A PROPOSED ALARM HANDLING SYSTEM MANAGEMENT PLAN FOR SNS WITH APPLICATION TO TARGET CONTROL SYSTEM *

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Abstract

We propose a plan for managing SNS alarms. We have developed a set of requirements for an SNS alarm handling system and have applied these to the control system for the SNS liquid mercury target to demonstrate how to implement them. We want to gain experience with the proposed requirements on a limited scale before applying them to the whole accelerator. The target system implementation is based on the EPICS alarm handler ALH [1]. The requirements address such topics as alarm classification, priorities, types of warning (visual, audible), hierarchies, and management under different modes of target operation. Alarms are currently organized by system and subsystem. Target control systems considered in the examples here include the Hg loop, three light water and one heavy water cooling loops. Modifications to ALH include addition of "drag and drop" capabilities for individual PVs and drop-down lists of selectable actions. One such action provides access to the alarm response procedures required for a process variable that shows an alarm. Alarm and operator action log files are maintained separately from instances of ALH launched for operator displays. Database reporting tools have been developed to aid analysis of data in the log files, e.g., generating lists of PVs that went into alarm ranked by frequency of alarm occurrence. Examples of the use of these and other capabilities will be presented.

INTRODUCTION

At SNS many attempts have been made from the beginning of operations to organize the alarms in ways that would be useful to the operators. Early implementations failed largely because too many alarms were being displayed. Alarm notification generally was not reliable enough to gain operator respect. Yet the operators requested and needed information about alarm conditions.

ALH is well-suited for target utilities (target cooling water loops and Hg loop). Previous experience had demonstrated the importance of having a well-tested system that had been operating for a while before turning it over to the operators. Care was taken not to repeat past mistakes. All process variables (PVs) were identified both by tag name and English text description to aid with rapid identification of what was in alarm.

This paper describes what has been done to make use of ALH, along with a suite of complementary tools, a success for the target systems (the target moderator is now included) and how this experience is being used as a basis to prepare an alarm system requirements document applicable to the entire SNS accelerator.

CURRENT IMPLEMENTATION OF ALH FOR TARGET SYSTEM ALARMS

Figure 1 shows the EPICS alarm handler display screen for the target utilities. The Hg loop hierarchy is expanded to illustrate some of the features used. In the panel on the left an "HgLoop" entry appears at the top. Each entry in the tree shows a pair of status indicators to the left: the first indicates whether the alarm has been acknowledged while the second shows the current status of the group of alarms identified by the group name. The arrowhead symbol indicates whether there are subgroups below "HgLoop" and the "P" indicates a link to a process that can be executed. In this case clicking on the link will run an instance of EDM and will display the Hg loop overview screen. All the "P" buttons on this panel bring up the respective subsystem overview screens.

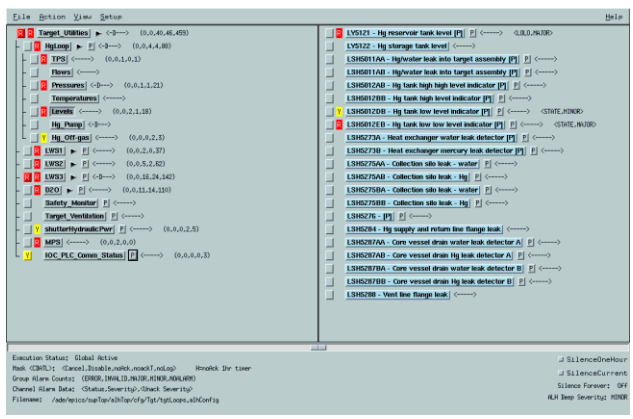

Figure 1: EPICS alarm handler ALH graphical interface for the target loops controls. The panel on the left shows the alarm groups hierarchy; the panel on the right shows alarm PVs for Hg loop tank/container levels.

The <-D---> character string is a mask used to help with alarm filtering and management, in this case notifying the operator that one or more PVs in the Hg loop have been disabled. PVs can be disabled manually or automatically (e.g., when a pump is turned off) so they do not indicate alarm conditions when a sensor is not connected or equipment is not in operation. Current alarm PV mask operations (by position in the mask string) include

- **C**ANCEL: The IOC does not send alarm events to the alarm handler
- **D**ISABLE: Alarm status and severity are not displayed

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- no**A**ck: Alarm acknowledgement is not required
- noack**T**: Alarm acknowledgement for transient alarms is not required
- no**L**og: Alarms are not logged

Greater use of these masking features is anticipated in the future when accelerator operating modes are reflected in alarm management.

The numbers in parentheses show the numbers of PVs in the HgLoop group that fall into one of the alarm categories:

- Error in data transmission e.g., the IOC is not connected to the network
- Invalid data e.g., incorrect data type
- MAJOR alarms
- MINOR alarms
- NO_ALARM (everything is fine)

The alarm hierarchy shown in the panel on the left side of Fig. 1 shows the current way alarms are classified: by function for each loop in the target. Some special categories related to machine protection, network communications, and IOC/PLC operating status are shown at the bottom of the hierarchy.

The panel on the right shows a list of PVs for levels of various tanks and containers associated with the Hg loop. Both a tag name and natural language description are given. The end of each line contains the mask string described previously, but now applicable to each PV, and further alarm status information.

A lot of functionality is built into the PV status display list in the right panel. Placing the mouse cursor over a tag name and clicking the middle mouse button will display the PV name in a pop-up window that can be dragged to a text editor, Probe, or input window for any application running on the file server. The "[P]" at the end of the description indicates whether the following "P" button has links to the online Alarm Response Procedures document. The "P" button implementation shown here supports use of a drop-down menu that will allow execution of commands or scripts.

Routine Practice

One of the first capabilities the target operators requested was fast access to the Alarm Response Procedures in the Control System Operator's Manual. These procedures were available online on another computer as PDF-formatted documents. Network access was set up and a PDF document reader identified so that the response procedures written for each PV that had alarm limits assigned could be displayed by clicking on a "P" button and making the appropriate selection from a drop-down menu list. Figure 2 shows use of COMMAND and STATCOMMAND to display procedures. The COMMAND lines exhibit the syntax for the drop down menu feature; the STATCOMMAND lines show an alternative implementation that brings up the appropriate alarm response procedure for the type of alarm limit exceeded.

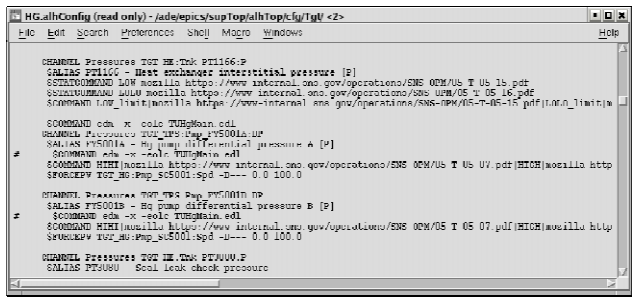


Figure 2: Excerpt from configuration file showing commands used to display Alarm Response Procedures.

Pressure, flow, and temperature readouts associated with the Hg loop can generate alarms when the pump is turned off. Under most circumstances when the pump is turned off there is no point in having alarms associated with pressure and flow PVs displayed for the Hg loop, so the operators requested that many of these alarms be turned off automatically when the Hg pump was off. Many of these were automatically turned off when the pump was not operating.

Figure 2 (near the bottom) also shows the use of the FORCEPV command to disable alarms associated with the Hg loop when the pump speed drops below 100 RPM (the speed setpoint "drive low" limit).

The alarm disable feature (mask pattern <-D--->) is used (manually) a lot by target operators when they know a particular readout is not working correctly, either because calibration is unreliable or the sensor is malfunctioning. This is usually a temporary condition which is fixed, allowing the alarm to be enabled again.

The ALARMCOUNTFILTER command is being used (see Fig. 3) to filter a transient alarm showing PLC operation status. This particular alarm occurred very frequently and could not be managed satisfactorily in the ladder logic for the PLC.

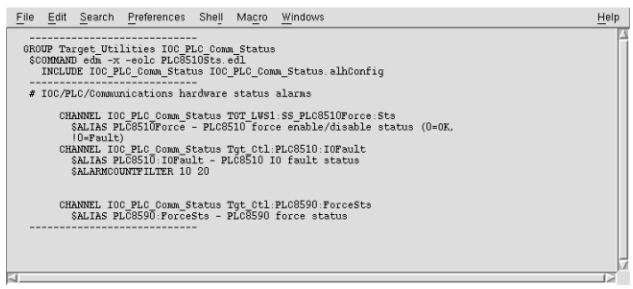


Figure 3: Example showing use of the ALARMCOUNTFILTER command.

Occasional Use

The alarm log files data are stored for long-term access in an ORACLE database. A database query system has been developed (ROCS: Reports Online for Control Systems) to provide access to alarm histories through an interface shown in Fig. 4. It can be used to display alarm sequences (Fig. 5) for a PV over a period of time to assist

in troubleshooting. A report can be generated listing PVs ranked by frequency of alarm occurance (Fig. 6) for a specified interval of time. These reports can be used very effectively in conjunction with the PV archiveviewer to do simple forms of data mining. An export feature permits transferring data from alarm log histories to spreadsheets for further analysis.

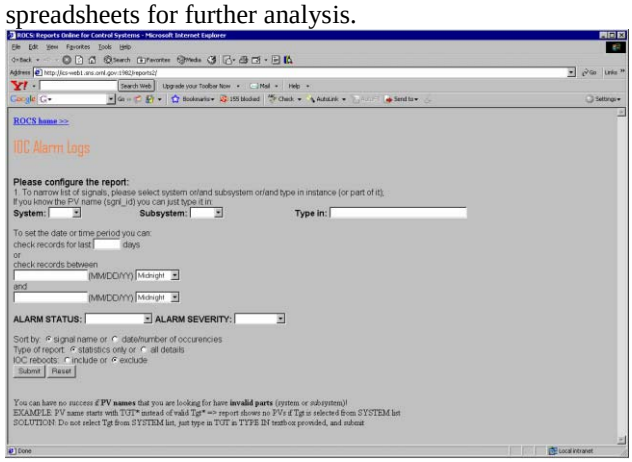
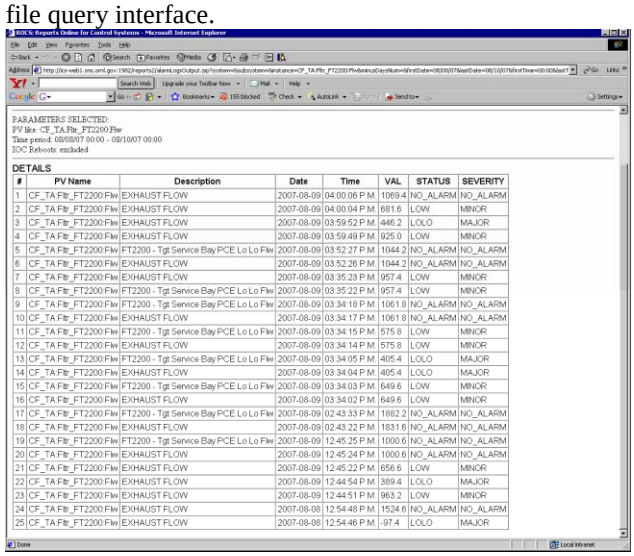


Figure 4: Reports Online for Control Systems alarm log file query interface.



#	PV Name	Description	Date	Time	VAL	STATUS	SEVERITY
1	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	04:00:06 P.M.	1069.4	NO_ALARM	NO_ALARM
2	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	04:00:04 P.M.	681.6	LOW	MINOR
3	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	03:59:52 P.M.	446.2	LOLO	MAJOR
4	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	03:59:49 P.M.	925.0	LOW	MINOR
5	CF_TA:Fltr_FT2200:Flw	FT2200 - Tgt Service Bay PCE Lo Lo Flw	2007-08-09	03:52:27 P.M.	1044.2	NO_ALARM	NO_ALARM
6	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	03:52:26 P.M.	1044.2	NO_ALARM	NO_ALARM
7	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	03:35:23 P.M.	957.4	LOW	MINOR
8	CF_TA:Fltr_FT2200:Flw	FT2200 - Tgt Service Bay PCE Lo Lo Flw	2007-08-09	03:35:22 P.M.	957.4	LOW	MINOR
9	CF_TA:Fltr_FT2200:Flw	FT2200 - Tgt Service Bay PCE Lo Lo Flw	2007-08-09	03:34:18 P.M.	1061.8	NO_ALARM	NO_ALARM
10	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	03:34:17 P.M.	1061.8	NO_ALARM	NO_ALARM
11	CF_TA:Fltr_FT2200:Flw	FT2200 - Tgt Service Bay PCE Lo Lo Flw	2007-08-09	03:34:15 P.M.	575.8	LOW	MINOR
12	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	03:34:14 P.M.	575.8	LOW	MINOR
13	CF_TA:Fltr_FT2200:Flw	FT2200 - Tgt Service Bay PCE Lo Lo Flw	2007-08-09	03:34:05 P.M.	405.4	LOLO	MAJOR
14	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	03:34:04 P.M.	405.4	LOLO	MAJOR
15	CF_TA:Fltr_FT2200:Flw	FT2200 - Tgt Service Bay PCE Lo Lo Flw	2007-08-09	03:34:03 P.M.	649.6	LOW	MINOR
16	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	03:34:02 P.M.	649.6	LOW	MINOR
17	CF_TA:Fltr_FT2200:Flw	FT2200 - Tgt Service Bay PCE Lo Lo Flw	2007-08-09	02:43:33 P.M.	1882.2	NO_ALARM	NO_ALARM
18	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	02:43:22 P.M.	1831.6	NO_ALARM	NO_ALARM
19	CF_TA:Fltr_FT2200:Flw	FT2200 - Tgt Service Bay PCE Lo Lo Flw	2007-08-09	12:45:25 P.M.	1000.6	NO_ALARM	NO_ALARM
20	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	12:45:24 P.M.	1000.6	NO_ALARM	NO_ALARM
21	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	12:45:22 P.M.	656.6	LOW	MINOR
22	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	12:44:54 P.M.	389.4	LOLO	MAJOR
23	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-09	12:44:51 P.M.	963.2	LOW	MINOR
24	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-08	12:54:48 P.M.	1524.6	NO_ALARM	NO_ALARM
25	CF_TA:Fltr_FT2200:Flw	EXHAUST FLOW	2007-08-08	12:54:46 P.M.	-97.4	LOLO	MAJOR

Figure 5: Alarm sequence from alarm log files for secondary central exhaust system flow used to diagnose low flow problem.

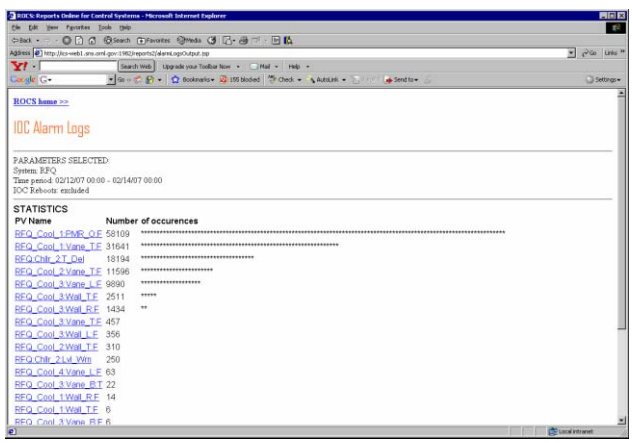


Figure 6: Alarm frequency histograms generated by a ROCS query.

When some PVs go into alarm, the operators like to start monitoring that PV and some related PVs using StripTool. By creating a StripTool configuration file ahead of time, the operators can use the "P" (execute an external process) button to start execution of StripTool for that configuration file to begin monitoring the PVs of concern.

ALARM SYSTEM REQUIREMENTS FOR THE SNS ACCELERATOR

In most cases the functional description documents for the accelerator systems and subsystems only identify which PVs need to have an alarm indication. No guidance or plan was prepared dealing with any details of an alarm system beyond requirements for individual PVs for one or more limits (low-low, low, high, high-high) and alarm severities (NO_ALARM, MINOR, MAJOR, INVALID). Alarm indications are given for PVs on the control screens using colors red, yellow, and green for major, minor, and no-alarm conditions, respectively. Use of blinking or visibility properties of graphical objects also indicate warnings or alarm conditions. This currently is the extent of alarm management being used.

Alarm system requirements documents were obtained for chemical and pharmaceutical process industries, commercial nuclear power plants, and flight control systems for aerospace applications; the ISA standard for alarm handling in the process control industry was studied. All these sources are being consulted for principles, concepts, and ideas for alarm system requirements that apply to the SNS accelerator control system.

Basic requirements that showed up in all cases included use of simple, clear, direct visual or audible alarms; establish priorities for alarms; and provide for alarm filtering

Alarm systems must use visual and audible means of getting the attention of the operator. Visual alarms must be simple, direct, and easy to interpret. There must be no ambiguity about what the alarm means because quick, correct actions must be taken. Audible alarm types must be limited to a few at most for the same reasons. Alarms used must be appropriate for the actions that must be taken. If personnel must evacuate an area immediately, an audible alarm needs to be very loud and uncomfortable so it cannot be ignored. Visual alarms must be very simple and display a single color that allows no possibility of misinterpretation.

Alarm priorities need to be established. Priorities are needed to guide decisions about how alarms are filtered and what type of alarm notification should be used.

REFERENCES

[1] http://www.aps.anl.gov/epics/extensions/alh/index.php The EPICS Alarm Handler