

UPDATED REQUIREMENTS FOR CONTROL ROOM ANNUNCIATION: AN OPERATIONS PERSPECTIVE

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ABSTRACT

The purpose of this paper is to describe the results of updating and aligning requirements for annunciation functionality and performance with current expectations for operational excellence. This redefinition of annunciation requirements was undertaken as one component of a project to characterize improvement priorities, establish the operational and economic basis for improvement, and identify preferred implementation options for Ontario Power Generation plants.

The updated requirements express the kinds of information support annunciation should provide to Operations staff to support the detection, recognition and response to changes in plant conditions. The updated requirements were developed using several types of information:

management and industry expectations for operations excellence, previous definitions of user needs for annunciation, and operational and ergonomic principles. Operations and engineering staff at several stations have helped refine and complete the initial requirements definition. Application of these updated requirements is expected to lead to more effective and task relevant annunciation system improvements that better serve plant operation needs.

The paper outlines the project rationale, reviews development objectives, discusses the approaches applied for requirements definition and organization, describes key requirements findings in relation to current operations experience, and discusses the proposed application of these requirements for guiding future annunciation system improvements.

I. THE NEED TO UPDATE REQUIREMENTS

The configuration of a nuclear power plant must be known and controlled at all times to ensure that the plant is operated in a manner that is analyzed to be safe. To achieve this objective, the control room operator requires information on plant and process status on a near continuous basis. In practice, it is only practical for operators to maintain a direct awareness through monitoring of a very small subset of the available plant parameters. Consequently, operators are reliant on control room annunciation to provide prompt alert to plant changes in order to identify conditions requiring intervention and to maintain an up-to-date understanding of changes in overall plant conditions.

Operational experience at CANDU stations has shown that the current control room annunciation does not provide the support needed by control room operators in all plant states as originally intended. For example, recent plant reviews of control room annunciation performance at Ontario Power Generation (OPG) plants have identified nuisance alarms as an important factor affecting the ability of operations staff to effectively monitor plant status [1,2]. These and other significant annunciation deficiencies have resulted in the creation of a number of permanent 'operator workarounds' to operational practices to compensate for less than adequate annunciation support.

Over the past five years within OPG and other utilities, there has been increased emphasis on the formalization, standardization, and simplification of operational practices in the pursuit of nuclear operational excellence. These initiatives have been promoted by industry organizations such as the Institute of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO) and are based on the principles and best operating practices developed by industry participants. As a consequence, the raised expectations for excellence in nuclear operations have begun to further highlight the longstanding performance limitations of current annunciation implementations.

The Plant Status Control program is an Ontario Power Generation Integrated Improvement Project (IIP) initiative [3]. The purpose of this initiative is to ensure that best industry Plant Status Control business processes are established and available to adequately support operators in acquiring and maintaining a current understanding of the status and control of plant systems, structures and equipment during all operating states. As part of the Plant Status Control program, a review of annunciation improvement needs and feasibility was undertaken to establish the operational need and rationale for future annunciation improvements to support current and evolving control room supervisory needs. The establishment of updated annunciation requirements, from an Operations-based perspective, was an initial step of this review.

II. OBJECTIVE AND APPROACH

The primary objective was to characterize current and future user needs for control room annunciation from a user-based perspective. These needs were specified through the development of requirement statements in two areas:

- Functionality - What information or services are required, and
- Performance - How well the information or service is to be provided.

Updated statements of user needs in these two requirement areas were developed by building on recent annunciation improvement initiatives and adding relevant new information from recent OPG and industry, standards and guidance concerning preferred operating practices. Five specific sources of information were included as the basis for this review:

- Organizational Expectations - OPG, INPO and WANO standards and guidance concerning conduct of operations and examples of operating excellence,
- Task Based User Experience - Previous definitions of user needs for annunciation from reviews at Darlington and Pickering [1,2] and 'good practice' principles drawn from a book on a systematic approach to industrial operations [4],
- Ergonomic Standards and Guidance - Recent international papers and

reports concerning the ergonomics of nuclear plant annunciation.

- Former CANDU Annunciation Improvement Work - Findings from the CANDU Owners Group (COG) and individual plant annunciation improvement initiatives, and
- Regulatory Expectations and Guidance - Recent standards, guidance, and contractor reports published by the Canadian Nuclear Safety Commission and the United States Nuclear Regulatory Commission pertaining to control room operations.

Updated statements of functional and performance requirements for annunciation were developed from these sources and organized into several categories. For example, functional requirements were organized with respect to the four primary functions of annunciation:

- Detect the occurrence of changes in systems and processes,
- Alert users only to changes that are relevant and important for the current operating state,
- Present information on plant changes in ways that communicates the nature and relative importance of changes and informs without with overwhelming or distracting, and
- Provide or Point users to additional plant information to understand and respond to the changes.

Performance requirements were organized with respect to three measurement dimensions:

- Alarm State Awareness - Measures of the support provided by annunciation to operators for specific Plant Status Control tasks,
- Annunciation Functions - Measures of the specific performance of component annunciation functions, and
- Operational Impact - Measures of the ways in which annunciation support affects overall operational effectiveness.

Following their initial definition, each set of updated requirements was circulated to Operations, Training and Engineering staff for review and refinement.

III. REQUIREMENTS FINDINGS

A selection of the functional and performance requirements established are outlined in Tables 1 and 2 respectively. Table 1 summarizes the functional requirements for each of the four primary annunciation functions. These requirements are presented as simplified statements of user needs with respect to specific information services.

Table 2 shows the performance requirements for one of the three measurement dimensions selected, that of Alarm State Awareness. These requirements are presented in terms of

the performance measures and criteria applicable to each of a number of specific operating contexts. Where known, estimates of current annunciation performance for each measure and operating context are provided for comparison with the updated performance criteria.

IV. AREAS FOR ANNUNCIATION IMPROVEMENT

A gap between user needs to support operational expectations, and current annunciation capabilities and performance establish an area for potential annunciation improvement. A comparison of current plant annunciation capabilities and performance with the updated user needs identified in this study revealed several gaps, and thus areas for consideration of annunciation improvements. The five areas judged to offer greatest cost/benefit improvement with respect to impact on plant operations were:

- Alarm State Display - Separation of fault and status alarms into separate list presentations and organization of fault alarm presentations by alarm importance.
- Prioritization - Determination of alarm importance as a function of operating state and operational consequence,
- Irrelevance Filtering - Suppression of irrelevant alarms from primary annunciation displays,
- Nuisance Alarm Elimination - Substantial reduction in the sources

of chronic nuisance alarms through engineering changes to instrumentation and re-alignment of alarm setpoints with current operating levels and states.

- Response Procedure Selection - Simplification of procedure selection by integrating, within primary alarm displays, the information necessary for identifying the specific location of each alarm's corresponding response procedure.

V. APPLICATION

The updated functional and performance requirements for control room annunciation are being used in two ways:

- First, as a baseline against which the functional capabilities and performance of current plant annunciation systems can be assessed on an on-going basis, and
- Second, to serve as a basis of user-needs to be met for guiding the development of technology specific system requirements for future annunciation improvement initiatives.

VI. CONCLUSIONS

Functional and performance requirements for control room annunciation have been updated and aligned with current expectations for operational excellence. The requirements were established from the perspective of the information needs of control room

operators concerning changes to plant systems, structures and equipment in order to support them in their unit supervision responsibilities. The requirements are based on an understanding of control room operator supervisory and control responsibilities, tasks, operating situations likely to be encountered, and evolving industry standards and guidance pertaining to recommended operating practices. Application of these updated requirements is expected to lead to more effective and task relevant annunciation system improvements that better serve plant operation needs.

VII. REFERENCES

1. T. Long and E. Davey. 'Darlington Annunciation: User Information Needs, Current Experience and Improvement Priorities'. Proceedings of the *IAEA Specialist Meeting on Experience and Improvements in Advanced Alarm Annunciation Systems in Nuclear Plants*. Chalk River, Ontario, 1996.
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3. Lane, L. 'Plant Status Control with an Operational Focus'. Proceedings of the annual *Canadian Nuclear Society Conference*, Toronto, Ontario, 2000.

4. Howlett, H. *The Industrial Operator's Handbook - A Systematic Approach to Industrial Operations*. Techstar Publishers, Pocatello, Idaho, 1996.

Table 1: Functional Requirements

Category	Simplified Requirement Statement
Detection	
- Coverage	Provide alarms for all safety & production conditions.
- Time Reference	Timestamp all alarm changes of state.
- State Detection	Detect and continuously determine plant state.
- Validation	Determine the validity of alarms (failure detection).
Alerting	
- Relevance Filtering	Provide relevance determination and filtering by plant state. Do not alert users to irrelevant alarms.
- Chatter Suppression	Suppress repeated user alerts for chattering alarms.
- User Alarm Removal	Provide user 'jumpering' for all alarms.
- Saliency	Provide alert signals that ensure attention re-direction.
- Non Annoyance	Provide non-annoying alert signals.
Presentation	
<u>Processing</u>	
- Importance	Determine alarm priority as function of plant state, condition consequence, and time to respond.
<u>Alarm Properties</u>	
- Change Identification	Identify the alarm change state (alarmed, unalarmed).
- Fault/Status	Identify alarm type - fault or status.
- Condition Status	Identify the conditioning status of active alarms.
- Importance	Identify alarm importance.
- Affiliation	Identify alarm functional/system affiliation.
- Message Format	Standardize message formats and content.
- Validity	Identify alarm validity.
<u>Primary Displays</u>	
- Darkboard	Configure alarms so they are unalarmed for normal operating conditions.
- Fault Order	Organize fault alarms by relative importance.
- Status Order	Organize status alarms by order of occurrence.
<u>Supporting Displays</u>	
- Span of View	Provide capability to view all active alarms.
- Historical Recall	Provide capability to review former alarm histories.
- Task Support	Provide alarm displays customized to task needs.
- User Customization	Provide capability for users to customize displays.
<u>System Failures</u>	
- Observability	Ensure system failures are readily identifiable.
Pointing & Providing	
- Direct Guidance	Provide direct linkage from alarm to response guidance.
- Response	Ensure there is a complete response for every alarm.

Table 2: Performance Requirements - Alarm State Awareness

Performance Aspect	Performance Measure	Operating Context	Current Performance	Criteria Standard	Impact of Standard Achievement
Acquisition					
Time to independently confirm fault alarm state and priorities following turnover	Time	FPSS	> 10 min	< 5 min	Reduction in time to acquire fault alarm state awareness
		Outage	> 20 min	< 10 min	Reduction in time to acquire fault alarm state awareness
Maintenance					
No proposed measures					
Loss					
Temporary loss of plant alarm state awareness	Number of incidences per shift	FPSS	2-3	0	Improved plant status awareness
		Outage	5-8	0	Improved plant status awareness
Missed fault alarms	Number undetected for > 1 hour/year	FPSS	Unknown	0	Elimination of missed alarm events
		Outage	Unknown	0	Elimination of missed alarm events
	Number resulting in SCRs/year	All	> 5	0	Reduced number of plant events
Recovery					
Time to reconfirm fault alarm state and priorities following temporary loss	Time	FPSS	> 10 min	< 5 min	Reduced time plant awareness is lost
		Outage	> 20 min	< 10 min	Reduced time awareness is lost