Microboone Cryogenic System

Design and Lessons

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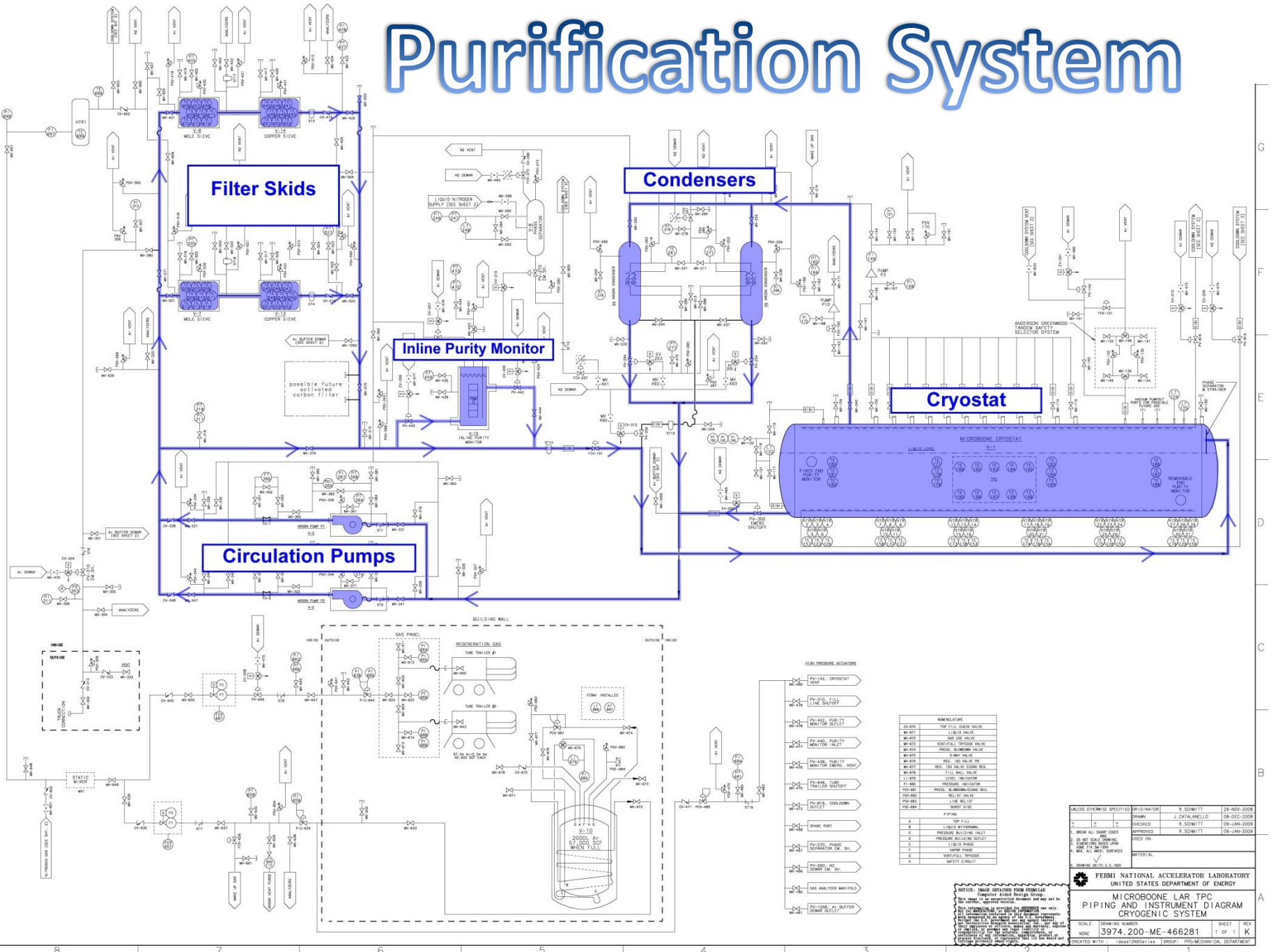
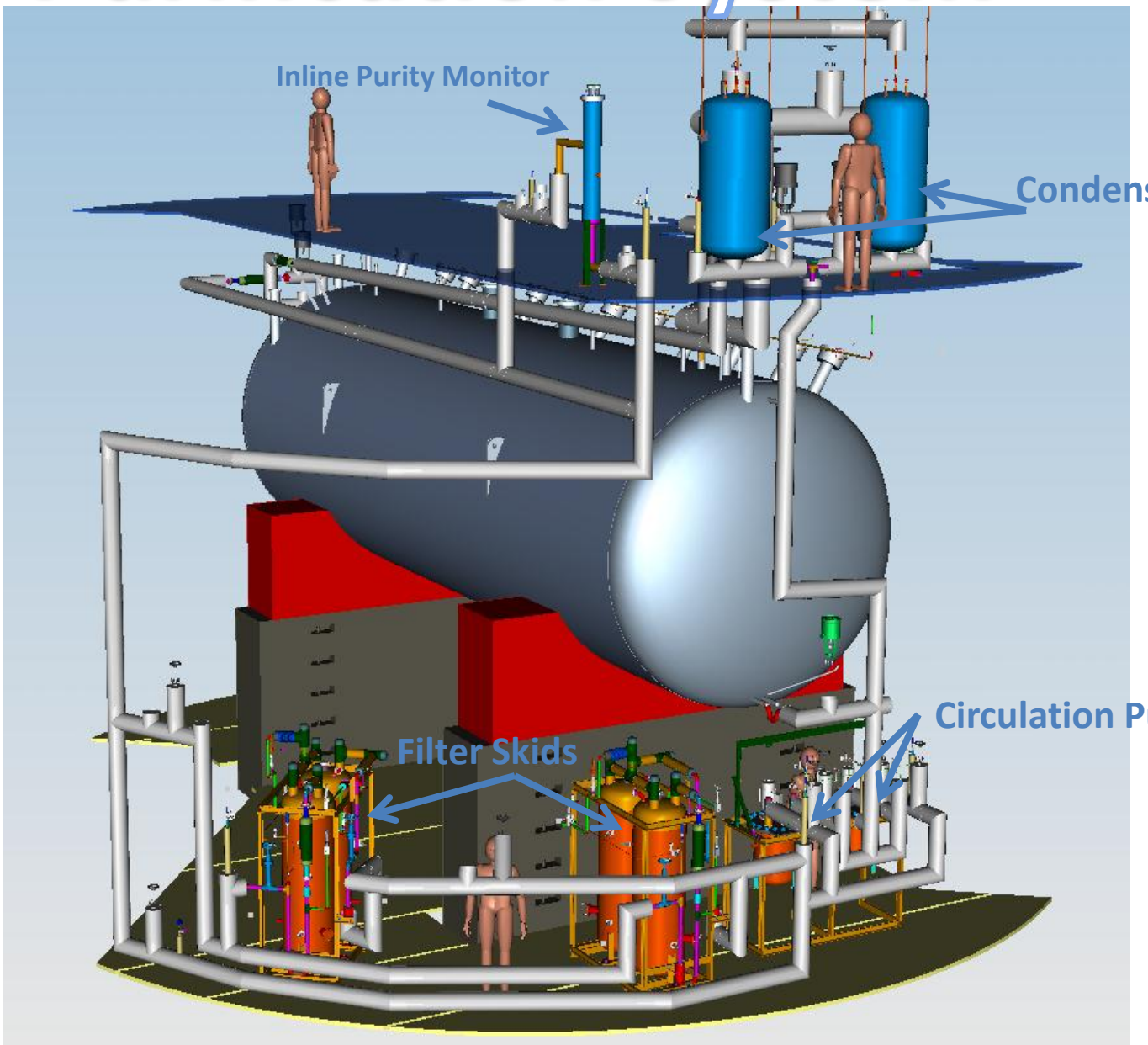
Cryogenic System Overview

- Main Subsystems
  - Purification System
    - Consists of the Cryostat, Circulation Pumps, Copper and Molecular Sieves (Filter Skids), and Argon Condensers
  - Cooldown System
    - Consists of the Cryostat, Compressor and Aftercooler, Heat Exchanger, and a Molecular Sieve
  - Buffer System for Test Run
    - Consists of the 11,000 gallon Argon Dewar, Circulation Pumps, and the Filter
  - Nitrogen System
    - Consists of the 11,000 gallon Nitrogen Dewar, Phase Separator, and Heat Exchanger

Purification System



Purification System



Purification System

- Cryostat
  - 150'' ID x 40 ft long x 7/16'' thick; weighs about 70,000 lbs
  - Full Vacuum – 30 psig
  - About 35,000 gal. Liquid Argon
  - Insulated by 16'' Closed Cell Spray on Polyurethane
  - Supported by 2 High Density (12-15 pcf) Polyurethane Saddles
  - Ribbed design

$q_{nozzles}$	210	W
q_{wire}	169	W
q_{saddle}	174	W
q_{vessel}	1965	W
Total heat load:	2518	W

Heat load calcs performed by Glenn Morgan

Cryostat at DZero

Purification System

- Circulation Pumps
  - Barber Nichols BNCP-32B Centrifugal Pumps
  - Used at CERN, LAPD, and others
  - 0.75 HP
  - Two in Parallel, One Spare
  - About 12 GPM Each, Variable Frequency Drive
  - About 1 Cryostat Volume Change per Day
  - Flow Rates Measured with Venturi Tubes

Purification System

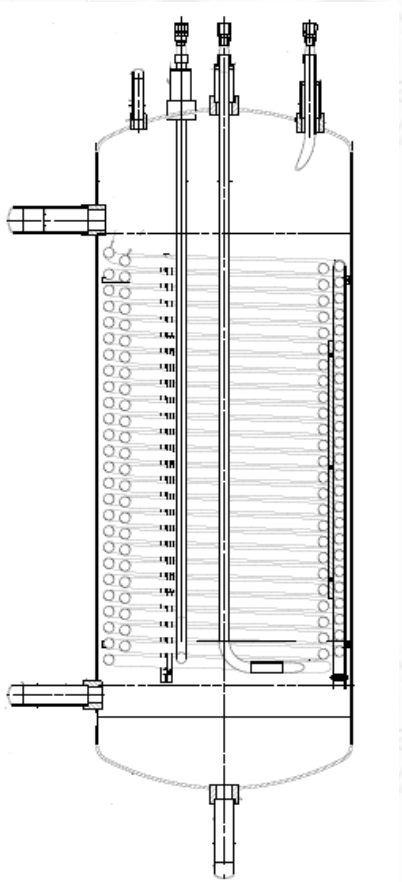
- Filter Skids
  - Two Skids, One Molecular and Copper Sieve Each
    - One Skid Active at a Time, Alternates with Regenerations
    - All Four Vessels and Inlet/Outlet Piping Vacuum Jacketed
  - About 3 cf of Filter Media in Each Vessel
    - Vessel Geometry Based on Flow Distribution and Water/Oxygen Capacity
    - Filter Media can be Filled/Emptied from Top Flange, No Disassembly Required
  - Sintered Metal Strainers on Skid Outlets and at Cryostat Inlet

Purification System

- Filter Skids
  - Regeneration of Both Vessels Simultaneously
  - External Gas Circulation Heater for Molecular Sieve
    - Heat with Nitrogen Gas
  - Tube Trailer with 2.5%/97.5% Hydrogen/Argon Mixture for Copper Sieve
    - 2,000 L Argon Dewar for Percentage Hydrogen Adjustment
  - Nine Internal RTDs per Vessel to Prevent Overheating
  - Flow Through Design
  - Analyzer Port After Each Vessel

Purification System

- Condensers
  - Two Argon Condensers
    - One Active, One Spare
  - Powered by Liquid Nitrogen
  - Coiled Design, Similar to LAPD Condenser
    - Run One or Both Coils
  - Design Load of about 9 kW
    - Large Capacity to De-Superheat due to the Cryostat Ullage Temperature Profile



- Cryogenic Piping is all Foam Insulated

2: Operational Heat Load Estimate
- 2.a: Cryostat Heat Leak - 2,589 Watts
- 2.b: Piping Heat Leak - 2,039 Watts
- 2.c: Pump Heat Loads - 1,019 Watts
- 2.d: Filter Heat Loads - 94.6 Watts
- 2.e: Condenser Heat Loads - 400 Watts
- 2.f: Valve Heat Loads - 262 Watts
- 2.g: Tap Heat Loads - 58 Watts
- 2.h: Electronics Heat Load - 716 Watts
- 2.i: Total Operational Heat Load (1.3 SF) - 9,461 Watts

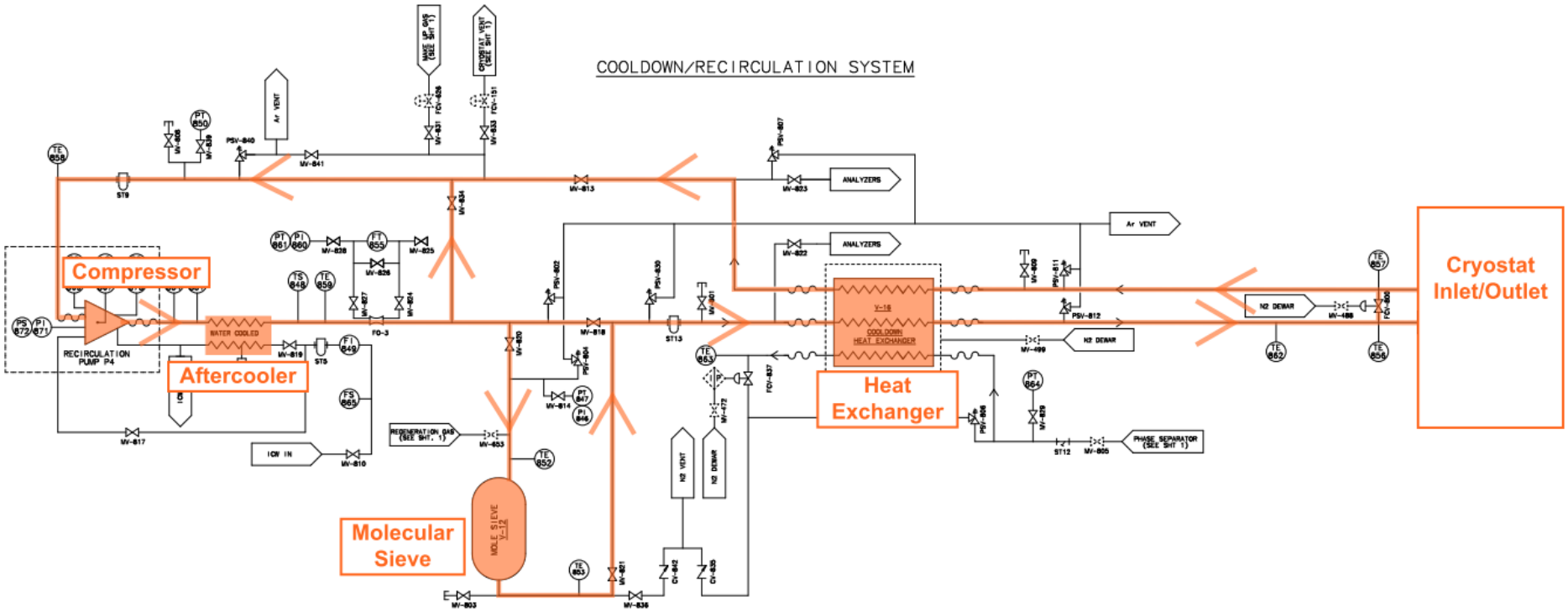
Purification System

- Gas Analyzer Manifold
  - Check Purity Levels from 12 System Sample Points
  - High/Low Sensitivity Sides
    - Low Sensitivity: 0 – 500 ppm Oxygen, and 5 – 23,500 ppm Water
    - High Sensitivity: 75 ppt Oxygen, 100 ppb Nitrogen, and 2 ppb Water
  - Send One or More Sample Point to Multiple Analyzers Simultaneously
  - Vacuum Pump Individual System Sample Point Tubing Routes
  - Small Bellows Pump to Build Pressure from Cryostat

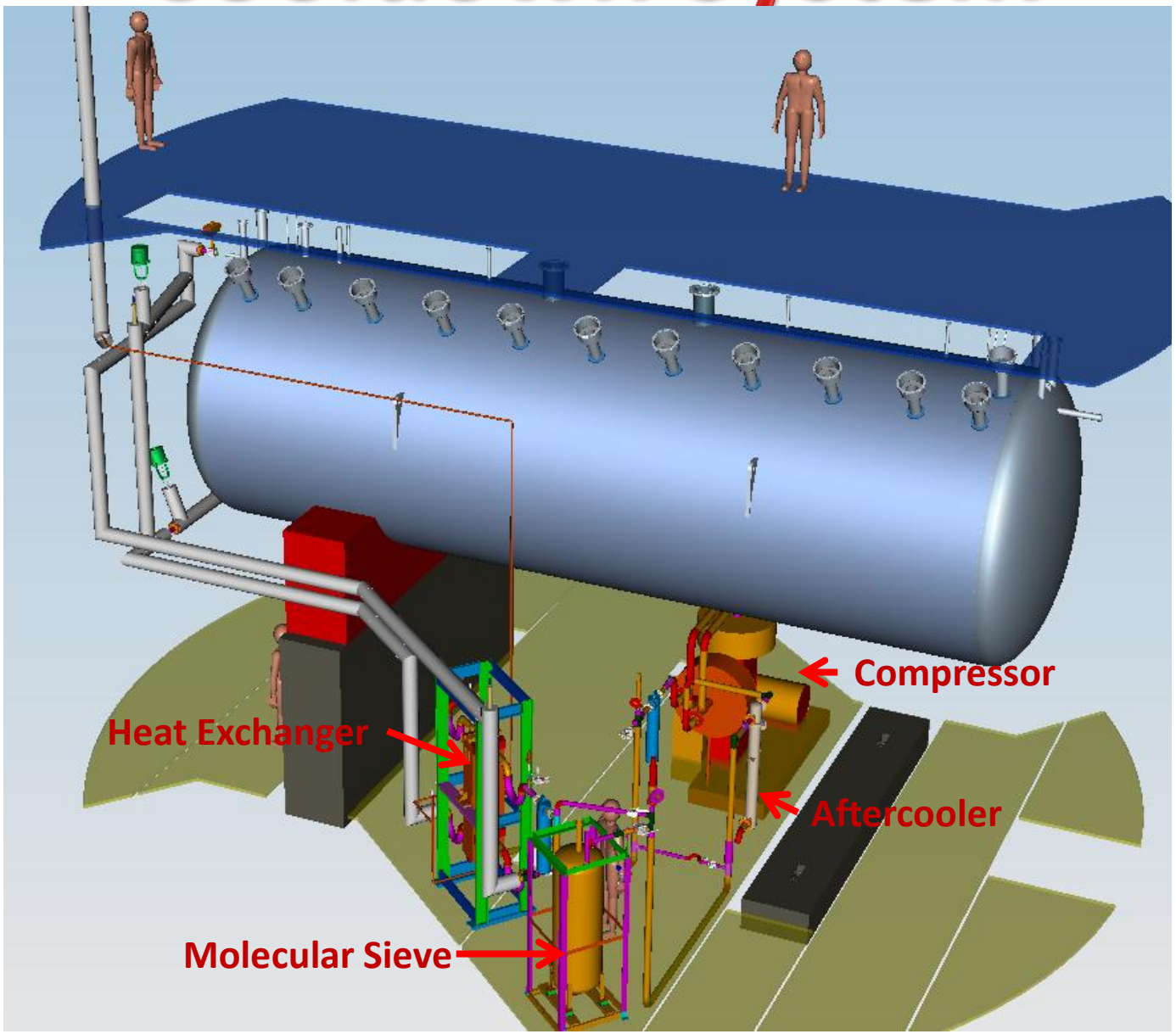
Buffer System for Test Run

- "Microboone June Run"
  - 11,000 Gallon Liquid Argon Buffer Dewar / Nitrogen Dewars
    - Argon Buffer Dewar Filled with One Tanker for June Run
    - Nitrogen Dewar Supplies Coolant for the Internal Condenser in the Argon Buffer Dewar
  - Argon Buffer Dewar in Place of Cryostat and Condensers for Equipment Testing
    - Circulation Pumps
    - Filter Skids
    - Inline Purity Monitor
    - Gas Analyzer Panel
    - Regeneration System

Cooldown System

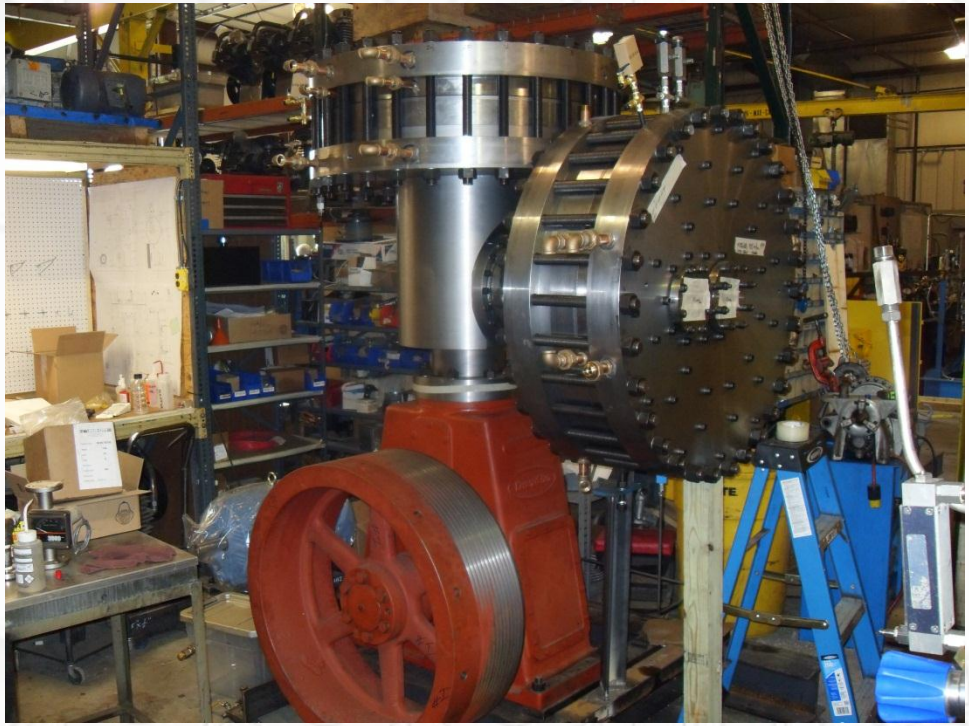


Cooldown System



Cooldown System

- Compressor
  - Used for Initial Recirculation as well as Cooldown
    - Design Rate About 36 lb/min Argon Gas
    - Cryostat has Externally Mounted Surface Heaters
  - Metal Diaphragm Type Compressor
    - One Stage
    - Two Parallel Diaphragms
  - 30 HP, 1800 RPM, Water Cooled Motor
  - Triple Diaphragm Construction, Automatic Leak Detection System



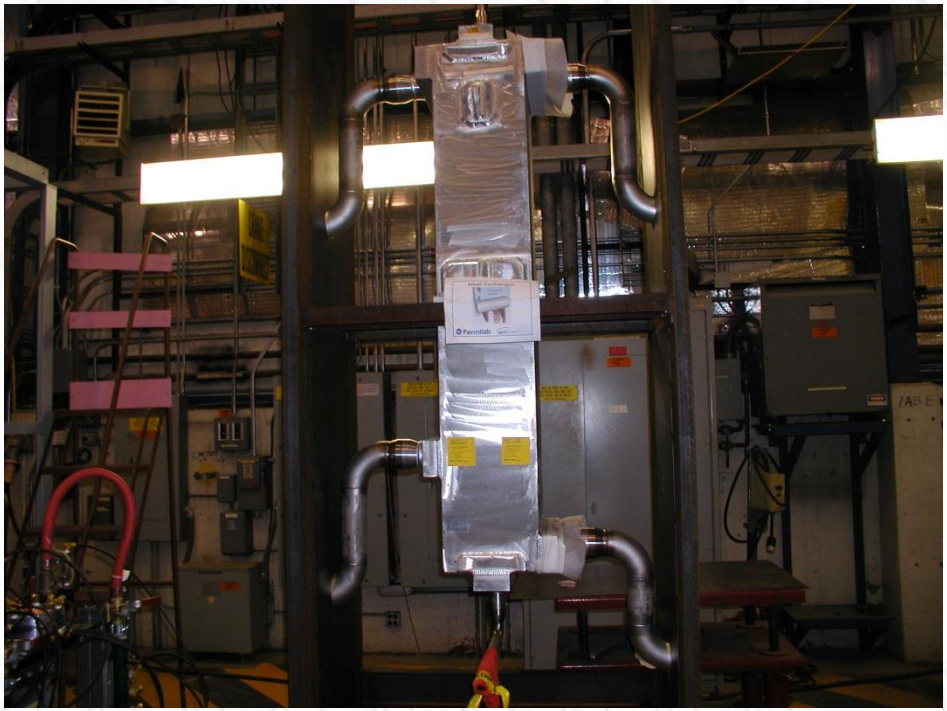
- Discharge Gas Cooled to around Room Temperature by Water Powered Basco Aftercooler
- Venturi Tube for Flow Measurement

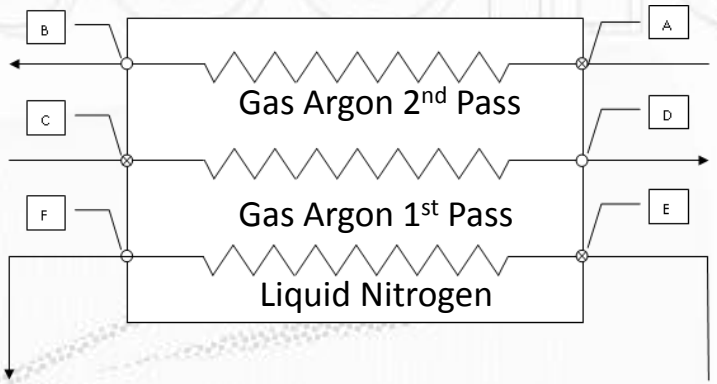
Cooldown System

- Molecular Sieve
  - About 12 cf of Filter Media
    - Filters Out Water During Initial Recirculation and Cooldown
    - Media can be Filled/Emptied from Top Flange
  - High Temperature Insulation
  - Analyzer Sample Ports on Outlet of Molecular Sieve and Cryostat

Cooldown System

- Heat Exchanger
  - Aluminum, 3 Pass Plate-Fin Design
    - 2 Passes Gas Argon
    - 1 Pass Liquid Nitrogen
  - Cool Gas Argon (1st Pass) from Room Temperature to Around 100 K over 2-3 Weeks
  - About 100 lb/hr Liquid Nitrogen Required
  - Cold Box Insulated with Nitrogen Purge
  - >95% Efficiency
  - Designed to ALPEMA and ASME BPVC VIII Standards





Comments and Considerations

- Mock-up in Lab F
  - Purification System (Pit Level)
  - Fit Condenser Lines
  - Outfit Heat Exchanger
  - Fix Alignment Issues

Comments and Considerations

- Contract Out Large Panels
  - Give Specifications, let Vendor Design
  - Maximum/Minimum Overall Dimensions and Port Locations
- Cooldown System Design and Cost Considerations
  - Equipment Cost ~$400K-500K
  - Different Methods of Temperature Control Possible
    - IE Nozzles, TPC Surface Heaters
- Gas Mixing System for Regeneration
  - Major Cost Savings Over Time