REQUIREMENTS FOR AND EXPERIENCE WITH THE VACUUM CONTROLS
DURING COMMISSIONING OF THE LEP UHV-SYSTEM

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ABSTRACT

The initial commissioning of the 127 sectors of the LEP Vacuum System requires local control facilities. On the scale of LEP, local control of one sector implies the supervision of vacuum equipment which may be spread over 480 metres, with pump power supplies located as far as 1700 metres from the pumps they drive. To minimize the cabling cost, all power supplies and control units are connected together via a Local Area Network. Light-pen driven consoles send messages to the equipment and display useful information for the vacuum operators. As of the control system, supervision was possible from the LEP Control Room as soon as the control system was made available at the various sites. After a brief description of the various components to be controlled, this paper will describe the particularities of the vacuum controls and report on our experience during the commissioning.

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1. Introduction

The LEP Vacuum System extends over 27 kilometres and is divided into 127 sectors. One sector can be as long as 474 metres. This size makes it mandatory that the control system be available during commissioning. The vacuum equipment is distributed over the length of a sector, whereas the ion pump power supplies and the sector valve controllers are located in underground service areas at the bottom of each access pit, which can be as far as 1700 metres from the sector to be commissioned. Both for financial reasons and also because of the risk of damaging components by the synchrotron radiation which is produced when LEP is running, the initial pumping and bakeout is made using mobile equipment, which is moved from one sector to another. For details see Ref. 1 also presented at this conference.

The spread of the equipment over such long distances requires that each item be connected to a local area network in order to be able to control it from a convenient place. This place is usually in the LEP ring tunnel, somewhere along the sector which is being commissioned. The local area network also forms the link to the main control system of LEP. Control at the level of a sector is achieved from the LEP ring tunnel or from the underground service areas by means of a menu driven display screen, using a light pen as input device.

Figure 1 gives the overall layout of the fixed and mobile vacuum equipment typically found within one sector. Figure 2 shows the equipment located in the underground service areas.

2. Requirements

2.1 Installed equipment to be controlled

The fixed equipment typically consists of two to seventeen ion pump power supplies, one sector valve controller and one pirani gauge supply per vacuum sector. Additionally there may be one multi-head ion gauge power supply, one NEG pump thyristor controller or several sublimation pump controllers in special sectors. One display screen with a light pen as input device, thereafter called a light pen console, is made available for each sector in the underground service area.

The mobile equipment consists of up to six mobile pumping stations, up to six high temperature water heaters for the bakeout, up to six thyristor controllers for the activation of the NEG pump and up to six ion gauge power supplies used to monitor the vacuum at the end of the bake out. In addition, each mobile pumping station includes a light pen console. Some mobile stations include a residual gas analyser used for vacuum quality measurements and as interlock source for the NEG pump.

Each of the above mentioned items, whether fixed or mobile, is able to exchange messages with any of the light pen consoles via the local area network.

A number of interlocks between various types of vacuum equipment have been implemented both in hardware and in software, in order to protect the vacuum system from unexpected pressure rises or operational errors. Interlocks to sensitive equipment like the beam separators or RF cavities have also been installed. Figure 3 outlines the various possible interlock mechanisms.

2.2 Commissioning sequence

A normal commissioning sequence starts by pumping down the system and baking it at 150°C for 24 hours. The NEG pump is then activated and the ion gauges are degassed. After a final NEG pump conditioning, the vacuum reaches a typical value of 1 to $2 \cdot 10^{-9}$ Pa. More details can be found in Ref. 1.

Four people are involved in the commissioning of each sector, two for the bakeout supervision and two for the vacuum commissioning. During the peak installation period, up to four sectors were commissioned per week.

3. Particularities of the LEP Vacuum Control System

The LEP Vacuum Control System is part of the main Control System of LEP, and as such has to follow a number of predefined rules^{2,3}). The description of the controls for the vacuum system has been published in⁴). The following will emphasise on the particularities of this system.

3.1 Size of the LEP machine

The very large size of the LEP machine made it mandatory to find solutions to minimize the cabling costs. The three answers to this requirement were:

- Share a single cable and hence a single supply between several ion pumps.
- Connect all the individual equipment through a local area network.
- Share a single cable within each sector between the local area network, the sector valve, the NEG pump interlock and a headphone line.

By doing so, not more than 5 cables are installed for a typical sector of 474 metres. However, in order not to lose too much in spatial resolution for leak detection, it became necessary to design a measuring device able to read the current of each individual ion pump.

3.2 Availability of the main control system

Due to the very tight schedule for the LEP construction it was not possible to use the main control system for the initial commissioning. We decided therefore to install one branch of the local area network for each vacuum sector, covering both the underground service area and the LEP ring tunnel in the vicinity of the sector to be controlled. Each branch of the local area network is connected to the main control system through a gateway.

The additional complexity of this extra layer in the communication system has been more than compensated by the flexibility it provided in the organisation of planning for the commissioning.

3.3 Mobile equipment

The extensive use of mobile equipment anywhere around the LEP machine poses the problem of identifying it and keeping track of it. To solve this problem, each light pen console is able to find which addresses are used and what type of equipment is available by scanning all possible addresses on the local area network. Hence the console builds up a dynamic table of all the equipment, fixed or mobile, which belong to the vacuum sector it is looking at.

The same approach is also used in the gateway which is used as the interface to the main control system of LEP.

3.4 Protection of the NEG pump

The operating pressure of the NEG pump during its activation is too high to keep the ion pumps or ion gauges on, but too low to have a safe interlock level from a Pirani gauge. The solution is to use residual gas analysers locked onto peak 40 as an interlock against an atmospheric leak.

3.5 Absence of classical control panels for most of the equipment

As it was clear very early in the project that all the equipment would have to be remotely controlled, very few systems were equipped with manual control panels. Therefore, the man/machine interface provided on the mobile control units had to be 'user friendly' enough to be easily used by vacuum technicians who have little or no skill in computer science.

3.6 Software for the light pen consoles

The software for the light pen consoles provides the user with a main menu. Each item of the main menu selects a specific type of equipment (pumps, gauges, etc.) and allows to display a global page with information on the selected items at the sector level. Global commands like switching the ion pumps on, are also possible from this page. Additional pages providing more detailed information can be selected from the global page. Figure 4 sketches the organisation for the software selecting the main menu of the light pen consoles.

4. Experience

The number of available menus on the light pen consoles have been increased progressively to cover all the required functionality and their performance has been improved using feedback from the operators. At the moment there exists seven main menus, allowing access to ion pumps, mobile pumping stations, thyristors units for NEG, super heated water units, ion gauges, pirani gauges and sector valves.

During the last few months of installation and commissioning, all operations could be successfully conducted from the tunnel by a team of 2 people per sector.

The reliability of the various components has proved to be adequate. The most frequent problems occur when the various components are first connected to the network. They are mainly due to cabling faults. The stability of the software still has to improve for some items of the menu. The experience gained so far will guide this improvement work.

Ion pumps, ion gauges and sector valves have progressively been made accessible to the main control room since summer 1988. In the more recent past, it has also become possible to monitor mobile equipment from the central control room. This should enable us to reduce the number of teams which must supervise the bakeouts, mainly during night time.

References

1. The LEP vacuum system: present status, Vacuum ...
2. LEP-SPS Controls Group, LEP Controls Note 54, 1986.
3. J. Altaber, P.G. Innocenti and R. Rausch, CERN Report No. SPS/85-28, 1985.
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Figure 1:

**Vacuum Equipment in
a typical sector in LEP**

Figure 2: Vacuum Equipment in the Underground Service Areas of LEP

Figure 3: Operating ranges and interlock connections

Figure 4: Monitoring Video Display

In order to communicate with other vacuum-related devices over the UTINET network, the light pen console must be given an address. This is achieved when the operator selects a three-digit number on thumbwheel switches.

The number on the thumbwheel switches must correspond to predefined and acceptable values that are stored in a table. Furthermore the number must not be already affected to another console.

Main menu to select data displays and commands for all instances of a given equipment in a sector (for instance, all heating units). Once the equipment type is selected, a directory of all the corresponding control assemblies is built. Data relative to the devices, like address, identification code, or channel is stored in this directory.

Pieces of equipment are sorted according to their position along the LEP ring.

Using this directory allows to associate data coming from different addresses with the corresponding devices and to display it accordingly.