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Evaluation of Flood Level under Main Feedwater Line Break Accident using GOTHIC Computer Code and Analytical Calculation by ANSI 56.11.

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1. Introduction

The design basis internal flooding is caused by postulated pipe ruptures or component failures. The flooding can cause failure of safety-related equipment and affect the integrity of the structure. Therefore, the plant internal flood protection shall be considered to assure safe shutdown of the plant and prevent uncontrolled release of radioactive material.

Though large diameter pipe rupture is significant in flooding analysis, split breaks should also be considered with consideration of a spectrum of pipe break size and power level. The pipe rupture analysis should be based on the most severe single active failure. For enveloping spectrum of pipe break condition, flood relief paths are necessary and passive flood protection without operating action, basically, shall be applied.

In this study, the evaluation of flood level in case of Main Feedwater Line Break (MFLB) was performed by using GOTHIC computer program and hand calculation.

2. Flooding Level Analysis

If MFLB accident occurs in an isolated room with drains, the flood level is determined using the following formula.

$$h = \frac{\int [\dot{Q}_{in}(t)dt - \dot{Q}_{out}(t)dt]}{A} \quad (1)$$

h	: flood height	m
A	: floodable area	m^2
$\dot{Q}_{in}$	: inflow rate	m^3/sec
$\dot{Q}_{out}$	: outflow rate	m^3/sec

Typical mass release rate was used and the following design input values were assumed for the evaluation of the flood height.

- The Room Size: *100m²* ($100m^2$)
- Pressure: *1 bar*
- Opening for Flood Drain: *0.3m×0.3m, El. 0.3m*
- Loss Coefficient Factor : *3.0*
- Inflow Rate : OPR1000 Typical Data, Fig.1
- Pressurized effect is ignored.
- Flood Source temperature is assumed to be *90ºC* for conservative calculation

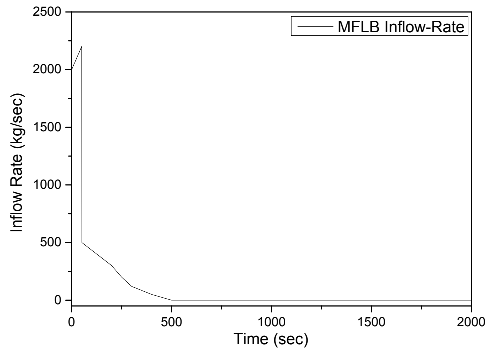

Fig. 1 MFLB Mass Release Data

The hand calculation and GOTHIC analysis were conducted for the comparison of the results.

2.1 Hand Calculation

For evaluation of flood height, the outflow rate should be calculated properly. Outflow rate is determined by static head of water height. In this study, Bernoulli's Equation and equation (Eq.5.2-1) of ANSI 56.11 "Design Criteria for Protection against the Effects of Compartment Flooding" The time history flood heights are calculated using the mass release rate data and the equation of outflow rate.

Bernoulli's Equation is as follow

$$\rho g \Delta h + \frac{1}{2}\rho v^2 + P = C \quad (2)$$

The outflow velocity is derived from (Eq. 2):

Eq.3 can be applied when the flood level is higher than the top of the opening drain [4], such as stairwells or floor openings.

$$Q_{out} = A\sqrt{\frac{2g\Delta h}{k}} \quad (3)$$

When the flood level is between bottom (0.3m) and top (0.6m) of drain opening, *Eq.4* can be applied.

$$Q_{out} = bg^{\frac{1}{2}}(2h/3)^{\frac{3}{2}} \quad (4)$$

ρ	: Density	kg/m^3
g	: Gravitational Acceleration	m/sec^2
k	: Pressure Loss Coefficient	
b	: Unobstructed Parameter of the Opening	

The flood level can be calculated using *Eq.1, Eq.3, Eq4* and mass release data by integration. The maximum flood level was evaluated as 0.823 m at 292 sec.

2.2 GOTHIC Analysis

GOTHIC computer program can be used for the flooding analysis. The nodalization is presented in Fig.2.

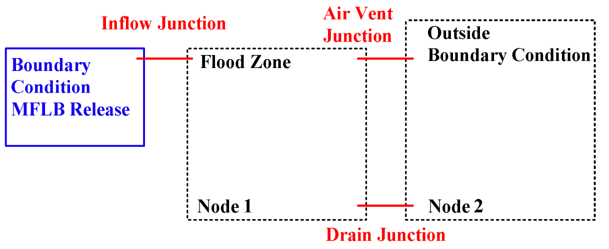

Fig.2 Nodalization of GOTHIC analysis

The nodalization consists of 2 nodes, 3 junctions and boundary condition. The node 1 is flood zone and node 2 is environment. The junctions represent MFLB inflow, air vent and flood drain, respectively. Boundary condition is applied for the MFLB mass release data which is identical as in the hand calculation.

For the conservative evaluation, air vent is modeled to prevent the pressure rise in flood zone due to MFLB mass-energy release. Fig 3 shows a junction between two volumes.

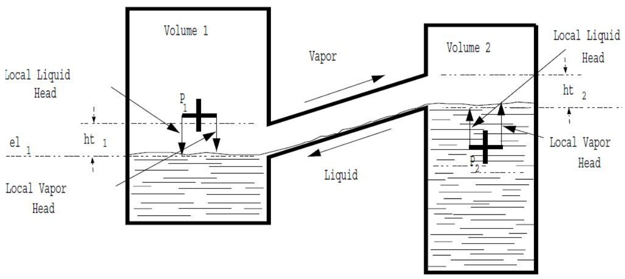

Fig. 3 The Concept of Junction in GOTHIC Computer Code

The maximum flood level is evaluated as 0.691 m at 271 sec in GOTHIC calculation.

2.3 Comparison of Results

In this study, the main differences between two methodologies come from the outflow rate. The comparison of outflow rates is shown in Fig.4

The result of outflow rates shows similar trend between two methodologies. However, hand calculation is underestimated compared to the GOTHIC analysis. In hand calculation, *Eq.4* is applied when the flood level is between 0.3m and 0.6m, but *Eq.3* is applied when the flood level is above 0.6m. So the result of outflow rate is discontinuous at 71sec and 772sec when flood height is 0.6m

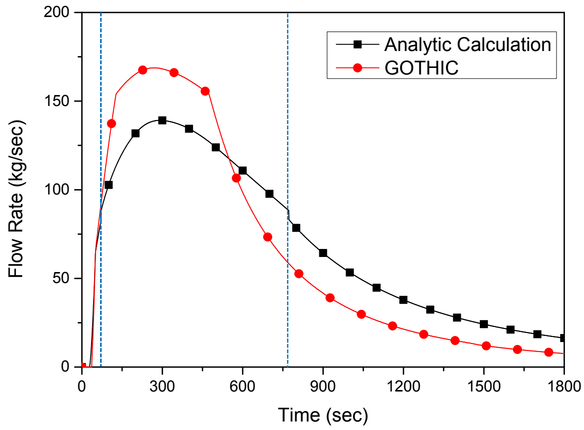

Fig. 4 Comparison of Outflow Rate

The comparison of flood height is shown in Fig.5. The result shows similar trend between two methodologies, but the hand calculation overestimates compared to the GOTHIC analysis.

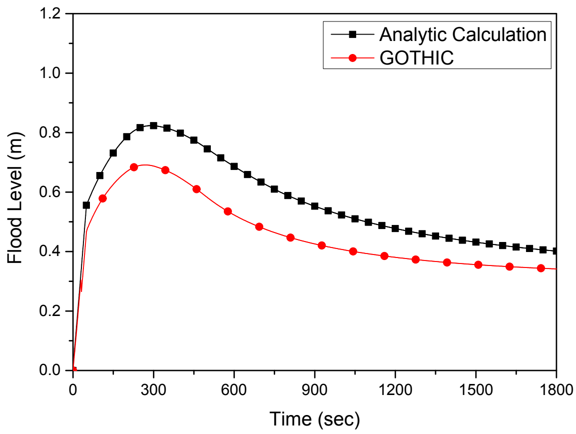

Fig. 5 Comparison of Flood Level

3. Conclusion

The flooding analyses were performed by hand calculation and GOTHIC analysis for an assumed MFLB condition.

The calculated flood levels were 0.823m and 0.691m for hand calculation and GOTHIC analysis, respectively. In comparison to the GOTHIC analysis, hand calculation showed conservative results. However, in actual flood protection design, margin for uncertainty shall be considered, in order to reflect the outflow reducing effect due to vortex and intake of air.

REFERENCES

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[4] ANSI 56.11, "Design Criteria for Protection against the Effects of Compartment Flooding", ANS, 1988