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Regulatory Framework of Safety for HTGR

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1. Introduction

Recent accident in Fukushima Daiichi plant in Japan makes big impacts on the future of nuclear business. Many countries are changing their nuclear projects and increased safety of nuclear plants is asked for from the public. Without providing safety the society accepts, it might be almost impossible to build new plants further. In this sense high temperature gas-cooled reactor (HTGR) which is under development needs to be licensed reflecting this new expectation regarding safety. It means we should have higher level of safety goal and a systematic regulatory framework to assure the safety. In our previous paper [1], we evaluated the current safety goal and design practice in view of this new safety expectation after Fukushima accident. It was argued that a top-down approach starting from safety goal is necessary to develop safety requirements or to assure safety. Thus we need to propose an ultimate safety goal public accepts and then establish a systematic regulatory framework. In this paper we are going to provide a conceptual regulatory framework to guarantee the safety of HTGR. Section 2 discusses the recent trend of IAEA safety requirements and then summarize the HTGR design approach. Incorporating these discussions, we propose a conceptual framework of regulation for safety of HTGR

2. Status of IAEA Safety Requirement

2.1 Revision of Safety Requirement

IAEA is revising the safety standards to ensure the highest level of safety reflecting the present consensus. IAEA Safety Standards Series No.NS-R-1[2], issued in 2000, defines the safety objectives, safety functions and what should be the safety in design. Most prominent change comes in dealing the severe accident. Art.5.31 states that "~important event sequences that may lead to a severe accident shall be identified ~, and that the accident management procedures shall be established taking into account representative and dominant severe accident scenarios". This NS-R-1 is recently under revision. The DS414 [3], revision of NS-R-1, is still under process. Requirement 20 of DS414 defines the design extension conditions (DEC). DEC are defined as accidents that are either more severe than design basis accidents or that involve additional failures. Art.5.25 states that "…a primary objective shall be to manage all design basis accidents so that they have no or only minor radiological impacts, on or off the site, and do not necessitate any off-site intervention measures." And art.5.26 "The design basis accidents shall be analyzed in a conservative manner. And art. 5.31 states that the design shall be such that DEC that could lead to significant radioactive releases are practically eliminated. What it means this "practically eliminated" might be argued, but the important change of concept is that even for PWRs, severe accident(SA) should be taken into account in design to practically eliminate the consequences and SA should not be handled with accident management as is required in previous standard. Also Requirement 5 Radiation protection states that "The design of a nuclear power plant shall be such as to ensure that radiation doses to workers at the plant and to members of the public…remain below acceptable limits and as low as reasonably achievable in and following accident conditions.

Other document to be referenced is safety guide GS-G-1.2 Review and Assessment of Nuclear Facilities by the Regulatory Body , which states in art.3.25 that "The safety objectives and regulatory requirements should cover, among other things:…- criteria for assessing radiological risks to workers and the public".

2.2 Concept of Safety Requirements Development

Apart from the revision of safety requirements, IAEA issued a TECDOC [4] on how the safety requirements should be developed for innovative reactors. The TECDOC defines general safety objectives and states that "the compliance with the safety objectives is achieved when the three fundamental safety functions *Confinement of radioactive material*, *control of the reactivity* and *removal of the heat from the core* are fulfilled for all the plant operational, accidental and post accidental conditions in accordance with radiological targets. The general logical process to generate the ㄴ afety requirements is schematically represented in Fig.1 below.

3. HTGR Design Approach

The NGNP project was initiated by Idaho National Laboratory and the principal objective is to support commercialization of the HTGR technology. The HTGR design is characterized by 1) the refractory triple isotropic layers coated fuel particles (TRISO CFP) which can retain the fission products and then provides a unique robustness of the first barrier for the fission products, 2) the inert, single phase helium gas as coolant and graphite with high temperature stability and long response times as moderator, 3) negative temperature coefficient of reactivity and 4) passive core cooling and decay heat removal by natural process, etc. It is argued that HTGR core cannot physically melt, and the radionuclide release from the fuel has limited increases during postulated accident events involving core heatup.

These characteristics support one of the objectives of the HTGR safety basis, which is to limit calculated dose from releases so that regulatory requirements for protection of the health and safety of the public and protection of the environment are met at an exclusion area boundary. This also supports the associated licensing objective of establishing the plant emergency planning zone at the EAB and supports flexibility in siting the HTGR plant with the objective of locating the HTGR in close proximity to industrial processes to improve the efficiency of energy transport to the processes. As regulatory requirements to satisfy NGNP has chosen Top Level Regulatory Criteria (TLRC) [5]. The TLRC are the same with the current LWR safety goals of U.S. NRC. So the HTGR design approach is the same with the current LWRs in a sense that the safety goals are some criteria the HTGR design shows to satisfy. In our paper [1], we showed the pitfall of this approach. It can be argued also whether the same safety goal or safety level be imposed to HTGR with asserted no core melting.

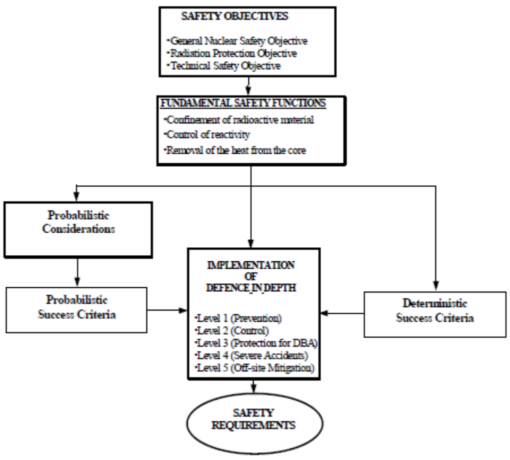

Fig. 1. Logical process for the generation of safety requirements

4. Safety Framework of HTGR

Our discussions in this paper and in the previous one [1] can be summarized as following ;

1) Current design practice is bottom-up approach which means that the design is performed to satisfy various codes and standards first. Then the design is shown to satisfy the safety goal
2) Recent Fukushima accident requires fortified safety concept. To persuade public, risk concept acceptable to public should be used. Also all the severe accident must be considered in design and acceptable limits in terms of dose be provided.
3) IAEA asserts new top-down process starting from safety goal be implemented in developing safety requirements, but it does not propose what this safety goal should be.

Harmonizing all these discussions, we like to propose new conceptual framework of safety for HTGR as Fig.2;

1) Safety Objective; general objective of NPP
2) Safety Goal; safety goal maximizing the safety features of HTGR is to express it in terms of dose limit at EAB. The dose should be less than a few mSv, say it 10 mSv, for DECs.
3) Instead of Safety Functions in Fig.1, “design for safe operation,” “design with inherent safety,” and “design feature for mitigation” aspects should be used to support the safety goal. We believe the safetu goal should be supported through all the aspects of plant life and not just by three design functions of Fig.1.
4) Detailed functions need to be developed to support these three aspects of design.

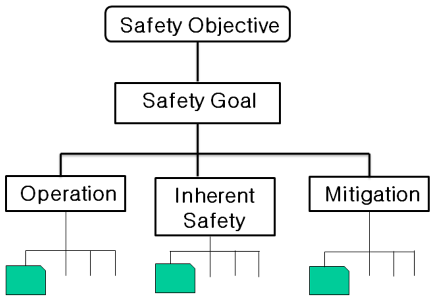

Fig. 2. Safety Framework of HTGR

5. Conclusions

Reflecting the increased safety expectation after Fukushima, the change of IAEA safety requirements and the current NGNP design practice, we have proposed a new conceptual safety framework for HTGR. A new safety goal in terms of dose limit was suggested and the development of safety requirements should be performed in top-down approach to support this safety goal. Future licensing also needs to be performed following this approach.

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