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Refer to: T010063-00-E
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Ref: HVAC specification for the new LDAS facilities being built at the observatories

In order to specify the requirements for the cooling capacity for the LDAS facilities that are being built at both observatories, a thermal load spreadsheet was developed using the best information available at the time to estimate the generation of heat by LDAS hardware. The immediate goal was to ensure that the LIGO I LDAS hardware installations at all sites would be operated in a adequately cooled environments for the period CY2001 – CY 2006. These heat loads were derived in the attached PDF copy of the Excel spreadsheet, "LDASPowerConsumption_v2.xls". *Note that this analysis deals only with LIGO I* since the LDAS configuration for advanced LIGO is not yet defined. A reasonable assumption is that 2X as much heat rejection capacity will need to be accommodated in the same space by, say, CY2006-2008. A follow-up analysis will be performed as the advanced LIGO computing systems become defined.

In discussions with O. Matherny prior to and during the CCB of 29 May 2001, it was pointed out that the previous analysis was silent on the thermal and humidity stability of the facilities. I was asked to develop a more complete specification. ***This information applies equally to both LHO and LLO.***

I have assimilated the following information:

[1] I contacted Mr. John Klohoker, the JPL contract reliability engineer, whom we have used in past analyses, for information on the long term effect of operating electronic equipment at elevated (85F-90F) temperatures. I had discussed with Otto the possibility of allowing the LDAS hardware to experience temperatures in this range. (see item #2 below). I was informed that extended operation at elevated temperatures has been shown

statistically to “reduce reliability of hardware by 10%-15%”. This corresponds to an increase in the failure rate per unit time between 1.11X - 1.18X.

[2] The concern that excessive ambient operating temperatures may stress LDAS hardware *exists today!* Recent experience at LHO leads us to believe that mitigation may be required for the Staging Building Mezzanine area where the LDAS hardware will initially be located. During the week of 22 May, Greg Mendell observed the following. There occurred a two-day period with daily highs of 101F and 98F, respectively. During that period, the air conditioning ran continuously day and night because the building temperature never dropped below the thermostat low setpoint of 69F. On the first of these days the temperature reached over 80 in the LDAS mezzanine area. The first night it cooled to the low 70s, and then the second day the upstairs once again reached a high of 78F-79F. *The indication is that the staging area HVAC plant is either insufficient or improperly tuned to keep the mezzanine cooled to the required temperature range.*

[3] A search of the Sun Microsystems www site by Greg Mendell uncovered a design guide document to specifying the construction of new computer areas: "Sun Microsystems Data Center Site Planning Guide". The interested reader is referred to http://www.ligo.caltech.edu/~lazz/distribution/SunCompRmSpec805-5863-10.pdf. *Sun states on p 29 that an ambient temperature range of 70 to 74 F (21 to 23 C) is optimal for system reliability and operator comfort levels. On p30, Sun states that the relative humidity range of 45% - 50% is optimal. On p34 Sun states that data centers need precision air conditioners, and need to be set accurately with a sensitivity of +/- 2 F and +/- 3% relative humidity. On p31, below Table 3-1, Sun states that temperature gradients should be less than 5 F per hour and 10% RH per hour.*

[4] The more relaxed specification that O. Matherny wants to use was suggested by device specifications for our T3 RAID arrays. These are also to be found at the Sun site, http://www.sun.com/storage/t3wg/specs.html . Greg had provided Otto with the numbers from this web page. The specifications for the T3 listed there are much more tolerant than the ones listed in the data center design document. I have asked for clarification from Sun on this matter. I suspect that the device specifications provide worst case extremes rather than recommended optimal environments.

[5] I checked with CACR at Caltech. Their unofficial recommendation is in accord with that found in the Sun design document in item #3 above: “*Temperature variations should be no more than +/- 6F in any 24 hour period and never more than +/- 4F in one hour. An overall range between 68F and 80F is reasonable*”.

Recommendations/ Requirements:

1. New LDAS facilities being built at BOTH SITES should follow the "Sun Microsystems Data Center Site Planning Guide" recommendations, in item #3 above.

2. The LHO Staging Building HVAC system needs to be tuned immediately to provide better performance in the LDAS Mezzanine area.

al: AL
cc: Sanders
Weiss
Coyne
Blackburn
Mendell
Document Control Center
Barish
Shoemaker
Whitcomb
Anderson
Roddy

REVISED Thermal budget estimate for the computer room in the Synchrotron Building Rm. 215 (mezzanine) for LIGO & SRL use

This revision reflects the implementation of large RAID 5 systems instead of large robotic tape systems

I. LIGO equipment

	Unit type	Number of Units (max)	Current per unit (idle)	Current per unit (active)	Volts AC	kWatts	BTU/hr
Data servers	Sun E450, 4xCPU, 1 GB RAM, 10 disks	4	4.0	--	120.0	**1.9**	**6553**
Disk farm, IDE/SCSI RAID 5	??? 1 TB Unit	8	7.5	--	120.0	**7.2**	**24573**
Disk farm, F/C RAID 6	Sun T3, 0.544 TB	2	--	3.8	120.0	**0.9**	**3072**
Beowulf cluster	PC, 1xCPU	200	0.7	--	120.0	**16.8**	**57338**
					Totals for LIGO	**26.8**	**91536**

II. SRL equipments

	Unit type	Number of Units (max)	Current per unit (idle)	Current per unit (active)	Volts AC	kWatts	BTU/hr
Minimum estimate	--	--	--	--	--	**5**	**17065**
Maximum estimate	--	--	--	--	--	**10**	**34130**
					Totals for SRL*	**5**	**17065**

*Uses maximum estimate; however the minimum is more likely

III. Totals

	Amps @ 120 VAC	kW	BTU/hr
Maximum estimate	**307**	**37**	**125666**
Minimum estimate	**265**	**32**	**108601**
Nominal Estimate	**265**	**32**	**108601**

Thermal budget estimate for Hanford

	Unit type	Number of Units (max)	Current (idle)	Current (active)	Volts AC	kWatts	BTU/hr
Data servers	Sun E450, 4xCPU, 1 GB RAM, 10 disks	3	4.0	--	120	**1.44**	**4915**
Disk farm, F/C	Sun T3, 0.544 TB	26	--	3.8	120	**11.70**	**39932**
Beowulf cluster	Linux box	104	0.7	--	120	**8.74**	**29816**
SMP boxes	Linux 4x CPU	3	2.0	2.8	120	**1.01**	**3440**
Workstations	Ultras, Sun	5	0.7	--	120	**0.42**	**1433**
Tape Robot	AIT-2	1	0.5	2.0	120	**0.24**	**819**
	Timberwolf/STK		1.0	6.0	120		

Totals

	Amps @ 120 VAC	kW	BTU/hr
Maximum estimate Minimum estimate Nominal Estimate	**196**	**24**	**80355**

Thermal budget estimate for Livingston

	Unit type	Number of Units (max)	Current (idle)	Current (active)	Volts AC	kWatts	BTU/hr
Data servers	Sun E450, 4xCPU, 1 GB RAM, 10 disks	3	4.0	--	120	**1.44**	**4915**
Disk farm, F/C	Sun T3, 0.544 TB	14	--	3.8	120	**6.30**	**21502**
Beowulf cluster	Linux box	56	0.7	--	120	**4.70**	**16055**
SMP boxes	Linux 4x CPU	3	2.0	2.8	120	**1.01**	**3440**
Workstations	Ultras, Sun	5	0.7	--	120	**0.42**	**1433**
Tape Robot	AIT-2	1	0.5	2.0	120	**0.24**	**819**
	Timberwolf/STK		1.0	6.0	120		

Totals

	Amps @ 120 VAC	kW	BTU/hr
Maximum estimate Minimum estimate Nominal Estimate	**118**	**14**	**48164**

Thermal budget estimate for MIT

	Unit type	Number of Units (max)	Current (idle)	Current (active)	Volts AC	kWatts	BTU/hr
Data servers	Sun E450, 4xCPU, 1 GB RAM, 10 disks	1	4.0	--	120	**0.48**	**1638**
Disk farm, F/C	Sun T3, 0.544 TB	1	--	3.8	120	**0.45**	**1536**
Beowulf cluster	Linux box	30	0.7	--	120	**2.52**	**8601**
SMP boxes	Linux 4x CPU	2	2.0	2.8	120	**0.67**	**2294**
Workstations	Ultras, Sun	2	0.7	--	120	**0.17**	**573**
Tape Robot	AIT-2	1	0.5	2.0	120	**0.24**	**819**

Totals

	Amps @ 120 VAC	kW	BTU/hr
Maximum estimate			
Minimum estimate			
Nominal Estimate	**38**	**5**	**15461**

Electrical parameters for thermal budget estimates

[BTU/hr]/Watt = 3.41297

	Unit type	Current per unit (idle)	Current per unit (active)	Volts AC	Watts per unit	BTU/hr per unit
Data servers	Sun E450, 4xCPU, 1 GB RAM, 10 disks	**4.0**	**--**	**120**	**480**	**1638**
Disk farm, RAID 5 IDE/SCSI 1 TB	?	**7.5**	**--**	**120**	**900**	**3072**
RAID 5, T3	Sun T3, per 544 (user) GB	**--**	**3.75**	**120**	**450**	**1536**
Linux workstation	PC	**0.7**	**--**	**120**	**84**	**287**
Linux server	4xCPU SMP PC	**2.0**	**2.8**	**120**	**336**	**1147**
Linux server	2xCPU SMP PC	**1.0**	**1.6**	**120**	**192**	**655**
Tape Robot	Large, Timberwolf	**1**	**6.0**	**120**	**720**	**2457**
Tape Robot	Small, AIT-2	**0.5**	**2.0**	**120**	**240**	**819**