

KALIMER

Safety Related Design Bases Events and Analysis Methodology for KALIMER

150

KALIMER (Korea Advanced Liquid Metal Reactor)

150 MWe (392 MWt)

KALIMER 가 가

Abstract

KALIMER (Korea Advanced Liquid Metal Reactor) is a 150 MWe (392 MWt) sodium-cooled pool-type metallic fuel reactor, which is being designed by Korea Atomic Energy Research Institute. KALIMER has advanced safety features superior to the previous liquid metal reactors. In this paper, recent safety issues regarding abroad pool-type liquid metal reactors were reviewed, and based on which event classification for licensing, safety related design bases events and acceptance criteria, and safety criteria for metallic fuel integrity were developed for KALIMER application, then methodology for safety analyses was discussed.

1.

()

, 1986

4 EBR-II [1] 가
가

KALIMER (Korea Advanced Liquid Metal Reactor) [2]

KALIMER 가

가

가 (HCDA: Hypothetical Core Disruptive Accident)

1.1

가 .

(1,000) 300 ,

가 .

가 가 ,

ATWS (Anticipated Transient Without

Scram) 가 , 가 (HCDA) 가 . HCDA

HCDA ,

가 (prompt neutron)

(prompt criticality)가 가 [3]. ,

(pool) KALIMER (loop) HCDA 가

, KALIMER

가

[4].

1.2

(swelling)

(irradiation) - (FCMI: Fuel Cladding Mechanical

Interaction) 가 , EBR-II ,

가

ANL (pyro-processing)

가

(ATWS)

가

bond 가 .

100 - 200 °C

(FCMI)

가

가 가

가

가 가

(UTOP)

1.3 KALIMER

KALIMER

[3]. , KALIMER

[5]

(defense in depth)

US ALWR [6]

가

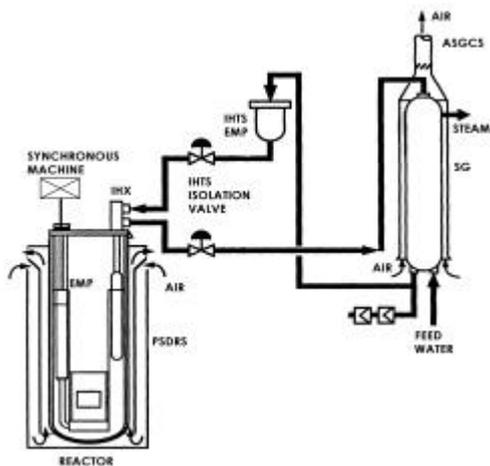
2. KALIMER

KALIMER

150 MWe (392 MWt)

KALIMER

19 m, 7.37 m



가

가

379

U-10%Zr

가

(Curie point)

가

1 KALIMER

SASS (Self-actuated Shutdown

System)가 , 6 가 (GEM)
 (IHX) (EMP)가 4
 , 2 (IHTS) 2
 (SG)가 (SGACS)

(Passive Safety Decay Heat Removal System, PSDRS)

PSDRS

1 KALIMER

(synchronous machine)가

3. KALIMER

(Design Bases Event, DBE)

가 가
 가 PRISM [7] 가
 , NRC [8]
 1 KALIMER [9]
 NRC 가 PRISM
 가 PSA
 가 가

1. KALIMER

Event Category	Frequency range (per reactor year) (nominal value)	Evaluation Criteria for Offsite radiological dose
1. Moderate Frequency Events (MFE)	$F \geq 10^{-1}$	US10CFR50 Appendix I
2. Infrequent Events (IE)	$10^{-1} \leq F < 10^{-2}$	US 10CFR50 Appendix I
3. Unlikely Events (UE)	$10^{-2} \leq F < 10^{-4}$	10 % of US10CFR100
4. Extremely Unlikely Events (EUE)	$10^{-4} \leq F < 10^{-7}$	US 10CFR100
5. Residual Risk Events (RRE)	$F < 10^{-7}$	US 10CFR100

(Moderate Frequency Events)

(Infrequent Events)

(Anticipated Operational Occurrences; AOOs)

가

Unlikely Events (Design Bases Event; DBA)
 NRC 가
 (single failure criterion) 가
 Extremely Unlikely Events (advanced reactor)
 DBE
 NRC 가 PRISM
 가 $10^{-7}/$ ($10^{-7}/$ $10^{-6}/$
 NRC 가
 $10^{-6}/$)
 가
 PRISM 가 가
 (Bounding Events; BE) [8] 2 EUE
 가 (best-estimate) NRC BE
 KALIMER PRISM
 2 BE , KALIMER 가

Residual Risk Events $10^{-7}/$
 (emergency plan)
 2. (Bounding Events)

BE-1.	(UTOP:Unprotected oerpower)
A -	
B -	(PSDRS)
BE-2.	(Station blackout)
-	, AC 24
BE-3.	(Protected loss-of-heat-sink events)
A - 12	100% RVACS
B - 75% RVACS	
BE-4.	(ULOF:Unprotected loss-of-flow)
A - 1	,
B - 1	, coastdown
BE-5.	(Steam generator tube rupture event)
BE-6. (Na)	(Large sodium leaks)
BE-7.	(Flow blockage)
BE-8.	(External events)

4. KALIMER

4.1

(DBE) (Beyond DBE)
 PSA KALIMER
 , 가가
 KALIMER 가
 PSA , BDE
 DBE BDBE ATWS
 가 가
 KALIMER
 (deterministic)
 2 (BE)

4.2

BOP (Balance of Plant)
 , 가
 가 ,
 가 ,
 1 IE, UE DBE , EUE
 . EUE .2 BE
 DBE DBE ,
 (deterministic)
 [9].
 (1) : 100% 가 가
 가 , 가 가
 1 IE , 가 UE DBE 가
 가 가 가
 EUE BE-1
 (2) (Loss of heat sink)
 (a) (Loss of Normal Shutdown Cooling): KALIMER
 ,
 (SGACS)

- PSDRS 가 . PSDRS IE , PSDRS
 가 EUE BE-3 .
- (b) IHX SG :
 IE UE
 가 EUE (SWRPRS)
 BE-5
 , BOP IE .
 가
- (3) : (coastdown) IE
 가
- BE-4
- (4) :
 가 가 PSDRS
 24 UE , 24 EUE BE-2 .
- (5) : UE DBE ,
- EUE BE-6 .
- (6) : 가
 가 , 2 ,
 IE .
- UE DBE , 가 EUE . 1
 가 BE-7 .
- (7) : IE DBE
 가
- (8) 가 : 가
 . IE DBE ,
- 가
- (9) : DBE IE , SSE (Safe Shutdown Earthquake) SSE
 가 UE , EUE
 . PSDRS 가 BE-8 .

43

NRC PRISM 가 , 가

100%

1.5-2 %

(1) BE-1: (Unprotected Transient Overpower Events)

가 12 가

가

BE-1A : 가

(shim motor)가

PKALIMER (control rod stop system; CRSS)

가 2 C ,

1 (shim motor)

BE-1B: PSDRS

PSDRS 가 BE-1A 가

(GEM) 가

(2) BE-2: (Station Blackout)

, 24

가 PRISM 가

GEM 가

(3) BE-3: (Loss of Heat Sink Events)

SGACS ,

가

BE-3A - (sabotage) PSDRS 가 12 가

BE-3B - PSDRS 가 75% 가

12

(divider wall),

(silo wall) , PSDRS

가

(4) BE-4: (Unprotected Loss-of-Flow, ULOF)

BE-3A - 1

BE-3B - 가 , 1
(coastdown) 10
1 가

가
가
가 가

(5) BE-5: (Steam Generator tube rupture event)

12

가 가
가 가

(6) BE-6: (Large Sodium Leakss)

가

(7) BE-7: (Flow Blockage to or from one Fuel Assembly) -

KALIMER

(1)

, (2)

, (3)

가 receptacle , (4)

(orifice stack plate)

, (5)

, (6) Wire wrapped rod bundle

(local Fault)

가

가

가

가

가

가

가

가

(8) BE-8:

DBE

가

4.4

KALIMER 가 가
 KALIMER 가
 DBE KALIMER KALIMER
 [9, 12] : (1)
 (2) / (3) (strain)
 (creep rupture) (4) ()
 (5) (BE) : (1)
 (가) (2) (3)
 가 , 가
 : (1) () (2)
 (3) (4)
 PRISM ,
 가 PRISM 가 가
 가
 -HT9
 (feed back)
 (hot channel)
 KALIMER 가 가

5.

KAERI SSC-K [13]
 SSC-K BNL CRBR (Clinch River Breeder Reactor) [14]
 SSC [15] KALIMER
 SSC-K 가 SSC-K
 [16]
 point kinetics
 , GEM (Gas Expansion

Modular) [17] SSC-K 가 . GEM 가
 가 , 가
 GEM 가 가 가 GEM .
 KALIMER [18]
 , [19] . KLAIMER
 , , , ,
 , (reflector) (shield) , ,
 12 , 2 (lower shield
 region), 6 , 4 가 (gas plena) .
 4
 ,
 . KALIMER . BNL SSC CRBR
 CRBR
 . KALIMER
 3 . COMMIX-1AR/P[20], SABRE [21], MATRA-
 LMR [22]

6.

KALIMER PRISM
 가 가 , PRISM NRC 가
 KALIMER . KALIMER NRC
 .
 KALIMER 가
 (DBE)
 , . KALIMER
 KALIMER 가

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