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Emergency Procedure Recommendation for Wolsong 2, 3 & 4 NPP

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Abstract

The current direction of emergency procedures for CANDU reactors is reviewed and compared based on scope, methodology and format preponderantly, and an attempt is made to integrate these procedures. As a result, a recommendation for Wolsong 2, 3 & 4 emergency procedures is presented as event-specific procedures, generic procedure and whose format is combination of logic diagram and technical basis document.

1. Introduction

The development of Emergency Procedures(EPs) is a pre-requisite to obtaining an Operating License from Atomic Energy Control Board (AECB) in Canada [1]. In the early 1980s most utilities in the world concluded that "event specific" procedures had pitfalls associated with correctly/incorrectly recognizing the event and also with the assumptions made about how the plant would respond to that event. To address these and related concerns, "generic" Emergency Operating Procedure(EOP) was developed. Until recently, the EPs in nuclear power plants has been mainly event-oriented [2-5].

Following the accident at Three Mile Island, many utilities and regulatory agencies emphasized the importance of "SYMPTOMS RESPONSE" and, in addition, acknowledged the shortcomings of explicitly reflecting conservative safety analyses assumptions in developing EPs. In various ways, utilities identified how a Main Control Room Operator(CRO) should measure and decide whether the response of specific functions was acceptable or not. In all cases, the application of symptoms response required defining the specific functions to be assessed, the relevant parameters to be measured and the satisfactory specific responses. When an unsatisfactory response was found, a recovery procedure was needed. The recovery procedures are basically of two types, an event-based or a symptom-based.

In 1987, the Canadian nuclear utilities, Ontario Hydro, New Brunswick Power and Hydro Quebec, responded to an initiative of the AECB by producing the "Emergency Operating Procedure Standards for Canadian Utilities" [6]. This document reflects a joint effort of these three Canadian nuclear utilities to apply principles of Symptoms Response in developing and implementing any EOP Program. However, it should be recognized that the "Standards" have not been developed in accordance with and under the jurisdiction of the Canadian Standards Association.

The development of the EPs for Wolsong units of Korea Electrical Power Corporation(KEPCO), which are based on a Canadian Utilities practices, is required strongly. Because of the inherent characteristics of Wolsong units, it is natural to review CANDU practices and Canadian standards to develop the EPs for Wolsong

units. In this report, the current direction of emergency procedures for CANDU reactors are reviewed and compared based on scope (events covered), methodology (event-oriented or symptom-oriented or hybrid) and format (method of presentation) preponderantly, and comprehensive integration of these procedures is carried out.

2. Review of Emergency Programs

The EPs of Point Lepreau, Pickering, Darlington and Wolsong Unit 1 were selected for a comparison. The events in EPs of each plants are shown on Table 1.

The technical basis for the EOP's at Point Lepreau is that control of a relatively few parameters("Critical Safety Parameters") will assure adequate fuel cooling and containment activity. By placing priority on control of certain parameters and by choosing parameters that the thermodynamic state of primary and secondary coolants, they parallel the "symptoms-oriented" approach.

The Point Lepreau EOPs are of two types. One type deals with plant upsets where the nature of the cause of the upset is identified and an event specific EOP exists for that cause. The second type of EOP is complementary to the event specific EOP in that it is used for upset conditions where the Critical Safety Parameters(CSPs) are outside defined acceptable value or the CSPs are trending towards their unacceptable or undesirable limits and the cause of the event is not recognized or the cause is recognized but no specific EOP exists. The EOPs consists of Logic Diagrams("Logigram" - Entry Conditions and Main Procedures)) and Task Procedures(Tabs). The logigram section represents the master logic for the EOPs, including required monitoring, instrumentation to be used, and a summary of corrective actions in priority. The Tabs provide the details of corrective actions and precisely specify which devices are to be operated or monitored.

The Darlington NGS A Operator Response Guidelines(ORGs) were developed based on Darlington Probabilistic Safety Evaluation to provide operations with a comprehensive and realistic information base for the preparation of abnormal incident, operating, and commissioning procedures, and for the training of operating personnel in handling accident situations. The selection of events was performed based on thorough review of potential initiating events those which could lead to event sequences in which fuel failures occur and grouping of these events together according to effect on the Diagnostic Parameters. The Darlington NGS A ORGs are in the form of a hybrid : symptoms-oriented, event-specific. This approach attempts to impose the rigor and discipline of the purely symptom based procedures on the familiar and direct event-based procedures. Symptom-oriented, event-specific procedures specify operator actions based on a symptom parameter hierarchy, which will be the same for all events, but a separate Guideline is written for each class of initiating events.

The Pickering Abnormal Incident Manuals(AIMs) have evolved over the last 15 years [12]. In the beginning, a large number of events (including e.g. loss of class I, II power) were addressed by the AIMs. But then it was decided to address only those events which potentially were a threat to fuel cooling and required operator actions at the beginning of optimal recovery.

Basically the type of AIM is an event specific, but in addition to the event based AIMs, there are two generic AIMs. One is a Power Reduction Action Guide, based on reactor trip/setback or stepback. This guide directs the operator to the event specific

AIM. The other is a Critical Safety Parameters Monitoring and Restoration procedure. If the event cannot be cleary identified then this procedure instructs the operator to monitor and control certain key safety parameters to ensure fuel cooling, subcriticality, intact containment. The Pickering AIMs consists of logic diagrams(Event Confirmations and Main Procedures with text format for option).

The Wolsong Unit 1 Emergency Operating Procedures(EOPs) were prepared by Korea Electric Power Corporation based on Operational Documents(OPDOCs). The OPDOCs provide a detailed analysis of the operating considerations for severe problems of the safety related process systems. These documents reviewed potential system impairments, ensured adequacy of the alarms and identified corrective operator actions. The Wolsong Unit 1 EOPs were prepared based OPDOCs and are of event-oriented procedures type.

3. Development of Wolsong 2, 3 & 4 Emergency Procedures

It can be complex and difficult for an operator to fulfil the recovery action necessary to recover the plant from upset condition. When the abnormal conditions cannot be clearly diagnosed, when the plant or operator response to any diagnosed abnormal condition proves inadequate, or when the plant response or corrective actions cannot be, or have not been, predicted, the event specific EPs may be inadequate.

For appropriate responses to the plant abnormal conditions the developments of more specific and detailed event-based EPs are required. Under these circumstances, if the critical safety parameters are trending in an unsafe manner, the symptom-oriented EPs should be used. Both event-specific and symptom-oriented EPs are advisable for the Wolsong units. The advantages and disadvantages of each types of EPs are shown on Table 2.

EPs should direct the operating staff to address threats to and deterioration of the safety barriers. The main safety barriers are:

(1) the fuel sheath
(2) the heat transport envelope, and
(3) the containment.

Actions to restore the integrity of the heat transport envelope and containment should also be addressed, where appropriate. As a minimum, the CSPs should include:

- PHT Inventory
- Subcooling Margin
- Reactor Power
- Steam Generator Pressure and Level
- Feedwater/Service Water Activity
- Containment Building Activity
- Containment Building Pressure

4. Conclusion

The scope of the recommended hierarchy for the Wolsong 2, 3 & 4 EOPs is based on the scope of Abnormal Operating Manual(AOM) and the urgency of the event. The AOMs have been being presented in four sections; entry conditions, operating objectives,

main procedures and technical basis documents. The AOMs should be easily recognized to the operator "Where he is", " Where he has come from" and "Where he may be going" via a logic diagram format. The logic diagrams shall contain governing conditions and operator actions. The purpose of the AOM is to concentrate on stabilizing the plant from the viewpoint of fuel cooling, heat sink and containment. Therefore, the contents of logic diagrams should be written in short and concise form to give appropriate and clear directions to the operator and to enhance comprehensive understanding under emergency conditions.

The logic diagrams are presented on the left side of each page in order of importance with vertical direction following plant response. On the right side of each page, comments will be described to give the operator the further information about indicators to be monitored and equipments to be operated. On the left side page of each logic diagram the operating objectives are provided in brief and concise sentences to describe what is to be accomplished in the procedure. Each AOM should be complemented by a technical basis document, identifying the response of all relevant and major CSPs, explaining the strategies and tactics adopted, rationale for each operator actions and identifying the specific limits of the AOM. The proposed logic diagram format is shown on Figure 1.

REFERENCES

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TABLE 1. Events in EP of Each Plant

Point-Lepreau	Darlington	Pickering	Wolsong-1
·Dual Station Control Computer Failure ·Loss of F/W ·Loss of I/A ·Loss of Service Water ·Loss of Class IV Electrical Power (Station Black-out) ·Large LOCA ·Small LOCA ·S/G Tube Failure	·Forced Shutdown ·S/G Press. Decreasing ·PHT Press. Decreasing ·Loss of PHT Inventory ·Loss of PHT Inventory with Emergency Coolant Injection ·S/G Level Decreasing ·S/G Tube Failure ·Channel Flow Reduction ·Loss of Unit Class IV Power ·Loss of Unit I/A ·Loss of Low Pressure Service Water Open System ·Moderator System Failures ·Failures While on Shutdown Cooling	·LOCA & ECC Operation ·F/W Line Break ·Main Steam Line Break ·Loss of Class IV & Class III ·S/G Tube Rupture ·Loss of Class IV ·Loss of Class III ·Loss of I/A ·Loss of Low Pressure & High Pressure Service Water ·Dual Computer Stall ·Moderator & Shield Cooling Failure ·Loss of RCW	·Dual Control Computer Failure ·Small LOCA ·Large LOCA ·Loss of F/W ·Loss of Condensate Water ·Loss of Electrical Power ·Loss of RSW ·Loss of RCW ·Loss of I/A ·Loss of Moderator System ·Loss of Moderator Cover Gas System ·Loss of End-Shield Cooling System

TABLE 2. The Advantages and Disadvantages of Each Type

	Event-Based	Symptoms-Based	Symptoms-Oriented, Event-Specific
ADVANTAGES	·simple to use ·familiar to operators ·provide more detailed and rapid recovery actions ·realistic in approach	·remedial actions independent of cause ·allows single procedure to deal with all events ·can handle with multiple failures	·if diagnosis is possible, numerous branchings of single symptoms-based procedure are eliminated ·handle minor misdiagnosis ·uniform hierarchy of symptoms leads to plant stabilization prior to diagnosis of event ·detailed recovery actions ·allow for variety of entry conditions ·deal with concurrent failures ·provides some guidance for unknown events
DISADVANTAGES	·subdivision of event class lead to more detailed procedures ·requires diagnosis prior to operator action ·difficult to deal with multiple events ·no guidance for unknown event	·if the event can be diagnosed, single procedure appears to be difficult to use ·requires major change in training and operating philosophy ·requires accident to have progressed far enough for unit trip; can lead to greater consequences	·includes extra steps not needed if event follows expected sequence ·requires operator to diagnose the type of event(but not specific event)

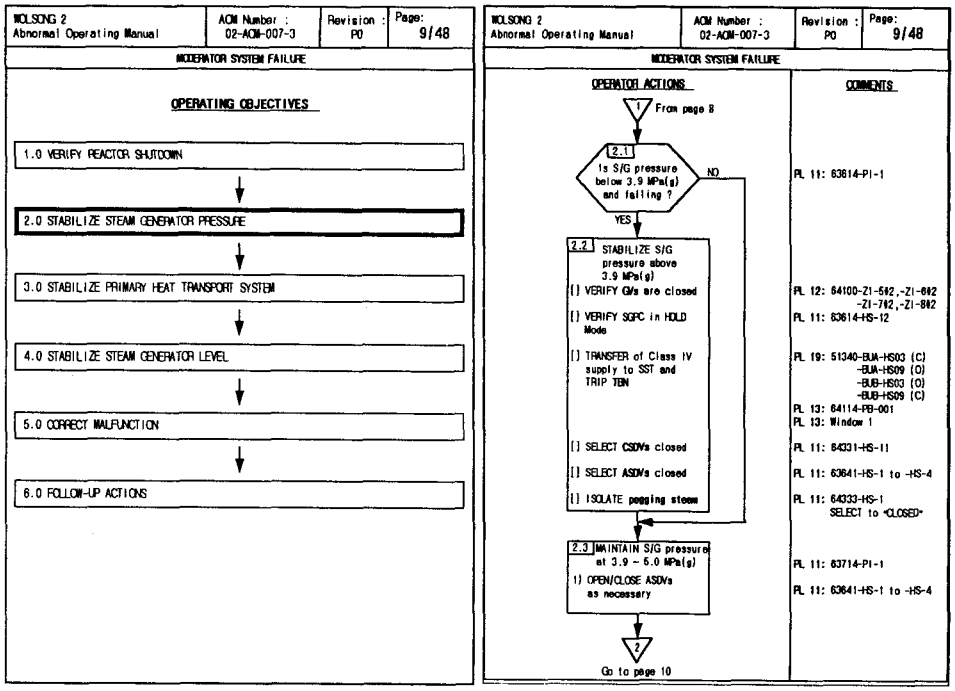

Figure 1. Proposed Abnormal Operating Manual for Wolsong 2, 3 & 4