LBLOCA Accident Analysis 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 environmental conditions resulted from Large Break LOCA which is one of the most severe DBAs.

2. ANALYSIS SCOPE

The LBLOCA is a limiting accident in terms of harsh environmental conditions which results from a primary side break. The possible location of an LBLOCA is either the Reactor Inlet Header (RIH), the Reactor Outlet Header (ROH) or the primary heat transport Pump Suction (PS). The break size of LBLOCA should cover from the upper boundary of the small break LOCA range up to the double ended guillotine break (100% break). The smaller break size results in a lower peak pressure and temperature in the containment but may result in a higher second peak after the consumption of the dousing water, when compared to the larger break size.

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. Analysis cases are similarly determined for the ROH and PS break.

3. MASS AND ENERGY RELEASE

The break discharge data for an LBLOCA is generated by a system simulation using the CATHENA code. 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 100% RIH break . The break discharge flow ceases early for the loss of ECI cases as expected. The SGCC hardly affects the break discharge since the primary side behavior is dominated by the break in the LBLOCA. 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 100% 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.

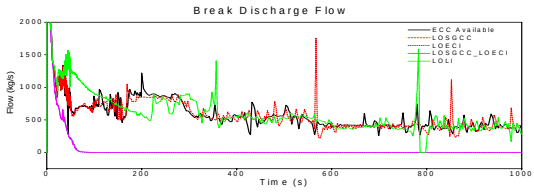

Figure 1. Break discharge flow for 100% RH Break

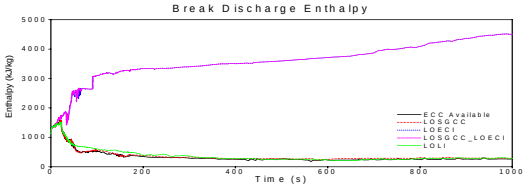

Figure 2. Break discharge enthalpy for 100% RH Break

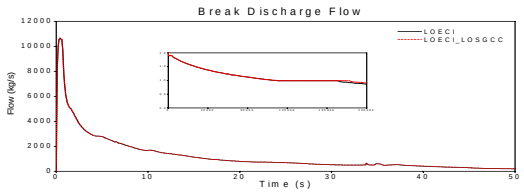

Figure 3. Break discharge flow for 100% RH Break Without ECI(Long Term)

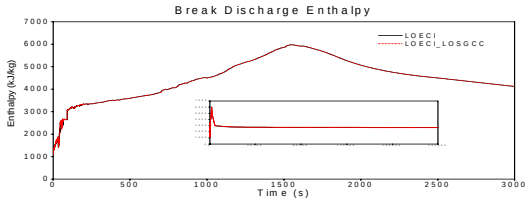

Figure 4. Break discharge enthalpy for 100% RH Break Without ECI(Long Term)

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 LBLOCA (RIH, ROH or PS) 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 and PS 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 LBLOCA Region 1. LBLOCA 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.

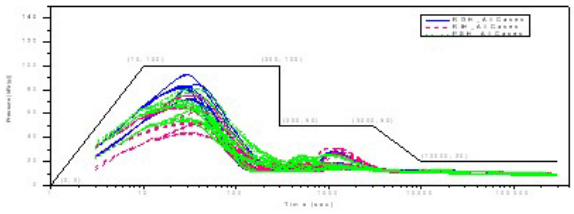

Figure 5. Containment Pressure Transient for all LBLOCAs

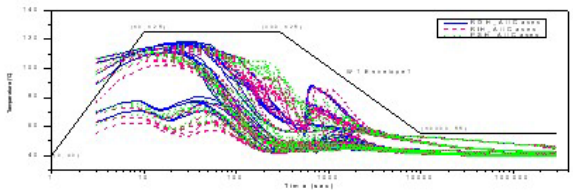

Figure 6. Containment Temperature Transient for all LBLOCAs(LBLOCARegion1)

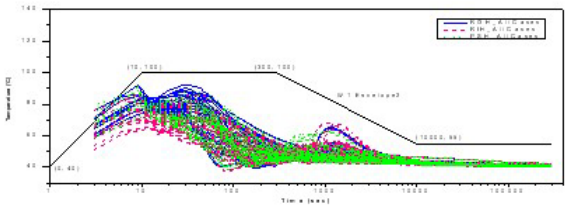

Figure 7. Containment Temperature Transient for all LBLOCAs(LBLOCA Region 2)

5. CONCLUSION

The environmental condition inside the containment for equipment environmental qualification of LBLOCA for Wolsong Unit 1 was established. These containment pressure and temperature envelopes at the earlier stage of accident is predicted to be the final envelope to be used in EQ along with Main Steam Line Break(MSLB). Using these envelopes, the equipment qualification test will be proceeded.

6. REFERENCES

1. B.N. Hanna et al., “CATHENA Theoretical Manua l and Input Reference,” AECL, 1995 October.
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.