

3

Three Dimensional Thermal-Hydraulic Behavior in Downcomer and Lower Plenum during Refill Phase

, , , , ,

19

LOCA 3

GRS UPTF test-6 TRAC-M/F7 Ver. 5.5 가 . TRAC UPTF

test-6 , 3

TRAC

ABSTRACT

The objective of this study is to investigate on three-dimensional thermal-hydraulic behavior in downcomer and lower plenum during refill phase under LOCA condition. Regarding this, the UPTF test-6, which was conducted by the GRS in Germany, was simulated by using TRAC-M/F77 Ver. 5.5 computer code. The TRAC results were compared with the available experimental data of UTPF test-6. The TRAC analyses demonstrated the code's capability to predict three-dimensional thermal-hydraulic behavior in downcomer and lower plenum during refill phase, both qualitative and quantitative points of view. In addition, it was found that the code described well the major phenomena such as ECC bypass, liquid entrainment with steam in the downcomer, lower plenum penetration, etc. during refill phase.

1.

(Korean Next Generation Reactor, KNGR)
 (Direct Vessel Injection, DVI)

[1].

(Low

Pressure Safety Injection, LPSI) ,
(In-Containment Refueling Water Storage Tank, IRWST)
. DVI
(Loss of Coolant Accident, LOCA) (Emergency Core
Cooling System, ECCS) 가 , 가
가
DVI [2].
ECCS 가 10 CFR 50 Appendix K[3] I.C.1.c “ ”
I.D.4 “ECCS Water Steam Interaction”
, DVI
. DVI , RELAP5 TRAC [4],
가 [5].
가 DVI 가 가 (Refill)
(Reflood) 가 가 (Bypass) 3
, (Entrainment), (Downcomer Penetration), (Countercurrent Flow),
가 , 가
가 가 [6], DVI 가
가 , 가
DVI , (1)
가 , (2) 가 가 ,
(3) DVI
. (Lower
Plenum) 3 ,
가 가 가 3 3
가 가 UPTF (Upper Plenum Test
Facility) , Test-6 Run-133 가
[7]. Test-6 Run-133
(ECC Bypass), (Downcomer Penetration)

M/F77 [8] UPTF-DVI 가 TRAC-
 . Test-6 Run-133 가

2. UPTF TEST-6

UPTF 4- 1300 MWe 가 (PWR)
 (Steam Injector)가
 (Blowdown)
 . 4
 2
 UPTF Test 6
 Effect Test) , 5 가 (SET, Separate
 (Flooding)
 (ECC Bypass) 가
 . Run 133
 가
 -3 34 , 1, 2 42
 1 .

1. UPTF Test 6 Run 133

Parameter	Experiment	Calculation
Initial pressure in downcomer (kPa)	257	260
Downcomer wall temperature (K)	460	475
Lower Plenum Water Inventory (kg)	0	0
Pressure in drywell (kPa)	256	259
ECC temperature (K)	388~390	375-394
Total ECC injection rate (kg/sec)	1473	1332
Total nitrogen injection rate (kg/sec)	1	1
Core simulator steam mass flow rate (kg/sec)	110	168
Steam mass flow rate into steam generator simulators (kg/sec)	29~33	0

3. TRAC

3.1 TRAC

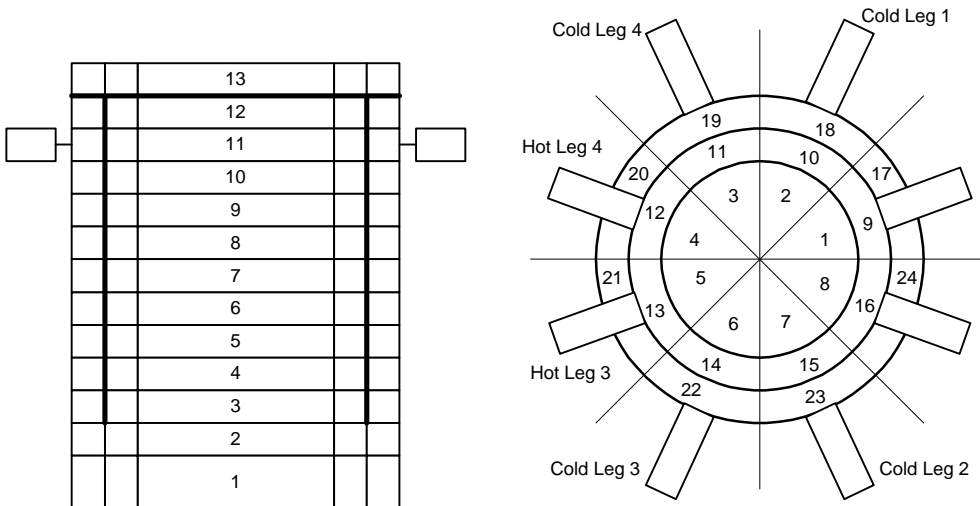
UPTF Test 6
 (Los Alamos National Laboratory)
 TRAC
 6
 . TRAC
 (Interfacial Heat Transfer)
 Equation)

가
 TRAC-M/F77 Ver.5.5 [8]

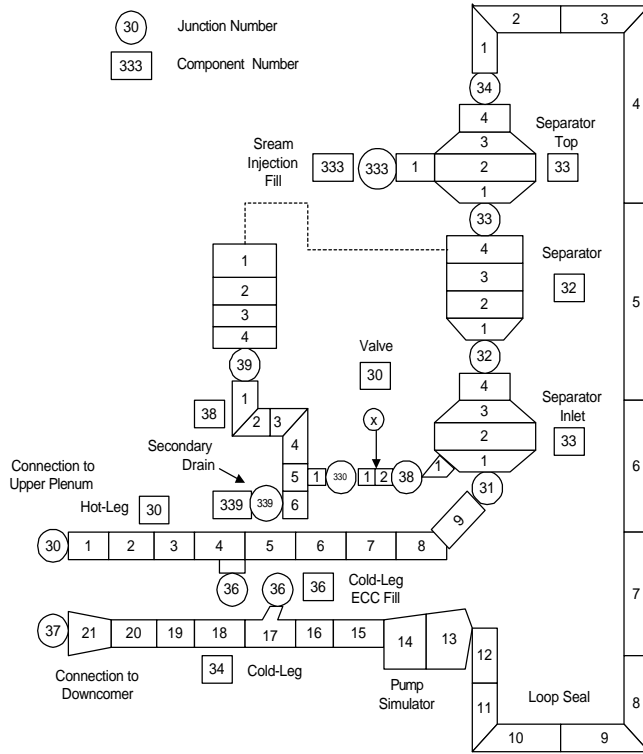
LANL
 , 2 -
 (Interfacial Drag),
 (Constitutive
 가 .

3.2 UPTF Test-6

UPTF Test-6 가 ,
 13 , 8 3
 1 .
 2 Test-6 .



1 UPTF



2 UPTF

4.

4.1.

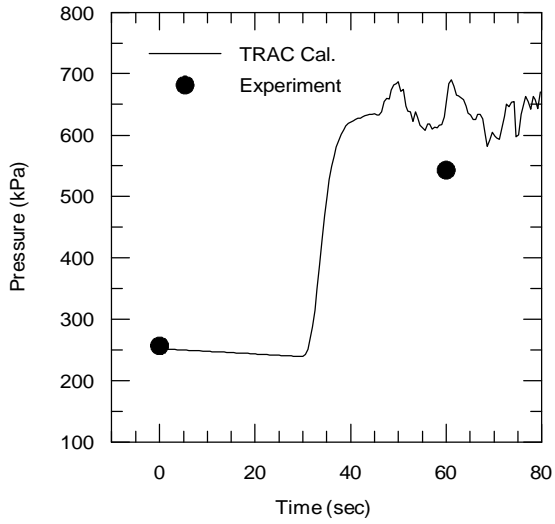
50 가 , 30 가 , 250 psia 가 , 60 가 , 3 가 , (subcooled)

TRAC “ (Condensation Oscillation)” kPa

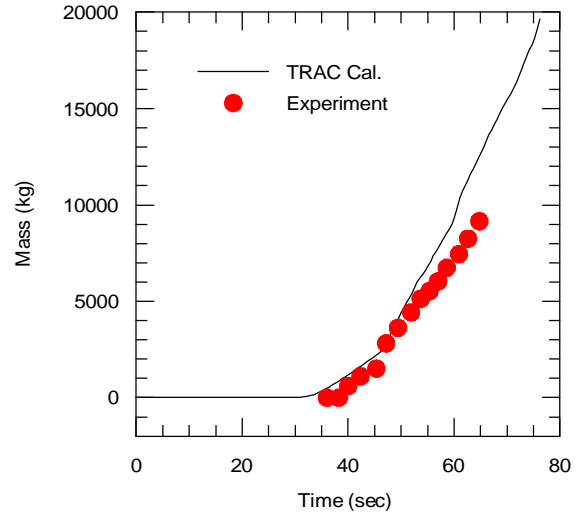
TRAC

4

TRAC



3



4

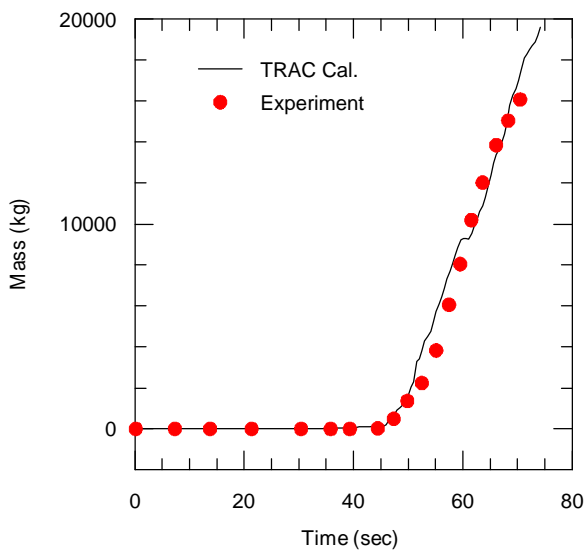
가 , TRAC 가 TRAC 가 , 30 가 . TRAC 가 45 .

4.2.

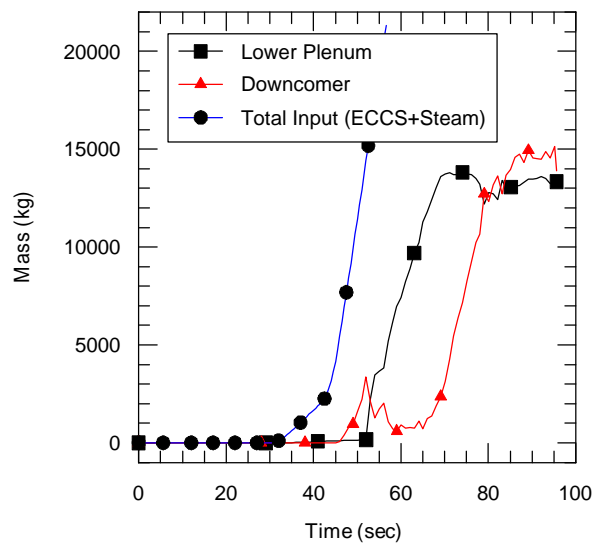
5

42

가 , TRAC 가 .



5



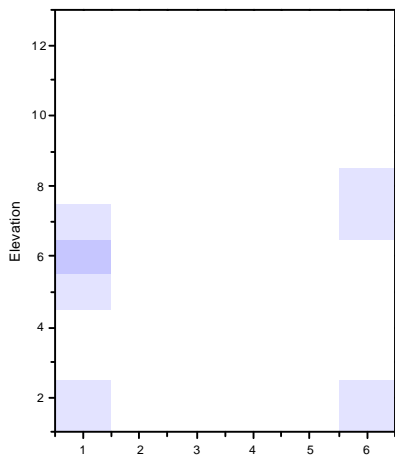
6

6 TRAC

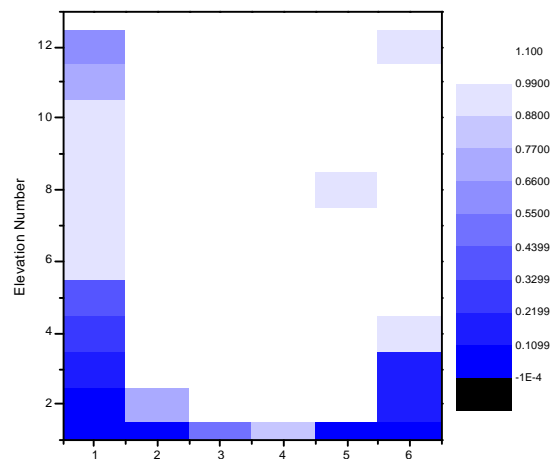
47 0 , 34 가
 (ECC Bypass)
 (Refill)가 47
 52 가
 가
 (Penetration)
 3000 kg 가
 (Lower Plenum Penetration)
 가
 (Entrainment) 55
 (Manometric Oscillation)

4.3 3

7 가 50 가
 75
 3 (Ring) , 가



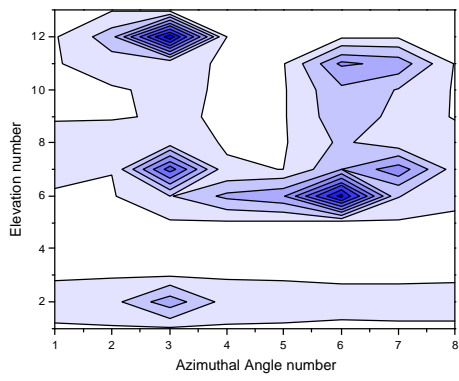
(a) 50



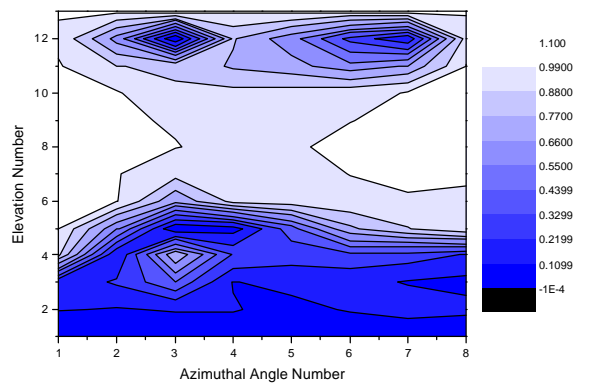
(b) 75

7.

가 50 가
 , 가
 75 가
 가
 3 가
 3 가
 8 가
 13 가
 8
 3 11 .50 (2,3)
 (Liquid Slug)



(a) 50

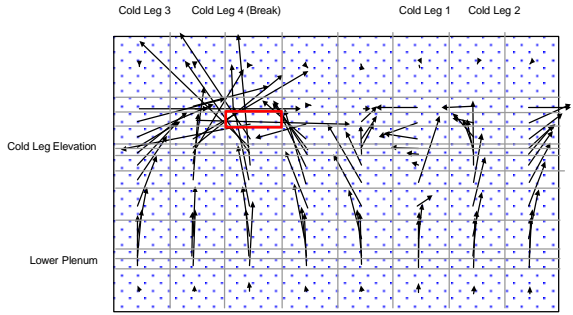


(b) 75

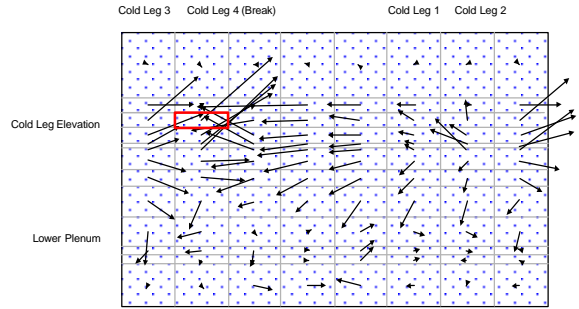
8 가 ()
 9 TRAC 50 50 75
 가 가
 (Liquid Slug) 75 50

가

50



(a) 50



(b) 75

9.

5.

가

가

3

3

TRAC-

M/F77

UPTF

가

1) TRAC-PF1/MOD2

3

가

UPTF

2)

가

3)

가

UPTF

[1] KEPCO, Korean Next Generation Reactor Standard Safety Analysis Report, Vol. 5, Feb. 1999

- [2] USNRC, *Final Safety Evaluation Report Related to the Certification of the System 80+ Design*, NUREG-1462, August 1994
- [3] United States Code of Federal Regulation, Appendix K to 10 CFR 50, *ECCS Evaluation Model*, September 1989
- [4] , TRAC-M/F77 가, '99, 1999. 10.
- [5] Chan Eok Park, et al., *An Estimation of ECC Bypass during the Reflood Phase of a Cold Leg Break LOCA in KNGR*, Proceedings of the KNS Autumn Meeting Seoul, Korea, October 1999.
- [6] USNRC, *Compendium of ECCS Research for Realistic LOCA Analysis*, NUREG-1230, December 1988.
- [7] M. Cappiello and L. Guffee, Red Star Report, Attachment 6, *Assessment Against UPTF Test 6 Run 133*, Los Alamos National Laboratory Memorandum Q-9, July 1988
- [8] J.W. Spore, et al., *TRAC-PF1/MOD2, Volume 1, Theory Manual*, LA-12031-M, NUREG/CR-5673, July 1993