GEMINI
OBSERVATORY

MCAO Adaptive Optics Module Electronics Enclosure Thermal Calculations

MCAO Preliminary Design Review Material

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This appendix consists of four sets of thermal calculations based on four different sets of ssumptions. There are two variables in question. The first is the heat input and the second is the coolant flow rate.

Most of the heat generated in the electronics enclosures comes from the deformable mirror drivers. Two different approaches to these electronics give two significantly different heat loads. Tom Price of Xinetics estimated heat output from the deformable mirror drivers of about 3 kW. There is an additional load from the other electronics of about 1.4 kW (as estimated by Mark Hunten) for a total of 4.4 kW. Paul Clark of the University of Durham estimates a heat load of 1.1 kW for his driver design, yielding a total of 2.5 kW.

The normal coolant flow rate supplied by the telescope infrastructure is 11.3 liters/minute. If necessary, by installing a larger pump, the flow rate can be increased to about 22 liters/minute.

Tables 1 and 2 show the two flow rates as applied to the Xinetics estimate. Tables 3 and 4 show the same two flow rates as applied to the University of Durham estimate.

Thermal Calculations for AO Module

Study 1: Based on Xinetics supplied heat load estimate of 4.4kW and coolant flow rate of 11 liters per minute

PART 1: TEMPERATURE RISE OF COOLANT IN ELECTRONIC BOXES

GIVEN:				
Coolant Density (Water)	1	gm/ml =	1000	gm/liter
Coolant Flow Rate:	11	liter/min =	11000	gm/min
Heat Load:	4.4	KW =	63007	Cal / min
Coolant Specific Heat:	1	Cal/gm*C		
ASSUME:				
Ambient Temp:	5	Cent.		
Inlet Temp = Ambient - 5:	0	Cent.		
FIND:				
D T:	6	Cent.		
Outlet Temp	6	Cent.		

PART 2: AVERAGE AIR TEMPERATURE IN ENCLOSURES

ASSUME:		
T = Coolant outlet temp + 6 =	12	Cent.

PART 3: HEAT LOSS TO ISS

ASSUME:			
Insulation: Plastazote LD45 (Same as Altair)			
Thickness of Delrin Pads:	0.01	m	
Thickness of Insulation:	0.025	m	
GIVEN:			
Frame temperature:	12	Cent.	
Conductivity of insulation:	0.043	W/mK	
Conductivity of Delrin:	0.25	W/mK	
Delrin pad Area:	0.063	m^2	
Insulated Area:	1.5	m^2	
FIND:			
Delta T:	7	K	
Heat loss into ISS:	11	W	50W max.

PART 4: HEAT LOSS TO DOME

ASSUME:			
Insulation: Plastazote LD45 (Same as Altair)			
Thickness at Optics:	0.1	m	
Thickness elsewhere:	0.05	m	
GIVEN:			
Conductivity of insulation:	0.043	W/mK	
Area at Optics:	5.2	m^2	
Area elsewhere:	12.1	m^2	
FIND:			
Heat loss into optics:	15	W	
Heat loss into dome:	70	W	
Total heat loss:	85	W	50W max

Table 1

Thermal Calculations for AO Module

Study 2: Based on Xinetics supplied heat load estimate of 4.4kW and coolant flow rate of 22 liters per minute

PART 1: TEMPERATURE RISE OF COOLANT IN ELECTRONIC BOXES

GIVEN:				
Coolant Density (Water)	1	gm/ml =	1000	gm/liter
Coolant Flow Rate:	22	liter/min =	22000	gm/min
Heat Load:	4.4	KW =	63007	Cal / min
Coolant Specific Heat:	1	Cal/gm*C		
ASSUME:				
Ambient Temp:	5	Cent.		
Inlet Temp = Ambient - 5:	0	Cent.		
FIND:				
D T:	3	Cent.		
Outlet Temp	3	Cent.		

PART 2: AVERAGE AIR TEMPERATURE IN ENCLOSURES

ASSUME:		
T = Coolant outlet temp + 6 =	9	Cent.

PART 3: HEAT LOSS TO ISS

ASSUME:			
Insulation: Plastazote LD45 (Same as Altair)			
Thickness of Delrin Pads:	0.01	m	
Thickness of Insulation:	0.025	m	
GIVEN:			
Frame temperature:	9	Cent.	
Conductivity of insulation:	0.043	W/mK	
Conductivity of Delrin:	0.25	W/mK	
Delrin pad Area:	0.063	m^2	
Insulated Area:	1.5	m^2	
FIND:			
Delta T:	4	K	
Heat loss into ISS:	6	W	50W max.

PART 4: HEAT LOSS TO DOME

ASSUME:			
Insulation: Plastazote LD45 (Same as Altair)			
Thickness at Optics:	0.1	m	
Thickness elsewhere:	0.05	m	
GIVEN:			
Conductivity of insulation:	0.043	W/mK	
Area at Optics:	5.2	m^2	
Area elsewhere:	12.1	m^2	
FIND:			
Heat loss into optics:	9	W	
Heat loss into dome:	40	W	
Total heat loss:	49	W	50W max

Table 2

Thermal Calculations for AO Module

Study 3: Based on University of Durham supplied heat load estimate of 2.5kW and coolant flow rate of 11 liters per minute

PART 1: TEMPERATURE RISE OF COOLANT IN ELECTRONIC BOXES

GIVEN:				
Coolant Density (Water)	1	gm/ml =	1000	gm/liter
Coolant Flow Rate:	11	liter/min =	11000	gm/min
Heat Load:	2.5	KW =	35799	Cal / min
Coolant Specific Heat:	1	Cal/gm*C		
ASSUME:				
Ambient Temp:	5	Cent.		
Inlet Temp = Ambient - 5:	0	Cent.		
FIND:				
D T:	3	Cent.		
Outlet Temp	3	Cent.		

PART 2: AVERAGE AIR TEMPERATURE IN ENCLOSURES

ASSUME:		
T = Coolant outlet temp + 6 =	9	Cent.

PART 3: HEAT LOSS TO ISS

ASSUME:			
Insulation: Plastazote LD45 (Same as Altair)			
Thickness of Delrin Pads:	0.01	m	
Thickness of Insulation:	0.025	m	
GIVEN:			
Frame temperature:	9	Cent.	
Conductivity of insulation:	0.043	W/mK	
Conductivity of Delrin:	0.25	W/mK	
Delrin pad Area:	0.063	m^2	
Insulated Area:	1.5	m^2	
FIND:			
Delta T:	4	K	
Heat loss into ISS:	7	W	50W max.

PART 4: HEAT LOSS TO DOME

ASSUME:			
Insulation: Plastazote LD45 (Same as Altair)			
Thickness at Optics:	0.1	m	
Thickness elsewhere:	0.05	m	
GIVEN:			
Conductivity of insulation:	0.043	W/mK	
Area at Optics:	5.2	m^2	
Area elsewhere:	12.1	m^2	
FIND:			
Heat loss into optics:	10	W	
Heat loss into dome:	44	W	
Total heat loss:	54	W	50W max

Table 3

Thermal Calculations for AO Module

Study 4: Based on University of Durham supplied heat load estimate of 2.5kW and coolant flow rate of 22 liters per minute

PART 1: TEMPERATURE RISE OF COOLANT IN ELECTRONIC BOXES

GIVEN:				
Coolant Density (Water)	1	gm/ml =	1000	gm/liter
Coolant Flow Rate:	22	liter/min =	22000	gm/min
Heat Load:	2.5	KW =	35799	Cal / min
Coolant Specific Heat:	1	Cal/gm*C		
ASSUME:				
Ambient Temp:	5	Cent.		
Inlet Temp = Ambient - 5:	0	Cent.		
FIND:				
D T:	2	Cent.		
Outlet Temp	2	Cent.		

PART 2: AVERAGE AIR TEMPERATURE IN ENCLOSURES

ASSUME:		
T = Coolant outlet temp + 6 =	8	Cent.

PART 3: HEAT LOSS TO ISS

ASSUME:			
Insulation: Plastazote LD45 (Same as Altair)			
Thickness of Delrin Pads:	0.01	m	
Thickness of Insulation:	0.025	m	
GIVEN:			
Frame temperature:	8	Cent.	
Conductivity of insulation:	0.043	W/mK	
Conductivity of Delrin:	0.25	W/mK	
Delrin pad Area:	0.063	m^2	
Insulated Area:	1.5	m^2	
FIND:			
Delta T:	3	K	
Heat loss into ISS:	4	W	50W max.

PART 4: HEAT LOSS TO DOME

ASSUME:			
Insulation: Plastazote LD45 (Same as Altair)			
Thickness at Optics:	0.1	m	
Thickness elsewhere:	0.05	m	
GIVEN:			
Conductivity of insulation:	0.043	W/mK	
Area at Optics:	5.2	m^2	
Area elsewhere:	12.1	m^2	
FIND:			
Heat loss into optics:	6	W	
Heat loss into dome:	27	W	
Total heat loss:	33	W	50W max

Table 4