Performance Comparison of Deflector and DVI+ Duct

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1. Introduction

An ECC direct bypass fraction during a late reflood phase of a LBLOCA is strongly dependent on the cross flow velocity in a Downcomer annulus (T.S. Kwon et al., 2003, H. Glaeser, 1992,1993). In the advanced DVI+ system for APR+ and the AP1000's ECC deflector system, the effect of a cross flow to an ECC direct bypass is controlled by a steam-water separation technique. An ECC duct to separate a steam-water interaction and an ECC deflector to control the ECC momentum are considerable design feature. An ECC flow deflector has a curved plate to change the momentum direction. The ECC extension duct attached on the core barrel plays a role of a downward ECC flow subchannel in a high speed cross flow field of the downcomer.

2. DVI Duct and Deflector

As shown in Fig.1, the ECC extension duct and ECC deflector could be installed at the core barrel's outer surface. The ECC water intake port is located on the axial line of the DVI nozzles. The diameter of the emergency core cooling water intake port is about one to two times the inner diameter of the DVI. Therefore, the emergency core cooling water is introduced more easily into the ECC extension duct. The length of the injection extension duct installed on the core barrel starts from the DVI nozzle to a lower downcomer.

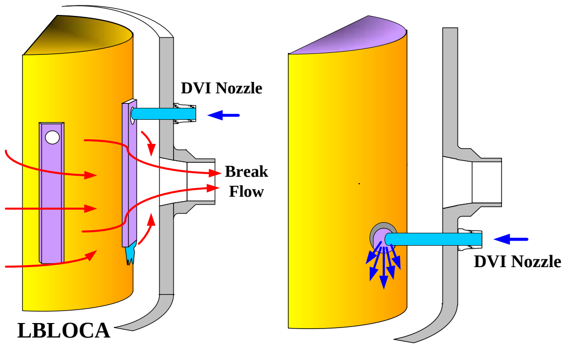
The ECC deflector of the AP1000 plant installed on the core barrel starts from the DVI nozzle at a lower downcomer annulus. The general shapes are shown in Fig.1

3. Test Results

3.1 Air-Water ECC Bypass Test

Test Conditions

To evaluate the ECC bypass performance of the ECC duct and the ECC deflector systems, the air-water 1/5-scale reactor downcomer model of the APR1400 is applied. The test loop has 4 cold legs, 2 hot legs blunt body, and 4 DVI nozzles. The reference plant is the APR1400 which is 2-loop pressurized light water reactor. The RCS of the APR1400 consists of 2 hot legs and 4cold legs. The DVI water injection velocity is fixed at 0.72 m/sec. The air velocities of 3 cold legs are varied from 5 m/sec to 20 m/s. The water level of the downcomer was controlled at low level.



(a) ECC duct (b) ECC Deflector

Fig. 1 ECC duct installation location

Test Results

The ECC direct bypass fractions are compared in Fig.2. The solid squared symbol represents the DVI-2 and DVI-4 combination for the 1/5-0scale air-water model of the APR1400. The total bypass fraction is about 42% at a velocity of 20 m/sec. The ECC direct bypass fraction hits about 68% for the combination of the DVI-3 and DVI-4 of 4-EDG system at the cold leg velocity of 18 m/sec. The ECC direct bypass is strongly mitigated when compared to the combination of the DVI-1 and DVI-4 injection. The results for the DVI+ duct system show that the ECC bypass performance of the 4-EDG system is lower than that of the 2-EDG system when the single failure assumption and the maintenance concept are applied at the same time during LOCA.

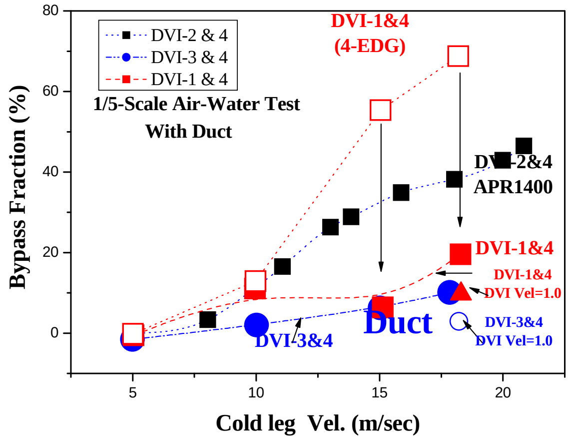


Fig. 2 ECC Bypass for DVI+ ECC Duct

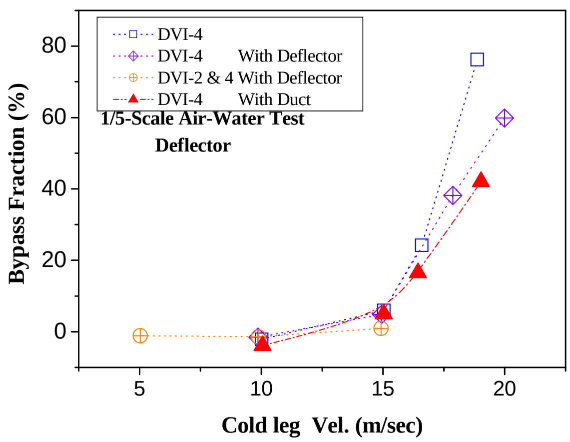


Fig. 3 ECC Bypass of the AP1000 ECC Deflector

Fig. 3 represents the performance of the AP1000's ECC deflector ECC system. The ECC deflector has the role of an ECC momentum directional controller. The direct bypass fraction of the ECC extension duct is about 10% for the velocity range of 0~15 m/s. while the ECC bypass fraction is increasing very sharply over 50~60 %.

In Fig. 4, the ECC bypass performance between the AP1000's ECC deflector and the DVI+ duct are compared. As shown in Fig.4, the ECC bypass fraction of the AP1000's ECC deflector is higher then that of the DVI+ duct in the velocity range of 15~20 m/s

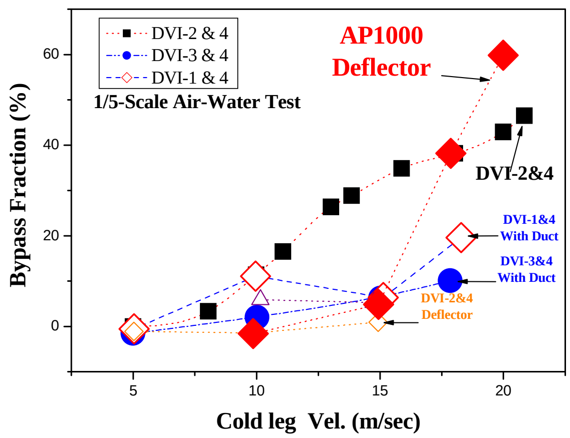


Fig. 4 Comparison of ECC Bypass between the AP1000's ECC Deflector and the DVI+ Duct

4. CONCLUSION

The ECC bypass fraction between the DVI+ and AP1000's ECC deflector systems was compared using an air-water test. The test results show that the ECC bypass fraction of the AP1000's ECC deflector systems is higher than that of the DVI+ system. To reduce the ECC direct bypass fraction for a high air-water or steam-water interaction flow field, the ECC penetration duct is a applicable feature for an advanced DVI system.

REFERENCES

1. T. S. Kwon, C. R. Choi, and C.-H. Song, "*Three-dimensional analysis of flow characteristics on the reactor vessel downcomer during the late reflood phase of a postulated LBLOCA", Nuclear Engineering and Design (NED)*, Vol. 226, pp.255-265(2003).

2. T. S. Kwon, C.-H. Song, B. J. Yun, and H. K. Cho, "*Effect of the Yaw Injection Angle on the ECC Bypass in Comparison with the Horizontal DVI", Nuclear Engineering and Design (NED)*, 225, pp.295-304(2003).

3. H. Glaeser, *"Downcomer and tie plate countercurrent flow in the Upper Plenum Test Facility(UPTF)", Nuclear Engineering and Design*, 133, 259-283 (1992).

4. T.S. Kwon et al, "Advanced DVI for ECC Direct Bypass Mitigation", *Nuclear Engineering and Design (NED)* Available online 9 March, 2009.