

Resilience Assessment Grid (RAG) for Facilitating Safety Consciousness of Nuclear Power Plant Personnel

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INTRODUCTION

A wide variety of countermeasures have been introduced in every Japanese nuclear power plant (NPP) in order to meet regulatory requirements issued after the severe accident at Fukushima-Daiichi NPP.



Maintaining the Cooling of Reactors under any Circumstance



Installation of Redundant and Diversified Power Supply

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INTRODUCTION

- ❑ Such countermeasures might improve the safety of NPPs. However, we must also consider the negative impacts of installing such large amount of measures.
- ❑ One negative impact is the time demand for training on operating the newly installed various countermeasures.
 - ◆ This extra time inevitably reduces the time available for operator training for normal and near-normal operations. This trade-off should be managed in a more intelligent way than the current practice.

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INTRODUCTION

- Another negative impact of such wide-ranging regulations is degradation of resilience potential.
 - ◆ Since many countermeasures have been installed, plant personnel are disciplined and trained to rely on them whenever a serious anomaly is envisioned.
- As far as the characteristics of the anomaly are within a presumed event envelope, the disturbance induced by the anomaly can be overridden by following the predefined operational procedures.
 - ◆ However, if the characteristics go beyond the envelope, then the plant personnel will have difficulty if they are too heavily trained and over-adapted to the predefined operational procedures.

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INTRODUCTION

- In such situations, it is highly desirable that the plant personnel can behave in a resilient manner.
 - ◆ In order to avoid the degradation of resilience potential, the authors have used the Resilience Assessment Grid (RAG) method .
 - ◆ Extensive studies of the Fukushima Dai-ichi accident conducted by the authors based on the principles of resilience engineering clearly showed that enhancing resilience potential is an issue of critical importance for every NPP.
 - ◆ Our approach toward an effective revision of the RAG questions and the resultant outcome will be shown in this presentation.

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METHOD: initial approach

- In the first phase, a preliminary study was conducted within the research institute (INSS) where two researchers with extensive experience as NPP operators were available.
 - ◆ During this phase, however, we experienced a serious difficulty: both researchers were reluctant to consider possible resilient behaviors needed to override unexpected situations.

Typical responses from operators

We can respond to any disturbances since we have well-established and properly-organized operation procedures.



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METHOD : initial approach

- They claimed that such procedures cover three classes of accident, namely, design-based events, severe accidents without core damage, and severe accidents with core damage.
 - ◆ Since they can depend on the operation procedures even for the second and third class of accidents, they did not feel that they need to prepare for unexpected situations, nor to improve their resilience potential.

METHOD : initial approach

- Based on this observation, we redefined the scope of our problem.
 - ◆ Even if the NPP personnel can respond to any accidents, it is highly undesirable for the NPP to suffer a serious event scenario which could lead to a severe accident.
 - ◆ **One such serious event would be enough to convince the Japanese people to abandon nuclear power generation.** Therefore, any anomalous event which could be a precursor to a severe accident must be strictly avoided.
- The RAG questions have been modified to reflect this condition.

METHOD : precursor of severe accidents

- We attempted to revise the RAG questions to focus on serious event scenarios, each of which could be a precursor to a severe accident.
 - Typical examples include multiple failure events such as leakage of coolant plus a failure of the high-pressure water injection system, or a loss of feedwater plus a failure of the reactor trip system.
 - ◆ Although the probability of simultaneous occurrence of such multiple anomalies is considered to be very low, the scenarios are selected to examine the safety of the NPP.
 - ◆ The RAG questions are modified to reflect this consideration. Since the scope of the questions is restricted to certain categories of possible events, the RAG questions are called the **restrictive RAG**.

METHOD : division-specific modification

- ❑ **As mentioned earlier, the NPP operators tend to believe they can handle various event scenarios based on the operation procedures.**
- ❑ **Since we introduced the restrictive RAG, operators have become less reluctant to answer those questions to assess the potential to respond and the potential to monitor.**
- ❑ **However, they are still reluctant to answer the questions to assess the potential to learn and the potential to anticipate.**

Typical responses from operators

**We can respond to any disturbances by following the operation procedures.
We may monitor the transients.
Anticipation and learning are not our business.**



METHOD : division-specific modification

- **A second modification was introduced in response to this reluctance.**
 - ◆ **In this second version, the operators were asked to mainly answer the questions to assess the potential to respond and the potential to monitor.**
 - ◆ **The plant personnel in the safety division, which is responsible for developing the procedures, were asked to mainly answer the questions to assess the potential to learn and the potential to anticipate.**
 - ◆ **It is not mandatory to answer questions of unassigned categories.**

METHOD : division-specific modification

- **The divided assignment of questions has been effective in reducing the psychological reluctance of plant personnel.**
- **This version of the modified RAG is called the cross-divisional RAG.**

METHOD : focusing on brittleness

- **We have tried to improve the acceptance of the RAG within the NPP.**
 - ◆ **To do this, we modified the questions to clarify and characterize the events and/or situations in which the NPP personnel feel serious difficulties in responding and monitoring in spite of the existence of well-established procedures.**
 - ◆ **This attempt is basically consistent with the proposal of a workshop concerning brittleness envisioned in workplaces [Lay, E. and Blanlat, M.].**
 - ◆ **This version of the revised RAG questions is called the **brittleness-oriented RAG**.**
 - ◆ **Note that questions concerning learning and anticipating are not modified in this version.**

METHOD : focusing on brittleness

- **In a preliminary test phase, the plant personnel who volunteered to contribute to RAG development showed strong support for a prototype of the brittleness-oriented RAG questions.**
- **This unexpectedly favorable response has encouraged and driven the development of the current brittleness-oriented RAG questions.**

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Revised RAG : Brittleness-oriented RAG

- Table 5. Brittleness-oriented RAG questions (**respond**)
1. Example of situation
 - Mention an event and relevant situation in which you recognize serious difficulty in carrying out an assigned task.
 2. Main factors causing the difficulty
 - What are the main factors contributing to the difficulty? (**e.g. insufficient hardware, lack of human resources, insufficient technical skills, etc.**)

Revised RAG : Brittleness-oriented RAG

3. Reasons for existence of the factors

- Mention the reasons why one of the undesirable factor is left as it is. (e.g. **ignorance of managers, lack of budget, poor training program, etc.**)

4. Possibility of elimination

- Assess the possibility of eliminating each of the reasons (**absolutely impossible, difficult but possible, possible**)

5. Elimination of the reasons

- Define practical procedures to eliminate the reason if it is possible.

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RESULTS : focusing on brittleness

- ❑ As far as the brittleness-oriented RAG is concerned, the plant personnel who volunteered to contribute to RAG development showed strong support for a prototype of the brittleness-oriented RAG questions.
- ❑ This unexpectedly favorable response has driven the development of the current brittleness-oriented RAG questions.

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RESULTS : focusing on brittleness

- ❑ Furthermore, the Kansai Electric Power Company had already released an important **position statement** that expresses a strong commitment to higher safety:
- ❑ In the light of the nuclear accident at the Fukushima-Daiichi Nuclear Power Station, we reviewed our own practices and attitudes toward nuclear power operations and **felt profound remorse that:**
 - ◆ our efforts on countermeasures against severe accidents, which are considered to be extremely infrequent, might have been inadequate;

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RESULTS : focusing on brittleness

- ◆ our awareness of voluntarily enhancing nuclear safety beyond legal and regulatory requirements might not have been enough; and
- ◆ our efforts to learn from abroad, such as collecting information on activities for enhancing safety and improving our nuclear power stations, might have been insufficient.
- We have been making company-wide efforts to further enhance nuclear safety. Every one of us shall remember the lessons learned from the accident and ceaselessly strive to enhance nuclear safety to protect the people not only in the plant-hosting communities but also the whole country.

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RESULTS : focusing on brittleness

- The personnel of Kansai Electric are all aware of the statements in the position statement issued in 2014.
 - ◆ However, it is not easy to maintain the awareness for years.
- The introduction of RAG for improving the resilience potential of the NPP closely matches the spirit behind the position statement.
- The project could make steady progress under the influence of the position statement and continuous use of the **brittleness-oriented RAG**.

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Concluding Remarks

- The brittleness-oriented RAG questions were well accepted, and were found to be useful for **raising consciousness concerning possible weak points** of the NPP even after large-scale renovations after the Fukushima Dai-ichi accident.
- After raising the consciousness, we can use the restrictive RAG and cross-divisional RAG to obtain more detailed insight into the organizational resilience.
- This approach will eventually lead to enhanced resilience potential within the organization.