Reassessment to prevent Flooding Hazard in the CPB

Keun-Pack CHANG [a*], Jin-Chul KANG [b], Ji-Won WHANG [a]
[a]*Plant Design Department,* [b]*Nuclear Design Department, KEPCO Engineering & Construction Company .Inc, 269 Hyeokssin-ro Gimcheon-si, Gyeongsangbuk-do, Republic of Korea, PA 39660*
[*]*Corresponding author: kpchang9@kepco-enc.com*

1. Introduction

Nuclear power plants are composed of various kinds of equipment such as tank, pump, heat exchanger and piping, etc. which accommodates or handles water because they require a great deal of water for cooling purposes. In case of losing cooling water, a nuclear reactor will overheat, leading to core damage, containment failure, and release of harmful radiation to the environment. This is what happened at the Fukushima Daiichi plant in Japan as a result of the tsunami on March 2011, causing severe damage to several nuclear power plants [1]. That is, water can be source of damage when flooding occurs. Flooding can damage equipment and knock out the plant electrical systems, disabling its cooling mechanisms [1]. An assessment of flooding hazard is one of the subjects for the safety approach for a nuclear power plant. In other word, the equipment and components which are important to safety need to be evaluated ensuring its safety function from flooding hazard. The related areas need be analyzed to ensure that all SCCs (Structures, Systems and Components) are protected from malfunctions caused by flooding from internal and/or external flooding sources.

The SKN 5&6 nuclear power plants are under construction by complying with more strengthened criteria referred to related standard or guidelines. This paper introduces why flooding reassessment needs to be done and what kinds of methods have to be implemented for mitigating flooding measures in the CPB (Compound Building) design for SKN5&6.

2. The Aim of Flooding Assessment for the CPB and Internal Flooding Sources

A flooding reassessment has been performed to evaluate flooding risk in the compound building even though there is no safety related equipment in it. The main purpose of flooding assessment is to ensure that (1) the flooding in the CPB does not affect any SSCs in the nearby auxiliary building adversely, (2) the flooding from a compartment can be controlled without release of radioactive material. In order to assess flooding risk in the CPB, following GA(General Arrangement) characteristics are taken into consideration.

- CPB is a building commonly used for SKN5&6. Therefore the CPB is located between two plants and connected to two auxiliary buildings which house many safety related components. That is, it is connected to auxiliary buildings through corridor at the levels of EL.100'-0", EL.120'-0" and EL.139'-6" in a northward and southward direction.
- CPB is composed of many kinds of compartments which houses (1) equipment that deal with various radioactively contaminated materials, laundry or decontamination related equipment and associated piping including fire protection systems, (2) waste drum storage area, (3) electrical/I&C equipment and associated HVAC equipment.

In General, the flooding sources can be brought about from various kinds of external or internal causes such as tsunami, natural weather event like heavy rain & snow as external events and LOCA, high energy line break as internal events, for example.

But, in this paper the internal flooding sources are focused on the compound building flood hazard assessment taking into account postulated piping ruptures, that is, non-seismic moderate energy line break in an earthquake, component failures like tank & vessel break and actuation of spray system or fire protection system etc.. The sources of compartment flooding include the effects of sources external to the compartment as indicated in the document, ANSI/ANS-56.11-1988 [4]. The external sources include backflow through floor and equipment drains, drainage flow from other areas (e.g., under doors) or flow through the damaged structures. It shall also include the fluid released by actuation of the fire protection system, or other spray systems [4].

The quantity of major flooding sources is shown below.

- Fire Protection System line rupture: 5,130gpm
- Plant Chilled Water System line rupture: 3,000gpm
- Fire Suppression System Actuation: 750gpm

3. Assessment of flooding hazard in the CPB

The guideline referred to the ANSI/ANS-56.11-1988 has been used to assess the flooding hazard in the CPB. It provides a hierarchy methodology for compartment flooding assessment from internal sources in light water reactors. The logic diagram for assessing the flooding hazard is shown on Fig.1 and it is stated roughly as follows.

1) Identification of the compartment(flood area) and its potential flood sources→ Selection maximum (limiting) flood source→ Calculation of the flood level comparing flow rate(inflow minus outflow)

2) Establishment of an estimate of the free floor area within the compartment
3) Development of a maximum expected flood height as a result of an inflow from the limiting flood source within the compartment (inflow parameters and outflow parameters)

As a result, following conclusions are summarized.
- More mitigating measures are required in the CPB design in accordance with results from flooding reassessment.
- The flood levels are either lower than the flood level or the protected elevation by curbing or ramp which is designed in the Auxiliary building.
- The flood levels shown in the current DBDs have no impact on the storage and implementation of mitigating strategies with no procedural change and no additional action required.

In addition, flood barrier Design Base Drawings (DBD) for the CPB have been developed and re-evaluated ensuring flooding strategy implemented in the design meet the new guidelines stated in the related document. For reference, DBDs are intended to identify watertight wall, roof, and floor slabs including flood height each flood zone and provides information regarding penetration /opening seal requirement to other division. The extent of barrier shown on the floor barrier DBDs is summarized on the Table 1 below.

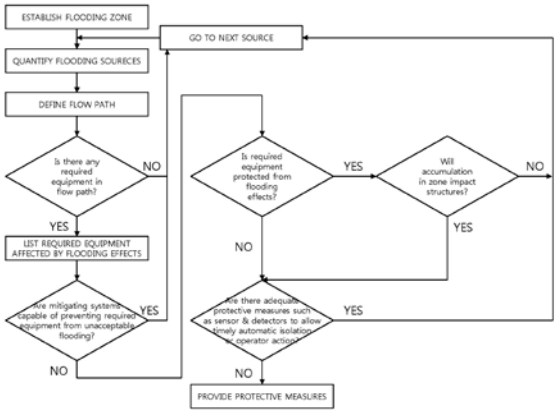

Fig.1. Hazards Methodology for Flooding Analysis (ANSI/ANS-56.11)[4]

Table 1. Extent of Barrier in CPB each level [2]

Level	Extent of Flood Barrier		Flood Height
	From	To	
EL.63'-0"	EL.63'-0"	EL.69'-0"	6'-0"
EL.77'-0"	EL.77'-0"	EL.77'-6"	6"
EL.85'-0"	EL.85'-0"	EL.85'-6"	6"
EL.100'-0"	EL.100'-0"	EL.100'-6"	6"
EL.120'-0"	EL.120'-0"	EL.120'-6"	6"
EL.139'-6"	EL.139'-6"	EL.140'-0"	6"
EL.157'-9"	EL.157'-9"	EL.158-3"	6"

4. Flooding Mitigating Measures in the CPB

The typical outflows of flooding parameters considered in the compound building are FDs (Floor Drain) as a drainage system and EOFs (Emergency Overflow) and so on. They are properly implemented to protect the maximum acceptable flood level in a given area or compartment from being exceeded. These are useful features to avoid accumulation of fluid passively. The number of FDs is newly added in the design to drain plentiful water from fire protection systems to comply with SRP3.4.1 (Rev.3) [4] & NEFA 804 code [5]. The number of EOF line is also added in the design to control flood levels from one elevation and another. They are implemented as a part of CPB plumbing design. Newly added EOFs are installed in the corridor and the compartments adjacent to the auxiliary building because the flooding sources in the CPB shall not affect the nearby auxiliary buildings adversely.
The other flooding protective measures introduced in the CPB design are sumps, pumps, watertight door and curbs or ramps.

5. Conclusions

Since 2011 *Fukushima Daiichi plant* accident, it has heightened attention to flood protection. And US NRC (Nuclear Regulatory Commission) has newly issued many flooding related standards and criteria. They recommend licensees to comply with more strengthened guidelines to evaluate flooding risks. One of the documents is SRP 3.4.1(Rev.3) which addresses assumption of double ended break instead of through wall crack for moderate energy lines in the non-seismic building as an internal flooding source.
Reassessment has been done according to the guidelines stated in the SRP3.4.1 (Rev.3). And additional design methods for flooding mitigating system are provided in the design to meet the criteria.
This paper has reviewed flooding risk in the CPB for SKN5&6 by flooding hazard re-evaluation which complies with new strengthened criteria and showed the flooding mitigating measures in the CPB are adequately implemented in the design.

REFERENCES

[1] Flood Risk at Nuclear Power Plants/Union of Concerned Scientists
[2] Flood Barrier Design Base – CPB EL.63'-0" ~EL.157'-9"
[3] SRP Section 3.4.1, Internal Flood Protection for Onsite Equipment failures
[4] ANSI/ANS-56.11-1988: Design Criteria for Protection Against the Effects of Compartment Flooding in LWR Plants
[5] NEFA 804-2010: Standard for Fire Protection for ALWR Electric Generating Plants