Graded Approach to the Development of a Contingency Plan for On-Line Maintenance

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1. Introduction

Many utilities perform preventive maintenance for safety systems during power operation to improve equipment reliability so as to focus on the work activities more easily and improve the quality of maintenance. Such a strategy can also reduce outage work activities, thus allowing resources to be utilized effectively. Preventive maintenance during power operation, known as on-line maintenance (OLM), requires an assessment and mitigation of risk, which can increase owing to out-of-service safety systems. One of the mitigation action plans is a contingency plan. EPRI recommends the development of a contingency plan for all planned system outages which include factors that strongly affect safety [1].

The Korea Hydro & Nuclear Power Company (KHNP) undertook the preventive maintenance of the Essential Chilled Water System (ECWS) of a Westinghouse plant as a pilot OLM implementation [2]. During the preparation of the work activities, a contingency plan was a pertinent issue during the discussions with regulators, especially regarding the scope and depth of the plan.

This paper discusses the purpose of a contingency plan, including as examples some cases of US utilities, and proposes a graded approach to develop a contingency plan for OLM in consideration of the risks.

2. Analysis of Contingency Plans in Use

2.1 Overview of Contingency Plans

A contingency plan is a plan to restore, or mitigate the loss of, key safety functions for the planned maintenance of safety systems. EPRI TR-1009788 states that "A Contingency Plan for all planned systems outages should be developed. In addition, all high safety impact evolution should have a contingency plan."

US utilities implemented a full-scope OLM and have taken many actions to mitigate risk. In addition, a number of contingency plans have been developed for the planned maintenance of safety systems. The contingency plans, however, are not guidelines or procedures that are separate from the maintenance work packages. The contingency plans are written in a variety of forms to address the actions to be taken. They are included in the maintenance procedures, as an operational risk evaluation form or as an additional sheet in the work packages.

2.2 Cases of Contingency Plan in US Utilities

In rare cases, a US utility develops a contingency guideline for an Emergency Diesel Generator (EDG) outage or a surveillance test [3]. The guideline provides contingency actions to be taken for a planned or unplanned diesel generator outage which exceeds 72 hours and performance test of 24 hour load runs at operating mode 1 or 2. It shows how to mitigate the risk by protecting the auxiliary feed water pump, the auxiliary feed water level control valve and other train residual heat removal pump. It also involves checking the stability state of the offsite power system and the weather conditions such as severe thunderstorms or heavy snowfall.

Other than the above case, most utilities use a form to address contingency actions or utilize a note in a maintenance procedure. Work activities for which a contingency plan is developed are determined based on the significance of the risk. The typical contents of a contingency plan and examples for high risk significant activities are as follows;

1) *Brief description of activities:* Replacement of drain valves along with the piping at the steam supply line to a Terry turbine-driven auxiliary feed water (TDAFW) pump.
2) *Identify potential problems and contingency actions:* The duration of the work requires nine hours and a work schedule must be established so as not to work simultaneously with the under-voltage testing of the bus which was scheduled on the same day. In addition, A & B EDG needs to be protected.
3) *The worst thing that can be happened*: A transient that would require the Terry turbine to function.
4) *What actions can be taken to mitigate the risks:* Final operator assessment prior to removing the TDAFW pump to ensure no significant trip-risk conditions exists.
5) *Additional actions:* Supervisor to be present in the field for continuous oversight. Operating crew will review the actions required to reset the TDAFW pump in the event that the pump is required to start and trips due to water accumulation.

2.3 A Contingency Plan for Pilot Implementation at a KHNP plant

The preventive maintenance of the ECWS was done as a pilot OLM implementation. The allowable outage time (AOT) for the system was 30 days, while the duration of the work was 10 days. The risk color was green, which meant an acceptable level of risk criteria without any additional actions to mitigate risk. However, the regulator requested the development of a contingency plan for the work because it was the first time to enter the Limiting Conditions for Operation (LCO) voluntarily. There were some arguments about how to develop a contingency plan for the work because there was no specific guideline on how to create such a plan. A contingency plan for the pilot OLM for the ECWS was developed as a separate guideline despite the fact that it was of low significance in terms of risk [4]. The contingency plan provided the following:

1) *Prerequisite:* Disallow any actions that may impact the availability of other ECWSs. Warning tags were tagged in the Main Control Room (MCR) and in the field.
2) *Contingency Plan applied:* When the duration of the work exceeds the planned duration and the standby ECWS fails.
3) *Contingency Actions:* Check that the temperature of the MCR is held under 26.5^{o}C and that the HVAC system of the room for safety systems has a cooling water supply.

3. Propose a Contingency Plan in a Graded Approach

A graded approach is requires to develop a contingency plan because more significant work requires additional contingency actions to mitigate the risk. This will be beneficial and effective to focus on more significant work so that better management of the risk is possible with less resource use.

A risk evaluation for the work involves checking the impact level when a component or system goes out-of-service for preventive maintenance while the system is on-line. Some items to be evaluated and the risk criteria are categorized in Table I.

Table I. Risk criteria based on the risk evaluations

Evaluations	High	Medium	Low
Rx Trip	Yes	N/A	No
ESF Actuation	Yes	N/A	No
Power Reduction	>5%	3% ~ 5%	<3%
AOT	<24 hr	24 ~ 72 hr	>72 hr
Work Durations	>75% LCO	50~75% LCO	<50% LCO
RIMS Results	RED	ORANGE	YELLOW GREEN

A contingency plan for the high- and medium-risk work should be developed. The work involving low levels of risk does not require a contingency plan; however, some contingency actions can be written in a maintenance procedure if necessary. A contingency plan for high risk significant work can be written as a separate guideline in some cases and should be reviewed and approved by the plant manager, as shown in Table II.

Table II. Contingency plan development and approval based on the level of risk significance

	High	Medium	Low
Contingency Plan	Required	Required	Not mandatory
Forms	Separate Guideline (If required)	Evaluation Form	Note in a procedure (If required)
Approved by	Plant Manager	Engineering Director	Team leader

4. Conclusions

A contingency plan was a much-discussed topic during the pilot OLM implementation when the regulator requested a specific guideline for the work, as referred to in the EPRI document. Later, an investigation of cases involving US utilities showed that not all systems require a contingency plan, as discussed in the above.

A graded approach to develop a contingency plan based on the level of risk significance will be effective to manage risk. The components or systems for preventive maintenance while the system is on-line will be identified to improve equipment reliability and safety. It would be required to evaluate the levels of risk for the identified components or systems, and develop a contingency plan in graded manner as proposed.

REFERENCES

[1] EPRI, Guidance for Developing and Implementing an On-Line Maintenance Strategy, EPRI TR-1009708, 2004
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[4] Hee Seung Chang et al., Insight from pilot On-line Maintenance for Essential Chilled Water System in a Westinghouse Plant, Transaction of the Korean Nuclear Society Spring Meeting, 2011.