IMPLEMENTING MAINTENANCE COMPLEMENT CHANGES AND EXPERIENCE WITH REGULATORY GUIDE G-323

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Abstract

G-323, the Canadian Nuclear Safety Commission (CNSC) guidance document on ensuring minimum staff complement, was released as an official document in July 2007. Shortly before the release of this document, Bruce Power was reviewing minimum complement with a particular focus on minimizing the number of maintenance staff on rotating shifts. The goals were both to increase the maintenance being performed on days, where it would be less error likely, and to reduce the number of personnel exposed to the health impacts of shift work. Although G-323 was not in effect at the time, a decision was made to work to the expectations of the document to the extent possible. This paper outlines the experience in performing this work, as well as lessons learned.

1. Introduction

In 2006, Bruce Power undertook an initiative to reduce the number of maintenance personnel on rotating shifts, and have the majority of planned maintenance performed on day shifts. There were several drivers for this initiative, including improved performance on day shifts and increases to employee health risks and stress levels associated with rotating shift work. In order to accomplish this, a review of the number of maintenance staff actually required for minimum complement was performed, and some Emergency Response Organization (ERO) roles which had been assigned to mechanical or control maintainers were reassigned to other staff.

CNSC Regulatory Guide G-323, Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities - Minimum Staff Complement [1], was issued in July 2007. However, the draft report became available during the work to identify the new minimum complement numbers. Therefore, Bruce Power decided to review the draft document and try to ensure that the intent of the document was met where possible on the 2006 minimum complement project.

2. Shift Work

Shift work is an essential part of modern society. Several industries require 24 x 7 staffing in order to meet safety or production requirements. Power utilities are among those groups. When looking at a nuclear power plant, staff are required in order to meet the basic needs of running the reactor units at all times. In addition, staff need to be available to respond to abnormal or emergency situations which may arise.

Unfortunately, humans do not deal well with rotating shift schedules, or moving from daytime to night time wakefulness. In her summary of data from the Canadian Community Health Survey and National Population Health Survey, Shields [2] noted significant issues related to shift work, including impacts on cardiovascular health, reproductive health, epilepsy and hypertension, as well as mental health issues such as depression and anxiety. In another Canadian study, Jamal [3] found higher stress levels, increased emotional exhaustion, and a greater incidence of both regular and psychosomatic health problems when comparing shift workers to their normal day time counterparts. Shift work has also been associated with increased divorce rates, abnormal eating patterns, and issues around socialization opportunities and self-esteem [4][5].

Performance also tends to be impacted by shift work. A study by Lamond, Dorrian, Burgess, Holmes, Roach, McCullogh, Fletcher, and Dawson [6] found that people on average achieved worse performance scores on their first night shift than on performance tests at 0.10 Blood Alcohol Content (BAC). Performance levels only improved to be better than a 0.05 BAC equivalence by the fourth night shift. This essentially means that personnel working rotating shifts at night may often be working at levels of performance impairment equivalent to legal intoxication in many countries.

These two issues result in a balancing act, where one wants to minimize personnel on rotating shifts while at the same time, ensuring that the correct people are included on shift in sufficient numbers. There is a significant amount of operating experience in CANDUs which can be used to help with estimating those numbers, but a robust and systematic method to confirm the final numbers and any supporting assumptions is also required.

3. G-323

G-323 [1] is a relatively broad document, which includes expectations around complement basis, implementation, compliance, periodic reviews, and subsequent changes. There are several expectations in each of these areas. Which of these areas will need to be considered will be dependent on the project, as some will be more or less relevant, depending on the situation.

Complement basis has two broad areas of expectations, the use of a systematic method of analysis and validation of the requirements. The systematic analysis is expected to consider several aspects including the required actions during the most resource intensive conditions, consideration of operating strategies, required interactions between personnel and strategy to ensure the provision of qualified relief, to name a few. Validations are expected to include the most resource-intensive credible events, and should be performed to demonstrate that several objectives are achieved. These objectives include the ability to maintain situational awareness, and ability to implement procedures within the required timeframes. Beyond these two areas, it is also expected that certain staff will be included in minimum complement including fuel handling staff, maintainers, emergency response personnel, and stores. A final expectation is that a systematic approach to training be used for all of the minimum complement positions.

Implementation will be one of the more consistently required areas as it focuses heavily on the documentation requirements. It is expected that the licensee will document the method used to determine the minimum staffing requirements as well as the analysis results. Procedural requirements are outlined showing licensees are expected to include such information as the number, the positions being filled, the required qualifications as well as any necessary limits on their locations in the facility. The inclusion in the procedures of compliance monitoring measures and actions to prevent non-compliance is also important. As noted above, it is expected that the completed systematic analysis and validation work will point the licensee towards the resource intensive design basis accidents. It is expected that these events will have documented staffing requirements that are noted on the coversheet of the design basis accident procedure for both field and Main Control Room (MCR) activities.

Compliance with the documented minimum complement requirements is expected. G-323 [1] looks at both the short and long term issues that could compromise compliance with these expectations. A process is required to be in place that ensures required positions are filled in the event of both planned and unplanned absences as well as during turnover. The risk of both short term and long term threats to minimum complement are expected to be planned for. A fitness for duty program is expected that can offer confirmation that the employees filling the minimum complement position are capable of performing the duties.

It is expected that a periodic review of minimum staff compliment is made that takes into account external standards and guidelines, relevant operational experience as well as the results internal drills and exercises.

Finally, any changes to minimum complement are expected to follow a comprehensive implementation plan that includes an analysis of the staffing levels as well as be effectively change managed. The licensee is expected to ensure that operational experience related such changes is applied where appropriate and that sufficient time for regulatory review and approval is built into the process.

4. Bruce Power Experience with G-323

As previously discussed, Bruce Power decided to review G-323 [1] and meet the intent to the extent possible, even though the document was not issued at the time that the maintenance minimum complement work was underway. There were two reasons for this. The first was that we were intending to apply our normal human factors processes for reviewing minimum complement, and wanted to confirm that they would meet these incoming requirements. The second was to ensure that we actually understood what the requirements were before they came into effect.

4.1 Human Factors on the Project

We had already created a Human Factors plan for the review work, as well as coordinated with other workgroups who were performing analysis and gathering background data when the draft version of G-323 [1] came out. In addition, much of the initial analysis had been performed. This included creating a change map, to clearly show how roles were being

reallocated, and performing operating experience (OPEX) interviews with people who had current roles in minimum complement, as well as people responsible for ensuring that minimum complement was present. In addition, Abnormal Incident Manuals (AIMs) had been analyzed by experienced operations staff, and timing and key roles identified.

The Human Factors (HF) specific work done on this project was based on G-276 [7] and G-278 [8], and laid out in line with the elements of NUREG-0711 [9]. The OPEX work undertaken included both interviews and database searches, and looked at previous drills and emergency response activations, both internal and external, individual roles and expectations at Bruce Power, and experience in confirming the presence of minimum complement. Changed roles were analysed to confirm that conflicting or excessive tasks had not been assigned to any individual. In addition, the task analysis confirmed that communication needs could be met, as the physical location of some roles had changed. Multiple validation activities, discussed further below, were undertaken. Other activities were also performed, but these formed the bulk of the HF review.

There were two distinct issues to be validated, the changes to the maintenance complement numbers and the re-allocation of ERO roles within Bruce Power. G-323[1] was highly relevant to the maintenance changes, as they were actually changing the numbers of persons available on site. As a result, all AIMs which required maintenance support were validated in a tabletop format with control and mechanical maintainers. It should be noted that this included only those AIMs which required maintainers who would be designated as 'mitigation'. Any AIM which activates the Emergency Operations Center at Bruce Power also requires that maintainers be available to fill the role of Emergency Entry/Repair Team, which does not have assigned tasks in the AIMs, but is required to be available to respond to emergent field issues during the event.

In addition, we needed to validate the re-allocation of ERO roles. The Off-Site Survey Team (OSST) was being relocated to a point outside of the stations as a result of this re-allocation. As well, although the initial HF review did not indicate any task conflicts, this needed to be confirmed. A dynamic validation was used to confirm this, with three validation activities being performed in conjunction with drills. The Loss of Coolant Accident (LOCA) drill was used, as LOCA is the most resource intensive emergency response, activating all members of the ERO. This drill included an Emergency Entry/Repair Team (EERT) repair in the field and a contaminated casualty in order to fully task the various roles. Three validation activities were performed in order to allow HF to observe and gather data at all three locations involved in the drill, Bruce A, Bruce B and the Central Maintenance and Laundry Facility (CMLF) located centrally on the Bruce Power site. G-323 [1] was less relevant to this aspect of the review. Although the normal location of the staff changed, the location limitations on the role were not changing.

The overall results of the validation were several ideas to improve the process and response as a whole, but no significant issues with the complement as designed. In addition, some unanticipated benefits to the new role assignments were found. In particular, improved times were realized in dispatching OSST to the field because of their new location outside the plant. This occurred because the reduced monitoring and security requirements of the new area

meant that the teams could perform the truck inspections while waiting for the Out of Plant Coordinator (OPC) to gather the weather and other data that was required before they could begin their surveys.

4.2 Meeting G-323

Our first step in ensuring that what we had done met G-323 [1] was to identify which sections were relevant to what we were doing at the time. Of the five sections, two were broadly identified as relevant: basis for minimum complement, and changes to minimum complement. Some requirements of implementation were also noted as relevant. Compliance and periodic review, while important aspects were not determined to be relevant to the review in progress. Documents outlining compliance and how it was to be maintained were in existence at Bruce Power and were not being changed. In addition, while we recognize the importance of periodically reviewing minimum complement to ensure it is still relevant to changes in the plant or expectations, we were focussed on a single review cycle for the purposes of this project.

Once the relevant sections were identified, a table was created identifying each line item in G-323 [1] and identifying how we felt it had been met. An excerpt from this table is included as Table 1, below. This table was provided unofficially to the regulator to try to facilitate communications.

Table 1 Excerpt From G-323 Line Review

Section	Requirement	Met
5.1	**Basis for Minimum Complement**	
5.1.1	*Systematic analysis of tasks*	
5.1.1a	Consider normal, transient design basis accident and emergency conditions	Bruce B normal complement was based on analysis performed early in station history, which has been supported and reviewed periodically based on experience. Other information is available in DIV-OPA-00001, DIV-OPB-00001 and B-REP-03600-00001.
5.1.1b	Consider accident scenarios described in the safety analysis and Probabilistic Safety Analysis (PSA)	DIV-OPA-00001, DIV-OPB-00001 and B-REP-03600-00001
5.1.1c	Consider operating strategies that define how nuclear facility personnel respond to transients, design basis accidents and emergencies	DIV-OPA-00003, DIV-OPB-00005
5.1.1d	Consider required interaction among personnel	Validated through drills, supported through HF analysis, and analysis outlined above.
5.1.1e	Consider staffing demands for concurrent use of transient, Design Basis Accidents (DBA) and emergency procedures	Validated through drills, supported through HF analysis, and analysis outlined above. Drills include use of AIMs, transient response and activation of Emergency Field Operations (EFO), for

		example.
5.1.1f	Consider staffing demands for monitoring indicators, displays and alarms	Previously validated through work outlined above and U3 and 4 validation work. Not changing.
5.1.2	*Validation of Staff complement requirements*	
5.1.2a	Relevant procedures can be implemented in a timely manner	MART response and other targets in ERO drill package - Emergency preparedness measures
5.1.2b	There is an effective and timely response to transients, design basis accidents and emergency conditions	MART response and other targets in ERO drill package - Emergency preparedness measures
5.1.2c	the plant can be effectively monitored contolled and stabilized	MART response and other targets in ERO drill package - Emergency preparedness measures
5.1.2d	There is effective communication and coordination of required actions	Emergency preparedness measures plus user feedback (question 5 communication)
5.1.2e	Personnel are able to maintain awareness of plant conditions	Emergency preparedness measures plus user feedback (question 2 situational awareness)
5.1.2f	Workload of complement staff is achievable	Emergency preparedness measures plus user feedback (question 1 overall achievability, question 6 workload)

In the above table, 'emergency response measures' refers to the targets included in the Emergency Response procedures, including the time to have the Off-Site Survey Team in the field, and the time for the Mutual Assist Response Team (MART) response. Where specific questions are referred to, these are the questions on the subjective feedback form used in the validation, and completed by participants and observers.

As can been seen in Table 1, only some of the work which was used to meeting the guidance of G-323 [1] came directly from the Human Factors work discussed in section 4.1. Much of the work was drawn from work performed by Operations, Ops Support or Emergency Measures. It is important when working to meet G-323 that it is not seen as the responsibility of a single section or department, but a coordinated effort across departments.

5. Challenges

The first challenge in performing this work, and in meeting the expectations of G-323 [1]. , as indicated above, was the need to coordinate across multiple groups. This was important both in terms confirming that we met G-323 and in terms of being able to accomplish the HF validation. The minimum complement procedure touches on several groups within both operations and maintenance, as well as personnel within the safety organization. In order to review and validate the minimum complement, coordination across all of these groups was

required. The improvement opportunities identified also often required support from across multiple workgroups. Although these groups generally do work well together, particularly in terms of the emergency response, the logistics of this coordination can, and sometimes did, pose challenges. This is particularly true when some of the groups involved may be constrained in their resources.

A second challenge that we faced came about in interpretations on G-323 [1]. Our interpretation and the interpretation of the HOPD group at the CNSC did not necessarily line up on G-323. The HOPD group includes the specialists in the area of Human Factors and Human Performance. Although we felt in our line by line review we had met all relevant aspects of G-323, the regulator felt that G-323 as a whole was not met. This issue is still partially open, as additional action items eventually came out of discussions with the regulator in order to meet their interpretation of G-323.

Although not specific to G-323, there are also always challenges around changing the way people work. People may be resistant to changes in their hours, work practices or staff structures for a variety of reasons, ranging from lifestyle to familiarity to comfort. This is important for two reasons. First, you need to consider people's concerns in presenting the change to help them adjust to it. Second, you need to consider the feedback that you are receiving in the context of these concerns. This means that it is very important to ask a wide variety of questions, and probe deeply into issues raised until you understand the sources of the issue.

6. Lessons Learned

The most important lesson that we learned from performing this review was the importance of coordination across work groups. As discussed above, there are aspects of G-323 [1] that require input and support from a very diverse collection of areas within any given company. In this particular case, the Human Factors section took the lead in documenting how each element was met, and so unofficially coordinated between these groups with relation to G-323. However, for future exercises performed under the guidance of G-323, it will be important to determine who is responsible for the coordination between the various involved groups, and begin that coordination work very early.

In addition, communication will be very important with any project related to minimum complement. There were several problems in terms of understanding the expectations of the CNSC, and where our interpretations were differing around G-323. For future projects, we will need to look for mechanisms to try to improve those issues.

There were also lessons from previous minimum complement reviews at Bruce Power which we are able to carry forward to this review, and which should be brought out here. One is the importance of always reviewing communication pathways when reviewing minimum complement. Very often, minimum complement reviews are done in terms of the people required to do the work, or workload reviews. However, it is also important to ensure that the people have access to the information they need to do the work. As obvious as this seems, understanding what information is required at any given point in the task, and where a person

is getting that information, as well as what could go wrong with the transmission of information, is of key importance.

In addition, ensuring the mechanisms and accountabilities are in place to confirm minimum complement will be a significant aspect of any broad-sweeping minimum complement review. This is perhaps particularly true of the Bruce Power site, where we are coordinating our response across several buildings on a very geographically large area. Any facility, though, will need to ensure that the right combination of face to face turnover requirements, reporting requirements and scheduling expectations are in place to ensure that complement is always present and able to be accurately tracked.

A final lesson learned concerns the scope of review. It is very important to consider broadly the work and workload of the groups directly changing on minimum complement, and of the groups that they interact with. It can be very challenging to identify all of these groups, and often surprises will be encountered. Early background interviews should include personnel from workgroups that are changing, but also personnel from groups who approve, oversee, prepare for or follow after the groups that are changing.

7. References

[1] Canadian Nuclear Safety Commission, "G-323: Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities - Minimum Staff Complement" 2007.

[2] M. Shields (Stats Canada), "Shift work and health", Health Reports, Vol. 13 Iss. 4, 2002, pp 11 - 33.

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[7] Canadian Nuclear Safety Commission, "G-276: Human Factors Engineering Program Plans" 2003.

[8] Canadian Nuclear Safety Commission, "G-278: Human Factors Verification and Validation Plans" 2003.

[9] US Nuclear Regulatory Commission, "NUREG-0711: Human Factors Engineering Program Review Model", Rev. 2, 2004.