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Temperature and Humidity Requirements for STAR

REV. A - February 23, 1996 -- Reduced the acceptable humidity level and set the electronic cooling to 60 F. Revised the date that the HVAC system needs to be ready. Clarified the nominal operating temperature. Reduced the allowed temperature variation in the WAH. These changes have been reflected in modifications to Requirements 2, 3, 4, 5, 6, and 8.

REV. B - March 6, 1996 Reformatted the document to distinguish between requirements which will affect the hall air conditioning system and requirements which may only affect a very localized area (e.g. SVT volume only).

Required Signatures:

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Temperature and Humidity Requirements for STAR

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This document is broken into two parts. Part A presents STAR Detector temperature and humidity requirements which will likely influence the requirements that the building air conditioning and heating system must satisfy for proper operation of the STAR detector. Temperature and humidity bounds are stated for the Wide Angle and Assembly Hall. Some parameters for the rack cooling system are also presented. Part B presents the specific SVT temperature and humidity requirements. We present these separately so that RHIC management and the designer of the building HVAC system can determine whether it's more cost effective to meet these requirements through the building AC system or by the SVT Group adding a separate, small capacity AC system especially for this small volume.

Part A

The STAR detector will operate in two distinct modes. When the detector is in the Wide Angle Hall (WAH), physics data and calibrations can be taken. When the detector is in the Assembly Hall (AH), assembly and repair are the main tasks. Therefore, we need to establish criteria for operating the detector in both areas. Temperatures are defined at beam height which is 170" or about 14'.

Requirement 1: The STAR climate control system shall allow the complete detector to operate every day. However, due to budget constraints we will allow either a full or partial shut down of the detector because of extreme outside temperatures for no more than 1 day/year while the detector is in the WAH and for no more than 10 days/year while it is in the AH.

Justification: Beam time at RHIC is very expensive. It is not cost effective to have circulated beam and for STAR not to be able to use it. Because of the long time (of order one month) to move the STAR detector from one hall to the other, there will be limited time to test the detector. The number of days to move the STAR detector are limited because we can only move STAR when RHIC is shutdown. There needs to be enough days to install new instruments and make repairs. Because the schedule is extremely tight there should not be a significant number of days when testing is prohibited.

Requirement 2: During operation of the magnet, the HVAC system must keep the temperature in the area where the magnet resides (ie, WAH or AH) less than the mean temperature of the magnet coils (85 F). Therefore, the maximum temperature in this vicinity should be 80 F or less, nominally 75 F.

Justification: To maintain the position of the coils, the mechanical design of the magnet relies on the condition that the temperature of the return steel is always less or equal to the temperature of the coils. With the expected coil temperature of 85 F during operation, this condition is met as long as the room temperature is somewhat below this value.

Some of the electronics and electrical equipment will be in the open air. For proper operation of the TPC laser the temperature of either Hall has to be less than 90 F. It will be necessary to supply make-up air to the water cooled racks. If the temperature of the make-up air is too high, then requirement 10 cannot be satisfied.

Requirement 3*:* During the magnet assembly phase, the temperature in the AH should be between 65 and 75 F.

Justification: Because of the magnet design, it is required that the coil packages always be under some compression in order to maintain their position. The magnet must be assembled at a temperature lower than the operating temp. so that compression is maintained in the coils. (This way since the aluminum coils expand at a higher rate than the return steel, you never loose compression.) The low end of the temperature requirement comes about because the coil packages are structurally limited to a maximum delta T of 30 F between the steel and the coils. If the magnet were assembled at 60 F and the maximum operating temperature of the coils were 90 F, we would be right at this limit. Backing away from this limit slightly results in the selected 65 F.

Requirement 4: The temperature regulation should be ±5 F or better in the WAH and AH.

Justification: Several components in STAR are very sensitive to temperature fluctuations. Differential temperature changes in the VPD cables will produce timing changes. The TPC laser can go out of calibration if the temperature change is too great. The factory specification for the TPC laser is ±3 C per 8 hours. During assembly of the magnet, there is a requirement to regulate the temperature to ±5 F in the assembly hall.

Requirement 5: The heating system must be able Requirement 3 by Fall of 1996 while the cooling system must be operational by April 1997.

Justification: Assembly of the steel is scheduled to start during the fall. Temperature must be stable for proper assembly and alignment. In order to satisfy requirement 3, it will be necessary to have the building at the proper temperature at that time. The cooling system has to be operational for the same reason before the warmer months begin.

Requirement 6: The allowable humidity for both the WAH and AH should be maintained between 10% and 60% during Detector testing and operation. Note: It must also be low enough that requirements 7 & 8 are satisfied.

Justification: A TPC sector is the most sensitive element to humidity. Measurements have shown that unsatisfactory leakage current occurs when the relative humidity is greater than 60%. We put the TPC humidity requirements and an unscientific survey of manufacturer's humidity requirements in the following table:

Humidity Upper Limit	**Humidity Lower Limit**
TPC @ 60%	
4 electronic items @ 95%	6%
4 electronic items @ 90%	8%
Power PC @ 80%	
TPC Laser @ 75%	
Specification 60%	Specification 10%

From this table, we take the lower humidity for STAR to be 10% with the maximum allowed humidity to be 60%. A separate enclosure for the detector would be more expensive and much less reliable than controlling the humidity.

Requirement 7: There should be no condensation of water in the detector or on any electronics. The dew point of the air shall always be below the temperature of cooling pipes located near electronics in either location (WAH or AH).

Justification: From experience working with detectors, we have found that high humidity can ruin electronics. For instance, there was extensive damage to electronics in the HISS cave at LBL until a heating system was installed to reduce the humidity. Quantitative tests have shown that moisture will damage energized electronics.[1]

The temperature of the heat exchanger will be approximately the same as the cooling water. To prevent condensation on the heat exchanger, the dew point of the air must be lower than the temperature of the heat exchanger.

Requirement 8: The minimum input water temperature for cooling water into the racks is 60 F.

Justification: It is necessary to keep the electronics operating at a low temperature to prevent chip failure. A suitable heat exchanger has been found. It needs 60 F cooling water. Engineering studies have shown that it is much less costly for the cooling system to be operated at one temperature rather than two. Therefore, we need to have the water cooling temperature at the same setting for the WAH and AH.
The cooling water to the TPC will be set at 75 F which is less stringent than the temperature requirements for the rack cooling water. Therefore, the temperature of the cooling water into the racks determines the dew point described in Requirement 7.

Requirement 9: The maximum temperature differential for an electronic module is 10 C (18 F).

Justification: To prevent excessive thermal stress in a crate, the FASTBUS specification is 20 C (36 F) rise. However, the FASTBUS specification assumes that the cooling water is much colder than we are using. A 10 C rise will allow Requirement 10 to be satisfied

Requirement 10: The maximum air temperature in a crate is 90 F.

Justification: For each 10 C increase in temperature, the probability that an IC fails increases by a factor two. Because much of STAR is located in a radiation area where there is limited accessibility, all electronics must be extremely reliable. Experience has shown that 90 F is the maximum comfortable temperature to run electronics.

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[1]West -Cap Ceramic Chip Capacitor Handbook, West-Cap Division, San Fernando Electric Manufacturing Co. 1501 First Street, San Fernando, CA 91341.

Part B

(The following supplemental requirements are for the SVT).

Requirement 5b: The temperature regulation should be ±3 F or better in the SVT volume.

Justification:: The SVT needs better temperature regulation and stability. Studies have shown that the temperature should not be above 78 F and that the regulation should be ±3F or better.

Requirement 8b: The allowable humidity within the SVT volume in both the WAH and AH should be maintained between 10% and 65%. The drift in humidity should be no greater than 3%/hour.

Justification: Just as for the TPC, the SVT prefers lower humidity. As the humidity changes, the SVT's calibration changes. By restraining the change to less than 3%/hour within the SVT volume, the recalibration task is straight forward.