
Modeling and Simulation for Each Test Article

Electromagnetic

- ANSYS Maxwell 3D
- Input current limited by in-house induction heater

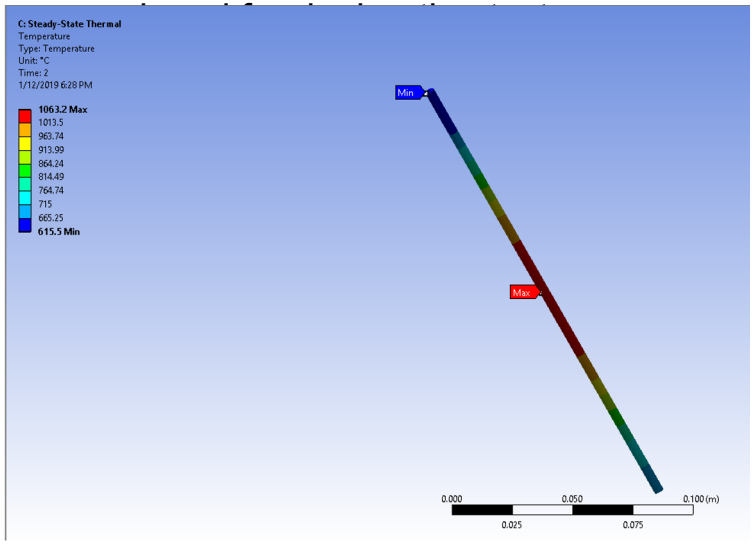


Outputs

- Ohmic loss contour

Thermal

- ANSYS Transient + Steady State Thermal
- Volumetric heating conditions imported via Maxwell ohmic loss map
- Ambient convection conditions

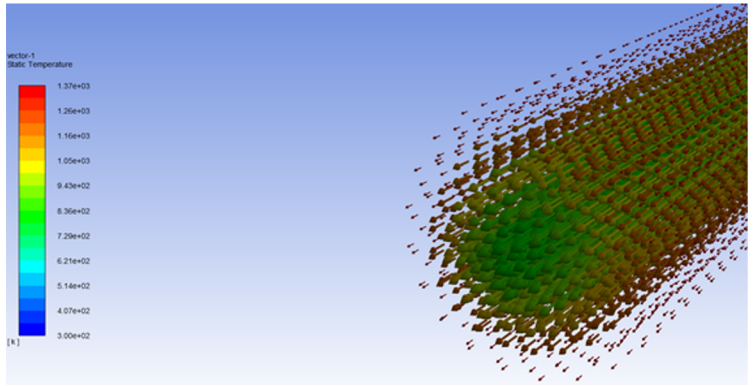


Outputs

- Transient and steady state temperature maps of test article heating without working fluid flow conditions

CFD

- ANSYS FLUENT
- Imports ohmic losses from Maxwell model
- Working fluid pressures assigned at inlet and outlet mesh boundaries
- Assumes thermally insulated test articles



Outputs

- Working fluid outlet conditions
- Steady state test article temperature

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Backup Slides

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Modeling and Simulation for Each Test Article

Electromagnetic

- Prescribed current in/out at coil leads
- Surrounding region assigned as air
- Coil dimensions:
  - 50mm inner ID (for flange clearance)
  - 8mm OD copper tubing
    - 1mm wall thickness
- Steel (generic) assigned to tube body

Thermal

- Assumed free convection coefficient of 10.3 W/(m^2 K)
  - Adjusted following dry heating tests at a given power level
- Steel (generic) assigned to tube body

CFD

- Inlet mesh: pressure inlet
  - Initial gauge pressure = regulated pressure
- Outlet mesh: pressure outlet
  - Outlet gauge pressure = ambient pressure
- Density-based solver
- GN2 assigned to working fluid volume
- Steel (generic) assigned to tube body

Test Stand P&ID

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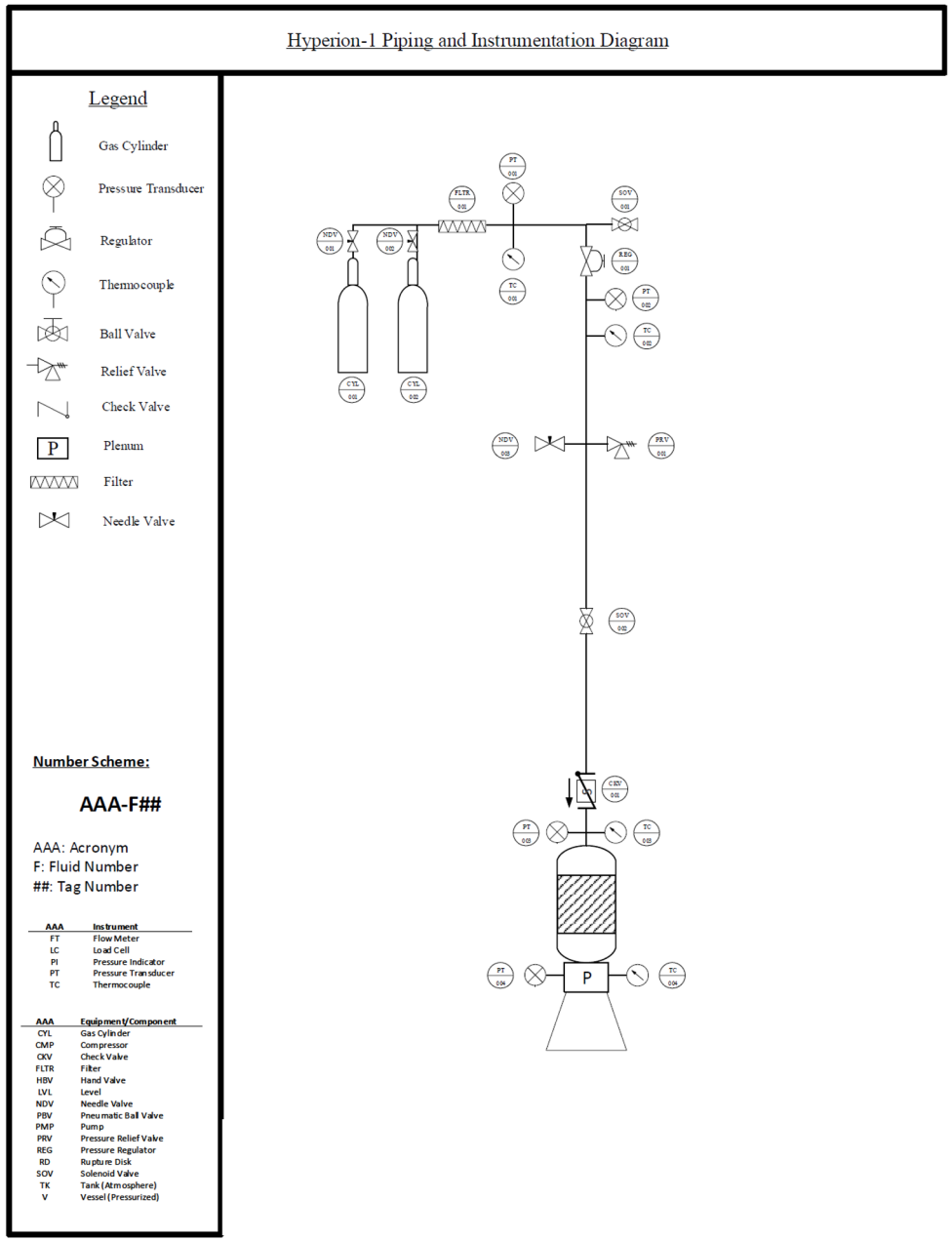

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