A DIFFERENT WAY TO SURVEY THE ESRF VACUUM SYSTEM

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Abstract

The ESRF is in operation since many years. Due to the aging vacuum system, but also driven by the development to increase the machine performances and the continuous upgrade of our vacuum installations we have been reviewing our philosophy of data acquisition and monitoring. This paper outlines our work on the development of a new vacuum user interface. Which not simply reflects the actual status of our vacuum system, but which provides a dynamic survey of computed vacuum signals highlighting unusual vacuum behaviours and making their identification and location easier from an operator point of view. It also presents the use of "shielded intelligent" units and their integration towards a dynamic remote control system. Their use and drawback will be discussed.

INTRODUCTION

The ESRF is operating since more than 15 years serving 43 beam lines, delivering a stable photon beam with 98% of availability and a mean time between failures of 64 hours. The vacuum system, as one of many subsystems, appears to play a crucial role in the operation of such a facility. The vacuum has a clear impact on the beam quality under certain operation modes as well as downtimes in case the vacuum failures become important. In order to anticipate such failures, we have developed new vacuum survey tools, which allow us to detect at an early stage and with a good precision most vacuum problems before they becomes critical.

The vacuum control system includes the remote operation of about 200 Penning gauges (IMG), 70 Pirani gauges, 400 sputter ion pumps, 60 Residual Gas Analysers (RGA) and 900 thermocouples.

Due to the hazardous environment, initially no intelligent board or electronics had been installed in the Storage Ring (SR) tunnel. Equipments are connected via long cables and numerous electrical connections. This turned out to be a bad choice in the case of thermocouples or RGA units. Temperature measurements dedicated to monitor the SR behaviour during its operation requires a high flexibility in terms of number of used channels, location and identification.

Also complicated measurement systems such like RGA, suffer from too many electrical connections and electronic sub-set-ups. Therefore our choice was to integrate the whole electronic device in one part not far from the analyser head and accessible via a Modbus TCP/IP protocol. During down times we take advantage from the integrated WEB server to perform maintenance work and do analysis.

It also became clear to distinguish the diagnostic requirements needed during SR operation and shutdown periods.

In order to follow-up these requirements a number of hardware and software modifications have been undertaken and are still ongoing.

HARDWARE LEVEL

Temperature Acquisition System

We have chosen twisted wires of Polyimide isolated thermocouples, directly connected to shielded modular PLC sub-units, in a master – slave configuration located inside the SR tunnel. This dramatically reduced the number of electrical connections, eases their installation and removed the requirement of local temperature compensation (see fig. 1).

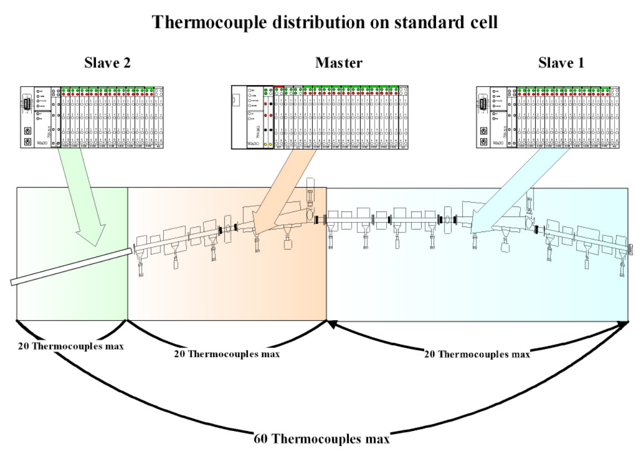

Figure 1: PLC set-up of a SR cell.

Their shielding was based on the fact that the neutron radiation doses rates and the losses due to Bremsstrahlung where low, with less than 1% for most sections of the SR. Therefore the main amount of radiation is due to scattered synchrotron radiation with important variations in its spatial distribution [1],[2].

Actually about 900 thermocouples are connected to 32 PLC units all around the SR tunnel and shielded with a 3mm lead cover.

Device Server

A Tango [3] device server program of our general control system accessing the PLC via a Modbus TCP/IP protocol does the data acquisition.

The PLC has two operation modes. In maintenance mode the device server stops its data polling and enables the modification of the actual system such as to add, remove or change names or location of thermocouples without any support from the computing services. Once these modifications have been completed, the PLC is set back into operation mode. This triggers the Tango device server to start with its data polling while dynamically updating any changes compared to its initial configuration. The restarts of the user application programs are necessary to upload the latest modifications.

We introduced a round-robin buffer at the device server level, keeping all measurement data of the SR thermocouples stored for at least three hours. The device server itself triggers the archiving of temperatures in our historical database, as soon as a significant data change is detected in this round-robin buffer.

The definition of alarm levels appeared to be a real problem due to most different thermocouple locations and various SR filling modes. Therefore we introduced alarm tables for each SR filling mode on the PLC level. The device server updates the PLC in case of a change in the SR filling mode, which triggers the PLC to upload the dedicated alarm table. While generating these alarms, new alarm levels can be acknowledged by the PLC. The alarm level increases over time for each thermocouple are stored and can be checked. This dynamic alarm level generation turns out as a sensitive diagnostic tool to identify slow degradation of RF-liners. It also helps to identify unusual heat loads which could be very difficult to recognize due to the different heat load in the various SR filling mode.

We develop a wireless, mobile PLC unit, which can be used for temporary temperature measurements. This allows an even faster installation and doesn't spoil our global survey with very specific problems or experiments. These signals are stored in our historical data base for data retrieving.

VACUUM GRAPHICAL USER INTERFACE (GUI) LEVEL

Our aim was to develop a new vacuum user interface, highlighting any significant changes on any of the SR pressure and temperature sensors, in order to get a global vision of this system. We could identify three different monitor modes which had proven to be useful in the past.

The first mode is a traditional survey of the absolute temperatures or pressures measurements along the SR. Each sensor is represented in a bar chart mode with its actual and saved maximal readout since its last manual reset. Thermocouples exceeding their filling mode dependent alarm level are highlighted in a different colour. This enables to identify any unusual pressure or temperature increase since the last check and appears to be a very useful tool for the day-to-day vacuum follow-up.

The identification and geographical localisation of a thermocouple showing a suspicious behaviour or alarm is done with the help of a graphical application program. This application uses the stored PLC thermocouple coordinates referring to its actual position in the SR cell and places them on an up-to-date cell layout from our drawing office (see fig. 2).

All these user applications are dynamically uploaded in case of any changes in the thermocouple set-up as their numbers, location, naming or alarm level.

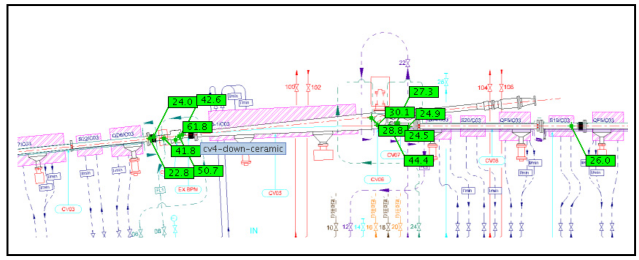

Figure 2: Example of a cell section layout.

Leaks are often identified in a very early state by using a reference pressure survey. During Machine Dedicated Time (MDT) in User Service Mode (USM like), the operator makes a reference survey of all SR Penning gauges and ion pump currents which is normalized to the stored beam current for each specific filling pattern.

The continuous survey of the actual normalized SR pressure readouts normalized with the reference pressure survey of a specific filling mode indicates the smallest unusual pressure variation (see Fig. 3). A derivation by a factor of several units (3-4) already indicates an unusual pressure rise which may indicate an initial phase of a leak or thermal problem.

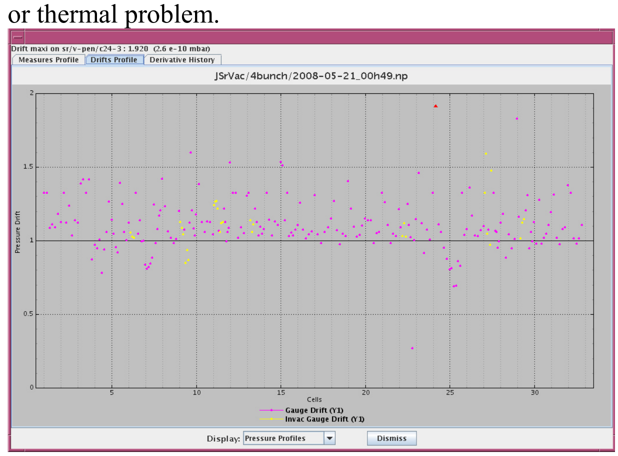

Figure 3: Example of a SR pressure reference survey.

The third mode is dedicated to giving a survey of any relative pressure and temperature changes within a short period of time from one to several hours. This derivate signal of gauge and pump pressures, normalises the actual pressure readings to the pressure readings taken sixty seconds earlier.

The thermocouples survey is done in a different way, due to their locations on the external side of the vacuum chambers and therefore slow response times. Instead of looking to the relative temperature changes, we normalized each thermocouple with the average value of all thermocouples belonging to the same family (i.e. installed at equivalent location on chambers of the same type).

These relative changes of all pressure sensors or thermocouples over the SR are displayed in a 3-

dimensional survey by using a dedicated colour code, as exemplified in Fig. 4.

This application is very helpful to immediately identify and localize any pressure or temperature increase linked to the actual SR operation such as: lifetime accidents, ID gap, cooling problems or and steering magnets problems, emittance instabilities, and other faulty equipment.

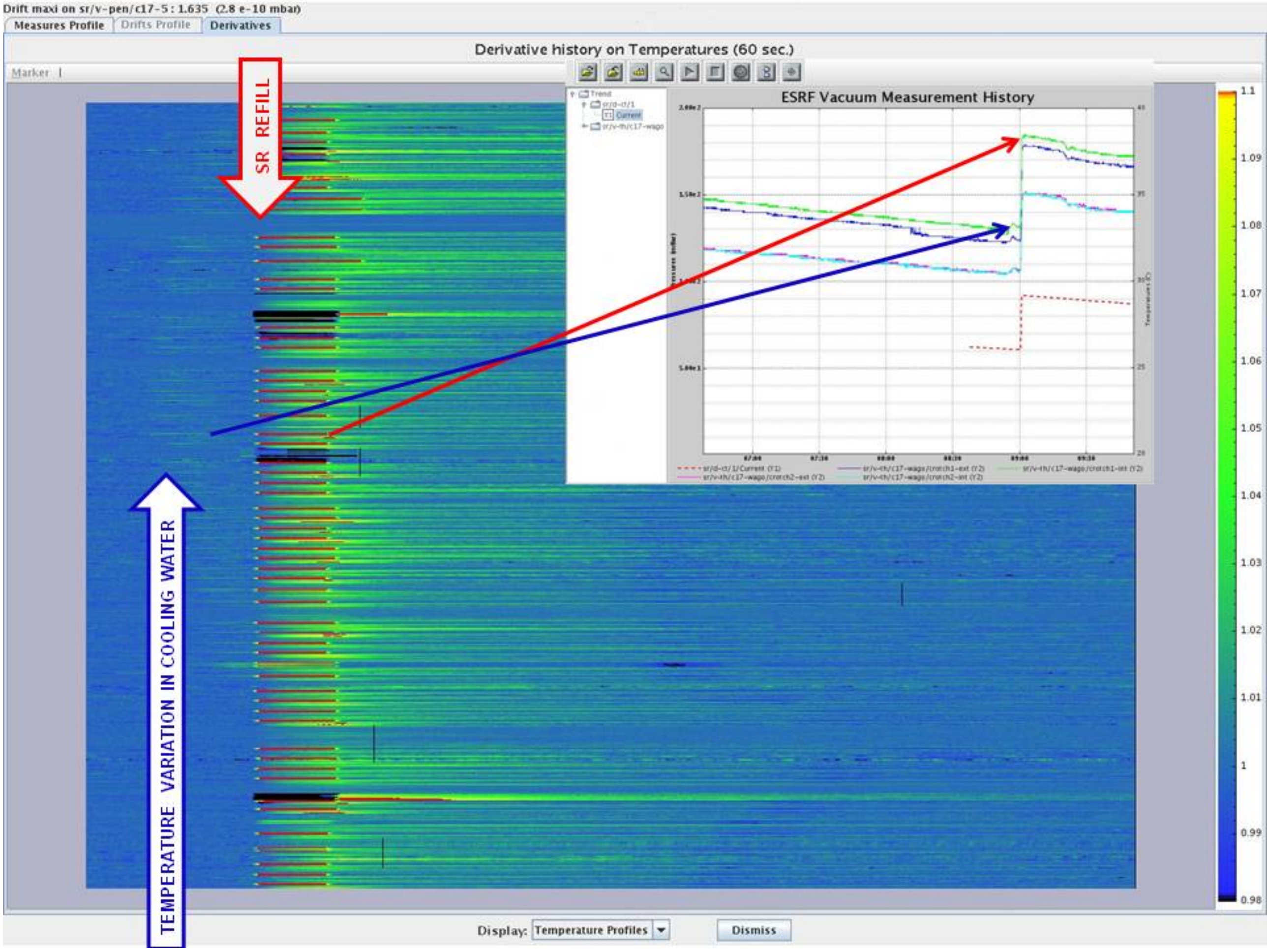

Figure 4: Example of a SR derivative temperature survey of thermocouples on crotch absorbers.

These software applications and necessary procedures to produce references are used and established by vacuum specialists and daily used by the shift crew to identify possible mis-functioning.

CONCLUSIONS

The designed temperature acquisition system based on shielded PLC units located inside the SR tunnel fulfilled our requirements of reliability and flexibility.

The vacuum user interface is permanently improving at the light of the experience and enriched with new features. The described tools clearly eased the follow-up of the vacuum system and helped to anticipate problems before they occur. The link to identify suspicious sensors on a cell layout allows the operator to make an early and enhanced diagnostic before calling the vacuum standby.

In many cases major problems could be anticipated and fixed during machine dedicated times.

We wish to include an enhanced diagnostic tool for the installed and running 60 RGA systems. We are searching for a smart algorithm, which indicated any significant changes with time and which would have a drawback to the SR beam quality.

ACKNOWLEDGMENTS

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[3] http://www.tango-controls.org (tango control system).