UPGRADE OF THE RGA SYSTEM

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Abstract

In the frame of the ESRF upgrade program, the accelerator Residual Gas Analyser (RGA) system has been reviewed. A campaign of RGA refurbishment has been started recently giving more reliability and accuracy on partial pressure vacuum control. Based on new technologies and on our operational experience, a new RGA monitoring application and diagnostic tools are being developed. This paper outlines the evolution of the actual RGA system focusing on the hardware installation description, on software and user interface developments. The continuous follow up of a defined number of partial pressure measurements using different dynamic control modes will be described.

INTRODUCTION

As vacuum quality is one of the most important parameters to guarantee the reliable operation of the accelerator, improving vacuum survey systems is a fundamental element. A refurbishment campaign of Residual Gas Analyser (RGA) system started a few years ago at the ESRF. To date, more than 40 new RGA units have been installed mainly along the Storage Ring (SR) at the most critical locations such as Insertion Device sections, crotches and cavities. Using faster interfaces, more reliable and accurate measurements, a new monitoring and alarm application has been developed which allows us to detect and identify at an early stage most vacuum problems before they become critical. This new application is then useful for real time diagnostic, failure analysis and preventive maintenance identification.

RGA HARDWARE UPGRADE

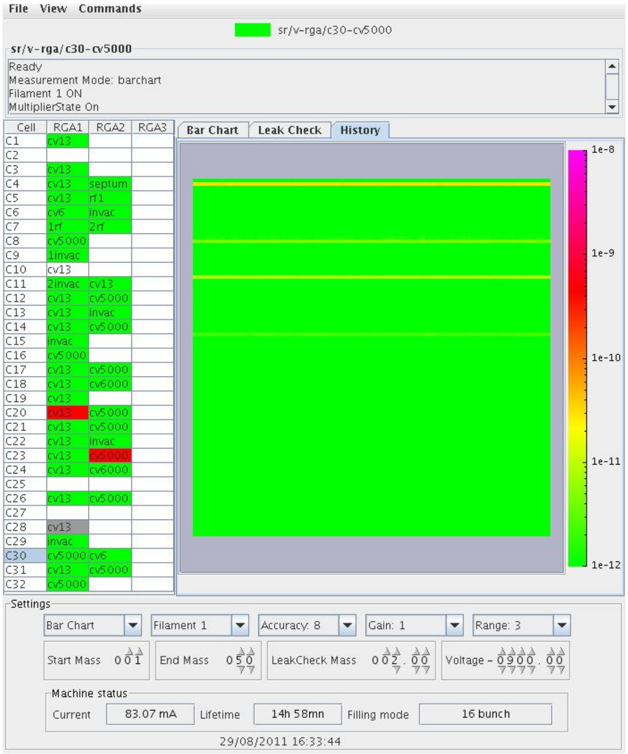
After many years of continuous use, maintenance and troubleshooting on RGA systems has become increasingly time consuming. Therefore, in the context of the ESRF upgrade program [1], new RGA controllers were chosen to afford more flexibility, accuracy and reliability in partial pressure measurements. MV2 control units from MKS were installed in the storage ring close to the RGA heads using lead shielding for protection against radiation. Data acquisition is done through a TAco Next Generation Objects (TANGO) device server program [2] on our general control system network which communicates with the RGA's control units via a *modbus* TCP/IP protocol. With the new MV2 units we take advantage from the integrated WEB server to monitor the instrument status from anywhere on the network.

RGA MONITORING SYSTEM

Device Server

As it has been previously reported [3], we used a *first-in-first-out* buffer at the device server level for keeping, at least, one hour of measurement data of all storage vacuum instruments, including RGA's. This enables the operator to crosscheck the fine structure of any suspicious signal. The acquisition time is about 1 scan every 40 seconds. All data is also archived in a historical database (HDB).

The analysis of these stored data in real time gives precise information and great help for troubleshooting.



sr/v-rga/c30-cv5000

Ready
Measurement Mode: barchart
Filament 1 ON
MultiplierState On

Cell	RGA1	RGA2	RGA3
C1	cv13		
C2			
C3	cv13		
C4	cv13	septum	
C5	cv13	rf1	
C6	cv6	invac	
C7	1rf	2rf	
C8	cv5000		
C9	1invac		
C10	cv13		
C11	2invac	cv13	
C12	cv13	cv5000	
C13	cv13	invac	
C14	cv13	cv5000	
C15	invac		
C16	cv5000		
C17	cv13	cv5000	
C18	cv13	cv6000	
C19	cv13		
C20	cv13	cv5000	
C21	cv13	cv5000	
C22	cv13	invac	
C23	cv13	cv5000	
C24	cv13	cv6000	
C25			
C26	cv13	cv5000	
C27			
C28	cv13		
C29	invac		
C30	cv5000	cv6	
C31	cv13	cv5000	
C32	cv5000		

Settings
Bar Chart
Filament 1
Accuracy: 8
Gain: 1
Range: 3
Start Mass 001
End Mass 050
LeakCheck Mass 002.00
Voltage - 0900.00

Machine status
Current 83.07 mA
Lifetime 14h 58mn
Filling mode 16 bunch

29/08/2011 16:33:44

Figure 1: Viewing of ESRF RGA monitoring application with real time absolute partial pressure survey (absolute mode).

RGA Application

The aim of the new user vacuum application is to give a global vision of any significant change on the partial pressures. Two different modes are used to follow up all RGA measurements within the application.

The first mode is the usual absolute partial pressure display in a bar chart, for a real time single scan, or in a colour intensity map for the last hour of saved scans using the colour scale for pressure representation - Figure 1. This mode is mainly useful for instrumentation troubleshooting or calibration purposes. Indeed, the absolute pressures can be difficult to interpret without a very good knowledge of the machine and without RGA analysis expertise.

The second mode is based on relative partial pressure survey. It consists in a 3-dimensional representation, as previously described, of selected partial pressures - masses M = {2, 12, 14, 16, 17, 18, 28, 32, 40, 44}. Each relative pressure corresponds to a pressure change against its own reference. There is one reference pressure for each mass per RGA and per SR filling mode. This is particularly useful for a first and quick analysis of vacuum events. Figure 2 is an illustration of the second mode showing typical partial pressure change signature in case of an air leak event. Air leaks are clearly linked to strong relative change of partial pressures corresponding mainly to masses 14, 28 and 40 (N, N_2, and Ar).

These different survey modes are very helpful in operation when a vacuum problem occur during the last hour corresponding to the buffer size and at a well identified location. However after one hour, RGA data analysis has to be done from absolute pressures data archived in our database. To gain time and to be sure that all relevant events will be detected and checked, a real time diagnostic tool and alarm archiving has been developed.

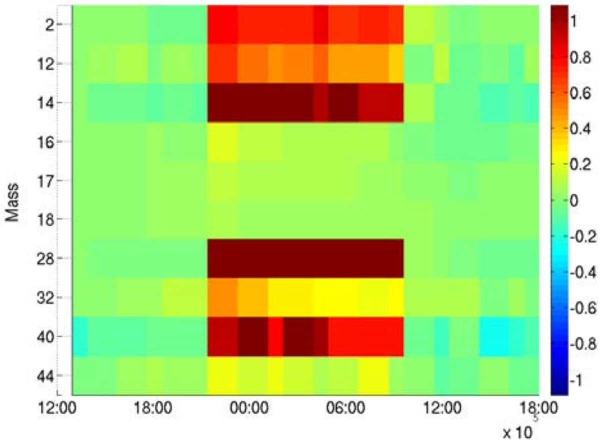


Figure 2: Viewing of ESRF RGA monitoring application with real time relative partial pressure survey (relative mode).

RGA Real Time Diagnostic

The RGA diagnostic is made in real time for each new scan (n^{th} spectrum). The diagnostic algorithm consists of Boolean tests and arithmetic operations in order to detect abnormal vacuum incidents and display corresponding alarms.

For the most part this consists of comparing all partial pressures for a selection of masses M, P(M,n), to threshold reference pressures. The pressure threshold values are an addition of two contributions: a mean adjusted reference pressure and a noise contribution as described in the formula below. Fp and Fσ are configuration parameters that can be adjusted by the user.

$$P_{lim}(M,Alarm) = \{F_P(M,Alarm) \times P_{ref}(M)\} + \{F_\sigma \times \sigma_{ref}(M)\}$$

With,

M = {2, 12, 14, 16, 17, 18, 28, 32, 40, 44}

Alarm = Alarm level as described in table 1.

$P_{lim}(M,Alarm)$ = Partial pressure threshold for mass M and for specified alarm level

$F_P(M,Alarm)$ = Partial pressure threshold factor for mass M and for specified alarm level

F_σ = Noise adjusting factor

$\sigma_{ref}(M)$ = Standard deviation of reference partial pressure

Based on feedback from all incidents logged over the years, we defined different alarm levels associated to air leak, water leak, and abnormal outgassing. Each alarm is triggered by fixed conditions on absolute and relative partial pressures. Their triggering conditions regarding absolute pressures are defined in Table 1. Conditions on relative pressure change are not described in this paper.

Table 1: Alarm level corresponding to vacuum events and main linked conditions.

Alarm	**Condition on absolute pressures**	**Description**
4	$P(M,n)>P_{lim}(M,4)$	Water Leak
3	$P(M,n)>P_{lim}(M,3)$	Air Leak
2	$P(M,n)>P_{lim}(M,2)$	Abnormal Outgasing
1	$P(M,n)>P_{lim}(M,1)$	Not identified / not critical
0	-	Normal

All alarm levels are displayed in real time by the RGA application and archived. This enables the operator to check abnormal incidents and their location in short time.

Figure 3 shows the archived and displayed alarm in the case of the air leak event corresponding to Figure 2. From the operation point of view, the alarm level is frozen when it appears until being released through the Graphic User Interface.

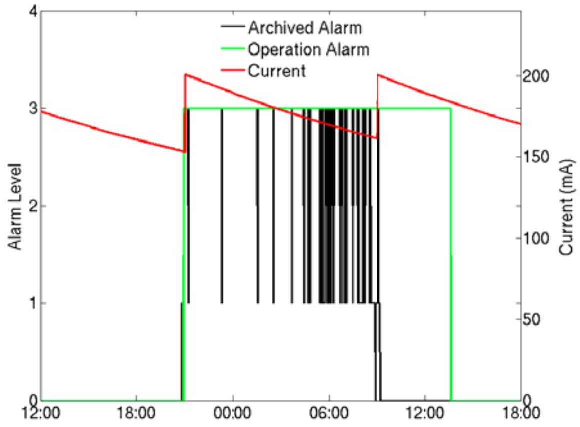


Figure 3: Alarm level evolution in case of air leak event.

CONCLUSION

It is a major objective of the ESRF Vacuum Group to continuously improve our vacuum survey tools taking into account new technologies, the upgrade of the accelerator and our operational experience. This new RGA application has already shown great potential for real time diagnostic of vacuum incidents and for failure analysis and preventive maintenance. The diagnostic algorithm has passed acceptance tests based on archived data analysis and the implementation of the Graphic User Interface is in progress. A commissioning phase will follow. This application has the main advantage of being tuneable to the needs and will be useful in a near future in the context of beamlines upgrade, especially for UHV beamlines directly connected to the storage ring vacuum. The next step of development will be a self configuring system with automatic reference setting. This system has to take into account the conditioning effect of new chambers as well as instrumentation noise drift.

ACKNOWLEDGEMENTS

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