Development of the Regulation Concept for a Fusion Reactor

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1. Introduction

Fusion energy has been studied in many countries such as U.S., France, Japan, Korea etc. Because it would provide much more energy for a given weight of fuel than any technology currently in use, and the fuel itself (primarily deuterium) exists abundantly in the Earth's ocean.

Nuclear fusion reactor uses tritium and deuterium as fuel while nuclear fission reactor uses uranium and plutonium as fuel. Besides, inherent design characteristics and driving condition of nuclear fusion reactor is different from those of nuclear fission reactor. Therefore, we cannot apply the regulation rules of nuclear fission reactor to nuclear fusion reactor without change and thus it is needed to development of the safety regulation concept which reflects the characteristics of nuclear fusion reactor.

Safety regulation of nuclear fusion reactor employs deterministic approach until sufficient data are secured. However, regulation methodology of nuclear fusion reactor should be based on risk-informed regulation (RIR).

In the present study, nuclear legislation of Korea and the General Design Criteria (GDC), Title 10 CFR Part 50 Appendix A of U.S. were reviewed. Through this, the validity of applying the fission reactor regulation to a fusion reactor was estimated, and the improvements from existing the fission reactor regulation were deduced for a fusion reactor.

2. Review of domestic and foreign nuclear legislation

2.1 Korea nuclear legislation

The main difference between fusion and fission reactor is fuel. Hence if tritium and deuterium are added as fuel for a fusion reactor to existing nuclear legislation, then the guideline for a regulation concept of a fusion reactor will be provided. In a fusion system, activation products like fission products, which are the most concern in the current nuclear regulatory system due to their decay heat, do not need to be considered [1]. In a fusion reactor, there is no decay heat and thus Articles related to the Emergency Core Cooling System (ECCS) can be omitted. In case of a fusion reactor, the terms in fission systems, such as core and fuel design limit, is not defined. The terms in fusion which is corresponding to the terms in fission should be developed. The examples of terms of fusion reactor are listed in Table 1.

Table 2. Examples of terms of fusion reactor corresponding with fission reactor

Fission	Fusion	Note
Core	First wall & Divertor	In GDC, reactor core is a part which should be just cooled
Reactivity	Plasma instability	Nuclear reactions of fusion & fission

Fuel	Blanket & Divertor	Blanket & Divertor are parts which should be cooled, but there is no thermal reaction.
Reactor coolant	Coolant of first wall/divertor	Very similar
Pressure vessel	Vacuum vessel	Very similar
LOCA	In/Ex-vessel LOCA	Considering In-Blanket LOCA and Loss of vacuum

2.2 U.S. 10CFR50 GDC

The major of the GDC consists of design, assembly, installation, test and performance requirements of structure, equipment and system for safety of light water fission reactor [2].

Some parts of GDC could be omitted for nuclear fusion reactor, and some parts of GDC could be applied to nuclear fusion reactor with or without improvements (Table 2).

Table 2. Applicability of GDC for fusion reactor

	No.	Criterion	Applicability
I. Overall Requirements:	2	Design Bases for Protection Against Natural Phenomena	O
II. Protection by Multiple Fission Product Barriers:	10	Reactor Design	R: define core, fuel design limit
	15	Reactor Coolant System Design	R: define reactor coolant pressure boundary
III. Protection and Reactivity Control Systems: : This prevents progress to severe accidents at the abnormal operations.	26	Reactivity Control System Redundancy and Capability	R: define reactivity / reactivity
	28	Reactivity Limits	R: reactivity, reactor coolant pressure boundary, pressure vessel

O : It is applicable for nuclear fusion reactor
R : Modification and compensation are needed
X : It doesn't related to nuclear fusion reactor

2.3 Discussions

Through the review process of Korea and U.S. regulation of nuclear fission reactor, It is concluded that the first step for development of regulation concept for nuclear fusion reactor is to define the terminologies of nuclear fusion reactor which correspond with the terminologies of nuclear fission reactor.

And then, needless regulation parts which are not related to nuclear fusion reactor could be omitted. However, most of safety concept and requirements of nuclear fission reactor could be applied to regulation of nuclear fusion reactor. Application of existing regulation technique of nuclear fission reactor for nuclear fusion reactor should be accessed about its validity and should be advanced adequately for characteristics of nuclear fusion reactor.

3. Conclusions

The fundamental requirements of used in fission reactors are applicable and they seem conservative to a fusion reactor. However, there are some parts which are needed to be modified and added, because of inherent characteristics of a fusion reactor.

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REFERENCES

1. 국내 원자력법
2. http://www.nrc.gov/(U.S. DOE standard)