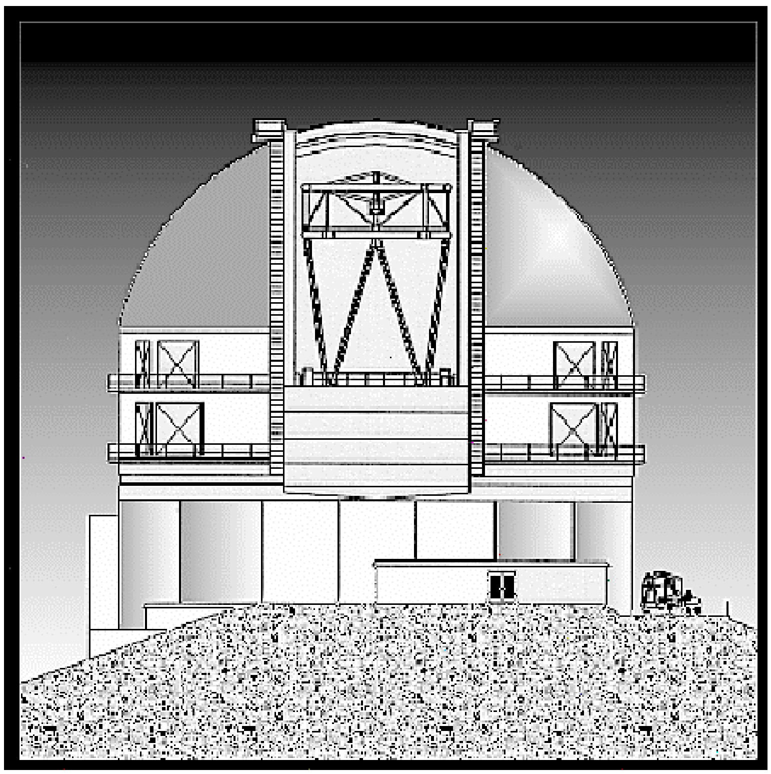
GEMINI
8-M Telescopes Project

SPE-TE-G0013
Revision 1

Enclosure Base, Support Facility, and Site Work Design Requirements Document



Telescope Structure, Building, and Enclosure Broup

October 27, 1993

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Section 1

GENERAL REQUIREMENTS

1.1 Scope of This Document

This document consists of the functional design requirements specification for the Gemini enclosure base, the telescope pier, the foundation system for the telescope pier and enclosure, the support facility and related site work. The Contractor shall provide Construction Documents for all the requirements in this document unless indicated specifically by N.I.C. (not in contract).

This document does not specifically address any design requirements for the Gemini telescope, the enclosure carousel, or the specific enclosure control system. Information on these topics can be obtained from one of the referenced documents listed in Section 1.2. Other items considered beyond the work scope of this document will be the specific design of the mirror coating vacuum chamber, the primary mirror cell cart, and the telescope top end transfer carts.

1.2 Related Gemini 8M Telescopes Project Documents

Information on other selected areas of the project can be found in the following documents. A more complete listing can be obtained from the Project Office.

SPE-C-G0010	Positioning Control System Design Requirements.
SPE-C-G0022	Gemini Enclosure Control System Overview.
SPE-TE-G0002	Gemini 8M Telescope Design Requirements Document.
SPE-TE-G0012	Gemini 8M Telescope Enclosure Carousel Design Requirements Document.
ICDG0005	Gemini Support Facility and Site Work Interface Control Document.

1.3 Definition of Key Terms and Abbreviations

The following key terms are used throughout this design requirements specification. Their specific meaning in the context of this specification are as follows:

- **Air Exhaust Tunnel -** The tunnel approximately 3 meters in diameter used to convey heated facility air away from the Gemini telescope optical path.
- **Altitude Angle -** The vertical angle of the telescope measured in degrees from the horizontal. The zero reference is at the horizon with positive values toward the zenith.
- **Azimuth Angle** - The horizontal angle measured in degrees. The zero reference point is toward the south. The positive rotation vector is toward nadir (opposite to zenith).

- **Coating Chamber Room Lifting Shaft** - The connecting device that extends the lifting capability of the shutter crane (N.I.C.) into the Coating Chamber Room during primary mirror handling.
- **CCP** - Carousel control panel.
- **Construction Drawings** - The drawings prepared by the Contractor and approved by AURA for use in the construction of the Work.
- **Construction Specifications** - The specifications prepared by the Contractor and approved by AURA for use in the construction of the Work.
- **Contractor** - The enclosure base, telescope pier, foundations, support facility and site work A/E design team.
- **Design Requirements Document (DRD)** - The provisions contained within this document.
- **Enclosure Base** - The stationary portion of the enclosure, including the stationary chamber floor, but not including the platform lift. The interior space is utilized primarily for the mirror recoating process and for telescope top end storage and maintenance.
- **Enclosure Carousel** (N.I.C.) - The rotating portion of the enclosure located above the top floor level of the enclosure base.
- **Enclosure Carousel Contractor (ECC)** - The enclosure carousel design/build team.
- **N.I.C.** - Not in contract.
- **Platform Lift** (N.I.C.) - The large capacity, vertically moving floor platform which travels between the lower level of the enclosure and the telescope chamber.
- **Rotating Telescope Floor** (N.I.C.) - The circular-disk floor connected to and supported by the telescope mount.
- **Shutter Crane** (N.I.C.) - The 40 metric tonne hoist device located within the structure of the carousel upper shutter. This crane provides lifting capability within the Coating Chamber Room.
- **Stationary Chamber Floor** - The floor that surrounds the rotating telescope floor, which is connected to and supported by the enclosure base perimeter structure.
- **Support Facility** - The building adjacent to the enclosure which houses the main support functions of telescope operations, telescope instrument assembly and disassembly, optomechanics and array/electronics labs, and the mechanical plant room.
- **Telescope Pier** - The concrete single wall cylinder, not including the azimuth track anchor bolt system, which support the telescope azimuth track.
- **T.B.D.** - To be determined.

1.4 Applicable Codes and Requirements

The following codes and regulations shall form the basis of compliance for design and construction, and the current edition utilized by the local building officials shall be used. In addition to the codes and regulations, the Contractor shall become familiar with the requirements of the Gemini Electronic Design Specification listed below in the execution of the Work under this Contract.

- Uniform Building Code.
- Uniform Mechanical Code.
- Uniform Plumbing Code.

- Uniform Fire Code.
- National Electrical Code.
- ASCE 7-88 (for wind load and load combination determination).
- "Recommended Lateral Force Requirements and Commentary," Seismology Committee of the Structural Engineers Association of California.
- ASHRAE Fundamentals Handbook.
- OSHA Health Regulations.
- Americans with Disabilities Act of 1990.
- Hawaii Department of Health - Air Pollution Ordinance.
- SPE-ASA-G0008 - Gemini Electronic Design Specification.
- Other applicable codes and requirements with specific application to the Mauna Kea, Hawaii, USA site and the Cerro Pachon, Chile site.

Where discrepancies exist between the requirements of the various codes, the requirements that offer the greatest protection to AURA will govern.

1.5 Design Approach for the Gemini Facilities

The Gemini Project will build two telescope facilities: one on Mauna Kea on the island of Hawaii, U.S.A. and the other on Cerro Pachon in Chile. For economy, the facilities shall be as similar as practical, and still satisfy performance requirements. However, the Contractor shall take site differences into account, such as soils conditions and the availability of certain construction materials, for the final design.

1.6 Useful Life of the Facility

The useful lifetime of the facility is likely to exceed 50 years. Therefore, due consideration of fatigue shall be given to all structural members and connections subjected to stress fluctuations, and all components shall be designed for 50 years of use. Any component not designed for 50 years of use shall be identified by the Contractor, and its application requires prior approval by AURA.

1.7 Design Drawings and Specifications

All detailed design drawings and specifications shall be submitted to AURA for review at the following milestones: 50%, 95%, and 100% completion. AURA shall have free access to all design calculations, and if considered inadequate, may require that further calculations shall be made to ensure that the requirements of the specifications are met.

All design drawings shall be generated in (or be transferrable to) AUTOCAD Release 12.

Dimensional units presented on the drawings will be as follows. On Mauna Kea, the dividing line will be at the north wall of the support facility.

- South of this wall, dimensions will be given in ft/in units for all. In addition, key overall dimensions will be given in System International (metric) units, with roundoff occurring in the metric values.
- North of this wall, all dimensions will be given in both ft/in and metric units, with the roundoff occurring for the ft/in values.

All design drawings prepared for the Cerro Pachon facility shall be in metric units.

For the Mauna Kea, Hawaii site, all drawings and specifications shall be presented in English.

For the Cerro Pachon, Chile facility, all drawings shall be presented in Spanish. The specifications for the Cerro Pachon facility shall be developed through the 100% review in English, and then translated into Spanish just prior to sending the construction documents out to bid. Therefore, two versions of these specifications will exist, and both must be kept current until the end of construction.

1.8 Material Specifications

The Contractor shall incorporate the following requirements into the construction specifications:

1. All materials specified shall be new and of high grade commercial quality. All materials shall conform to at least the minimum requirements specified in the American Society for Testing and Materials (ASTM) Standards in Building Codes.

2. Insure satisfactory notch toughness for structural steel subjected to the depression temperature specified in Section 2. Perform Charpy impact tests on all lots of structural steel subject to the depression temperature, as described in ASTM A 370-91a, Sections 19 through 28. Test specimens shall be tested at the depression temperature specified in Section 2. The minimum average test results for acceptance shall indicate that the possibility of embrittlement and brittle fracture will not be present for all temperatures above the depression temperature.

3. Workmanship shall be of a high-grade of commercial practice and adequate to achieve the accuracies and surface finishes called for on all drawings and in the specifications.

4. All manufacturing processes, such as plating, welding or heat treatment, shall be specified and performed in such a manner as to achieve the strength and properties required without introducing any material defects such as hydrogen embrittlement, excessive grain growth, or residual stress concentrations.

Section 2

ENVIRONMENTAL CONDITIONS

2.1 Observing Conditions

The following data represent environmental conditions during which the telescope will be in operation. The support facility and enclosure base shall remain fully operational in support of the telescope throughout the range of conditions indicated. The depression temperature shall apply locally to all exterior cladding, structural steel, and mechanisms that are directly exposed to the nighttime sky. The depression temperature specified is the temperature to which an exposed object will cool through radiation to the nighttime sky.

Dead loads, live loads, ice and/or snow loads, temperature effects, and wind or seismic loads shall be combined per the ASCE 7-88 Standard when determining the critical case for stresses and deflections.

2.1.1 Mauna Kea

Operating wind speeds: Up to 30 m/sec (67 mph) from any direction.

Operating temperature range: -15^{o}C to +20^{o}C (+5^{o}F to 68^{o}F).

Operating humidity range: 5% to 90%.

Air pressure range: 600 mb to 700 mb.

Depression temperature: -25^{o}C (-13^{o}F).

Maximum uniform ice build-up: 25 mm (1.0 in) or 22 kg/m^2 (4.7 psf).

2.1.2 Cerro Pachon

Operating wind speeds: Up to 30 m/sec (67 mph) from any direction.

Operating temperature range: -15^{o}C to +25^{o}C (+5^{o}F to 77^{o}F).

Operating humidity range: 5% to 95%.

Air pressure range: 700 mb to 800 mb.

Depression temperature: -25^{o}C (-13^{o}F).

Maximum uniform ice build-up: 25 mm (1.0 in) or 22 kg/m^2 (4.7 psf).

2.2 Survival Conditions

The following data represent the extreme environmental conditions to be used for design purposes. Under survival conditions, the enclosure carousel and enclosure base will be in the fully-closed configuration when determining wind load and icing effects on the enclosure base. The snow loading and the ice loading shall be assumed to act concurrently. The design precipitation event shall be used for the performance of all wall systems and weather seals.

Dead loads, live loads, ice and/or snow loads, temperature effects, and wind or seismic loads shall be combined per the ASCE 7-88 Standard when determining the critical case for stresses and deflections.

2.2.1 Mauna Kea

Fastest-mile wind speed of a minimum duration of 1 sec located at 10 m above ground level:	67 m/sec (150 mph) from any direction.
Design air temperature extremes:	Min = -15°C (+5°F); Min = -25°C (-13°F) (For portions exposed to the nighttime sky); Max = 25°C (77°F).
Max diurnal temperature difference:	30°C (54°F) (For determining forces and deflections caused by expansion or contraction).
Seismic ground acceleration:	Zone 3 requirements given in the Uniform Building Code.
Average annual precipitation:	380 mm (15").
Design precipitation event:	25 mm (1.0") rainfall rate per hour acting concurrently with 30 m/sec (67 mph) wind from any direction.
Snow loading on projected horizontal surfaces:	150 kg/m^2 (31 psf) (Drifted snow loading must also be considered).
Additional ice loading on exposed surfaces not covered with snow (76 mm):	68 kg/m^2 (14 psf).
Additional ice loading on all protruding edges:	167 kg/m (112 lb/ft) (Acting along the edge).

2.2.2 Cerro Pachon

Fastest-mile wind speed of a minimum duration of 1 sec located at 10 m above ground level:	54 m/sec (120 mph) from any direction.
Design air temperature extremes:	Min = -15°C (+5°F); Min = -25°C (-13°F) (For portions exposed to the nighttime sky); Max = 30°C (86°F).
Max diurnal temperature difference:	30°C (54°F) (For determining forces and deflections caused by expansion or contraction).
Seismic ground acceleration:	Zone 4 requirements given in the Uniform Building Code.
Range of annual precipitation[1]:	11.4 mm to 487 mm (0.45" to 19.2").
Design precipitation event:	25 mm (1.0") rainfall rate per hour acting concurrently with 30 m/sec (67 mph) wind from any direction.
Snow loading on projected horizontal surfaces:	170 kg/m^2 (35 psf) (Drifted snow loading must also be considered).
Additional ice loading on exposed surfaces not covered with snow (25 mm):	22 kg/m^2 (4.7 psf).
Additional ice loading on all protruding edges:	Negligible on Cerro Pachon.

[1] Information shown is from nearby CTIO, during the time period spanning from 1965 to 1992.

Section 3

TELESCOPE PIER AND PIER FOUNDATION

3.1 General Description

The telescope pier is a cylindrical structure constructed from reinforced cast-in-place concrete. The telescope pier foundation for the Mauna Kea Telescope Site consists of a reinforced cast-in-place concrete mat in the shape of a circular, faceted disk bearing directly on the supporting soils (see Figure 3-1). The geometric proportions and construction materials of the pier and mat foundation have been optimized individually for the Mauna Kea Telescope Site and the Cerro Pachon Telescope Site to provide the required performance for the support of the Gemini Telescope. Final design documentation of the telescope pier and foundation shall be based on the following requirements.

3.2 Dimensions and Details

All control dimensions and details for the telescope pier and foundation, including embedded items, openings, and blockouts, shall be incorporated and fully depicted in the final construction drawings. Figure 3-1 summarizes the overall telescope pier information for both Telescope Sites, along with details of the Mauna Kea mat foundation layout. Figure 3-4 gives the elevations of platforms interior to the telescope pier in order to locate required embed plates for beam connections and ledgers. The mat foundation will be lightweighted by providing formed voids within the interior of the structure. In order to clear the enclosure platform lift (N.I.C.) depression and the trenches in the coating chamber room, the top surface of the mat will be depressed 1400 mm (4'-7") below finished floor level.

The foundation system for the Cerro Pachon site is not currently available, pending additional soils information and further finite element analysis.

3.3 Materials

The following material specifications shall be incorporated into the design documents:

- Cast-in-place concrete used in the construction of the pier and mat foundation shall have a minimum 28-day compressive strength of 27.6 MPa (4000 psi). Necessary precautions shall be taken during construction to prevent freezing of the concrete during the initial curing period. Air entrainment admixtures shall be added to the concrete in recommended quantities to provide resistance to freeze-thaw cycles.
- Reinforcing steel shall conform to the requirements of ASTM A615 or equivalent, with a minimum yield strength of 414 MPa (60,000 psi). Reinforcing size and spacing shall be designed on the basis of the gravity and lateral loading conditions given in Figure 3-2, by coordination with the telescope azimuth track anchor bolt pattern, and by the minimum required by applicable design code.

3.4 Telescope Azimuth Track Anchor System

Details of the azimuth track anchor system (N.I.C.) are shown in Figure 3-3 to illustrate the interface required at the top of the pier. Step #1 shown in the upper left corner of this figure depicts the final configuration of the telescope pier top at the end of construction under this scope of work. The indicated size and lap length of the vertical reinforcement extending up from the top of the pier may be modified to optimize the final design. However, the final spacing of the protruding vertical reinforcement must be coordinated with AURA to avoid conflict with anchor bolt locations. The telescope azimuth track installation and the final concrete lift to complete the remaining 750 mm height of the telescope pier are N.I.C., and the work will be performed by others at the time of anchor system installation.

3.5 Soil Bearing Capacities

Actual soil bearing values shall be calculated using the load combinations given in Figure 3-2, in addition to dead loads and surcharge loads. Soil bearing values shall fall within the safe allowable bearing pressures set forth in the respective geotechnical reports for the Mauna Kea Telescope Site [1] and the Cerro Pachon Telescope Site [2]. For reference, the deepest geotechnical boring drilled on Mauna Kea, B-1, is approximately 18 m (59 ft) south of the center of the telescope pier.

3.6 Access Platforms

Figure 3-4 shows the two interior access platforms used to service the Gemini Telescope (N.I.C.) and the Telescope cable twister (N.I.C.). The only access to these telescope service platforms is by way of an access gantry suspended from underneath the telescope chamber floor (see Section 4.4.5), and a door leading through the wall of the telescope pier.

The floor loading capacity for all pier access platforms shall be as follows:

Dead load: Applicable self-weight + Telescope cabling and Telescope cable twister.
Live load: 488 kg/m^2, or a 1400 kg concentrated load acting on 4 wheels over a 0.91 m x 0.61 m area
(100 psf, or a 3100 lb concentrated load acting on 4 wheels over a 3 ft x 2 ft area).

The platforms shall have a solid top surface of checkered steel plate or equivalent to prevent objects from falling to a lower level.

3.6.1 Lower Access Platform

The lower platform serves as the main entry to the interior of the telescope pier for both personnel and telescope cabling. Access to this platform is by way of a gantry which terminates adjacent to the exterior wall of the pier. The door leading through the wall of the pier shall provide a good air seal, and the door swing shall be toward the pier exterior. The telescope cabling will pass below the door sill and will be supported by the platform on its route to the cable twister.

The platform surface will completely fill the interior of the pier, except for a 1650 mm (5'-5") diameter opening at the platform center for the cable twister and an opening for the ladder leading down to the roof of the HROS room, as shown in Section D of Figure 3-4. The upper interior platform is reached by a set of stairs originating at this level. Support for the jib crane located on at the upper access platform level may be required, as described in Section 3.6.2.

3.6.2 Upper Access Platform

The functional requirement for the upper platform is to provide access to the telescope azimuth bearing assemblies, and to provide vertical support and torsional support to the telescope cable twister. A one-meter wide continuous area must be kept unobstructed adjacent to both the inside telescope pier wall and the perimeter of the cable twister. Additionally, clearance must be maintained for the telescope hard stop assembly shown in Section B of Figure 3-4.

The lower left-hand view shown in Figure 3-4 shows the openings located through this platform. An 840 mm diameter opening at the platform center is required for passage of the cable twister. The Telescope cable twister is mounted to the platform with connections located on a 2000 mm diameter; vertical and torsional loading is currently T.B.D. for the cable twister. A removable access hatch cover and a 1500 kg (3300 lb) capacity jib crane provide vertical access for the passage of telescope bearings during telescope installation and for servicing; the support column may extend down to the lower platform level to provide required bending moment resistance.

The access stair is located 180^{o} from the platform access hatch, and its functional requirement is to provide personnel access, but with as small a floor opening as possible. To accomplish this, the stair has been arranged to have a midlevel landing to allow objects to be manually lifted between this landing and either the upper or lower platform level. In this manner, personnel can keep both hands on the handrail. To allow even a smaller floor opening size, the stair may consist of two sections of vertical ladder to either side of the landing.

3.7 HROS Room

The high-resolution, optical spectrograph (HROS) instrument package (N.I.C.) will be located within the telescope pier, as shown in Figure 3-5. The room interior does not require conditioning to maintain a constant temperature. However, the rate of temperature change within the HROS room is important. Results from a thermal analysis of this room indicate that insulation must be provided at the ceiling/roof to provide $R \geq 4.2\ ^{o}C\ m^2/W$ (for example, 102 mm (4") of cellular polyurethane/polyisocyanurate). Air conditioning duct openings through the wall of the Telescope pier to provide future capability are currently shown on Figure 3-1. Provide a design for removeable air-tight sealing of these openings to provide $R \geq 4.2\ ^{o}C\ m^2/W$. The door leading into the HROS room must be air-tight and equivalent to a cold storage entry door.

In order to achieve an interior floor surface that is flush with the enclosure lower level floor, a concrete slab-on-grade shall be placed on controlled fill.

The roof must be sealed and sloped 1:96 (1/8" per ft) toward one side to contain oil leaks from the telescope hydrostatic bearing system. The sealing system shall extend upward on the sides of the telescope pier to an elevation 152 mm (6") above the highest point of the roof, and the entire roof shall have the ability to contain a total depth of 152 mm (6") of hydrostatic oil above the lowest point of the roof. Figure 3-5 indicates four pipe sleeves located through the roof to allow the passage of cables from the telescope to instruments located in the HROS room. Removeable, insulated, air-tight caps shall be provided for each pipe sleeve.

A 2000 kg (4400 lb) capacity monorail hoist shall be provided to cover the region indicated in Figure 3-5.

3.8 Vibration Isolation

The telescope pier and telescope pier foundation must be vibrationally isolated from the rest of the structure. All utilities and air ducts that connect to the telescope pier shall have flex connections to prevent the transfer of vibration. The coating chamber, which is supported by one rail bearing directly onto the telescope mat foundation, shall have a vibrationally-isolated foundation under the other rail. The telescope mat foundation shall have a structural isolation break (SIB), consisting of a minimum 13 mm (1/2") gap filled with compressible joint filler, at the perimeter interface with the concrete slab-on-grade located under the enclosure platform lift.

Section 4

ENCLOSURE BASE DESIGN REQUIREMENTS

4.1 General

Details of the enclosure base are illustrated in Figure 4-1, Figure 4-2, and Figure 4-3. The shape is a right circular cylinder, with a portion extended beyond the cylinder to provide additional space for the Coating Chamber Room. The entire structure is stationary with respect to the carousel.

4.2 Interfaces

The following interfaces shall be considered in performance of the Work. Careful coordination of all interfaces shall be required.

4.2.1 Interface with the Carousel

The Gemini Telescope enclosure carousels will be designed, fabricated, and erected by the Enclosure Carousel Contractor (ECC).

The following information will be communicated to AURA from the ECC, and from AURA to the Contractor:

1. Carousel azimuth track (N.I.C.) and anchor bolt geometric configuration.
2. Loading conditions to the azimuth track from the bogie/stanchion system (N.I.C.), grouped according to load combinations. The bogie/stanchion loads will include 3-D vertical and horizontal reactions at each location, along with a minimum stiffness requirement for the enclosure base top ring girder to assure proper behavior of the bogie system.
3. Passive and active carousel shell air system requirements.
4. Electrical power and communications requirements for the carousel, and the required panel locations for termination of the Contractor's electrical and communications service (near the carousel slip ring system).
5. Carousel lightning protection system requirements and connection points.

As the Contractor's Construction Document preparation progresses, other carousel interface requirements, when identified, shall be brought to the attention of AURA.

As each interface requirement is fully addressed by the Contractor, this information shall be communicated to AURA in drawing and/or written form for review. AURA will then forward the information to the ECC.

4.2.2 Interface with the Platform Lift

The Gemini Telescope enclosure platform lifts will be designed, fabricated, and erected by the Enclosure Carousel Contractor (ECC).

The following information will be communicated to AURA from the ECC, and from AURA to the Contractor:

1. The finalized platform lift geometric configuration.
2. Loading conditions to the foundation system located within the enclosure base, grouped according to load combinations.
3. Perimeter sealing requirements to the stationary telescope chamber floor.
4. Active ventilation system connection to the stationary floor air plenum.
5. Electrical power requirements for the carousel, and the required panel locations for termination of the Contractor's electrical service.

As the Contractor's Construction Document preparation progresses, other platform lift interface requirements, when identified, shall be brought to the attention of AURA.

As each interface requirement is fully addressed by the Contractor, this information shall be communicated to AURA in drawing and/or written form for review. AURA will then forward the information to the ECC.

4.3 Enclosure Base Perimeter Wall Structure

The functional design requirements for the perimeter system are as follows:

- Provide a level surface from which the enclosure carousel will be erected.
- Provide structural support for all loading conditions induced by the enclosure carousel.
- Provide structural support for the stationary telescope chamber floor.
- Provide structural support for the external cladding system wind and ice loads.
- Provide thermal isolation of the enclosure base from the external environment.
- Provide a weather-tight and dust resistant exterior wall system for the enclosure base.

4.3.1 Structural Framing

Figure 4-1 shows the general arrangement of the ring girder support columns located around the perimeter of the base. The gravity, wind, seismic, and acceleration forces which act on the enclosure carousel must be transferred safely and within the allowable deflection criteria down to the concrete foundation system provided by others. Enclosure base columns must also have capacity to resist horizontal wind forces transferred to it by the exterior cladding between the telescope chamber floor and the foundation level. Two columns have been "bridged over" and removed to allow sufficient clear width for the installation access opening (see Section 4.3.2).

To limit the number and size of foundation anchor bolts required, the Contractor is urged to first analyze the column baseplates as pinned connections, and only if enclosure drift cannot be controlled, then fix baseplates.

Diagonal steel bracing shall be provided between columns, as required, to resist lateral forces caused by earthquake or wind effects, and to resist torsional forces caused by wind torque and acceleration or deceleration of the enclosure carousel azimuth motion. Coordinate the locations and connection points of steel bracing to allow clear door openings through the perimeter wall as required.

4.3.2 Installation Access Opening

The functional design requirement for this opening is to allow for the installation or removal of the primary mirror, primary mirror cell, telescope structure, telescope azimuth track, and the coating plant after enclosure erection. Routine personnel and equipment access are provided by an adjacent cargo door and personnel door.

Figure 4-1 shows the location of this opening, which is adjacent to the enclosure platform lift. The clear dimensions for this door are also indicated in Figure 4-1. Exterior wall panels and panel structural supports shall have a bolted, modular attachment system for ease of disassembly and assembly. Wall panels and structural supports shall be sized to allow removal by a forklift operating from the platform lift, which in turn will be located at different elevations as required (the platform lift will have the ability to stop at any position along its length of travel).

4.3.3 Exterior Skin/Cladding

The functional requirements of the exterior cladding are as follows:

- Provide thermal control for the enclosure base.
- Provide sound weather protection for the enclosure base.
- Provide a low maintenance exterior surface.
- Safely carry ice buildup loads through the connections back to the enclosure columns.
- Safely carry all wind pressure effects, including corner pressure effects, through the connections back to the enclosure columns.

The Contractor shall choose an economical system for the exterior wall with the approval of AURA. Consideration shall be given to minimizing the amount of on-site labor required for installation.

The wall system shall be insulated to provide R $\geq$ 3.3 ^{o}C m^2/W (for example, 80 mm (3") of cellular polyurethane/polyisocyanurate). The Coating Chamber Room may require special attachment points for its interior wall system.

Door openings, as shown in Figure 4-1, shall be incorporated into the overall cladding scheme. A set of double doors also lead through the perimeter wall at the lower and upper levels of the connecting link. A protective roof and two side walls are required for the cargo door, as pictured in Figure 4-1.

All doors shall be weather-tight and insulated.

All exterior surfaces of the enclosure base (including the roof of the Coating Chamber Room extension) shall be coated with a white titanium dioxide paint.

4.3.4 Passive Ventilation of the Enclosure Base

The functional requirement of the vents is to allow buoyancy-driven ventilation of the enclosure base during the daytime to replace the warmest air located at the top of the enclosure base. Make-up air vents 2.0 m (W) x 1.0 m (H) (6.6 ft x 3.3 ft) shall be located at four locations around the perimeter of the enclosure base at both the top and near the bottom. The vents shall have operable louvers which fully close when not in use.

4.3.5 Coating Chamber Room Extension

Figure 4-4 shows the plan size and height of this extension. The Contractor shall design a wall system and roof system that is compatible with the remainder of the facility. To protect the roof membrane from falling ice, FRP square-mesh grating (or other method approved by AURA) will be placed directly over the roof membrane from the enclosure base wall and outward for 3 m (9.8 ft).

4.4 Stationary Telescope Chamber Floor

The stationary chamber floor is supported by the enclosure base perimeter wall structure. It will essentially be a flat annular ring with its top surface equal in elevation with the telescope mount floor, and extends from the enclosure base perimeter wall to within several centimeters (as required for seismic separation) of the rotating telescope floor.

The functional requirements of this floor are as follows:

- Separate the telescope chamber thermally from the enclosure base.
- Provide the upper and lower sealed surfaces of the active air flushing plenum.
- Provide an access level from which telescope maintenance can be conducted.
- Provide a staging level from which instrumentation can be installed on the telescope.
- Allow the primary mirror and mirror cell to pass vertically into the enclosure base.
- Allow the telescope top end assemblies to pass vertically into the enclosure base.
- Allow personnel access by way of stair and elevator entrances.
- Provide seismic and vibration isolation from the rotating telescope floor.
- Provide a flooring surface that is low maintenance and durable against damage caused by heavy loaded rubber wheeled carts (2270 kg or 5000 lb capacity) and foot traffic.

4.4.1 Active Ventilation System Within the Chamber Floor

The functional design requirements for this system are as follows:

- Provide the air conveyance system for active flushing of the telescope chamber under low or zero external wind speeds.
- Create a thermal barrier between the enclosure base and the telescope chamber.
- Equalize the temperature of the telescope chamber floor to the ambient chamber temperature.

Figure 4-5 highlights this system and indicates the air path from the telescope chamber, through the chamber floor, and into the air exhaust duct. The system is comprised of the following:

- The telescope chamber floor upper surface.
- Air intake vents located within the rotating telescope floor (N.I.C.), with additional intake provided by the perimeter air gap between the stationary floor and the rotating telescope floor.
- An insulation layer located on top of the lower surface of the floor structure.
- A flexible seal connection to the telescope pier to complete the bottom surface.
- A deeper air plenum section located along the outside perimeter wall.
- Interior radial partitions to channel the air flow to the air plenum section.
- A duct connecting the plenum space to the air exhaust tunnel.

The stair opening, elevator opening, and platform lift are also part of the overall system, and more information can be found in Sections 4.4.4 and 4.5.

The interior structure of the stationary floor shall allow for radial and outer perimeter partitioning of air flow, as shown in Figure 4-5. The overall floor depth shall be kept as shallow as is practical in order to maintain sufficient air flow speed.

4.4.2 Design Loading

The telescope chamber floor shall be designed for the following loads:

Dead load: Applicable self-weight.
Live load: 295 kg/m^2, or a 2270 kg concentrated load supported on four rubber wheels located 1.2 m apart each way (60 psf , or a 5000 lb concentrated load supported on four rubber wheels located 4 ft apart each way).

Additional items which are supported below the telescope chamber floor, such as the access gantries to the telescope pier, the top end transfer crane, the loading dock crane, and the Coating Chamber Room ceiling shall have their load included with the loads indicated above.

4.4.3 Interface With the Rotating Telescope Floor

The rotating telescope floor must rotate freely without contacting the stationary chamber floor at any time. A sufficient gap must be provided between the two different structural systems to prevent collision during a seismic event. This gap also serves as a vibration isolation break.

Figure 4-6 depicts this condition and a method for closing this gap. The diameter of the rotating telescope floor is 14.6 m (47.9 ft), and the final gap size shall be the sum of the enclosure drift and telescope drift at this elevation.

4.4.4 Interface with the Stair and Elevator

The continuity of the active ventilation system within the telescope chamber floor must be preserved in the vicinity of the stair and elevator openings. For the stair opening, the last flight of stairs into the telescope chamber will be thermally insulated, as shown in the left-hand portion of Figure 4-16. A handrail system shall be provided around the floor opening.

The right-hand portion of Figure 4-16 indicates the elevator opening configuration. To allow for chamber floor continuity, a thermally insulated "lid" will cover the opening. This lid will have vents around the side perimeter to allow continuity of air flow within the stationary chamber floor. A seal system shall be provided around the perimeter. To allow a standard elevator to be specified, a dedicated mechanical system for raising the lid just prior to the arrival of the elevator shall be provided. An open steel framework will surround the elevator opening to keep the live loading on the lid to an absolute minimum, and to provide a fast thermal time constant. The Work under this Contract will include the following.

4.4.5 Telescope Pier Access Gantries

Two access gantries provide access to the telescope pier, as depicted in Figure 4-6. Both gantries are suspended from the underside of the stationary telescope chamber floor and are connected to the stair/elevator tower. The upper gantry must gain access through the chamber floor plenum. A gap sufficient to prevent collision during a seismic event with the telescope pier and either access gantry must be maintained.

The upper access gantry shall be designed for a live load of 500 kg/m^2 (100 psf). The lower access gantry shall be designed for the more critical of the loading specified for the upper gantry, or a moving load of 1400 kg (approximately 3100 lb).

The lower access gantry floor also serves as a Telescope cable raceway, as indicated in Section A-A of Figure 4-15. Space requirements for this raceway will be provided by AURA.

4.4.6 Air Exhaust Duct

The air exhaust duct connects to the side of the chamber floor air plenum and extends down to grade along the exterior wall of the enclosure, as shown in Section A-A of Figure 4-5. The duct system shall have sufficient strength to resist the survival conditions given in Section 2.2, and be durable against ultraviolet exposure and windborne dust. Its appearance shall be compatible with the remainder of the Gemini Telescope facility.

4.4.7 Telescope Chamber Daytime Air Conditioning

To achieve the Gemini Telescope science requirements, the telescope chamber must be air conditioned during the day. Section 7.6.3 describes this mechanical system in detail.

The four air conditioning units are distributed on the stationary telescope chamber floor, as shown in Figure 4-5. Their height shall not exceed the safe zone to avoid collision with the telescope (see Figure 4-17).

4.5 Enclosure Platform Lift

The functional requirements for the platform lift (N.I.C.) are as follows:

- Provide a safe conveying system for transporting the primary mirror and mirror cell between the telescope chamber and the enclosure base.
- Provide a safe conveying system for exchanging top ends on the telescope.
- Provide a method for conveying instrumentation packages into and out of the telescope chamber if too large to bring up in the enclosure personnel elevator.
- Participate in the active flushing system for the stationary telescope floor.

Figure 4-3 shows the overall configuration of the lift with respect to grade elevation and platform travel. The platform size is shown in the upper right-hand portion of Figure 4-9.

In general terms, the platform lift is supported by the stationary chamber floor at the interior edge, and by guide columns at the exterior edge. Vertical movement is provided by a system of four screw jacks loaded in tension and connected at the top to the guide columns. The interior columns extend down from the chamber floor to within a few centimeters of the finished floor. This gap below the columns prevents vibration from being transferred from the enclosure into the telescope pier foundation. This gap will be closed by a jacking mechanism when the platform lift is in use in order to transfer loads directly into the foundation.

As indicated in the lower left-hand view in Figure 4-5, the Telescope top end guide rail must be extended across the stationary chamber floor in order to temporarily locate one top end out of the way during top end exchange.

The controls (N.I.C.) for the platform lift will be located both at the telescope chamber level and at the enclosure base floor level. An intercom system (N.I.C.) between the upper and lower floor control panels will be provided by others. The wiring for the controls and intercom shall be accommodated as part of the enclosure base design.

A handrail system must be in place around the perimeter of the platform lift under all operating conditions. Interlocks shall be designed into the system to prevent platform lift movement if handrail sections are missing.

4.6 Electrical Power

Power supplied to the enclosure for both the Mauna Kea Telescope Site and the Cerro Pachon Telescope Site shall be 277/480 Volt, three phase, 60 Hz, with neutral. The enclosure base shall also have available 120/208 Volt, three phase, 60 Hz, with neutral.

Provide 120V, single phase outlets with ground fault protection at an interval not exceeding 20 m (66 ft) along the outside perimeter of the stationary telescope chamber floor.

4.7 Carousel Control Panel and Emergency Stops

The carousel control panel (N.I.C.) and carousel emergency stop controls (N.I.C.) are located as shown in Figure 4-7. The stationary chamber floor shall accommodate the cabling required for this system, which will be installed by others.

4.8 Enclosure Base Crane Systems

Two crane systems are supported from the stationary telescope chamber floor. A 9000 kg (10 ton) capacity telescope top end transfer crane shall be provided to temporarily support a top end during top end exchange (see Figure 4-12).

The second crane is located directly adjacent to the cargo door (see Figure 4-1). The required capacity is also 9000 kg (10 tons).

4.9 Coating Chamber Room

4.9.1 General Description

The coating chamber room must provide a controlled space with limited access in which primary and secondary mirrors are stripped of their coatings, washed, and recoated in an environment containing few airborne contaminants. Figure 4-4 shows the overall arrangement of the Gemini facility, and Figure 4-8 displays the detail of the coating chamber room. The following is a general description of the chain of events which take place during primary mirror recoating (also see Figure 4-9):

1. The primary mirror lifting fixture (N.I.C.) and the primary mirror cart (N.I.C.) are both stored within the coating chamber room in the mirror wash and prep area. The mirror lifting fixture is lifted clear of the mirror cart by the carousel shutter-mounted crane (N.I.C.) and lifting shaft (N.I.C.), similar to Section A in Figure 4-2. This frees the primary mirror cart to be conveyed from the coating chamber room through the large

access door to a position centered on the platform lift (N.I.C.). Air bearings and air motors are used as the conveyance device on the cart (see Figure 4-10).

2. The platform lift, containing the mirror cart, is raised up to the telescope chamber level.
3. The mirror cart is driven from the platform lift to a position directly under the telescope, which is locked in a zenith-pointing orientation. The mirror cart upper platform is raised to engage the primary mirror cell.
4. The primary mirror cell assembly is unbolted from the telescope, and the mirror, mirror cell, and cart upper platform are lowered to clear the telescope mount. The complete assembly is then driven back onto the platform lift.
5. The primary mirror, primary mirror cell, and primary mirror cart are brought down from the telescope chamber to the enclosure lower level by means of the platform lift.
6. The mirror assembly and the cart are driven back into the coating chamber room to a position directly under the crane lifting shaft (see Section A in Figure 4-8).
7. The primary mirror is lifted clear of the mirror cell, and the cart containing the mirror cell is driven back out of the coating chamber room.
8. A wash stand (N.I.C.) is positioned directly beneath the primary mirror, and the mirror is lowered to engage the wash stand. The mirror lifting assembly and the crane lifting shaft are raised out of the way.
9. After the primary mirror has been stripped and cleaned, it is lifted to allow the wash stand to be removed from under the mirror.
10. The coating chamber base (N.I.C.) is separated from the upper section and driven to a position directly under the primary mirror, and the mirror is lowered into the coating chamber base.
11. The coating chamber base and primary mirror are driven under the upper coating chamber section, the coating chamber is resealed, and recoating process is performed.
12. The coating chamber base is separated from the upper section, and the chamber base containing the recoated primary mirror is driven to a position under the lifting fixture and lifting shaft. The primary mirror is then lifted to clear the coating chamber base, the chamber base is driven back under the upper section of the coating chamber, and the chamber is resealed.
13. The mirror cell, conveyed by the mirror cart, is brought into a position under the primary mirror. The primary mirror is then lowered into the mirror cell.
14. The complete mirror assembly and cart are taken out of the room through the large access door to a position centered on the platform lift. The mirror assembly and cart are raised into the telescope chamber for the installation process.
15. After final use, the primary mirror cell cart is brought back down into the enclosure base and driven into the coating chamber room through the large access door to its stored position over the mirror wash area. The mirror lifting fixture is lowered onto the cart, and the lifting shaft is withdrawn.

4.9.2 Internal Environment

The location of the coating chamber room, shown in Figure 4-4, effectively isolates it from the remainder of the Gemini facility, which allows the coating chamber room to be completely closed off when not in use.

Mirror recoating will only be performed when the telescope is not in service. During the occupancy period, the interior temperature and humidity shall be controlled, as described in Section 7.15. Otherwise, no temperature and humidity control will be provided, and the room temperature shall normalize to the ambient surrounding conditions.

Particulate contamination will be controlled within the room by the following. The walls, including the telescope pier, and the ceiling shall have an interior surface which allows for the complete wash-down of the interior space prior to the coating operation. After the room has been cleaned and prepped, "sticky mats" shall be provided on the exterior side of personnel door entrances to trap potential tracked-in particulates. All personnel entering the room after the room prep phase until after the completion of the coating process will be required to gown up within the room in clean chemical suits and booties over street shoes during mirror stripping, or clean room suits and booties at a minimum when chemicals are not being used.

Fan forced ventilation, positive air pressure requirements, and air filtering for the Coating Chamber Room are described within Section 7.14.

4.9.3 Ceiling Height, Electrical Outlets and Lighting Requirements

A clear height of 8 m (26.2 ft) shall be provided throughout the coating chamber room from the finished floor elevation to the ceiling. This height allows the complete coating chamber to be moved into or out of the room. The ceiling is hung from the stationary telescope chamber floor, which is located approximately 3 meters above the ceiling. The ceiling support structure must have the ability to cantilever under the rotating telescope floor. A flexible air seal shall be provided at the telescope pier/ceiling interface.

Fused power outlets with ground fault protection shall be provided for 120V T.B.D. amp service at T.B.D. locations. In the enclosure base extension, provide electrical outlet strips along and above work benches.

Lighting intensity shall be appropriate for workshop use anywhere within the room.

4.9.4 Internal Access

Figure 4-8 indicates the required door access through the interior walls. Access throughout the space shall be provided, and a minimum walkway clearance of 1 m (3.3 ft) shall be maintained on at least one side of the coating chamber. All access doors into the coating chamber room shall be keypad locked to prevent unauthorized entrance.

4.9.4.1 Primary Mirror Access Door

The functional requirements for this door are as follows:

- Provide safe passage of the primary mirror cell cart into and out of its stored position over the mirror wash area.

- Provide safe passage of the combined assembly of the primary mirror, primary mirror cell and cart into and out of the coating chamber room.
- Provide and maintain a good air seal to limit dust infiltration when closed.
- Provide reliable and low maintenance operation over the lifetime of the facility.

The required door size is 6 m high x 10 m wide (19'-8" x 32'-10"). These controlling dimensions result from the combined height and width of the primary mirror, mirror cell, and mirror cart. The coating chamber also must be transported either into or out of the room, and a height taller than 6 meters may be required. The final door size shall be confirmed with the final dimensions of these components.

Three different door systems are under consideration:

- A vertically-stacking panel door.
- A roll-up door.
- A moveable partition which can be stacked adjacent to the telescope pier.

The Contractor shall base the final selection on both cost and performance. The selected door system shall be a premanufactured unit produced by a company with at least five years experience with similar installations.

Two control panels shall be provided for actuating this door: one within the coating chamber room and one just outside the coating chamber room. Controls shall be located such that an unobstructed view of objects located near the door threshold is provided. Controls shall be set up such that motion can be stopped at any position and can be reversed from any stopped position.

4.9.4.2 Other Access Doors

An integral personnel access door of 1 m width x 2 m height (3-4" x 6'-8") shall be provided in the lowest door panel of the primary mirror access door, or adjacent to the access door. In the other dividing wall, provide a roll-up door opening of 3 m width x 2.3 m height (9'-10" x 7'-6"), and a personnel access door of 1 m width x 2 m height (3-4" x 6'-8"). Doors shall contain dust seals to limit dust infiltration.

4.9.5 Mirror Wash and Prep Area

The functional requirements for this zone are as follows:

- Provide an area for lifting the primary mirror out of the mirror cell, and replacing the primary mirror on a wash stand (N.I.C.).
- Provide an area in which the old primary mirror coating is chemically stripped off, and all residue is removed.
- Provide a collection system for neutralization and disposal of the used mirror wash chemicals.
- Provide a storage area for the primary mirror cell cart and mirror lifting fixture when not in use.

Detailed information on each component is given in the following discussion.

4.9.5.1 Lifting Shaft Interface

The lifting shaft provides the link to enable the carousel shutter crane (N.I.C.) to provide primary mirror lifting capability within the Coating Chamber Room (see Figure 4-8). The loading capacity of this lift will be 40,000 kg (44 tons).

The ceiling within the coating chamber room and the stationary floor above shall contain a sleeve to allow passage of the lift shaft. The center of the lifting shaft is located on a radius 12030 mm (39'-5 5/8") from the pier and enclosure center, and 60.00° counterclockwise from the centerline passing through the platform lift. The lifting shaft shall be designed to not protrude above the surface of the telescope chamber floor when not in use, and still allow the primary mirror cart and mirror lifting assembly to be stored directly underneath within the Coating Chamber Room.

Operation of the carousel shutter crane will be by means of wall mounted controls (N.I.C.) located to give an unobstructed site line to the area of primary mirror lifting.

4.9.5.2 Mirror Stripping and Washing Area

Figure 4-11 depicts a section through the mirror stripping and washing area. The floor slab has been thickened to act as a mat foundation to distribute loading from the coating chamber wheel track, and the fully loaded primary mirror cart load distributed to four air bearings.

A trench system shall be located as shown in Figure 4-11, with a trench cover consisting of FRP square mesh bar grate. The grating provides a non-slip surface from which personnel can work while stripping and washing the primary mirror. The trench interior shall be epoxy-coated and sloped internally to drain toward the platform lift depression where it is collected in a piping system for conveyance to the collection and treatment tank. In this manner, underground piping is kept to an absolute minimum, and trench surfaces can be easily inspected and repaired. During the coating process, the anticipated amount of collected fluid is T.B.D. liters (T.B.D. gal).

The coating chamber rails shall have removeable covers to provide protection, when in place, from mirror washings. Any liquid that does enter the rail depression must be conveyed into the trench at the location where both intersect. The chamber rail system and all floor surfaces that are subject to chemical exposure shall be painted with an epoxy-based coating to prevent corrosion.

The coating chamber rails also serve as the guiderail system for the primary mirror cart. The forces acting on the guiderail are T.B.D..

The following types and quantities (quantities T.B.D.) of mirror stripping chemicals must be provided for use in the area: nitric acid, sulfuric acid, hydrofluoric acid, phosphoric acid, hydrochloric acid, and potassium hydroxide. All chemicals shall be stored in approved cabinets. Provide a minimum of one eye wash stand and one safety shower adjacent to the chemical storage cabinets and mirror wash area, or as required by OSHA requirements. Potable water and distilled water shall be conveniently available in the mirror wash area. At least 4 wash basins with countertop space shall be located along the exterior perimeter wall.

4.9.6 Coating Chamber

Figure 4-8 shows the coating chamber and adjacent support area, along with coating chamber dimensions. An area of the enclosure base perimeter wall has been relocated outward to provide more space for the coating chamber room. This area has been reserved for the coating chamber electrical panels, coating chamber controls, and miscellaneous coating chamber support.

The coating chamber has been positioned such that the vacuum pumps are located away from the wash area. Four screw jack mechanisms (N.I.C.) raise the upper portion of the chamber, which frees the motorized bottom portion to be driven within the confines of the coating chamber room. The inner rail is supported on a foundation wall which bears on the telescope mat foundation. The outer rail shall be supported by a vibrationally-isolated foundation system. The total weight of the coating chamber is 54,000 kg (59.5 tons), of which the upper portion weighs 28,000 kg (30.9 tons). Adequate foundation support shall be provided for the concentrated loads caused by the upper chamber screw jack mechanisms. Allowance shall be made in the design for the jack support to be misaligned by 0.30 m (1.0 ft) in any direction from the permanent centerpoint location.

The rail system leading from the permanent position of the coating chamber to a position adjacent to the primary mirror access door shall be capable of carrying the moving combined load of the upper and lower sections of the coating chamber, or the weight of the primary mirror and the lower section of the coating chamber.

A 2000 kg (4400 lb) capacity monorail crane shall be provided directly above the vacuum pumps, as shown in Figure 4-8. Sufficient space is necessary to the side of the coating chamber to allow the crane to place the removed pump onto a conveying cart (N.I.C.) for transport out of the room.

Electrical requirements for the coating chamber is approximately 200 KVA, which is based on the operation of 1 magnetron, 4 diff pumps, 2 routes blowers and 2/4 roughing pumps. This requirement must be verified with the development of the coating chamber design. Refer to Section 7.6.2 for detailed information on the coating chamber mechanical system requirements.

4.10 Top End Storage and Maintenance

Two telescope top end assemblies (N.I.C.) will be stored and maintained within the enclosure base when not in use on the telescope, as shown in Figure 4-12. The top ends are conveyed between their parked position and the platform lift on a path that just clears the outside wall of the enclosure base. The following is a description of the process of exchanging telescope top ends (refer also to the description contained on Figure 4-12).

1. The top end not taking part in the exchange is positioned directly under the top end monorail crane. The crane lifts the top end clear of the cart and transports the top end radially toward the telescope pier until it is out of the way of the second top end.
2. Both the emptied cart and the remaining top end on its cart are transported individually into the telescope chamber by the platform lift.
3. With the telescope locked in horizon-pointing, the emptied cart is positioned in front of the telescope. The top end presently on the telescope is transferred to the cart. The assembly is then moved out of the way.
4. The second top end on its cart is positioned in front of the telescope. This top end is transferred to the telescope, and the telescope is positioned out of the way of the platform lift.
5. The empty cart is taken down into the enclosure base by the platform lift. The empty cart is positioned directly under the top end monorail. The crane transports its top end radially back toward the outside wall to a position directly above the empty cart. The top end is then transferred to the cart, and the cart is moved to its parked position.
6. The telescope top end on its cart remaining in the telescope chamber is then brought down into the enclosure base by the platform lift. The top end and cart are then driven to a position adjacent to the other top end, as indicated in Figure 4-12.

Air bearings and air motors (N.I.C.) provide mobility to the top end carts. A guide rail shall be provided under the center of cart rotation, as shown in Figure 4-12. Because of the narrow cart base, the guide rail will also provide uplift capacity in the event of an earthquake. The guide rail must interface with the rail section located within the platform lift (N.I.C.). Details of the top end cart as shown in Figure 4-13, and both the Telescope top end and the storage cart will be designed and fabricated by others.

The design parameters for this rail system are as follows:

- Cart wheelbase size: T.B.D.
- Air bearing locations, surface area, and operating pressure: T.B.D.
- Maximum vertical force per air bearing without seismic effects: T.B.D.
- Maximum vertical force per air bearing with seismic effects: T.B.D.
- Maximum uplift guide rail load with seismic effects: T.B.D.
- Maximum horizontal thrust on guide rail caused by seismic load: T.B.D.

The guide rail system shall be supported by an independent foundation. When not in use, a steel checkered plate shall be provided over the rail to keep out debris. The top surface of the rail shall be set such that the checkered plate is flush with the finished floor elevation.

4.11 Enclosure Stair and Elevator

The enclosure stair and elevator provide vertical access between the enclosure and support facility lower level, the support facility upper level, the two telescope pier access gantry levels, and the telescope chamber floor. Figures 4-14 and 4-15 illustrate the configuration of both the enclosure stair and elevator.

4.11.1 Enclosure Stair

The stair shall consist typically of steel bar grate treads and landings, and shall be supported by a non-enclosed steel frame system. The enclosure stair and handrail system shall be designed per the loading and configuration requirements given in the applicable building codes. Unless code requirements dictate otherwise, the minimum stair width shall be at least 1 meter (40").

In order to thermally separate the telescope chamber from the enclosure base, the last stair landing into the telescope chamber shall be fully enclosed and thermally insulated (see Figure 4-16). A thermally insulated door provides access into what is now an extension of the telescope chamber.

4.11.2 Enclosure Elevator

Figure 4-14 shows the vertical layout for the elevator. The elevator shall conform to the following requirements:

Elevator type:	Standard hydraulic passenger/freight.
Cab size:	1.63m x 2.4m (5'-4" x 7'-11").
Cab load capacity:	2040 kg (4500 lb).
Total travel:	13.50m (44'-3 1/2").
Travel rate:	38m per minute (125 ft/min).
Entrance type:	Satin finish stainless steel.

Elevator doors between facility levels are all in-line, and the two access gantry level elevator doors are located in-line on the opposite side.

If allowable by code, the elevator shaft shall be steel framed, but left unenclosed to prevent "pumping" of air between the enclosure base and the telescope chamber. Provide horizontal support for cab rails at intervals and for lateral loads specified by an elevator manufacturer with experience producing this type of elevator. Cab rail lateral loads will be different on Mauna Kea, Hawaii and Cerro Pachon, Chile. The elevator shaft will be connected laterally to the stationary telescope chamber floor to provide proper rail alignment. Refer to Section 4.4.4 for information on the thermal isolation system that exists at the stationary chamber floor.

The heat producing components (pumps, motors, relays, etc) of the elevator will be located remotely within the mechanical plant room.

4.12 Heating, Cooling, and Ventilation Inside the Enclosure Base

No heating or cooling shall be required within the enclosure base outside of the requirements for the coating chamber room. However, a ventilation system consisting of operable openings within the top and bottom of the enclosure base walls will provide buoyancy-driven daytime ventilation. Refer to Section 4.3.4 for more information.

4.13 Power Outlets and Lighting

Fused power outlets with ground fault protection shall be provided for 120V, single phase outlets with ground fault protection at an interval not exceeding 20 m (66 ft) outside of the coating chamber room.

A lighting level of T.B.D. shall be provided within the enclosure base outside of the coating chamber room.

4.14 Lightning Protection of the Enclosure

The Enclosure Carousel Contractor will provide the lightning protection system for the carousel to a location just below the rotating interface. It will be the Contractor's responsibility to incorporate the continuation of this lightning protection system, provided by others, with that of the remainder of the enclosure base. The final ground at the base of the enclosure shall be connected to the facility grounding mat.

4.15 Floor Slab-On-Grade

The finished floor elevation of the entire enclosure base is 13,758 ft on Mauna Kea. This matches the elevation of the lower level of the support facility, and also the outside grade of the parking area to the north. These elevations allow the transport of telescope instruments and equipment through the cargo door and into any region of the enclosure base or lower level of the support facility without changing elevations.

4.15.1 General Regions of the Base

The floor slab directly under and in the vicinity of the cargo door monorail shall be designed to support the moving wheel loads from a loaded flat bed truck. Areas of the floor slab outside this region shall be designed to support the moving wheel loads from a fully-loaded pneumatic tire fork lift with a 4540 kg (5 ton) capacity. The exterior threshold edge of the enclosure cargo door and the removeable panel access region shall both be protected with a full-length, galvanized, embedded steel angle.

4.15.2 Floor Region Supporting Air Bearing Systems

The floor slab surface in areas over which the air bearings of the primary mirror cart and the top end carts traverse shall be specified to conform to the stricter of the following requirements applicable to the air bearing system, or the minimum building code requirements. The local planarity and overall planarity requirements are based on air bearing sizes of 36" to 60" for the primary mirror cart, and 21" to 27" for the top end carts. The air bearing size shall be reconfirmed through AURA prior to completion of construction documents.

- Local planarity requirements for the finished top concrete surface:
  Primary mirror cart: +/- 1/4" in 10 ft, as determined by a 10 ft straight edge;
  Top end carts: +/- 3/16" " " " " .
- Overall planarity requirements for the finished top concrete surface:
  Primary mirror cart: +/- 1/4" from a true plane;
  Top end carts: +/- 3/16" " " .
- 0.1% maximum slope in the finished concrete surface.
- Cracks of size T.B.D. or larger shall be cleaned of all loose materials with an oil-free high-pressure air jet. Epoxy fill the cracks smooth and flush with the adjoining surface.
- Steps shall be blended by grinding to a slope angle of 1:20 or shallower.
- Projections shall be blended by grinding to a slope angle of 1:20 or shallower.
- Construction joints shall be keyed to prevent vertical shift of the adjacent surfaces. Clean the joint with oil-free high-pressure air jet or groove with 1/8" masonry saw and fill with backer rod per ACI 301-72. Fill joint smooth and flush with adjoining surfaces using sealistic fill.

The top concrete surface shall be a smooth, steel trowelled finish free of trowel marks, ridges, or voids. Either a commercial concrete sealant or a commercial, solventless, epoxy-based coating shall be applied to the concrete surface to close surface porosity and fill surface "valleys." A list of approved sealants and coatings will be supplied to the Contractor by AURA during the course of construction specification preparation.

4.15.3 Frost Heave

On Mauna Kea, the potential for frost heave of the slab-on-grade adjacent to the exterior wall will be low [1]. However, its potential occurrence must be addressed by means of foundation wall insulation or other approved method.

Section 5

ENCLOSURE FOUNDATION SYSTEM

The design requirement for the foundation system shall be to distribute the combined gravity and lateral loads into the surrounding soils within the safe allowable bearing pressures set forth in the respective geotechnical reports for the Mauna Kea Telescope Site [1] and the Cerro Pachon Telescope Site [2]. Loads transferred to the foundation include the enclosure carousel loads, the enclosure base loads, the primary mirror transport loads, and the telescope top end transfer load.

The foundation system for both sites consists of a continuous, cast-in-place concrete foundation and foundation wall consisting of a ring approximated by a 24-sided polygon, with enclosure base column centerlines intersecting the midpoint of each straight foundation segment. The footing elevation shall be stepped, as required, to maintain adequate depth below lowest adjacent grade. The cast-in-place foundation wall shall be used to distribute the concentrated column loads into an effective uniform load on the foundation. The foundation wall also serves as a retaining wall across the east portion of the Mauna Kea facility.

The design of the enclosure foundation system will be based on the combined loading of the carousel and the enclosure base. The Enclosure Carousel Contractor shall supply the loading combination results for the carousel.

Section 6

SUPPORT FACILITY BUILDING

6.1 General Requirements

The functional design requirements for the support facility are as follows:

- Provide a facility with as low a profile as practical to limit air flow boundary layer lifting;.
- Provide an area where heated or heat producing functions are thermally separated from the enclosure.
- Provide sufficient comfort-enhanced floor space to allow on-site personnel to service the telescope facility.
- Optimize the organization of the various functions to minimize the required floor area.
- Provide the computer control room with close proximity to the enclosure stair and elevator.
- Provide a protected space for instrumentation work.
- Provide a mechanical equipment facility with as much separation from the telescope as is practical to limit vibration transfer to the telescope pier.
- Provide the necessary structural capacity, and mechanical and electrical expansion capability to allow for future expansion of the upper level across the entire support facility lower level.
- For the Mauna Kea site, provide the necessary structural capacity, and mechanical and electrical expansion capability to allow for future expansion to the south of the support facility, excluding the southwest corner at the mountain power entrance.

6.1.1 Mauna Kea Telescope Site

The Mauna Kea Gemini site is located on the summit ridge between the UH 88-inch facility and the CFHT facility. Figure 6-1 shows the Mauna Kea site and indicates the local topography and the sublease boundary. Figure 6-2 shows the detail of the complete Mauna Kea Gemini facility.

6.1.2 Cerro Pachon Telescope Site

The Cerro Pachon Gemini site is located approximately 70 straight-line kilometers east of the Chilean coastal town of La Serena, and approximately 10 straight-line kilometers southeast of the Cerro Tololo Inter-American Observatory (CTIO). Figure 6-3 illustrates the topography surrounding the Gemini site, and Figure 6-4 provides additional detail specific to the Gemini site. Figure 6-5 shows the detail of the complete Cerro Pachon Gemini facility.

6.1.3 Information and Drawings Common to Both Facilities

Figures 6-6 through 6-12 show detailed plan views, elevations, and sections through the support facility. The depiction shown is typically that for the Mauna Kea facility. However, the Cerro Pachon facility will be very similar to that of the Mauna Kea facility, so the figures are generally applicable to both sites.

The sections which follow describe in detail the various functions contained within the support facility and their respective design requirements. Specific detail on the support facility thermal control system can be found in Section 7.

6.2 Facility Design Requirements

6.2.1 Civil Design

Figure 6-1 shows the finished grade elevations on the Mauna Kea site, locations of retaining walls, location of the support facility with respect to the center of the telescope pier, locations of the air exhaust duct, water storage tank, septic tank and seepage bed, and mirror wash treatment tank. On Mauna Kea, the support facility will be oriented parallel to the summit ridge and centered on a radial line passing through the center of the telescope pier. Important cost drivers in this work will be the following:

- The sequence of construction necessary to keep the summit ridge access road open to the CFHT facility with minimal interruptions, and
- The amount of excavated material removed from the site, both temporarily for backfill on the roadbed and around foundation walls, and permanently as excess material.

The CFHT access road must be kept open during construction activities. Figure 6-13 illustrates the three stages of construction necessary to relocate the access road while keeping the existing CFHT access road open. The fourth stage prior to actual facility construction will be the relocation of the existing electrical and communications lines (N.I.C.).

The progression of Mauna Kea site earthwork will ultimately affect the amount of excavated material temporarily stockpiled at the concrete batching plant located at the 13,250 ft elevation in Submillimeter Valley on Mauna Kea. Construction of the eastern portion of the Gemini facility must be conducted in a manner to keep the CFHT access road open, while minimizing the amount of temporarily stockpiled, excavated material.

The retaining wall system and guardrail along the relocated road and the loading/parking shall consist of concrete walls utilizing the most economical construction method. Three systems under consideration are as follows:

1. Precast concrete crib-lock wall system, similar to the existing retaining wall system located near the Keck facility on Mauna Kea.
2. Reinforced earth retaining wall.

3. Precast or cast-in-place concrete cantilever retaining wall.

The exterior color and texture of these walls shall be compatible with the surrounding cinder material.

The existing 24-inch telescope enclosure must be removed from the site. The scope of Work under this contract will be as follows:

1. Demo the existing enclosure and remove to an approved disposal site in Hilo.
2. Demo the existing telescope pier, telescope pier foundation, and enclosure foundation and remove to an approved disposal site in Hilo.

A septic tank and seepage bed to handle 200 gallons of wastewater per day shall be provided in the southwest corner of the site per Figure 6-1. A 5000 gallon potable water tank shall also be provided in the southwest site corner.

To the northwest of the enclosure, a mirror wash holding tank of T.B.D. gallons shall be provided to neutralize washings before disposal to the auxilliary seepage bed (see Figure 6-1).

6.2.2 Architectural Design

6.2.2.1 Control Dimensions

Layouts of the Gemini support facility have been developed based on input received from the Gemini group managers, personnel from NOAO, personnel from CTIO, and others. Thus, room sizes have essentially been set. Approximate plan dimensions within the facility are shown in Figures 6-6, 6-7, and 6-9.

The clear height within the lower facility level has been set by the requirement for a minimum of 3.66 m (12’ - 0") within the Instrument Prep and Storage Room.

6.2.2.2 Circulation and Fire Ratings

Figure 6-2 shows the main circulation between the enclosure and the support facility through the connecting link. At the lower level, the main path is through the Instrument Assembly/Disassembly and Prep Room to any desired room, or to a stair which leads to the upper support facility level.

The upper level circulation is from the outside at the parking area, into a vestibule, and then into either the Telescope Operations Room, Crew Room, or Restroom. The vestibule also provides access to the stair leading down to the lower support facility level.and a corridor passes through the connecting link into the stair and elevator in the enclosure base.

The functions on the upper support facility level have been arranged to allow easy expansion into the future area located over the Mechanical Plant Room.

Fire ratings in corridors, around the emergency generator, within the electrical room, and within the mechanical plant room shall conform to code.

6.2.2.3 Roof System

The roof shall be slope sufficiently to allow positive drainage, but no less than 1:96 (1/8" per ft).

There exists the potential for ice to fall off the enclosure carousel and cause damage to the roof of the support facility and the connecting link. Provide a means of removeable protection with a fast thermal time constant, such as FRP square-mesh grating or other method approved by AURA, which is placed over the roof membrane to provide protection for a minimum distance of 3 m (9.8 ft) from the enclosure, and allows easy access to the roof membrane for repair or replacement.

6.2.3 Structural Design

6.2.3.1 Foundations

The foundation walls on the south and east sides of the support facility on Mauna Kea act as retaining walls. In order to keep the CFHT access road open by limiting the eastward encroachment of the foundation Work, a foundation system, such as cast-in-place slurry piles, shall be investigated. If it can be demonstrated that a cantilevered, cast-in-place retaining wall system is more economical and still allows the CFHT access road to remain open, then this will be the system of choice.

The west and north foundations and interior column foundations will be shallow continuous footings and spread footings, respectively.

6.2.3.2 Vibration Control

Vibration control shall be provided for the mechanical plant room floor. The floor slab shall be thickened and isolated around its perimeter from the surrounding foundation walls, column closures, and slab-on-grade. Housekeeping pads, if required, will be built over the top of this slab.

6.2.3.3 Upper Level Floor Loading and Depressed Floor

The upper level floor loading shall be based on the following loading throughout:
- Dead Load: Applicable self weight
- Live Load: 488 kg/m2 (100 psf)

The floor area within the telescope operations room and the computer room will consist of a raised access floor system. To maintain a level floor system, depress the structural floor in this area by 0.30 m (1’ - 0").

6.2.3.4 Structural Systems

The framing system shall consist of steel wide flange shapes for floor and roof members, and steel wide flange shapes or steel tubes for columns. The floor shall consist of normal weight concrete over steel deck. The lateral force resisting system shall be comprised of moment frames to give full flexibility for space utilization in future expansions.

6.2.3.5 Future Expansion

The roof structure, columns, and foundations in the area of the mechanical plant room shall be designed to accommodate a future floor and new roof loading. Also, potential two-story growth to the south over the present parking area shall be provided for.

6.2.4 Mechanical Systems

6.2.4.1 General

The HVAC and thermal systems located in the plant room must handle the combined requirements of the Telescope, the enclosure and the support facility building. Refer to Section 7 for detailed information on these systems.

6.2.4.2 Compressed Air

Compressed air is required for the following:

- The primary mirror support system.
- The primary mirror active force actuators.
- The air carts used to transport the primary mirror cell and the secondary support structure.
- The "shop air" system (hand tools, etc.).

The primary mirror support system requires a flow rate of 10 s.c.f.m. (4.7 litres/sec) at a supply pressure that shall not exceed 0.5 p.s.i.g.(3.5 kPa) for a time period of thirty minutes. Once the primary mirror support plenum (N.I.C.) is filled, compressed air must be supplied to the plenum at a T.B.D. (estimated to not exceed 1 s.c.f.m.) rate to replace air leaking from the plenum. The air supplied to the plenum must be very clean and extremely dry. Exact water content and filter specifications for the air supplied to this system are T.B.D.

The primary mirror active force actuators require air at a pressure that will not exceed 50 p.s.i.g. (344.5 kPa) and a flow rate that is negligible. The air supplied to the force actuators must be very clean and extremely dry. Exact water content and filter specifications for the air supplied to this system are T.B.D.

Operation of the primary mirror air cart requires a volumetric flow rate of 350 standard cubic feet per minute (165 litres/sec) at a pressure of 50 p.s.i.g. (344 kPa). The filtering requirements and the maximum water content specification for this air are T.B.D.

The shop air requirements will not exceed 10 s.c.f.m. (4.7 litres/sec) at minimum at maximum supply pressures of 80 and 110 p.s.i.g. (550 and 756 kPa). The filter requirements and water content specifications for this system shall be taken as the values typically used for air tools.

The Contractor shall assess the above requirements and design a compressed air supply and distribution system which includes, at the supply end of the system(s): the compressor(s), storage plenum(s), regulator(s), air dryers or dehumidifiers, and air filters. The distribution portions of the system(s) shall include rigid air lines (the Contractor shall size the rigid conduits; flexible air lines are N.I.C.), and water traps. The compressor(s), air dryers and filters shall be located in the mechanical plant room. Figure 6-14 shows which rooms and locations require low capacity lines, as well as the locations of high capacity (air cart) lines and taps.

6.2.4.3 Plumbing

Plumbing systems shall be designed for the following:

- potable water system.
- septic system.
- mirror wash collection system.
- Trench drain system.
- Deicing system for the heat exchangers.
- Propane fuel system.

Plumbing located throughout the facility shall run above grade as much as is practical.

Curbs and door trench drains will be required to contain leaks in areas containing large quantities of liquids.

6.2.4.4 Interlocks

Interlock devices shall be utilized to safeguard the lives of personnel and protect support facility equipment. Interlock devices will be required at several locations in the support facility and the enclosure base structure to prevent personnel from entering areas having high air velocities.

All interlock devices shall be of mechanical design only; devices which rely on electric power will not be accepted.

(a) Exhaust Tunnel Access Door Interlock System

Personnel must not enter the air exhaust tunnel while the high capacity exhaust fans and fan backdraft dampers are operating. The air exhaust tunnel access door is located in the east wall of the plant room, and is shown on Figure 6-8.

The Contractor shall consult the National Electrical Code for requirements concerning the placement of fan disconnect switches, and design an interlock system to prevent access into the exhaust tunnel while the fans are operating.

(b) Upper Gantry Pier Access Door Interlock System

Personnel must not enter the door leading to the access gantry surrounding the top of the Telescope pier while the high capacity fans are in operation.

The Contractor shall design an interlock system to prevent access through this pier access door while the exhaust tunnel fans are operating.

6.2.5 Electrical Design

6.2.5.1 Mountain Power Site Service Entrance

Figure 6-16 indicates the relocation of utilities, which will be performed by others. A 750 KVA transformer (N.I.C) will be located at the south end of the site, and 4-4" ES stub-outs will mark the termination of the power relocation work. The service voltage entering the facility will be 480V, 3 phase.

6.2.5.2 Power Distribution

The 480V, 3 phase power will be used for the enclosure carousel drives and lights, and the demand is approximately 170 KVA (to be confirmed as detailed carousel design progresses). The termination point for carousel power will be near the location of the carousel slip ring assemblies. Other large motor loads, such as the platform lift (N.I.C.) and the enclosure elevator, will also use the 480V service.

A step-down transformer will be located in the mechanical plant room to provide 120V/208V power for distribution within the facility.

6.2.5.3 Motor Generator Power

The motor generator system is located within the mechanical plant room, and will provide clean power for the telescope drives, instrument rotator servos, and observatory time system. Approximate demand will be 50 KVA.

6.2.5.4 UPS Power System

The Uninterruptible Power Supply (UPS) system is located within the mechanical plant room, and consists of two 15 KVA units providing 120 VAC power. The UPS system will provide 10 minutes of continuous power in the event of mountain power interruption.

6.2.5.5 Emergency Generator

The emergency generator is located in a small room adjacent to the link to the enclosure (see Figure 6-2). Its capacity will be 100 KVA, and it will be powered by propane.

6.2.5.6 Telephone and Fiber Optics

Sufficient empty conduits shall be made available for the installation of this work by others. Figure 6-16 illustrates the enclosure/ support facility communications plan.

6.2.5.7 Fire Protection System

A smoke detector system shall be installed throughout the support facility. In the computer room, smoke detectors shall be located in both the ceiling and under the raised floor, and an approved substitution for a halon system shall be used for fire suppression.

6.2.5.8 Raceway System

Raceways are required to convey signal, control, and communications lines between various locations in both stories of the support facility and enclosure. The support facility raceway systems shall connect to the enclosure raceway systems within the enclosed connecting link, which forms the physical interface between the support facility and the enclosure. The raceway locations in the connecting links are shown on Figure 6-2, at the locations labeled "cable way." Raceways in the Telescope chamber are N.I.C., and therefore the upper level support facility raceways must terminate at the connecting link.

A raceway system in the lower floor level of the support facility shall conveys lines between the array/electronics clean lab, the optomechanics clean lab, the instrument room, and the plant room. This raceway system shall connect into the enclosure lower floor raceway system at the lower floor cable way.

Signal, control, and communications lines in the raised floors of the Computer Room and Telescope Operations Room in the upper level of the support facility shall be conveyed to other locations through the upper level cable way. The upper level cable way shall connect to the lower level cable way though riser cable ways located on both sides of the support facility/enclosure base structure interface.

A raceway system shall be provided in the lower level of the enclosure to convey lines between the plant room and aluminizing room. This raceway system shall terminate at the lower level cable way.

The raceways may be of the open ("wire ladder") or enclosed ("screw can") type with removeable covers. Raceways sizes are T.B.D., pending the completion of an AURA database being assembled to quantify the total number of signal, control, and communications lines (including telephone lines) that are required between the various locations in the support facility and enclosure.

The Contractor shall provide plan and elevation view layouts of the raceway system within both stories of the support facility and the lower level of the enclosure.

6.3 Connecting Link to the Enclosure

The support facility building is physically separated from the enclosure by a minimum distance of 2 m (6.6 ft). The enclosed connecting link allows personnel, instrumentation, and equipment access between the enclosure and support facility (see Figures 6-2 and 6-6). A seismic gap of T.B.D. mm (T.B.D. inches) must be maintained between the link and the enclosure to avoid interaction of the two structures.

The connecting link also provides utility access into the enclosure, as shown in Figure 6-2. Utilities that service the Telescope continue up along the inside wall of the enclosure, across to the lower access gantry, and then toward the telescope pier (see Figure 4-14).

6.4 Lower Facility Level

The lower support facility finished floor level has been set to 13,758 ft to match the finished floor level of the enclosure. Figure 6-7 indicates the layout and dimensions for this level.

6.5 Upper Facility Level

The upper support facility finished floor level has currently been set to 13, 773 ft. This value was based on the 12 ft clear height requirement in the Instrument Assembly/Disassembly and Prep Room, 1 ft depression for the raised computer floor in the Telescope Operations and Computer Room, and an allowance of 2 ft depth for the structure, HVAC, and electrical systems for the second level floor between these areas. The upper level finished floor level may be adjusted, depending on the depth requirements for the second level floor.

Figure 6-9 illustrates the layout and dimensions for this level.

Section 7

SUPPORT FACILITY THERMAL CONTROL SYSTEM

7.1 Definition of the Support Facility Thermal Control System

The support facility thermal control system is defined as the system which:

- Provides for the daytime air conditioning of the enclosure;
- Provides conditioned air for certain rooms within the support facility;
- Provides nighttime forced air flow rates through the shell air space, chamber, and floor of the enclosure;
- Removes heat from the vacuum chamber pumps for the aluminizing operation;
- Removes heat from electronics and instrumentation packages located in the enclosure chamber;
- Removes heat from the primary mirror and active optics assemblies located in the primary mirror support cell;
- Removes heat from the hydrostatic bearing oil supplied to the telescope altitude and azimuth bearings;
- Removes heat from helium coolers located in the support facility plant room;
- Removes heat from a laser scanning system used to periodically clean the reflective coating of the primary mirror surface.

All of the heat produced by the equipment in the support facility thermal control system is rejected away from the telescope through the support facility air exhaust tunnel.

7.2 Support Facility Thermal Control System Work Requirements

Work requirements to be performed by the Contractor are listed throughout the following sections composing this portion of the D.R.D. The work requirements are again listed in Deliverables (Section 7.22).

The work requirements summarized in Section 7.22 consist primarily of load calculations, hardware specifications, performance data, and layouts to enable AURA to select between two design options for the chiller units which form the principal part of the support facility thermal control system.

7.3 Environmental Data for Design of the Support Facility Thermal Control System

A common support facility thermal control system is to be used at both of the Gemini sites. Since Mauna Kea has a higher altitude and a greater diurnal temperature swing than Cerro Pachon, a support facility thermal control system based on Mauna Kea environmental conditions will result in a system with slightly oversized load capacity for the Cerro Pachon site.

Environmental data from the Mauna Kea site will be used to design the support facility thermal control system. The following values of density, temperature, and humidity shall be used for the thermal design of the support facility.

7.3.1 Ambient Air Pressure and Density

Average air pressure:	650 mb = 64.956 kPa = 9.43 lbs/in^2	
Average ambient air density:	0.82 kg/m^3	(Assumes 650 mb @ 2.5 ^{o}C)
Average heated room air density:	0.76 kg/m^3	(Assumes 650 mb @ 2.5 ^{o}C)

7.3.2 Temperatures

The following temperature values shall be used to calculate the sensible heat loads and loses for the support facility. Separate periods of temperature variation are defined for winter and summer. The minimum winter temperature value listed corresponds to the 5th percentile of the ambient air minimum temperature distribution at Mauna Kea. The maximum summer temperature value listed corresponds to the 90th percentile of the ambient air maximum temperature distribution. The average winter and summer ambient temperature values are obtained by applying the Mauna Kea mean annual diurnal temperature swing of 13 ^{o}C (23.4 ^{o}F) to the percentile values.

Maximum daytime ambient air temperature, summer:	13 ^{o}C (55.4 ^{o}F)
Average nighttime ambient temperature, summer:	0 ^{o}C (32.0 ^{o}F)
Minimum nighttime ambient air temperature, winter:	-8 ^{o}C (17.6 ^{o}F)
Average daytime ambient temperature, winter:	5 ^{o}C (41.0 ^{o}F)
24 hour constant temperature of conditioned support facility rooms, or the design dry bulb temperature of the support facility rooms:	25 ^{o}C (77.0 ^{o}F)

7.3.3 Relative Humidity of Ambient Air and Moisture Content of Support Facility Air

The mean annual value of the relative humidity of the ambient air is 40%, and this value shall be used for determining the support facility latent heat load due to infiltration and outside air by passing the support facility conditioning system.

The moisture content of air in the support facility conditioned rooms (the computer, crew, instrumentation, control, offices, and restrooms) must be maintained such that at the design dry bulb temperature, the air moisture content is located within the physiologic comfort zone as defined by ASHRAE.

7.3.4 Infiltration

The sensible heat loss from the support facility air can be determined by either the leakage method or by a predicted airflow rate (volumes/hr). If the leakage method is used and it is necessary to determine an air tightness rating based on leakage area, the average value of ambient air velocity to be used is 8 m/s, which corresponds to the 50th percentile value of the ambient wind velocity at Mauna Kea.

7.4 Load Calculations Required

AURA has determined the daytime air conditioning load of the enclosure. This load and the temperature range of the conditioned air to be supplied to the enclosure are listed in the load database, Section 7.6.

The Contractor shall determine the heating and cooling loads for the following rooms in the support facility: the restrooms, offices, and crew, control, computer, and instrumentation rooms. The plant room does not require heating or cooling. AURA will convey the most current database (containing the electric and lighting loads for the support facility) to the Contractor to facilitate this work.

In addition, the coating facility room in the base of the enclosure must be heated while re-coating operations are in progress.

The Contractor shall determine the heating load for the coating facility (See Section 7.15).

7.4.1 Wall Insulation R Value for Support Facility and Coating Plant Room

The Contractor shall determine the R value of the insulation required to insulate the walls of the support facility and the coating plant room.

7.4.2 Coating and Insulation R Value for the Support Facility Roof

Support facility roof designs were modeled by AURA to determine whether the roof would be a source of local seeing effects. (Gemini Technical Note TN-TE-G0016, "Gemini Support Facility Roof Thermal Analysis", July, 1993). A copy of this report can be obtained from AURA. The roof insulation is placed over steel deck plate, which could eventually form the floor of an expanded support facility. The report concluded that:

- The R value for the roof insulation (not including of the asphalt sealing membrane) over the support facility shall be greater than 2 m^2-$^oC/W$;
- The roofing insulation should be sealed with an asphalt barrier membrane having a minimum thickness of 7 mm (1/4");
- The Asphalt seal membrane should be painted with white titanium dioxide paint.

The Contractor shall use the above values as design guidelines for the roof of the support facility, and shall ensure that the outer roof surface shall be coated with white titanium dioxide paint. The support facility roof system adjacent to the enclosure must be protected from damage that could result from falling ice.

7.5 Insulation R Value Specifications

Insulation is required in the ceiling of the HROS room (located in the base of the telescope pier), in the walls of the enclosure base structure, and in the bottom surface of the stationary chamber floor. The Contractor shall ensure that insulation with the following minimum R value specifications are included at these locations.

- The ceiling insulation of the HROS room shall have an R value not less than 4.2 $^{o}C\text{-}m^2/W$;
- The insulation in the walls of the enclosure base structure and at the bottom surface of the stationary chamber floor shall have an R value not less than 3.3 $^{o}C\text{-}m^2/W$.

7.6 The Support Facility Thermal Control System Load Database

The load database provides a list of data to be used in the design of the support facility thermal control system. The data consists of all presently known load, temperature, and plumbing information to allow the Contractor to select thermal control system components such as heat exchangers, pumps, and compressors. Many parameters, especially relating to plumbing details, have yet to be determined, and are therefore designated "T.B.D." (To Be Determined). Of greater importance, the type of coolant and the coolant temperature range required for the enclosure daytime air conditioning has yet to be determined, and is a work requirement to determined by the Contractor as outlined in subsequent Sections. Because of this unknown information, the load database is not based on coolant delivery temperatures. Instead, the concept of "load environment temperature regime" is used to categorize the database.

7.6.1 Load Environment Temperature Regimes

The "load environment temperature" is defined as the temperature of the medium (gas or fluid) that is transferring heat to the load side of the heat exchanger or evaporator used to control the load temperature. The load environment temperature must not be confused with the required delivery temperature of the coolant introduced into the heat rejection side of the heat exchanger or evaporator located in the load environment. The coolant delivery temperatures will in all instances be less than the load environment temperatures, and the magnitude of the temperature difference between the load environment and the delivered coolant will depend on the coolant flow rates, the load flow rates (fluid or gas flow rate through the heat exchanger) and the load temperatures, and heat exchanger efficiency values.

Three separate temperature regimes have been identified for the load environments of the Gemini enclosure and support facility. Table 7-1 summarizes the loads and environmental temperatures for the three regimes, and lists the known minimum, maximum, and target delivery coolant temperatures for the loads.

The pages following Table 7-1 are a database containing all of the presently known information for each of the loads, grouped together by load temperature regime, and beginning with the upper temperature regime. The database will be continuously updated, and AURA will immediately forward new information to the Contractor as it becomes available.

Currently, thermal control of the primary mirror and active optics listed in the "very low temperature" load regime of Table 7-1 are provided by a stand alone modular chiller of 5 kW capacity (N.I.C.) detailed in Section 7.6.4. The chiller would be located in the air exhaust tunnel (Section 7.10) and reject heat to the tunnel air. Information on the primary mirror and active optics thermal control system is included in Table 7-1 and Section 7.6.4 because AURA may elect to remove heat from the chiller by specifying that it be fitted with a water/glycol cooled condenser (N.I.C.) that would operate in the "upper" temperature regime. To allow for this contingency, the Contractor should add 7 kW (assuming the coefficient of performance of the 5 kW chiller = 3.0) to the existing loads in the upper temperature regime when determining the capacity of the central chiller system as described in Section 7.19.3.

Table 7-1. Load Environment Temperature Regimes and Coolant Temperatures

Load Environment Temperature Regime	Load Environment Description w/ (Min, Max (°C)) Temps	Coolant Temperatures (Min, Max, (°C))	Load (kW)
"Upper" (10 °C to 43 °C)	Support Facility Conditioned Air (air in support facility rooms) (20, 25)	(coolant temp in heat exchangers in ducts) (12,20) (Est.) (target deliv.temp = 12)	20(Est.)
	Helium Coolers (cooler housing temperature) (10, 38)	(coolant temp. in cooler housings) (10, 38) (target deliv. temp = 20)	20
	Laser Scanner (laser housing temperature) (18, 25)	(coolant temp. in laser housing) (18, 25) (target deliv. temp = 20)	9
	Hydrostatic Bearings (refrig. temp.range in bearing oil chiller condenser (N.I.C.)) (30 °C to 43 °C)	(coolant temp. to hydro. bearing chiller condenser) (15, 25) (target deliv. temp = 20)	50
	Aluminizing Plant (temp. of pump housings) (12, T.B.D.)	(coolant temp. in pump housings) (12, T.B.D.) (target deliv. temp = 12)	190
	Cassegrain Instruments (air temp. in elecronics box) (15, 20)	(coolant temp. in heat exchangers in boxes) (0, 2) (target deliv. temp = 0)	6
	VME Buss Crates (air temp. in electronics box) (15, 20)	(coolant temp. in heat exchangers in boxes) (0, 2) (target deliv. temp = 0)	5
"Low" (-8 °C to 5 °C)	Enclosure Daytime Conditioned Air (air temp. in enclosure chamber) (-8, 5)	(coolant temp.delivered to condensers/htxs in cham.) (T.B.D., T.B.D.) (target deliv.temp = TBD)	100
"Very Low" (-15 °C to T.B.D.) (N.I.C.)	Primary Mirror/Active Optics Thermal Control (N.I.C.) (temp. of radiant htx in mirror cell) (-15, T.B.D.)	(coolant temp. in radiant htx in mirror cell) (T.B.D., T.B.D.) (N.I.C.) (target deliv.temp=TBD)	5 (N.I.C.)

7.6.2 The Upper Temperature Load Regime (10 ºC to 43 ºC)

Application:	**Support Facility Air Conditioning**
Source:	Air in offices, control, computer, instrumentation, crew and restrooms in the support facility.
Source location:	Air fluid heat exchanger(s) located in ducts in mechanical plant room.
Load at source:	20 kW total for combined rooms (Est.)
Control of load:	Contractor determines system required to deliver coolant at the target delivery temp.
Location of control console:	Distributed temperature and humidity sensors in rooms; as determined by Contractor.
Temp. at load environment:	Room Temperature (20-25 ºC)
Humidity requirements:	ASHRAE physiologic comfort zone
Type of coolant specified:	T.B.D.
Min. coolant delivery temperature:	T.B.D. (target temperature of 12 ºC)
Temp. stability of delivered coolant:	T.B.D.
Max. temperature rise of coolant:	T.B.D.
Max. flow rate of coolant	T.B.D.
Max. pressure capacity plumbing:	T.B.D.
Total number of coolant circuits:	T.B.D.
Conduit length (per circuit):	T.B.D.
Conduit type and size:	T.B.D.
Conduit insulation requirements:	T.B.D.
Pressure drop per circuit:	T.B.D.
Pump type and size (per circuit):	T.B.D.
Pump power requirements (per circuit):	T.B.D.
Time of operation:	Assume 24 hr operation
Load profile:	T.B.D.
Information source:	R. Ford, AURA, Gemini T.S.B.E.G.

Notes:

7.6.2 The Upper Temperature Load Regime (10 ºC to 43 ºC), Continued.

Application:	**Helium Coolers for Instrumentation Packages**
Source:	Cooling jacket of Gifford-McMahon Cycle helium coolers (N.I.C.)
Source location:	Helium coolers are located in plant room.
Load at source:	20 kW (includes all future anticipated requirements of four cooling units @ 5 kW/unit)
Control of load:	Contractor to maintain delivered coolant at the target delivery temperature, and control the flow rate of coolant delivered to the load.
Location of control console:	Centrally located console in plant room.
Temp. at load environment:	10 ºC to 38 ºC (ambient operating temp range)
Type of coolant specified:	Water (PO has determined from the cooler maker the use of water glycol solution is acceptable)
Min. coolant delivery temperature:	5 ºC (Target temperature of 20 ºC)
Temp. stability of delivered coolant:	T.B.D.
Max. temperature rise of coolant:	33 ºC (38 ºC at outlet)
Max. flow Rate of coolant:	9.5 litres/min per 5 kW cooler = 38 litres/min total @ 20 ºC water supply temperature
Max. pressure capacity plumbing:	100 psig
Total number of coolant circuits:	One per compressor.
Conduit length (per circuit):	T.B.D.
Conduit type and size:	T.B.D.
Conduit insulation requirements:	T.B.D.
Pressure drop per circuit:	T.B.D.
Pump type and size (per circuit):	T.B.D.
Pump power requirements (per circuit):	T.B.D.
Time of operation:	Assume 24 hrs/day
Load profile	Assume constant
Information source:	David Robertson, AURA, Gemini Instrumentation Group; D. Mclean, CTI-Cryogenics,Mansfield, Ma.

Notes:

1. "The compressor was designed to operate with water having a PH value of 6.0 to 8.0 and a calcium carbonate concentration of less than 75 p.p.m. (typical municipal drinking water). For applications of lower PH or greater hardness, water conditioning will be necessary."

2. Water glycol coolant is compatible with the compressor.

7.6.2 The Upper Temperature Load Regime (10 °C to 43 °C), Continued.

Application:	**Laser Scanner for Mirror Cleaning Operations**
Source:	Housing of Lumonics EX-740 series laser (N.I.C.)
Source location:	Laser mounted on scanning column mounted to floor of enclosure
Load at source:	9 kW
Control of load:	Contractor to maintain delivered coolant at the target delivery temperature, and control the flow rate of coolant delivered to the load.
Location control console:	Centrally located console in plant room.
Temp. at load environment:	T.B.D.
Type of coolant specified:	Water; Lumonics has noted the use of water/glycol is acceptable.
Min. coolant delivery temperature:	18 °C (target temperature of 20 °C)
Temp. stability of delivered coolant:	T.B.D.
Max. temperature rise of coolant:	7 °C (25 °C outlet temp.)
Max. flow rate of coolant:	10 litres/min @ 20 °C supply
Max. pressure capacity plumbing:	40-60 psig (laser)
Total number of coolant circuits:	One
Conduit length (per circuit):	T.B.D.
Conduit type and size:	T.B.D. (See note 1)
Conduit insulation requirements:	T.B.D.
Pressure drop (per circuit):	T.B.D.
Pump type and size (per circuit):	T.B.D.
Pump power requirements (per circuit):	T.B.D.
Time of operation:	Assume 4 hrs per cleaning period, once every two weeks of telescope operation.
Load profile	Assume constant while in operation
Information source:	Lumonics, Inc.

Notes:

1. Cooling water connections at the laser are 3/8" Swagelok fittings, labeled "Water In" and "Water Out".

2. "Coolant containing a high concentration of minerals or suspended solids should be filtered out prior to use in order to avoid corrosion or plugging of the laser cooling system. Standard commercial grade water filters and medium fine replacement cartridges are sufficient for this purpose"

7.6.2 The Upper Temperature Load Regime (10 °C to 43 °C), Continued.

Application:	**Hydrostatic bearings**
Source:	Condenser (N.I.C.) of hydrostatic bearing oil cooling system
Source location:	(N.I.C.) Heat exchanger (hydrostatic chiller unit refrigerant to thermal control system water/glycol) located in plant room.
Load at source:	50 kW (See Note 1.)
Control of load:	Contractor to maintain delivered coolant at the target delivery temperature, and control the flow rate of coolant delivered to the load.
Location control console:	Centrally located console in plant room.
Temp. at load environment:	T.B.D.
Type of coolant specified:	Water Glycol (supplied to source heat exchanger in plant room) (75 % Water, 25% Glycol Specified)
Min. delivery temperature of coolant:	15 °C (target temp. of 20 °C)
Temp. stability of delivered coolant:	T.B.D.
Max. temp. rise of coolant:	10 °C (25 °C outlet)
Max. Flow Rate of coolant:	5700 litres/hr
Max. pressure capacity plumbing:	T.B.D. (Pressure rating of source heat exchanger)
Total number of coolant circuits:	One
Conduit length (per circuit):	T.B.D.
Conduit type and size:	T.B.D.
Conduit insulation requirements:	T.B.D.
Pressure drop (per circuit):	T.B.D. (45 kPa through heat exchanger)
Pump type and size (per circuit):	T.B.D.
Pump power requirements (per circuit):	T.B.D.
Time of operation:	Nighttime hours, w/ possible daytime operation
Load profile:	T.B.D.
Information source:	S.K.F. Correspondence w/ AURA, Gemini Telescope Structure, Building, Enclosure Group. Bill Delmer, Keck Telescope Mechanical Engr.

Notes:

1. The SKF chiller capacity is 35 kW. Assuming a coefficient of performance of 3.0, the compressor work for the chiller is 12 kW, and the total heat rejection at the condenser (to be removed by the water/glycol coolant) is 47 kW.

7.6.2 The Upper Temperature Load Regime (10 ºC to 43 ºC), Continued.

Application:	**Aluminizing Plant**
Source:	Water jackets or coils attached to vacuum pumps (N.I.C.)
Source location:	Aluminizing facility- Enclosure basement
Load at source:	190 kW 4 off diffusion pumps @ 25 kW/each =100 kW 2 off rotary vane pumps @ 20 kW/each = 40 kW 1 to 4 magnetrons@12 kW/each; Assume 48 kW Total Load = 188 kW
Control of load:	Contractor to maintain delivered coolant at the target delivery temperature, and control the flow rate of coolant delivered to the load.
Location control console:	Centrally located console in plant room.
Temp. at load environment:	T.B.D.
Type of coolant specified:	Water Glycol Mixture (% composition T.B.D.)
Min. coolant delivery temperature:	12 ºC minimum allowed, due to thermal strains. (target temperature of 12 ºC)
Temp. stability of delivered coolant:	T.B.D.
Max. temp. rise of coolant:	T.B.D.
Max. flow rate of coolant:	diff. pumps = 385 litres/hr each = 1540 litres/hr. vane pumps = 90 litres/hr each = 180 litres/hr. magnetrons = (T.B.D.)
Max. pressure capacity plumbing:	T.B.D.
Total number of coolant circuits:	T.B.D. (seven to ten)
Conduit length (per circuit):	T.B.D.
Conduit type and size:	T.B.D.
Conduit insulation requirements:	T.B.D.
Pressure drop (per circuit):	T.B.D.
Pump type (per circuit):	T.B.D.
Pump power requirements (per circuit):	T.B.D.
Time of operation:	Est. 2 times per year
Load profile:	T.B.D.
Information source:	Ron Adams, SERC, England

Notes:

1. Flow rates listed are based on unknown assumptions concerning water coil or water jacket efficiencies, and coolant outlet temperatures at the water coils or water jackets. The information will be updated pending work performed by SERC and forwarded to the Contractor as soon as possible.

7.6.2 The Upper Temperature Load Regime (10 °C to 43 °C), Continued.

Application:	**Cassegrain Instrument Package**
Source:	Fluid/air heat exchanger attached to side of electronics crates (N.I.C.)
Source location:	Bottom Mirror cell - Enclosure chamber
Load at source:	6 kW
Control of load:	Contractor to maintain delivered coolant at the target delivery temperature, and control the flow rate of coolant delivered to the load.
Location control console:	Centrally located console in plant room.
Temp. at load environment:	Constant: 15-20°C
Location control console:	Centrally located console in plant room.
Type of coolant specified:	Water Glycol
Min. coolant delivery temperature:	0 °C (Heat Exchanger design by D. Montgomery) (target temp of 0 °C)
Temp. stability of delivered coolant:	T.B.D.
Max. temp. rise of coolant:	2 °C (D. Montgomery)
Max. pressure capacity at load:	T.B.D. (Est at 30 p.s.i.g.)
Max. flow rate of coolant:	46.2 gal/min (D. Montgomery)
Max. pressure capacity plumbing:	T.B.D.
Total number of coolant circuits:	T.B.D.
Conduit length (per circuit):	T.B.D.
Conduit type and size:	T.B.D. (Size est. at 3/4" pipe)
Conduit insulation requirements:	T.B.D.
Pressure drop per circuit:	T.B.D. (Est. at 30 psi for 200 foot system with ten 90° bends)
Pump type (per circuit):	T.B.D. (Centrifugal or positive displacement)
Pump power requirements (per circuit):	T.B.D.
Time of operation:	Assume 24 hrs
Load profile:	Constant
Information source:	David Montgomery, AURA, Gemini Instrumentation Group, "Technical Details of Mounting Instruments at the Cassegrain Focus " David Robertson, AURA, Gemini Instrumentation Group.

Notes:

1. The 15 to 20 °C temperature requirement for the load environment (air surrounding the electronics packages) is based on reliability for the electronic components.

7.6.2 The Upper Temperature Load Regime (10 ºC to 43 ºC), Continued.

Application:	**VME Buss Crates (Electronics Cabinets)**
Source:	Fluid/air heat exchanger attached to electronics cabinets (N.I.C.)
Source location:	Distributed throughout enclosure chamber
Load at source:	Est. 10 Crates @ 0.5 kW/Crate = 5 kW
Control of load:	Contractor to maintain delivered coolant at the target delivery temperature, and control the flow rate of coolant delivered to the load.
Location control console:	Centrally located console in plant room.
Temp. at load environment:	Constant: 15-20ºC (Elec.Reliability Considerations)
Type of coolant specified:	Water glycol
Min. coolant delivery temperature:	0 ºC (See Cassegrain Instrument Package) (target temp of 0 ºC)
Temp. stability of delivered coolant:	T.B.D.
Max. temp. rise of coolant:	2 ºC (See Cassegrain Instrument Package)
Max. flow rate of coolant:	T.B.D. (Est at 38 gal/min for combined circuits)
Max. pressure capacity plumbing:	T.B.D.
Total number of coolant circuits:	Up to 10
Conduit length (per circuit):	T.B.D. (varies with crate location)
Conduit type and size:	T.B.D.
Conduit insulation requirements:	T.B.D.
Pressure drop per circuit:	T.B.D.
Pump type (per circuit):	T.B.D.
Pump power requirements (per circuit):	T.B.D.
Time of operation:	24 hrs/day
Load profile:	Assume constant
Information source:	AURA, Gemini Controls Group

Notes:

1. V.M.E. = "versa-module-European", a free standing or rack mounted electronics cabinet.

7.6.3 The Low Temperature Load Regime(-8ºC to 5ºC)

Application:	**Daytime Air Conditioning of Enclosure**
Source:	Enclosure chamber air.
Source location:	Enclosure chamber, *four distributed locations*.
Load at source:	100 kW (*Specified by AURA*)
Control of load:	Contractor to maintain delivered coolant at the target delivery temperature (T.B.D.), and control the flow rate (T.B.D.) of coolant delivered to the load.
Location control console:	Console located in telescope operations room.
Temp. at load environment:	Variable : Range -8 to 5 ºC (See Notes 1 and 2)
Type of coolant specified:	Water Glycol or Refrigerant, depending on option selected.
Min. coolant delivery temperature:	T.B.D. (target delivery temperature T.B.D.)
Temp. stability of delivered coolant:	T.B.D. (Est. at plus or minus 0.25 ºC)
Max. temp. rise of coolant:	T.B.D.
Max. flow rate of coolant:	T.B.D.
Max. pressure capacity plumbing:	T.B.D.
Total number of coolant circuits:	Four
Conduit length (per circuit):	T.B.D. (plant room or exhaust tunnel to chamber, depending on chiller design option)
Conduit type and size:	T.B.D.
Conduit insulation requirements:	T.B.D.
Pressure drop per circuit:	T.B.D.
Pump type (per circuit):	T.B.D.
Pump power requirements:	T.B.D.
Time of operation:	Daytime hours
Load profile:	Assume starts at sunup, proceeds in sinusoidal fashion to peak at noon, and falls in sinusoidal fashion to zero at sundown
Information source:	R. Ford - Telescope Structure, Building, Enclosure Group.

Notes:

1. AURA has determined the load for the daytime air conditioning of the enclosure at 100 kW.
2. -8 ºC corresponds to the 5th percentile of the ambient air minimum temperature distribution at Mauna Kea.
3. 5 ºC corresponds to the 100th percentile of the ambient air minimum temperature distribution at Mauna Kea. (100 percent of the time, in a 24 hour period, the minimum air temperature will be below 5 ºC)
4. Deicing circuits will be required for the evaporators or heat exchangers located in the chamber.

7.6.4 The Very Low Temperature Load Regime (-15ºC to 5 ºC)

Application:	**Primary Mirror Thermal Control System, and Active Optics Thermal Control System (N.I.C.)**
Source:	(N.I.C.) Coolant reservoir acting as radiative sink for backside of primary mirror, and coolant coils or jackets attached to devices associated with the active control of primary mirror.
Source location:	Mirror cell in enclosure Chamber.
Load at source:	5 kW
Control of load:	(N.I.C.) Temp. sensors located on devices as inputs to control system acting on coolant flow rates
Location of control console:	T.B.D. (N.I.C.)
Temp. at load environment:	T.B.D.
Type of coolant specified:	Water Glycol
Min. delivery temperature of coolant:	-20 ºC to -15 ºC
Temp. stability of delivered coolant:	plus or minus 1 ºC
Max. temp. rise of coolant:	T.B.D.
Max. flow rate of coolant	37.8 litres/min (For primary mirror temp. control system only) Flow rates for active optics T.B.D.
Max. pressure capacity plumbing:	80 psi
Total number of coolant circuits:	Est. at one dozen
Conduit length (per circuit):	T.B.D.
Conduit type and size:	T.B.D.
Conduit insulation requirements:	T.B.D.
Pressure drop per circuit:	T.B.D.
Pump type (per circuit):	T.B.D.
Pump power requirement (per circuit):	T.B.D.
Time of operation:	Daytime hours, w/ possible nighttime operation
Information source: the	Justin Greenhalgh, R.A.L., "Conceptual Design of Gemini Primary Mirror Thermal Management System", and L. Stepp, Gemini Optics Group

Notes:

1. Modular chiller unit proposed is Neslab Custom HX-1000A
2. Chiller capacity: 28kW at 25 ºC, 3 kW at -15ºC.
3. Dimensions: Height, 1.62 m
   Width, 1.16 m
   Depth, 0.736 m
   (The chiller unit must fit into the exhaust tunnel)
4. An option exists whereby the modular chiller would be fitted with a fluid cooled condenser (N.I.C.) and cooled with water glycol, as described in Section 7.6.1.

7.7 Ambient Air Flow Regimes

The support facility thermal control system must operate over a wide range of ambient air flow, 0 - 30 m/s. For design purposes, three separate regimes of ambient air flow have been identified. Discrete ambient air velocity values are used to define the regimes. One flow regime is defined to exist in the daytime, and two distinct flow regimes are defined for the nighttime hours:

- The daytime ambient air flow regime: Ambient air velocity = 8 m/s
- The 5th percentile nighttime air flow regime: Ambient air velocity = 0 m/s
- The 70th percentile nighttime air flow regime: Ambient air velocity = 11 m/s

7.8 Fan Forced Ventilation

The support facility thermal control system includes fan forced ventilation to control the temperature of certain surfaces and air volumes within the enclosure and support facility. The air handling devices are divided into the two separate categories of low and high capacity.

7.8.1 Low Capacity Fan Requirements

A number of low capacity fans will be required to distribute conditioned air within the support facility. A low capacity fan will also be required to maintain positive air pressure (with respect to the ambient air and enclosure basement air) in the aluminizing facility room to prevent particulates from entering the room.

The Contractor will determine the fan types, fan capacities, fan pressure requirements, and fan hardware requirements for all low capacity fans.

Distribution system duct work requirements are described in Section 7.17. Pressure requirements for the aluminizing room fan are covered in Section 7.14.1.

7.8.2 High Capacity Fan Requirements

7.8.2.1 Exhaust Tunnel Fans

High capacity fans will be required to:

- Ventilate the heat exhaust tunnel during the daytime ambient air flow regime to remove heat from modular condenser/compressor units;
- Ventilate the enclosure chamber, shell, and floor air volumes during the 5th percentile nighttime air flow regime;
- Ventilate the enclosure chamber, and floor air volumes during the 70th percentile nighttime air flow regime.

The operating scenarios for the three high capacity ventilation tasks outlined above are described in more detail in Sections 7.10, 7.11, and 7.12. AURA has determined nominal baseline values for the fan volumetric flow rates and fan static pressure requirements. AURA has also determined the fan hardware requirements necessary to accomplish the three high capacity ventilation tasks above.

- A total of eight fans are to be utilized; four fans will be located at each end of the exhaust tunnel;
- The fans are to be of the vane-axial type;
- The capacity of each fan shall be not less than 14 m^3/s at 125 Pa static pressure (30,000 c.f.m. at 1/2" water);
- The air density used for determination of fan performance must be 0.82 kg/m^3 (Section 7.3.1);

- Each fan shall have a back draft damper capable of remote actuation. It is not necessary for the damper to be modulated, or set to any position other than full closed and full open. The backdraft dampers shall be pneumatically operated, although electrically activated dampers will be accepted;
- Individual control switches for remotely actuating each fan and damper (8 fan manual on/off switches, and 8 damper manual on/off switches) shall be located in the plant room ventilation control console (Section 7.21.4);
- The Contractor shall provide AURA with a manufacturer performance curve for the fans selected, along with drawings itemizing all fan dimensions, including data concerning the backdraft damper. Data concerning the fan noise levels must be included.

7.8.2.2 Coating Plant Room Fan

A high capacity fan will also be required to ventilate the aluminizing facility during mirror coating stripping operations.

AURA has determined the fan volumetric flow rate necessary to ventilate the aluminizing facility during stripping operations.

- The required ventilation rate = 3.5 m^3/s (7,500 c.f.m.);
- Air handling options can include a single or multiple vane-axial or tube-axial fans.

The Contractor will determine the number of fans, type of fans, and fan pressure rating.

More details and specifications concerning the stripping operation ventilation task are described in Section 7.14.

7.9 Shell Air Flow Valves

The shell air volume is the air space confined between the chamber wall and the outer structural shell of the enclosure. Thermal modeling of the enclosure (Gemini 8M Enclosure, Support

Facility, and Site Plan Preliminary Design Review, Gemini RPT-TE-G0015) has demonstrated that:

- Passive air flow between the ambient air and the shell air volume will reduce the daytime air conditioning load for the enclosure chamber air;
- Active (fan forced) air flow between the ambient air and the shell air volume is necessary at night for low values of ambient wind speed to force the temperature of the outer structural shell of the enclosure closer to the ambient air temperature and thus minimize "shell seeing";
- Active air flow through the shell air volume is not required to control shell seeing for high values of ambient windspeed. Furthermore, to prevent "louver seeing" at high values of ambient windspeed, the shell air volume must be contained and not allowed to escape and flow over the open shutter.

The active and passive flow requirements above require the use of two sets of flow valves. One set of valves are located in the top of the enclosure structure (N.I.C.). The other set are located in the enclosure base structure, and control the flow between the ring plenum, the shell, and the ambient air. The positions of the shell air flow control valves for the three regimes of ambient air flow are shown on Figure 7-1.

When the base structure shell air flow valves are open, flow may occur only between the ambient air and the shell air. With the valves in the closed position, flow may only occur between the shell air and the air within the ring plenum beneath the stationary enclosure floor.

Control of the shell air volume temperature is an integral part of the support facility thermal control system. The following sections describe the overall high capacity ventilation requirements for the support facility for the various ambient air flow regimes, and include shell air flow requirements.

7.10 Support Facility Thermal Control System Ventilation During the Daytime Ambient Air Flow Regime

Figure 7-2 shows the nominal ventilation configuration for daytime heat removal from the support facility heat exhaust tunnel. The enclosure chamber air is air conditioned and the enclosure chamber is sealed to minimize the infiltration heat load (wind forced) of outside air. To minimize solar driven heat gain into the enclosure chamber, a passive ventilation flow circuit is utilized between the ambient air and the shell air volume confined between the chamber wall and the outer structural shell of the enclosure. The enclosure shell air valves (N.I.C.) located at the top of the enclosure structure are open, as are the flow valves in the enclosure base structure. (Data from the UKIRT enclosure suggest that such an arrangement can result in air exchange rates upwards of 50 shell air volumes per hour during the peak solar event.)

The large damper located in the riser to the enclosure floor air plenum (Designated "Closed" on Figure 7-2) is shut to prevent warm air from the exhaust tunnel from rising into the enclosure, and to prevent conditioned air from being sucked out of the enclosure when exhaust tunnel fans are in operation.

Modular air cooled condenser/compressor units (located in the portion of the exhaust tunnel directly adjacent to the support facility) from the support facility thermal control system chiller units reject heat into the tunnel air. All heat rejecting devices must be located in the air exhaust tunnel. The nominal tunnel dimensions are 3m by 3m by 14m long. (The tunnel dimensions adjacent to the plant room will depend on the work outlined in Section 7.20.3) The modular units have a environmental operating temperature (E.O.T.) which represents the maximum temperature of the air mass surrounding the unit. To enable efficient operation of a condenser, the temperature of the air in the exhaust tunnel must always be held below the condenser E.O.T. When the air temperature in the exhaust tunnel rises above the condenser E.O.T., makeup air at ambient temperature must enter the tunnel. The makeup air is provided by continuously or periodically operating a single fan located at either end of the tunnel, which sucks ambient air in through open back draft dampers located on fans at the opposite end of the tunnel. The Contractor shall:

- Determine the dimensions of the riser conduit joining the support facility air exhaust tunnel to the enclosure air plenum;
- Determine the size, mounting details, and operating mechanism for the large damper located in the riser from the air exhaust tunnel to the enclosure plenum. The damper shall be controlled from the ventilation control console located in the plant room. (Section 7.21.4);
- Determine the flow pressure loss coefficient for the large damper: The maximum air flow through the damper (112 m^3/s) occurs under the conditions expressed in this Section, and the exhaust tunnel fan specifications are listed in Section 7.8.2.1;
- Determine the E.O.T. of all devices rejecting heat into the air exhaust tunnel (condensers for the chiller system options are described in Section 7.19.4);
- Recommend which of the following techniques are more reliable and cost efficient:

a. Providing exhaust tunnel heat removal by periodically operating one of the high capacity fans (described in Section 7.8.2.1) located at one end of the exhaust tunnel, or:

b. Providing exhaust tunnel heat removal by providing an additional fan (the capacity, type, and pressure rating of which are to be provided by the Contractor) dedicated to the sole purpose of daytime heat removal from the tunnel. The fan would operate in either continuous or periodic fashion, as determined by the Contractor. The fan must be located at the south end of the exhaust tunnel;

- Determine a means of mounting the devices in that portion of the tunnel adjacent to the support facility such that:

a. The devices do not impede air flow, foot traffic, and equipment conveyance through the tunnel. The Contractor shall calculate the exhaust tunnel flow pressure loss due to the devices obstructing the cross sectional area of the tunnel, and determine the reduction in maximum flow capacity (four fans in operation at the plant room end of the tunnel) caused by this flow restriction. The Contractor shall ensure that the devices do not prevent foot traffic and the operation of the overhead rail hoist system (indicated in Figure 6-8) used to convey equipment through the tunnel.

b. The devices may be readily serviced and maintained. The Contractor shall ensure that the devices are located such that they may be readily serviced and maintained from a location inside the tunnel.

c. The devices do not prevent gaining access into the tunnel through the access door in the west wall of the plant room. The devices must be located in the tunnel such that they do not block foot traffic or equipment conveyance through this door.

7.11 Support Facility Thermal Control System Ventilation During the 5th Percentile Nighttime Ambient Air Flow Regime

Figure 7-3 shows the optimum operating configuration for ventilation at low ambient wind speed (5th percentile). The large damper located in the riser to the enclosure floor air plenum (Designated "Open" on Figure 7-2) is in full open position. The optimized configuration requires all eight high capacity fans (Section 7.8.2.1) to be operating, whereby equal volumes of air are being moved through the shell air space and the chamber air volume. Air in the chamber is sucked through surface grates (always open) in the rotating telescope floor, then moves radially through the stationary telescope floor and enters the ring plenum, where the flow exits the enclosure through the riser connected to the exhaust tunnel. Ambient air enters the shell air volume at the top of the enclosure through the open enclosure shell air valves (N.I.C.) and moves through the shell into the ring plenum. The base structure shell air flow valves are closed to permit air flow only between the shell air and ring plenum, thus preventing "short circuit" flow between the ambient air (at the base of the enclosure) and the ring plenum.

In the event telescope observing is affected by the thermal plume exiting a tunnel end, the fans on that tunnel end are switched off and the back draft dampers are actuated, and the flow will exit the opposite end of the tunnel. In the event the closed off tunnel end is the south tunnel end, a small amount of makeup air must enter the south tunnel entrance through an open back draft damper to allow efficient heat rejection from the condensers located adjacent to the support facility plant room at the south end of the exhaust tunnel.

The fan and backdraft logic for the various operating conditions is summarized in the following table.

Table 7-2. Fan and backdraft damper logic for support facility thermal control system ventilation during the 5th percentile nighttime ambient air flow regime.

Operating Conditions	North Fans	North Dampers	South Fans	South Dampers
Optimum Normal	4 On	4 Open	4 On	4 Open
Telescope Observing South	4 On	4 Open	0 On	1 Open
Telescope Observing North	0 On	0 Open	4 On	4 Open

7.12 Support Facility Thermal Control System Ventilation During the 70th Percentile Nighttime Ambient Air Flow Regime

Figure 7-4 shows the optimum operating configuration for ventilating the enclosure during the 70th percentile nighttime ambient air flow regime. Ventilation of the shell air volume is no longer required, and the shell air flow valves located in the enclosure carousel (N.I.C.) and in the enclosure base structure are closed to prevent flow between the shell air volume and the ambient air (See also Figure 7-1). With the shell air flow valves in this configuration, the shell air volume is connected to the low pressure plenum air volume; heat can not escape from the shell air volume and drift through the light path.

The operation of four fans only is required, and AURA requires the four south fans to be operated with the four south dampers open.

Table 7-3. Fan and backdraft damper logic for support facility thermal control system ventilation during the 70th percentile nighttime ambient air flow regime.

Operating Condition	North Fans	North Dampers	South Fans	South Dampers
All conditions	0 On	0 Open	4 On	4 Open

7.13 Integrated Design Requirements for the High Capacity Ventilation System

AURA has specified that the static pressure requirements for the high capacity exhaust tunnel fans (Section 7.8.2.1) shall be not less than 125 Pa (1/2" water) for a flow rate (per fan) of 14 m^3/s (30,000 c.f.m.). At the earliest possible date after contract execution, AURA will supply the Contractor with layouts detailing the enclosure structure in the vicinity of the enclosure/enclosure base structure interface, layouts of the enclosure shell air flow valves, and layouts of the rotating telescope floor. The Contractor shall use the data from these layouts, together with the data presented in sections 7.7 through 7.12 above, to perform the integrated design of the support facility high capacity ventilation system, and to substantiate AURA's pressure rating value for the high capacity fans. The deliverables shall include:

- Layouts detailing how the high capacity fans are fit into the ends of the exhaust tunnel, showing the locations of the backdraft dampers in relation to the fans;
- Layouts of the ring plenum and the stationary chamber floor, detailing how the flow (entering the stationary floor from the open grates in the top of the rotating telescope floor) will be balanced going into the ring plenum;

- Layouts of the riser from the exhaust tunnel to the plenum, detailing the location of the large damper in the riser, and detailing the damper operating hardware (Section 7.10);
- Layouts of the enclosure to base structure rotating interface; detailing air seals at the interface (to prevent air flow "short circuits" between the shell air and ambient air in the vicinity of the rotating interface while the shell air volume is being force ventilated);
- Layouts of the base structure shell air flow valves, detailing the valve dimensions and valve actuation hardware.

In addition, the Contractor shall convey the following information to AURA:

- Analysis itemizing the total values of static and dynamic friction caused by the air seals at the rotating interface of the enclosure/enclosure base structure while the shell air volume is being ventilated at the flow rates defined for the 5th percentile value of the nighttime ambient flow regime;
- Analysis itemizing the total static and dynamic pressure drop of the air as it moves through the system, for each flow channel, valve, and orifice, from the enclosure shell air vents to the exhaust tunnel ends, and from the open grates in the rotating telescope floor to the exhaust tunnel ends, at the ventilation requirements defined for the 5th percentile value of the nighttime flow regime.

7.14 Fan Forced Ventilation for the Aluminizing Facility

The ventilation requirements for the aluminizing facility were specified in Section 7.8.2.2. Because of the damage risk to equipment posed by the acidic stripping solutions, the exhaust air from the stripping operation ventilation must not pass into the support facility exhaust tunnel.

- The ventilation requirement shall be achieved with a single wall mounted fan and damper unit in the west wall of the aluminizing facility, located directly adjacent to the mirror wash and prep area;
- The fan and damper unit shall be located high enough above the floor grade of the aluminizing facility for the exhaust stream to clear the top of the adjacent heat exhaust tunnel;
- The ventilating fan and damper unit shall be provided with simple manual control boxes located near or on the devices. RS232 serial interface is not required for operation from any remote console;
- Makeup air for the stripping ventilation shall be provided by a damper located in the south wall of the aluminizing room just above the floor grade of the room. The damper shall have simple manual control, although electric or pneumatic control from a control box near the damper will be accepted.

The Contractor shall produce layouts detailing the locations of the fan, inlet damper, and control box locations within the aluminizing facility.

7.14.1 Positive Air Pressure Requirements and Air Filtering for the Aluminizing Facility

Following the stripping operations, the air inside the aluminizing facility room must be maintained at a pressure greater than the ambient air and the air in the enclosure base structure. Air ducted into the room shall be filtered to remove particulates.

The Contractor shall design a fan and filter system to maintain a positive pressure differential of not less than 140 Pa (0.02 p.s.i.g.) between the aluminizing facility room and the ambient air and the enclosure basement air. The air ducted into the room shall be filtered to remove particulates down to 50 micron diameter. The Contractor shall produce a layout showing the location of the fan, filter, and fan control box.

7.15 Heating of the Aluminizing Facility

The aluminizing facility room is the only space in the enclosure having a heating requirement. The aluminizing facility must have a heating system which will intermittently be used during the biannual aluminizing operations. The heating system shall be capable of maintaining room within the physiologic comfort zone as defined by ASHRAE. The design temperature values listed in Section 7.3.2 are to be utilized for calculating heat loss from the room.

- The heating system is not required to maintain the comfort zone requirement at the stripping operation ventilation rate listed in Section 7.8.2.2.

The Contractor shall produce layout showing the heater types, heater locations, and locations of the temperature sensor(s). The insulation type and R rating to be installed in the walls of the coating plant room are to be determined by the Contractor (Section 7.4.1).

7.16 Fan Forced Ventilation Rates in the Support Facility

The crew, control, computer, offices, instrumentation rooms and restrooms located in the support facility must have sufficient ventilation to provide an acceptable level of air quality as specified in ASHRAE standard 62.

- No air exhaust or relief air vents related to support facility ventilated rooms shall exhaust air through the roof of the support facility; all air exits shall pass into a duct or ducts connected to the air exhaust tunnel.

7.17 Distribution of Conditioned Air to the Restrooms, Offices, and Crew, Control, Computer, and Instrumentation Rooms

Currently, two options exist for introducing conditioned air into rooms located in the support facility. The first option involves heat exchangers, electric heating elements, and fans located in open ended duct works in the support facility to provide conditioned air to the rooms. Coolant for the heat exchangers is supplied from the plant room, and the ducts do not extend into the plant room.

The second option involves closed loop air supply and return ducts extending into the plant room (which is located directly adjacent to the conditioned rooms) All heat exchangers, heaters, humidifiers and fans are then located in the plant room. One advantage of this design is that a leaking overhead heat exchanger will not damage computer equipment or other material located in the conditioned rooms. Other advantages are fan noise is minimized, and service and maintenance on the distribution system would be confined to the plant room.

- The Contractor shall design and cost a distribution system based on the second design option listed above. Duct work layouts must be included to satisfy the work requirements outlined in Section 7.22;
- The layouts shall include the location of all temperature and humidity sensors in the support facility rooms.

7.18 Fan Forced Ventilation of the Plant Room

Two separate ventilation requirements are necessary for the plant room. One ventilation rate is needed for normal operation. The other ventilation rate is required to remove contaminated air in the event of fluid or gas leaks.

7.18.1 Plant Room Ventilation for Normal Operation

Nominal ventilation must be provided to maintain the plant room air quality within the ASHRAE standards.

7.18.2 Plant Room Ventilation for Leak Events

Capability for high ventilation rates will be required in the event of fluid spills on the plant room floor. Since caustic or acidic solutions are not expected to reside in the plant room (as is the case for the aluminizing facility), and since the operation of the thermal control system requires that at all times not less than one of the high capacity exhaust fans in the exhaust tunnel will be operating, a wide range of ventilation rates can be provided for by merely mounting adjustable louvers in the common plant room/exhaust tunnel wall, and additional adjustable louver for make up air purposes in the eastern portion of either of the north or south plant room walls (directly west of the wall separating the plant room from the instrument prep/assembly room). The Contractor will provide the following information to AURA:

- A nominal plant room ventilation flow rate to maintain acceptable air quality standards and air temperature during the normal operation of the support facility thermal control system;
- A maximum plant room dilution flow rate based on whichever of the following conditions poses the worst hazard to human health:

  a. A refrigerant leak resulting in all of the refrigerant in one of the chiller units escaping into the plant room air, or:

b. A coolant leak resulting in the entire plant room floor covered in water/glycol solution, or:
c. An oil leak (hydrostatic bearing system) resulting in the entire plant room floor covered in oil.

The Contractor shall size the louvers and determine the louver control hardware necessary to provide for both of the above ventilation flow rates, and provide layouts showing the locations of the louvers and louver controls in the plant room walls.

7.19 Chiller Design Options for the Support Facility Thermal Control System

AURA has identified two separate design options for the support facility thermal control system chillers. Both options utilize two equal capacity chiller units to create a low temperature "sink" of water/glycol. Even though the overall reliability of a two chiller system is lower than the reliability value for a system with a single chiller, the two chiller system has a special operational advantage in that at least some portion of the overall load of the facility may still be maintained in the event one of the two chiller units malfunctions. In addition, repair and maintenance operations may be performed on one of the chillers while the other still maintains a portion of the load.

The differences between the two design options are explained in detail in the following sections. The option finally selected for construction will be based upon considerations of initial cost, operating cost over time, the total system footprint (both in the plant room and exhaust tunnel), and the reliability of one option compared to another.

7.19.1 Design Option A: Twin Chillers with Stand Alone Enclosure Air Conditioning System

Design option "A" is presented on Figure 7-5. (The block diagrams do not depict valves, motors, compressors, coolant storage tanks, control circuits, etc.) Two equal capacity chiller units serve all the loads in the upper temperature regime. The condensers for these chiller units reject their heat into the air exhaust tunnel. The chiller evaporators connect to a "ring main" of water glycol. Heat exchangers plumbed to this ring main (see Section 7.19.4) serve all of the loads except the daytime air conditioning of the enclosure. The temperature of the water glycol exiting the chillers into the ring main must be maintained at the target delivery temperature required for the cassegrain instruments and VME buss crates (0 ^{o}C). (Table 7-1).

The low temperature load imposed by the daytime air conditioning of the enclosure is served by a discrete refrigeration system not associated with the water glycol chillers.

7.19.2 Design Option B: Twin Chillers Only

Figure 7-5 presents the thermal block diagram for design option "B". The stand alone system for the daytime air conditioning of the enclosure no longer exists, and all loads are now served by the water glycol ring main. Thus all loads are cooled by the water glycol solution. The water glycol in the ring main must now be below the lower bound value (-8 °C) of the low temperature load regime representing the enclosure air conditioning.

7.19.3 Chiller Capacities for the Design Options

Table 7-4 summarizes the loads and the times the loads will be imposed on the chiller systems. The 7 kW load represented by the modular chiller thermal control system for the primary mirror and active optics (N.I.C.) is included since AURA may elect to cool the condenser of this chiller with water glycol.

Table 7-4. Chiller system load occurrence table

Load Description	Load Occurrence	Load (kW)
Aluminizing operation	Biannual, for one week period	190
Enclosure (daytime) air conditioning	Daytime Only	100
Hydrostatic oil cooling	Observing (Nighttime), possible daytime	50
Support facility conditioned air	Continuous (24 hrs)	20 (Est)
Helium coolers	Observing only (Nighttime)	20
Laser scanner	Every two weeks, for 4 hr period, days	9
Primary mirror thermal control system	Assume continuous (24 hrs)	7
Cassegrain instruments	Assume continuous (24 hrs)	6
VME buss crates	Assume continuous (24 hrs)	5

AURA has estimated the support facility conditioned air load at 20 kW. The minimum nominal capacity of the chiller systems is set by the fact that only the support facility conditioned air load must be maintained while re-coating operations are in progress. To determine the base capacity of the chiller systems, the Contractor shall:

- Determine the support facility conditioned air load (as outlined in Section 7.4);
- Add the 190 kW load imposed by the re-coating operation to obtain the minimum nominal capacity of the chiller system;
- Add a 15% contingency value to the minimum nominal capacity to obtain the baseline capacity of the system;
- Divide the baseline capacity value by two to obtain the baseline capacity, per chiller unit, for the twin chiller system.

7.19.4 Heat Exchangers

The block diagrams of Figures 7-5 and 7-6 depict heat exchangers (for example, "HTX 1" on Figure 7-5) attached to the water glycol ring main created by the twin chiller units. The purpose of these heat exchangers is to "lift" the temperature of the coolant in the ring main so the coolant temperatures at the load inlets are at the target temperature specifications listed on Figure 7-1, and throughout the load database, Section 7.6. Although three heat exchangers are shown (HTX 1, HTX 2, and HTX 3) in the Figures, the Contractor should reevaluate the requirements and specifications for these devices. The final design and selection of the plant room heat exchangers will depend on flow rates, load profiles, ring main temperature, heat exchanger type, and heat exchanger efficiency values. The Contractor shall determine the optimum configuration, as described in the following sections.

7.19.5 Condensers

7.19.5.1 Air Cooled Condensers

Figure 7-5 depicts four modular air cooled compressor/condenser units located in the air exhaust tunnel. The compressors are connected to the evaporators serving the daytime air conditioning of the enclosure. The Contractor may select a different number of condensers if appropriate. The condensers must be located in that portion of the air exhaust tunnel adjacent to the plant room; the condensers may not be sited at any location outside of the tunnel.

Figures 7-5 and 7-6 also depict two air cooled condensers located in the exhaust tunnel associated with the modular chiller units described in the following sections. The Contractor may elect to use more than two condensers in order to distribute the total footprint for these devices (Section 7.10). However, the malfunction of any given condenser must not affect the operation of both chiller units.

7.19.5.2 Fluid Cooled Condensers

The thermal block diagrams do not depict the use of fluid cooled condensers for the large capacity chiller units which form the core of the thermal control system. For such a scenario, the fluid cooled condenser(s) would be located in the plant room, and additional pumps and plumbing would then be required to move the fluid to air cooled heat exchangers located in the exhaust tunnel. Because the fluid cooled condensers would use up more space in the plant room, and because of the added complexity and reliability considerations posed by the additional plumbing and pumps, AURA elected not to consider the use of fluid cooled condensers in the preliminary stages of design requirements. However, the Contractor has the option of utilizing such devices, provided it can be proven they will result in a superior design when ranked by the parameters of initial cost, operating cost, footprint size, and reliability, as described in Section 7.20.

7.20 Selection Criteria for the Chiller Design Options

Contractor will consider the following criteria to determine which of the two chiller design options are selected.

7.20.1 Initial Cost

- The Contractor shall determine the initial cost of both systems, including shipping (to Hilo, Hawaii only).

7.20.2 Operating Cost

- The Contractor shall estimate the yearly operating cost for the two options.

7.20.3 Footprint

The Contractor shall produce footprint layouts for each of the two options. The layouts must include:

- Footprints for all devices located in the plant room. The layouts must include the plant room duct work requirements of Section 7.17;
- Footprints for all devices located in the air exhaust tunnel;
- Footprint sizes for devices located on the chamber floor; the evaporators (chiller design option A), and for the heat exchangers (chiller design option B);
- Elevation view of all devices located in the air exhaust tunnel to determine the pressure drop due to the devices obstructing the cross sectional area of the tunnel and to determine the effect on foot traffic and equipment conveyance through the tunnel (Section 7.10 and 7.13).

7.20.4 Reliability

The Contractor shall compare the reliability of the chiller design options.

7.21 Control

The Contractor shall provide temperature and ventilation control systems for the support facility thermal control system, as specified in the following sections.

7.21.1 Coolant Temperature Control and Coolant Flow Control

The Contractor's load temperature control responsibilities were listed throughout the various entries in the load data base of Section 7.6, and are again listed below for convenience.

The Contractor shall design the control system to regulate the flow rate, and maintain the coolant delivered to the following devices at the target delivery temperatures:

- The duct heat exchangers used to maintain the air temperature within certain rooms inside the support facility;

- The heat exchangers or evaporators used to maintain the (daytime) air temperature inside the telescope enclosure;
- The housings of the helium coolers;
- The housing of the laser scanner;
- The fluid cooled condenser for the hydrostatic bearing oil chiller;
- The housings (or water jackets) of the vacuum pumps and magnetrons in the coating room;
- The heat exchangers used to maintain the air temperature inside the cassegrain instrument package;
- The heat exchangers used to maintain the air temperature inside the VME buss crates.

7.21.2 Location of Temperature Control Consoles

Requirements for temperature control consoles are listed below. The Contractor shall produce layouts showing the locations and approximate sizes of these consoles.

- Temperature control of the support facility conditioned air shall be provided by set point sensors (temperature and humidity) located in the conditioned rooms of the support facility.
- Temperature control of all other loads shall be provided by a single centrally located console in the mechanical plant room.

7.21.3 Ventilation Control

Ventilation control requirements involve the fans and dampers located throughout the support facility and enclosure base structure.

The Contractor's ventilation control design responsibilities are defined as follows:

- Control of low capacity air handling units and dampers located inside the support facility.
- Control of the eight high capacity ventilation fans and backdraft dampers located at the ends of the air exhaust tunnel;
- Control of the damper in the air exhaust tunnel riser;
- Control of the aluminizing facility ventilating fan and damper;
- Control of the plant room ventilating dampers;
- Control of the enclosure base structure shell air flow valves.

7.21.4 Plant Room Ventilation Control Console

The high capacity tunnel ventilation fans and backdraft dampers, and the riser plenum damper shall be operated from a control console located in the plant room. The control console must be equipped with a locally operated selector switch such that the devices can be controlled from the telescope operations room. (control from the control room N.I.C.)

The Contractor shall produce a layout showing the location and approximate size of the ventilating console within the plant room.

7.22 Deliverables

Contractor work requirements for Section 7 of this document include, but are not limited to, the list below, followed by the Section number in which it was described:

1. The heating and cooling loads for the conditioned rooms in the support facility, includes determination of the wall insulation R value; (7.4);
2. The heating load for the coating plant room, includes determination of the wall insulation R value (7.4);
3. Thermal design for the support facility roof (7.4.2);
4. The fan types, fan capacities, fan pressure ratings, and fan hardware requirements for the distribution of conditioned air in the support facility (7.8.1);
5. The performance curves for the exhaust tunnel fans, along with drawings itemizing all fan dimensions, including data concerning the back draft dampers. Fan noise data must be included (7.8.2.1);
6. The number of fans, and fan performance data for ventilation of the aluminizing room (7.8.2.2);
7. The dimensions of the riser conduit joining the support facility air exhaust tunnel to the enclosure air plenum (7.10);
8. The size, mounting details, and operating hardware for the riser damper (7.10);
9. The flow pressure loss due to the riser damper (7.10);
10. The E.O.T. of the devices rejecting heat into the air exhaust tunnel (7.10);
11. Recommendation of the technique for air exhaust tunnel heat removal (7.10);
12. Method of mounting devices in the air exhaust tunnel (7.10);
13. Layouts of the high capacity fans in the exhaust tunnel ends, showing dampers (7.13);
14. Layouts of the ring plenum and the stationary chamber floor, detailing how the flow is balanced (7.13);
15. Layouts of the enclosure to base structure interface, detailing the air seals (7.13);
16. Layouts of the base structure shell air flow valves, detailing the valve dimensions and valve actuation hardware (7.13);
17. Calculations itemizing air seal friction (7.13);
18. Calculations itemizing pressure drop (7.13);
19. Layout(s) of fan, inlet damper, and control box locations for the aluminizing facility, including locations of heaters and temperature sensor(s) (7.14, 7.15);
20. Design of fan and filter system to keep coating plant room air at positive pressure, and layout of the fan, filter, and control box (7.14.1);
21. Duct work layouts for distributing conditioned air to the support facility rooms, including locations of temperature and humidity sensors (7.17);
22. Layouts showing the size, type, and locations of the plant room ventilating louvers (7.18.2);
23. Determination of chiller capacity (7.19.3);
24. Number, type, and size of heat exchangers (7.19.4);
25. Number, type, and size of condensers (7.19.5);
26. Initial cost of chiller options (7.20.1);
27. Operating cost of chiller options (7.20.2);
28. Footprints for chiller options (7.20.3);

29. Reliability of chiller options (7.20.4).
30. Design of coolant temperature and flow control system (7.21.1);
31. Layouts showing locations and sizes of temperature control consoles (7.21.2);
32. Design of ventilation control systems (7.21.3);
33. Layout showing the location and size of the plant room ventilation console (7.21.4).

List of References

1. Harding Lawson Associates, "Preliminary Geotechnical Recommendations, Proposed Gemini 8-Meter Telescope, Mauna Kea, Island Of Hawaii, Hawaii," HLA Job No. 21540.1,2841MI, January 18, 1993.

2. IDIEM, "Geotechnical Characterization - Pachon Hill," Vols I and II, 1992

Figures