RETROFITTING ALARM PRIORITIZATION AT BRUCE A: STRATEGY DEVELOPMENT AND IMPLEMENTATION EXPERIENCE

E. Davey and D. Hickey
Control Centre Technology Branch
AECL, Chalk River Laboratories
Chalk River, Ontario, Canada K0J 1J0

B. Babcock
Ontario Hydro, Nuclear Technology Services

G. Schildroth and J. McAuley
Ontario Hydro, Bruce A Operations

A prioritization strategy for computer-displayed control room alarms has been developed for Bruce A to better assist operations staff in visually identifying key alarms and judging the relative importance of alarms. The strategy consists of assigning each alarm indicative of a problem to be addressed to one of five priority categories. Each alarm is assigned to an alarm category based on an off-line analysis of the consequence and response characteristics applicable to the alarm for three plant operating contexts. The colour of the alarm message is used to convey the priority category of each alarm in computer-based alarm displays. In addition, alarms indicative of non-problematic changes in the state of plant equipment and processes are given a separate colour assignment to visually differentiate them from alarms indicative of problems.

This paper outlines the user-based approach employed in the prioritization strategy development, describes the key features of the prioritization strategy adopted, and discusses the initial experience in systematically determining the priority assignments for all 6000 computer-based alarms associated with each generating unit.

Background

CANDU plants employ computer-based alarm systems to alert control room staff to abnormal operating conditions and changes in plant configuration as a result of the automatic responses of plant automation. This annunciation, along with the routine monitoring of control room displays and field communication, enables operations staff to keep up-to-date with the current plant conditions and predict future plant states. Current CANDU alarm systems are implemented as part of the plant digital control computer software and contain a database of several thousand alarms that provide coverage for all plant safety and power production functions.

At Bruce A, alarms are presented on the control room annunciation displays with no indication of importance or priority. Consequently, operators are required to judge the relative importance of each alarm in real-time and adjust their response to plant conditions accordingly. This approach is acceptable for plant states where the alarm generation rate is low (e.g., stable full power steady state conditions). However, for other phases of plant operation, such as manoeuvres, upsets or outages, the operator's task to identify

important alarms among many active alarms and to prioritize response actions based on determining the relative importance of each new alarm becomes more complicated.

As part of a major station retrofit program, the capabilities of the control room computer-systems are being improved and modernized for Units 3 and 4. This development now allows designers to retrofit substantial improvements to the control room alarm systems. One development initiative has been the visual indication of priority for all computer-displayed alarms.

Strategy Development

CANDU operations staff have consistently identified three factors as essential components in determining alarm importance and thus priority [1]. These three factors are:

- Context - the current plant state and operating trends within which individual alarm importance should be judged.
- Consequence - the impact on plant safety or production that the annunciated condition will have.
- Response - the nature of response required and the timeframe for response to the annunciated condition.

For the Bruce A Rehabilitation project application, several project and operational constraints led to an alarm importance determination approach where operators would retain overall judgment of relative alarm importance but would be provided with a predefined indication of alarm consequence. Visual indication of the relative consequence of an alarm condition assists operators in two ways. First, it can provide a visual alert to the alarms of greatest importance that should be attended to first. Second, it can provide an initial means for operators to order their decision-making and response planning activities to a list of alarmed conditions.

Operators must rationalize safety and production concerns simultaneously as part of their normal response to alarms. Based on the plant conditions, and the nature of alarms, operators decide on a response that provides the best fit for balancing current safety and production concerns. Thus, an alarm categorization approach was selected that could support such practical decision-making based on an ordered list of alarm consequence categories that address safety and production priorities in an integrated way.

Operational experience and past designs also have proven that two types of alarms (i.e., faults and status) are both important to supporting operators in their supervision and control of plant processes and systems. Faults are alarms that indicate process conditions have exceeded their normal expected range or equipment state and are no longer acceptable for the current plant operating conditions. Status alarms are alarms that indicate a change in process conditions or equipment state that the operating crew should be alerted to but are not viewed as problems. Experience in other nuclear power plants [2] and the CANDU Owner's Group annunciation improvement project [1] have demonstrated that visually differentiating these types of alarms assists operators in alarm response.

For example, operators focus more attention on faults than status alarms during upset response.

The initial strategy development was lead by operations and annunciation analysts from AECL, Chalk River Laboratories who drew on the collective experience of Bruce A operations, training and engineering staff. A key factor to the success of the project was the strong participation of operations and training staff in initial concept development and pilot testing of the alarm prioritization approach and consequence categories definition.

Implementation

Following pilot testing of the recommended alarm importance determination approach with a few hundred representative alarms, effort shifted to the full-scale engineering implementation of the approach. This involved categorization of several thousand alarms into fault and status categories and the assignment of a consequence category to each alarm. This analysis was undertaken by a team of two operators and completed over a two month period. To simplify the management of alarm information and searches for specific alarm properties, an alarm analysis support tool was developed based on a relational-database and customized analyst interface displays. The use of such a tool improved the effectiveness of the analytical team by minimizing the time required in alarm record sorting and management, and enabled analyst efforts to be focused exclusively on fault/status and consequence category assignments.

Conclusions

An approach to prioritizing and categorizing computer-displayed alarms for Bruce A NGS Units 3 and 4 has been developed and station implementation is underway. The prioritization approach selected is based on the same factors and assists the same alarm importance determination reasoning as currently practiced by Operations staff. In addition, the approach is consistent with the prioritization approach and visual coding applied to the annunciator window alarms. The initial application experience has confirmed that the procedure established for priority assignment determination is practical, can be applied in a cost-effective manner, and leads to reproducible priority determinations from independent analysts.

References

1. E. Davey, M. Feher and K. Guo. (1995). An Improved Annunciation Strategy for CANDU Plants. Paper presented at the American Nuclear Society Conference 'Computer-based Human Support Systems: Technology Methods and Future'. Philadelphia, Pennsylvania, 1995 June 25-29.

2. J. Easter and L. Lot. (1992). Back-Fitting a Fully Computerized Alarm System into an Operating Westinghous PWR: A Progress Report. Paper presented at the IEEE Fifth Conference on Human Factors in Nuclear Power Plants, Monterrey, California, 1992 June 7-11.