

CONTROL ROOM ANNUNCIATION -
PROBLEM ASSESSMENT AND SELECTION OF IMPROVEMENT PRIORITIES

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ABSTRACT

In 1997, Pickering B undertook a project to examine current annunciation practice and identify improvement opportunities and priorities. The objectives and scope of the study were to:

- Document the deficiencies with control room annunciation and the subsequent operational and financial impacts to station operations,
- Develop an Operations-based definition of the requirements for annunciation to adequately support control room staff,
- Propose annunciation improvements based on a comparison of the annunciation deficiencies identified and the operational needs to be met,
- Assess the relative operational impact, and financial benefits and costs of the improvement initiatives proposed, and
- Recommend annunciation improvement priorities that offer a mix of operational and financial return for improvement investment.

This paper discusses the rationale for the project, outlines the approaches applied in achieving the assessment objectives, reviews the key assessment findings and describes the improvement initiatives recommended.

INTRODUCTION

Current operational experience and former studies indicate that more than 80% of the operator's time on shift is occupied by tasks other than those involved with direct process supervision and control of the unit. Even during instances when the unit is directly monitored, it is only practical for Operations staff to maintain an awareness of a very small subset of the available plant parameters. Consequently, Operations staff depend on the plant annunciation systems to alert them to plant changes requiring intervention and to assist them in maintaining an up-to-date awareness of all important changes in plant conditions.

Ideally, annunciation should ensure that control room staff are promptly alerted to and supported in their response to all changes in device, equipment, system or plant conditions that may impact on operational goals. Thus, annunciation should perform three functions under all operating conditions:

- detect the occurrence of plant changes,
- alert users to plant changes important for the current operating situation such that:
 - only operationally relevant plant changes are annunciated, and
 - the demands imposed on user's attention to recognize the plant changes fits with the demands of other concurrent control room tasks, and
- points users to additional plant information to understand and respond to the changes.

Operational experience at Pickering B and other CANDU stations has shown that the existing control room annunciation implementations do not provide the support needed by Operations staff in all operating situations (1,2) as required for operations at 'world class' performance levels. This is a result of:

- the inability of the current systems to meet their original operational intent,
- a better understanding of the role of the annunciation system in supporting safety and production needs, and
- a redefinition of the roles and standards of annunciation system performance in the move toward 'Nuclear Excellence'.

For example, recent internal and external audits of control room operations at Pickering B have identified nuisance and unnecessary alarms as an important factor affecting the ability of Operations staff to effectively monitor plant safety and production state (3). At full power steady state, typically 64% of the alarms enunciated could be eliminated due to nuisance or irrelevancy reasons.

In response to this situation, an assessment of control room annunciation was launched in January of 1997, as a component of a larger station 'Quality of Work' initiative to improve the effectiveness of station operations in several areas. The assessment was undertaken by a three person team experienced with annunciation practice and comprising

expertise in station operations, engineering design and operations support, and annunciation improvement concepts.

The project team was directed to examine all aspects of control room annunciation use with the intent of establishing a comprehensive basis for annunciation improvements in support of all operational states in the future. However, the initial emphasis of improvement work will be to improve plant annunciation in support of full power steady state plant operations.

STATION ANNUNCIATION

CANDU plants employ several alarm systems to alert Operations staff to various normal and abnormal operating conditions and changes in plant configuration as a result of the automatic responses of plant automation. At Pickering B, as with most CANDU plants, the two most prevalent annunciation systems employed by control room staff are:

- *Computer Driven CRT System for Alarm Presentation* - This system provides comprehensive alarm functionality for six thousand plant parameters, providing full coverage of both production and safety aspects of plant operation. Alarms are presented to the operator on two dedicated overhead alarm monitors in two alarm lists organized by order of occurrence. When both displays become full, new messages begin to overwrite the oldest previously displayed alarms.
- *Window Annunciators* - The Window annunciator system provides basic alarm functionality for a limited number (i.e., ~150 versus the 1000s of potential plant alarms) of key safety-related and a few production related alarms. Thus, it does not provide as full annunciation support associated with the production side of the plant. These indicators were originally intended to meet several requirements, for example:
 - Backup - Provide a minimum annunciation coverage in the event of a loss or unavailability of the computer driven annunciation system, and
 - Independence - Provide independent annunciation of key special safety system alarms for regulatory compliance.

The computer driven annunciation system is the primary source for alarm information used by Operational staff most of the time. When the number of active alarms exceeds the display capacity or the alarm occurrence rate makes the displays unreadable, Operations staff shift to alternative alarm detection strategies, for example:

- Increased monitoring of current plant parameters important to the current phase of operations, and
- Reliance on the Window Annunciators for automatic detection and annunciation of primary safety and production related alarms.

ASSESSMENT APPROACH

In achieving the project objectives, the assessment team applied the following approaches:

- *Characterization of Annunciation Issues* - Deficiencies with the support provided by the control room annunciation systems were identified from a number of sources (e.g., discussions of annunciation system behaviour with operators and trainers; reviews of annunciation system documentation, operating logs and event reports; assessment team member personal experience; and reviews of recent annunciation investigations by other stations). A scale of operational impact statements, incorporating both safety and production perspectives, was developed and applied to assist in ranking each identified deficiency by relative operational importance.
- *Definition of Annunciation Role* - A statement of the role annunciation should play in supporting control room operations across all plant operating states was developed. This statement provided definition of the functions and behaviours the annunciation systems should exhibit to support control room staff, and served as an interim standard against which proposed improvement initiatives could be assessed. This role statement was derived from existing station specifications and a recent definition of annunciation requirements from an operational perspective (2).
- *Identify Annunciation Improvements* - Areas for annunciation improvement were identified by matching the current annunciation deficiencies with the specific aspects of the operational role defined for annunciation. Individual improvement options for each role aspect were developed based on the assessment team's understanding of the annunciation techniques available and retrofit approaches applicable to Pickering B annunciation needs.
- *Assess Operational and Financial Impact* - The operational impact of each proposed improvement initiative was estimated by summing the numerical contribution of all applicable operational impacts, alleviated by the improvement, for each applicable plant state. This led to a ranking of proposed improvement initiatives by overall operational impact.

The financial impact for each proposed improvement was determined based on a sum of financial benefits and implementation costs. The financial benefits were estimated from a determination of past operational costs attributable to current annunciation deficiencies and a projection of these costs forward into the remaining life of the station as typical costs that could be avoided by a specific annunciation improvement. The costs of implementing each improvement option were estimated based on current station and AECL engineering experience.

- *Identification of Improvement Priorities* - Improvement priorities were established by selecting those proposed annunciation improvement initiatives that offered greatest operational impact and cost/benefit.

ASSESSMENT FINDINGS

The key assessment findings included:

- *Extent of Deficiencies Identified* - Prior to this review there was general acceptance that the station annunciation deficiencies were primarily associated with the computer-based annunciation system. However, the assessment team identified similar and equally extensive limitations with the local panel alarm features and window annunciators.
- *Compensation for Annunciation Deficiencies* - Station operating practice has evolved to compensate for deficiencies in annunciation support. Examples include the revision of the station upset response strategy and acceptance of on-going 'work-arounds' that contribute to operating inefficiencies.
- *Costs of Poor Annunciation* - The operating cost to the station of current annunciation deficiencies is estimated to be approximately \$1,800,000 per year based on a study of costs associated with station events as documented in Significant Event Reports (SERs). This cost is attributable to the costs of replacement power for shutdown units, event investigations, unnecessary response to and maintenance of alarms that are not really problems, equipment damage, and alarm administration effort in all states of operation that detract from the time available for other work.

If no annunciation improvements are accomplished over the remaining station life, a minimum cumulative expenditure of \$28,800,000 is anticipated as a result of the current annunciation deficiencies. This cost represents the cost penalty of making no annunciation improvements and serves as a baseline against which the financial return from specific improvements can be measured.

There is a high probability that the true costs of the current annunciation deficiencies are substantially higher than the \$1,800,000 indicated from SER review alone. The day-to-day operating inefficiencies as a consequence of poor annunciation and the 'workarounds' introduced as compensation are well known to Operations staff (e.g., dependence on manual review of printed alarm summaries to track the alarm state when the alarm generation rate or total number of alarms are high).

- *Lack of a Consistent Annunciation Strategy* - The lack of a comprehensive, operationally focused and consistently applied annunciation strategy has been a key

contributing factor to the presence of many annunciation deficiencies. This finding is consistent with the understanding of the causes of annunciation deficiencies at other CANDU plants.

- *Primary Deficiencies* - Improvements in two areas have the potential to eliminate most of the current annual cost of poor annunciation:
 - Resolution of alarm generation deficiencies (e.g., correction of chronic nuisance alarms, addition of alarms for important conditions not currently annunciated, and disabling alarms not the responsibility of a unit), and
 - Correction of computer-based annunciation deficiencies (e.g., improved usability of alarm list displays in all plant conditions, application of plant mode and local equipment state conditioning, and standardization of message texts).

RECOMMENDATIONS FOR IMPROVEMENT

The primary recommendations from the assessment fall in four areas:

- *Establish a Standard - Annunciation Strategy* - The definition of an overall annunciation strategy for the Pickering B control room should be undertaken as the first improvement initiative. Such a strategy would serve as a standard to guide the maintenance of current annunciation implementations to be retained, and development and assessment of future annunciation improvements.

The development of this strategy should draw on current station operational experience, the development experience of the recently completed CANDU Owners Group (COG) annunciation improvement program and international annunciation experience. Consideration should be given to defining the strategy in conjunction with other stations and industry partners with similar needs.

- *Resolve Alarm Generation Problems* - Three improvement initiatives offer large financial return and positive operational impact, and are recommended for immediate implementation. The initiatives are:
 - Resolution of current nuisance (i.e., chronically cycling) alarms by field device changes, adjustment of alarm thresholds, and introduction of deadbands or chatter filters,
 - Addition of alarms for important conditions that are not currently annunciated, and
 - Disabling of alarms that are not the responsibility of specific units.

- *Undertake Interim Improvements* - Three improvement initiatives are recommended for interim implementation to provide better annunciation support in upset response and outage management on a short-term basis. These improvements are:
 - Revision of alarm major/minor assignments to improve operational consistency and reduce display flooding in the first few minutes of upset response,
 - Updating the priority assignments of annunciator windows to better highlight annunciators of importance, and
 - Standardizing annunciator window identification and labeling of annunciators to simplify access to alarm response information.

In the long-term, more fundamental improvements to computer-based annunciation will permit the computer-based annunciation system to be used in all operational phases, thus reducing the need and Operations staff dependence on these interim improvements. These three improvements are recommended for short-term use since they offer interim operational benefit and can be implemented quickly, with low cost.

- *Launch Improvements to Computer-based Annunciation* - Improvements to computer-based annunciation offer substantial operational and financial benefit to station operations. A number of improvement initiatives have been proposed (e.g., re-organization of message list displays, application of conditioning, dynamic prioritization of alarms consistent with operational importance to plant state). The merits of several of these initiatives have been recently validated through simulator trials at Point Lepreau and Darlington as part of the CANDU Owners Group annunciation improvement program (4).

STATUS OF IMPROVEMENT INITIATIVES

To date, improvement initiatives have been completed on one of the three alarm generation problem areas. A systematic review of alarms in the fall of 1997 led to the software jumpering of alarm sources that are not the responsibility of specific units. This improvement alone has reduced the day-to-day alarm occurrence rate by one third. Planning is now underway for future engineering programs to undertake additional annunciation improvements.

CONCLUSIONS

This study has characterized current Pickering B control room annunciation deficiencies and established improvement priorities based on operational impact and cost/benefit considerations. The study has also established an interim standard for guiding annunciation improvements until a complete station annunciation strategy is established. These results are expected to provide a comprehensive basis for guiding future station annunciation improvement initiatives.

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REFERENCES

1. R. Olmstead, J. Pauksens and W. Goddyn. (1989). New Approaches to Alarm Annunciation for CANDU Power Plants. Paper presented at the Canadian Nuclear Society annual conference, Ottawa, Ontario, 1989 June 4-7.
2. T. Long and E. Davey. (1996). Darlington Annunciation: User Needs, Current Experience and Improvement Priorities. Paper presented at the IAEA topical meeting on 'Experience and Improvements in Advanced Alarm Annunciation Systems in Nuclear Power Plants', Chalk River, Ontario, 1996 September 17-20.
3. R. Manners, L. Zucker, J. Keniston, M. Reid, N. Blair-Johns, G. Fowles and M. Tindall. (1996). Unit 5 Startup Monitoring Team Results. Memorandum to K. Talbot from Monitoring Team, 1996 July 17.
4. M. Feher, E. Davey, D. Rivera and L. Lupton. (1996). Validation of the Computerized Annunciation Message List System (CAMLs). Paper presented at the IAEA topical meeting on 'Experience and Improvements in Advanced Alarm Annunciation Systems in Nuclear Power Plants', Chalk River, Ontario, 1996 September 17-20.