# Regulation Plans on Severe Accidents developed by KINS Severe Accident Regulation Preparation TFT

Kyun-Tae Kim [a*], Ku Young Chung[a], Hanbee Na[a]
[a]*Korea Institute of Nuclear Safety,62 Gwahak-ro, Yuseong-gu, Daejeon 34142, Republic of Korea*
[*]*Corresponding author: kkt@kins.re.kr*

## 1. Introduction

Tohoku earthquake on March 11 2011 whose magnitude was 9.0 triggered powerful tsunami wave which caused around 20,000 people death and missing and hundreds of thousands people refugee. Some nuclear power plants in Fukushima Daiichi site had lost their emergency reactor cooling function for long-time so the fuels inside the reactors were molten, and the integrity of containment was damaged. Therefore, large amount of radioactive material was released to environment [1].

Because the social and economic effects of severe accidents are enormous, Korean Government already issued "Severe Accident Policy" in 2001 which requires nuclear power plant operators to set up "Quantitative Safety Goal", to do "Probabilistic Safety Analysis", to install "Severe Accident Countermeasures" and to make "Severe Accident Management Plan"[2].

After the Fukushima disaster, a Special Safety Inspection was performed for all operating nuclear power plants of Korea. The inspection team from industry, academia, and research institutes assessed Korean NPPs capabilities to cope with or respond to severe accidents and emergency situation caused by natural disasters such as a large earthquake or tsunami. As a result of the special inspection, about 50 action items were identified to increase the capability to cope with natural disaster and severe accidents [3].

The Fukushima nuclear disaster highlighted the need for regulations pertaining to severe accidents. The National Assembly passed an amendment to the Nuclear Safety Act to mandate the submission of accident management plans, and the government promulgated the revised Act on June 22, 2015. Accordingly, the Korea Institute of Nuclear Safety organized the Severe Accident Regulation Preparation TFT to develop follow-up measures to the revised Nuclear Safety Act.

Article 2 (Definition) of the Nuclear Safety Act was revised to include definitions for "accident management" and "severe accident." Article 20 (Operating License) requires the submission of accident management plans (including management of severe accidents) as part of operating license applications. Under Article 21 (Standards for License), accident management plans must meet the standards set by the committee. Article 3 of Supplementary Provisions stipulates that existing nuclear power plants (nuclear power plants in operation and those that have applied for operating licenses) must submit accident management plans within three years from the date of enforcement.

The TFT has developed a draft on "Notice on Accident Management Plans" in consideration of the objective of the revised Nuclear Safety Act and overseas regulatory changes following the Fukushima nuclear disaster. The TFT has developed regulatory standards and revised provisions in relation to severe accidents.

This paper summaries oversea regulatory trend of severe accidents before and after the Fukushima nuclear disaster and drafts of regulation on the standard of Accident Management Plans and severe accident prevention and mitigation features to be considered in NPP design.

## 2. Review of International Efforts to Enhance Safety against Severe Accidents

This section summaries oversea regulatory trend on severe accident before and after the Fukushima Accident.

### *2.1 Vienna Declaration on Nuclear Safety*

Vienna Declaration on Nuclear Safety was adopted at Diplomatic conference on February 9th, 2015. According the Declaration, that new nuclear power plants are to be designed, sited, and constructed, consistent with the objective of preventing accident mitigating possible release of radionuclides causing long-term off site contamination and avoiding early radioactive releases or radioactive release large enough to require long-term protective measure and action. Also comprehensive and systematic safety assessment are to be carried out periodically and regularly for existing installations [4].

### *2.2 IAEA*

IAEA published a new specific safety requirement (No. SSR-2/1) named 'safety standard on nuclear power plants: Design' which states that the plant event sequences that could result in high radiation doses or in a large radioactive release have to be 'practically eliminated' and plant event sequences with a significant frequency of occurrence have to have no, or only minor, potential radiological consequences[5].

### *2.3 Japan*

Japan nuclear regulatory authority announced new safety requirements for nuclear power plants on June

19th, 2013. The requirements intensify defense-in-depth against nuclear accidents by strictly supplementing features for design-basis accident and event and newly require to install features to prevent multiple failures, to prepare for intentional airplane crash and so on[6].

*2.4 US*

US regulates NPP operators to prepare for extensive damage caused by intentional air plane crashes and fire & explosion due to beyond design basis accident [7]. Accordingly, US NPP operators had developed EDMG (Extensive Damage Management Guideline) to prepare for extensive damage.

*2.5 EU*

After the Fukushima Accident EU council amended Directive 2009/71 and promulgate Directive 2014/87 in 2014. The Directive added the definition of severe conditions in Article 3(11) and inserted some obligations such as nuclear safety objective for nuclear installations, implementation of the nuclear safety objective for nuclear installations, Initial assessment and periodic safety reviews and On-site emergency preparedness and response in Article 8[8,9].

## 3. Rulemaking for Regulatory Control of Severe Accidents

This section summaries the TFT's regulation draft to prevent and mitigate severe accidents.

*3.1 Standard of Accident Management Plans*

The approval criteria for accident management plans will be established from three perspectives. The first, pertaining to the fulfillment of safety goals, examines "emission of radioactive materials causing long-term pollution", "external emission of radioactive materials in the early stage", and "mass emission of radioactive materials that call for long-term resident protection". The second perspective is the validity of accident management in consideration of defense in-depth. The evaluation items include "establishment of strategies for the design basis accident stage, severe accident prevention stage and severe accident mitigation stage", "prevention of accident expansion and recovery to a safe state", and "command and control system for the implementation of accident management strategies". The last perspective of education and training focuses on "establishment of regular education and training plans to maintain the efficacy of safety management plans".

*3.2 Prevention of Severe Accident*

To prevent multiple failure accidents from causing significant damage to reactors or spent fuel storage facilities, multiple failure accidents to be considered in design must be specified in the technical standard, as shown in the table below.

**Table 1 Multiple failure accidents to be considered in design**

| Classification | Type of Accident |
|---|---|
| Accidents that must be considered | ● Anticipated transient without scram<br>● Loss of AC Power System<br>● Loss of Ultimate heat Sink<br>● Multiple Steam Generator Tube Ruptures<br>● ISLOCA<br>● Loss of Safety Injection or Recirculation<br>● Loss of Cooling Function of Spent Fuel Pool<br>● Loss of Shutdown Cooling Function |
| Additional considerations | Accidents evaluated as having a similar occurrence rate and influence as the aforementioned accidents in probabilistic safety assessment |

*3.3 Mitigation against Beyond-Design Basis External Event*

The technical standard must specify measures to prevent disasters beyond design basis from causing significant damage to reactors or spent fuel storage facilities, and to minimize the loss of containment function of containment buildings.

- Natural disasters including geological, meteorological, hydrological, and marine phenomena
- Manmade disasters including accidents involving industrial facilities and transport modes
- Intentional aircraft collision
- Extensive damage caused by the accidents

*3.4 Mitigation of Severe Accident*

For containment buildings to maintain their containment functions during severe accidents, severe accident phenomena to be considered in design must be specified in the technical standard, as shown in the table below..

**Table 2 Severe Accident Phenomena to be considered in design**

| Classification | Severe Accident |
|---|---|
| Severe accident phenomena that must be considered | ● Combustion and Explosion of Combustible Gas<br>● High Temperature or Overpressure in Containment<br>● Molten Core-Concrete Interaction |

| | |
|---|---|
| | ● High Pressure Melt Ejection and Direct Containment Heating<br>● Steam Explosion<br>● Containment Bypass |
| Additional considerations | Severe accident phenomena evaluated as having similar occurrence rate and influence as the aforementioned phenomena in probabilistic safety assessment |

*3.5 Safety Assessment for Severe Accident*

The safety assessment of severe accident is performed to verify severe accident prevention and mitigation capability, and radiological consequences.

The severe accident prevention capability is assessed to verify that nuclear fuel's integrity will be kept due to the countermeasures against multiple failure accidents. The severe accident mitigation capability is assessed to verify the integrity of containment is kept against severe accident phenomena. The radiological consequences are assessed in terms of radiation dose that should be under the limit level which may causes significant health effect to nearby residence by means of severe accident countermeasures.

*3.6 Probabilistic Safety Assessment*

The probabilistic safety assessment shall be performed to verify that the risk increase to nearby residence due to the operation of nuclear power plants is extremely low. The quantitative health objective of Severe Accident Policy in 2001 is adopted as quantitative safety goal to assess the risk increase to nearby residence. Also, as a quantitative measure to assess the effect on the environment, the frequency of large release of radioactive isotope which mainly contributes long-term off-site contamination should be less than $1.0X10^{-6}$ /year.

## 4. Conclusions

Nuclear Safety Act has been amended to require NPP operators to submit Accident Management Plant as part of operating license application. The KINS Severe Accident Regulation Preparation TFT had first investigated oversea severe accident regulation trend before and after the Fukushima accident. Then, the TFT has developed regulation draft for severe accidents such as Severe accident Management Plans, the required design features for new NPPs to prevent severe accident against multiple failures and beyond-design external events, countermeasures to mitigate severe accident and to keep the integrity of containment, and assessment methodology on safety assessment plan and probabilistic safety assessment.

## REFERENCES

[1] Korean Nuclear Society, "Final Report on the Fukushima Accident", p.1, 2013.3.11
[2] Korean Ministry of Science and Technology, "Severe Accident Policy", 2001.08
[3] Korean Government, "Report of the Korean Government Response to the Fukushima Daiichi Nuclear Accident", 2011.08
[3] Nuclear Safety Act, 2015
[4] Vienna Declaration on Nuclear Safety, 2015
[5] IAEA, Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series SSR-2/1, 2012
[6] JAPAN, New Regulatory Requirement, 2013
[7] US, 10 CFR 50.54(hh)(2)
[8] EU council, Directive 2009/71, 2009
[9] EU council, Directive 2014/87, 2014