

Initial MR Evaluation for Plants Shut Down for Extended Periods

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1. Introduction

Maintenance Effectiveness Monitoring Programs (known as MR) for CANDU plants have been developed since March 2007. KHNP is currently operating four CANDU plants and all the plants have their own MR programs. The first CANDU unit operated by KHNP has been in operation for 29 years and is to extend its lifetime. This plant was shut down for refurbishment from April 2009 to July 2011.

Therefore, an initial evaluation must be conducted prior to implementing the program. The initial evaluation assesses the Systems, Structures and Components (SSCs) against the established performance criteria using historical plant data for a period of at least two fuel cycles or 36 months in order to determine if the SSCs meet the performance criteria. The initial evaluation period for Wolsong Unit 1 includes the refurbishment shut down period. The other KHNP plants, which are Pressurized Water Reactors (PWRs), were not shut down for longer than one operating cycle in their initial evaluation period.

This paper presents the effect of the extended shut down period on the initial evaluation of the plant in order to determine which SSCs do not meet the performance criteria.

2. Initial Evaluation Methods and Results

This section describes the MR initial evaluation method and the effect of the extended shut down period.

2.1 Initial evaluation method of maintenance effectiveness monitoring program

The performance criteria of the CANDU maintenance effectiveness monitoring program are developed based on a three year period including two operating cycles. The industry guideline NUMARC 93-01 describes the method for conducting the initial evaluation.

The second phase of evaluation assesses the specific SSCs against the established performance criteria using the historical plant data in order to determine if the SSCs meet the performance criteria. The historical data used to determine the SSCs performance consists of the data for a period of at least two fuel cycles or 36 months, whichever is shorter. If the SSCs do not meet the established performance criteria, a cause determination is performed. If the unacceptable performance is not maintenance preventable, the SSC is placed in the

normal performance monitoring status [(a)(2)] and are addressed in the preventive maintenance program. If it is determined that an acceptable performance trend has not been demonstrated or the corrective action has not solved the problem, the SSC is placed in the intensive monitoring status [(a)(1)] and (a)(1) monitoring goal is set for the SSC. According to NUMARC guideline [1], for existing plants that have been shut down for extended periods, (i.e. longer than one operating cycle) the evaluation should consider the existing equipment operating history to the maximum extent possible.

2.2 Historical review for selecting initial evaluation period

The first CANDU unit in KHNP was built in 1983. The twenty-first refueling outage of the unit was conducted from April 2009 to July 2011. This is considered an extended period of refurbishing outage. During this outage, many SSCs were refurbished including the pressure tubes. All fuels were extracted from the Calandria, which is similar to reactor core, and refueled after refurbishment was completed. The duration of the no fuel period was approximately two years (between May 2009 and April 2011).

KHNP extended the initial evaluation period to five years period including the three year operating period and two year shut down without fuel period because the industry guidelines recommend to extend the historical data period to the maximum period where possible.

2.3 Initial evaluation results for the extended period

During the five year evaluation period, 3806 items, including 3513 issues notifications and 293 work orders, were identified. This number is 1.6 times higher than the other unit's number of evaluation items, but the recent three-year record is similar in all CANDU units as shown in Table 1.

Table 1. Number of evaluation items in the CANDU units

Plant	No. of Notification	No. of Work Order	Total
Unit 1 (5 years)	3513	293	3806
Unit1 (3 years)	2179	69	2248
Unit 2 (3 years)	2226	76	2302
Units 3&4 (3 years)per unit	2008	361	2369

The number of functional failures (FFs) and the number of exceeding the reliability performance criteria (RPC) in the Unit 1 is higher than that of Unit 2. In the recent three year history, the number of FFs is similar to that of Unit 3 and 4 and the number of exceeding RPCs is higher than that of the other units (refer to Table 2).

The initial evaluation period in Unit 1 was extended to five years. If the issues are older than three years, are already resolved, and are not repetitive functional failures, the issues are not considered as (a)(1) issues any more. Those FFs were already fixed and thus there were no further issues in the plant.

Table 2. Number of FFs and exceeding RPCs in the CANDU units

Plant	No. of FFs	No. of Exceeding RPCs	No. of (a)(1)
Unit 1 (5 years)	84	10	4
Unit 1 (3 years)	53	6	4
Unit 2 (3 years)	44	4	2
Units 3 & 4 (3 years) per unit	54	2.5	1.5

In the NUMARC guideline, unavailability is defined as the planned and unplanned unavailable hours during the required operational hours. Regulatory inspection procedures define the unavailability as the time that an SSC is unavailable during periods when the SSC was required to be available. Under the MR, unavailability is customarily charged from the time of the demand failure or discovery of a degraded or failed condition until its restoration. For the period prior to a demand failure or discovery, additional unavailability may be charged from when the condition first existed if the fault exposure time can be determined. However, for the MR purpose, if the fault exposure time cannot be determined, additional unavailability need not be charged [2].

In the availability performance criteria (APC) area, the number of exceeding APCs in Unit 1 is much less than that of other CANDU units. Only one criterion is exceeded in the APC as shown as Table 3. This is significantly less than other CANDU units. In Unit 1, the period when all fuel was extracted from the reactor core is considered to be time when the SSC is not required to be available for safety functions.

Table 3. Number of exceeding APCs in the CANDU units

Plant	No. of exceeding APCs	No. of (a)(1)
Unit 1 (5 years)	1	-
Unit 2 (3 years)	6	-
Units 3 & 4 (3 years) per unit	2 (RPC & APC)	-

Furthermore, cases where the criteria of exceeding APCs entered into (a)(1) were not found in the CANDU

units. In most cases, the reason for exceeding the APCs is not preventive maintenance, but rather is induced by corrective maintenance. Unavailability induced by corrective maintenance is not a primary focus of setting APCs or balancing between RPCs and APCs.

During the out-of-fuel period, 34 unavailability work orders are identified but did not accumulate into the APCs because the period is not considered to be a time when the SSC is required to be available.

3. Conclusions

The CANDU MR program is the last project developing maintenance effectiveness monitoring program for operating KHNP plants. This plant had been shut down for an extended period that was longer than one operating cycle. In most cases, the initial evaluation requires the historical data review of two operating cycles or three years. In this particular case, an extended historical data review was recommended by NUMARC 93-01.

The result of the initial evaluation for this plant demonstrates that the extension of the historical review is not sensitive in the number of FFs. There were more FFs identified in this unit, but it was not due to the time extension. For the average number and recent three year history, the number of FFs was similar to that of other CANDU units. The FFs older than three years were already fixed and did not affect the (a)(1) decision.

The out-of-service time during the out-of-fuel period is not considered unavailability because most safety functions are not required during this time. Furthermore, the out-of-service times of work order were not accumulated into APCs by this reason. A small number of exceeding APCs were identified during the extended period.

Extending the period of the initial MR program evaluation is a reasonable approach for locating degraded SSCs. However, during the refurbishing outage, already known issues were fixed. The plant corrective actions were effective based on the recent operating history because the exceeding RPC issues older than three years are cleared and there are no further issues for the RPC.

REFERENCES

- [1] Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NUMARC 93-01 Revision 3, NEI, July 2000.
- [2] Reactor Safety-Initiating Events, Mitigating Systems, Barrier Integrity, NRC Inspection Procedure 71111, NRC, May 2003