UPGRADE OF THE ESRF VACUUM CONTROL SYSTEM

D. Schmied, E. Burtin, P. Guerin, M. Hahn, R. Kersevan*, ESRF, France

Abstract

The whole vacuum control system of the electron storage ring (SR) of the ESRF is in operation since more than ten years now. Apart from difficulties to have appropriate support for the old system, we start facing problems of aging and obsolescence.

We have been reviewing our philosophy of data acquisition and remote control in order to upgrade our systems with state of the art technology, taking into account our operational experience. We have started installing shielded "intelligent" devices inside the SR and taking advantage of the latest developments linked to new technologies, such as OPC Server (Openness, Productivity, Connectivity), Webpage instrument control and more.

This paper outlines our actual work dedicated for Programmable Logical Controller (PLC) applications.

INTRODUCTION

Our initial aim was the exclusive use of off-the-shelf vacuum equipment being totally integrated in our general control system [1, 2]. This appeared to have many advantages such as:

- share of human resources for development, failures and maintenance tasks is possible
- flexibility in the case of upgrades
- common historical database for storage ring (SR) and beam lines is possible

But we also faced control problems during shutdown periods, due to modification and maintenance work of different sub-systems. The control of vacuum equipment and monitoring of bake out was sometimes impossible via the standard control system.

Parts of the control system and vacuum instrumentation start to show aging problems or getting obsolete with more frequent failures or maintenance problems.

Triggered by the replacement of our entire network of FE-computers from a diskless VME based real-time operation system to industrial PC's under LINUX, we easily migrated most of our vacuum equipment while redefining parts of our remote control.

The remote operation of all permanently installed SR vacuum equipment concerns 200 inverted-magnetron gauges, 70 Pirani gauges, 400 sputter ion pumps (SIPs), 60 residual-gas analysers (RGAs), 360 non-evaporable getter (NEG) pumps and 2000 thermocouples (TCs).

Due to the hazardous environment, no intelligent board or electronics has been installed in the SR tunnel, which implied long cables and numerous electrical connections. This turned out to be a bad choice in the case of TCs, as well as the fact that our data acquisition system was simultaneously dedicated for bake-out and vacuum chamber monitoring.

Temperature measurements to monitor the vacuum chambers' temperature during operation requires a high flexibility in terms of number of used channels and their identification, and seems to be much more dynamic compared to the requirements for our bake out monitoring.

EVOLUTION OF THE ACTUAL SYSTEM

Initiated by the described weaknesses of our system, but also because of new, future machine requirements, our temperature monitoring system needs to be adapted.

The installation of in-vacuum undulators and NEG coated vacuum chambers requires a much higher level of control, monitoring and data storage, in order to meet the ultra-high vacuum specifications of the installed chambers, and the correct operation of the storage ring, front-ends, and beam lines.

To contribute to the smooth operation of our SR, there is a need for a reliable vacuum alarm system. Actually, we have a "two-state" vacuum alarm which consists of the state "ok" or "tripped" based on our interlock system. Even if the status for each vacuum equipment is reported to the general vacuum application, an overall evaluation is missing which allows the operation crew to recognize critical situations, or which helps the vacuum group to anticipate failures. For that reason, we have started with the implementation of more sophisticated alarms for our pressure measurements and SIPs operation.

Our aim is to include also temperature measurements and in some locations partial pressure measurements.

TEMPERATURE MONITORING SYSTEM

The actual temperature acquisition system consists of ~2000 thermocouples placed along the vacuum chamber walls or inside the vacuum system for bake out and machine diagnostics. Each of the 32 vacuum sections is equipped with two connection boxes to transfer from TCs to Cu-extension cables in order to connect them to the temperature acquisition unit located outside the SR tunnel.

The thermocouples we originally chose were too thin, and due to radiation and bake out their external liner (fiberglass material) became extremely brittle. The long cable length and multiple electrical connections showed to be a frequent source of faulty temperature indications leading to troubled interpretations of their meaning.

Lack of flexibility and frequent changes, made it extremely difficult to keep track and maintain a reliable system since any in-situ changes implied the update of resources and restart of server/client programs.

*On sabbatical leave at the SNS/ORNL, Oak Ridge, USA

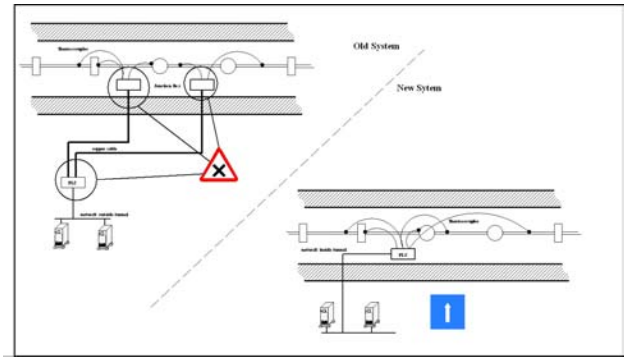

Figure 1: Temperature acquisition layout.

For these reasons, the presently installed thermocouples, including Cu-extensions, will be maintained for bake out monitoring, but will no longer be accessible via the general control system.

New thermocouples dedicated for machine diagnostics will be installed. We choose twisted wires of kapton® isolated thermocouples, which will be directly connected to a small modular PLC unit located inside the SR tunnel.

We installed one of these PLC's without shielding in order to check its radiation hardness relative to the chosen location. Measurements showed a total dose of 3.78Gy before its failure. Comparative temperature measurements with our standard measurement system (Figure 2) indicate a slow degradation of the actual measurement signal but no erroneous measurements or other problems related to communication or failures.

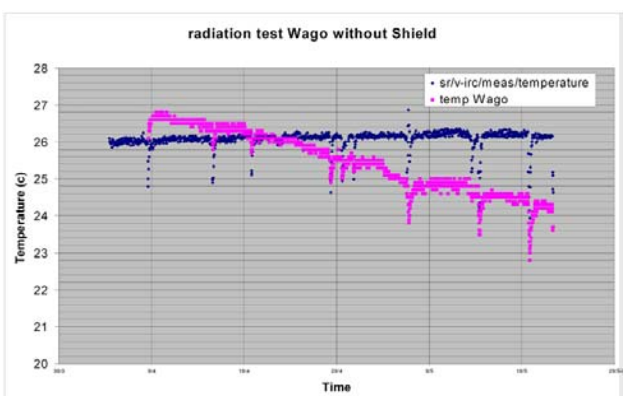

Figure 2: Temperature profile of an unshielded PLC.

With 3 mm of Pb-shielding, the dose rate could be reduced to 20mGy/month without any degradation of the measurement signals. This could be confirmed with a test unit, installed since more than 2 years and without any remarkable degradation.

In order to improve the experienced control problems due to frequent changes, we transfer most of the configuration and identification resources on the PLC level. Simple server programs of our general control system access the PLC Ethernet interface, via the TCP/IP protocol for data acquisition. With the help of OPC servers and a dedicated PC server, we are able to modify and configure the actual system by ourselves, such as add, remove or change names of thermocouples, without support from the computing group. Once the modification has been completed, the PLC dynamically updates the user applications and historical database. This dynamic upload of configuration changes should significantly improve our reliability, since the mismatch of names, channels within different applications was often a source of problems in the interpretation of equipment and machine operation and performance.

BAKEOUT MONITORING SYSTEM

With the aim to keep our vacuum control system in its actual state, we prepared a fast plug-in layout for a mobile bake out monitoring PLC. This concerns the survey of total and partial pressure measurement, temperature measurement, NEG activation, interlock and alarm handling. Refer to the pressure monitoring; we will keep the serial interface for the standard remote operation and use in parallel the analogue signals. All analogue and digital signals are pre-cabled and accessible in the electronic racks of each vacuum section.

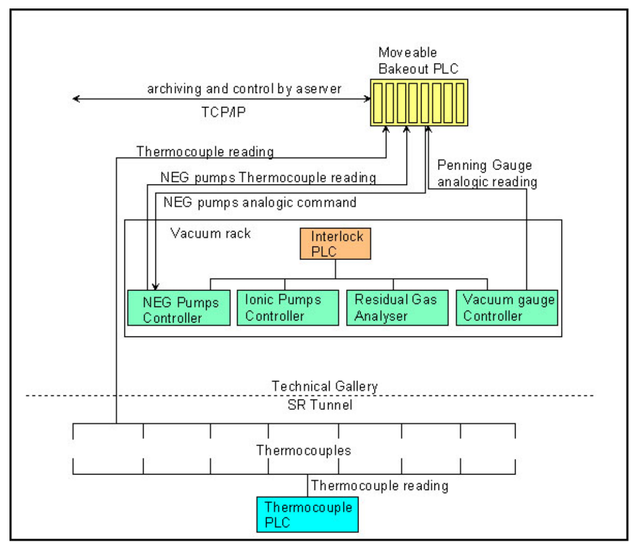

Figure 3: Layout of bake-out monitoring.

The monitoring of the bake out and control of the NEG activation is available through dedicated graphical applications via the embedded PLC Web server program. The archiving of the various signals is done on a dedicated PC via the TPC-IP interface and OPC servers.

CONCLUSIONS

The fact that we are faced to a large number of analogue (2600) and digital I/O (2000) signals dictates the use of high level PLC, with massive calculation power, which presents a clear overkill considering our requirements. This reflects not only an economical point of view but also the fact that these systems, because of their complex architecture and multiple interfaces, are often subject to modifications. Their maintenance appears similar to those of PCs regarding batches or software/ hardware changes.

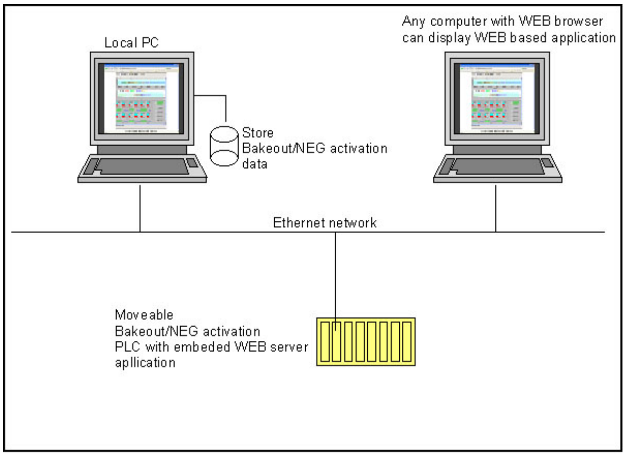

Figure 4: Monitoring and archiving of bake out data.

Since we need to split these signals due to cable length and space problems, but also from an operational point of view, our choice was to reduce the permanently installed signals to a minimum, and therefore allow a structure based on simple PLC units. More sophisticated PLCs are used for our mobile PLC systems, which are considered as stand-alone-units, independent of the ongoing activities during shutdown periods. We take advantage of the Web server technology, which we found easy to use and to modify since there is no code to be written. The fact that it is portable to various platforms appears to be of great advantage, without the necessity for any control system. The need for these improvements became evident during commissioning phases where the control system was not yet ready or different systems were used (SR, beam lines) or systems were subjected to frequent changes.

The shielded PLC units installed in the SR tunnel for temperature acquisition perform very well. Some of the units are installed since 2 years without any degradation or failures. The dynamical update of changes made to the system and its mirroring into the historical database or user interfaces works very well.

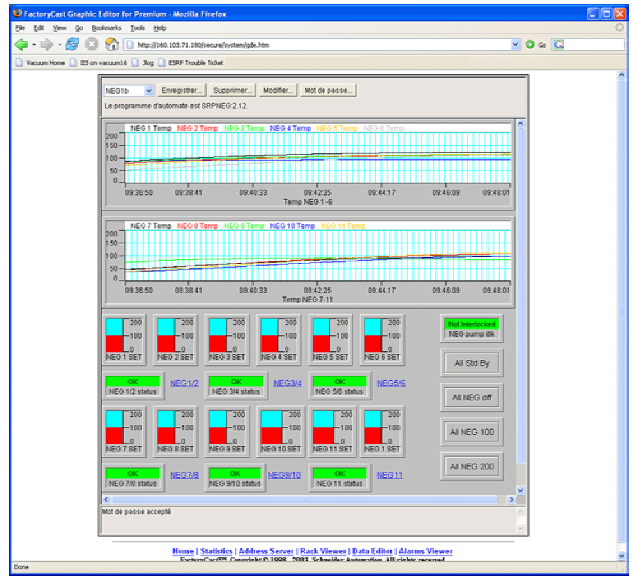

Figure 5: Web server based user interface.

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REFERENCES

[1] D. Schmied, “ESRF Vacuum Control System”, 41st IUVSTA Workshop, Brdo Pri Kranju, Slovenia, June 2004.

[2] D. Schmied, “Vacuum Control and Operation”, CAS Vacuum Technology, Snekersten, Denmark, June 1999.