NSLS-II VACUUM CONTROL FOR CHAMBER ACCEPTANCE

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Abstract

The National Synchrotron Light Source II (NSLS-II) uses extruded aluminium chambers as an integral part of the vacuum system. Prior to installation in the Storage Ring all dipole and multipole chamber assemblies must be tested to ensure vacuum integrity. A significant part of the chamber test requires a full bakeout of the assembly, as well as control and monitoring of the titanium sublimation pumps (TSP), non-evaporable getter pumps (NEG) and ion pumps. Data that will be acquired by the system during bakeouts includes system temperature, vacuum pressure, residual gas analyzer (RGA) scans, ion pump current, TSP operation and NEG activation. This data will be used as part of the acceptance process of the chambers prior to the installation in the storage ring tunnel. This paper presents the design and implementation of the vacuum bakeout control, as well as related vacuum control issues.

INTRODUCTION

The NSLS-II storage ring is made up of 30 cells and 30 straight sections. Each vacuum cell consists of five basic chambers; an upstream matching multipole chamber, a dipole chamber, a high dispersion section multipole chamber, a second dipole chamber, and a downstream matching multipole chamber. There are RF-shielded bellows connecting these chambers together. The straight sections, either 6.6 m or 9.3 m long between the cells are for insertion devices and for special sub-systems such as RF cavities, injection devices, , and so forth. [1]

Most of the NSLS-II storage vacuum chambers are made of extruded aluminium with specific cross-sections. These vacuum chambers allow in-situ bakeouts to 150˚C to help remove absorbents, such as water, and contaminants on the inner surface.

VACUUM CHAMBER BAKEOUTS

The vacuum chambers undergo at least two bakeout cycles prior to their installation in the storage ring. Once the chambers are instrumented with vacuum components such as NEG strips, small ion pump, gauging and RGA, they are prepped for the first vacuum bakeout. A turbomolecular pump backed by a dry mechanical pump is used to pump down the vacuum chamber and check for leaks using a helium leak detector. The vacuum level and residual gas composition are monitored during the bakeout using vacuum gauges and residual gas analyzer. The entire chamber will be baked at 150˚C for ~ 16 hours to remove absorbed water and other contaminants from the surfaces. At this stage most vacuum controllers are manually operated. RGA readings are logged with a local Windows computer. The NEG strip is powered and controlled by a DC power source with degassing and activation of NEG done manually.

The second vacuum bakeout occurs at the end of girder integration, after the installation and alignment of the magnets and chambers on the girder assembly, and with the integration of peripheral components, such as large ion pumps, TSP, photon absorbers, and vacuum gauges. A typical girder assembly ready for bakeout is shown in Figure 1.

Figure 1: Typical NSLS-II girder assembly

The final bakeout will be carried out in storage ring tunnel after the installation and alignment of individual chamber/magnet girders in the tunnel, the connection of the five girder chambers with RF shielded bellows and the mounting of the RF shielded gate valves at the ends of the cell. It's planned to take a similar approach to the bakeout of an entire cell in the storage ring. This paper focuses on girder bakeouts.

VACUUM GIRDER ASSEMBLY BAKEOUT

There are several variations of girder assemblies; hence the bakeout system must be flexible and adaptable to accommodate different zone configurations.

Each girder assembly is divided into several bakeout zones. The heating of the chamber itself is accomplished by the use of a rod heater inserted into a dedicated channel along the chamber length. Appendage components are heated using custom silicon heating jackets. All heating zones are controlled by a multiple zone bakeout system, a BNL design incorporating 12 or 24 Omega signal zone temperature controllers with solid state relays housed in a common chassis. Over temperature interlocks are provided to protect chamber assemblies from overheating. All temperature controllers are connected through RS-485 links. The 24 zone carts will also be used for storage ring cell bakeout where up to 3 carts are needed for each cell.

The vacuum chamber is pumped down with a turbomolecular pump backed by a dry mechanical pump during the bakeout. The vacuum level and gas composition are monitored continuously using vacuum gauges and RGA during the bakeout. The temperature of the chamber is raised slowly by the cal-rod heater, and controlled by the programmable temperature controller with inputs from the installed type E thermocouples on the chamber surface. A ~ 2.5 hour ramp period is programmed to reach the designed temperature value. The entire vacuum chamber is then held at 150˚C for ~12 hours to remove absorbed water and other contaminants from the surfaces. The sputter ion pumps, titanium sublimation pumps, and NEG strips are degassed during the soak period.

Table 1 shows all the components and controllers used for one girder baking. The number may vary with different girder. The vacuum device controllers used for one girder are assembled in one rack.

Table 1: Typical Vacuum Components and Controllers of Girder Bakeout System

Cold Cathode Gauge (CCG)	2
Convection Pirani Gauge (TCG)	1
Vacuum Gauge Controller (VGC)	1
Sputter Ion Pump (IP)	2
Ion Pump Controller (IPC)	1
Titanium Sublimation Pump (TSP)	1
Titanium Sublimation Pump Controller (TSPC)	1
Non-Evaporable Getter Strip (NEG)	1
DC Power Supply for NEG Strip	1
Bakeout Cart (BC)	1
Residual Gas Analyzer (RGA)	1
Turbomolecular Pump Station (TMP)	1
I/O Controller	1
Data Server	1
Uninterruptible Power Supply(UPS)	1

CONTROL FOR CHAMBER BAKING

Overview

The core of the Experimental Physics and Industrial Control System (EPICS) [2] has been chosen as the basis for NSLS-II control system. Figure 2 shows the architecture of the EPICS based vacuum bakeout control system.

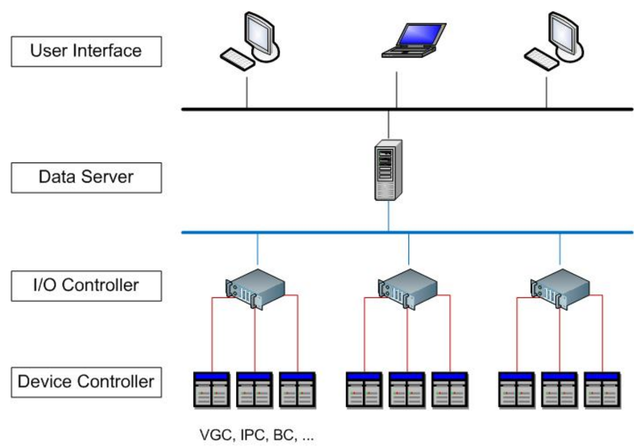

Figure 2: Control architecture for girder assembly bakeout.

Input and Output Controller (IOC)

Considering that the parameters to be monitored and controlled are much less than 1000 for girder bakeout system, we adopted soft IOC which runs on a Moxa DA-710 [3]. The Moxa works as both the IOC and terminal server. The DA-710 is based on the Intel x86 processor and runs on pre-installed Linux platform. It comes with 4 PCI slots for expansion modules and supports up to 32 serial ports.

Operator Interface

All of the monitor and control panels are created with software tools in Control System Studio (CSS) [4], which is an Eclipse-based collection of tools to monitor and operate large scale control systems.

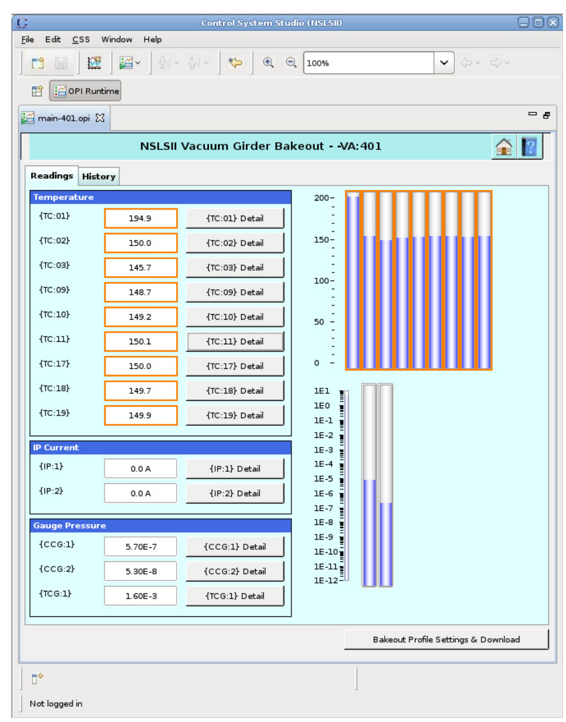

Figure 3: Main display screen for temperature readings and pressure readings.

A user-friendly interface was developed based on working experience with vacuum operators and engineers. The interface allows the operators to edit the desired ramp/soak profiles and provides the option to use predefined recipes. All zone temperatures, and gauge pressure readings are shown on main display panel as shown in Figure 3. Currently only local controls to the vacuum components are required. For future tunnel bakeout, remote controls will be required and provided.

Data Logging

Channel Archiver is used to log all temperatures, ion pump current, and gauge pressure readings. A low-cost Acer Aspire Revo series PC is used as the data server. This PC also works as the gateway between campus computers and I/O controllers due to network security issues. Users on the campus network are required to log onto the gateway computer to gain access to the girder bakeout system.

Data browser provides an easy way to review and analyze logged data. Figure 4 shows the historical view of the temperature readings.

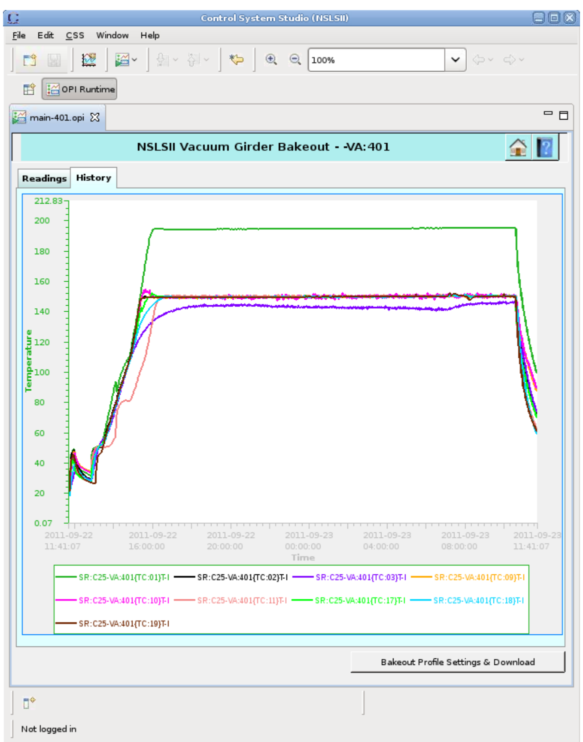

Figure 4: Historical data with data browser.

Interlock

It is necessary to have vacuum interlocks to protect vacuum assemblies from over pressure. The interlock is provided by a MKS 937B gauge controller. A Cold Cathode and Pirani gauge pair provides an adjustable setpoint that is hardwired to each of the vacuum controllers including the ion pump controller, tsp, bakeout cart and NEG controllers. The setpoint status can be monitored via the serial communication port of the gauge controller.

SUMMARY

To date, 4 fully assembled girder chambers have been processed and successfully baked. The girder bakeout control system has worked well. We're still learning from the girder bakeout and intend on improving system performance.

REFERENCES

[1] NSLS-II Preliminary design report, 2008, http://www.bnl.gov/nsls2/project/PDR.
[2] EPICS, http://www.aps.anl.gov/epics.
[3] Moxa, http://www.moxa.com.
[4] CSS, http://cs-studio.sourceforge.net.