ALARM RATIONALIZATION: PRACTICAL EXPERIENCE RATIONALIZING ALARM CONFIGURATION FOR AN ACCELERATOR SUBSYSTEM *

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Abstract

A new alarm system toolkit has been implemented at SNS. The toolkit handles the Central Control Room (CCR) annunciator, or audible alarms. For the new alarm system to be effective, the alarms must be meaningful and properly configured. Along with the implementation of the new alarm toolkit, a thorough documentation and rationalization of the alarm configuration is taking place. Requirements and maintenance of a robust alarm configuration have been gathered from system and operations experts. In this paper we present our practical experience with the vacuum system alarm handling configuration of the alarm toolkit.

INTRODUCTION

Two Alarm Handler Systems were used at Spallation Neutron Source (SNS), the standard EPICS Alarm Handler (ALH), and a soft-IOC based Alarm Handler which was implemented at SNS [1]. Both of them have disadvantages and have become difficult to maintain with the increasing numbers of alarm events in a large accelerator facility like SNS. For the 218 individual vacuum process variables (PVs), 27 summaries were configured in the soft-IOC based ALH system. Operator had to drill down through many screens to get the actual alarm. Moreover, it is hard for a system engineer to add new alarms.

Recently a new alarm handler toolkit, the Best Ever Alarm System Toolkit (BEAST) [2], has been developed and implemented at SNS. The toolkit is implemented in Java, based upon the Control System Studio (CSS) platform [4]. It handles the SNS alarms by providing tools to annunciate alarms and log alarm related actions.

The BEAST is based upon a Client/Server architecture; it provides tools for annunciation, logging, and web report generation. The Alarm Server reads the alarm configuration from the RDB, connects to all the requested PVs, monitors their state changes, and generates alarms. It also handles acknowledgment, annunciation, and latching. The configuration, including alarm latching, annunciation, user guidance, related display, and current state, etc., is stored in a relational database.

The vacuum alarm is one of the most critical to protect the machine. It must be immediately presented to the operator who can then react accordingly.

The required vacuum levels vary over the different accelerator subsystems, i.e. the Front End, the Warm Linac which includes the Drift Tube Linac (DTL) and Coupled Cavity Linac (CCL), the Superconducting Linac (SCL), and the Ring which includes the High-energy Beam Transport (HEBT) line, the accumulator Ring and the Ring to Target Beam Transport (RTBT) line. These levels are summarized as in Table 1.

Table 1: SNS Vacuum Major Alarm Levels

Subsystem	Major Alarm Level
Front-End	$5x10^{-4}$ to $5x10^{-6}$ Torr
DTL, CCL, SCl,	$1x10^{-6}$ Torr
HEBT, Ring, RTBT	$5x10^{-6}$ Torr

ALARM DOCUMENTATION AND RATIONALIZATION

The definition and configuration process for the vacuum subsystem alarms have been worked out with the vacuum experts and the operation team on the vacuum system operation and requirements.

Alarm Configuration

The decision to configure an alarm must meet the following three criteria:

- The event requires operator attention and action
- The alarm is the best indicator of the situation's root cause.
- The alarm is truly resulting from an abnormal situation.

Alarm Rationalization

Alarm Rationalization is a sound, consistent methodology to determine and prioritize alarms. Each alarm that is added to the alarm system or reviewed should undergo rationalization.

A good philosophy for the alarm configuration is as follows [3]:

- Area / Subsystem: Front End, CCL, DTL, SCL, etc.
- Process Variable (PV) name: alarm trigger PV
- Alarm item: alarm information, such as beam line gauge
- GUI: an accompanying EDM screen

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- Minor Alarm, warning: MINOR alarm level
- Major Alarm trip point: MAJOR alarm level
- Purpose of alarm: notify operations of an trigger alarm
- Operator guidance: the operator instruction information on how to deal with the alarm.
- Failure consequence: the consequences if operator fails to respond.
- Operator Response Time: operator reaction time
- Contact info: the information on who should be contacted if the alarm cannot be handled by operator.

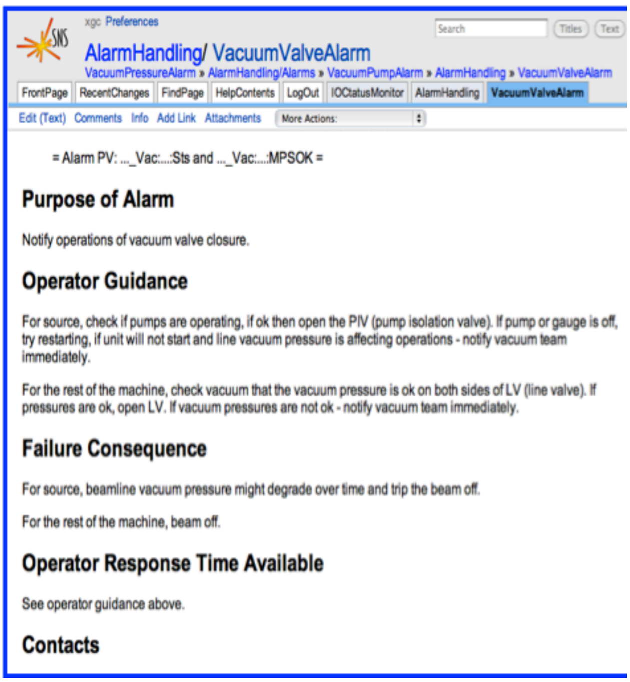

Figure 1: The rationalization for an alarm on wiki page.

Applied to the vacuum system, we decided to create three types of vacuum alarms:

1) Elevated vacuum pressure:
   Might, for example, indicate a leak in the vacuum vessel.
2) Valve status:
   A valve that is supposed to be open is found closed.
3) Pump status:
   A pump that is supposed to be running is found off.

Along the SNS linac, there are many pressure sensors, valve and pump readbacks. Instead of adding each one individually to the alarm system, we decided to summarize them for 7 areas: Front end, CCL, DTL, SCL, HEBT, Ring, RTBT.

For each area, vacuum system experts can control which of the vacuum sensors are used to compute the alarm and at what level. They can disable alarms from pumps which are temporarily not required, or disable alarms from faulty sensors. In case of a severe vacuum problem, for example, in the DTL, operators receive one "DTL Vacuum Pressure" alarm instead of one alarm from each vacuum sensor in the DTL.

The purpose, Operator guidance, and Failure consequence are different for the different areas. Figure 1 shows an example how the valve alarm is configured.

The alarm configuration is hierarchically arranged by System (vacuum), Area and PV in the final level (Figure 2).

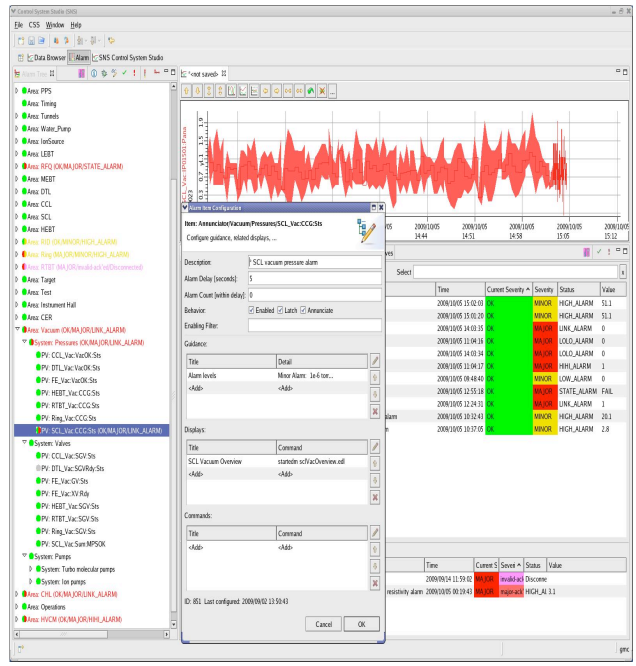

Figure 2: Configuration menu .

The rationalization for a PV or related group of PVs is also described on a wiki page (Figure 1). There is a link from the configuration menu to the related displays for the PV in the alarm GUI, for example to Ring vacuum EDM screen (Figure 3). From the context menu of an alarm tree, some CSS tools can be easily accessed and used for the further investigation of an alarm, such as EPICS PV Tree, Data Browser, PV Table, Probe, etc. A meaningful alarm message is also important for audio annunciation to get quick operator response and action.

The alarm system cannot replace the constant surveillance by qualified operators. Also, it is also not an interlock system. For example, when an interlock causes a vacuum valve to close, the alarm system will inform operators of a vacuum valve closure in some area of the machine. A related display link will quickly guide them to the location. It is up to the experience and judgment of the operator to determine the best course of action.

INTEGRATE ALARMS

A good alarm system is based upon the stable and reliable vacuum system. A standardization of the vacuum control system at SNS has ultimately been implemented with the aim of easing commissioning, maintenance and upgrade work. Two major upgrades were made in the past three years.

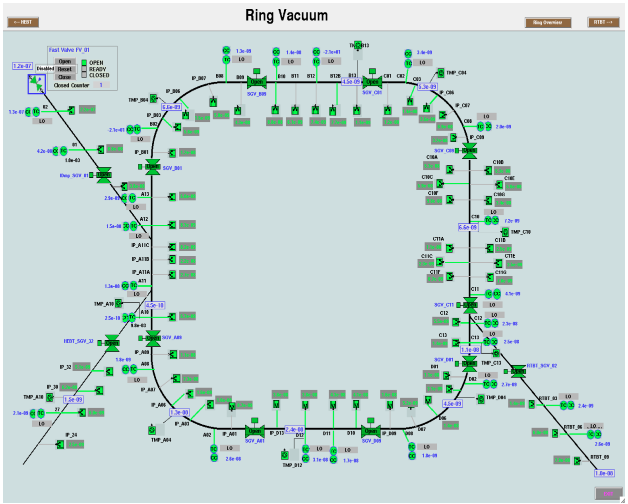

Figure 3: Ring vacuum display.

The Front-End (FE) comprised of a 35-70 mA volume H- source, a multi-element electrostatic Low-Energy Beam Transport (LEBT) section, a 402.5MHz Radio Frequency Quadrupole (RFQ), and a 2.5MeV Medium-Energy Beam Transport section (MEBT) [6]. The original vacuum design by Lawrence Berkeley National Laboratory used Allen-Bradley PLC-5 and remote I/O communication. The FE IOC interfaced with the PLC-5 and Flex I/O via A-B 6008-SV1R VME modules, remote I/O communication. The IOC and PLC shared the responsibility of interlocks; the PLC performs the basic and first level interlocks. More complex interlocks were implemented in the IOC, such as pumps and valves control depending on the status of upstream and downstream gauges or related devices and requiring valid status before energizing these devices. The IOC logic also enforced the inter-system constraints on the isolation valves. In this first upgrade, PLC-5 and remote I/O communication were replaced by Allen-Bradley ControlLogix PLC, ControlNet communicate to Flex I/O and Ethnet/IP interface to IOC. The interlocks formerly implemented in the IOC were moved to PLC logic for the quick protection.

In the second upgrade, recently a number of Beckhoff modules and custom circuit boards designed by Jefferson Lab were replaced in the superconducting linac vacuum system. Several different custom-built boards were used for the vacuum pressure monitoring, the interlock logic and valve control. Beckhoff ethernet couplers BK9000 with the digital I/O and analog modules were used to provide the discrete I/O signals to the vacuum chassis, read vacuum pressure, and to interface to the IOC.

The new standardized vacuum control system is implemented with Allen-Bradley ControlLogix PLC that communicates with IOC using EtherNet/IP [5]. The communications between PLCs are via ControlNet. Digi PortServer is used to interface with the vacuum gauge and pump controllers over serial communication for reducing the number of PLC I/O connections, solving the problem of IOC hang. A benefit of the upgrade at the Front-End and SCL vacuum controls has been an improvement in response time and reliability in the execution of interlocks.

The real alarm PVs are running in VME IOCs, and some of the calculation records used for alarm summaries are running in the Linux soft- IOCs.

SUMMARY

The vacuum alarm configuration with the new alarm system toolkit has been operational at the SNS since June 2009. The alarm system has proved successful, getting the quick response of both operator and vacuum expert.

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