

Improvement Status of the Emergency Operating Procedures for Wolsong CANDU-6 Plants

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1. Introduction

Emergency Operating Procedures(EOPs) should be prepared for transients or accidents that have caused plant parameters to exceed reactor protection system set points or engineered safety feature set points, or other established limits [1]. EOPs include operator's actions, components and systems required to recover Critical Safety Parameters(CSPs) and to mitigate accidents.

In this study, the EOPs for Wolsong CANDU-6 plants have been improved complying the technical requirements of CNSC [2], NRC [1,3], INPO [4,5] and domestic regulatory authority as follows: (1) the EOP structure for Wolsong Units 3,4 has been reestablished, (2) accident diagnosis process has been optimized to achieve plant stabilization quickly and safely. (3) entry conditions to the event-oriented EOPs and operating actions have been improved. On the basis of human factors engineering, standardized format and terminology have been used to prepare the EOPs. The technical adequacy of the improved EOPs has been validated through safety analysis and full-scope simulator tests.

2. Methods and Results

Through the review of the current EOPs and their technical bases, the items to be improved were derived and reflected to the improved EOPs. In this section, the improvement process and results are described.

2.1 EOP Improvement Process and Results

Table I shows the structure of the current Wolsong Unit 3,4 EOPs.

Table I: The structure of the current Wolsong Unit 3,4 EOP

Type	Related EOPs
Post-Trip Actions and Accident diagnosis	• EOP-001 (PRAG)
Critical Safety Parameters	• Ensure integrity for physical shielding wall against discharge of radiological materials • 12 safety parameters(reactor power, subcooling margin, etc.)
Event-oriented EOP	• Similar to the Optimal Recovery Procedures in PWR plants • EOP-003 ~ 015

Symptom-oriented EOP	<ul style="list-style-type: none"> • Similar to the Functional Restoration Procedures in PWR plants • EOP-002 (CSPMRP)
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Figure 1 shows the operating strategy of the Wolsong Unit 3,4 EOPs.

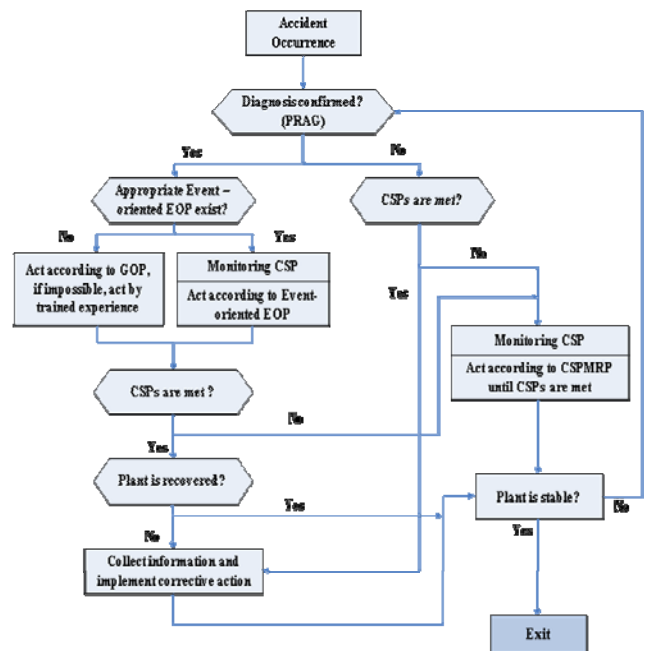


Fig. 1. Operating strategy of the Wolsong Unit 3,4 EOPs

The utility requirements for EOP improvement were derived from:

- Review of the documents on the Wolsong EOP related problems
- Interview with plant operators

The regulatory authority requirements were derived from:

- Special inspection results reports of Wolsong Units 1,2,3 and 4
- Finding and recommendations of periodic inspection
- Investigation reports of plant events

Additional items to be improved were identified from periodic safety review results on Wolsong CANDU-6 plants, EOP technical association meeting minutes, and special inspection results on the EOPs in USA.

Table II shows 320 items derived through the above process.

Table II: The number of items to be improved

Category	The number of items	Category	The number of items
EOP Event	11	EOP Implementation	6
EOP Diagnosis	39	EOP Usage	7
Contents of each EOP	134	EOP Maintenance	6
EOP Basis	11	EOP Training	9
EOP Writing	70	Transfer to other procedures	7
EOP V&V	6	Others	12

The improved EOPs(draft) revised considering the 320 items in Table II were reviewed by the EOP Task Force Team(TFT) in Wolsong CANDU-6 plants and 628 opinions were suggested by the EOP TFT. Table III shows the reflection status of the opinions to the improved EOPs.

Table III: Reflection status of EOP TFT opinions to the improved EOPs

Item	The number of opinions
Total opinions	628
Reflected opinions	554
Non-reflected opinions	70
Corresponding to Wolsong Unit 2 only	3
Corresponding to Wolsong Unit 1 only	1

As shown in table III, 554 opinions were reflected to the improved EOPs.

The major improvements are as follows:

- Change of some procedure's titles to exactly represent the contents of the corresponding EOP
- Adoption of "Continuous Action" and "Parallel Action"
- Flow chart format using conditional key words, "IF-THEN-ELSE"
- Minimization of tautological steps by logic restructuring
- Optimization of diagnosis symptoms according to each accident : main diagnosis / detailed diagnosis
- Provision of customized handouts according to each accident
- Turbine trip at the earlier step in the event-oriented EOPs
- Standardization of shutdown cooling system pressurization method
- Removal of the event-oriented EOP titled "Moderator Cover Gas System Failure"
- Improvement of logic and contents in each EOPs for written correctness, technical accuracy, usability, and operational correctness.

2.2 Improved EOPs Validation

Validation of emergency operating procedures was performed through safety analysis and simulator tests. The safety analysis code, CATHENA(Canadian Algorithm for THERmalhydraulic Network Analysis) developed by AECL, has been used, which has been used in not only in the safety analysis for Wolsong Units 2,3,4 but also in the re-analysis for Wolsong Unit 1.

The results of the safety analysis indicated that the plant can be placed into safe shutdown states with the improved EOPs until shutdown cooling begins. This means that the results of safety analysis meet the overpressurization limits and safety standards of fuel integrity which is as follows:

- Fuel integrity (R-8, R-10):
Sheath temperature < 800 °C
- Overpressurization limits (R-77):
Maximum pressure < 11.9MPa(g) [SDS1]
Maximum pressure < 13.0MPa(g) [SDS2]

Validation of the improved EOPs was performed twice using the full-scope simulator in the Wolsong training center and it indicated that the improved EOPs could maintain the plant safe and stable states in emergency conditions.

3. Conclusions

This study has been performed as a part of the Wolsong CANDU-6 EOP improvement project. The format, applicable conditions and logic of the EOPs have been improved. Uncertainty analysis and validation for the setpoints used in the improved EOPs have been being performed. This project is expected to produce the improved EOPs which are legible, intelligible and more suitable for Wolsong CANDU-6 plants.

REFERENCES

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