Steam Generator Replacement of Hanul Plant Unit 3, 4

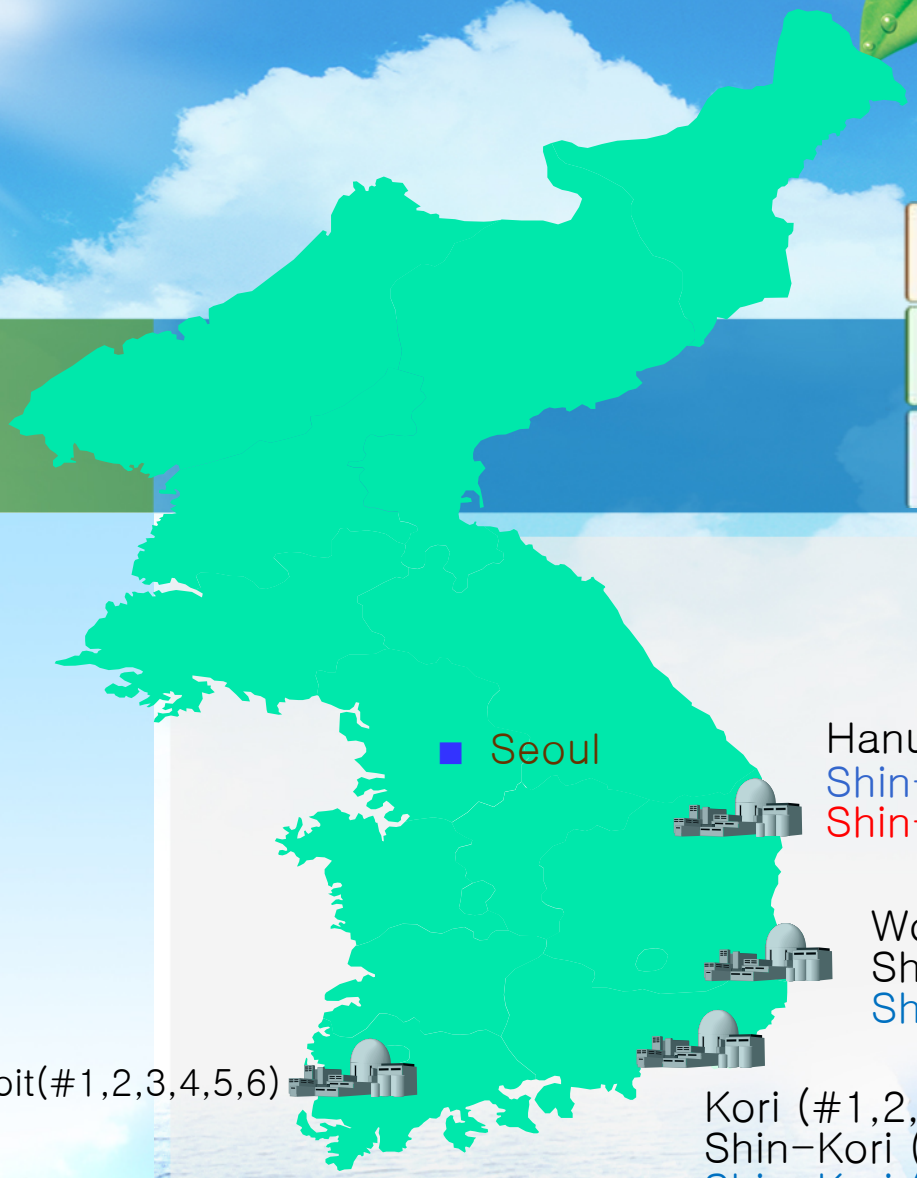
Radiation Safety Management

KHNP

JEONG-SEOP LEE

KHNP

In operation	**23 units** (20,716 MW)
under construct.	**5 units** (6,600MW)
planning	**4 units** (5,600 MW)



Hanul (#1,2,3,4,5,6)
Shin-hanul (#1,2)
Shin-hanul (#3,4)

Wolsong (#1,2,3,4)
Shin-Wolsong (#1)
Shin-Wolsong (#2)

Hanbit(#1,2,3,4,5,6)

Kori (#1,2,3,4)
Shin-Kori (#1,2)
Shin-Kori (#3,4)
Shin-Kori (#5,6)

Contents

1. Introduction

Goal

- Secure the radiation safety
- Minimize the Radioactive Waste Generation during SGR

(*SGR : Steam Generator Replacement)

SGR Period

Hanul unit 3 (12th O/H)	Hanul unit 4 (10th O/H)
2014. 3. 24 ~ 2014. 9. 30 (191days)	2013. 5. 10 ~ 2013. 8. 2 (84days)

2. Main Process of SGR

1 Installation of the refueling pool cover

2 Preparation of the construction materials

3 Installation of the temporary auxiliary crane

4 Installation of the scaffold & Removal of the insulation

5 Installation of shielding materials & fixing device

6 Cutting the main steam pipes

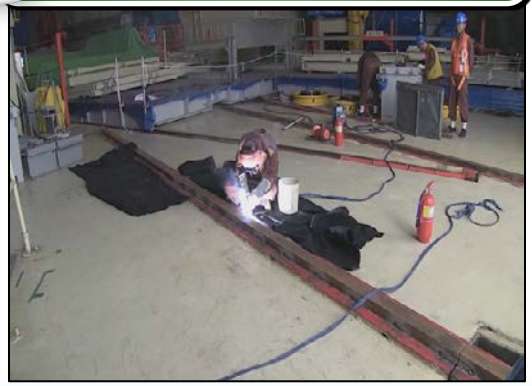
2. Main Process of SGR

7 Disassembly of the PWR

8 Disconnection of S/G upper fixture

9 Marking the cutting area of RCS pipes

10 Installation of the rail

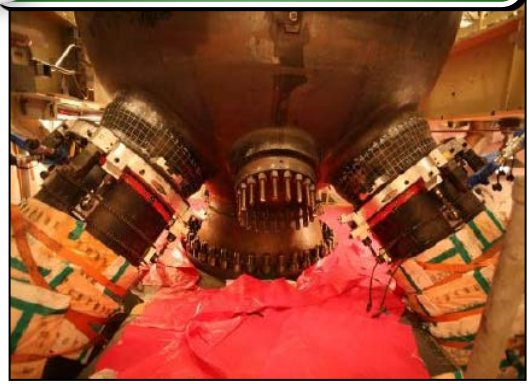


11 Installation of the lifting equipment (TLD/HLU)

12 Disconnection of S/G lower fixture

2. Main Process of SGR

13 Cutting the RCS pipes



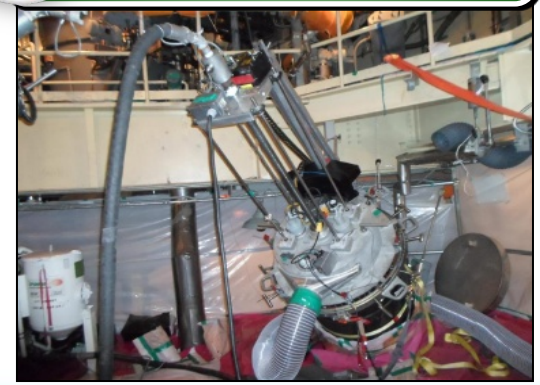
14 Coating the S/G surface

15 Preparation of taking out S/G from RCB

16 Taking out the S/G

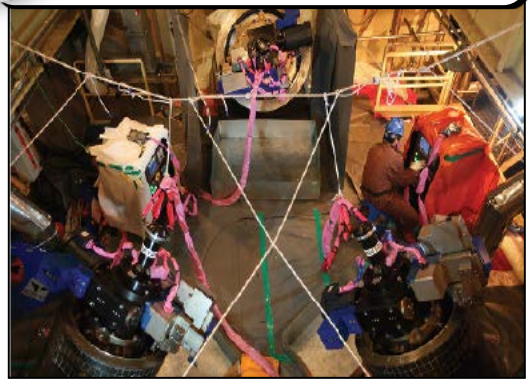
17 Storage of the S/G in OSGSF

18 Decontamination of the inside of RCS end pipes



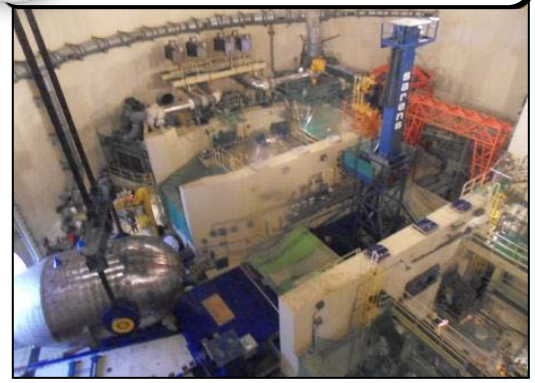
2. Main Process of SGR

19 Processing of RCS pipe cutting planes



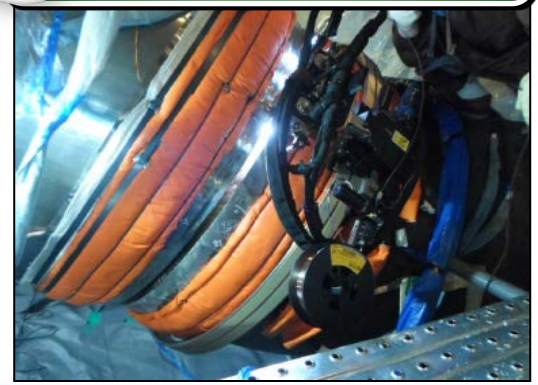
20 New S/G transportation

21 Bringing of the new S/G into RCB



22 Fitting up of the new S/G on the RCS pipes

23 New S/G and RCS pipes outside welding



24 RCS pipe inside welding

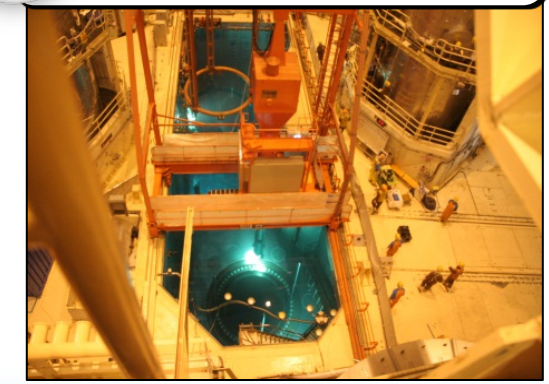
2. Main Process of SGR

25 Inspection & removal of foreign materials

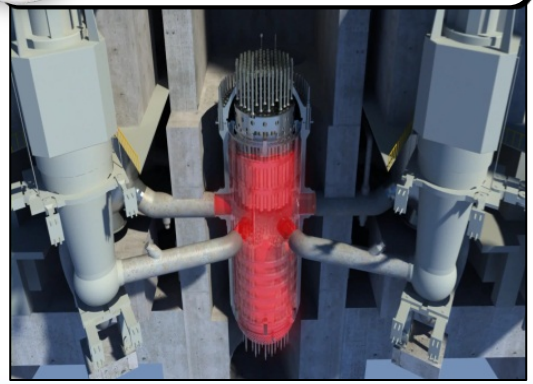
26 Welding of the MS/FW pipes

27 Installation of the insulation materials

28 Loading of the nuclear fuel



29 Reactor start-up



30 Starting power operation

3. Radiation Safety & Dose Management

Dose Management Goal

- Individual dose : ≤16 mSv/y
  - Unavoidable case of excess exposure : ≤20 mSv/y
  - Legal limit : ≤50 mSv/y, ≤100 mSv/5y

The highest record of individual dose

	Works	Individual dose (mSv)
Hanul Unit 3	Welding of the RCS Pipes	6.87
Hanul Unit 4	Welding of the RCS Pipes	5.0

3. Radiation Safety & Dose Management

Internal exposure during the SGR period

	Number of worker	Works	dose (mSv)
Hanul Unit 3	1	RCS pipe inside decontamination	0.25
Hanul Unit 4	0	-	-

Managing the worker

- The Internal exposure dose ranges in from 0.1 to 1 (mSv)
  - Record a dose level of the internal exposure
  - Manage the workers more carefully

3. Radiation Safety & Dose Management

Collective Dose (man-mSv)

	SGR		Note
	Goal	Result	
Hanul Unit 3	680	588	Start the SGR during Overhaul simultaneously
Hanul Unit 4	210	179	Decrease of dose rate in Hanul Unit 4 because of long-term shutdown (about 600d)
Hanul Unit 1	930	885	Start the SGR during Overhaul simultaneously
Hanul Unit 2	815	812	Start the SGR during Overhaul simultaneously
Kori Unit 1	-	1,516	Start the SGR during Overhaul simultaneously
Oconee Unit 1	-	1,050	
St.Lucie Unit 2	-	1,070	
Ringhals Unit 3	-	1,326	

3. Radiation Safety & Dose Management

A collective dose in SGR

(man-mSv)

Works	Hanul Unit 3 (12th O/H)			Hanul Unit 4 (10th O/H)		
	Goal	Result	(%)	Goal	Result	(%)
Pipe works (FW/MS/LI)	65.00	49.34	75.91	5.00	3.41	68.20
RCS pipes Clamping & supporting	56.00	69.98	124.96	15.00	13.99	93.27
RCS pipes Cutting, Grinding, welding and replication	284.00	289.92	102.08	120.00	106.57	88.81
RCS Pipes inside decontamination	50.00	37.99	75.98	10.00	7.56	75.60
Removal/Installation of insulation materials on the S/G & pipes	50.00	23.81	47.62	3.00	4.56	152.11
OSG movement, load & unload, transport and RSG installation	12.00	6.42	53.50	4.00	3.79	94.75
OSG outside cleaning, decontamination, coating and shielding	17.00	11.99	70.53	2.00	0.79	39.50
Installation/Removal of the shielding materials	33.00	13.42	40.67	7.00	3.93	56.11

3. Radiation Safety & Dose Management

A collective dose in SGR

(man-mSv)

Works	Hanul Unit 3 (12th O/H)			Hanul Unit 4 (10th O/H)		
	Goal	Result	(%)	Goal	Result	(%)
Removal of the S/G residual water & Welding of the primary nozzle sealing surface	7.00	5.49	78.43	2.00	1.60	80.00
Movement and Storage of construction materials and crane works	14.00	9.07	64.79	2.00	1.61	80.50
Mechanical measurement and inspection	12.00	5.36	44.67	5.00	3.33	66.60
Removal/Installation of S/G support fixture and Platform	66.00	12.41	88.64	7.00	4.90	70.03
Others	14.00	12.41	88.64	28	23.62	84.3
Total	680.00	588.27	86.51	210.00	179.66	85.55

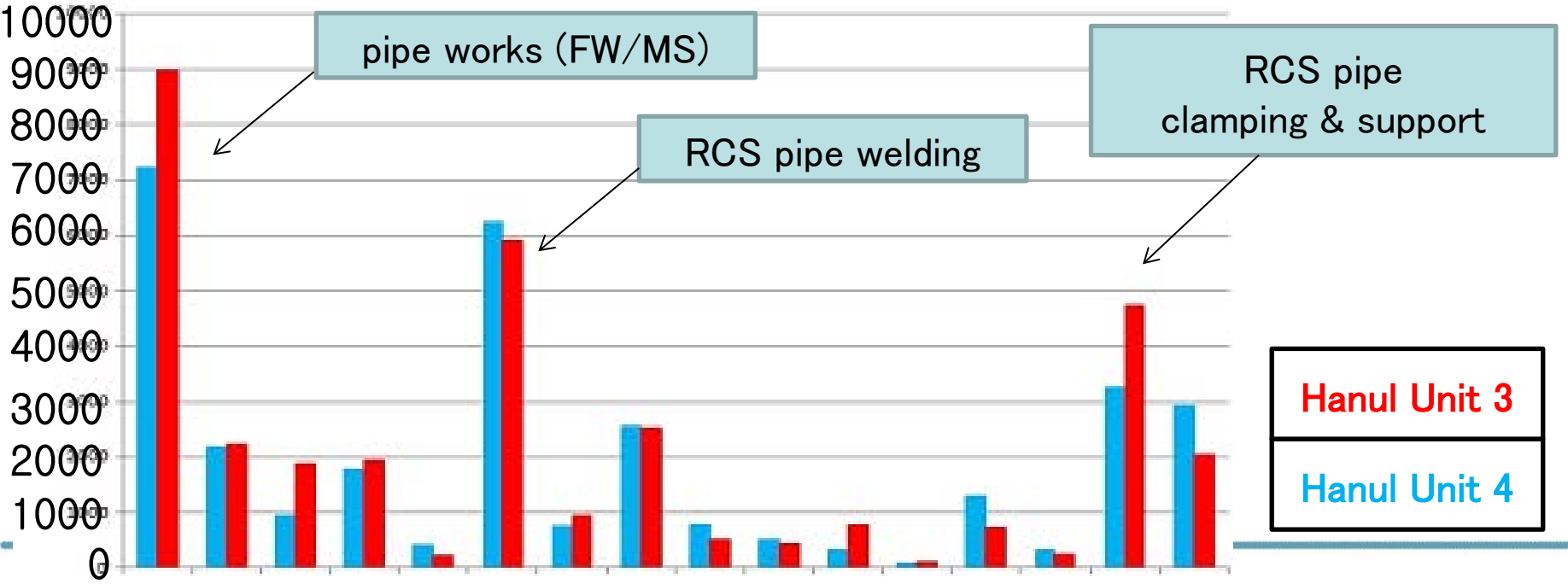
3. Radiation Safety & Dose Management

A number of gate access to RCA during SGR period

(Unit : counts)

	Hanul Unit 3 (12th O/H)	Hanul Unit 4 (10th O/H)
Daily maximum	687	728
Daily average	317	333

(Unit : counts)



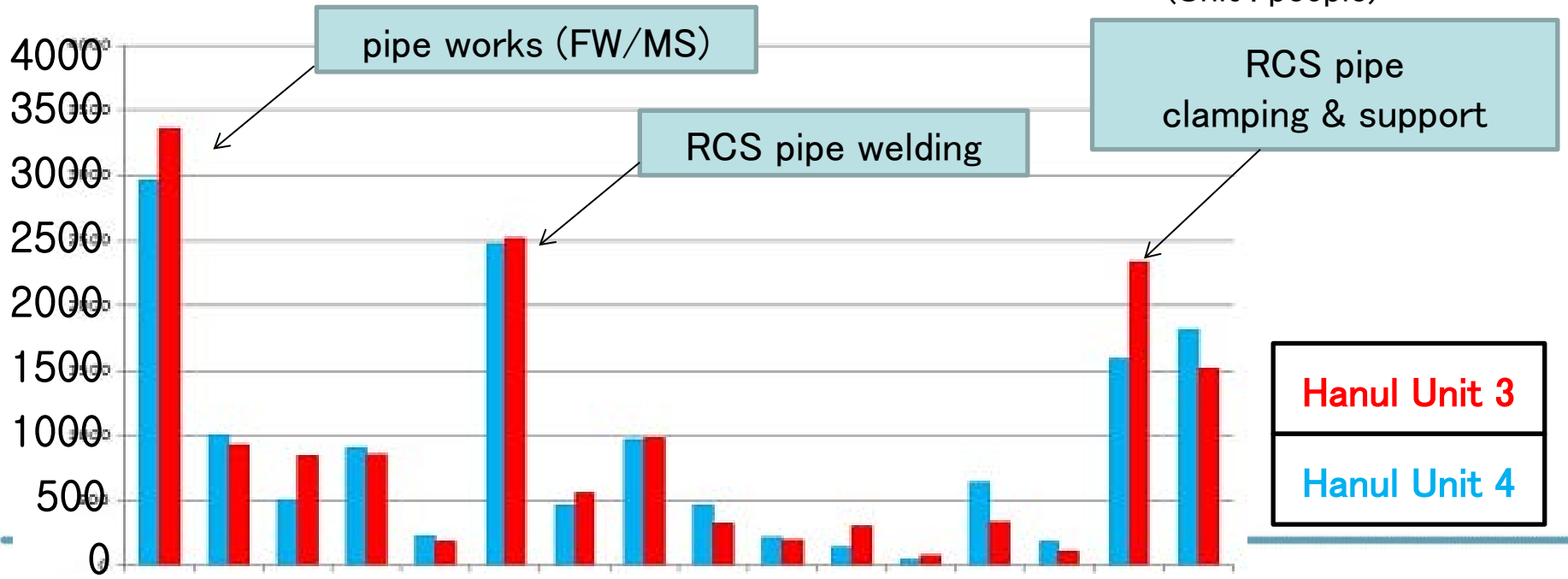
3. Radiation Safety & Dose Management

A number of people entering RCA during SGR period

(Unit : people)

	Hanul Unit 3 (12th O/H)	Hanul Unit 4 (10th O/H)
Daily maximum	299	308
Daily average	143	164

(Unit : people)



3. Radiation Safety & Dose Management

○ Methods of reducing radiation exposure dose

Applied Methods

- Conducting pre-mockup training
- Radiation Shielding : S/G & RCS pipes
- Installation of the movable air cleaning Units
- Continuously monitoring air contamination level
- Decontamination of the inside of RCS end pipes
- Installation of the step-off barriers
- Measurement of radiation and radioactivity per day, per work
- Managing the transportation of the old S/Gs

3. Radiation Safety & Dose Management

○ Conducting pre-mockup training

Training center

S/G model

RCS pipes cutting

RCS pipes decontamination

Shielding Plug installation

RCS pipes Grinding

RCS pipes Welding

FOSAR

3. Radiation Safety & Dose Management

○ Conducting pre-mockup training

OSG transportation





3. Radiation Safety & Dose Management

○ Radiation Shielding

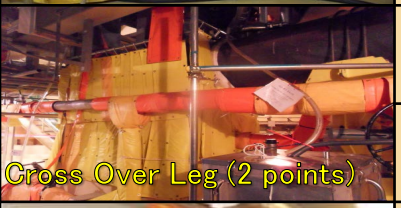
Using radiation shielding materials

(Unit : EA)

Units	Possession	plan	result	Borrowing	
Hanul Unit 3 (12th O/H)	1,989	3,445	3,190	Kori	400
				Wolseong	650
				Hanbit	200
				Hanul (unit 1)	400
Hanul unit 4 (10th O/H)		1,292	1,020	–	

3. Radiation Safety & Dose Management

○ Radiation Shielding (RCB 86ft)

Installation point		Hanul Unit 3 (12th O/H)			Hanul Unit 4 (10th O/H)			
		Dose rate (mSv/h)		EA	Dose rate (mSv/h)			EA
			Before Shielding	After Shielding			Before Shielding	After Shielding	
 Rx Drain pipes (2 points)	Maximum	20.0	0.3	300	Maximum	0.20	0.08	160
	spatial	0.3 ~ 0.5	0.03 ~ 0.17		spatial	0.02 ~ 0.05	0.01 ~ 0.03	
 Cross Over Leg (2 points)	Maximum	3.0	0.12	1,100	Maximum	–	–	–
	spatial	0.1 ~ 0.4	0.04 ~ 0.1		spatial	–	–	
 Refuleing Pool Blind Flange	Maximum	200	3.00	150	Maximum	12.5	5.50	40
	spatial	1.0 ~ 7.0	0.2 ~ 0.3		spatial	0.70 ~ 1.50	0.40 ~ 0.75	
 Drum storage area of RCS pipe inside decontamination materials (2 points)	Maximum	13.0	3.0	510	Maximum	3.0	1.2	320
	spatial	5.0	0.8		spatial	0.1~0.2	0.05~0.1	

3. Radiation Safety & Dose Management

○ Radiation Shielding (RCB 100ft)

Installation point		Hanul Unit 3 (12th O/H)				Hanul Unit 4 (10th O/H)			
		Dose rate (mSv/h)		EA		Dose rate (mSv/h)		EA
		Before Shielding	After Shielding			Before Shielding	After Shielding	
 Hot-Leg (2 points)	Maximum	7.0	0.15	200	Maximum	0.50	0.20	120
	spatial	0.25	0.03 ~ 0.13		spatial	0.05 ~ 0.1	0.03 ~ 0.10	
 PZR Spray Line	Maximum	1.0	0.14	200	Maximum	0.25	0.1	60
	spatial	0.4	0.03 ~ 0.1		spatial	0.05 ~ 0.15	0.03 ~ 0.08	
 Cross Over Leg (4 points)	Maximum	0.25	0.12	100	Maximum	0.25	0.15	160
	spatial	0.15	0.04 ~ 0.1		spatial	0.06 ~ 0.18	0.03 ~ 0.10	
 SG Room (2 points)	Maximum	0.15	0.07	240	Maximum	0.02	0.003	100
	spatial	0.03 ~ 0.15	0.03 ~ 0.07		spatial	0.003~0.02	0.001 ~ 0.003	

3. Radiation Safety & Dose Management

○ Radiation Shielding (RCB 109ft & 116ft)

Installation point		Hanul Unit 3 (12th O/H)			Hanul Unit 4 (10th O/H)			
		Dose rate (mSv/h)		EA	Dose rate (mSv/h)			EA
			Before Shielding	After Shielding			Before Shielding	After Shielding	
 PZR Surge Line	Maximum	0.15	0.08	70	Maximum	0.15	0.08	60
	spatial	0.05 ~ 0.10	0.02 ~ 0.05		spatial	0.05 ~ 0.10	0.02 ~ 0.05	
 Pipes and valves	Maximum	0.8	0.04	320	Maximum	–	–	–
	spatial	0.2	0..01 ~ 0.04		spatial	–	–	
Total (EA)		**3,190**			**1,020**			

3. Radiation Safety & Dose Management

○ Radiation Shielding for the transportation of the old S/Gs

Shielding Structure

Shielding Structure

3. Radiation Safety & Dose Management

○ Installation of the movable air cleaning units

capacity (cfm)	installation area
2,000	RCB 142ft
750	RCB 86ft
560	RCB 100ft

3. Radiation Safety & Dose Management

○ Continuously monitoring Air contamination levels

Continuous air monitor

CAM-300G

i-CAM

Air sampler

3. Radiation Safety & Dose Management

Air Contamination levels

Works	Hanul Unit 3 12th O/H		Hanul Unit 4 10th O/H	
	S/G 01	S/G 02	S/G 01	S/G 02
RCS Pipes Cutting	1.00E-05 Bq/cc (0 DAC)	1.91E-05 Bq/cc (0 DAC)	1.56E-05 Bq/cc (0 DAC)	1.6E-05 Bq/cc (0 DAC)
S/G Lifting	1.14E-05 Bq/cc (0 DAC)	1.58E-05 Bq/cc (0 DAC)	1.13E-05 Bq/cc (0 DAC)	4.21E-06 Bq/cc (0 DAC)
RCS Pipes Plugging	1.46E-02 Bq/cc (2.77 DAC)	3.42E-03 Bq/cc (8.13 DAC)	1.53E-06 Bq/cc (0 DAC)	3.65E-06 Bq/cc (0.008 DAC)

3. Radiation Safety & Dose Management

The use of the respiratory protective equipments

(Unit : EA)

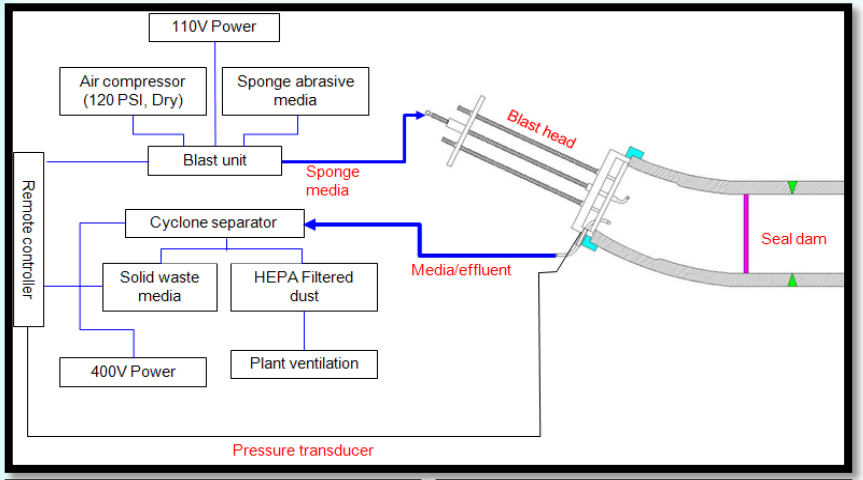
	Hanul unit 3 (12th O/H)	Hanul unit 4 (10th O/H)
Half-face cartridge respirator	780	450
Full-face cartridge respirator	53	38

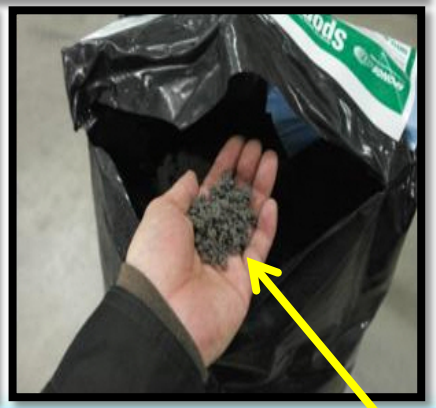
Half-face cartridge respirator

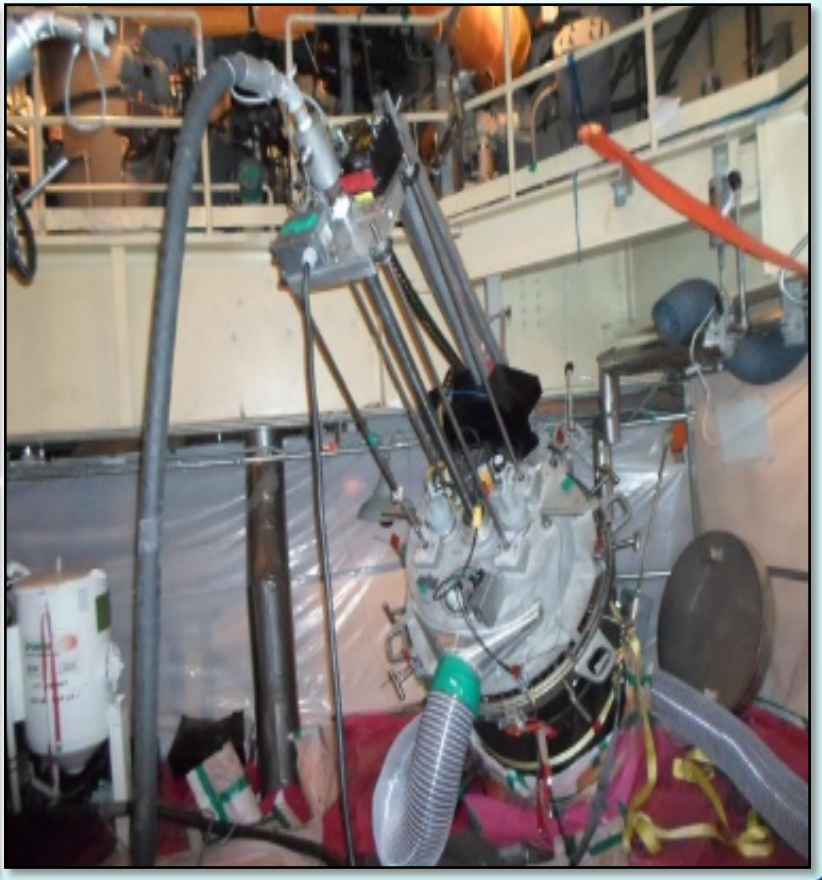
Full-face cartridge respirator

3. Radiation Safety & Dose Management

○ Pipe End Decontamination(PED) of RCS pipes







sponge medias for the decontamination

3. Radiation Safety & Dose Management

○ Installation of the step-off barriers

3. Radiation Safety & Dose Management

○ Managing the transportation of the S/Gs

Procedure

Transportation approval → Transportation inspection

	Hanul Unit 3 (12th O/H)		Hanul Unit 4 (10th O/H)	
	S/G 01	S/G 02	S/G 01	S/G 02
Transportation approval	2014. 4. 14		2013. 5. 27	
Transportation inspection	2014. 4. 21	2014. 4. 24	2013. 6. 9	2013. 6. 11

3. Radiation Safety & Dose Management

○ Managing the transportation of the S/Gs

Legal limit

- Package external surface : ≤2mSv/h (exclusive use : ≤10 mSv/h)
- 2m from the surface of the transport vehicle : ≤0.1 mSv/h
- Surface contamination level : ≤ 4 Bq/㎠

(in case of the loose surface contamination)

Result

	Hanul Unit 3 (12th O/H)		Hanul Unit 4 (10th O/H)	
	S/G 01	S/G 02	S/G 01	S/G 02
Surface (mSv/h)	0.63	1.08	0.19	0.027
2m from the vehicle (mSv/h)	0.007	0.008	0.00055	0.00043
Surface Contamination (Bq/㎠)	BKG	BKG	BKG	BKG

3. Radiation Safety & Dose Management

○ Managing the transportation of the S/Gs

4. Radioactive Waste Management

Generated amount of the solid radioactive waste

(Unit : drum)

	Goal	Result
Hanul Unit 3	110	104
Hanul Unit 4	280	91
Hanul Unit 1	273	250
Hanul Unit 2	294	244

Declining methods of radioactive wastes

- Iron
  - high level contamination : Drumming
  - low level contamination : Long-term storage for decreasing activity
- Other radioactive wastes : Drumming

4. Radioactive Waste Management

Waste Drumming

Radioactive waste	Drums		Storage
	U3-12th	U4-10th	
Waste generated from the RCS pipe inside decontamination work	7	6	High contamination level waste temporary storage facility
S/G insulation materials	59	81	Low contamination level waste temporary storage facility
RCS pipes cutting chips & welding supplies	7	3	
Waste generated from replacement of tubing line in measuring instrument	3	–	
RCS pipes insulation materials	8	–	
RCS clamping bolt & small bore pipes	3	–	
Others	17	1	
Total	104	91	

5. Improvement

- **Weakness**
  - Unsatisfactory control of working environment
    especially in cleaning conditions of RCB

- **Improvement**
  - Designate the supervisors and inspect the working environment
  - Clean up the working environment during & after work

5. Improvement

- **Weakness** : Inaccuracy of the expected dose management goal
  - Underestimate the dose attenuate effect according to the long-term shutdown of the Hanul unit 4
  - Applied in the maximum spatial dose rate for setting up the dose management goal
- **Improvement**
  - Applied in the average spatial dose rate of the real working environment of the hanul unit 3 for setting up the appropriate dose management goal

Thank you for listening