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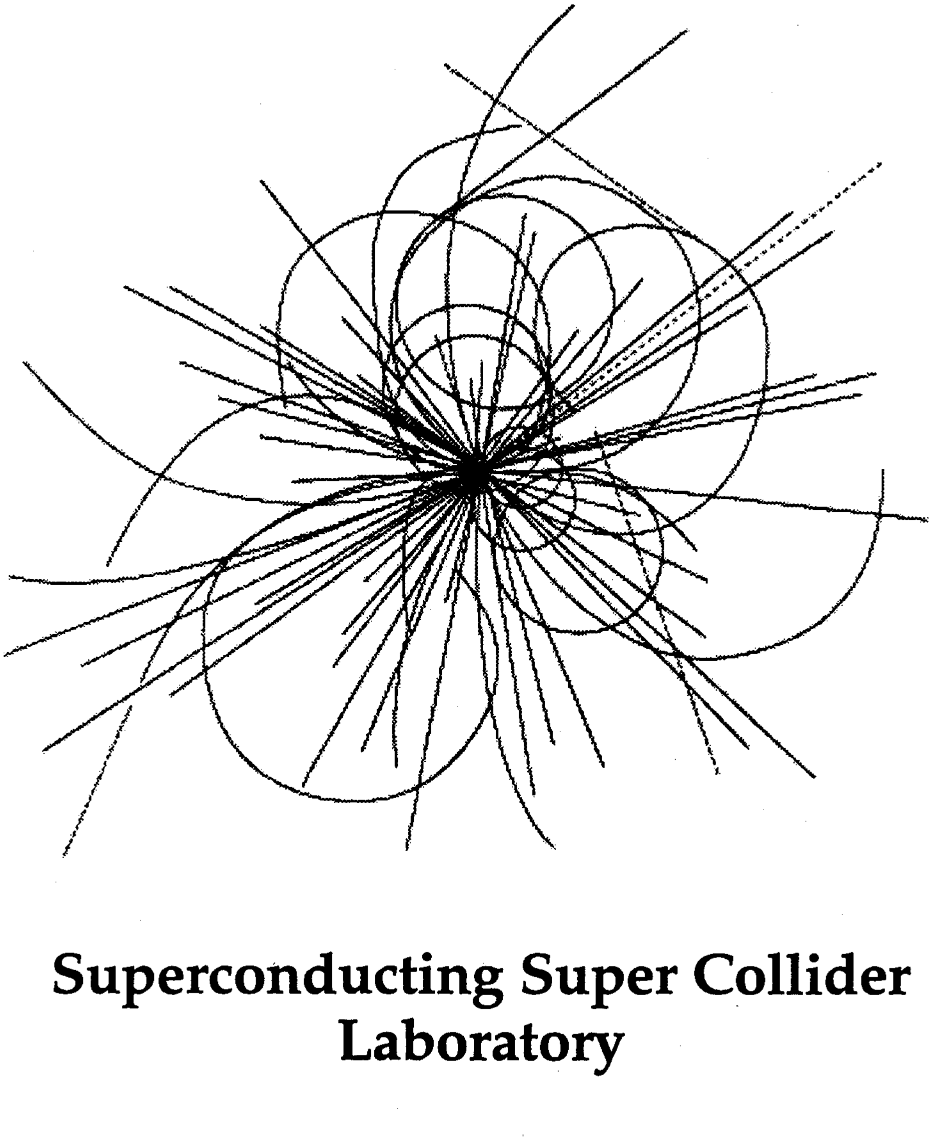

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Low Conductivity Water Plants—Issues of Process Control*

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LOW CONDUCTIVITY WATER PLANTS-ISSUES OF PROCESS CONTROL

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ABSTRACT

The SSC laboratory will require a large number of widely distributed low conductivity water (LCW) cooling systems to support accelerator operations. In addition to designing the physical plants, plans must be made for control / information systems and the human organization to run them. Initial considerations in these areas are presented.

INTRODUCTION

Various SSC accelerator components such as resistive magnets, radio frequency equipment, and power supplies will use LCW cooling to reject heat. The cooling water must be deionized to prevent short circuits due to current flow through the water and the erosion of piping components by electrolysis. When cooling is needed for equipment in radiation areas intermediate closed loop systems will be used. Heat from the LCW will be transferred to industrial cooling water, ICW, systems and then to the atmosphere by means of cooling ponds or towers.

A total of about 35,000 gpm of deionized water is needed for the operation of the accelerator systems. This water will be provided from 34 plants located around the complex. The location of these plants is shown in Figure 1. Systems for LINAC, LEB, MEB, HEB, Transfer Lines and Test Beams (TB) will service both above and below ground components. For the Collider only surface components will be water cooled.

The LCW systems contain the equipment, devices, and instruments required to produce, cool and distribute the LCW. For some systems ICW plants will be an integral component of the LCW plants but for others it will be provided from an external source. In addition there will be a centralized regeneration plant for the deionizer beds.

Because of the wide geographical distribution of the LCW plants and a projected small staff to operate and maintain them, each system must operate in a "lights out" or fully automatic mode under control and monitoring from a single central location.

In this paper we discuss the requirements and human organization needed to control and maintain the LCW system.

SYSTEM DESIGN CONSIDERATIONS

The LCW plants are considered as a technical utility and therefore must provide highly reliable continuous service. They will be designed, installed and commissioned individually in time to support their "customers" the accelerator components. The primary requirements for the LCW are for the most part uniform for the whole of the SSC. The systems need to provide a continuous flow of water at a maximum temperature of 90 degrees

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F and resistivity of 5 MΩ by maintaining a constant differential pressure across supply and return of 80 psid. Environmental considerations require that the return pressure from the LCW must be lower than that of the ICW. Plants diversify in their capacities, level of redundancy, and whether they contain an integral ICW plant.

To develop an LCW system for the SSC one must first define it (decide its boundaries) then determine its requirements and goals. From this, a set of modular tasks can be created which implement the desired LCW system. Conceptually these tasks can be assigned to one of two broad categories depending on if they deal with the movement and transformation of energy / material or information. For implementation these tasks can be handled in one of three ways. They can be carried out by process equipment (plant hardware), information systems (computers, networks, software, etc.), or by humans. This analysis is outlined schematically in Figure 2. The distribution of the tasks for implementation provides insight into the level of automation in the system and the human effort needed to run it. The above generally follows models developed for industrial CIM systems (Williams 1989,1992).

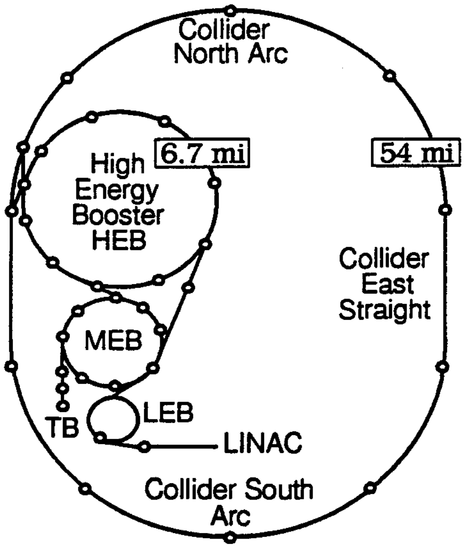

Figure 1. SSC LCW plant locations

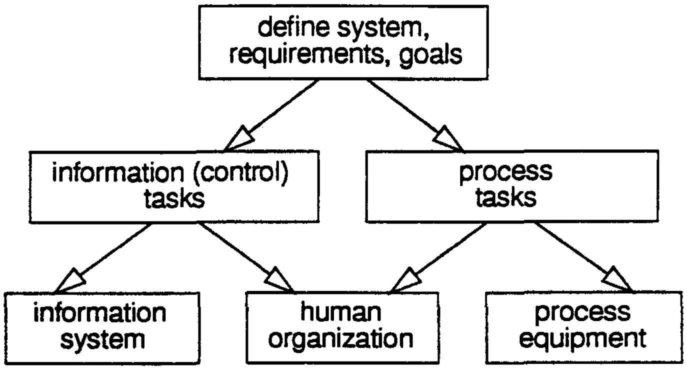

Figure 2. Determining tasks for implementing an LCW system

Qualitatively it is clear that to minimize the long term cost tasks should be implemented with the process equipment and information systems rather than with the human organization. Unfortunately this leads to a higher initial capital cost. Thus the process should (1) be designed to minimize direct manual labor, (2) minimize maintenance labor by maximizing component reliability, providing backup equipment, and selecting components with minimum routine maintenance requirements, and (3) minimize routine operations manpower by providing control automation to the fullest extent possible.

SYSTEM ARCHITECTURE

A suggested architecture for an LCW system "enterprise" to support the SSC is given in Figure 3. It shows process plants, control systems, data management, and major groups in the human organization. This architecture is based on the assumption of an independent LCW unit in the SSC. The ultimate laboratory organization may not reflect this but this exercise helps identify requirements which must be met.

The LCW plants shown at the bottom of the figure are designed in a modular fashion to meet the requirements stated above. Each module carries out a specific system function or regulates a deliverable LCW parameter such as water temperature. The modules necessary to implement ICW systems are also shown but these are only present in those plants with integral ICW control systems. Plants with external ICW would have a communications link with the remote ICW control system.

The information system links the process plants with the human organization. At the bottom this is essentially an industrial process control system. This control system is envisioned as a relatively simple two level hierarchy. On the average each LCW plant is estimated to have 200-300 I/O points and thus should require only a single process controller per site. There may additionally be specialized unit controllers covering for example water quality. Each process controller should be able to support an optional (portable?) local operator interface for plant commissioning, maintenance, and stand alone operation when needed. The second level centralizes control of all the plants and would reside in or near the laboratory central control room. From here an operator should have all control functions available at the local operator interface level. This supervisory level would also link with an information management data base that contained plant historical data, configurational data, and other information relating to the LCW systems. The mandate for data base would be to provide easily accessible, timely, accurate LCW data to those in the organization who need it. This data base forms the core of the upper part of the information system.

As indicated in Figure 3 the process control system and data base would provide links with other SSC control and information systems. This provides the needed integration of LCW systems with the rest of the laboratory.

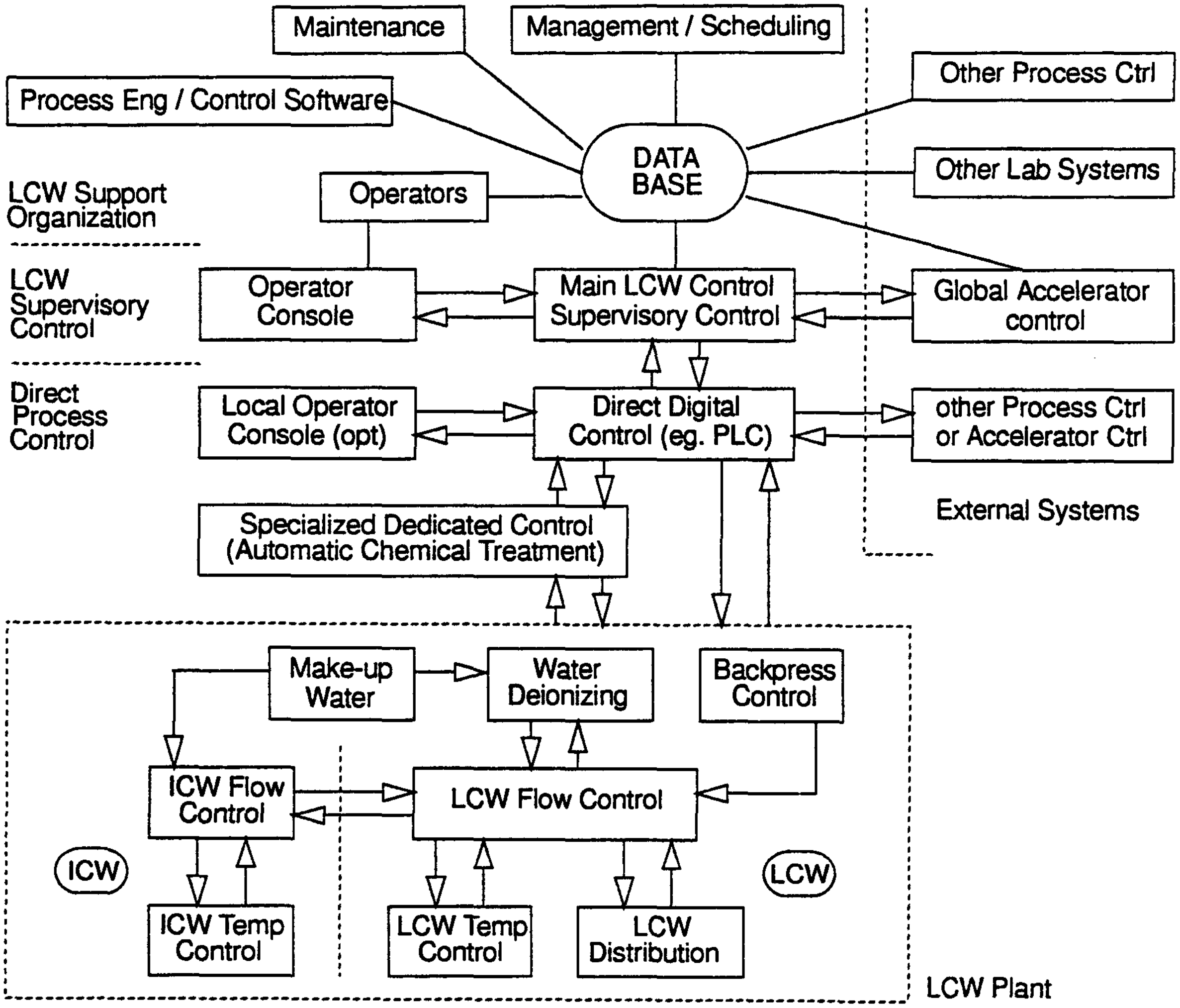

Figure 3. LCW process and the Information management system

At the top of Figure 3. the various functional groups in the LCW systems organization are shown. It may be possible that a given individual could function as a member of more than one group. The groups represent general task areas which must be covered to support the LCW plants and operations. These include maintenance, operators, process engineers, and management / scheduling.

HUMAN ORGANIZATION

Thus far the SSC laboratory has focused on the design and construction of the physical plants and control systems but has not modeled as completely the human efforts involved in running and maintaining them. A few considerations in this area are now presented.

An important question relates to the number of operators needed to run the LCW systems and what are their tasks. Placing a full time operator at each plant (34) is too costly in terms of manpower, thus the plants will be run under remote control from a central location. The minimum number of operators on duty could then be reduced to one. Assuming that an operator delivered six hours of effective work (watching the operator console) during a shift, then each plant would receive ~10.5 minutes of operator attention. Therefore the operation of a plant cannot require careful operator analysis of raw information or long term careful watching of the operation to make adjustments. Obviously to run with a single full time operator the system would need to be fully automated and self diagnosing. In reality is difficult to reach 100% automation and thus an operator is needed to cover a few residual operations. One scenario for a single operator system would be as follows. The operator is responsible for covering these residual control operations for all the 34 systems. This will likely take most of his attention and time. The operator must also provide the first line of fault and problem analysis. When a problem with the system is identified (an alarm or inconsistent operation) the operator would be responsible to determine whether maintenance or process engineering is best suited to handle it. He would then call on someone else to carry out detailed work on the problem. These people in turn can access the information necessary to further analyze the problem through the central data base without having to be in the central control room or at a plant site.

With an enhanced information management system tasks which often fall to operators could be distributed to others in the organization outside of the control room. Process engineers could work on tuning, improving and optimizing control loops. Maintenance personnel could carry out trend analysis on component performance, operation, and failure patterns to identify equipment for repair, recalibration, or replacement before a system failure (which could impact the total accelerator operation) actually occurs. Management could directly generate accurate operations reports and perform other analysis from the information in the system. Some of these activities could in fact be automated by these groups outside operations and the central control room.

Another area where humans interact with the LCW plants is in the replacement and regeneration of deionizer beds and replacement of carbon filters. Should this be done on a time schedule or by monitoring when a bed / filter is actually used up? Carrying this out on a time basis would necessarily assume a worst case water quality and thus cause beds to be regenerated too often. This would prematurely wear out the deionizer resin, increase regeneration costs (material and manpower), and require the construction of a larger (increased capacity) regeneration facility at the SSC. There is also the costs of the human effort necessary to replace and transport the deionizer beds from the LCW plants to the regeneration facility. More efficient use the deionizer beds requires increased plant control and instrumentation. The plant would have to determine when a bed has failed and then have a replacement bed available to automatically switch over. The failed bed could then be replaced and regenerated on a more relaxed schedule (which uses less manpower).

These provide representative issues which must be addressed in the development of LCW systems at the SSC.

REFERENCES

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