中国辐射防护研究院

The Brief Introduction of Eye-lens Radiation Dose Survey in Chinese NPPs

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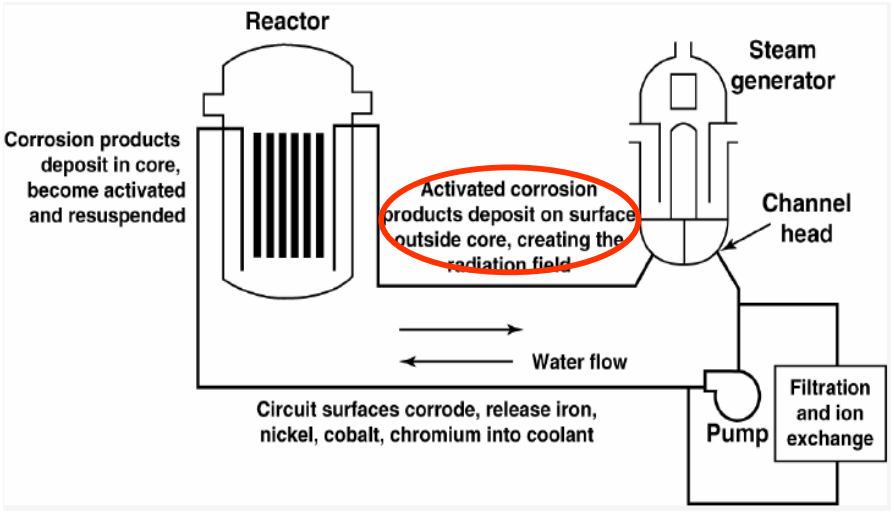
Contents

Background and Introduction

- **To reduce the collective dose: pay more attention to the ACPs**
- **Activated corrosion products, deposited on the surfaces outside core, are the main contributors for external radiation field during the outage of NPPs.**
- **Objective:**
  - **Identification of radionuclides and their specific activities**
  - **Dose contribution for external radiation field**



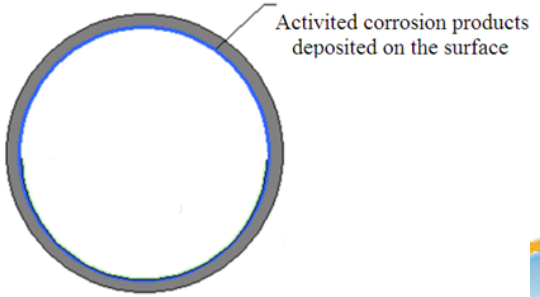
$^{58}Ni\ (n,p)\ ^{58}Co$

$^{59}Co\ (n,\gamma)\ ^{60}Co$

$^{54}Fe\ (n,p)\ ^{54}Mn$

$^{50}Cr\ (n,\gamma)\ ^{51}Cr$

$^{58}Fe\ (n,\gamma)\ ^{59}Fe$



Background and Introduction

➢ Equivalent dose limit for Eye-lens□ ICRP□ IAEA□

Threshold dose for cataract		Equivalent dose limit for Eye-lens	
old	new	old	new
5Gy	0.5Gy	150mSv/a	**20mSv** per year averaged over 5 consecutive years and 50mSv in any single year

FIRST EURADOS INTERCOMPARISON EXERCISE OF EYE LENS DOSEMETERS FOR MEDICAL APPLICATIONS

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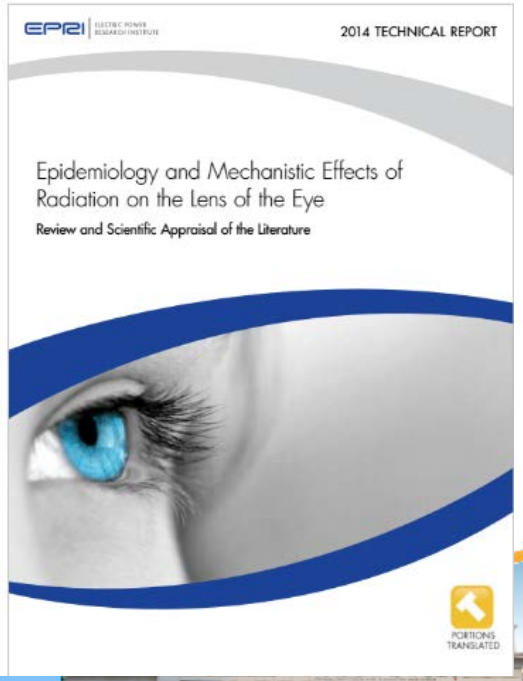
In the context of the decrease in the eye lens dose limit for occupational exposure to 20 mSv per year stated by the recent revision of the European Basic Safety Standards Directive 2013/59/EURATOM, the European Radiation Dosimetry Group (EURADOS) has organised in 2014, for the first time, an intercomparison exercise for eye lens dosemeters. The main objective was to assess the capabilities of the passive eye lens dosemeters currently in use in Europe for occupational monitoring in medical fields. A total of 20 European individual monitoring services from 15 different countries have participated. The dosemeters provided by the participants were all composed of thermoluminescent detectors, of various types and designs. The irradiations were carried out with several photon fields chosen to cover the energy and angle ranges encountered in medical workplace. Participants were asked to report the doses in terms of $H_p(3)$ using their routine protocol. The results provided by each participant were compared with the reference delivered doses. All the results were anonymously analysed. Results are globally satisfactory since, among the 20 participants, 17 were able to provide 90 % of their response in accordance with the ISO 14146 standard requirements.



Background and Introduction

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Challenges for radiation protection managers

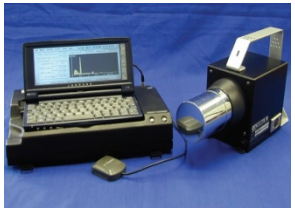
- Method of Eye-lens dose monitoring, such as dosimeter, dose evaluation, calibration and so on.
- Measurement program for NPPs.
- Status of occupational exposure for Eye-lens in nuclear industry (where, what, how much?).
- How to protection of eye-lens?

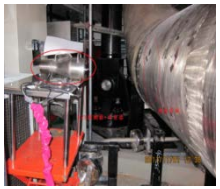
Background and Introduction

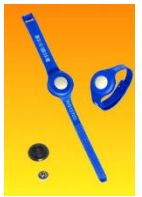
- Situation of weakly penetration radiation & Hp (3) in NPPs
  - **An research project has been initiated since 2014.**
    - **Characterization of beta/gamma energy spectrum, and source term.**
    - **The value of H*(10), H’(3), H’(0.07) and their ratios**
    - **The value of Hp(10), Hp(3), Hp(0.07) and their ratios.**
    - **Shielding factors of various PPE.**
    - **Up to now, more than 10 measurement campaigns have been performed during the outage of NPPs.**


Dose-rate


Beta spectrum


Gamma spectrum



Source term characterization



Individual dose

By: Liu Liye*, Wei Yingjing, Wei Xiaofeng, Cao Qinjian, Zhao Yuan, e

Background and Introduction

Method of data analysis

2 sets of monitoring data

— 3 personal dose: Hp(10), Hp(3), Hp(0.07)

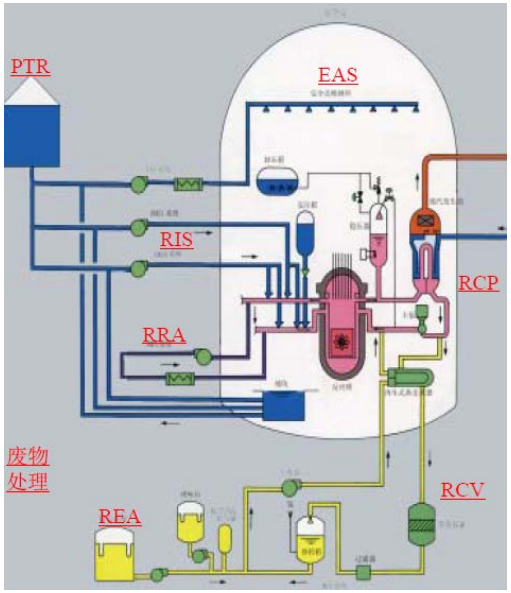
— 2 ratios: Hp(3)/Hp(10), Hp(0.07)/Hp(10)

5 kinds of tasks

Category of work	Typical tasks	System
Pool Decontamination	flush, scrape, scrub	Reactor pool
Vessel maintenance	mount and dismount, weld	SG， pressurizer
Valve maintenance	disassemble, grind, decontaminate, examine and repair	RCV,RCP, RRA
Pump maintenance	disassemble, remove, grind, examine and repair	RCV,RCP, RRA,PTR,TEP,RIS
Other	examine	tunnel

Background and Introduction

➢ Measurement projects of Eye-lens dose in NPPs □ Tianwan, Qinshan phase Ⅰ/Ⅱ/Ⅲ□

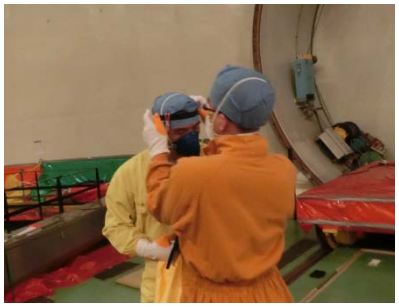


Measurement program

✓ **Measuring systems**□ RCS,RRA,RCV,PTR……

✓ **Measuring facilities**□ pump, valve, pool, water container, waste treatment, heat exchanger……

✓ **Type of job**□ Maintenance of valve and pump□ clean of pool□ Maintenance of SG ……



Method of data analysis

Measuring Method

— Recording information: γ & β spectrum; Hp(10); Hp(3); Hp(0.07)

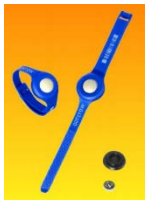
— Instruments：

HPGe detector

Microspec-2TM (Canada)

DMC2000

EYE-D

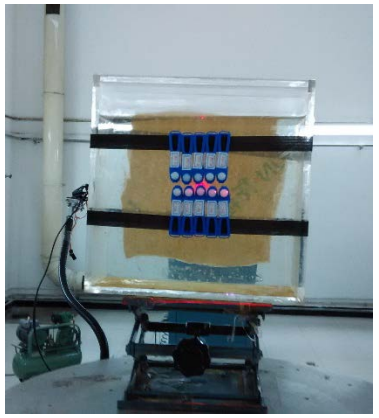


Finger-ring

Background and Introduction

➢ Standard radiation field for the calibration of extremity and eye-lens dose

β-ray including $^{90}Sr+^{90}Y/^{85}Kr/^{147}Pm$



γ-ray standard radiation field (Cs-137）

➢ Calibration phantom

- ➢ Rod phantom for extremity dose
- ➢ Slab phantom for eye-lens dose

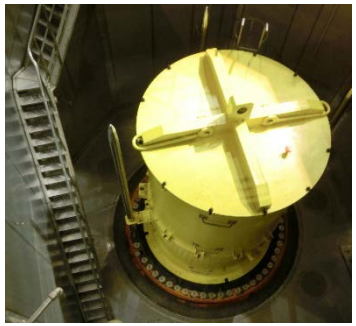
Background and Introduction

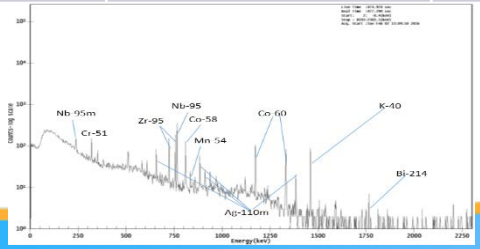
Contents

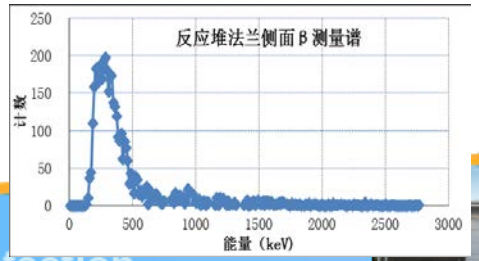
Results and discussion

❖ Measured Amount

Outage	Worker	γ-spectrum	β-spectrum
304	35	16	—
403	32	25	25
112	64	42	37
305	53	23	24
404	52	23	23
211	88	60	57
113	38	25	24
212	32	23	—
total	**394**	**237**	**190**







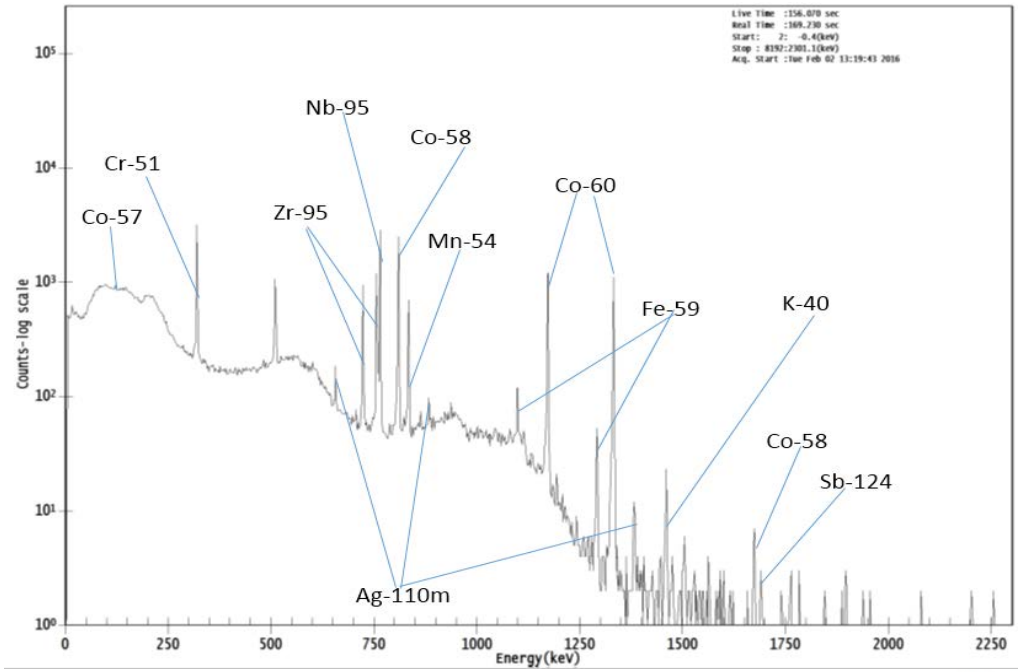
Results and discussion

➢ γ & β spectrum

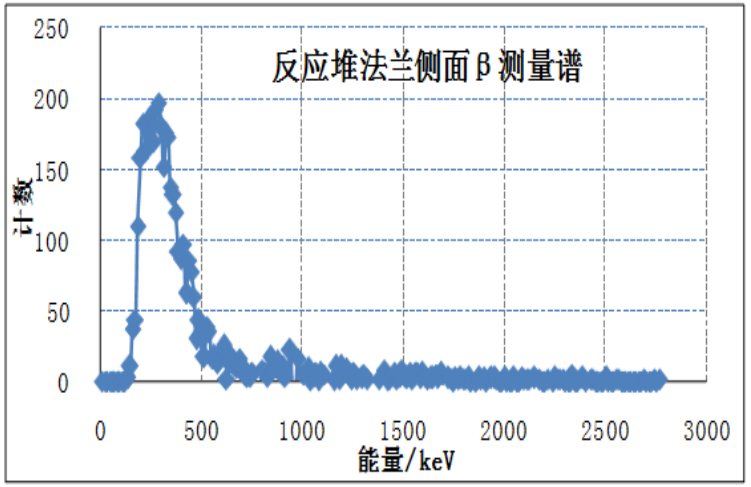
- ✓ **Main radionuclides for gamma-ray：**

  ^{58}Co、^{60}Co、^{95}Nb、^{95}Zr、^{51}Cr、^{59}Fe、^{54}Mn、^{110m}Ag、^{124}Sb.

- ✓ **Energy range of β-rays：** <500keV



gamma-ray spectrum



β-ray spectrum

Results and discussion

❖ Maximum dose —— $H_p(10)$ $H_p(3)$ $H_p(0.07)$

outage	*Hp*(10) μSv	Radiation task	*Hp*(3) μSv	Radiation task	*Hp*(0.07) μSv	Radiation task
304	722	SG	797	SG	1220	PTR601VB
403	490	SG	635	PTR602VB	1240	PTR602VB
112	456	SG	670	SG	2000	PTR602VB
305	**1080**	PTR602VB	1120	PTR602VB	**6430**	PTR602VB
404	592	SG	661	SG	964	SG
211	946	SG	**1170**	SG	911	SG
113	489	SG	617	SG	466	SG
212	534	SG	692	SG	667	404

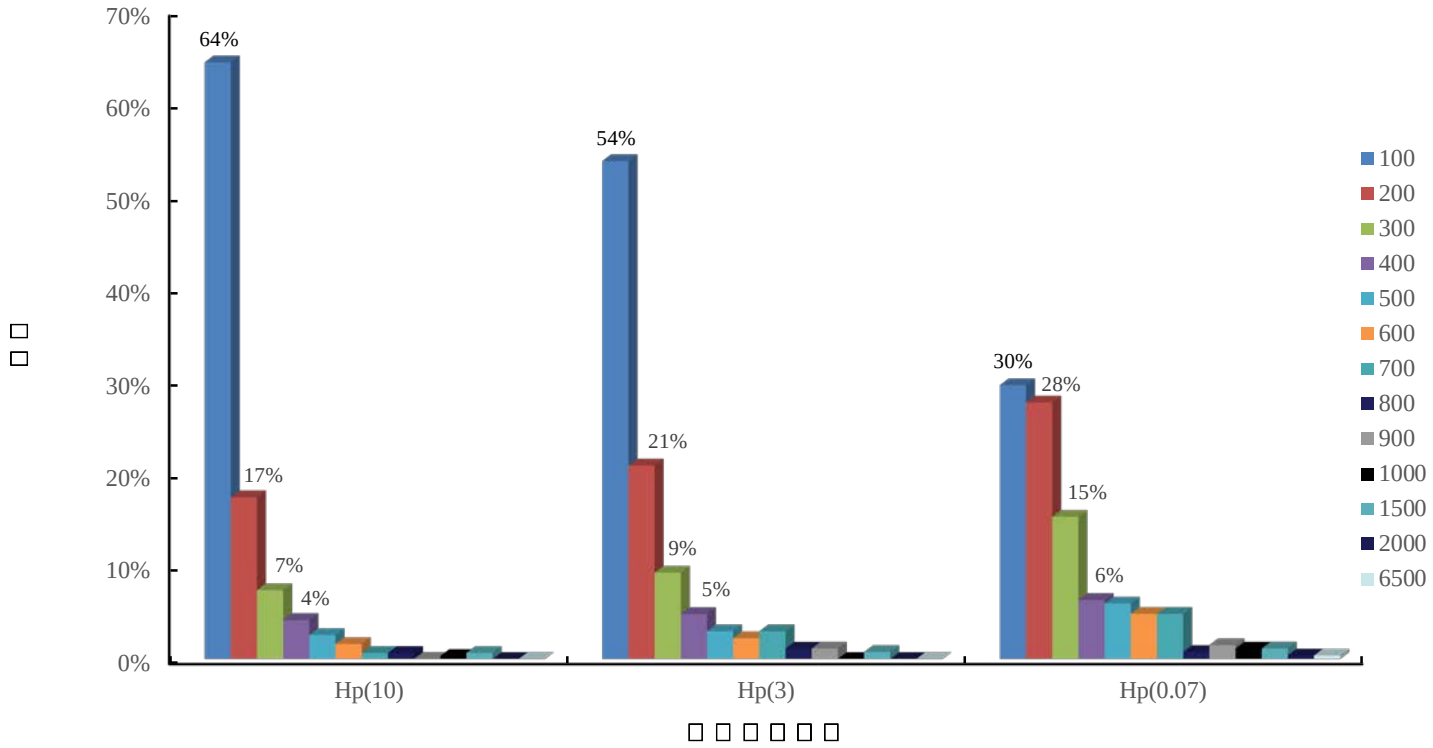
Results and discussion

❖ Maximum ratio —— $H_p(3)/H_p(10)$ $H_p(0.07)/H_p(10)$

Outage	*Hp*(3)/ *Hp*(10)	*Hp*(3)*	maintenance	*Hp*(0.07)/ *Hp*(10)	对应 *Hp*(0.07)*	maintenance
304	2.71 （2.13）#	295 (228)	3PTR601VB （3RRA001VP）	11.2 （7.60）	1220 (661)	3PTR601VB （3PTR 水箱去污）
403	3.08 （2.81）	635 (47.8)	4PTR602VB	7.22	130	装料后堆芯池去污
112	2.14	304	1PTR001BA 水箱去污	7.38 （6.33）	2000 (95)	1PTR602VB （1RPE011PS地坑）
305	2.02	105	3RRA021VP解体	10.5 （4.85）	629 (194)	3PTR601VB （装料后堆芯池去污）
404	2.62	57.6	余排泵AC解体	6.62 （3.81）	344 (137)	4PTR601VB （余排泵AC解体）
211	2.30	64.5	构件池去污	8.66	840	2PTR602VB
113	2.07	89.1	RCP220VP	4.07	122	2#上充泵解体
212	4.30 （1.93）	172 （228）	PTR602VB （装料后堆芯池去污）	5.48 （3.32）	219 （445）	PTR602VB （构件池去污）

Results and discussion

❖ Dose distribution for every worker

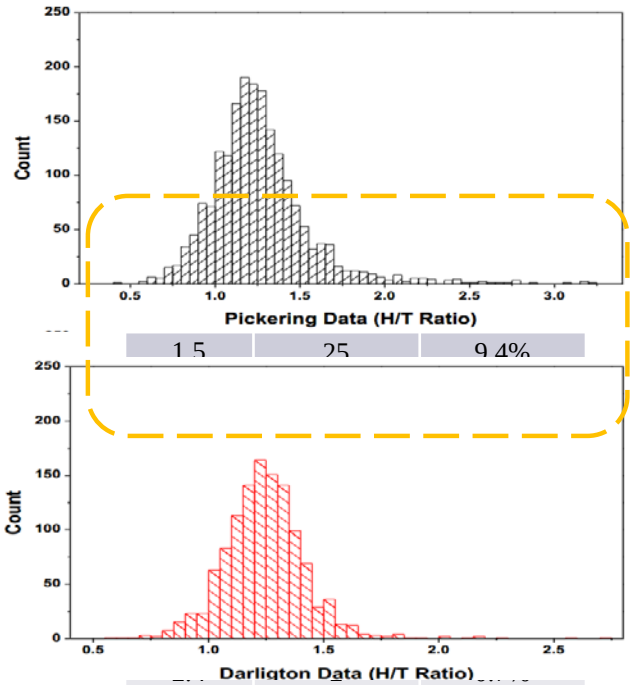


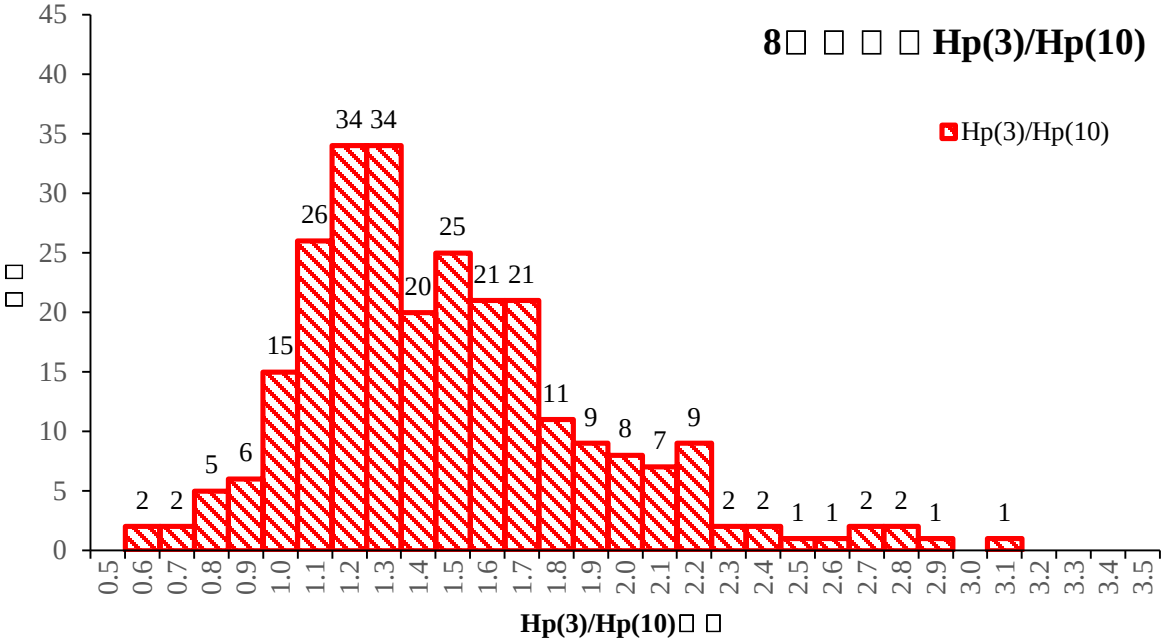
$H_p(10)$：<200μSv，82%; $H_p(3)$ ： < 200μSv，75%; $H_p(0.07)$：<300μSv，73%.

Results and discussion

❖ Distribution of ration of $H_p(3)$ to $H_p(10)$ for every worker

□ □	人数	比例
0.5		
1.5	25	9.4%
2.5	1	0.4%
2.6	1	0.4%
2.7	2	0.7%
2.8	2	0.7%
2.9	1	0.4%
3.0		
3.1	1	0.4%
3.5		
合计	227	100%





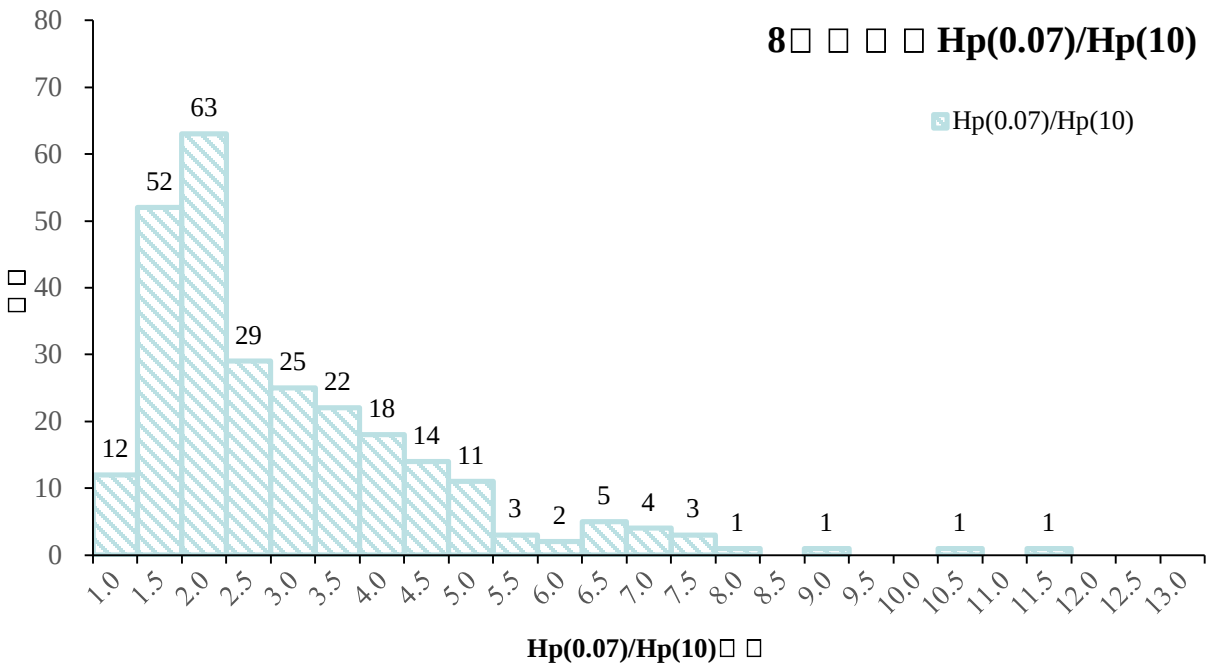
$H_p(3)/H_p(10)$: mostly between 1.0~1.7, account for 68%

>1.7, 21%

Results and discussion

❖ Distribution of ration of $H_p(0.07)$ to $H_p(10)$

□□	人数	比例
1.0	12	4.5%
1.5	52	19.5%
2.0	63	23.6%
2.5	29	10.9%
3.0	25	9.4%
3.5	22	8.2%
4.0	18	6.7%
4.5	14	5.2%
5.0	11	4.1%
5.5	3	1.1%
6.0	2	0.7%
6.5	5	1.9%
7.0	4	1.5%
7.5	3	1.1%
8.0	1	0.4%
8.5		
9.0	1	0.4%
9.5		
10.0		
10.5	1	0.4%
11.0		
11.5	1	0.4%
12.0		
12.5		
13.0		
合计	235	100%

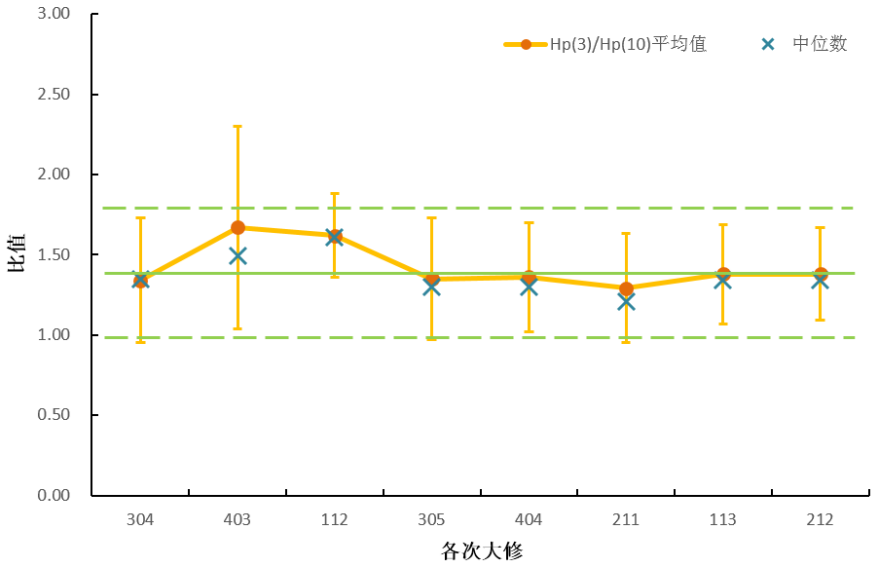


$H_p(0.07)/H_p(10)$: <5.0，~92%

Results and discussion

❖ Average and median of ratio of $H_p(3)$ to $H_p(10)$

□ □	$H_p(3)/H_p(10)$	
	average	median
304	1.34 ± 0.39	1.35
403	1.67 ± 0.63	1.49
112	1.62 ± 0.26	1.61
305	1.35 ± 0.38	1.30
404	1.36 ± 0.34	1.30
211	1.29 ± 0.34	1.21
113	1.38 ± 0.31	1.34
212	1.38 ± 0.29	1.34
AVE.	**1.40 ± 0.40**	1.32



（绿色实线为全体的平均值，虚线为1σ的标准偏差）

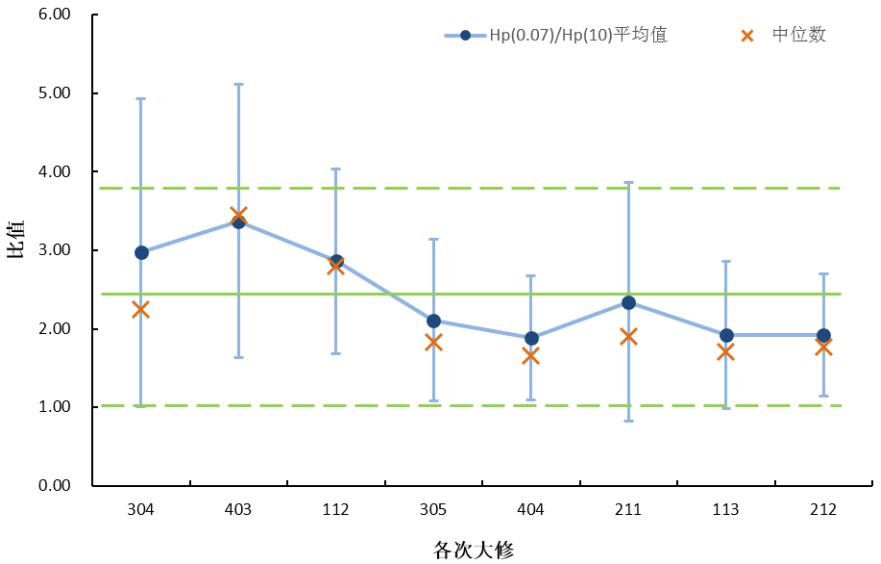
头部剂量/胸部剂量：Darlington电厂（1200个）：1.2±0.2

Pickering电厂 （1950个）：1.3±0.3

Results and discussion

❖ Average and median of ratio of $H_p(0.07)$ to $H_p(10)$

Outage	$H_p(0.07)/H_p(10)$	
	Average	median
304	2.97 ± 1.96	2.25
403	3.37 ± 1.74	3.45
112	2.86 ± 1.18	2.80
305	2.11 ± 1.03	1.83
404	1.88 ± 0.79	1.66
211	2.34 ± 1.52	1.90
113	1.92 ± 0.94	1.71
212	1.92 ± 0.78	1.77
Ave.	**2.44 ± 1.39**	1.99



（绿色实线为全体的平均值，虚线为1σ的标准偏差）

Results and discussion

❖ Typical radiation work during the outage in NPPs

Category of work	Typical tasks	System
Pool Decontamination	flush, scrape, scrub	Reactor pool
Vessel maintenance	mount and dismount, weld	SG, pressurizer
Valve maintenance	disassemble, grind, decontaminate, examine and repair	RCV,RCP, RRA
Pump maintenance	disassemble, remove, grind, examine and repair	RCV,RCP, RRA,PTR,TEP,RIS
Other	examine	tunnel

Results and discussion

❖ average dose of the typical tasks

Category of work	Ave. $H_p(10)$ /μSv	Ave. $H_p(3)$ /μSv	Ave. $H_p(0.07)$ /μSv	Ave. $H_p(3)$/ $H_p(10)$	Ave. $H_p(0.07)$/ $H_p(10)$
Vessel maintenance	263	345	379	**1.38**	1.77
Valve maintenance	126（109）	174（130）	393（217）	**1.52（1.35）**	2.97（2.32）
Pool Decontamination	65.4	94.5	158	**1.46**	2.64
Pump maintenance	53.6	70.7	137	**1.50**	2.81
other	174	197	179	0.69	2.26

注：括号内为不包含铅衣作业的平均值

Contents

Conclusions

- Eye-lens dose monitoring is necessary during outage for NPPs.
- To pay more attention to the workers of vessel maintenance, Pool Decontamination and SG maintenance.
- To develop monitoring program according to the surveying results.
- Further investigations will be needed to determine **the ratio of Hp(3) Hp(10)**.
- Further simulation to find out the main contribution of Hp(3).

Thanks for your attention