RESPONSE TO AUDIT ISSUES

APR1400 Topical Reports

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD
Docket No. PROJ0782

Review Section	**TR Realistic Evaluation Methodology for LBLOCA of the APR1400**
Application Section	**Topical Report: APR1400-F-A-TR-12004 Realistic Evaluation Methodology for Large-Break LOCA of the APR1400**
Issue Date	**08/13/2015**

Audit Issues No. 46

The guidance in RG 1.157, Section 3.4.2 establishes acceptable controls for the calculation of bypass flow. The expression for the bypass fraction shown in Section 2.1 of Appendix F appears to be incorrect. M_water_out is defined as the liquid flow rate discharged through the lower plenum which would be indicative of the amount that has not been bypassed in the test. Confirm and if necessary, provide the correct the expression. Also confirm that the bypass fractions shown in Figures 2-3, 2-7 and 2-8 in Appendix E are correctly calculated and compared.

Response

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            ]^{TS} The M_{water_out} is the measured liquid flow rate discharged through the lower plenum.

In MIDAS tests, the downcomer water level is maintained at the predetermined constant value. The liquid flow rate discharged through the lower plenum which would be indicative of the amount that has not been bypassed in the test. That is, the liquid flow rate through the lower plenum can be calculated by following equation.

            [   ]^{TS}

The expression for the bypass fraction above is obtained from the mass balance.

Even though the typos in the topical report, Figure 2-3, 2-7 and 2-8 of Appendix E are calculated correctly based on the above modified equation. Therefore, these figures do not need to be modified.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Report

Topical report will be revised as mentioned above.

There is no impact on Technical or Environmental Report.

Replace with next page A

labeled 'ECCW Injection Nozzle', is the DVI injection nozzle number through which ECCW was injected. The major test results are also depicted in Figure 2-3 and Figure 2-4.

The bypass fraction and the condensation ratio were calculated as follows:

$$Bp\_fraction = \frac{M_{Water\_out}}{M_{SI\_in} + M_{Condensate}} \tag{1}$$

$$Cond\_ratio = \frac{M_{Condensate}}{M_{Steam\_in}} \tag{2}$$

Where, M_{SI_in} (kg/s) was the total ECCW injection flow rate, M_{Water_out} (kg/s) is the liquid flow rate discharged through the lower plenum, M_{Steam_in} is the steam injection flow rate, and $M_{Condensate}$ (kg/s) is the condensation rate which is calculated as follows:

$$M_{Condensate} = M_{Steam\_in} - M_{Steam\_out} \tag{3}$$

Where, M_{Steam_out} (kg/s) is the steam flow rate discharged through the break.

The total steam injection flow rate used in the tests was ranged [   ]^{TS}. Table 2-4 presents the scaled MIDAS test conditions and corresponding APR1400 conditions.

The ECCW bypass fractions measured in 15 tests are presented in Figure 2-3 as a function of the total steam injection flow rate. In the cases of one SIP injection through DVI-4 (located nearby the broken cold leg), the DVI-4 injection tests Test 110 through Test 114, the bypass fraction abruptly increased as the total steam injection flow rate increased. The maximum bypass fraction reached almost [   ]^{TS}. It was also observed that very steep increases of the bypass fraction became weakened as the steam flow rate increased. A similar tendency was also observed in the tests that ECCW injected through both DVI-2 and DVI-4 (Test 100 through Test 108; two SIPs operated). The bypass fraction converged into an asymptotic value of about [   ]^{TS} as the steam flow rate increased. In the case of one SIP injection through DVI-2 (located on the opposite side of the broken cold leg), Test 109, the bypass fraction was only [   ]^{TS}; even though the steam flow rate was as high as [   ]^{TS}. These test results indicate that most of the ECCW injected through the DVI-2 nozzle, which was the farthest from the broken cold leg, penetrated into the lower plenum, and that most of the ECCW injected through the DVI-4 nozzle, which was closest to the broken cold leg, bypassed through the break.

Figure 2-4 shows the condensation ratio as a function of the total steam injection flow rate. The condensation ratio is defined as a condensed fraction of the total steam flow rate. The condensation ratio decreased as the total steam injection flow rate increased. For the DVI-2 or DVI-4 injection tests (one SIP operated), the condensation rate was about half of the condensation rate for DVI-2 and DVI-4 injection tests (2 SIPs operated) under the same total steam injection flow rate. This is because the condensation rate is almost proportional to the ECCW injection flow rate, as shown in Table 2-4.

2.2   Code Assessment

2.2.1   RELAP5/MOD3.3/K Model Description

The RELAP5/MOD3.3/K input model of the MIDAS facility is shown in Figure 2-5 and Figure 2-6.

The downcomer is modeled [   ]^{TS}. Each channel of the upper downcomer region (i.e., the region above the cold leg) is modeled [   ]^{TS}. DVI-4, which is the closest DVI nozzle to the break, is connected to Volume 130-2. DVI-2, which is the farthest DVI nozzle from the break, is connected to Volume 140-2. Each channel of the lower downcomer region (i.e., the region below the cold leg) is modeled [

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labeled 'ECCW Injection Nozzle', is the DVI injection nozzle number through which ECCW was injected. The major test results are also depicted in Figure 2-3 and Figure 2-4.

The bypass fraction and the condensation ratio were calculated as follows:

$$Bp_{fraction} = 1 - \frac{M_{Water\_out}}{M_{SI\_in} + M_{Condensate}} \tag{1}$$

$$Cond\_ratio = \frac{M_{Condensate}}{M_{Steam\_in}} \tag{2}$$

Where, M_{SI_in} (kg/s) was the total ECCW injection flow rate, M_{Water_out} (kg/s) is the liquid flow rate discharged through the lower plenum, M_{Steam_in} is the steam injection flow rate, and $M_{Condensate}$ (kg/s) is the condensation rate which is calculated as follows:

$$M_{Condensate} = M_{Steam\_in} - M_{Steam\_out} \tag{3}$$

Where, M_{Steam_out} (kg/s) is the steam flow rate discharged through the break.

The bypass fraction is defined by using the liquid flow rate discharged through the lower plenum. The liquid flow rate discharged through the lower plenum is the same as accumulated liquid rate to downcomer that is the summation of ECCW injection rate with consideration of bypass and steam condensation, since downcomer water level is constantly maintained.

The total steam injection flow rate used in the tests was ranged [   ]^{TS}. Table 2-4 presents the scaled MIDAS test conditions and corresponding APR1400 conditions.

The ECCW bypass fractions measured in 15 tests are presented in Figure 2-3 as a function of the total steam injection flow rate. In the cases of one SIP injection through DVI-4 (located nearby the broken cold leg), the DVI-4 injection tests Test 110 through Test 114, the bypass fraction abruptly increased as the total steam injection flow rate increased. The maximum bypass fraction reached almost [   ]^{TS}. It was also observed that very steep increases of the bypass fraction became weakened as the steam flow rate increased. A similar tendency was also observed in the tests that ECCW injected through both DVI-2 and DVI-4 (Test 100 through Test 108; two SIPs operated). The bypass fraction converged into an asymptotic value of about [   ]^{TS} as the steam flow rate increased. In the case of one SIP injection through DVI-2 (located on the opposite side of the broken cold leg), Test 109, the bypass fraction was only [   ]^{TS}; even though the steam flow rate was as high as [   ]^{TS}. These test results indicate that most of the ECCW injected through the DVI-2 nozzle, which was the farthest from the broken cold leg, penetrated into the lower plenum, and that most of the ECCW injected through the DVI-4 nozzle, which was closest to the broken cold leg, bypassed through the break.

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