Risk-Informed Nuclear Safety Management Program Development in CGNPC

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Abstract: This paper presents the safety management system designed for CGNPC. It's developed based on the idea adopted from NRC, the Reactor Oversight Process (ROP). A system independent from the classic one is planned to be built with which system, risk management in three level including Unit level, Site level and multi-site level is provided in risk-informed manner using performance indicators and risk significances evaluated from internal and licensee events. The reports are provided both monthly and quarterly to the risk management committee to support decision-making.

Keywords: PRA, Risk-informed, ROP

1. INTRODUCTION

China General Nuclear Power Group (CGNPC) has always taken the nuclear safety as the first social responsibility. By the end of DEC 2013, the installed capacity of CGN's operating nuclear generating units has reached 8,330 MWe, and 16 other nuclear generating units are currently under construction involving a total installed capacity of 18,800 MWe.

To ensure safe operation of nuclear power plants, effective measures are taken for prevention against any accident. Risk management programs, processes, and associated tools are important element for forming a safety culture and a safety conscious work environment.

From 2010, CGN implemented a research of the Reactor Oversight Process (ROP) [1] to develop the risk-informed and performance-based methodology for independent supervision and management of NPPs' safety. ROP is designed to focus on those plant activities most important to safety. With this process, NRC can put greater regulatory attention to facilities with significant issues while maintaining a base level of regulatory attention on plants that perform well.

CGN's Risk-informed nuclear safety management system is adopted from ROP for monitoring and evaluations from three NRC strategic performance Areas, including reactor safety (to avoid accidents and mitigate accident consequences), radiation safety (to ensure the radiation safety of the power plant workers and the public) and plant safeguards (to prevent damage and eliminate terrorist threats). Performance indicators (including MSPI) and At-power significance determination process (SDP) is developed for NPPs. Also, action matrix is implemented.

2. RISK-INFORMED NUCLEAR SAFETY MANAGEMENT

The objective of ROP is public health and safety as a result of civilian nuclear reactor operation. To achieve this goal, three strategic performance areas and seven safety cornerstones are provided. The safety goal is guaranteed as long as strategic performance and seven safety cornerstones are in good manner.

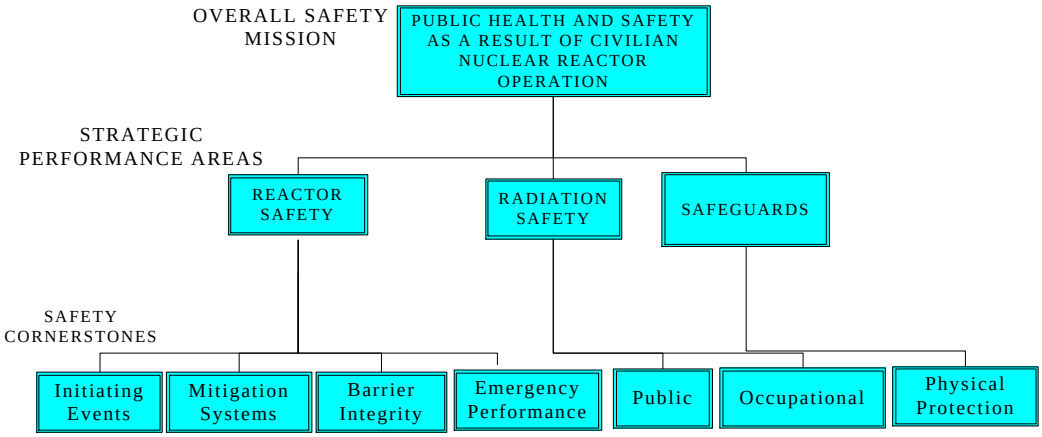

Fig. 1 Regulatory Framework of ROP

The safety cornerstones are defined as:

- ✧ Initiating Events: to limit the frequency of those events that upset plant stability and challenge critical safety functions, during shutdown as well as power operations.
- ✧ Mitigation Systems: to ensure the availability, reliability, and capability of systems that mitigate plant transients and the reactor accidents.
- ✧ Barrier Integrity: to ensure that physical barriers protect the public from radionuclide releases caused by accidents.
- ✧ Emergency Preparedness: to ensure that actions taken by the emergency plan would provide protection of the public health and safety during a radiological emergency.
- ✧ Public Radiation Safety: to ensure adequate protection of public health and safety from exposure to radioactive material released into the public domain as a result of routine civilian nuclear reactor operations.
- ✧ Occupational Radiation Safety: to ensure adequate protection of worker health and safety from exposure to radiation from radioactive material during routine civilian nuclear reactor operation.
- ✧ Physical Protection: to evaluate Each Licensee's Physical Protection System.

2.1. PROCESS FRAMEWORK

The Reactor Oversight Process (ROP) integrates the NRC's inspection, assessment, and enforcement programs. We adjusted the process to make it fit for CGN. The process framework justified is shown in fig.2 as below:

Assessment program collects information from CGN events reporting system and performance data reporting system, performance indicators (PIs) and significance of major safety events are provided to arrive at objective conclusions about unit's safety performance. Based on this assessment information, the CGN determines the level of agency response using action matrix. Management actions such as self-check, self-evaluation and site investigation are taken considering the level of potential risk of units. The assessment information are then released to CGN for management reference.

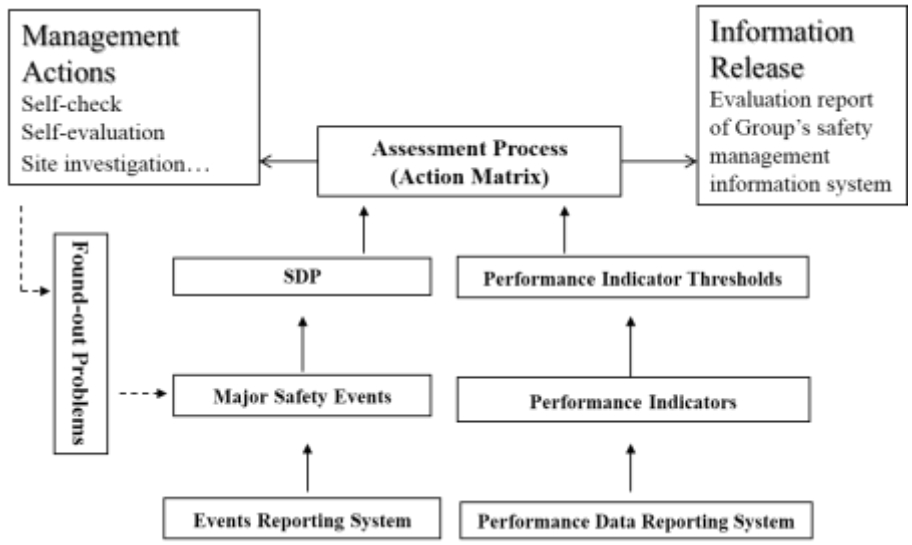

Fig. 2 Process Framework of ROP

2.2. PERFORMANCE INDICATORS

In this program, performance indicators are built in three levels: corporation level, plant level and safety cornerstones level.

Indicators in corporation level focus on serious accidents in multi-site during one year. Three indicators from industry trends program (ITP) [2] was applied.

A risk-based indicator is applied to plant level manage configuration risk. 23 indicators, mainly from NEI 99-02 rev6 [3] is used to cover seven cornerstones.

2.3. AT-POWER SDP FOR EVENTS

The Significance Determination Process (SDP) [4] uses risk information to assess the safety significance of findings in internal and licensee events from events reporting system. Currently, at-power SDP is developed to characterize the safety significance of issues associated with reactor safety. Other SDP tools is planned to be developed in 5 years.

Both at-power SDP phase I and phase II are developed for ten operating plants in CGN by 2012. A database based on Oracle 10i and a website based on J2EE is built to support daily assessment works.

Also, SDP phase III is developed. Any finding with potential risk of ΔCDF higher than 10^{-6} should be analyzed using plant-specific PRA model following SDP phase III instruction.

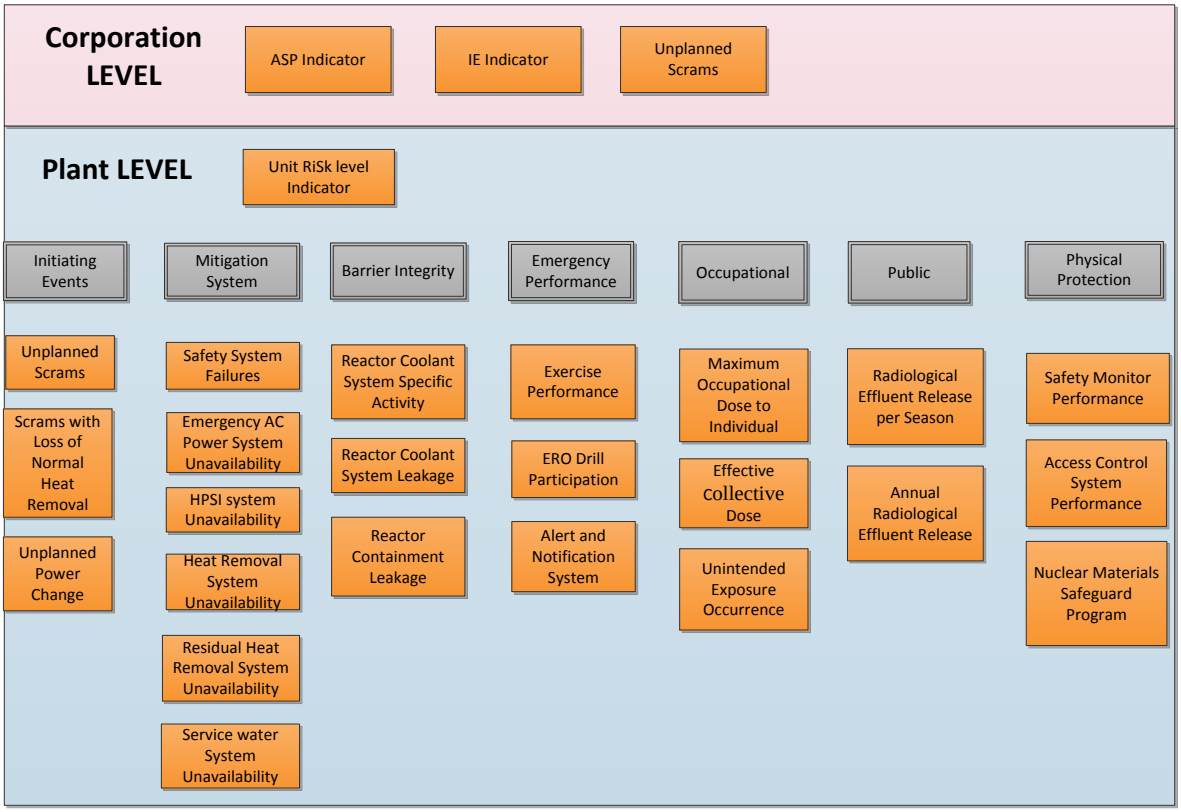

Fig. 3 Performance indicators

2.4. ACTION MATRIX

After the level of significance associated with performance indicators and safety-significant events, a plant-specific action matrix is appointed to the unit according to the overall performance in the last quarter. And the action matrix is shown as below:

Table 1: Action Matrix

Plant Performance	Management Actions
All Performance Indicators and Safety Cornerstones Green	Maintain Routine Management
One White Input in Different Cornerstones, or Two White Inputs in Different Cornerstone Groups	Plant Takes Corrective Action on White Findings and Reports the Corrective Action to the Safety and Information Management Department of CGNPC for the Record
One Degraded Cornerstone (two White Inputs or one Yellow Input) or any three White Inputs in a	Plant Develops Corrective Action and Reports to the Safety and Information Management Department of CGNPC and the Department Supervises and Inspects the Implementation of the Corrective Action

Performance Area	
One Repetitive Degraded Cornerstone, Multiple Degraded Cornerstones, Multiple Yellow Inputs, or one Red Input	Plant Develops Performance Improvement Plan and Reports to Safety and Information Management Department of CGNPC and the Department Supervises and Inspects the Implementation of the Performance Improvement Plan. The Department Organizes Experts to Conduct On-site Investigation for Reasons of Performance Degradation.
Unacceptable Degraded Performance, More Than two Red Inputs	The Safety and Information Management Department of CGNPC Organizes Experts to Conduct On-site Investigation for Reasons of Performance Degradation. If Necessary, the Department Advises the Safety Management Committee to Suspend Production for Rectifications.

2.6. Regular Information Release

Quarterly Report on nuclear safety regulation of Operating Power Plants in CGN is released within one month after each quarter. Submit the summary report of the indicators of operating units and event evaluation status, which mainly focus on the status of cornerstones of NPPs, the plants' response to the risk findings and corrective actions. After the release of the quarterly report, multi-site risk indicators and event evaluation results are released on the official website of CGN for look-up of CGN managements and site managements.

Annual Report on Nuclear Safety Regulation on operating plants of CGN of last year is released in the first month of the year. In addition to the overall safety states of the sites last year, the report will also provide statistics and key indicators concerned to the nuclear industry trends.

3. CONCLUSION

Risk-informed safety management approach can be used for monitoring safety status of NPPs in accordance with performance indicators and assessment results of events for each NPP, and developing and taking management measures based on significance of plant-specific safety degradation. This approach can focus on nuclear safety findings, particularly those with potential high risks. This program is of great value providing risk-informed insights for safety managers to perform nuclear safety management for multi-unit with limited manpower resources and focus on activities with greater potential risk.

During the research, a series of joint R&D projects have been carried out between CGN and Nuclear and Radiation Safety Centre under the Ministry of Environmental Protection of P. R. C. With the help of risk-informed nuclear safety management indicator model, CGN is available to strengthen its supervision on NPPs from different perspectives.

References

[1] USNRC, NUREG-1649, Reactor Oversight Process, Revision 4, 2006

[2] USNRC, IMC 313, Industry Trends Program, Revision 2, 2008

[3] USNRC, NEI 99-02, Regulatory Assessment Performance Indicator Guideline, Revision 6,2009

[4] USNRC, IMC 609, Significance Determination Process, Revision 5,2011