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Environmental Envelope of SBLOCA for Wolsong Unit 1 Environmental Qualification

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1. INTRODUCTION

An equipment environmental qualification(EQ) is required to guarantee the safety function of safety related systems, structures and components during the harsh conditions which occur as a consequence of an accident. The first step of an EQ program is to identify the events causing the harsh environmental conditions and to determine the environmental conditions. These environmental envelopes are generated by two steps, the generation of mass and energy release data and an analysis of the containment pressure and temperature. This paper shows the procedure and results of building a environmental envelopes for Small Break LOCA which is one of the most severe DBAs, specially in the view of long term.

2. ANALYSIS SCOPE

The mass and energy release from the accident of SBLOCA is bounded by that of LBLOCA in the early stage of accident, but in the long term, SBLOCA is predicted to generate the harsh conditions. The possible location of SBLOCA is either the Reactor Inlet Header (RIH), the Reactor Outlet Header (ROH). The break size of SBLOCA is from 0.3% of Header cross section to the largest feeder size (2.5% of Header cross section).

In the CANDU reactor, each design basis accident includes dual failures which assume a coincident single failure in any Special Safety Systems (SSS). For impairments of the Emergency Core Cooling System (ECCS), three different cases, the loss of Emergency Coolant Injection (ECI), the loss of Steam Generator Crash Cooldown (SGCC) and the loss of Loop Isolation (LI) are considered. For impairments of the containment systems, only a partial loss of dousing is considered because the other impairments such as a loss of containment isolation and deflated airlock door seals result in a lower containment pressure and temperature when compared to a single failure.

3. MASS AND ENERGY RELEASE

The break discharge data for an SBLOCA is generated by a system simulation using the CATHENA code. The CATHENA model includes the heat transport system and the ECCS. The heat transport system model covers the two primary loops including the pressurizer and the secondary side including the feedwater and steam system. The ECCS model covers the high pressure, medium pressure and low pressure recovery injection. Wolsong 1 emergency operating procedure requires an operator to trip the PHT pump for LOCA condition. The operator action time of 900 s (15 minutes) is considered for the PHT pump trip. The general analysis methodology is similar to that used in the safety analysis report. For the ECI available cases, the break discharge data up to a low pressure ECI start time are provided for containment thermalhydraulic analysis from the CATHENA system simulation. Thereafter the break discharge data is generated by containment analysis code PRESCON2. For the loss of ECI cases, the break discharge from the CATHENA system simulation ends early. In order to provide the necessary long term break discharge data, a steam discharge for a post-blowdown heatup period is assumed.

Figure 1 and 2 show the break discharge flow and enthalpy for 2.5% RIH break. The break discharge flow ceases early for the loss of ECI cases as expected. The loss of SGCC delays the injection of ECC. Therefore it reduces the discharge flow and increase the discharge enthalpy. Break discharge flow increases for the loss of loop isolation case since the coolant inventory of the intact loop is also transferred to the broken loop. The long term break discharge flow and enthalpy for 2.5% RIH break with ECI failure are shown in Figure 3 and 4. The break discharge for other break sizes and locations have generally a similar trend.

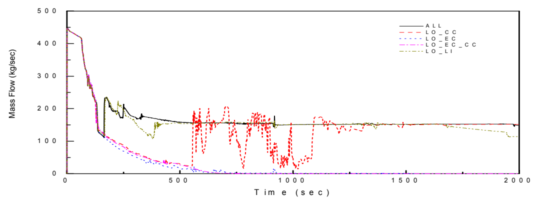

Figure 1. Break discharge flow for 2.5% RH Break

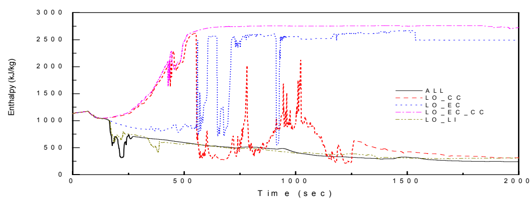

Figure 2. Break discharge enthalpy for 2.5% RH Break

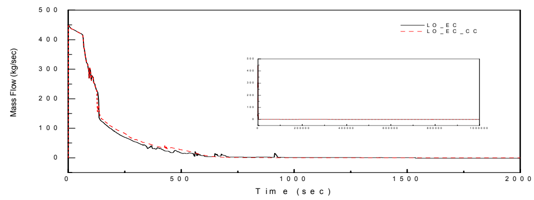

Figure 3. Break discharge flow for 2.5% RH Break Without ECI(Long Term)

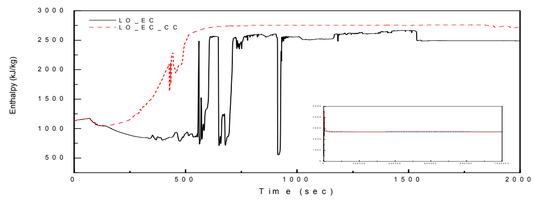

Figure 4. Break discharge enthalpy for 2.5% RH Break Without ECI(Long Term)

4. CONTAINMENT PRESSURE AND TEMPERATURE

The containment thermal-hydraulic behavior is simulated using the PRESCON2 code. The model used in this analysis is composed of 9 nodes and 26 links. The break location in the containment corresponding to an SBLOCA (RIH, ROH) is node 6 or 7. For the normal dousing case, 4 out of 6 dousing headers are assumed to function. Only 2 dousing headers are assumed to function for the partial loss of dousing case.

Figure 5 shows the containment pressure transients for all the 9 nodes from all the RIH, ROH breaks. Grouping of the containment regions for the pressure condition is not proposed because the difference in the pressure transient between the nodes is very small. A containment pressure envelope which covers all the pressure transients with a margin is drawn.

The temperature transient in the containment is somewhat different depending on the regions. Nodes 6, 7 and 9 (fuelling machine rooms and moderator room) have a higher temperature transient due to the direct impact of the break discharge. These nodes are grouped and named as SBLOCA Region 1. SBLOCA Region 2 covers the remaining nodes (node 1, 2, 3, 4, 5 and 8) and has a lower temperature transient. Two containment temperature envelopes which cover regions 1 and 2 respectively are drawn as shown in Figures 6 and 7.

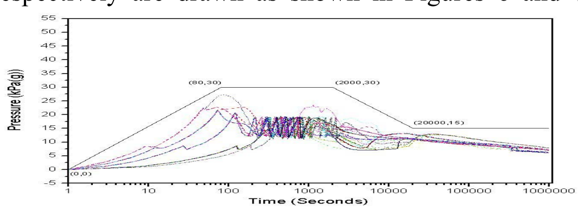

Figure 5. Containment Pressure Transient for all SBLOCAs

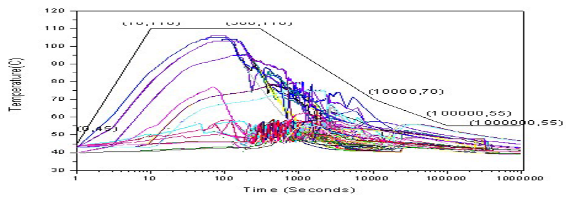

Figure 6. Containment Temperature Transient for all SBLOCAs(SBLOCA Region 1)

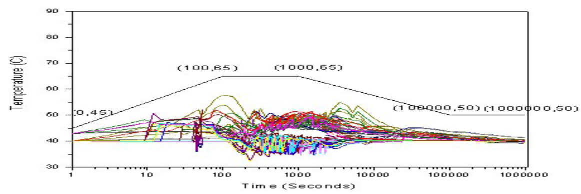

Figure 7. Containment Temperature Transient for all SBLOCAs(SBLOCA Region 2)

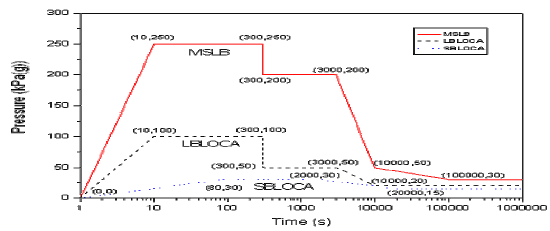

Figure 8. Containment Pressure Envelope (All events)

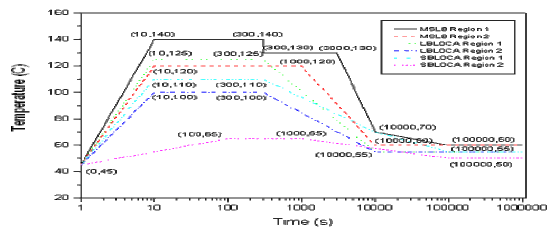

Figure 9. Containment Temperature Envelope (All events)

5. CONCLUSION

The environmental condition inside the containment for equipment environmental qualification of SBLOCA for Wolsong Unit 1 was established. These containment pressure and temperature envelopes will compose the total envelope for the EQ along with those of LBLOCA and MSLB. Using these envelopes, the equipment qualification test will be proceeded.

6. REFERENCES

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2. M.S. Quraishi et al., "PRESCON2 Program Descri ption and User's Manual," AECL, 1991 December
3. "Wolsong 2,3,4 Final Safety Analysis Report," K HNP.