PRESENTATION OF THE NEW ESRF VACUUM CONTROL APPLICATION FROM AN OPERATIONAL POINT OF VIEW

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Abstract

The ESRF is in operation since more than 15 years. Due to the aging vacuum system, we are faced with failures such as air or water leaks, overheating of RF-liners or poor chamber alignment. In order to anticipate these failures and therefore reduce down times, we have developed new diagnostic tools allowing us to detect as early as possible and with a maximum of precision any vacuum hazard before it becomes critical. Also driven by the development to increase the machine performances and the continuous upgrade of our vacuum installations, we search for new tools to safely commission these upgrades. 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.

INTRODUCTION

Triggered by the replacement of our entire network of front-end computers from a diskless VME based real-time operating system to industrial PC under LINUX, we migrated most of our vacuum equipment while redefining major parts of their remote control.

The control system is in charge of the remote operation of all permanently installed vacuum equipment. It concerns 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, 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. Temperature measurements dedicated to monitor the SR behaviour during 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.

EVOLUTION OF THE ACTUAL SYSTEM

Initiated by the described weaknesses of our aging systems but also because of new future machine requirements we needed to review our vacuum monitoring system in order to guarantee a smooth SR operation. The installation of new machine parts such like (cryogenic) invacuum undulators or NEG coated vacuum chambers as well as pushing the machine performances to higher limits regarding stored currents, filling pattern or changed lattices require a much higher level of monitoring. It became clear to distinguish the 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 UPGRADE

Temperature acquisition system

New thermocouples dedicated for machine diagnostics have been installed. 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.

In order to improve the experienced control problems such as frequent changes of location, names and numbers, we transfer most resources of thermocouple configuration and identification data on the PLC level. A Tango device server program of our general control system accessing the PLC via a Modbus TCP/IP protocol does the data acquisition. We are able to modify and configure the actual system by ourselves, such as to add, remove or change names of thermocouples without support from the computing services. Once this modification has been completed, the PLC dynamically updates the user applications and historical database. This set-up improved significantly the reliability of our temperature measurements, which before was spoiled due to a complicated set-up of hardware and software which involved different persons to perform any modification.

Residual gas analysers

The maintenance of RGA systems are important, especially if these equipment are running continuously for partial pressure analysis. The time consuming calibration of multipliers or the trouble shooting of aging analyser heads and adjusted electronic is even more difficult in the case of a split set-up with even more electrical connections and electronic parts. Therefore our choice was to integrate the whole electronic device in one part not far from the analyser head also 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.

SOFTWARE UPGRADE

Device server

We introduced a round-robin buffer at the device server levels for keeping the measurement data of all SR vacuum sensors for at least one hour. This enables the person on standby to crosscheck the fine structure of any suspicious signal. The sampling period has been set to one second for the Cold Cathode gauges; as for ion pump currents and thermocouples this period has been increased to three seconds.

The device server itself triggers the archiving of vacuum data in our historical database, as soon as a significant data change is detected in this round-robin buffer. This dramatically improved our stored data resolution, since the sampling rate of all vacuum signals decreased from thirty to one second and therefore ensures that we are not loosing any important information in our history.

The analysis of these stored data, give us many precise information and great help in the trouble shooting failures like: faulty RF liners, cavity instabilities or faulty equipment.

Vacuum application

The aim of the new user vacuum application is to give a global vision of any significant change on the SR pressure and temperature sensors. We have developed three different monitoring modes which prove useful.

The survey of the absolute temperatures or pressures measurements along the SR together with their measured maximum readout appears to be very useful tool for the day to day vacuum follow-up. Each sensor is represented in a bar chart with its actual and maximal readout in different colours since its last reset. This enables to identify any pressure or temperature increase. The reset of these maximum readouts is manually realized once the daily check has been finished. We can easily correlate pressure increases with lifetime accidents or other machine related changes thanks to the precise time stamping of each pressure or temperature peaks.

The temperature profiles can be displayed by families. This allows the detection of unusual heat loads, cooling problems or misalignments.

Each thermocouple is associated with a set of data defining its geographical location, its alarm level and its name. It can be easily identified and geographically localized thanks to an application program that uses the up-to-date cell layout produced by the drawing office.

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 (see fig. 1).

Leaks are often identified in a very early state by using a reference survey. During Machine Dedicated Time (MDT) in User Service Mode (USM like) the operator makes a reference pressure survey of all SR Penning gauges and ion pumps which is normalized to the stored current. These pressure reference surveys are stored in dedicated machine filling pattern files. The continuous survey of the actual normalized SR pressure readouts normalized with the reference pressure survey of the actual filling mode displays the smallest unusual pressure variation in the SR (see fig. 2).

The third mode is dedicated to give a survey of any relative pressure changes within a period of one hour. This derivate pressure profile of gauges and pumps divides the actual pressure readings with the pressure readings taken sixty seconds earlier.

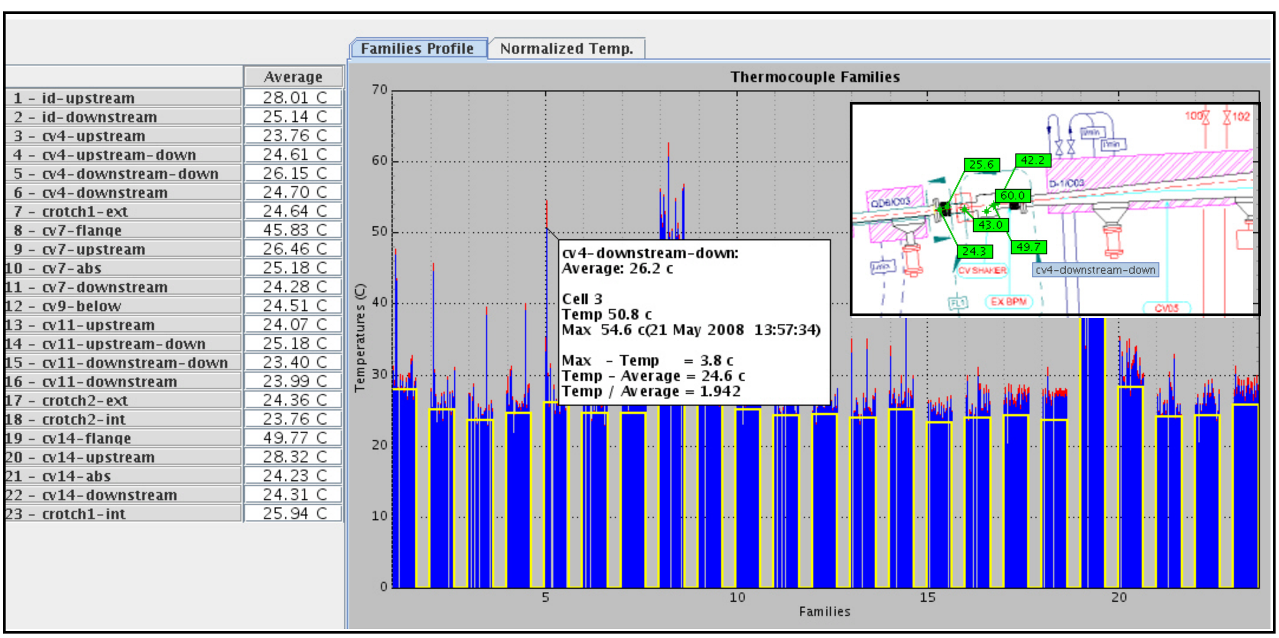

Figure 1: Example of SR family temperature profile with their geographical location

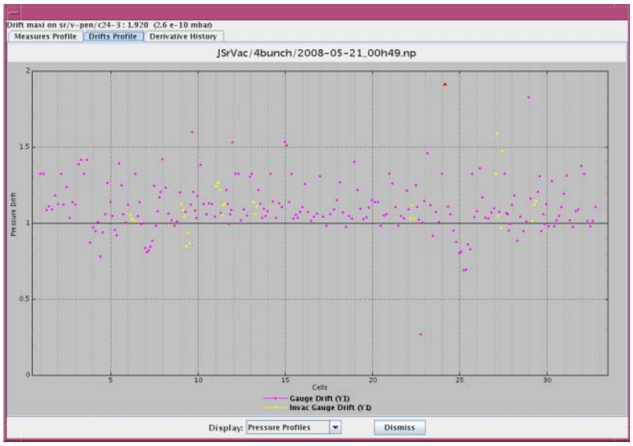

Figure 2: Example of a SR pressure reference survey

These relative changes are displayed in a colour code of a 3-dimentional survey, where all pressure sensors of the SR are represented over a time period of 1 hour. This application is very helpful to immediately identify and localize any pressure increase linked to the machine operation such as: lifetime accidents, ID operations but also faulty equipment (damaged cables).

The thermocouples survey is done differently. Due to different locations and slow response times instead of looking to the relative temperature changes we are normalizing the dedicated thermocouple with the average value of all the thermocouples of the family. This allows showing unusual thermal behaviour which may indicate problems with RF-liners or local heating.

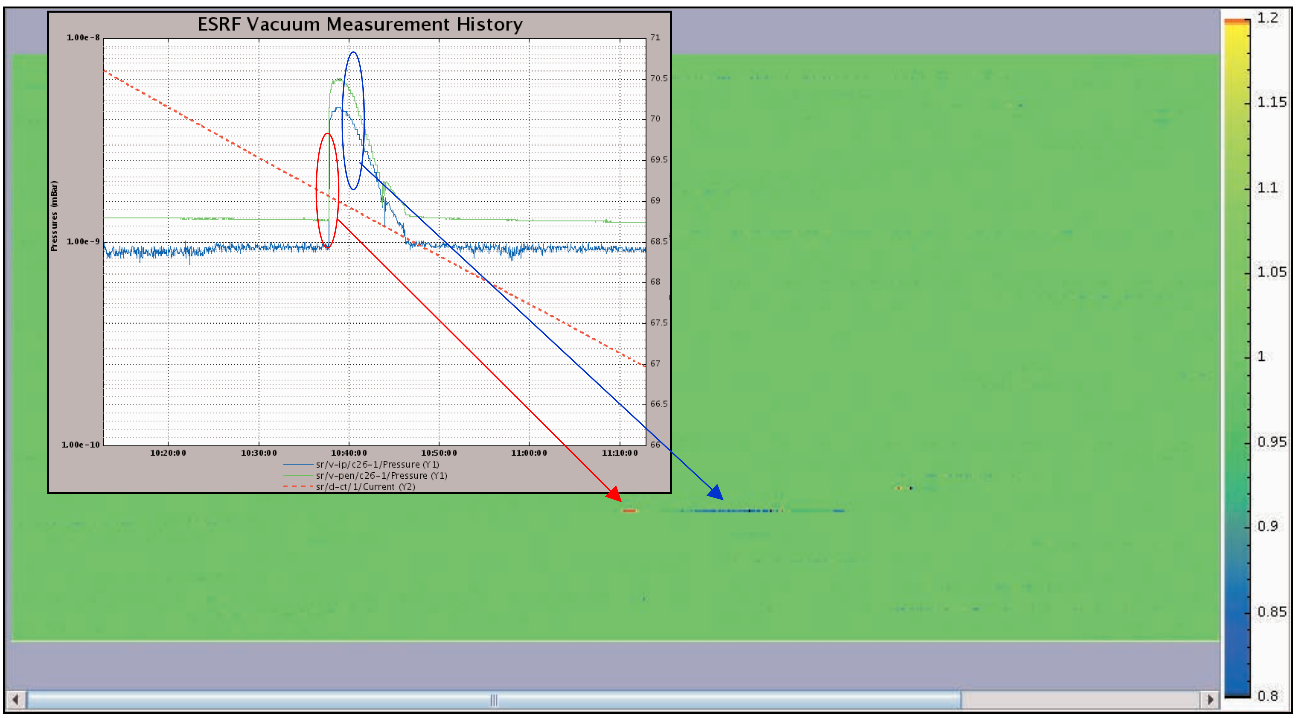

Figure 3: Example of a SR derivate pressure survey

CONCLUSIONS

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. A next step will be to extend the geographical localization to all vacuum equipment in addition to the thermocouples. The application layout is dynamically refreshed after any change in the geographical coordinate associated to any device. Further we wish to include a closer diagnostic tool on the installed and running 60 RGA systems. We are searching for a smart algorithm which indicated any significant changes with time. We are thinking to focus on certain atomic mass units, which could identify leaks, faulty ion pumps or contaminations from UHV beam lines based on a similar layout as the derivate pressure profile. The permanent improvement of the vacuum system will continue. The key of its success is the dynamic and proactive collaboration between equipment, specialists, operation specialists and software developers.

ACKNOWLEDGMENT

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