ISOE ALARA Workshop(2010.08.30; Kyung Joo)

A Draft Suggestion on the Dose Constraints for Korean NPPs Based on ICRP103 Recommendations

2010.08.30

Hee Geun KIM

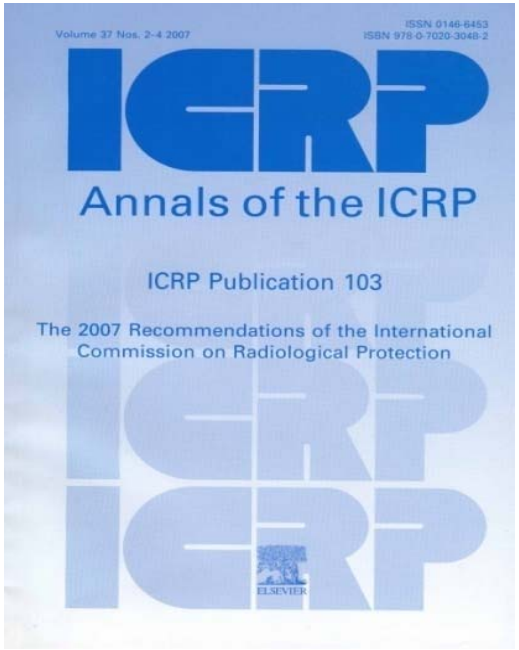
Nuclear Power Laboratory
KEPCO Research Institute

Topics for Presentation

1. Introduction
2. ICRP-60 Experiences
3. Brief Summary of ICRP-103
4. ICRP-103 Implementation Plan
5. Concepts of Dose Constraints(DCs)
6. Korean RP Regulations for DCs
7. Draft Suggestion of Dose Constraints

ICRP-103 Recommendations (2007)

1. Introduction, 2. Aims and Scope,
3. Biological Aspects, 4. Quantities in Radiological Protection, 5. System of Radiological Protection of Humans,
6. Implementation,
7. Medical Exposure,
8. Protection of the Environment,
Glossary & Reference
Annex A. Health Risks,
Annex B. Basis for Dosimetric Quantities.



Current Status of Korean Nuclear Industry

- Power reactors: 24 units in op. & 4 units under con.
- Research reactors: 1unit in operation
- Fuel fabrication facilities: 1unit in operation
- RGs & RIs are used at over 4,000 facilities
- Radwaste facility will be constructed by Dec. 2012

The impact of the ICRP 103 will be significant.
(Main Items: Optimization and dose constraints)

Impact analysis on the ICRP-103 and draft suggestion of constraints are essential

Nationwide ICRP-60 Experiences

ICRP 60 Publication (1990)

Mid-term research (1992~1997) to incorporate recommendations into the relevant national atomic energy laws and regulations by MOST/KINS

Draft of RP regulations (1997)

Ministerial Notice on Radiation Dose
(practical ICRP 60 implementation
through step by step approach; 1998~2003)

ICRP-60 Implementation to Korean Nuclear Industry
(Dose limits, Effective dose, Internal Dosimetry, Effluent Control Limits)

ICRP-60 Experiences for NPPs

ICRP 60 Publication (1990)

1st phase Longterm Dose Reduction Plan(LDRP) (1991~2000) to meet the ICRP-60 reduced dose limits (20mSv/y, 1mSv/y)

Project to set up the ICRP-60 implementation & countermeasure plan/Feedback to 2nd phase LDRP to reduce the occupational dose (1999~2000)

2nd phase LDRP Implementation (2001~2007) & 3rd phase LDRP Implementation(2008 ~2017)

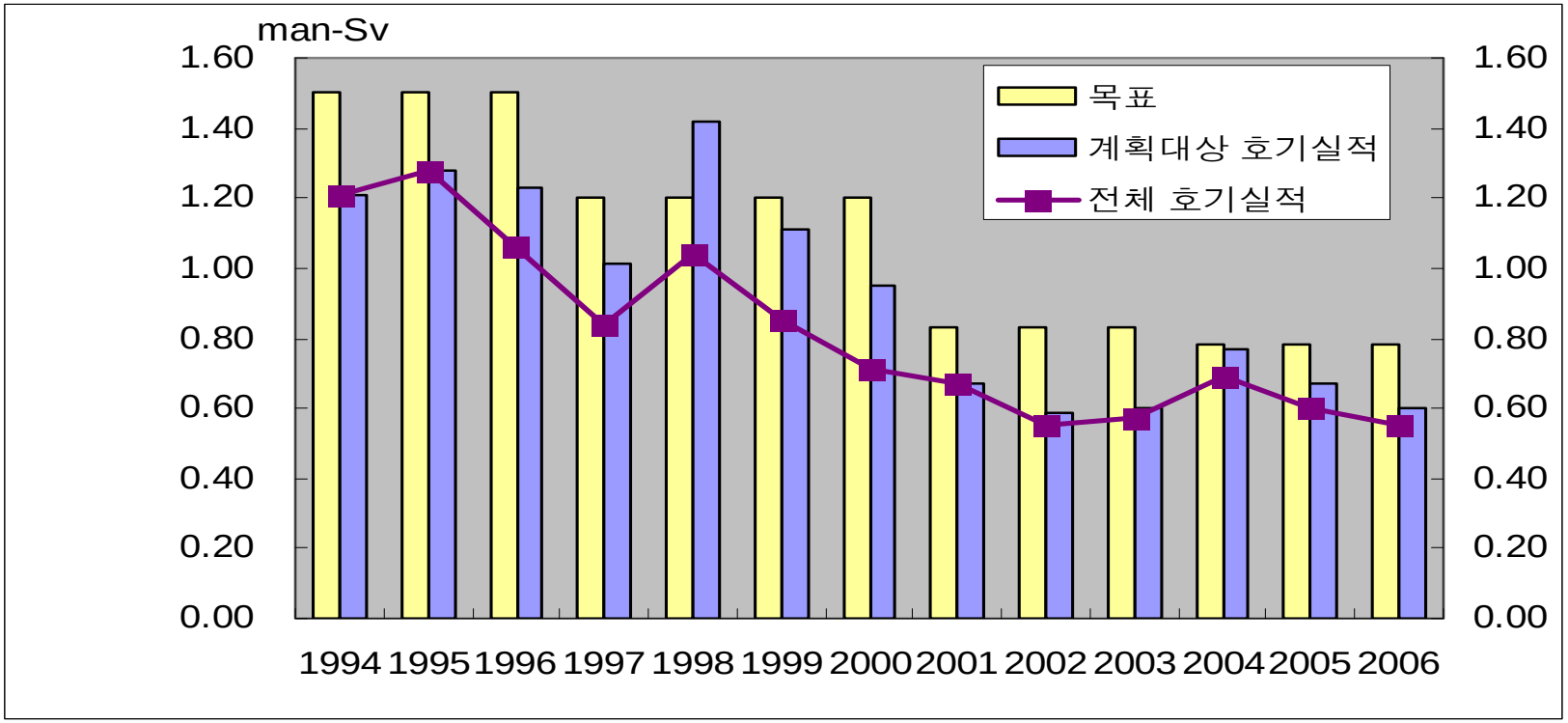
ICRP-60 Implementation for Korean NPPs

(LDRP, Two-TLD Algorithm, Internal Dose Assessment, Effluents Control & C-14, Free Access Conditions, RMS Setpoint, Derived Release Limits)

Longterm Dose Reduction Plans(1st and 2nd Phase)

o Reduction techniques

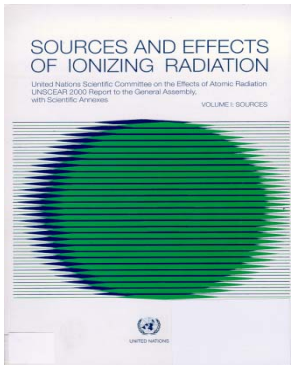
- Plant operation upgrading: High pH, Fine filters, etc
- System upgrading : RTD, New nozzle dam, Low or free Co.
- New Facility : Tritium Removal Facility(Wolsong NPPs)
- Procedure upgrading: Internal dose, ALARA, Peer reviews o The doses(man-Sv) have been continuously decreasing



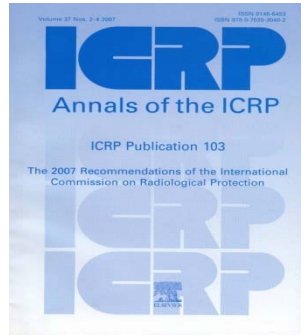
Brief Impact Summary of ICRP-103

- Consolidated updates since 1990 (ICRP-60)
- Updated science, but no fundamental change
  - New radiation and tissue weighting factors
  - Overall detriment still 5% per Sv
- Process based → Situation based
- Demonstrate protection of the environment
- Stability
  - Fundamental principles unchanged
    (with more emphasis on optimization in all situations)
    ⇒ Main Issues: Dose Constraints and Reference Levels
  - Dose limits unchanged

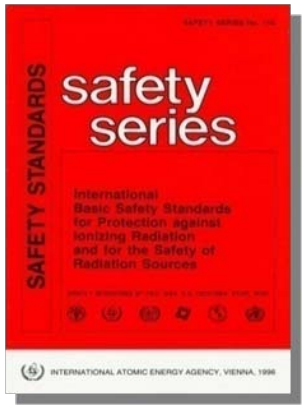
National Legislation Process



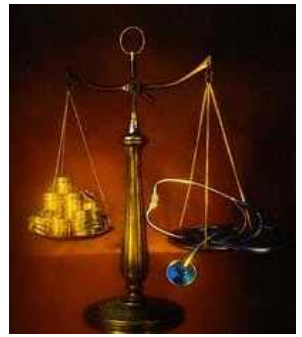
UNSCEAR, BEIR etc



ICRP-103
Recommendations (2007)



IAEA Basic Safety
Standards (2010)



National Legislations

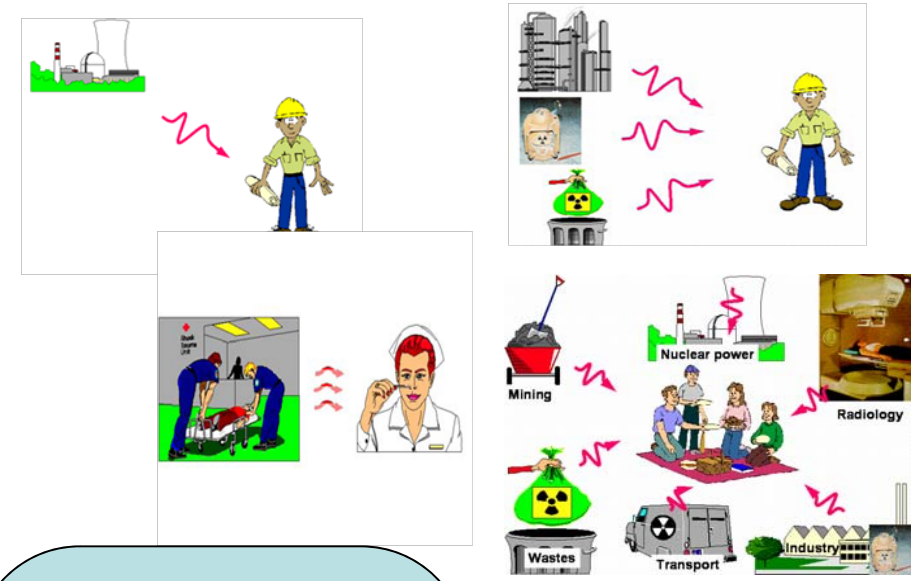
Implementation Takes Time…

- **ICRP 1977 Recommendations (Publication 26)**
  - **International standards : 1984**
  - **National standards : 1989**
- **ICRP 1990 Recommendations (Publication 60)**
  - **International standards : 1996**
  - **National standards : 2000 ~2002**
- **ICRP 2007 Recommendations (Publication 103)**
  - **International standards : 2010?**
  - **National standards : 2013 ~?**

Research Plan for ICRP 2007 Implementation by KINS (Reference: K.W.Cho's Presentation of KINS)

Year	Detailed Research Plan
2008	- Analysis of the ICRP 2007 recommendations - Identification of requirements
2009	- Comparative analysis of existing laws and ICRP 103 - Identification of troublesome on implementation
2010	- Research on the solution of the troublesome - Issuance of the first draft of national laws
2011	- Opinion hearing and analysis on the first draft - Feasibility study on the requirements
2012	- Issuance of the final draft new laws and regulations
2013	- Formal legislation process

Dose Limits and Dose Constraints



From a single source in all exposure situations

From all regulated sources in planned exposure situations

Dose Constraints/ Reference Levels

Dose Limits

Dose constraints : A prospective and source-related restriction on the individual dose from a source, which provides a basic level of protection for the most highly exposed individuals from a source, and serves as an upper bound on the dose in optimization of protection for that source. For occupational exposures, the dose constraint is a value of individual dose used to limit the range of options considered in the process of optimization. For the public exposure, the dose constraint is an upper bound on the annual doses that members of the public should receive from the planned operation of any controlled source.

Dose Limits, Constraints, and Reference Levels

		Exposure Situations		
		Planned	**Existing**	**Emergency**
Exposure Types	**Occupational**	Dose Limits Dose Constraints	n/a	Reference Levels
	Public	Dose Limits Dose Constraints	Reference Levels	Reference Levels
	Medical	Diagnostic Reference Levels (Dose Constraints)	n/a	n/a

Dose Assessment Process

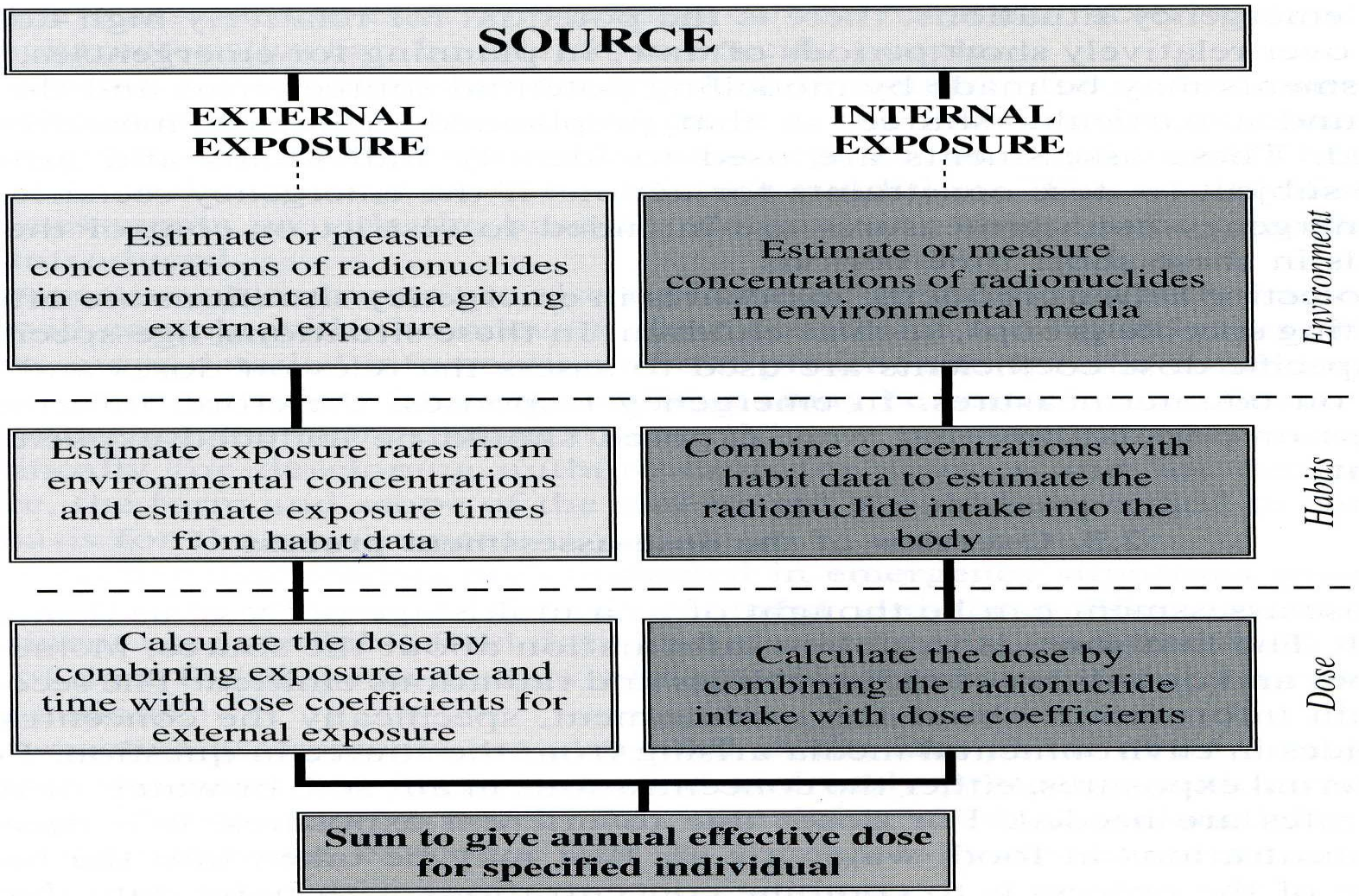
- Dose to the public cannot be measured directly.
- It is necessary to characterize an individual, either hypothetical or specific, whose can be used for determining compliance with the relevant dose constraint.
- This individual is defined as the "representative person".
- The goal of protection of the public is achieved if the relevant dose constraint for this individual for a single source is met and radiological protection is optimized.
- The representative person should be borne in mind: reasonableness, sustainability, and homogeneity
- Three age categories for estimating annual dose
  - 0-5years(1-year-old infant), 6-15years(10-year-old child), 16-70years(adult)

Dose Assessment Process

- Representative person is:
  - For the purpose of protection of the public, it is necessary to characterize an individual receiving a dose that is representative of the more highly exposed individuals in the population.
- A number of factors should be taken into account
  - Must account for all relevant pathways of exposure
  - Must consider spatial distribution of radionuclides to ensure that the group receiving the highest dose is included
  - Habit data should be based on the group or population exposed and must be reasonable, sustainable, and homogeneous
  - DCF have to be applied according to specific age categories
- Dose to the representative person may be calculated using deterministic or probabilistic methods
- Using the 95^{th} percentile of behavior in deterministic calculations is a cautious assumption for defining an intake rate.

Dose Assessment Process

ICRP Publication 101



Minister's Notice No. 2008-31
Article 16 (Detriment protection for the environment)

1. Regulations to be applied to the design of the nuclear power plant

a. annual dose at the exclusion area boundary by the gaseous effluents

1) air absorbed dose by gamma rays: 0.1 mGy

2) air absorbed dose by beta rays: 0.2 mGy

3) effective dose by external exposure: 0.05 mSv

4) skin equivalent dose by external exposure: 0.15 mSv

5) organ equivalent dose by particulate, H-3, C-14 and iodines: 0.15 mSv

b. annual dose at the exclusion area boundary by the liquid effluents

1) effective dose: 0.03 mSv, 2) thyroid equivalent dose: 0.75 mSv

2. Regulation to be applied to the operation of many nuclear power plants within the same site boundary

1) effective dose at the exclusion area boundary : 0.25 mSv

2) thyroid equivalent dose at the exclusion area boundary : 0.75 mSv

Dose Constraints for Design Stage

- The example of collective dose for Korean NPPs design
  - Target of collective dose : 1.0 person·Sv/unit·yr
    - Trend of advanced reactor : 1.0 person·Sv/unit·yr
    - EPRI URD : 0.7 person·Sv/GWe·yr
  - Expected dose at NPP design : 0.76 person·Sv/unit·yr
- KINS KNGR's Safety Requirement(Dose constraints)
  - Maximum individual dose : 5.0mSv/yr, Average dose : 2.0mSv/yr
- The example of dose constraints for Korean NPPs design
  - Maximum individual dose : 10mSv/yr, Average dose : 2.0mSv/yr
- Expected occupational dose
  - Maximum individual dose : 7.0mSv/yr, Average dose : 0.84mSv/yr
  - No meet for dose constraints. But the minimum workers involved and increase worker capability at operation/maintenance period

Dose Distribution in Korean NPPs (2010, RPD)

Year	Operating reactors	Monitored workers	Measurably exposed workers[a]	Annual collective effective dose (man-mSv)	Average annual effective dose (mSv)	
					Monitored workers	Measurably exposed workers
1990	9	4651	3064 (65.9)	14 863	3.20	4.85
1991	9	4060	2538 (62.5)	8181	2.02	3.22
1992	9	4725	2779 (58.8)	11 557	2.45	4.16
1993	9	4627	2701 (58.4)	11 445	2.47	4.24
1994	9	5416	2989 (55.2)	10 968	2.03	3.67
1995	10	6004	3062 (51.0)	12 853	2.14	4.20
1996	11	5965	3230 (54.1)	11 702	1.96	3.62
1997	12	7903	3337 (42.2)	10 032	1.27	3.01
1998	14	9326	3969 (42.6)	14 496	1.55	3.65
1999	15	8410	3920 (46.6)	12 678	1.51	3.23
2000	16	8073	3968 (49.2)	11 393	1.41	2.87
2001	16	8336	3715 (44.6)	10 749	1.29	2.89
2002	17	8345	3461 (41.5)	9315	1.12	2.69
2003	18	8743	3801 (43.5)	10 289	1.18	2.71
2004	19	9870	4278 (43.3)	13 029	1.32	3.05
2005	20	9810	4292 (43.8)	11 933	1.22	2.78
2006	20	10 190	4677 (45.9)	10 960	1.08	2.34
2007	20	11 435	5235 (45.8)	12 811	1.12	2.45

[a]Percentage of workers with a measurable exposure dose (annual average of 0.1 mSv or more) among all of the monitored workers.

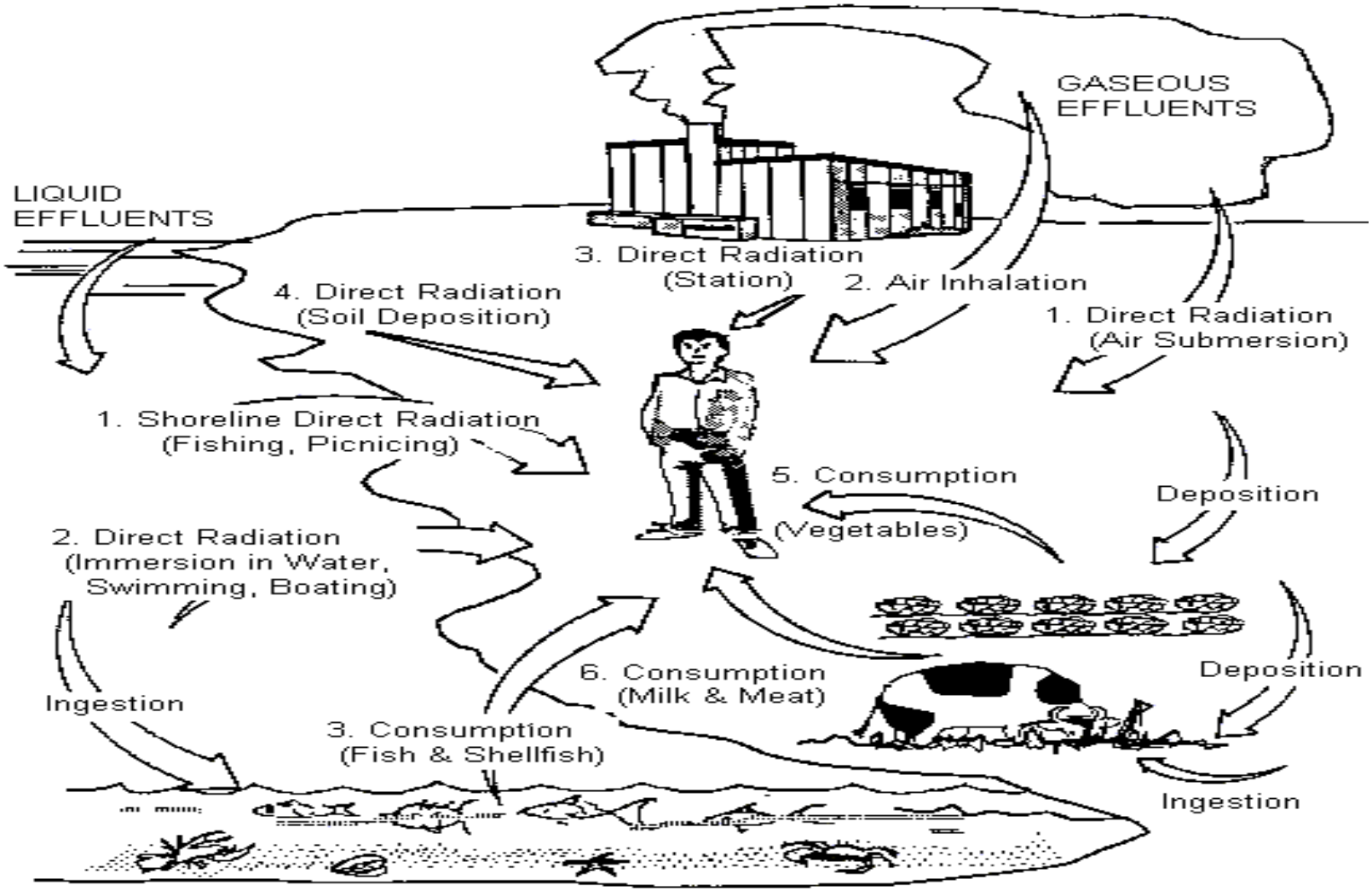
Dose Distribution in Korean NPPs (2010, RPD)

Year	Collective effective dose by exposure type (man-mSv)				NPP workers dose distribution (mSv)						
	External		Internal		<0.1	≥0.1	≥1	≥5	≥10	≥15	≥20
	Gamma	Neutron	PWR	PHWR							
1990	14 125	15	0	723	1587	982	1033	553	286	122	88
1991	7896	62	0	223	1522	1042	938	358	140	43	17
1992	10 805	31	0	721	1946	920	1081	420	209	107	42
1993	11 159	96	0	190	1926	899	1053	388	195	117	49
1994	10 163	177	0	628	2427	1158	1073	429	211	103	15
1995	12 024	373	0	456	2942	1182	1018	455	229	106	72
1996	10 988	211	0	503	2735	1248	1136	515	213	105	13
1997	9327	197	1	507	4566	1439	1194	494	143	60	7
1998	13 330	377	4	785	5357	1517	1397	642	283	120	10
1999	11 498	333	0	847	4490	1591	1425	564	256	84	0
2000	10 477	310	0	606	4105	1716	1494	512	181	65	0
2001	9767	329	0	653	4621	1515	1489	478	178	55	0
2002	8382	409	3	521	4884	1541	1300	447	131	42	0
2003	8926	548	6	809	4942	1719	1388	487	155	52	0
2004	11 781	452	3	793	5592	1901	1477	546	253	101	0
2005	10 463	644	1	825	5518	1912	1577	543	209	51	0
2006	9664	639	2	655	5513	2295	1682	519	168	13	0
2007	11 661	419	3	728	6200	2578	1857	516	240	44	0

Dose Constraints for O/M Stages

- The dose limits: 100mSv/5years(averaging 20mSv/yr)
- Occupational dose trend of Korean NPPs
  - A total of 135,889 workers were monitored from 1990 to 2007 with the number continuously increasing over time
  - The average annual doses have been continuously decreasing
  - The number of workers receiving high doses has been decreasing since 1990 and no workers received a 20mSv/yr after 2000
  - Workers who received >15 and 10mSv/yr also decreased
  - However, the fraction of >10mSv/yr is about 4% of total workers and the fraction of 15mSv/yr is about 1.3% of total workers
- Most exposure occurred during refueling period(23:77)
- The external dose accounted for 95% and 5% internal
- Dose Constraint for O/M : > 80% of limit(16mSv/yr)

Exposure Pathways and Public Dose Calculations



Exposure Pathways for the Public

[단위 : mSv/yr · man]

구 분	Plume	지표면	호 흡	농작물	우 유	육 류	계
유효선량	3.79E-05	1.47E-09	1.43E-03	2.82E-03	2.19E-04	9.09E-05	4.60E-03
비율(%)	0.83	〈0.01	31.10	61.33	4.76	1.98	100

[단위 : mSv/yr · man]

구 분	수산물섭취			해상활동			계
	어 류	해조류	연체갑각류	해변활동	수 영	해상작업	
유효선량	3.40E-06	7.53E-07	1.06E-06	3.04E-09	1.18E-10	1.46E-08	5.23E-06
비율(%)	65.00	14.40	20.26	0.06	〈0.01	0.28	100

2007 REMP Report for Kori NPP Site; gaseous pathways & dose(upper left), liquid pathways & dose(below left) and public dose contribution(right)

[단위 : mSv/yr · man]

핵 종	기 체		액 체		계	
	선 량	%	선 량	%	선 량	%
^{3}H	4.56E-03	99.17	4.50E-06	86.12	4.56E-03	99.16
^{41}Ar	1.05E-05	0.23	-	-	1.01E-05	0.22
^{58}Co	-	-	3.19E-08	0.61	3.19E-08	〈0.01
^{60}Co	-	-	3.32E-07	6.35	3.32E-07	0.01
^{85}Kr	1.95E-07	〈0.01	-	-	1.95E-07	〈0.01
^{110m}Ag	-	-	2.09E-07	4.00	2.09E-07	0.01
^{125}Sb	-	-	4.46E-09	0.09	4.46E-09	〈0.01
^{123m}Te	-	-	8.83E-08	1.69	8.83E-08	〈0.01
^{132}I	7.34E-09	〈0.01	-	-	7.34E0-09	〈0.01
^{133}Xe	2.76E-05	0.60	1.57E-12	〈0.01	2.76E-05	0.60
^{135}Xe	2.67E-10	〈0.01	-	-	2.67E-10	〈0.01
^{137}Cs	-	-	5.94E-08	1.14	5.94E-08	〈0.01
계	4.60E-03	100	5.23E-06	100	4.60E-03	100

Dose Contraints for the Public

- DCs for public: Notice No.2008-31 Article 16(Detriment protection for the environment)
- Exposure pathway for public near Korean NPPs
  - Contaminated food intake caused by tritium(about 90% or more)
  - Multi reactor units in a site: Minimum 6 units and more 10 units (Maximum 3 units in USA)
  - More conservative X/Q(smaller margin for public dose)
  - Should be monitored for Carbon-14 (no margin for public dose)

	Koir Site	Yonggwang Site	Ulchin Site
Atmospheric Dispersion Factor(sec/m^3)	2.973E-05	2.252E-05	1.423E-05
C^{14} Public Dose (mSv/yr)	0.052	0.032	0.024
H^3 Public Dose (mSv/yr)	0.015	0.006	0.002
Total	0.067	0.038	0.026
Percent for Notice No. 2008-31	26.9	14.48	10.24

Dose Contraints for the Public

- Should consider the main exposure pathways
  - Gaseous exposure(>95%): Inhalation& food intake/consumption
  - Liquid exposure(Minor): Seafood consumption
  - More than 90% of total dose caused by tritium
- Cautious decision: Maximum individual, Representative person
- Draft dose constraint for the member of public
  - No classification for gaseous and liquid effluents
  - Dose constraint for single reactor init: 0.1～0.2mSv/yr
  - Dose constraint for a site : 0.6mSv/yr
  - Delete the dose constraint for a site, if necessary
  - Many comments and feedback from stakeholders
  - Consider the difficulty of operation and maintenance for nuclear power plants

Thank You