AO Bench Cold Enclosure Preliminary Design

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5/21/10

1. Scope and Objectives:

The primary objectives in the preliminary design of the AO bench cold enclosure are aimed at keeping optical alignment during observation through minimizing thermal turbulence, isolating and eliminating vibration due to coolant fluid flow, and maintaining constant temperature. Secondary objectives include consideration of air quality management, maintenance and adjustment, transportability, installation, and constraining cost.

2. Requirements:

The cold enclosure-specific and flow-down requirements from the AO system and telescope are listed below in table 1. There remain a few undetermined requirements that will need to be addressed in the detailed design phase of development; however, those requirements that impose the greatest constraints to the design have been addressed.

Table 1. AO Bench Cold Enclosure Requirements

Title	Value
Internal Operating Temperature	-15C
	+/- 0.5C
Ambient Operating Temperature	0C
	+/- 5C
System Coolant Supply	0C Glycol from facility supply
Thermal Dissipation (to Coolant)	The NGAO Cold Enclosure shall not dissipate more than 50 Watts to the Telescope Cooling system
Thermal Dissipation (to Ambient)	The NGAO Cold Enclosure shall not dissipate more than TBD Watts to the AO room
Transition Time: Standby to Observe	TBD
Transition Time: Cool down (Off to Standby)	24hr
Vibration	AO Room (or Nasmyth platform) Vibration Spec
Mass	TBD
Cleanliness	class 1000
Access	Maintenance personnel shall have access to optical layout from top.
	Maintenance personnel shall have access to optical bench support (legs) interface from bottom.
Window Ports	The NGAO Cold Enclosure shall not cause optical windows to tilt more than TBD mrad relative to first incident optical surface along beampath internal to enclosure
	NGAO Enclosure windows shall not allow condensation to form during observations or cool down
Wiring	Keep wiring harness minimal in length.
	Maintain seal around wire harnesses.

3. Design Architecture:

The bullet points listed below summarize the design architecture of the cold enclosure system:

- High thermal resistance insulation panel built into supporting frame for the enclosure
- Actively cooled walls to mitigate parasitic loads from ambient environment
- Individually cooled thermal loads on A/O optical bench
- Maintains positive N2 or dry air purge pressure during “observe” state
- Replaceable desiccant for humidity removal
- Controlled high volume “chilled air” flow to facilitate “cool down” state

- Health monitoring points feedback to system control for safety interlocks

3.1. System Architecture:
Figure 1, below, is a representation of the overall cooling system, showing the chiller loop for the chilled air purge and individual component heat load cooling. This system utilized the existing glycol infrastructure with a heat exchanger to remove heat from the cold enclosure chiller system. Shown in figures 2 and 3 are the system representations of the cool-down and standby/observing modes. During cool down mode, the internal volume cooling is maximized through both wall cooling and heat exchange with the interior air volume. In observing and standby mode, the heat exchange with the internal air volume is stopped to eliminate turbulence. In this operating mode the system relies on the wall cooling to address the parasitic load from the ambient environment, and glycol connection to the individual, high heat load components.

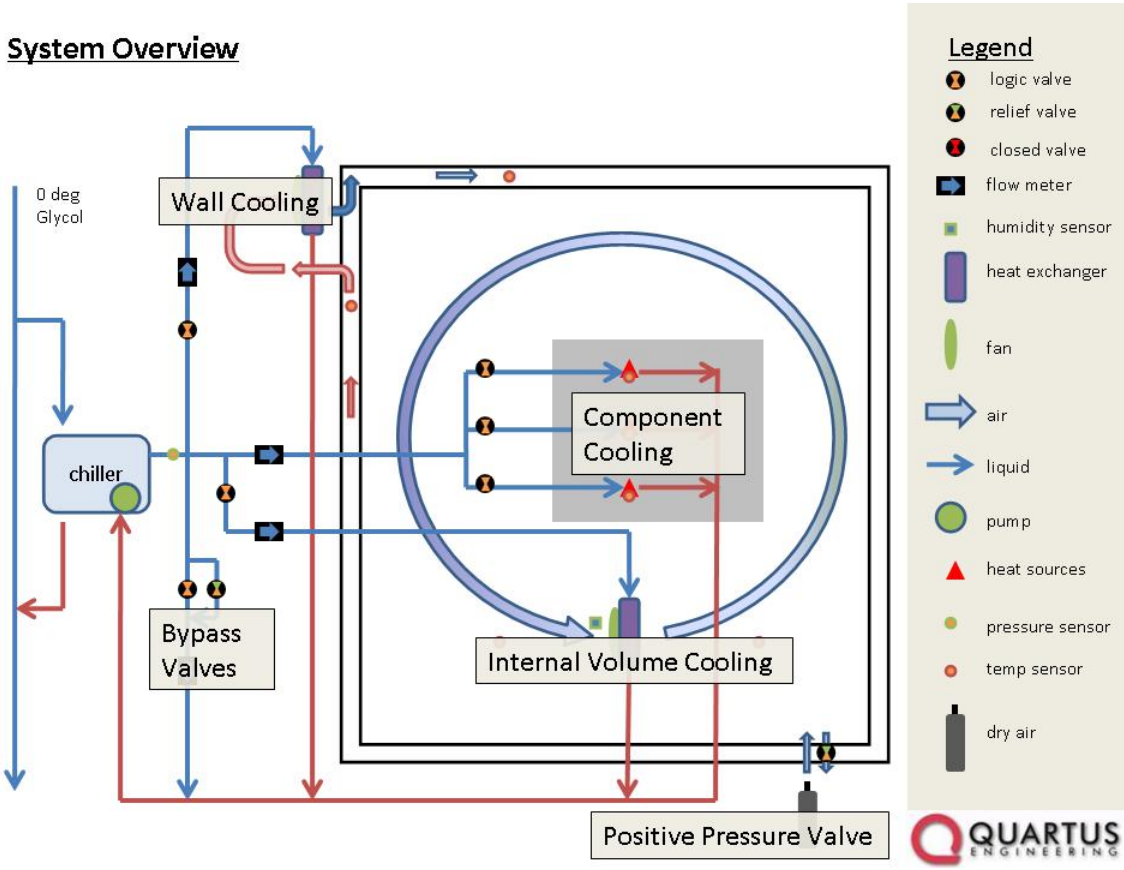

Figure 1. Cooling system overview with the legend of component representations to the right

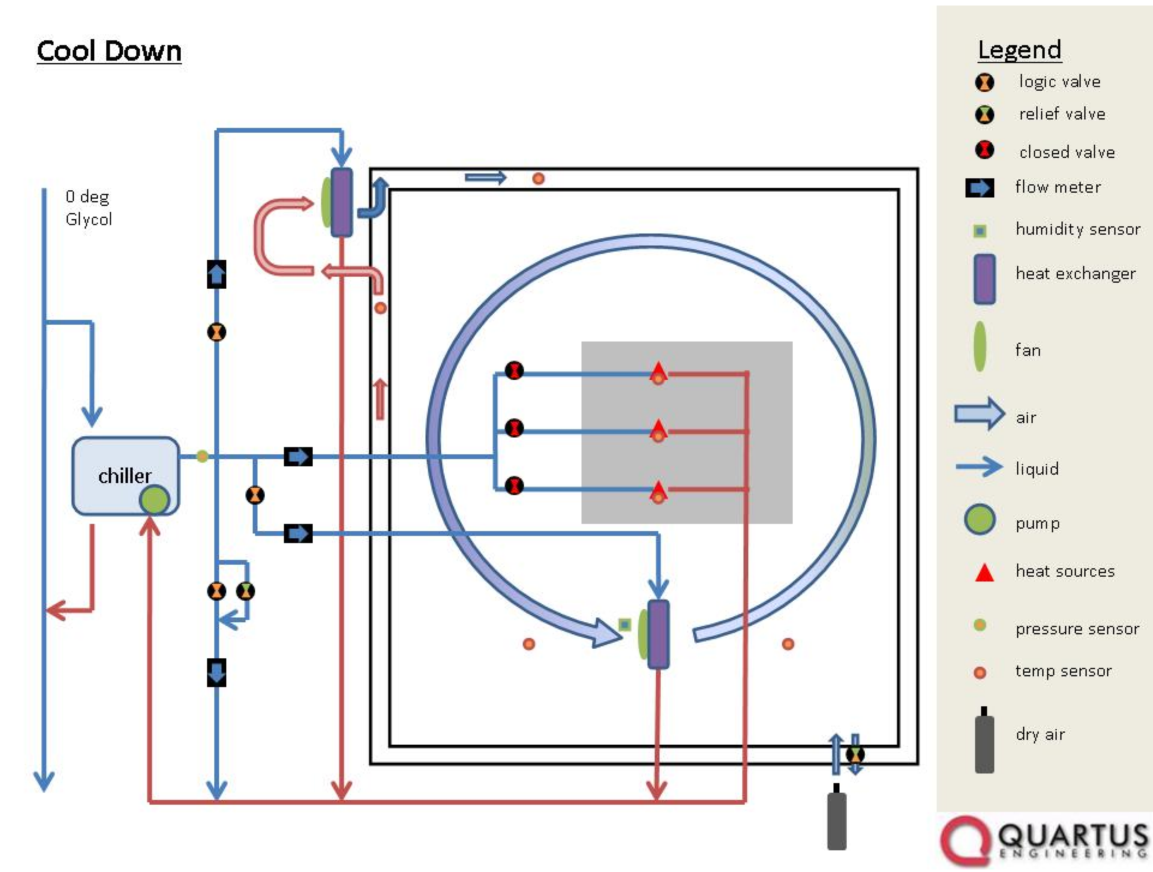

Figure 2. In the cool down operational mode, cooling is maximized through the heat exchange of the internal air volume and the wall cooling.

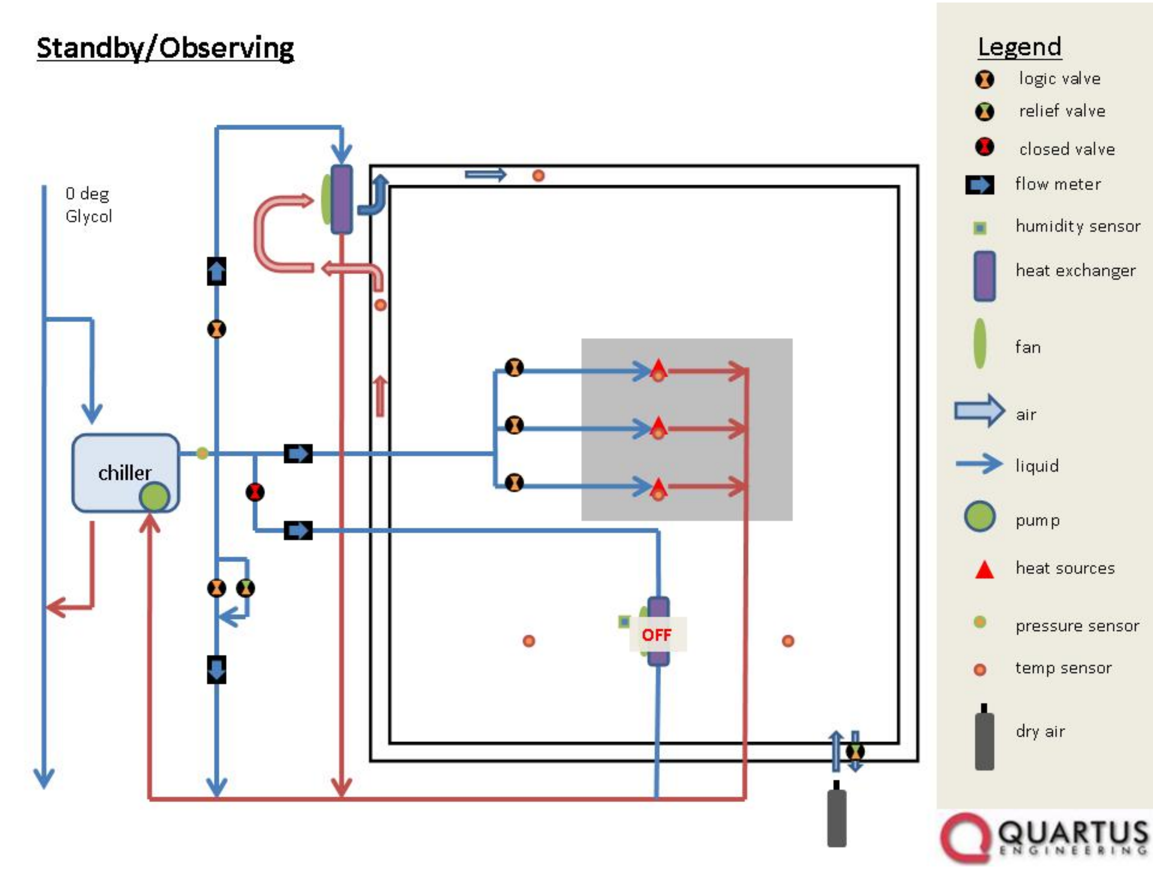

Figure 3. During standby and observing operational mode, the heat exchange of the inside air volume is stopped, and cooling is continues through the walls and direct glycol cooling of the individual heat loads on the bench.

3.2. Cooling system implementation

3.2.1. Actively cooled enclosure walls

The enclosure wall design, shown in figure 4, is based on a single foam insulating concept. The foam is encapsulated with an aluminum cap on the inside of the enclosure, with a composite (fiberglass/carbon-fiber) shell on the outer three sides. Chilled air is fed through the wall and into a cooling cavity formed by the aluminum cap for convective cooling of the walls. This part of the design architecture ensures that the parasitic load from the ambient environment is eliminated.

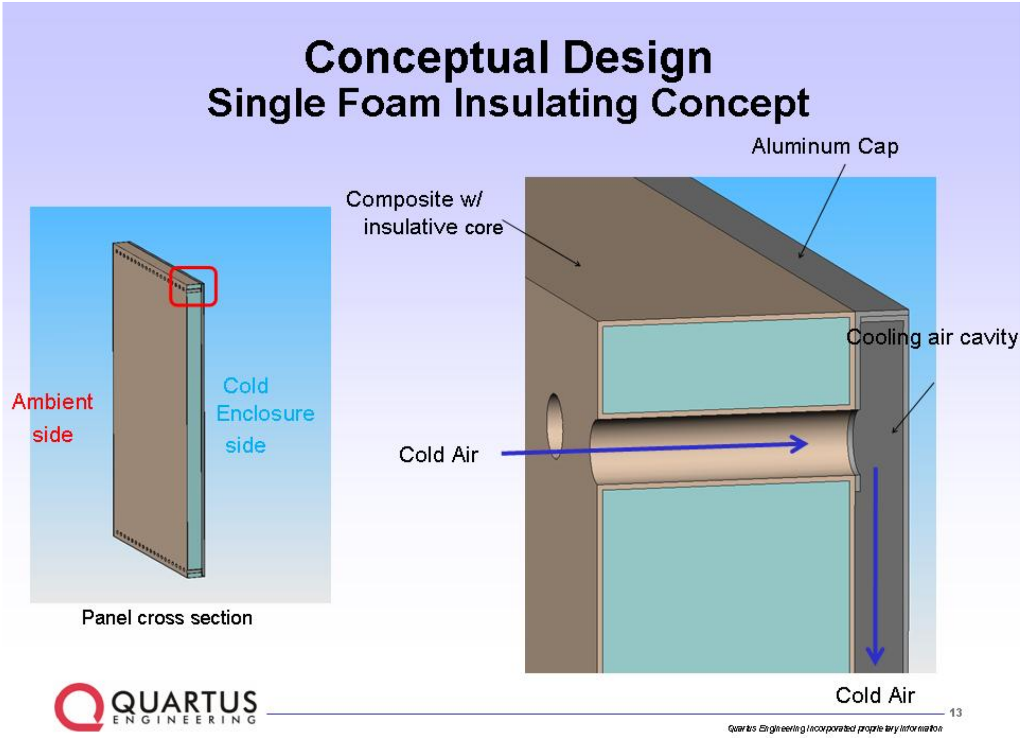

Figure 4. Shows a panel cross-section of the single foam insulating core design concept with aluminum inner cap, cooling air cavity, and composite outer structure.

Figure 4, below, shows the conceptual design of the enclosure, with the air-cooled panels supported by an aluminum frame. The enclosure is decoupling from the AO bench is maximized through floor support. Isolation of the windows will be accomplished with a TBD damping material where the bellows connections are made. Also considered in the design is the parasitic load of the metallic legs, which can be managed through using insulating materials such as ceramics for the balls in the kinematic mounts and insulation of the leg intrusion into the enclosure. More detailed analysis of these parts will take place in the detailed design phase.

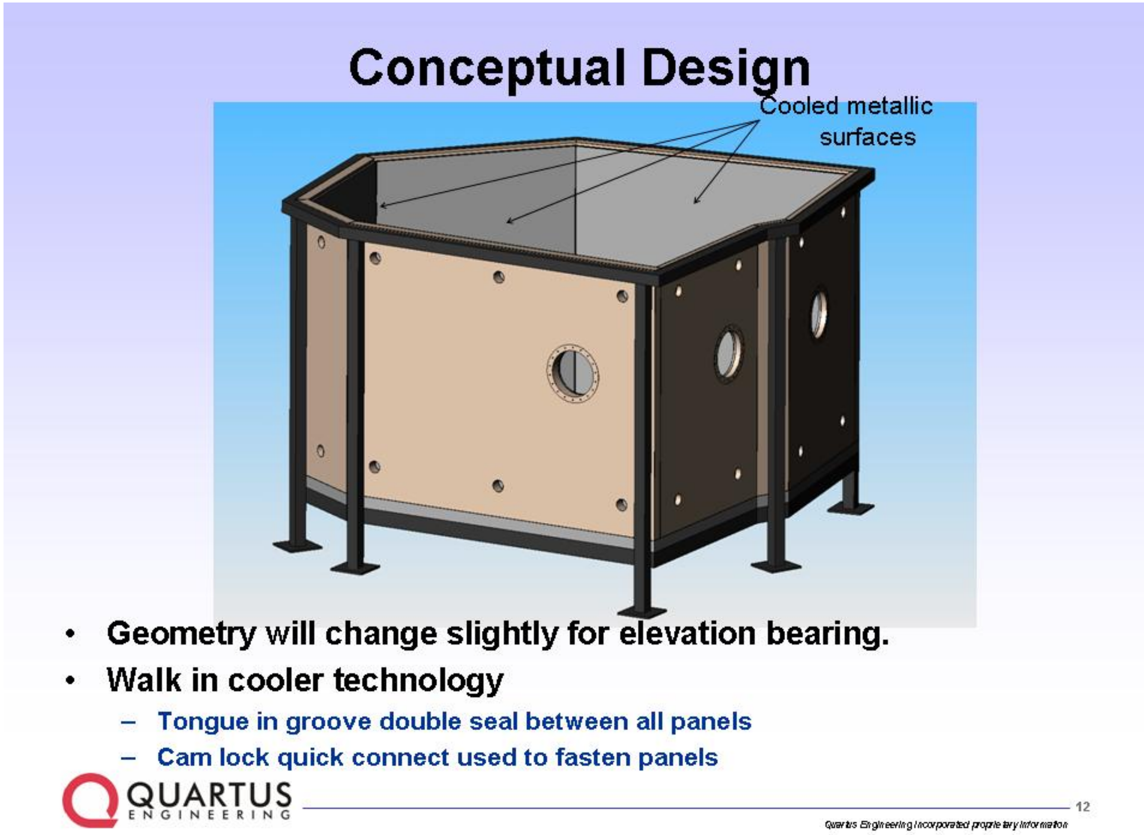

Figure 5. Conceptual design of the cold enclosure

3.2.2. Chiller selection

The cold enclosure system must provide a means to achieve a set point temperature below ambient. The design proposed here will utilize -20C to -15C glycol fluid as heat transfer media. “Chilled” glycol fluid requires a chiller, and currently two options are being investigated. The first technology is Vapor Compression Cycle Chiller. Several vendors have various options that are able to meet our needs. The downside to the VCC is that the require compressor heaters for operation in a 0 C environment. The second option, TECs driven Chillers, may be able to reach desired temperatures. We are currently in dialog with vendors. This would be a desirable solution due to the lack of vibration.

3.2.3. Chilled Air and Glycol system

Two Glycol to air heat exchanger with fans will be employed: one to do the heat exchange with cooling walls, located exterior of the enclosure and connected to wall channels via ducting. The second will heat exchange for cooling of interior air volume, located under A/O bench within the enclosure. This will also serve the glycol chilled cold plates to individual components. Cold plates and heat sources will be insulated from enclosure’s internal air volume where possible.

3.2.4. Individual component/heat load cooling

There are multiple components residing on the AO bench that represent significant heat loads that require direct cooling. The proposed design concept here is to cool directly utilizing cold plates connected to the chilled glycol system. Figures 6 and 7 show components on the AO bench encapsulated with insulation and surrounded by a cold plate for heat removal.

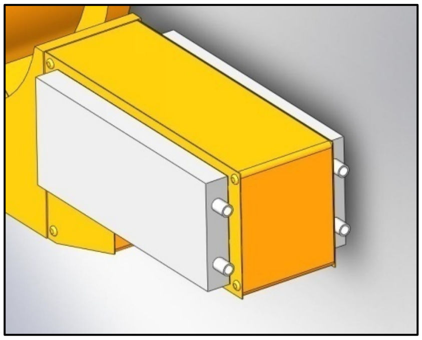

Figure 6. Shows the conceptual design for cold plate cooling and insulating of the individual heat load that reside on the AO Bench

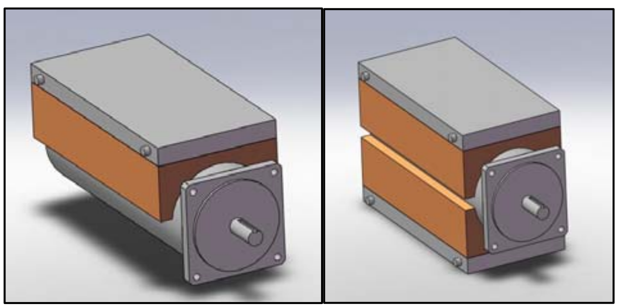

Figure 7. A motor encapsulated with insulating material and isolated through a cold plate that will be connected directly to chilled glycol.

3.3. Other considerations (currently being addressed)

- Engaging fabricators for ROM Quotes.
- Thermal analysis on cold plate to motor interface.
- Air quality management system.
- Elevation ring and enclosure clearances.
- Design of airflow to panel interface.
- Design of features to allow removal of panels.
- Design of window interfaces.
- Design detail for shipping interfaces.

4. Detailed analysis

For the preliminary design, hand calculations were made to estimate the heat removal requirements to first order. Some Finite Element thermal analysis has been completed on the individual components residing on the bench, and on the enclosure walls, but detailed FEA should be completed on the entire system for the detailed design phase.

5. System Costs

Quartus Engineering will provide a complete system cost estimate by the end of May, 2010.

6. Detailed Design

A follow-on Detailed Design project proposal from Quartus Engineering will be supplied by the end of May, 2010,