Current Status and Future Regulatory Direction on Sump Clogging Issue

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1. Introduction

A significant progress in resolving the sump clogging issue has been achieved since the USNRC Generic Letter 2004-01 was issued [1]. In Korea, the issue was begun to be discussed in regulatory framework through safety review and plant inspection since 2005 [2]. KINS has performed the licensing review for several plants including Kori Unit 1 and SKN Units 3, 4, according to the technical requirement of USNRC. Due to the efforts from the industry side and regulatory side, the newly designed improved strainer can be installed at some plants. However, some challengeable concerns such as chemical effect and downstream effect still need a further research.

The present paper is to discuss the current status of issue resolution and the related regulation based on the up-to-date achievements and review findings. Also the future regulatory direction on the new concerns related to the issue is discussed.

2. Status of Sump Performance Issue

2.1 Status of Methodology

The methodology to resolve the sump clogging issue is schematically described as Fig. 1, which starts from the containment walk-down and leads to strainer installation through the vendor testing. The important parts of the NEI 04-07 [3] and the guidance in the related USNRC Safety Evaluation (SE) were fully implemented.
The methodology was applied to the several licensing applications such as Kori Unit 1 continuous operation [4].

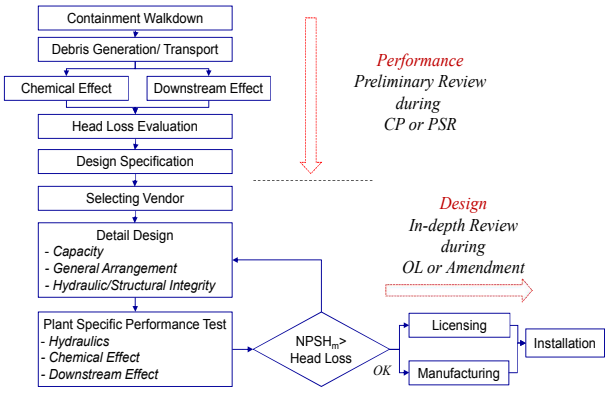

Fig. 1 Methodology of Licensee

The important features are discussed as follows.

2.2 Debris Generation and Transport

The amount of debris generated by loss-of-coolant accident (LOCA) is determined by the spherical-shaped zone-of-influence (ZOI) model which is described in USNRC Regulatory Guide 1.82 Rev. 3 [5]. According to the guide, the distribution of debris size and plant-specific materials in containment including unqualified coating are also considered.

Based on the NEI 04-07 and USNRC SE, the transport logic tree and computational fluid dynamics (CFD) analysis are jointly used to determine the fraction of debris to reach the sump screen before recirculation. For the APR1400, the early transport of debris to Hold-up Volume Tank (HVT) before establishing a steady state flow field was additionally considered since a significant amount of debris can be collected to HVT, which was not considered in NEI 04-07 [6].

2.3 Head Loss and Screen Area

The head loss across the sump screen is preliminarily calculated by the NUREG/CR-6224 correlation [7] using the debris quantities and characteristics above to assure the sufficient margin of NPSH and the required area of screen. Actual screen area was finally fixed based on the strainer testing at the vendor's test facility.

2.4 Chemical Effect and Downstream Effect

The effect of chemical precipitates in containment under LOCA situation on head loss across the debris bed is considered by the plant-specific head loss testing in which the debris surrogates is prepared with WCAP-16530-NP method [8].
Debris particle smaller than the hole size of the strainer can be introduced to the clearance or gap of valves, pumps, and the fuel assembly grid. The effect of the strainer-bypassed particles was evaluated based on the WCAP-16406-P method [9].
However, the effect of bypassed debris on long term core cooling was not fully investigated and further study is needed. [10]

2.5 Performance Testing

Performance of sump strainer is tested by the vendor's test facility using a prototypical strainer module and the pre-fabricated debris mixture and chemical precipitates were used according to the USNRC Revised Review Guidance [11]. Head loss across the debris bed over the

strainer is measured and corrected to consider the deviation from real situation. Bypass test and thin bed test are also conducted.
Currently downstream effect testing for fuel assembly was not provided yet, thus, further study is needed.

2.6 Specific Design and Installation

Specific design including strainer framework structures, perforated plate, connecting ducts, and plenums is conducted. Mechanical integrity is also evaluated. During the installation, the interaction with the existing components and structures was minimized.
Especially at SKN Unit 2, a pre-operational testing of recirculation flow path was conducted with the new sump strainer at 2010 [12].

3. Status of Strainer Installation

Table 1 shows the status of sump strainer installation for the plants and schedule which was prepared by licensee [13]. Several designs including CCI, TPI and AECL were adopted for those plants while it is noticed the Korea vendor designed strainer will be provided for the selected plants.
Review of FSAR change due to sump strainer will be planned before the strainer installation. In-depth review of the specific part of the design and the vendor testing will be conducted. Witness inspection on the vendor‘s performance testing may be performed in case-by-case.
It is expected the complete resolution of the issue of all the plants including the installation of sump strainer will be completed in 2016.

Table 1. Status of Sump Performance and Design

Plant	CP	Performance /Design	Installation
Kori 1	’72.5	Completed (CCI)	2009
Kori 2	’78.11	Completed /Ongoing	in 2012
Kori 3,4	’79.12	Completed /Ongoing	in 2013
YGN 1,2	’81.12	Completed /Ongoing	in 2014
UCN 1,2	’83.1	Ongoing	in 2016
YGN 3,4	’89.12	Ongoing /	in 2014
UCN 3,4	’93.7	Ongoing /	in 2015
YGN 5,6	’97.6	Ongoing /	in 2015
UCN 5,6	’99.5	Ongoing /	in 2015
SKN 1,2	’05.7	Completed (TPI)	2010
SWS 1,2	’07.5	Completed (TPI)	in 2011
SKN 3,4	’08.2	Completed /Ongoing (AECL)	before OL
WS 1	’78.2	Completed /Ongoing	in 2014
WS 2	’92.8	Completed /Ongoing	in 2015
WS 3,4	’94.2	Completed /Ongoing	in 2015

4. Future Regulatory Direction

Based on the up-to-date achievements and review findings regarding the sump clogging issue and its resolution, the followings will be expected.

1) Refinement of the methodology may include the reduction of amount of debris and the required strainer area. For those applications, more specific and reliable justification will be required.
2) Regarding the chemical effect, the plant specific evaluation and prudent observation of the testing are strongly requested since the head loss can be changed even with the addition of small amount of chemical precipitates.
3) Regarding the downstream effect, the amount and ratio of fiber and particles to block the fuel assembly grid should be determined in detail. Adverse effect of fuel temperature on downstream effect at the core should be considered. Also effects of chemical and crud on the long term cooling should be evaluated in combined manner.
4) Important findings of foreign regulatory activities will be considered and may be applied if appropriate.

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