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Residual gas analysis on the Daresbury synchrotron light source

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Residual Gas Analysis (RGA) is a useful diagnostic tool for vacuum systems. One of the original design features of the Daresbury Synchrotron Radiation Source (SRS) vacuum system was a multiplexed, remote operation RGA facility. This has now been operational for more than fifteen years and has been used extensively to monitor vacuum leaks, performance of the vacuum system and contamination levels. By monitoring these parameters routinely, much useful information can be obtained about some of the operational characteristics of the SRS and about warnings of developing leaks or electron beam steering problems. It has not been possible to consistently and reliably monitor the SRS vacuum system in the way intended because of limitations in the multiplexing hardware and control software of the RGA facility. Recently a new multiplexing and data handling system has been developed for us by a commercial company and installed as an upgrade to part of the SRS. In this paper the hardware of the new system is described, a software program to acquire routine RGA data is illustrated and the application of this data to understanding more about the way the SRS 'cleans up' after exposure to atmosphere is detailed.

Introduction

It is usual for the vacuum system of a synchrotron light source to include relatively low cost Residual Gas Analysers (RGA's) of the quadrupole type. It is widely accepted that RGA is an important diagnostic facility, particularly during commissioning of a light source and when vacuum or accelerator problems arise. Although it is possible to use such analysers for quantitative studies, it is more common to use them for qualitative work¹ where the absolute value of a peak height is not as important as the general comparison

of different mass peak heights. Previous work at our laboratory² has shown considerable variation in both the absolute and relative sensitivities of a small sample of nominally identical quadrupole analysers even after careful setting up by the user. This implies caution when interpreting the results produced by an RGA.

Accelerator vacuum systems require, for the most part, that all electronic instrumentation be located some distance from the beam envelop because it is a high radiation environment. It is useful to have RGA's located at strategic positions around the accelerator with a central control system which

allows interrogation at the point of interest. Hence, it is necessary to have a remotely operated RGA system that will function satisfactorily over considerable distances ($\approx 100\text{m}$ for the Synchrotron Radiation Source (SRS) at Daresbury). When the SRS was designed and built, there was no commercial RGA equipment available that provided these basic requirements. A custom built system was purchased³ which provided the basic diagnostics but owing to design limitations, this was later replaced by a commercial system. However the reliability of this system has been poor.

This paper will outline some of the problems encountered in using the system, the difficulties of upgrading and how a partial upgrade of the RGA system has been achieved.

The Installed RGA System

The RGA system installed is shown in the block diagram of figure 1. Two such systems were installed, one for the storage ring straight sections and one for the beam ports. Both systems are basically identical. Each analyser is directly connected to an RF generator and then by up to 100 metres of cable to a multiplexer system. The multiplexer allows individual analysers to be connected so that the ion source filament is continuously powered to maintain the correct operating temperature at the ion source. The other potentials to the head are biased to ensure equilibrium is quickly reached when an analyser is selected. Each channel also has a protection facility which is connected to a total pressure gauge and an isolation switch to safely disconnect an individual analyser from the system during maintenance. These individual multiplexer channels are then connected to a further multiplexer unit that controls the signals to and

from the central operating system which is basically a PC with the appropriate software loaded and suitable control interfaces. The system can be controlled remotely from any number of control computers via an RS 232 network, only one connection being permitted at any one time.

Although this system has proved to be very useful, it has not been reliable, particularly as regards the multiplexing arrangement. A great deal of system management has been required over the years to keep the system operating in a satisfactory way. Indeed, in the event of an emergency (e.g. an air leak in the storage ring preventing SRS operation) it has often been necessary to operate an RGA locally, i.e. by direct connection to a control unit at the analyser head.

Automatic collection of data from each analyser at regular intervals, could, in principle, be achieved by using a program running on the remote PC. The program would need to make a connection to each analyser in turn, wait for stable conditions, obtain RGA data and then store the information in a suitably named file on the remote PC. Much time and effort was spent trying to achieve this, but the unreliability of switching (multiplexing) between analysers meant that the system would often crash. It was decided that manufacturers should be approached about a possible upgrade to the system in order to improve reliability.

Constraints on the upgraded RGA System

The most fundamental constraint was the requirement that the analyser heads installed on the SRS facility would not be changed, there are two reasons for this. First would be the high cost of replacing some 33 gauge heads. The second

reason was that it would mean that the SRS would be out of operation for too long.

Manufacturers were asked to provide a system that would interface to the existing analysers, use the existing RF generators and to make use of the existing cables as far as possible. Supplied software was to provide all the facilities of the existing software, but with the added provision of recording data from each analyser on a schedule. If possible the software was to be platform independent, so that both IBM™ PC and Macintosh™ systems could be used to operate the system remotely.

System Upgrade

Available funds restricted us to a part system upgrade for six of our analysers. This also had the benefit of allowing us to evaluate the new system thoroughly. The hardware configuration for this upgrade is shown in figure 2.

The cluster server computers (100MHz 486 PC's) can each control up to eight RGA's. In principle, therefore, only one cluster server would be necessary to drive the six analysers chosen to be upgraded in this exercise. However it was decided that two cluster servers would be purchased to provide some flexibility in the system allowing two remote computers at a time to be connected to the new system. The cluster server connects to an RGA control unit located close to the server, but approximately one hundred metres from an RGA on the SRS. RF generators in fact had to be purchased with a bakeable adapter cable to interface to the existing quadrupole gauge head.

The software package driving the RGA system runs in an X Window session to allow the remote computer to connect to

it via Ethernet and operate the RGA system. It allows the user to write 'macro' programs to carry out automatic data gathering in any of the modes provided by the software. The macro program that performs data collection is written as a simple text file, and the versatility of the program language is such that quite complicated procedures can be set up to match user requirements.

Routine Data Collection

As mentioned earlier, the most important feature of this upgrade is to provide continuous collection and storage of RGA data. Ideally all the analysers on the machine would be operational at all times and data for all masses available over many decades of pressure would be collected. Clearly this is not practical. The time required to measure and record the ion current at a particular mass will depend on the sensitivity setting of the analyser, the accuracy of measurement required and the speed of operation of the software. Large quantities of data also require large quantities of disk space. Compromises have to be struck with the aim being to cover as many fault conditions as possible together with gathering information on the behaviour of the vacuum system under different beam conditions.

Some fault conditions are:

- opening up of new leaks
- development of existing leaks
- beam steering problems
- contamination

For example, in the past, we have experienced problems with contamination at the cathode in the electron gun. In this case we monitor the relevant peaks associated with this

contamination and work closely with the RF systems group to identify its source. For this we use a dedicated RGA in the multiple ion monitoring mode, also known as peak jump mode, to monitor the relevant peaks.

To monitor the residual gases within the storage ring vacuum system is more complex. Gas scans are collected for each of six analysers by running a macro program once a day on a scheduler. This program collects data that can be used to monitor the state of the vacuum system in general. However, by operating in this way it is unlikely that single events will be picked up. Hence, if a particular problem occurs, for example a small air leak develops, we would use the closest analyser to the leak to monitor continuously the development of the problem.

Application of Data Gathered

This paper has outlined some of the applications of RGA in our accelerator. An example of data gathered with the new RGA system soon after commissioning is presented in figure 3.

The data was taken after part of the SRS storage ring vacuum system was vented to atmosphere during scheduled maintenance. The graph shows how the partial pressure of water (mass 18 AMU) changes in time, and how this correlates with the lifetime of the electron beam. The period over which the data was recorded is 62 days, starting with a period of 11 days for accelerator physics commissioning. It is interesting to note that on day 39 the lifetime dropped dramatically for a few days after a beam loss caused by an unknown event. The RGA system shows a rise in the water peak corresponding to this event which may in fact be due to

a shift in the electron beam orbit. If the problem had continued, the RGA system would have been of valuable assistance in identifying the precise nature of the problem so that remedial action could have been taken.

Summary

An upgrade to the Daresbury SRS RGA system has been achieved without changing the installed analysers. The system now offers a reliable method of data collection, storage and retrieval.

References

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Figure Captions

Figure 1.

Overview of the installed RGA system for the SRS

Figure 2.

Block diagram of the upgrade to the RGA system for the SRS.

Figure 3.

Changes in Partial pressure of water and of beam lifetime over a period of two months in the SRS after a machine let up.

FIGURE 1

FIGURE 2