Status Report of the New Vacuum System for the 8pLP Experimental Line.

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INTRODUCTION

In the preparation for the future nuclear experiments with RIBs of the SPES project, new, more reliable and long-lasting vacuum systems are requested [1]. As Proof-of-Principle model, the old beam line to the 8pLP experiment in II Experimental Hall was completely renewed in terms of layout, hardware and controls (see Fig. 1).

VACUUM SYSTEM DESCRIPTION

The vacuum is generated by a couple of Turbo-Molecular Pumps (TMPs) with a nominal pumping speed of 250 lt/s for N₂ backed by a of dry multi-roots Primary Pumps (PPs) with a maximum pumping speed of 27 m³/hr. A second identical PP is used to pump down the line from atmospheric pressure. In addition, at both ends of the line, two 150 lt/s Ion Pumps (IPs) are installed to achieve a better vacuum level (see Fig. 2).

All these pumps, and the relative valves and sensors, are operated by one single control rack, which permits a local and remote control of the vacuum cycles. One important feature of this system is that, when there is no beam requested, the PPs and TMPs are running at lower speed – respectively 3000 rpm and 39600 rpm. The nominal speed is reactivated when the beam-on condition is set by the general control system. This fact has two beneficial effects: one is in terms of power consumption, while the other concerns with the pump lifespan.

The control rack is fully reconfigurable by the operator, who can define which valves, pumps, sensors, and all the remote connections of the beam line are controlled. This feature can be used also for the installation on long beam lines, i.e. when it is needed to control a double number of devices. We implemented a second important feature, i.e. the possibility to substitute a faulty control rack in short time also by untrained staff.

CONTROL SYSTEM

The control is based on a Siemens S7-300 PLC connected to vacuum devices via digital I/O and RS 485 standard. The local HMI¹ is provided by a 10” touchscreen (Siemens Basic Panel). The PLC is installed on a modular chassis following the 19” rack standard to make easier the substitution of a spare one in case of fault.

The control system was designed and documented in detail by LNL personnel before its realization. In particular the mechanical aspects, the electrical scheme and the operational logic were formalized, both as guidelines and requirements, for the production of the PLC code.

The actual assembly of the Hardware (HW) and Software (SW) was carried out by one single external company, which is strongly specialized in engineering related to industrial automation. The development of the HW and SW has been the subject of continuous interactions with LNL staff with the purpose of producing a prototype matching the specification provided. The specifications regarded the number of pumps, valve and sensors to control, as well as the distribution of the electrical power to these devices were specified.

The remote control is provided by EPICS [2-3] and will be developed internally in the next year. The main characteristic is that the list of the relevant exchange variable of the vacuum system is stored in a dedicated DB (Data Block) and is promptly available for the development of the communication interface.

At LNL, after the manufacturing phase, we added further HW parts as well as PLC code to solve unforeseen configuration problems. These changes were possible only because we produced internally the PLC electrical scheme and its SW guidelines. These two documents are fundamental to have a full accessible apparatus, despite the manufacturing is given in outsourcing. This fact is not only important to solve particular issues, but also to extend and modify in the future the control system internally. Another important result is that the produced code is well modularized, understandable and maintainable by people familiar with the guideline independently by the supply company.

Fig. 1. Picture of the beam line in the II Experimental Hall from the point of view of the 8pLP apparatus. The beam line is composed by a single quadrupole doublets (in foreground covered by the supports and cable trays). In the background of the picture the control rack is visible.
Fig. 2. Diagram of the Piping and Instruments (P&I) of the vacuum system installed. This vacuum section is bounded by two gate valves. The pressure form low to ultra high vacuum regime is measured by one pirani and one penning gauge. The pirani gauges installed at the outlet of the TMPs are used to check the vacuum level in the pump and its gas load.

ON SITE ACCEPTANCE TEST

The test regarded the correct functionality of the nominal vacuum cycles, namely Vacuum, Fore-Vacuum and Venting. We simulated all the possible fault conditions and checked the system reactions. We tested also the system functionality in case of a trip on the electrical supply. We found and solved other few errors in the cabling of the safety switch and the emergency power system. Concerning the SW, the GUI\(^2\) was improved, making the pressure values visible (see Fig. 3). And the operational state of the pumps was highlighted with three different colours. Further refinements regarded the trigger hysteresis for the speed change of the PPs.

Despite some little imperfections remained, such as the magnetothermic switch positions and the lack of spare power plugs, the control rack was successfully commissioned.

CONCLUSIONS

The decommissioning of the old beam line started around the end of March 2014, followed in May by the installation of the new vacuum pipes and beam supports. The final leak test was done in June. The TMPs were installed in July and afterwards the control rack in September. The acceptance test for the whole system took place between October and November. Only at the end of this activity the IPs could be installed (February 2015).

In the prospect of replicate the prototype, the HW engineering seems to be the key point. Moreover, a better standardization of the PLC components would reduce the costs. The HMI panel solution adopted for this prototype is not an optimized solution both under the points of view economical and technical, since it is too large and cumbersome. The air cooling system of the rack is well dimensioned, but a more compact solution is possible, and would reduce the complications when the rack is moved across small passages between the beam lines. Besides the modifications described in the acceptance test paragraph, minor mechanical changes regarding the lock of the front-panel could improve the prototype functionality.

![Fig. 3. Photo of the HMI of the control rack. The P&I of the beam line is displayed with all important variables and status of the devices, such as the pressure and the rotation speed of the pumps. The valves can be operated touching the gray circles. On the right four automatic procedures can be selected.](image)

\(^2\) Graphical User Interface