# Development of Korean EDMG

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## 1. Introduction

In Korea, considerable activities are being carried out following the Fukushima accident in order to further enhance nuclear safety, including the improvement of EOPs and SAMGs, from beyond-design-basis external events that might impact nuclear power plants.

However, most of these activities focus on safety improvement of each nuclear power plant unit against extreme hazards, though some considerations are given to multi-unit events. Therefore, additional safety feature is also needed to more effectively cope with site-wide events affecting multiple units.

For this reason, KHNP(Korea Hydro and Nuclear Power Company) has developed Korean EDMG for site-wide extreme hazard management, based on US EDMG (Extensive Damage Mitigation Guideline) and FSG (FLEX Supporting Guideline)

## 2. U.S. EDMG and FGS.

In U.S., there are two mitigation strategies to cope with extreme natural or man-made hazards.

First, EDMG (Extensive Damage Mitigation Guidelines) is strategies to provide the nuclear plants with special protection against extreme man-made and natural hazards causing a total loss of unit power (AC and DC) or loss of normal control from both Control Room and Remote Shutdown Panel.

Multi-year efforts were made by the U.S. Nuclear Regulatory Commission (NRC) in conjunction with the nuclear industry in the aftermath of the terrorist events on September 11, 2001, in order to come up with mitigation measures against man-made hazards (especially, aircraft attack on a nuclear power plant). As a result, the development/implementation and subsequent regulatory inspection of so-called Extensive Damage Mitigation Guidelines (EDMG) were completed in December 2008 for each nuclear power plant of the USA [1-3].

EDMG could be effectively implemented under the circumstances associated with loss of large areas of the plant due to explosions or fire, including an aircraft impact.

The entry conditions for EDMG are loss of all personnel in the control room and any equipment/ supplies in control building. EDMG approach is aimed at providing initial emergency responses and alternative methods of plant operation to mitigate the consequences affecting single unit at a site.

Secondly, FGS is FLEX Supporting Guideline. Following the Fukushima accident, the NRC has endorsed the Diverse and Flexible Coping Strategies, called FLEX [4], which was proposed by the Fukushima Response Steering Committee of the US nuclear industry [5,6]. This FLEX approach is aimed at providing diverse and flexible means to obtain power and water to support key safety functions as well as capability to cope with events affecting multiple units simultaneously.

The implementation of FLEX approach proposed by the U.S. nuclear industry and endorsed by the NRC following the Fukushima accident is expected to even more upgrade the coping capabilities of nuclear power plants against extreme hazards such as earthquake or flooding that might have devastating effects on all units of the site.

The objective of FLEX is to establish an indefinite coping capability to prevent damage to the fuel in the reactor and spent fuel pools and to maintain the containment function by using installed equipment, onsite portable equipment, and pre-staged offsite resources. FLEX increases defense-in-depth for beyond-design-basis scenarios to address an extended loss of AC power (ELAP) and a loss of ultimate heat sink (LUHS).

## 3. Korean EDMG

### *3.1. Approach*

KHNP is trying to develop Korean EDMG for effectively managing extreme hazards that might simultaneously affect multiple units at a site based on U.S. EDMG and FLEX.

As shown Figure 1, Korean EDMG will be developed to have two different types of EDMGs :

- "Site EDMG" to be used for effective technical support to activated TSCs and management of corporate emergency response resources in coordination with the EOF as necessary to identify the overall status of all units at the site and determine the mitigation strategies at site level to support the activated TSC(s) in their coping with the evolving accidents.; and
- "Plant-Specific EDMG (for Extreme Event)" to be used by the Technical Support Center (TSC) of a

unit where a total loss of control has occurred or plant control cannot be established from the Control Room and Remote Shutdown Panel.

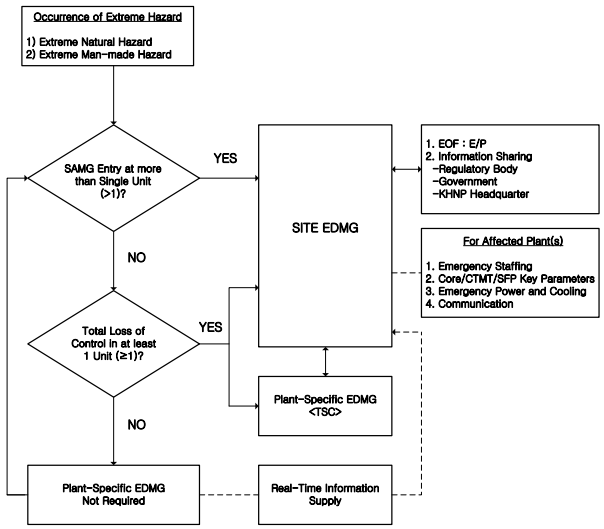


*Fig. 1 Korean EDMG System*

### *3.2. Site EDMG*

A Site EDMG provides actions to identify the overall status of all units at the site and determine the mitigation strategies at site level to support the activated TSC(s) in their coping with the evolving accidents.

"Site EDMG" is entered in one of these two different cases: a) the SAMG is entered in more than a single (>1) unit, i.e., multi-unit events involving potential core damage; or b) a total loss of control occurs in at least one unit, where a total loss of control refers to an extreme hazard that results in a total loss of unit power (AC and DC), or prevents operation from the Control Room and Remote Shutdown Panel. A total loss of control here implies a situation where plant control cannot be established from the Control Room and Remote Shutdown Panel.

The Site EDMG is entered when the aforementioned entry conditions are met. Once entered, the staff will be activated and use the "Site EDMG". Depending on the specific functions of EOF, the site information will need to be transmitted to the regulatory body, government, and KHNP headquarters through an appropriate channel.

The Site EDMG needs to address: a) emergency staffing; b) acquisition of key parameters of reactor core, containment and spent fuel pool for the unit(s) affected the events; c) emergency power and cooling for accident management; and d) communication issues.

### *3.3. Plant Specific EDMG*

Plant-Specific EDMG is divided into two different types of Plant-Specific EDMG : 1) "Plant-Specific Initial Response EDMG," and 2) "Plant-Specific TSC Response EDMG".

"Plant-Specific EDMG (for Extreme Event)" to be used by the Technical Support Center (TSC) of a unit where a total loss of control has occurred or plant control cannot be established from the Control Room and Remote Shutdown Panel.

The TSC staff will be activated when a total loss of control occurs at their associated unit. Upon activation, they will then use the "Plant-Specific EDMG" to cope with the total loss of control at their unit. Note that in the event of a total loss of control, the affected TSC will also become operational. The TSC will communicate with regard to performance of their own functions in terms of the Site EDMG and Plant-Specific EDMG, respectively.

The "Plant-Specific Initial Response EDMG" is primarily aimed at mitigating a special situation where no AC and DC power is available at the plant as a result of an extreme event. As such, it is similar to the EOP for "Loss of all AC Power" or an equivalent procedure/ guidance. However, it provides further guidance tailored to an extreme event (e.g., earthquake or terrorist act) which might result in combinations of failures, destroying some of the site infrastructure, causing loss of a large area on the site, disrupting the normal command and control structure, disabling some communications system, or rendering some instruments for key parameters failed.

"Plant-Specific TSC Response EDMG" provides guidance to the TSC staff so that they can advise the plant operators in terms of alternative methods of data acquisition or plant operation using available resources to mitigate the consequences of an extreme event that results in a total loss of unit power (AC and DC), or prevents operation from the Control Room and Remote Shutdown Panel.

Therefore, the Plant-Specific TSC Response EDMG will contain various means of maintaining or restoring safety functions and safety functions support, under the assumption of: 1) a total loss of unit power; and 2) a loss of normal plant control from the Control Room and Remote Shutdown Panel. The TSC staff should use the TSC Diagnostic Flow Chart in parallel with the TSC Response EDMG to determine if other SAMG strategies should be implemented.

When TSC has been manned upon notification of an emergency, command and control is transferred from the shift supervisor of the Control Room to the TSC manager of the unit. The staff is also mustered along with the TSC staff when the entry conditions for the Plant- Specific Initial Response EDMG are met.

Specific TSC Response EDMG is entered when TSC is mustered upon notification of an emergency, and control of plant equipment cannot be established from the Control Room and Remote Shutdown Panel.

When activated, TSC staff will use "Plant-Specific TSC Response EDMG for Extreme Event," and "TSC Diagnostic Flow Chart (DFC)" to determine the

appropriate Severe Accident Management Guidelines strategies for mitigating the consequences of this event.

## 4. Conclusion

In this study, the accident mitigation approaches in US are reviewed. The most effective ways to strengthen the defense-in-depth of nuclear power installations are presented as EDMG and FLEX against extreme hazards such as a beyond-design-basis external event (BDBEE) that took place at Fukushima.

A combination of the US EDMG and FLEX is applied to develop Korean EDMG, which will be developed to have two different types of EDMGs : "Site EDMG" to be used for effective technical support to activated TSCs and management of corporate emergency response resources in coordination with the EOF as necessary; and "Plant-Specific EDMG (for Extreme Event)" to be used by the Technical Support Center (TSC) of a unit where a total loss of control has occurred or plant control cannot be established from the Control Room and Remote Shutdown Panel.

The development of Korean EDMG is expected to further enhance mitigation and coping capabilities against site-wide extreme hazard in Korea where a relatively large number of units are assembled on each nuclear power plant site.

## REFERENCES

[1] Nuclear Energy Institute, "Industry Mitigation Strategy Study Guideline," NEI-05-07, Revision 0, September 2005.
[2] Nuclear Energy Institute, "B.5.b Phase 2 & 3 Submittal Guideline," NEI-06-12, Revision3, July 2009.
[3] USNRC, "The Evolution of Mitigating Measures for Large Fire and Explosions: A Chronological History from September 11, 2001 through October 7, 2009," ADAM Access Number ML092990417.
[4] Nuclear Energy Institute, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," NEI-12-06, Revision 0, August 2012.
[5] USNRC, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," EA-12-049, March 12, 2012.
[6] Federal Register, "All Operating Power Reactor Licensees: Order Modifying Licenses (Effective Immediately)," EA-02-026, 67FR9792, March 4, 2002.