EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE

CERN - ST Division

CERN-ST-2001-005
30 January 2001

UPGRADING OF THE AIR-CONDITIONING OF THE COMPUTER ROOM IN THE COMPUTER CENTRE FOR THE LHC ERA

J. Lindroos and G. Peón

Abstract

Built in the beginning of 1970's, the Computer Centre air-conditioning and cooling systems were designed to be modular and easily adaptable to the unpredictable future needs of computing. The infrastructure of LHC-computing that will be housed in the existing Computer Room with its five Computing farms and over 11000 PC's increases the requirements of cooling and air-conditioning power to a new level. The nominal thermal loads from the equipment rise from the current design maximum of 1MW to estimated maximum of 2MW in the future. This paper presents calculations and proposes solutions to meet the new nominal requirements. The air-conditioning system must also be able to cope with a situation of power cut in the main supply. A calculation of the temperature evolution during the power cut and a justified operation strategy for this scenario is also presented.

Presented at the 4th ST Workshop
Chamonix, France, 30 January - 2 February 2001

1 INTRODUCTION

This paper presents the main modifications needed to the existing air-conditioning system of the Computer Room in the Computer Centre to maintain the present ambient conditions, when the heat dissipation from the equipment be 2MW. This is the announced heat load after year 2005, the start of LHC computing. The temperature conditions in the Computer Room in steady state and power cut situations are also presented with conclusions and propositions for further studies.

1.1 History

The construction of the Computer Centre was started end of 1960's and the installation and start-up of the air-conditioning system was done in the beginning of 1970's when the operation was moved from building 510 to this new building 513. The requirements for air-conditioning were rigorous. The system was to be designed and constructed in a manner that allowed any kind of data handling equipment to be installed without needing major modification on the air-conditioning system. This means for example that the air could be supplied both from the ceiling and from the false floor. The false floor option has not been used up to this day but it can prove to be useful in the future. Free cooling was one of the innovative aspects of the system. Although it was not very much used at that time, it has shown to be very energy efficient as the chillers can be stopped for long periods of time.

The thermal loads in the old computer centre in building 510 were measured and a thermal load twice the measured one was used as the baseline for the design. In thirty years, there has not been any problem with the cooling power of the system. Some of the chiller's power has later been taken for other installations than the Computer Room. After the reception of the installation, the Computer Centre air-conditioning was proposed as a reference for future installations on computer rooms.

1.2 The Existing Air-conditioning System

The Computer Centre air-conditioning was originally designed to cover the 2'080 m^2 Computer Room and annexed office blocks. Today, the Computer Room is divided by a wall and only 1'440 m^2 is occupied by computers. The rest is occupied by office barracks (Barn area) built inside the hall.

Altogether 10 stations placed on the roof level serve the Computer Room and the annexed office blocks. The stations have functions for filtering, cooling (all stations), heating (two stations) and humidification. A maximum of 8 stations is allowed to operate simultaneously, 2 being in redundancy. The current nominal cooling power is 1,3 MW for the Computer Room (1.05 MW for the equipment and 0.25 MW from lighting and external loads) and 0.55 MW for the office blocks. The total cooling power is therefore 1,85MW. With all the system overheads (fresh air cooling, - fan motors etc.), the nominal cooling requirements account for 2.4 MW. However, at present, only 4 or 5 stations operate at the same time due to the low thermal load in the Computer Room (estimated load in the room 0.5 MW).

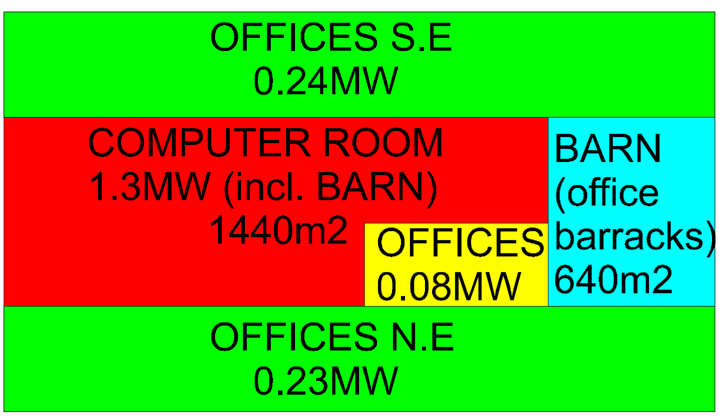


Figure 1: Cooling power distribution in the Computer Centre

Two out of three 1.2 MW chillers installed in parallel produce the chilled water needed by the stations. The third one is on redundancy.

The stations deliver air at constant temperature of 14°C to the common concrete plenum. From here, the air goes to the Computer Room via steel ducts and supply air plenums. The exhaust air is sucked from above the false ceiling. The 14 ambient air temperature probes situated in different zones of the Computer Room control 119 motorized regulation dampers in the supply air ducts to keep the temperature at a given set point value.

Normally the ventilation operates on free-cooling from autumn to spring, however some users need cooling also during this period and for them there is a smaller chiller of 200kW dedicated for this purpose.

The three cooling towers located on the roof have been renewed in 1998. They serve the condensers of the chillers and have a total capacity of 4,5MW.

Figure 2: Scheme of the existing chilled water network

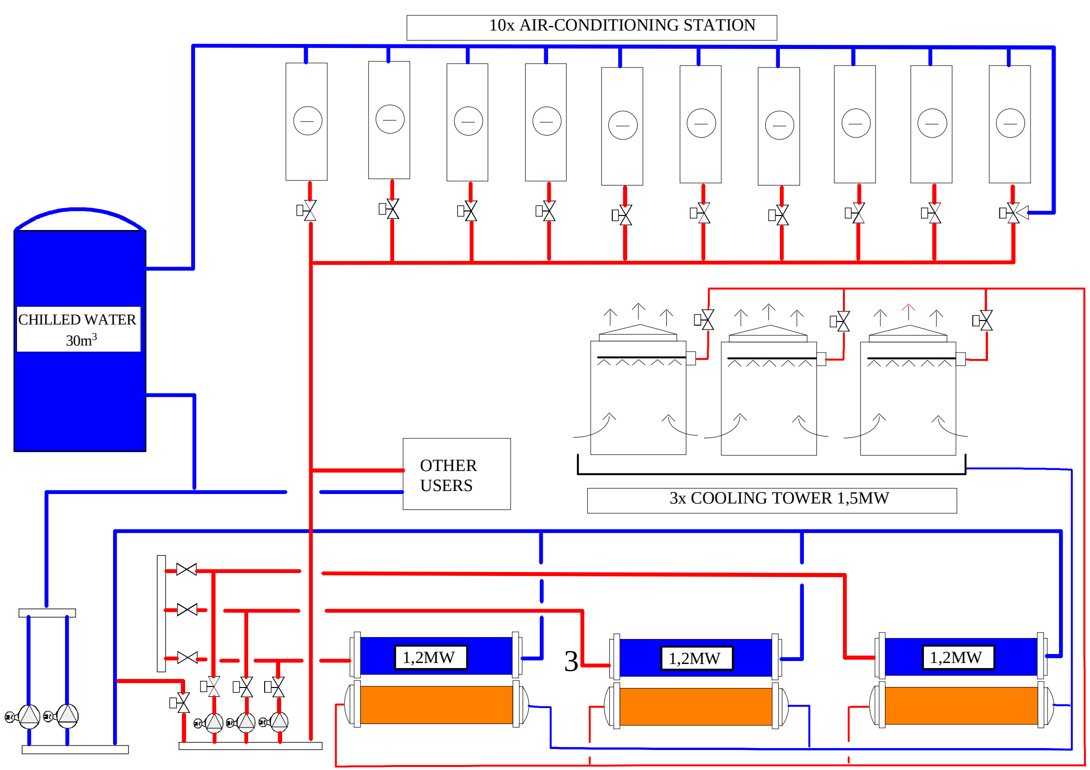
1.3 Air-conditioning in the LHC Era

To meet the cooling requirements of the LHC computing, modifications to the existing system and some new installations are needed. To cover the additional need for space for the equipment, the barn area is transformed back to a computer room.

To supply the needed air flow to the Computer Room, all annexed spaces must be disconnected from the system. This way all the stations are available for the Computer Room and the maximum air flow can be obtained. Maximum nine stations out of the 10 would be operating simultaneously, leaving 1 station for redundancy.

The existing chilled water capacity is not sufficient to cover the future needs. One chiller of 1,2MW has to be added to supply the needed chilled water cooling to the stations and to cover the needs of the other users also.

The installed cooling towers however can provide enough cooling for the chillers in these new conditions.



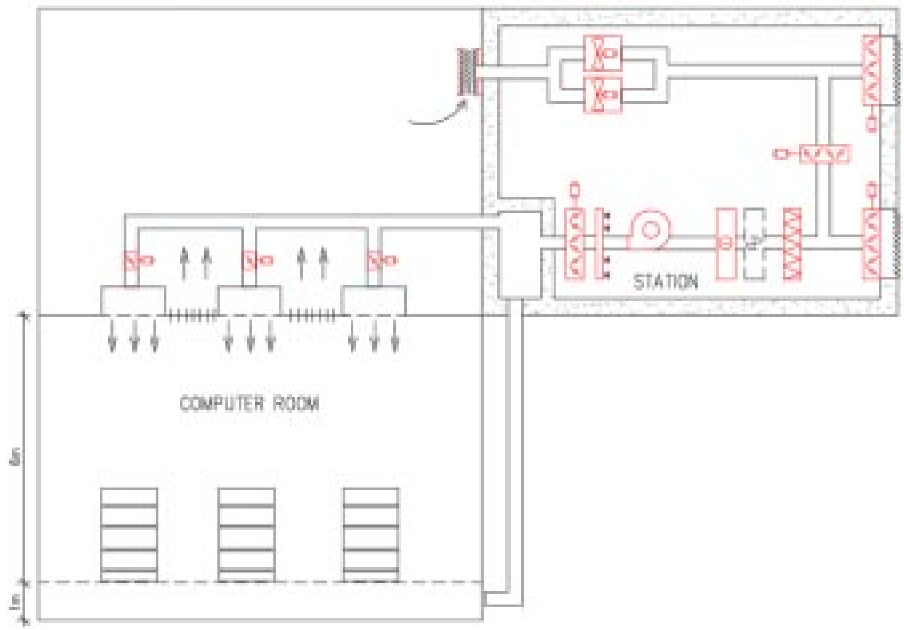


Figure 3: Scheme of the air conditioning system in the Computer Room

Table 1
Comparison table between present and future installation

Value	Today	LHC era
Area	1440m^2	2000m^2
Volume	8640m^3	12000m^3
Max. number of stations operational	8 (+2 in redundancy)	9 (+1 in redundancy)
Air flow per station	85 000 m^3/h	85 000 m^3/h
Maximum air flow	680 000m^3/h	765 000m^3/h
Flow to Computer Room (inc. The Barn)	430 000m^3/h	765 000m^3/h
Flow to office blocks	250 000m^3/h	-
Fresh air flow	25 000m^3/h	6 000m^3/h
Maximum heat dissipation from Eq.	1,05MW	2MW
Total dissipation in the Computer Room	1,3MW	2,25MW
Total cooling in nominal conditions	2,4MW	2,7MW
Temperature difference	14/22°C (dT 8°C)	14/23°C (dT 9°C)
Chilled water capacity	2,4MW	3,6MW
Cooling tower capacity	4,5MW	4,5MW
Electrical power supply	1500kW	1800kW
Secured power supply	22kW	500kW

2 STEADY STATE CASE STUDY

In the steady state situation the total heat dissipation from the equipment is 2MW and the 9 air-conditioning stations are delivering 765000m^3/h of air at temperature of 14°C.

2.1 Presentation of the Model

In order to estimate the temperature around the computers, a model of the Computer Room has been made. The computers are housed in 400 racks arranged in a repetitive manner. Taking profit of the repetitive pattern and to reduce computing time, only the simplest repetitive unit has been modeled. It consists of half a rack that contains four layers of computers. To better remove the heat generated in the computers, the computers are equipped with fans. The air passage through the computers is represented in green in the left figure of Fig. 3. The four planes in the XZ plane of the right figure of Fig. 3, represent an hypothetical heat dissipating surface of the computers. The red arrows represent the air supply through a grill and the green surface represent the exhaust plane. All the four limiting planes of the model have symmetry boundary conditions applied.

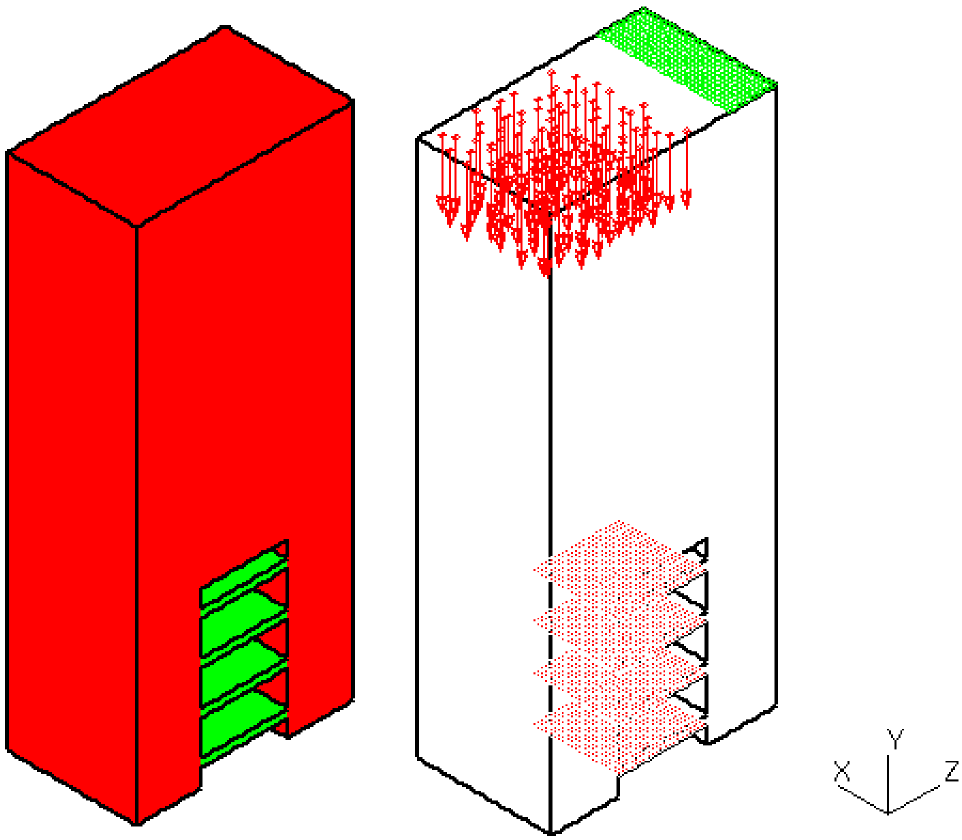


Figure 4: Model geometry and boundary conditions

2.2 Results

The most interesting results for our study is the temperature around the computer area. Fig. 4 shows the temperature map on the YZ plane at the central point of a rack. It is observed that the highest temperature at the entrance of the computer's ventilation system is about 29^{o}C. The hottest computers are those further from the ventilation. Fig. 5 illustrates the air speed provoked by the ventilation system inside the computers.

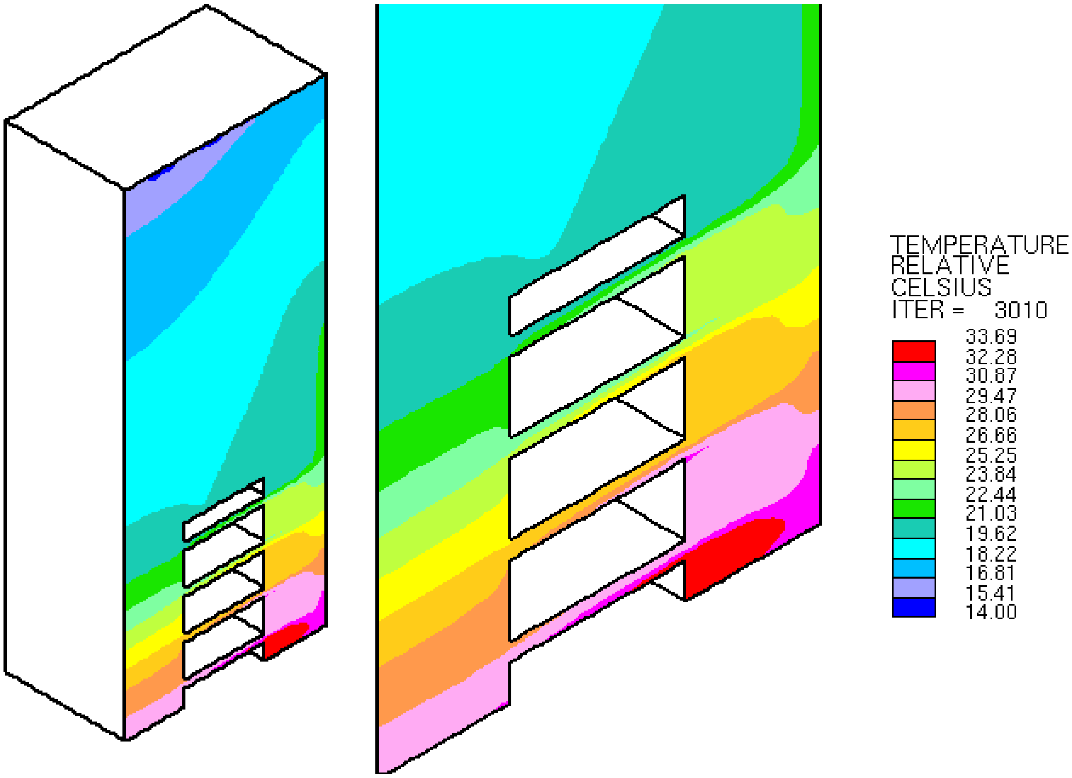


Figure 5: Temperature map at the centre of a rack

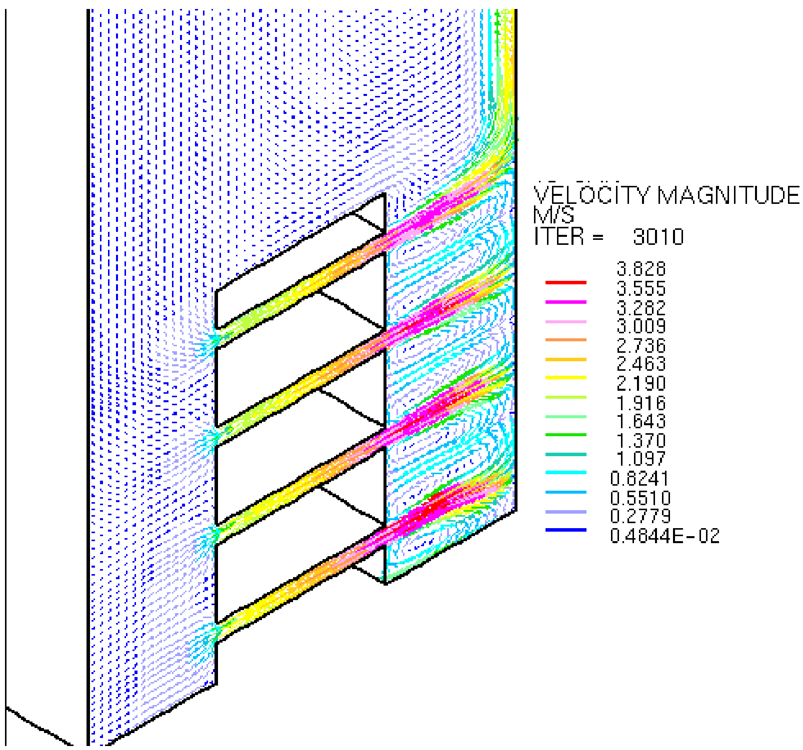


Figure 6: Air velocity provoked by the ventilation system inside the computers

3 POWER CUT OPERATION STUDY

In case of a general power cut in CERN, the first diesel set starts to supply the network after a switch over time of 45 seconds. In this first phase only the safety equipment will be supplied. The second set will start supplying other connected equipment after about 1.5 minutes. The air-conditioning equipment in the Computer Centre will be powered when the two diesel generator sets are in operation.

3.1 System Operation During the Power Cut

In a power cut situation, the UPS keeps supplying the computing equipment in the Computer Room. The secured network can not power all the air conditioning equipment because the power of the diesel is limited. To keep the required electrical power as low as possible, only the fans and pumps will be powered. This will require some 500kW of electrical power. Since there is normally a delay of 1.5 minutes. (it could be in the worst case 3 minutes) before the start of the second diesel set, the Computer Room is without any cooling during this period and the temperature rises rapidly. After the switch over time, the diesel starts to power the fans in the stations and the chilled water pumps. A 30m^3 chilled water tank is connected in series with the pumps and the stations. The warm air exchanges heat with the water circulating in the cooling coil and, since the chillers are not running, the temperature in the tank rises and so does the air pulsed to the Computer Room.

3.2 Results

The starting room temperature for the calculation is 22°C (set point). The calculations show that the temperature will be about 25°C after 1.5 minutes without air-conditioning. If at this time the fans and pumps are powered, after 10 minutes the temperature will be 30°C and after 30 minutes, which is thought to be the worst case scenario, the temperature will be 42°C.

In the calculation it has been considered that part of the heat is stored in the materials, the computers and the metallic racks.

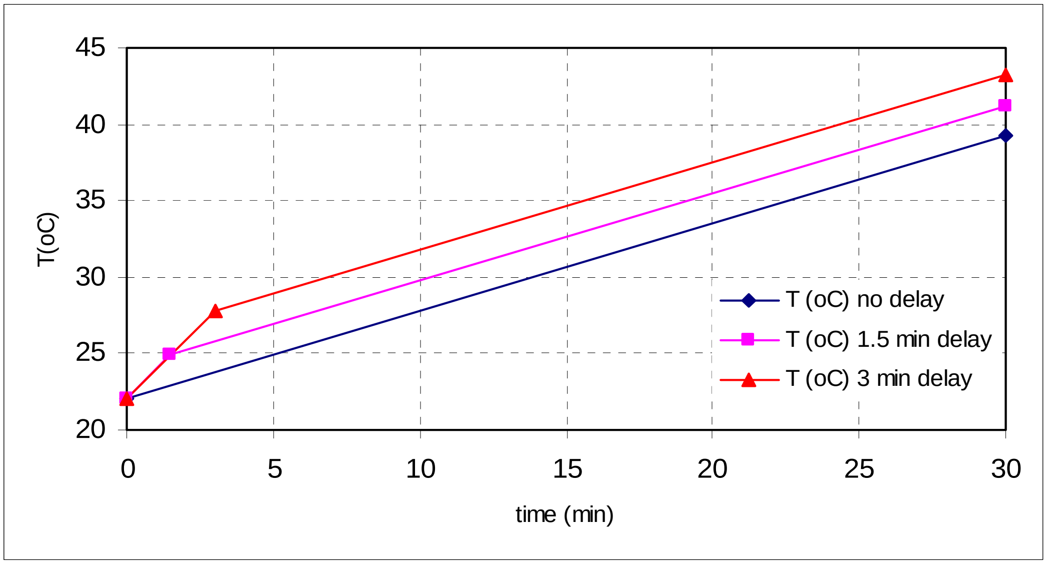


Figure 7: Temperature evolution with different switch over times

4 CONCLUSIONS

The study shows that the increased thermal loads in the Computer Room from the LHC computing could be handled with the existing system when the presented modifications, new installations and system readjusting are done. However, the system will run at its limit and the redundancy is reduced.

The temperature distribution in the room is not satisfactory. The calculations show that temperatures are too high in the occupied zone. Further studies are needed to find solutions on how to distribute the air in a better way.

The reduced cooling capacity during a power cut results in a maximum temperature that is above the acceptable temperature limit (less than 35°C) in the worst case scenario (30 minute power cut). If the autonomy of the UPS is less than 20 minutes, the temperature will stay below the target temperature and only the minimum of equipment needs to be powered by the secured supply. The values given by the manufacturers on the acceptable speed of temperature rise however is exceeded (max. 5K/h).

5 DISCUSSION AND FURTHER STEPS

To resolve the problem of air distribution in the Computer Room further calculations and studies are needed. The problem comes from the fact that the supplied air does not penetrate deep enough in to the room to mix the air in the occupied level. A study using jet type air diffusers should be done to see what would be the temperatures with this kind of system. One approach is to introduce part of the air from the false floor, which is a method largely used in computer rooms. This would be easy to implement since some ducting exists already connecting the supply air plenum and the false floor.

Once the UPS solution and autonomy time has been defined, it is possible to study further how to provide more cooling power in a case where the autonomy of the UPS exceeds the 20 minute critical point. There exist at least two possibilities to add redundant cooling power. Firstly, one chiller could be connected to the secured power network. Secondly, an interconnection with another chilled water network would add the volume of chilled water available. This connection could be done to the networks of the Booster/PS.

When the use of the Computer Room and the equipment to be installed is better defined, more studies and calculations will be performed to find the adequate design and operation strategy.

REFERENCES

[1] ASHRAE Handbooks

[2] A. Funken, Les réseaux eléctriques de sécurité du CERN, CERN-ST-2000-036