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The Flooding Water Source Analysis following the Feed Line Break at the Compartment outside Containment for Nuclear Power Plant

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1. Introduction

The Periodic Safety Review(PSR) has been performing for the operating nuclear power plant in Korea. One of the PSR evaluation items is environmental qualification[1,2]. Flooding issue for nuclear power plants designed and built in 1970 is extremely severe for main steam header compartment and main feed water line region of intermediate building and lower floor. This study presents to analyze flood level of feed water line breaks for the Westinghouse nuclear power plant. This analyses provides the mass and energy releases using the developed methodology for a break outside containment. For the analyses RETRAN-3D computer program is used.

2. Analysis Methodology

A calculation for flood water source at the main feed water line isolation compartment is now performing by hand calculation. But, this method is overly conservatism. Therefore, using the self developed methodology, flood water source was calculated with RETRAN-3D computer code[3,4,5].

2.1 Current Flood Level Analysis Method

The following equation 1 and 2 describe amount of volumetric water to calculate flood level. A calculation for flood level compartment is hand calculation. This methodology calculates flow as the critical flow with initial piping pressure at break piping location. However this method is very conservative.

$$\nabla P = K\frac{\rho V^2}{2g_c} \qquad \text{Eq.1}$$

$$Q = \frac{M_L}{\rho_\infty} = A_C\left(\frac{2\Delta P g_C \rho}{K\rho_\infty^{\;2}}\right)^{\frac{1}{2}} = A_C\left(\frac{2\Delta P g_C}{K\rho_\infty^{\;2}}\right)^{\frac{1}{2}}\left(\frac{\rho}{\rho_\infty}\right)^{\frac{1}{2}} \qquad \text{Eq.2}$$

2.2 Analysis Methodology using the Computer Code

This analysis model utilizes the RETRAN-3D computer program to simulate the thermal hydraulic response of the nuclear steam supply system. The analysis model incorporates detailed modeling of the thermal hydraulic network of the main feed water and the auxiliary feed water systems along with the actuation and control system components.

The criteria are defined as the physical design and operational parameters of the feed water line and steam generator design that must be in reasonable agreement with those of target NPP. The flooding behavior is greatly sensitive of break location between check valve upstream and downstream. Sensitivity analysis for the break location is performed. Table 1 represents summary of methodology.

Table 1. Summery of methodology

Parameters	FLB Flooding	Parameters	FLB Flooding
1. Initial Condition		4. Reactor Trip	
Power (%)	102, 75, 25	Low RCS Flow	OFF
RCS Flow	Thermal Design Flow	High Neutron Flux	OFF
RCS	(+) Uncertainty	High PZR Water Level	OFF
PZR Pressure	Nominal	High PZR Pressure	OFF
PZR Level	Nominal	Low PZR Pressure	OFF
SG Pressure	Nominal	Lo-Lo SG water level	ON
SG Level	(+)Uncertainty	Safety Injection	OFF
FW Enthalpy	Max	OPDT /	OFF
FW Flow	Max.	5. SG Isolation	
Break Type	DER / Split break	FW Isolation	Max. Delay
2. Reactor Kinetics		Steam Line Isolation	Max. Delay
MTC	Min	6. Safety System	
AT	Min	Safety Injection	
DO	Min	Flow rate	Min
BET	Max.	Enthalpy	Max.
3. Control Systems		AFW Injection	High
Control Rod	OFF	Flow rate(Faulted/Intact)	Max./Min.
PZR Prop.	OFF	Enthalpy	Max.
PZR Backup Heater	OFF	PZR	Min
Spray	OFF		

Figure 1 is control logic system for main feed water flow. This control logic controls feed water valve closing with lead/lag feedback of main steam flow, feed water control valve and steam generator water level. This system modeled to describe the real system transient in the RETRAN-3D computer code.

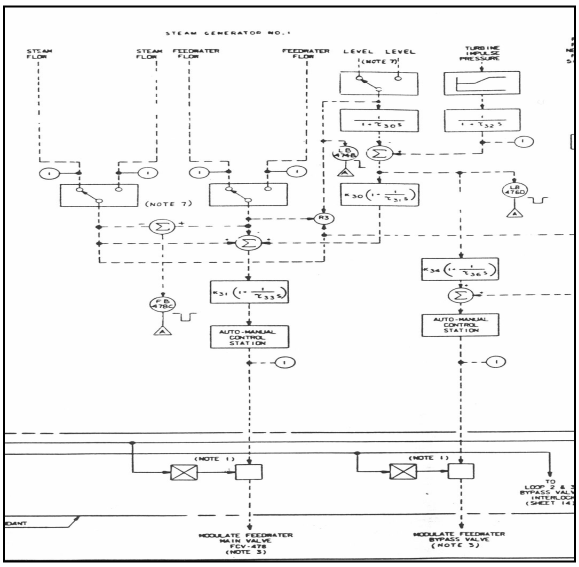

Figure 1. Control logic for main feed water flow

2.3 System Model Boundary Condition of Computer Code

The RETRAN-3D input models have control volume, flow connection junction, pressurizer, steam generator, reactivity, control system etc. as shown in figure 2. Main feed water pump model was treated as boundary condition. Boundary condition is setup with Mathcad program considering pump characteristics and piping system resistance.

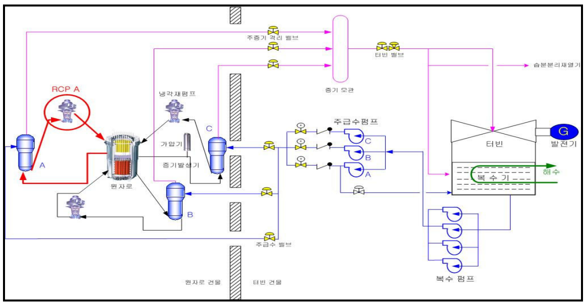

Figure 2. System model boundary of RETRAN Code

3. Applications and Results

Figure 3 is maximum flood level when main feed water isolation valve is not closed before check valve. Figure 4 shows flood level when main feed water valve closes by trip signal. Figure 5 is maximum flood level for spectrum cases. Spectrum analysis is performed for the power levels, break size and types[6,7,8].

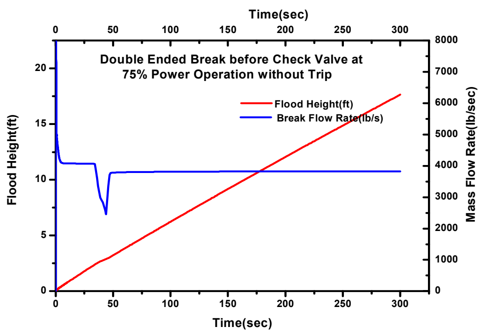

Figure 3. Flood level without trip(Before check valve)

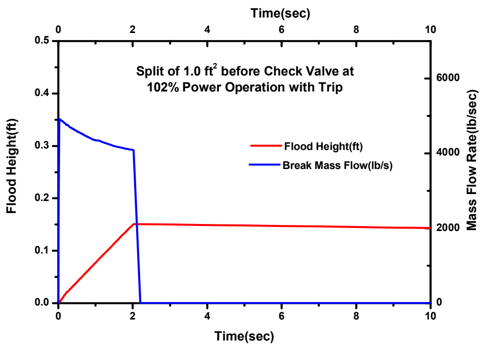

Figure 4. Flood level with trip(Before check valve)

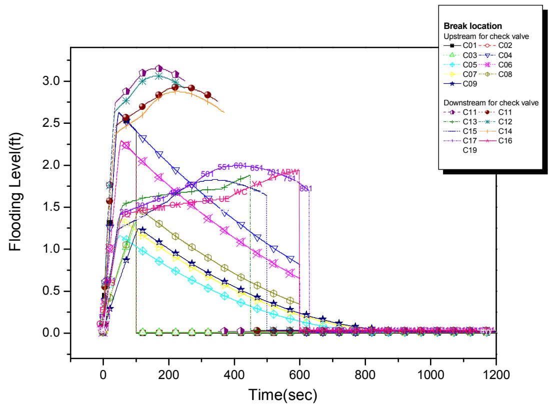

Figure 5. Maximum flood level for spectrum cases

4. Conclusion

A calculation for flood level at the main feed water piping compartment is performed by flood level computational analysis based on the RETRAN-3D model. The new developed method was applied to flood level analysis following main feed water line break. Analysis result shows that flood level was remarkably lower than that of current method (12.9ft to 3.11ft). In conclusion, this flooding water source calculation can be used for other PWR plants to optimize flood level at the compartment.

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