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THE REQUIREMENTS FOR STRUCTURAL ROBUSTNESS OF NUCLEAR POWER PLANTS AGAINST EXTERNAL EVENTS IN THE REGULATORY FRAMEWORK IN JAPAN

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INTRODUCTION

The regulatory body of Japan, the Nuclear Regulation Authority of Japan (NRAJ), is in the process introducing a new set of requirements on nuclear power plant's safety design. The requirements are brought into force immediately when NRAJ enacts a series of regulatory documents and review guides, which are undergoing a public consultation process at the time of writing. The skeleton of the regulatory framework was made public in late January 2013, and the regulatory documents and review guides will be enacted in July 2013.

The new regulation will require licensees to install or to reinforce systems and components of nuclear power plant facilities. Some of the measures are already realized in existing plants in Japan because the preliminary actions were taken by the licensees and by the former regulatory body, Nuclear and Industrial Safety Agency (NISA), in order to reduce risks associated with safety weakness seen in the Fukushima Daiichi nuclear accident. Nevertheless, there are several regulatory requirements newly introduced in the draft documents. They include, for instance, requirements on three-dimension geological profiling to be used in the seismic wave propagation analyses, tsunami hazard assessment and inundation protection structures, structural robustness of specific safety facilities against design extension conditions.

These requirements will be put in place in the existing nuclear power plants and the NRAJ will verify the compliance before the reactors are restarted to generate energy. This will reduce the risk of severe accidents associated with extreme external events. However, it may also be necessary that the regulatory framework and the requirements be reviewed by experts through the international cooperation as is done by the IAEA.

REGULATORY FRAMEWORK

Regulatory amendments to be made to the current regulatory requirements on nuclear installations in Japan are specified in the draft administrative documents, which, at the time of writing, are in a public consultation process. NRAJ will put them into force in July 2013, as the legislation requires NRAJ to enact the amendments for nuclear power plants in ten months of period after the date of its establishment (amendments regarding fuel cycle facilities will be put in place in fifteen months of period). The administrative documents are in two levels of categorization, namely, NRAJ regulatory documents and NRAJ review guides.

New requirements will be defined in several documents. Among other things, they include; the regulatory document on sites, structure, systems and components (draft), the regulatory document on technical requirements of commercial reactors and associated facilities (draft) and the review guide concerning the interpretation of the regulatory document on sites, structure, systems and components (draft). Major evolutions in the requirements regarding structural and mechanical robustness of structure, systems and components are made in the third and fourth layers of defense in depth.

Changes in the Third Level Defense

Amendments in the third level of defense requirements are; widened definitions of systems and components that are necessary to cope with design basis accidents, redefinitions of seismic hazard assessment methodologies, introduction of the concept of design basis tsunami height assessment. Turbine generators, offsite power transmission lines and switchyards and containment isolation valves are examples of the newly added systems and components, reliabilities of which will be improved by means of the third level defense. Requiring three-dimension geological profiling of a site area is one of the major changes of seismic ground motion prediction processes in order to refine seismic propagation settings. The design basis tsunami height assessment includes tsunamigenic source characterization and assessment on tsunami hazard height and run-up height in the site.

Changes in the Fourth Level Defense

All requirements in the fourth level of defense are newly added in the regulatory framework and are widely varied from prevention to mitigation of severe degradation of the reactor core. Main measures are; introduction of transportable stand-by cooling systems, provision of alternative sources of electric power and water, means of depressurization of reactor primary coolant systems and the containment, preventive methods of hydrogen explosions and mitigation methods of radiological releases.

Requirements on structural robustness for the safety systems of the fourth level defense are basically in the same level, compared with the structural requirements of systems highly important to safety. These structure, systems and components (with seismic safety classification S-class) are required to withstand and to maintain safety functions against design level earthquake SL-1.

In addition to this, regulation and guides require further redundant safety systems to be installed as well. This group of systems and measures is named as “specific safety facilities” and are required to withstand external events beyond the design basis. According to the draft review guide, specific safety facilities need to be designed to maintain necessary functions in and after a malevolent act (encouraging postulation of intentional collision of a jet airliner into the reactor building) and to prevent adverse effects from earthquakes or tsunamis which are, by a certain rate, larger than design basis earthquake and tsunami. However, the draft review guide does not specify how much rate for this exceedance is acceptable.

COMPARISON WITH IAEA SAFETY REQUIREMENTS

IAEA safety requirements on the design of nuclear power plants provide the concept of an analysis using design extension conditions. IAEA’s SSR-2/1 requires the member states to perform the analysis in order “to identify the additional accident scenarios to be addressed in the design and to plan practicable provisions for the prevention of such accidents or mitigation of their consequences”. IAEA safety requirements also recommend deriving such design extension conditions by a best estimate approach, while acknowledging member states may employ more stringent approaches.

Contrary, considering the current draft regulations and guides by NRAJ, all hardware requirements are apparently more design basis. Scope of systems and safety functions of the “specific safety facilities” are given in the regulatory documents and effects of external events onto such facilities need to be set on the design basis hazards with a certain exceedance rate.

CONCLUSIONS

Based on the request by the NRAJ, the nuclear power plants in Japan need to undergo verifications done by the NRAJ before restarting the reactors. NRAJ will review about the licensees’ compliance to the nuclear safety requirements. This process will demonstrate that the existing nuclear power plants in Japan sufficiently implement measures to reduce the risk of severe accidents induced by extreme external events. However, there are apparently some differences between NRAJ approaches and

the IAEA safety requirements. It may also be necessary that the regulatory framework and the requirements be reviewed by experts through the international cooperation as is done by the IAEA.

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