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

by

J-N. Bienfait, U. Epting, N. Fietier, P. Strubin

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J.N. Bienfait, U. Epting, N. Fietier and P. Strubin

CERN, LEP-VA, CH-1211 GENEVA, Switzerland

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. Part of the vacuum equipment is scattered over a sector. The ion pump power supplies and the sector valve controllers are located at the bottom of each access pit, which can be at 1500 metres from the sector to be commissioned. For financial reasons, initial pumping and bakeout are made using mobile equipment, which is moved from one sector to the other.

The spreadout of the equipment over such long distances requires that each item be connected to a network in order to be able to control it from a central place. Control is achieved by means of a menu driven display screen, using a light pen as input device. During the peak installation period, up to four sectors are commissioned each week.

2) REQUIREMENTS

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 can be one ion gauge power supply, one NEG pump thyristor controller or several sublimation pump controllers in special sectors.

The mobile equipment consists of up to six mobile pumping stations, up to six super heated water units for the bake out, 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 display screen with a light pen. Each of the above mentioned items is able to exchange messages with any of the control displays via a local area network.

A normal commissioning sequence starts by pumping down the system and baking it at 150ºC for 24 hours. The NEG pump is then activated and the ion gauges are degased. After a final NEG pump conditionning, the vacuum reaches a typical value of 2 to 4*10⁻¹¹ Torr.

Four people are involved in the commissioning of each sector, two for the bakeout supervision and two for the vacuum commissioning.

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 operation errors. Interlocks to sensitive equipment like separators of RF cavities have also been installed.

3) EXPERIENCE

More than fifty sectors have been commissioned so far. The number of available menus on the display screen have been increased and their performance has been improved using feedback from the operators. At the moment there exists seven main menus, allowing to access ion pumps, mobile pumping stations, thyristors, super heated water units, ion gauges, pirani gauges and sector valves. A typical menu displays summary information for all controlled items on its first page and allows to get detailed information through additional pages. Global commands, like on and off commands or settings of current or temperature can be sent from the global menus.

The reliability of the various components has proved to be adequate. The most frequent problems occur when the various components are connected to the network. They are mainly due to cabling faults.

Ion pumps, ion gauges and sector valves have progressively been made accessible to the main control room since last summer. In the recent past, it has become possible to monitor mobile equipment from the central control room. This should enable us to reduce the number of teams who supervise the bakeouts, mainly at night time.
LEP COLLIDER VACUUM CONTROL SYSTEM

The Vacuum Control System had to be realised taking into consideration the following constraints:

* The very large size of the LEP collider ring (27 km circumference).
  * Ultra-high vacuum must be achieved and maintained around the whole ring.
  * The Structure of the ring: it is divided into 8 octants and is composed of 127 vacuum sectors. The maximal length of a vacuum sector is 474 m.
  * Pieces of equipment are located all around the ring.
  * Each sector can be considered as an independent entity from a vacuum point of view.
* The need to minimise the number of operators required for vacuum commissioning.
* That most of the operators are not familiar with refined computer technology.
  * Convenient man-machine interfaces had to be achieved.
* That hardware and software interlocks must protect the vacuum system and other related systems against unexpected pressure rises or incorrect operations.

The present Vacuum Control System allows:

* To operate the Vacuum System with a reduced number of operators.
  * Within each sector all equipment can be controlled directly from light pen consoles via the UTINET network.
  * Typically, two or three operators are required to complete the commissioning process (pumping, leak check, baking and outgassing) on a sector.
* To display pressure and status data relative to a sector in a comprehensive way.
  * Light pen driven consoles are used to access items and supervise vacuum performance.
  * Graphic display facilities such as bar graphs which are easy to use to monitor data.
  * Use of light pens as a convenient way of entering commands.
* To connect to the LEP main controls system in order to convey all the required information to the main control room.

Schematic Layout of the Vacuum System in a Sector (Fig. 2.3)
Vacuum Controls System in the Underground Service Areas (Fig. 2.2)
Accessing the Vacuum Equipment from the Main Control Room

Process Control Assembly (1 per octant)
- Alarm programs
- Local data storage
- Equipment directory unit

MAIN CONTROL ROOM
Display of all kind of data coming from the LEP collider.
Monitoring of the equipment.

Vacuum-related Data extracted from the MIL-UTINET Interface

Magnetic Interlocks Data
Electricity Data
Fire Detection Data

Cooling and Ventilation Data
Controlled Access Data
MIL-1553 bus
Vacuum Controls System in the Underground Service Areas

- Head End Unit:
  - Generates the UTINET clock
  - Monitors the turn-around of data from stations
  - Resynchronises data to the clock
  - Detects collision

- Light Pen Console:
  - Displays data relative to different kinds of equipment in order to supervise vacuum performance
  - Allows to select predefined commands with light pens. These commands consist mainly of:
    - starting or stopping processes
    - modifying values of parameters
    - reinitialising alarm or failure detectors

- MIL-UTINET Interface:
  - Allows data transfer from devices to the Process Control Assembly via the UTINET network and the MIL1553 bus
  - Scans permanently the whole field of UTINET addresses to provide the Process Control Assembly with the directory of all devices connected to UTINET in a sector.
2.3 Schematical Layout of the LEP Vacuum System in a sector

Mobile devices are only used for commissioning. They are removed when electron and positron beams are circulating in the LEP collider. Fixed devices operate in presence of beams in order to preserve a low vacuum. Each device is identified by a family code and a member code. The family code identifies the type of equipment. The member code represents the position along the ring.

Vacuum Equipment on a typical sector (e.g. 213)
(The number of items is indicated in parentheses)
1. Pirani and Penning Gauges (6)
2. Roughing Valves (6)
3. Roughing and Turbomolecular Pumps (6)
4. Light Pen Consolos (6)
5. Mobile Thyristor Regulators for NEG (6)
6. Bakeout Heating Units (6)
7. Ionisation Gauges (12)
8. Sputter Ion Pumps (24)
9. Pirani Gauge (1)
10. Sector Valve (1)

Mobile Equipment

UTINET:
Multi-drop, multi-master CSMA/CD local area network

* A single station may take control of the UTINET segment and transmit directly to another station
* Stations are directly connected to the data highway
* A single UTINET segment may interconnect up to 127 stations
* Data synchronisation and collision detection are monitored by a single special station called Head End Unit
Monitoring the LEP Vacuum System:
Operation ranges and interlock connections

In order to cover the full pressure range from atmospheric pressure down to 1E-11 Torr, vacuum pumps and gauges are teamed up. No single pump operates and no single measurement device can be operated without being damaged or without losing accuracy over this broad pressure range. Operating conditions are specified for each type of device on the diagram.

Enable opening if nominal speed on turbomolecular pump and no failure detection on roughing station.
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 allocated to another console.

Main menu to select data and command displays 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 identification code, UTINET address, 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.
4.2

Monitoring Video Display (2)