

# ICRP-60

가

## Radiological Consequences from KNGR Design Basis Accidents Based on the Framework of Alternative Source Term and ICRP-60

360-9

NRC DBA TID-14844 Regulatory Guide 1.4, 1.25, 1.77, NUREG-1465 Regulatory Guide 1.183 1995 2000, NUREG-1465

1990 ICRP 가

ICRP-60 DBA ICRP-60 가 DBA 가 가

### Abstract

In 1995 and 2000, NRC issued the accident source term of NUREG-1465[1] and Regulatory Guide 1.183[2], as an alternative source term (AST) to TID-14844[3] and Regulatory Guide 1.4[4], 1.25[5], and 1.77[6], to assess radiation dose from design basis accidents (DBA). The alternative source term of NUREG-1465 was developed as a representative source term to reflect the insight of a few ten years research on severe accidents. ICRP did an important role to develop and to change the standards on radiation protection. In 1990, ICRP published ICRP-60[7] as a baseline to assess radiological effects on human body and published succeeding ICRP recommendations. The methodology to assess the radiation exposure to human body has been changed with improvement of knowledge on interactions between radiation exposure and human body. In Korean Next Generation Reactor (KNGR) Project, the framework of AST and ICRP-60 is being applied to assess radiation doses from DBAs. In this paper, the radiation doses from DBAs were estimated based on the different frameworks of accident source term and dose assessment. The results were compared each other and the design margin of KNGR was evaluated.

1.

NRC DBA  
 TID-14844 Regulatory Guides 1.4,  
 1.25 1.77  
 NUREG-1465 Regulatory Guide 1.183  
 1995 2000  
 NUREG-1465

LOCA

가

ICRP . 1990 ICRP  
 가

ICRP-60 DBA

ICRP-60  
 가

가

ICRP-60 가

가

ICRP-60 가

2. DBA

가

가

(Exclusion Area Boundary, EAB)가

가

가

(DBA)

가가

DBA

- (Steam Line Break, SLB)
- (Feedwater Line Break, FWLB)
- (RCP Locked Rotor, RCP LR)
- (Control Rod Ejection Accident, CEA)
- (Letdown Line Break, LDLB)
- (S/G Tube Rupture, SGTR)
- (LOCA)
- (Fuel Handling Accident, FHA)

2.1

가

DBA

가

가

가

- LOCA
- DBA LOCA
- 가

$$\dot{Q}_{in} = f_{rel} \cdot A_{core}$$

(TID-14844

Reg. Guide 1.4)

NRC

$\dot{Q}_{in}$  :  
 $f_{rel}$  :

. NRC

NUREG-1465

NUREG-1465

가

$A_{core}$  :

NUREG-

1465

가 ,  
 가

2-1

가

1

2-  
 LOCA

2-2

Non-LOCA

- Non-LOCA  
 Non-LOCA

2-3

2-2

2-3

- 가

LOCA

2-2

$$C_{rcs} = F_{pp} (f_{fm} + f_{ff} \cdot f_{gap}) \frac{A_{core}}{M_{rcs}} + C_{rcs-TS}$$

가

- 가

$$C_{rcs} = F_{pis} \cdot C_{rcs-TS}$$

가

,  $f_{fm}$ ,  $f_{ff}$ ,  $f_{gap}$

가

$F_{pp}$ ,  $F_{pis}$  Power Peaking Factor  
 Iodine Peaking Factor

2-1.

.  $C_{rcs}$ ,  $C_{rcs-TS}$

Tech.

Spec.

$M_{rcs}$

LOCA	TID-14844 Reg. Guide 1.4	NUREG-1465
Non-LOCA	Reg. Guide 1.25 Reg. Guide 1.77 SRP 15	Reg. Guide 1.183 SRP 15.0.1

2-2. LOCA

		TID-14844	NUREG-1465
		PWR BWR	PWR, BWR
		100%	100%
			(1.8hr)
		3	8
( )		100% 50% -	100% 40% 30% (Cs, Rb)
		91 % 4 % 5 %	4.85 % 0.15 % 95 %
		ANSI/ANS-56.5 SRP-6.5.2	NUREG/CR-5966 NUREG/CR-6189

NUREG/CR-5966[8]      NRC  
NUREG/CR-6189[9]

Non-LOCA      2-3

(Cs, Rb)      가

2.2      가

(EAB),      DBA      (LPZ)      가

2-3. Non-LOCA

		1]	2]
		R.G 1.25 R.G 1.77	R.G 1.183
( )	Kr-85 N.G I-131	10 (30) % 10 % 10 % 10 % -	10 % 5 (10) % 8 (10) % 5 (10) % 12 (0) %
( / )		91 % 4 % 5 %	4.85 % 0.15 % 95 %
( / )		99.75 % 0.25 % -	97 % 3 % -

- ( )  
 $D_{off,in} = (x/Q)_{off} \cdot BR \cdot \sum_i (F_{i,in} \cdot Q_i)$
  - ( )  
 $D_{off,ex} = (x/Q)_{off} \cdot \sum_i (F_{i,ex} \cdot Q_i)$
- $D_{off,in}, D_{off,ex} :$
- $D_{on,in}, D_{on,ex} :$
- $F_{i,in}, F_{i,ex} :$       i      ( )      ( )
- $x/Q_{off} :$
- $Q_i :$
- $BR :$

1]      FHA  
2]      CEA

DBA

DBA  
,  
,  
,  
가  
가  
(ICRP) 가 ICRP  
가 ICRP  
가 DBA 가  
2-4  
2-5  
2-6

2-5.

( : rem/Ci)

I)	TID-14844 R.G 1.109 [12]		FGR No.11 [13]	ICRP-68 [14] ICRP-71 [15]
I 131E	1.48E+06	2.56E+03	-	7.40E+04
I 132E	5.35E+04	1.45E+02	-	1.15E+03
I 133E	4.00E+05	5.65E+02	-	1.48E+04
I 134E	2.50E+04	7.69E+01	-	5.55E+02
I 135E	1.24E+05	3.21E+02	-	3.40E+03
I 131O	-	-	-	5.55E+04
I 132O	-	-	-	7.03E+02
I 133O	-	-	-	1.15E+04
I 134O	-	-	-	1.85E+02
I 135O	-	-	-	2.52E+03
I 131P	-	-	3.29E+04	2.81E+04
I 132P	-	-	3.81E+02	3.55E+02
I 133P	-	-	5.85E+03	5.55E+03
I 134P	-	-	1.31E+02	1.78E+02
I 135P	-	-	1.23E+03	1.22E+03
Rb 86	-	7.37E+03	3.44E+03	3.44E+03
Cs134	-	9.10E+04	4.63E+04	2.52E+04
Cs136	-	1.38E+04	7.33E+03	4.81E+03
Cs137	-	5.35E+04	3.19E+04	1.78E+04

<sup>1)</sup> E : elemental, O : organic, P : particulate

2-6.

( : rem-m<sup>3</sup>/Ci-sec)

2-4. 가

가	가		
가	ICRP-9[10] (1959)	ICRP-26[11] (1977)	ICRP-60 (1990)
		가 가 ALARA	가
가	가		가
			<sup>1)</sup>
	TID-14844 R.G 1.4 R.G 1.109	ICRP-30 EPA FGR No.11 EPA FGR No.12	ICRP-68 ICRP-71 ICRP-72 ICRP-74

<sup>1)</sup> =

I)	R.G 1.4 R.G 1.109		FGR No.12 [16]	ICRP-72 [17]
KR85M	4.63E-02	2.49E-02	2.77E-02	2.53E-02
KR85	4.25E-02	5.58E-04	4.40E-04	9.42E-04
KR87	3.08E-01	1.96E-01	1.52E-01	1.46E-01
KR88	7.51E-02	4.84E-01	3.77E-01	3.60E-01
XE131M	1.51E-02	5.02E-03	1.44E-03	1.37E-03
XE133M	3.15E-02	1.04E-02	5.07E-03	4.71E-03
XE133	9.70E-03	1.13E-02	5.77E-03	5.14E-03
XE135M	2.25E-02	1.08E-01	7.55E-02	6.85E-02
XE135	5.90E-02	6.16E-02	4.40E-02	4.11E-02
XE138	1.31E-01	2.74E-01	2.13E-01	2.01E-01
I 131E	-	9.51E-02	-	-
I 132E	-	5.65E-01	-	-
I 133E	-	1.51E-01	-	-
I 134E	-	6.51E-01	-	-
I 135E	-	3.89E-01	-	-
I 131O	-	-	-	-
I 132O	-	-	-	-
I 133O	-	-	-	-
I 134O	-	-	-	-
I 135O	-	-	-	-
I 131P	-	-	6.73E-02	-
I 132P	-	-	4.14E-01	-
I 133P	-	-	1.09E-01	-
I 134P	-	-	4.81E-01	-
I 135P	-	-	2.95E-01	-
Rb 86	-	1.78E-02	1.78E-02	-
Cs134	-	3.89E-01	2.80E-01	-
Cs136	-	5.42E-01	3.92E-01	-
Cs137	-	5.84E-01	4.48E-01	-

<sup>1)</sup> M : meta stable, E : elemental, O : organic,  
P : particulate

**3. DBA**

가

DBA

가

3-1

**4. DBA**

가

DBA

ICRP-60

[22].

DBA

1997 1

가

가

ICRP-26

가

, DBA

2000-08 [18]가

**4.1**

가

TID-14844 Reg. Guide 1.4

2

DBA

가

DBA

가

4-1

3가

[19].

4-1

Case A

가

98-12 [20]

2001-02 [21]

ICRP-60

(Thyroid Dose)

가

(Whole Body Dose)

가

Case B

(1997

)

가

ICRP-60

( )

(Total

**3-1. DBA**

가

Effective Dose Equivalent)

Case C

가

가		
(LOCA)	2000-08	10CFR50 NUREG-1465 R.G 1.183
(Non-LOCA)	SRG 15 <sup>1)</sup>	R.G 1.183 SRP 15.0.1
	SRG 15 ( , )	R.G 1.183 SRP 15.0.1 ( )

<sup>1)</sup>

Reg.

Guide SRP 15

. Case C

(Total Effective

Dose)

가

가

• 2000

(EAB)

가

•

EAB

(0-

- 2hr) :  $8.92 \times 10^{-4} \text{ sec/m}^3$
- : 0.15 vol%/day
- Non-LOCA 가 , Case B C
- Iodine Spiking , Tech. Spec.
- LOCA (Spray Removal Containment Mixing) 2-2 Case A SRP-6.5.2 Case B Case C NUREG/CR-5966[8] STAR NAUA
- Non-LOCA 4-2 .
- Non-LOCA 2 4-3 [23,24].
- LOCA STARDOSE [25] Case A 2 , Case B Case C 가 2 가 , Non-LOCA 가
- Case C FGR No.12

4.2 가

DBA 4-1 , 4-4 가 EAB 4-5

4-2 . Case A , Case B C

4-1. 가

Case			
Case A	R.G 1.4	ICRP-9	
Case B	R.G 1.183	ICRP-26	
Case C	R.G 1.183	ICRP-60	

4-2. <sup>1)</sup>

RCS->SG->	SG Tube	Dried	Undried
		1	Flashed : 1 Unflashed : 100
		1	100
RCS->		Flashed : 1 Unflashed : 100	
RCS->			
SFP->	500		

<sup>1)</sup> 1

4-3. Non-LOCA ( 2 )

DBA	RCS		
	(%)	(lbm)	
SLB(FP) <sup>1)</sup>	1.0	540	RCS->SG
SLB(ZP) <sup>2)</sup>	0.0	540	RCS->SG
FWLB	0.0	540	RCS->SG
RCP LR	4.0	540	RCS->SG
CEA	15.0	3772	RCS->CTMT 540
LDLB	0.0	41700	RCS->Env 540
SGTR(LOOP)	0.0	72200	RCS->SG
SGTR (LOOP+SF)	0.0	289700	RCS->SG
FHA <sup>3)</sup>	0.415	6.3E+05	SFP->FHA

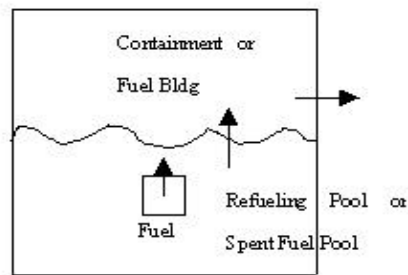
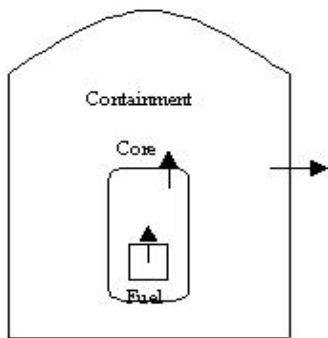
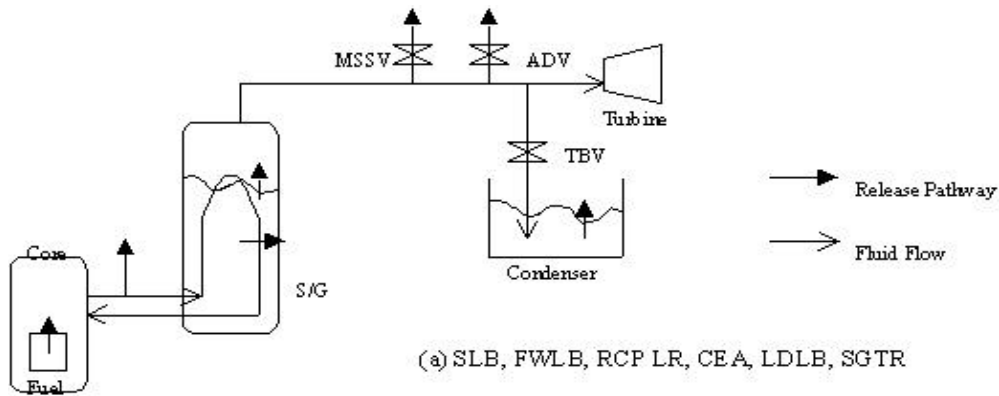
<sup>1)</sup> FP : SLB during Full Power Operation  
<sup>2)</sup> ZP : SLB during Zero Power Operation  
<sup>3)</sup> FHA 1

4-4. 가 DBA 가

Case	I <sup>1)</sup>	DBA (Ci) <sup>2)</sup>				
		LOCA	SLB(FP)	FWLB	CEA	SGTR(LOOP)
Case A	Xe-133	3.88E+04	1.19E+03	9.70E+01	4.87E+03	1.29E+04
	I-131E	1.09E+03	2.94E+02	5.55E+01	2.41E+01	6.22E+01
	I-131O	1.84E+02	1.39E+00	1.44E-01	5.80E+00	3.83E+00
	I-131P	6.29E+01	-	-	-	-
	Cs-137	-	-	-	-	-
Case B Case C	Xe-133	1.86E+04	5.49E+02	9.70E+01	4.87E+03	1.29E+04
	I-131E	3.20E+01	2.34E+02	5.40E+01	2.34E+01	6.05E+01
	I-131O	5.55E+00	1.35E+01	1.73E+00	6.96E+01	4.60E+01
	I-131P	6.23E+02	-	-	-	-
	Cs-137	8.76E+01	5.59E+01	1.85E-01	2.00E-03	6.76E-01

<sup>1)</sup> E : Elemental, O : Organic, P : Particulate

<sup>2)</sup> 2 (LOCA 가 2 )



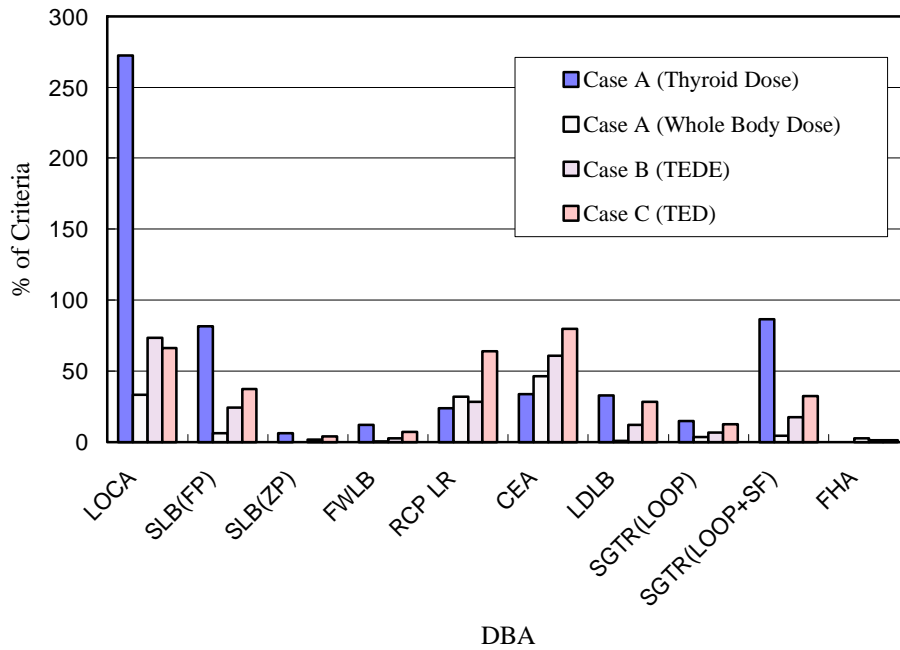
4-1. DBA



4-5. 가 DBA 가

DBA	(rem)		<sup>1)</sup> (rem)		/ (rem)			
	Case A		Case A		Case B	Case C		
	LOCA	817.5	300.0	8.3	25.0	18.3	16.5	25.0
SLB	Full Power	244.1	300.0	1.5	25.0	6.0	9.3	25.0
	Zero Power	18.4	300.0	0.022	25.0	0.4	0.9	25.0
FWLB	35.9	300.0	0.04	25.0	0.7	1.7	25.0	
RCPLR	7.1	30.0	0.8	2.5	0.7	0.9	2.5	
CEA	25.2	75.0	2.9	6.25	3.8	5.0	6.25	
LDLB	9.8	30.0	0.02	2.5	0.3	0.7	2.5	
SGTR	LOOP	44.3	300.0	0.8	25.0	1.6	3.1	25.0
	LOOP+SF	259.0	300.0	1.1	25.0	8.0	16.0	25.0
FHA	0.07	75.0	0.15	6.25	0.08	0.08	6.25	

<sup>1)</sup>



4-2. DBA 가

LOCA 4-4 5.  
 Non-LOCA 가 , ICRP-60 가  
 가 , ICRP-  
 4-2 4-5 60 DBA  
 Case A LOCA 가  
 가 ( )가 가  
 , SLB SGTR(LOOP+SF) 가 .  
 TID-14844 ICRP-9  
 Case B Case C DBA  
 가 가 ICRP-60  
 Case A RCP LR, CEA, FHA DBA  
 ICRP-60  
 ( ,  
 ) Case B Case C 가  
 NUREG-1465  
 Case B 가 가 . Non-  
 ICRP-26 2-5 LOCA .  
 가 , LOCA TID-14844  
 NUREG-1465 , 가  
 Case C LOCA NUREG-1465  
 Case B LOCA 가 .  
 . LOCA NUREG-1465  
 LOCA  
 ICRP-60 , NRC  
 ICRP-26 LOCA  
 RCP LR CEA Case A case B  
 가 가

6.
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  - 4) Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors", Rev.2, US NRC, 1974.
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  - 18) 2000-08 , " , , , 2000.
  - 19) " (III) - - , 2000.
  - 20) 98-12 , " , , 1998.
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  - 22) KNGR(III), N-001-END461-001, "Technical Report : New Source Term Study Report", Rev.A, KOPEC, 10/30/2000.
  - 23) KNGR(III), Memo from KOPEC/NSSS to KOPEC/AE, NND/ES-00064M, " 3 Offsite , 11/07/2000.
  - 24) KNGR(III), Memo from KNFC to KOPEC/AE, NFD/ES-00087M, " 3 Dose Analysis , 11/02/2000.
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