辽宁红沿河核电有限公司
LIAONING HONGYANHE NUCLEAR POWER CO.,LTD

The Practices and Researches of HYH Plant Optimized Radiation Protection

1 Background

2 Practices & Researches

3 Summary

1 Background

Radiation Protection Principles

辐射防护最优化是辐射防护三原则之一，是核电站辐射防护体系的重要组成部分。

As one of the three principles of radiation protection, the ALARA principle is a major component of plant radiation protection system.

WANO Index

集体剂量是WANO 对核电站进行评比的十个指标之一，辐射防护最优化的主要目的正是工作人员的集体剂量。

Collective dose is one of the ten rating indexes proposed by WANO, and the ALARA principle aims to optimize collective dose.

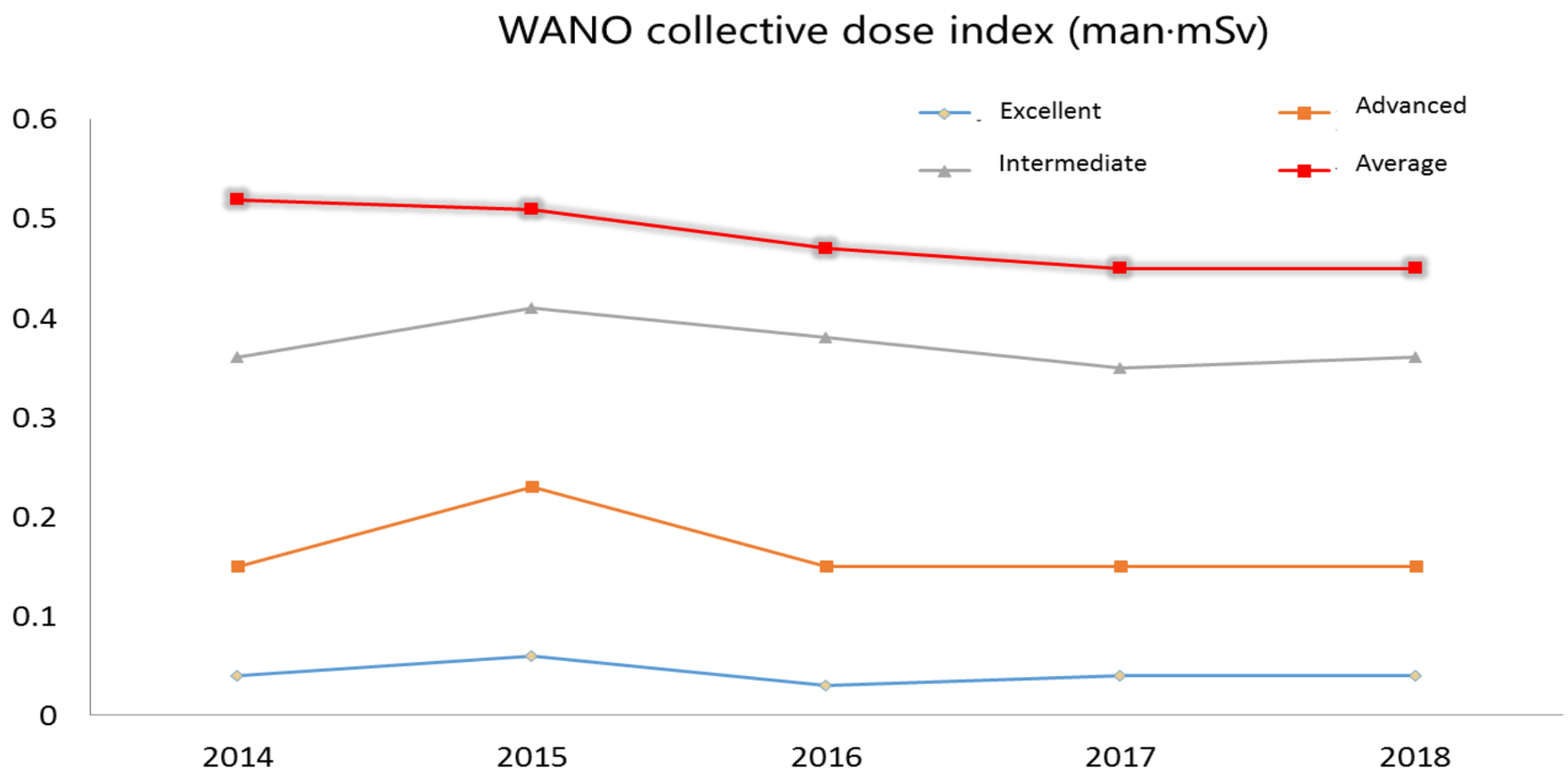
Public Concern

自福岛核事故后，公众对核电站核与辐射安全的关注提升到了新的高度。

After the Fukushima event, the public concern of nuclear and radiation safety has reached a new level.

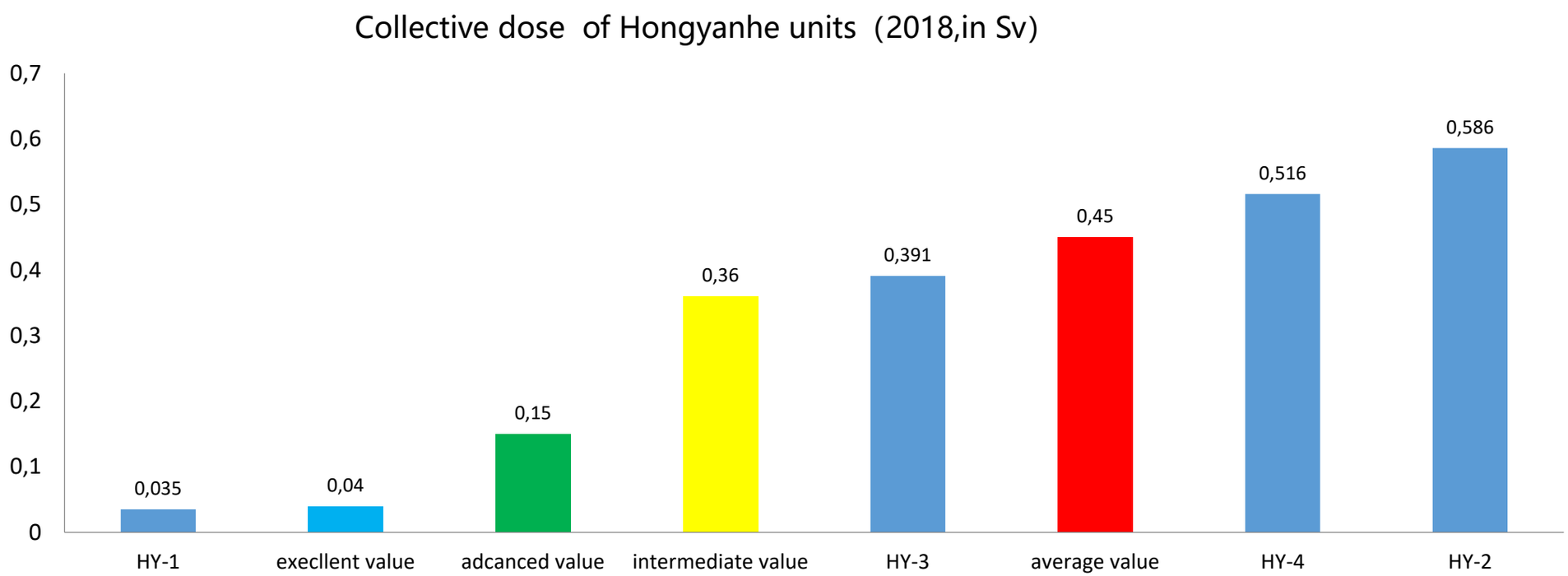
WANO benchmark value of collective dose is declining

集体剂量WANO标杆值呈下降趋势



- **The overall source term condition of CPR1000 units is in the middle/lower class of all types of units.**

CPR1000型机组总体源项水平在世界各类型机组中处于中下游水平



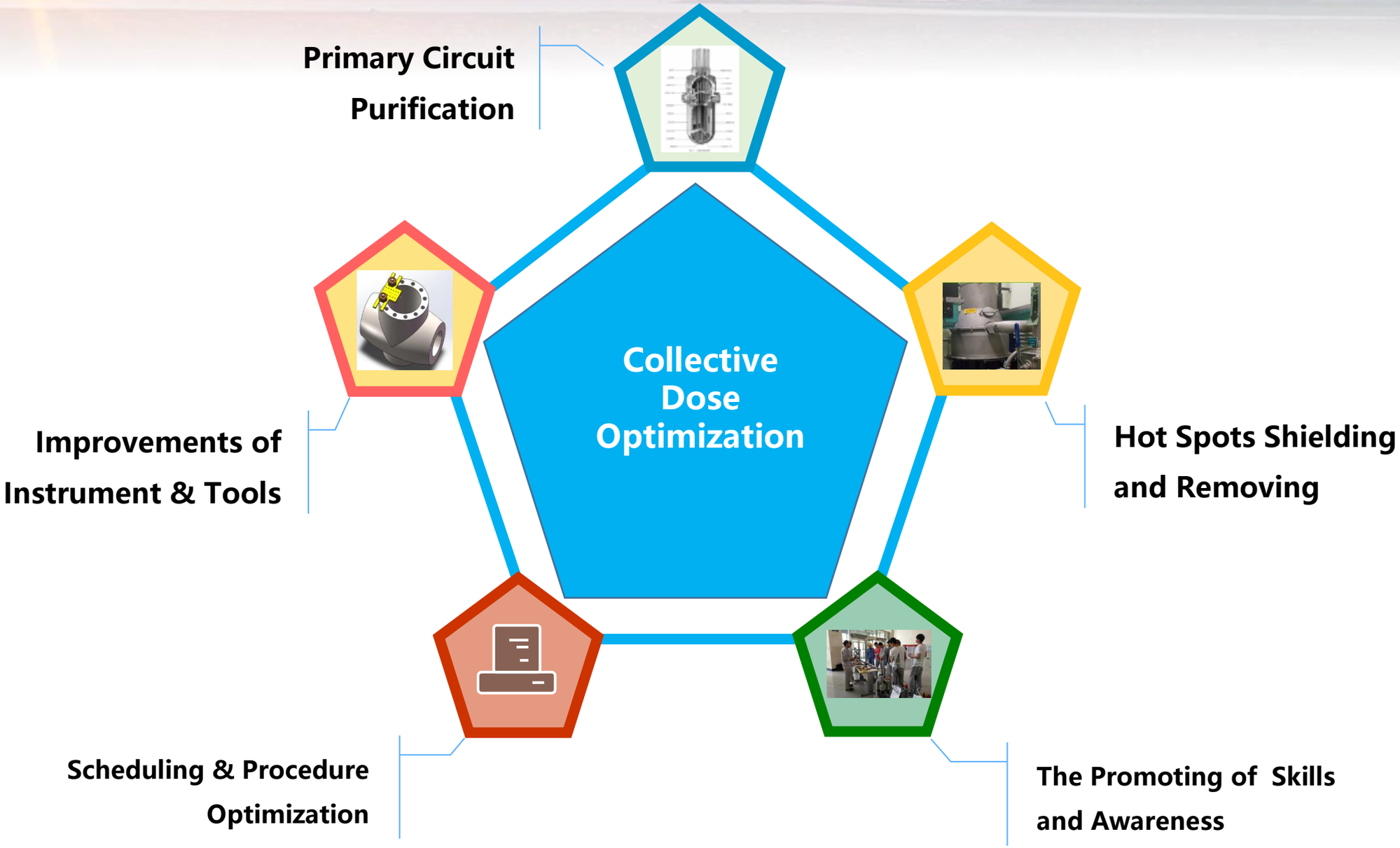
There was no outage for unit 1 in 2018 so the collective dose was lower, and unit 3 was around average value, but unit2/4 was higher than average value.

Optimized radiation protection practices and a five-dimensional model

辐射防护最优化实践及五维度模型

The optimization of radiation protection mainly involves source term control, work planning, development of tools & new materials and the improvement of management, so as to reduce working time, dose rate and individual expose dose, and eventually improve plant radiation safety level.

Based on practices, the Hongyanhe plant radioprotection group has summarized and developed a five-dimensional model for collective dose optimization.


Primary Circuit Purification
Improvements of Instrument & Tools
Collective Dose Optimization
Hot Spots Shielding and Removing
Scheduling & Procedure Optimization
The Promoting of Skills and Awareness

2 Practices & Researches

2.1

Primary Circuit Purification

1. Acid reducing control during downward phase of outages
2. Modification of primary circuit filter
3. Threshold and process optimization of RCV001FI replacement
4. TEP006DE operation optimization in outages
5. Purification time extension
6. Purification during unit start-up
7. Purification during unit temporary shut-down
8. Source terms investigation program by gamma camera
9. The use of ORFO in pool decontamination
10. Underwater dust cleaning
11. The monitoring of weakly penetrating radiation
12. Programs in research

Primary Circuit Purification—1. Acid reducing control during downward phase of outages
主回路净化—1. 大修期间下行阶段酸性还原控制

For the 4 units of HYH Plant, the primary circuit would be set in acid reducing environment from subcritical stage to the beginning of oxidation and purification during outage downward phase, except for when the unit suffers serious fuel failure in the previous cycle. Under this condition, source terms such as Co-58 released are easier to transform from colloid form (hard to remove and easy to form hot spots) to ionic form (dissolved in coolant), avoiding a secondary deposition in the subsequent transfer process, such as elbows, valves, etc.

The control measures are as follows: after the unit enters the sub-critical state, TEP006DE is put into operation for rapid delithiation, and the pH of the primary circuit switches from neutral alkali to acidity; meanwhile, primary circuit hydrogen is controlled to be more than 5cc/kg during downward purging of the primary circuit. Acid reducing control used in outages effectively helped to avoid super high dose rate hot spots, except for RCP521/522/523/524VP in RX5m inner ring.

Dissolved Hydrogen in Primary Circuit		
Unit Phase	Non-acid control	Acid control
Subcritical	5~20 approaching 5	9~11
RRA connected	＜3	3~5
Air chamber in pressurizer extinguished	＜3	3~5
Oxidation	＜3	＜3

Primary Circuit Purification—2. Modification of primary circuit filter
主回路净化—2. 一回路水过滤器技术及管理改进

Equipment Code	Unit	Mesh Aperture Before	Mesh Aperture Now
RCV001FI	1、2、3、4	8″-0.45μm	During Operation 8″-0.1μm During outage 8″-0.45μm
RCV003FI\004FI	1、2、3、4	4″-5μm or 4″-1μm	4″-1μm
PTR001/003/004FI	1、2、3、4、8、9	16″-5μm or 16"-0.45μm	16"-0.45μm

Primary Circuit Purification—3. Threshold and process optimization of RCV001FI replacement
主回路净化—3. 氧化净化期间RCV001FI更换阈值及流程优化

If RCV001FI replacement is conducted during oxidation purification, the purification unit will suffer a capacity reduction, which will compromise the purification effect. Therefore, the isolation time of RCV001FI during replacement should be minimized. Measures are

- Adjust the pressure difference threshold of RCV001FI replacement to avoid unnecessary replacement.
- The process of filter replacement before oxidation purification, during oxidation purification and the start-up stage of the unit was optimized. After optimization, the isolation time of RCV001FI was reduced from 8 hours to 2 hours.

Radioactivity Threshold for Replacement		Pressure Difference Threshold for Replacement	
OP	Outage	OP	Outage
KRT010MA 2nd Alarm 65mSv/h	KRT010MA 2nd Alarm（65mSv/h）. However, during oxidation purification the replacement can be postponed as by the evaluation of the plant source term control team	1.38bar	1.9bar during the operation of RCV letdown dual orifice in the outages

Primary Circuit Purification—4. TEP006DE operation optimization in outages
主回路净化—4. 大修期间TEP006DE运行优化改进

Phase 1

According to referenced plant practice, use mixed positive and negative ions resin demineralizer of boron recovery system (TEP006DE), to replace chemical and volumetric control system demineralizer (RCV001/002DE) during outage downward phase.

Purification efficiency↗ Operating cost↘

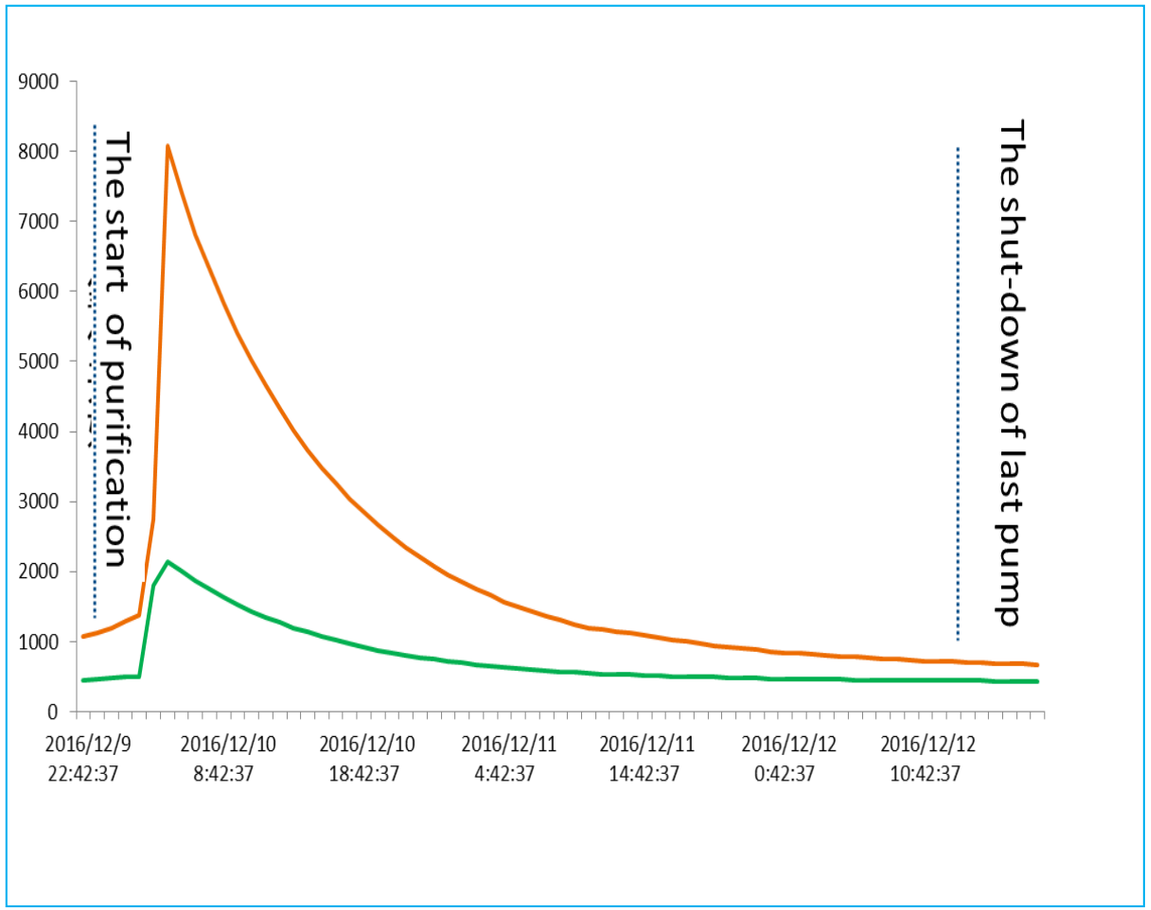
Phase 2

Resin in TEP006DE demineralizer get reduced from 1500L to 500L; the operation time changed from only in shut-down stage to in both start-up and shut-down stage.

To reduce cross contamination source term and primary circuit sulfate content

Primary Circuit Purification—5. Purification time extension
主回路净化—5. 净化时间评价和适当延长

Purification duration is an important factor of oxidization and purification. In addition to the basic radiochemistry criteria, this duration is invariably the result of the balance between both work schedule and radiation level. Purification duration was properly extended to receive a better source term under the evaluation of the following terms: continuous monitoring on RCV letdown pipeline and system index measurement.



Primary Circuit Purification—6. Purification during unit start-up
主回路净化—6. 机组上行专项净化

During the start-up after H203 outage, a special purification that lasted 6h was conducted on ‘primary circuit cold pipe 60 ℃’ platform to remove the impurities introduced by outage maintenances. For RRA system, this special purification is equivalent to 20% purification time of a regular outage purification.

	点名	当前值	游标值	单位	描述	下限	上限	限高	限低	线宽
☑	2KRI010MAN	0.00723	0.0753	Gy/h	RCV Front End Filter ∀ Dose Rate	-0.016152	0.097425			1
☑	2KRI001MAN	0.00006	0.000075	Gy/h	RCV Reactor Coolant ∀ Dose rate	0.000039	0.000083			1
☑	2RCP001P0IP1	0	0			-1	6			1

Primary Circuit Purification—7. Purification during unit temporary shut-down
主回路净化—7. 机组临停专项净化

Special purification program was executed previous to H302 outage during the temporary shut-down.

- No oxidation operation
- Using RCV demineralizer to do purification
- Lithium is added to keep pH in a neutral alkaline environment

Two purification platforms

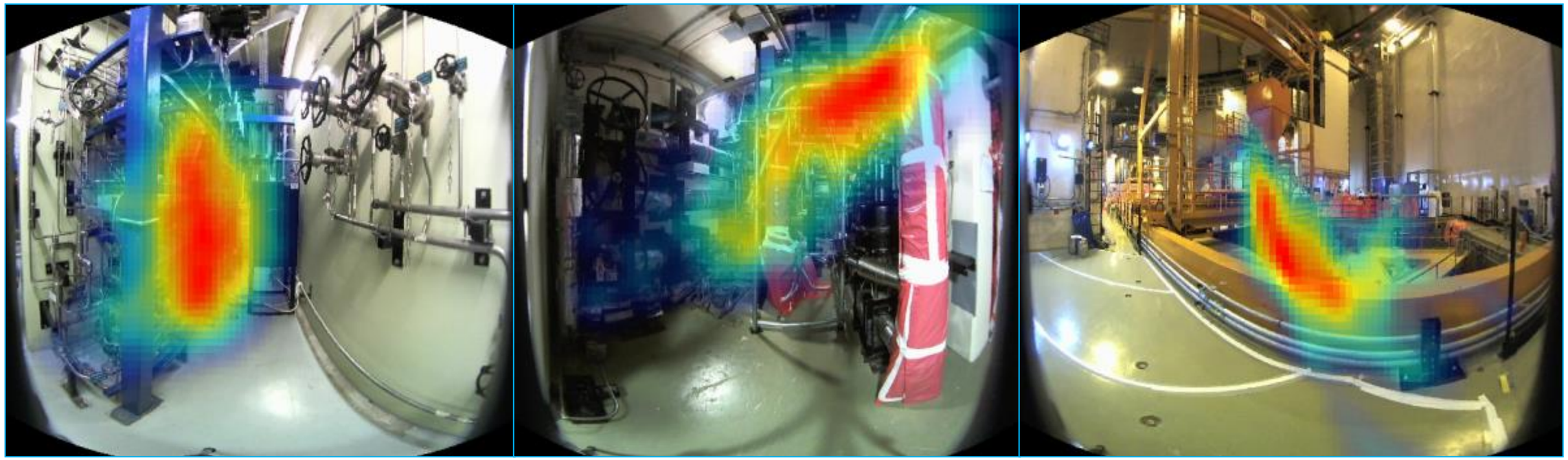
- NS/SG mode: Continuous purification for 4d to remove fission products
- NS/RRA mode: T < 90 ℃, main pump running and continuous purification for 5d to remove corrosion products

Unit	State	RCP	RCV	RRA
H102	停堆6H after shut-down	217	217	
	停主泵后main pump shut-down	281	304	455
	低低水位low-low water lever	379	235	212
H202	停堆6H after shut-down	360	741	
	停主泵后main pump shut-down	188	619	222
	低低水位low-low water lever	222	608	149
H302	停堆6H after shut-down	211	210	
	停主泵后main pump shut-down	178	205	328
	低低水位low-low water lever	246	337	425

The purification in temporary shut-down benefited H302 outage with a relatively low radiation index. The collective dose of H302 reached the first quarter level of all CGN units.

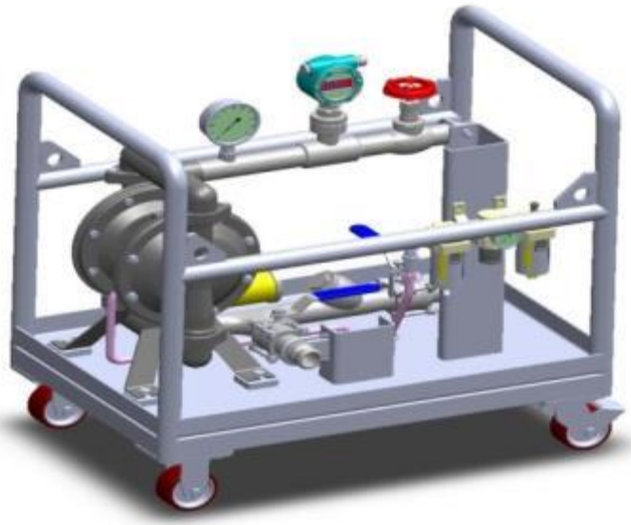
Primary Circuit Purification—8. Source terms investigation program by gamma camera
主回路净化—8. 通过伽马相机进行源项调查项目

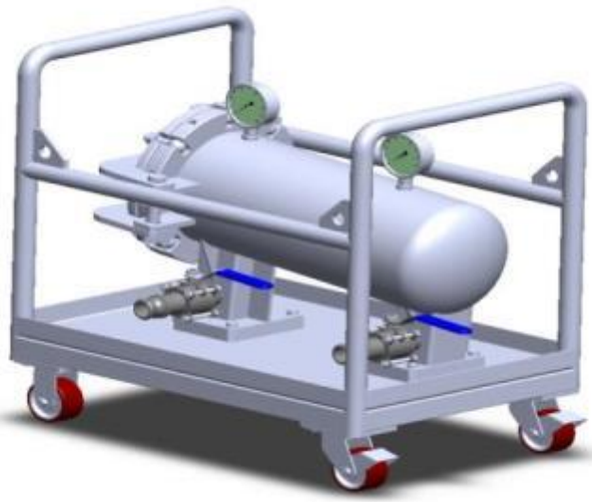
The purpose is to take dose rate photo of all RCA buildings in different working conditions, and to build a plant dose rate photo album.



Primary Circuit Purification—9. The use of ORFO in pool decontamination
主回路净化—9．ORFO在水池去污排水中的应用

Before and during the decontamination of reactor pool and assembly pool, ORFO is used in the discharging pipe line ‘PTR601/602VB to RPE011PS’. ORFO pump can accelerate the discharge, and ORFO filter can collect high dose rate impurity and lower the dose rate level of RPE011PS.





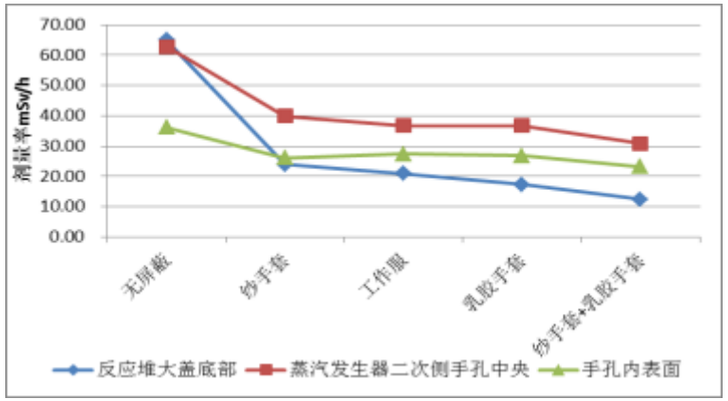
Primary Circuit Purification—10. Underwater dust cleaning
主回路净化—10. 水下吸尘

During outages, underwater dust cleaning collects the corrosion waste and the high dose rate particles in the reactor pool.

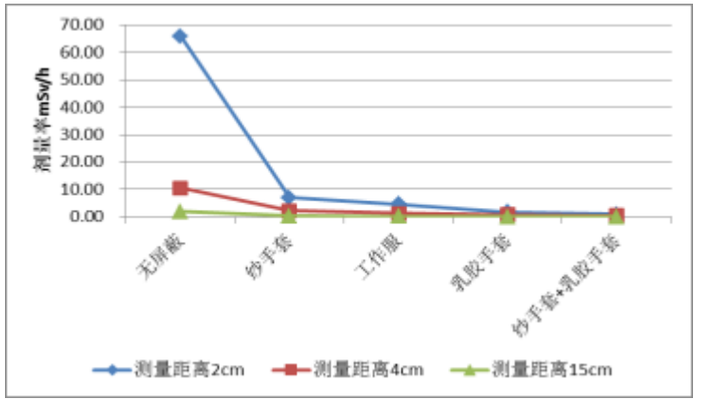
Primary Circuit Purification—11. The monitoring of weak penetrating radiation
主回路净化—11. 一回路弱贯穿调查项目

According to the monitoring conducted in H202, the general weak penetrating radiation level is low. The places with high directional dose equivalent rate H′(0.07) are the man hole center of SG (44.07mSv/h), the lower part of reactor cover (64.98mSv/h), man hole supporting plate (16.19mSv/h), main pump bearing (24.72mSv/h), and some valves such as RCP-121V (48.03mSv/h).

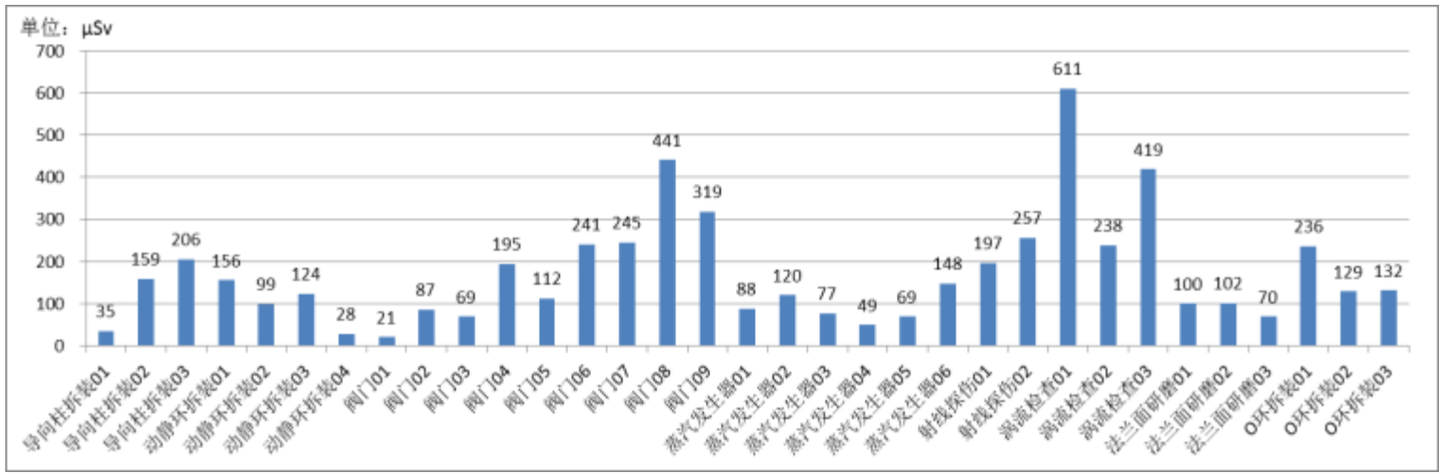
Shielding effects of protective articles



Penetrating results of samples



Hand monitoring result in H202



Primary Circuit Purification—12. Programs in research
主回路净化—12. 在研项目

1、Co材质替代	For some wear-resisting and anti-corrosion alloy contains Co used in valve seat, CRDM and coolant pump bearing bush, HYH plant is seeking for a Co free replacement.
2、化学去污	Chemical decontamination conducted on the auxiliary system RRA/RCV can reduce radiation level. HYH plant is planning to apply this practice.
3、表面预处理	Component surface pre-processing could reduced the amount of corrosion product deposition. HYH plant plans to apply practices like electro polishing (EP) and SCrP in the future replacement of primary circuit components.
4、一回路注锌	The introduction of zinc into primary circuit to reduce stress corrosion effect of SG U-pipe is under evaluation.
5、一回路PH调整	Raising the PH value of primary circuit to 7.2 to reduce the deposition corrosion products on the surface of fuel. HYH is working on the evaluation of this practice.

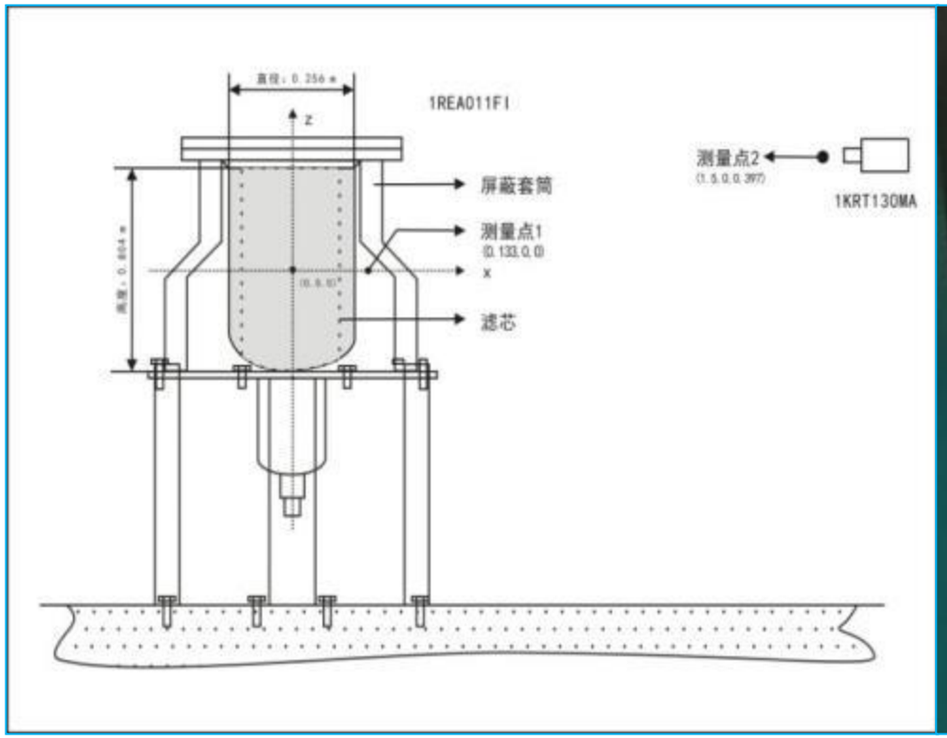
2.2

Hot Spots Shielding and Removing

1. Shielding installation during construction
2. Shielding with new material
3. Special shielding on RIC004MT
4. Fixed shielding installation
5. Flushing during outage
6. Flushing of chemical sampling pipeline

Hot Spots Shielding And Removing—1. Shielding installation during construction
热点去除及屏蔽—1. 工程建设期间进行屏蔽安装

Some fixed filter shielding, for example the REA011FI shielding devices of unit1-4, were carried out during the construction period, taking advantage of the fact that there was no radiation then.

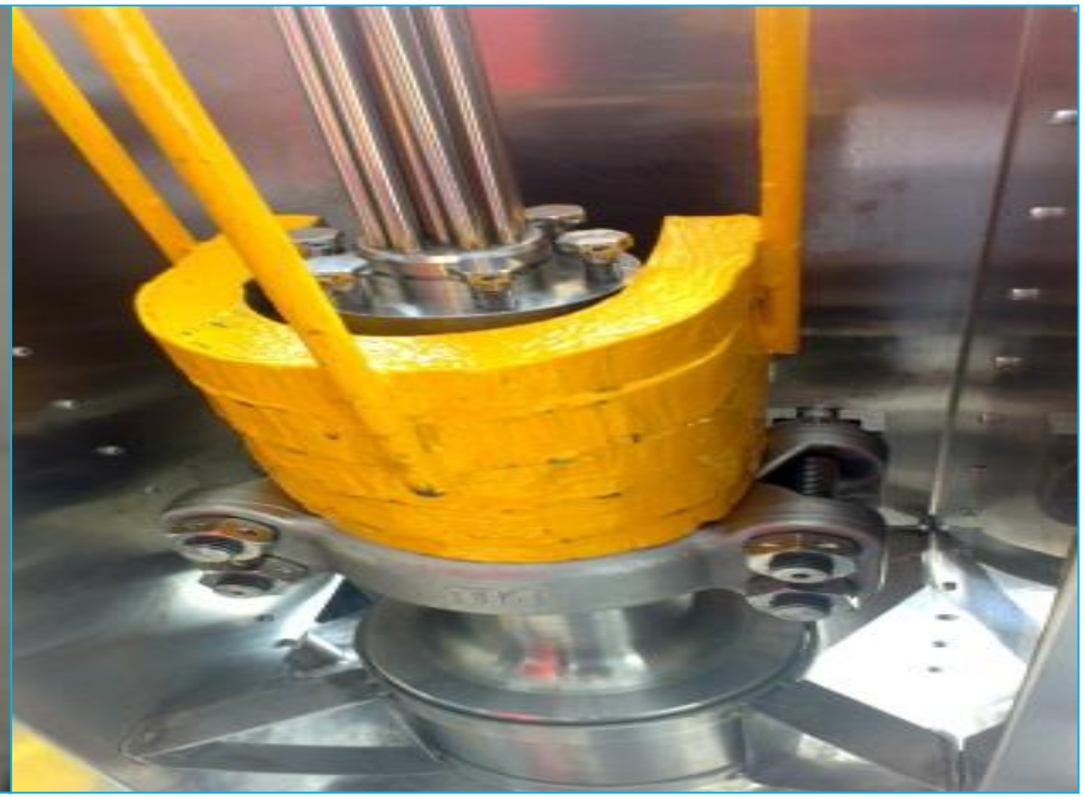


Hot Spots Shielding And Removing—2. Shielding with new material
热点去除及屏蔽—2. 应用新材料进行屏蔽改进

The new shielding material has the characteristics of good shielding effect, special model design and easy construction. Some of the CGN units including HYH plant have applied the new material to shield PTR hot spots

Hot Spots Shielding And Removing—3. Special shielding on RIC004MT
热点去除及屏蔽—3. 热电偶屏蔽改进

For some high-radiation areas, special shielding tools can be used for temporary protection. According to the characteristics of RIC004MT thermocouple replacement work, a customized shielding was developed.



Hot Spots Shielding And Removing—4. Fixed shielding installation
热点去除及屏蔽—4. 固定屏蔽改造安装

For some high radiation areas, fixed shielding can better provide shielding effect and meet seismic regulations.

Temporary shielding on RCV002/003RF was replaced by fixed shielding in HYH.

Hot Spots Shielding And Removing—5. Flushing during outage
热点去除及屏蔽—5. 大修专项冲洗

Flushing programs have been applied on the following pipelines in the previous outages to reduce the radiation level.

- Primary circuit U-shape pipeline
- Reactor safety injection system valve (RIS004/005/006VP) pipeline
- The pipeline in which the reactor main coolant system valve (RCP121/221/321VP) is located
- Reactor main coolant system valve (RCP122/222/322VP) pipeline
- Reactor main coolant system valve (RCP521/522/523/524VP) downstream pipeline

Hot Spots Shielding And Removing—6. Flushing of chemical sampling pipeline
热点去除及屏蔽—6. 化学取样管线热点临时冲洗

After H499 outage, H4KRT026MA showed a maximum value of 0.000425Gy/h, and the maximum contact dose rate of pipelines between H4REN456VP and H4REN560VP reached 19.2mSv/h. A program of four flushing lines were de signed, and SED water was used to flush the pipelines.

Outage	Measuring Time	H4KRT026MA Value（Gy/h）
H499	Before flushing program	0.000331
	After flushing program	0.000190

2.3

Improvements of Instrument & Tools

1. SG flushing and drying equipment improvement
2. Heat preservation modification
3. Valve seat grinding fixing holder
4. PTR spray pipe scaffold set up process improvement
5. Reactor vessel head “O “- ring support bracket
6. Pool decontamination method improvement
7. Special tool for argon filling
8. RRA pump lifting device
9. RRA bolt torque checking device modification
10. Temporary reactor cover installation during RPV
11. Reactor cover guide leg position mark
12. SG U-shape pipe eddy inspection technology improvement

Improvements of Instrument & Tools —1. SG flushing and drying equipment improvement
工具及工艺改进—1. SG冲洗烘干设备的改进及应用

The secondary side of SG tube sheet gets washed and then dried for about 12 hours in a regular outage maintenance.

Before optimization

Personnel should enter the generator room every 15 minutes to measure the temperature and check the status of the fan and pipe to prevent fire.

After optimization

A monitoring and temperature control system was developed that allow remote monitoring of dryer and air pipe status in the outer corridor.

Benefit

The application of this instrument reduced the dose by 95%.

Improvements of Instrument & Tools —2. Heat preservation modification
工具及工艺改进—2. 保温工艺改造

Before optimization

Double closed heat preservation, difficult to assemble or disassemble, especially in small space.

After optimization

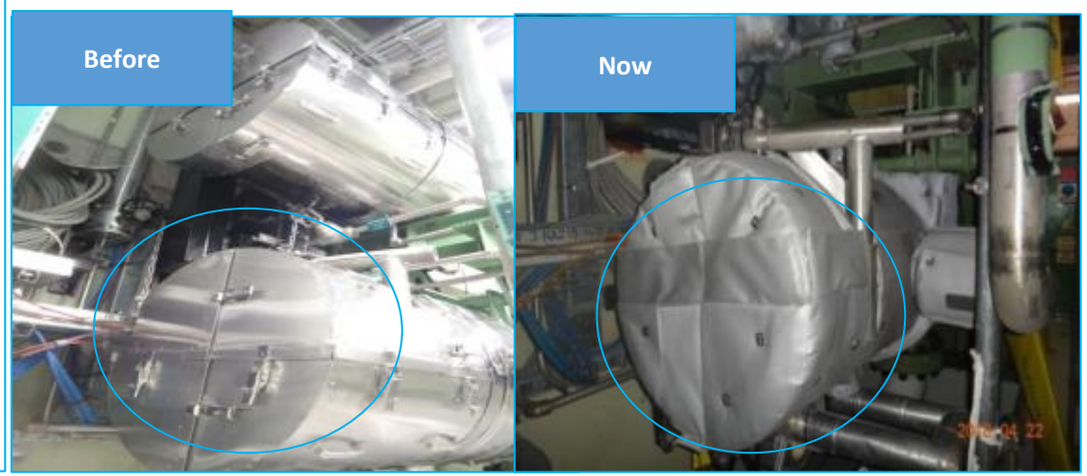
Easily detachable pad heat preservation.

Implementation area

- RCP212/215VP
- RRA001/021VP、
- RCV001EX、RCV002/003RF

Benefit

Assembly/disassembly time can be reduced by about 60%. The average collective dose reduction for the above area is about 1.8man·mSv in each outage.



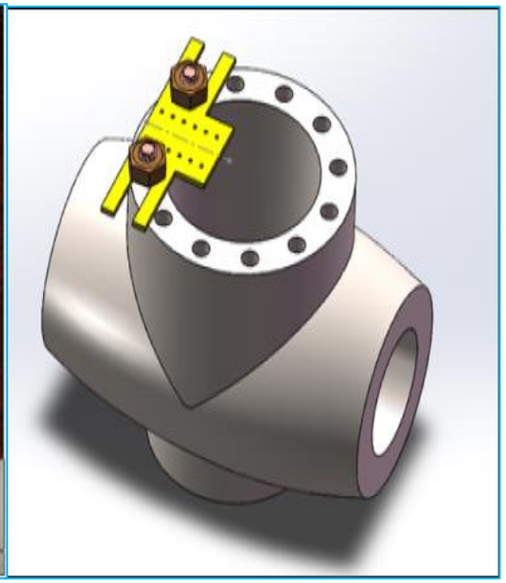
Improvements of Instrument & Tools —3. Valve seat grinding fixing holder
工具及工艺改进—3. 阀座研磨专用固定支架

Before optimization

- Use a binding belt to fix the grinding machine. Fixing and adjusting cost time. Some valves (such as RRA006/007VP) cannot be fixed.

After optimization

- Allows fixing the grinding machine and holder at low background area.
- Support seat of different sizes.
- Only 2 bolts are needed to fix the grinding machine.



Benefit

The application of this special holder can reduce the fixing of the grinding machine by 20min, effectively reducing the dose.

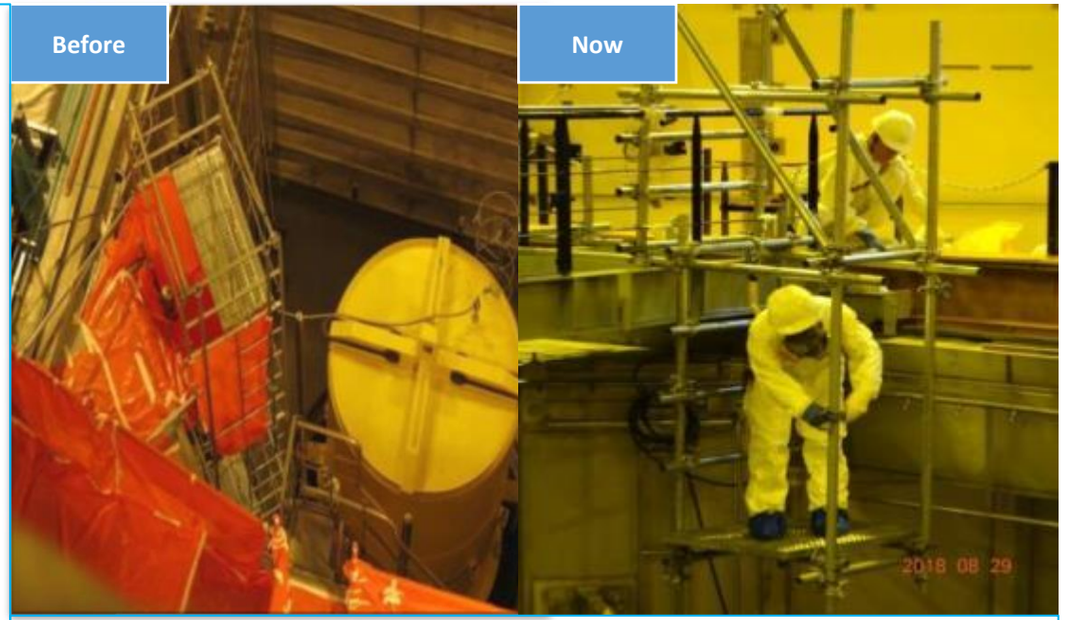
Improvements of Instrument & Tools —4. PTR spray pipe scaffold set up process improvement
工具及工艺改进—4. PTR喷淋管线脚手架搭设工艺改进

Before optimization

The operation area is located in the reactor pool. To set up the maintenance platform in the high-dose area is time-consuming and may cause a lot of scaffolding contamination, and the subsequent decontamination increases the amount of radioactive solid waste.

After optimization

Overhanging scaffold is set with the support of the small bridge above the pool.



Benefit

Working hours reduced by 90%, reducing collective dose by 0.9man.mSv, and reducing radioactive solid waste generated by scaffold decontamination by 90%.

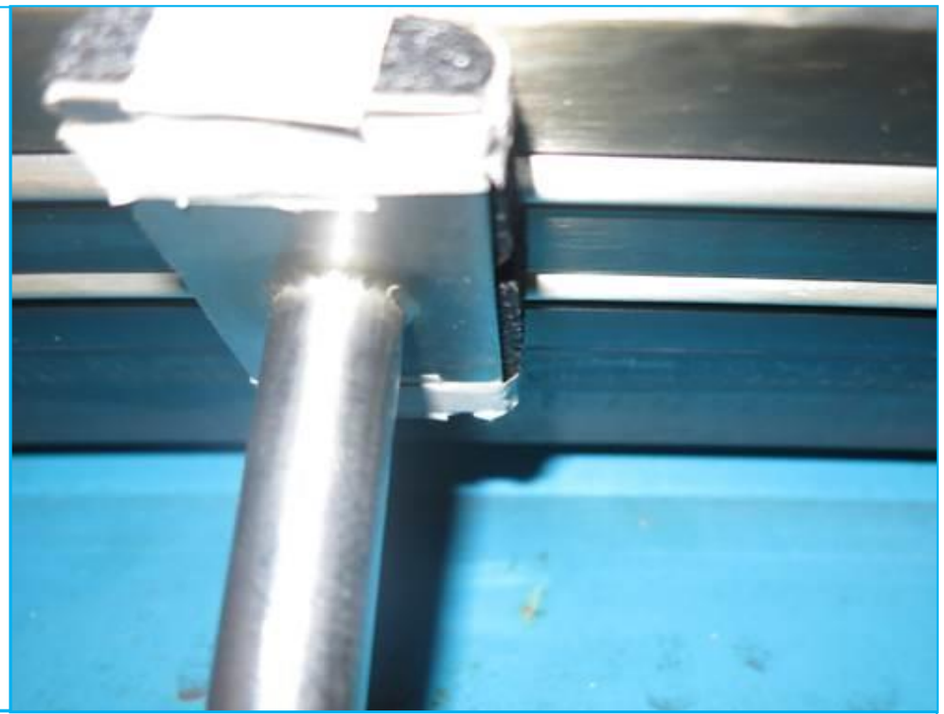
Improvements of Instrument & Tools —5. Reactor vessel head “O “- ring support bracket
工具及工艺改进—5. 大盖O环支撑架应用

Before optimization

When installing O-ring on the reactor pressure vessel head, in order to prevent O-ring from falling off, external manual support was needed.

After optimization

A special O-ring support bracket was developed to replace manual support.



Benefit

O-ring installing time decreased by 0.5h, reducing 0.2man·mSv dose in an outage.

Improvements of Instrument & Tools —6. Pool decontamination method improvement
工具及工艺改进—6. 水池去污工艺改进

Before optimization

The decon of pools by the old method used to need 7 worker to go down the pool and 5 more to assist in order to finish a 4-step process.

After optimization

The new foam-based method replaced the manual scrubbing, reducing 2 workers and 2 assist workers needed.

Benefit

In a single decon task, the time working down the pool was reduced to by 40%, saving 3man.mSv.

Improvements of Instrument & Tools —7. Special tool for argon filling
工具及工艺改进—7. BOSS充氩专用工具

Before optimization

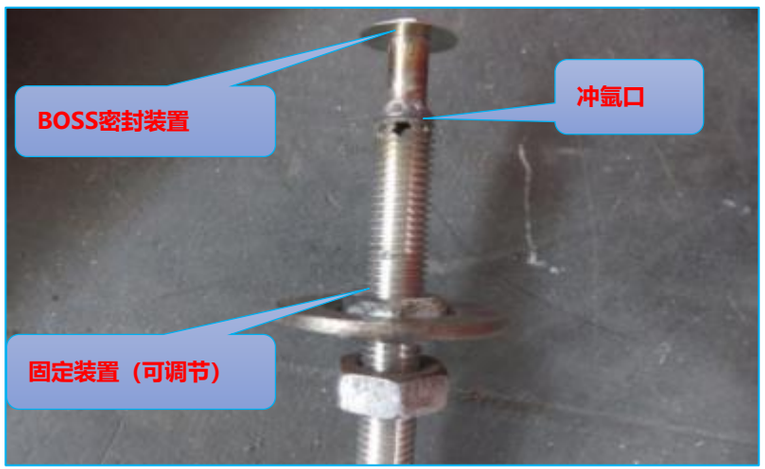
In previse BOSS pipe line weld defects recovery, duo to the pipe ventilation and negative pressure, the argon gas around welding lines would get diluted. To solve this problem, disassembly of a nearby valve for argon supply wound be necessary, causing extra working time and dose.

After optimization

A special tool, with sealing device to seal BOSS welding position, was invented to fill argon. This application can help to partly avoid the trouble of disassembly of the nearby valve in BOSS pipe line weld recovery.

Benefit

Maintenance task welding efficiency was improved and valve disassembly tasks reduced. About 1.5man.mSv of collective dose reduced in each outage.



Improvements of Instrument & Tools —8. RRA pump lifting device
工具及工艺改进—8. RRA泵解体吊运工具

Before optimization

In RRA002PO pump disassembling and checking, dose rate was high around pump (contact 6.9mSv/h, ambient 200uSv/h), working space was small, pump body was difficult to lift, lifting process was slow with turnover risk.

After optimization

To solve this problem, a special lifting equipment was invented and applied after bearing test. This equipment has effectively reduced the turnover risks and saved lifting time.

Benefit

About 0.85man.mSv dose reduced in each similar task.

Improvements of Instrument & Tools —9. RRA bolt torque checking device modification
工具及工艺改进—9. RRA螺栓力矩校验工艺优化

Before optimization

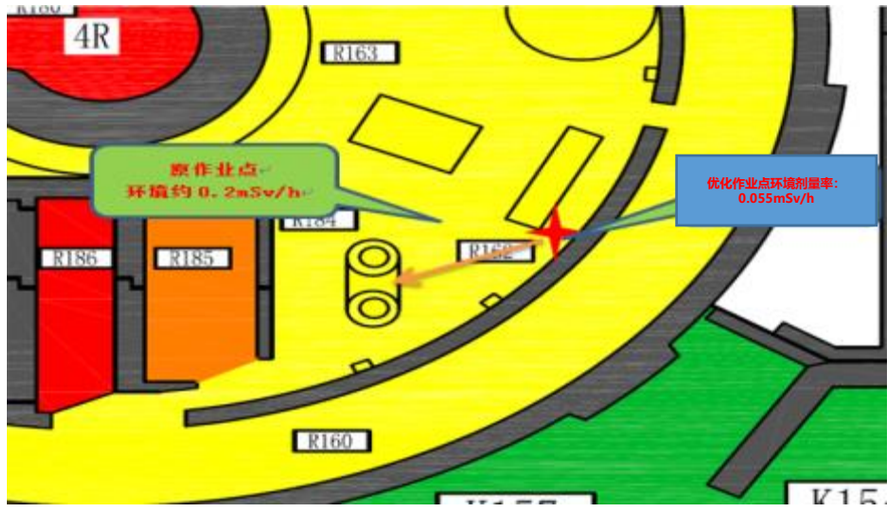
The external checking of H4RRA001/002RF in room R184 with high dose rate (contact 1.8msv/h, ambient 0.2msv/h) includes the bolt tensioning that needs 10 people to work in turns for about 6-8hours.

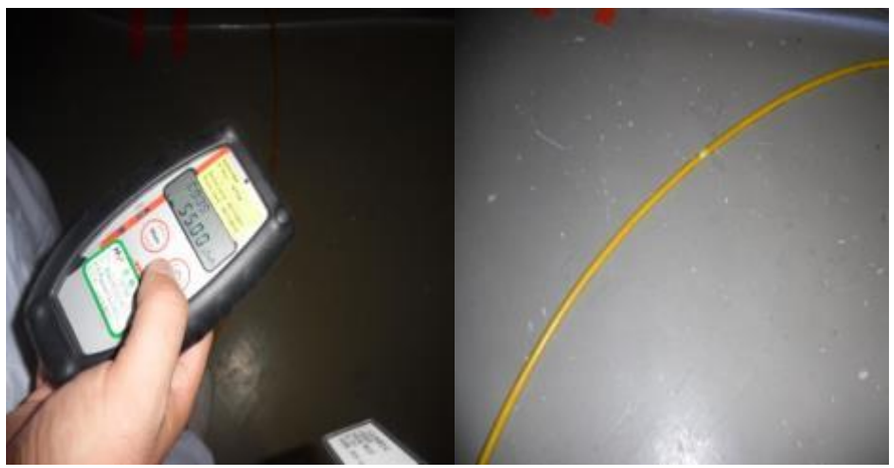
After optimization

The hydraulic oil pipe length get expanded, the workers can work in a lower dose rate area.

Benefit

About 0.4man.mSv dose reduced in each similar task.





Improvements of Instrument & Tools —10. Temporary reactor cover installation during RPV
工具及工艺改进—10. RPV期间假封头安装

Before optimization

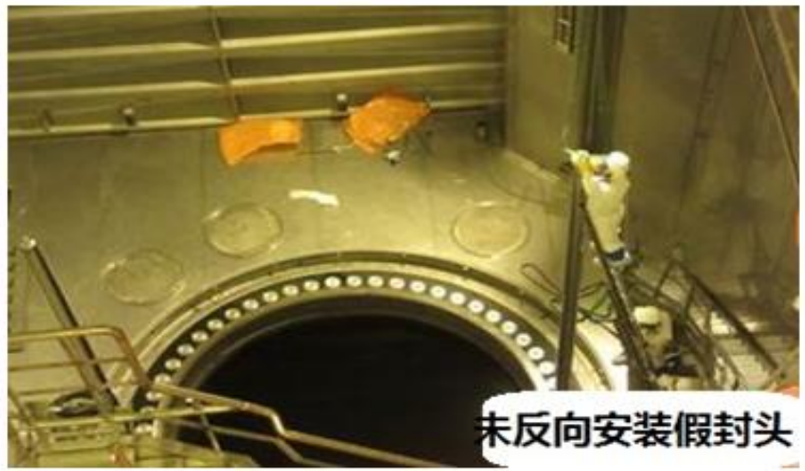
Before this optimization, temporary reactor cover was not installed during outage RPV activities. In the guide leg shifting task performed down the reactor pool beside reactor vessel, workers needed to climb a 6m ladder to the leg top. The work was with high dose rate, falling risk and could introduce foreign items into reactor vessel.

After optimization

Temporary reactor cover scheduled to be installed during RPV, eliminating the risk falling and providing shielding.

Benefit

About 4man.mSv dose reduced in each 10-year outage.



Improvements of Instrument & Tools —11. Reactor cover guide leg position mark
工具及工艺改进—11. 压力容器顶盖导向柱位置标记

Before optimization

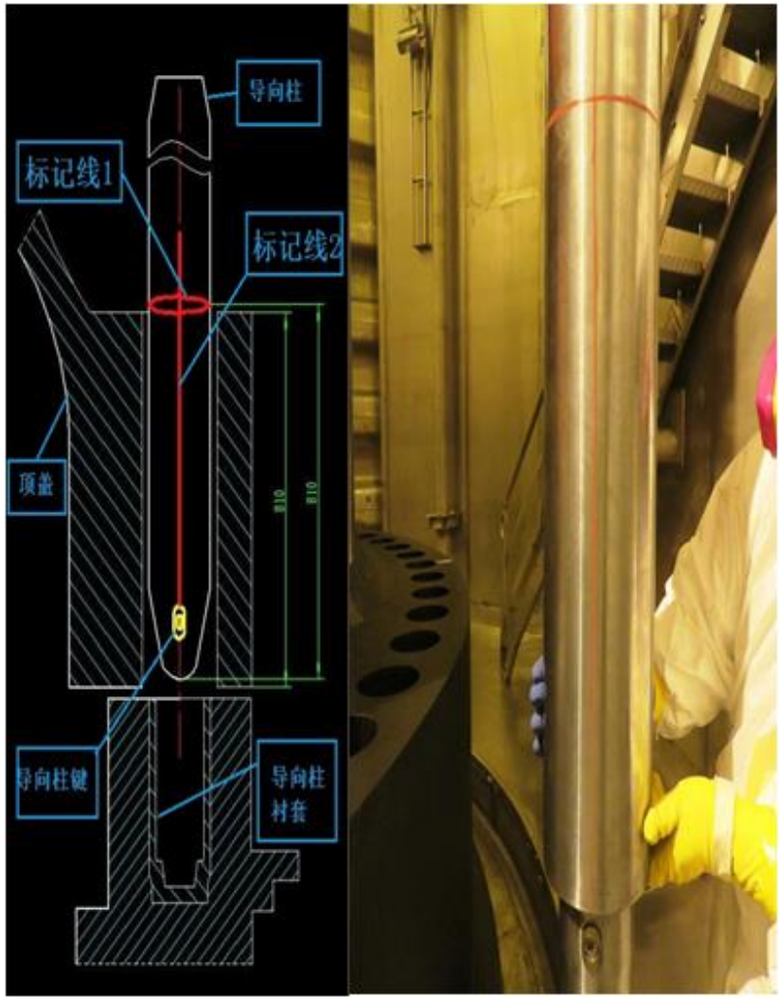
In the installing of guide leg, workers have to check the installation completion through the gap of cover flange by laying on pool bottom. The work processing is slow, difficult, and with high dose rate.

After optimization

Visual marks were marked on certain positions of guide legs, according to sizes of main stud hole, button and button slot, making it easy to check work progress.

Benefit

About 0.4man.mSv dose reduced in each outage.



Improvements of Instrument & Tools —12. SG U-shape pipe eddy inspection technology improvement
工具及工艺改进—12. 蒸汽发生器传热管涡流检查工艺改进

Before optimization

During SG heat transferring pipe eddy inspection, workers need to perform equipment operation in SG room high dose rate area.

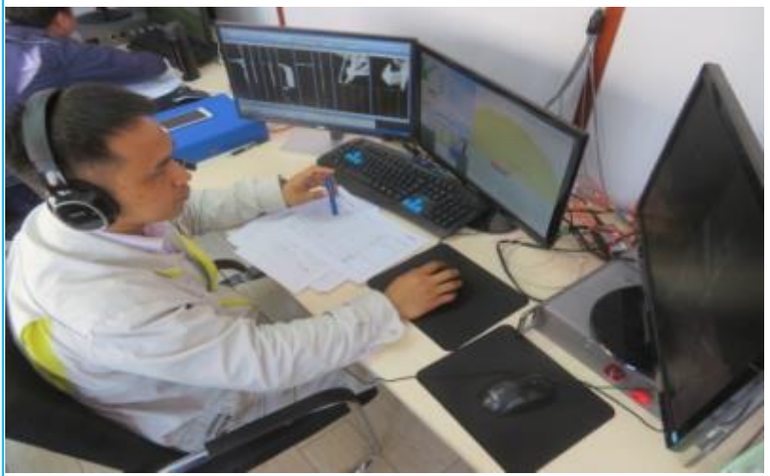
After optimization

To improving detector stability through equipment optimization

To reduce work time in SG room by optimizing eddy inspection logic

Benefit

About 1man.mSv dose reduced in each SG eddy inspection.



2.4

Scheduling & Procedure Optimization

1. Intensive maintenance area work optimization
2. Optimization of maintenances in room NA215 during outage
3. Maintenances adjusted to low dose rate period
4. Decon process optimization of fuel transmission pool
5. Rescheduling RRA001/002RF heat preservation removal
6. Pneumatic head disassembly process optimization

Scheduling & Procedure Optimization—1. Intensive maintenance area work optimization
窗口及工序优化—1. 密集检修区域工作优化

Taking H105 outage as an example, the work packages reviewing found that a large number of non-radioactive and radioactive maintenances cross-existed in 4 high-dose areas, challenging contamination and dose control. Through overall planning and optimization, the set up and demolition hours of the sites have been reduced by 50%

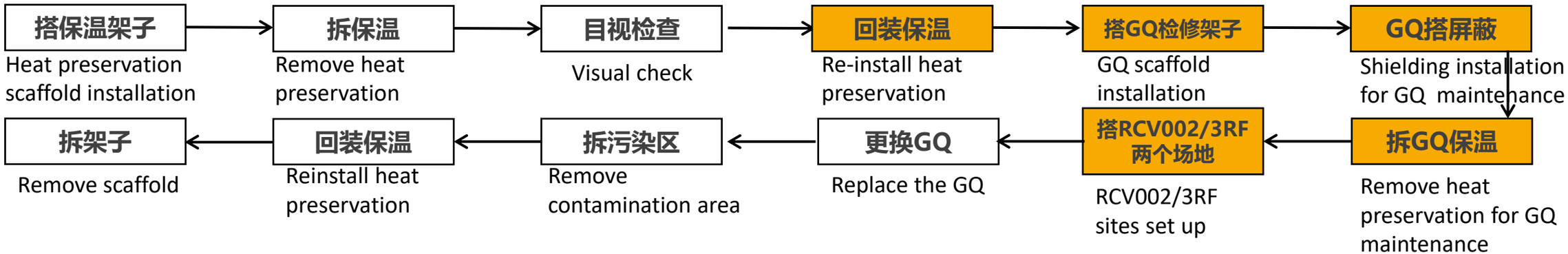
The maintenance optimization principles are as follows

- ✓ Tasks in the same system position get scheduled in the same working window
- ✓ Non- contamination before contamination work
- ✓ Low loose contamination before high contamination
- ✓ High-dose equipment before low-dose equipment
- ✓ Down-stream device before up-stream device
- ✓ Overall working site and shielding
- ✓ First block one end of the passage and finish the tasks with contamination risk there, and then unblock and then deal with tasks on the other end.

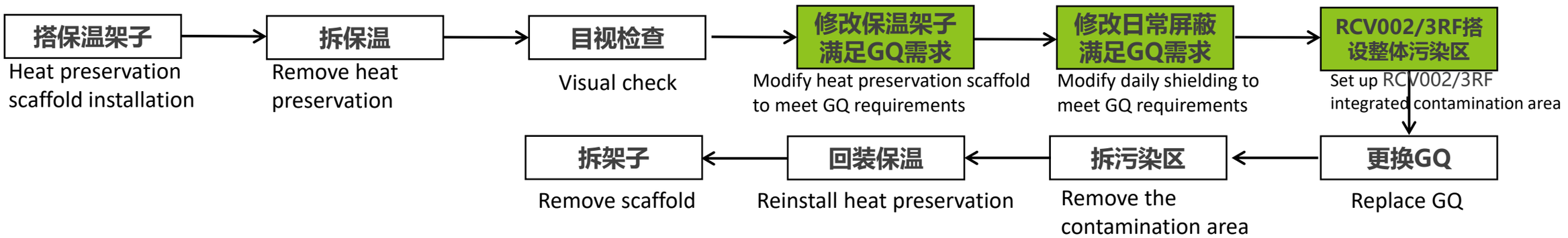
Room	Maintenances	Relevant branch
N214	3 valve disassembles、6 BOSS repairing、electrical instrument control check、service cooperation, total 44 tasks	Static motor、service、I&C、electrical、BOSS
W217	3 valve disassembles、9 BOSS repairing、4non-GQ、17 valve torque checks 、7 VELAN、7 electric actuator, total 81 tasks	Static motor、service、I&C、electrical、BOSS、TS
W218	3 valve disassembles、8 non-GQ、8 valve torque checks 、7 VELAN frame、12 electric actuator、service cooperation, total73 tasks	Static motor、service、I&C、electrical、BOSS、TS
R144	8 valve disassembles、6 BOSS repairing、28 valve torque checks 、2 vessel opening, service cooperation, total 88 tasks	Static motor、service、I&C、electrical、BOSS、TS

Scheduling & Procedure Optimization—2. Optimization of maintenances in room NA215 during outage
窗口及工序优化—2. 大修期间NA215房间各项工作窗口优化

Work sequence before optimization 优化前



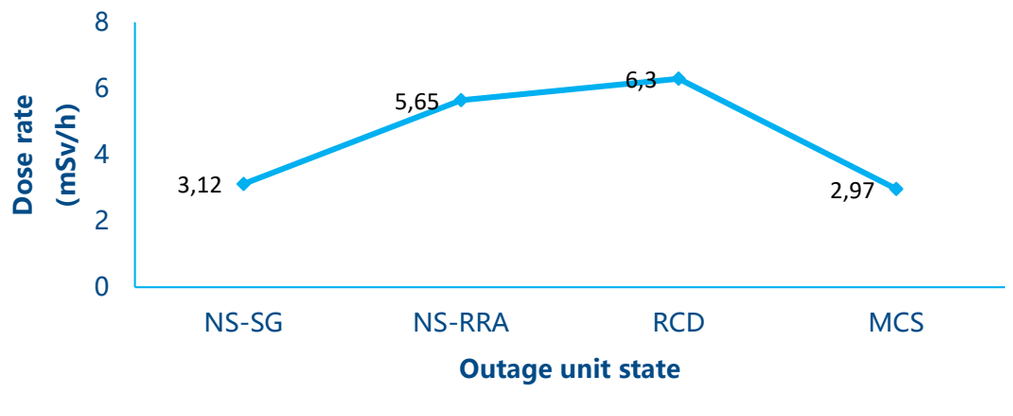
Work sequence after optimization 优化后



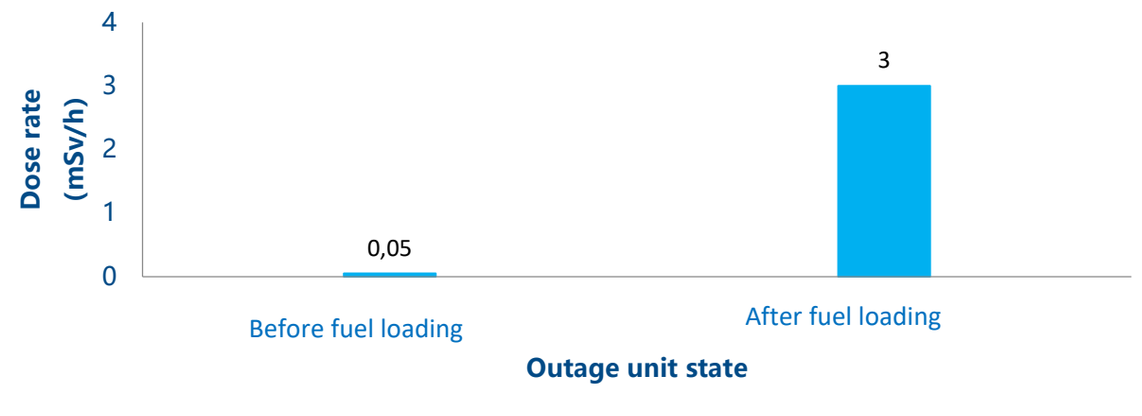
One time of shielding construction and removal + one time of heat preservation removal and installation, 80% of scaffold erection time and 40% of site erection time are reduced by this optimization.

Scheduling & Procedure Optimization—3. Maintenances adjusted to low dose rate period
窗口及工序优化—3. 检修窗口调整至低剂量率窗口执行

Shifting H1RCV001EX anchor bolt reinforcement to when the system is filled with coolant, at which time the dose rate dropped to the lowest level, about 50% of the highest. About 3.5 man.mSv dose get reduced by this practice in H103 outage.

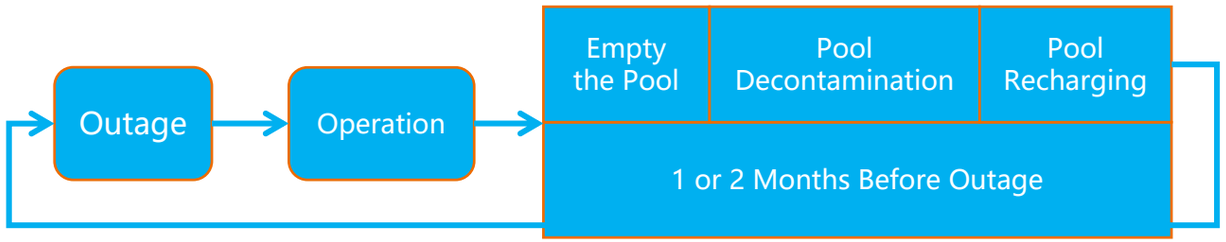


During unit first outage, the contact dose rate of H4PTR404TW before fuel unloading was much lower than that after loading fuel. The Replacing of H4PTR404TW sealing ring was firstly arranged after loading. The work was rearranged to the time before unloading, and about 0.5 man ·mSv was optimized.

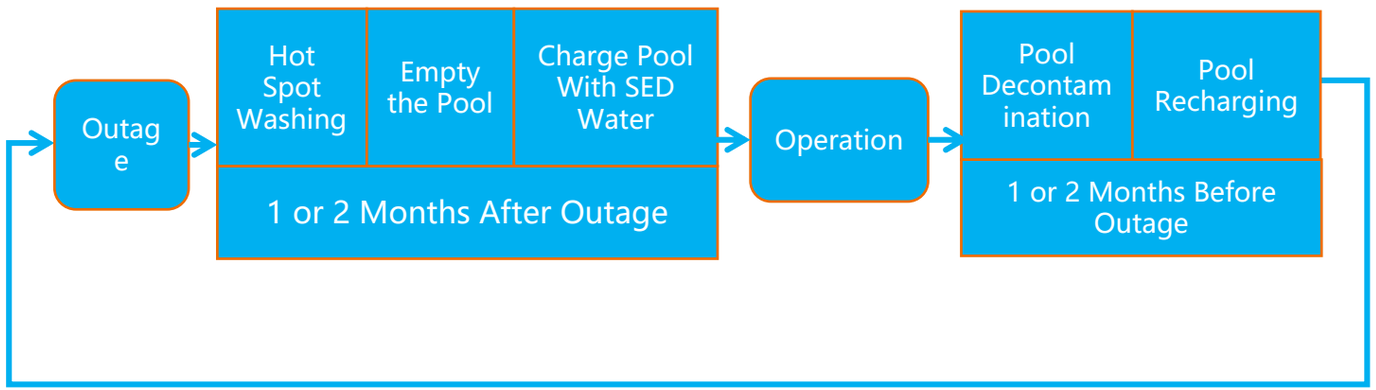


Scheduling & Procedure Optimization—4. Decon process optimization of fuel transmission pool
窗口及工序优化—4. 传输池去污工序优化

Before optimization 优化前



After optimization 优化后



Hot Spot	Pre-wash（μSv/h）	Post-wash（μSv/h）
1	32000	28800
2	3680	1050
3	7120	780
4	1960	431
5	4100	101
6	1230	86
7	1050	81
8	1800	160

Reduce the number of radiation hot spots in public areas. Take H2 unit as an example, the number of hot spots was reduced from 8 to 2, which was estimated to reduce collective dose by 3.7 man·mSv

Scheduling & Procedure Optimization—5. Rescheduling RRA001/002RF heat preservation removal
窗口及工序优化—5．RRA001/002RF保温拆除窗口优化

In the previse outages, heat preservation removal removing of RRA001/002RF was performed in MCS State, during which time the ambient dose rate was about 1mSv/h. After coordinating, the work was rescheduled to conduct in NS/RRA state(before oxidation and purification), the ambient dose rate was about 100uSv/h, saving about 0.8man·mSv dose in each outage

Scheduling & Procedure Optimization—6. Pneumatic head disassembly process optimization
窗口及工序优化—6. 气动头解体工序优化

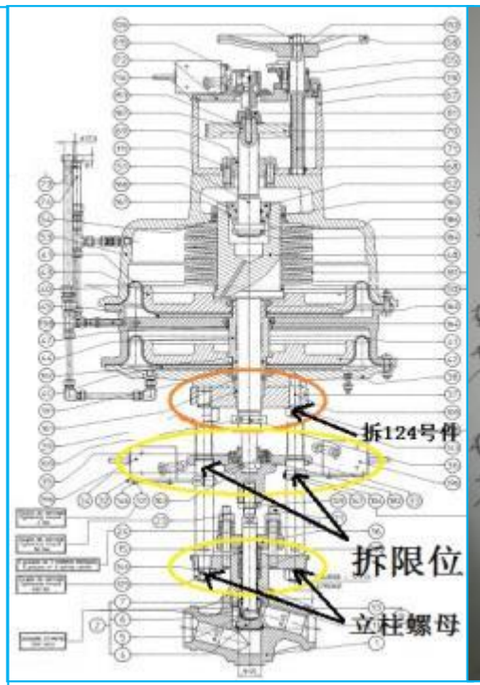
Maintenance Task: Pneumatic head of chemical and volumetric control RCV system valve located in R185 disassembly

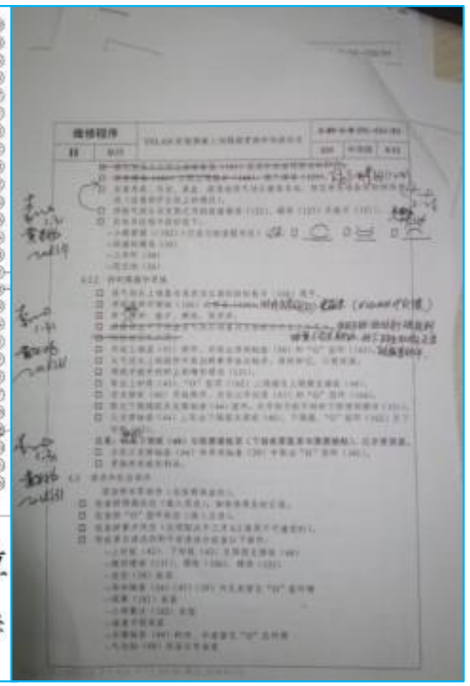
The original process

Remove the position limit switch of the pneumatic valve and fixing leg and lift the pneumatic head out for maintenance. Reinstall and adjust the position of the limit switch when reassembling. 1.5h/set.

The new process

Remove the nut (part no. 124) and the pneumatic head, do not remove the nuts and position limit switch. When reassembling, do not need to reinstall the fixing leg and adjust the position limit. 0.5h/set.





Taking H203 outage as an example, 4man.mSv was reduced by the optimization of the disassembly of five pneumatic heads in high-dose area.

2.5

The Promoting of Skills & Awareness

1. Systematic and detailed training programs
2. Accurate communication/notification of safety information
3. Onsite survey/training program
4. Smart plant program
5. Good practice promotion
6. Experience feedback handbook
7. The ‘Four Entering’ of experience feedback
8. Publicity activities

The Promoting of Skills & Awareness—1. Systematic and detailed training programs
技能、意识提升—1. 精益化培训

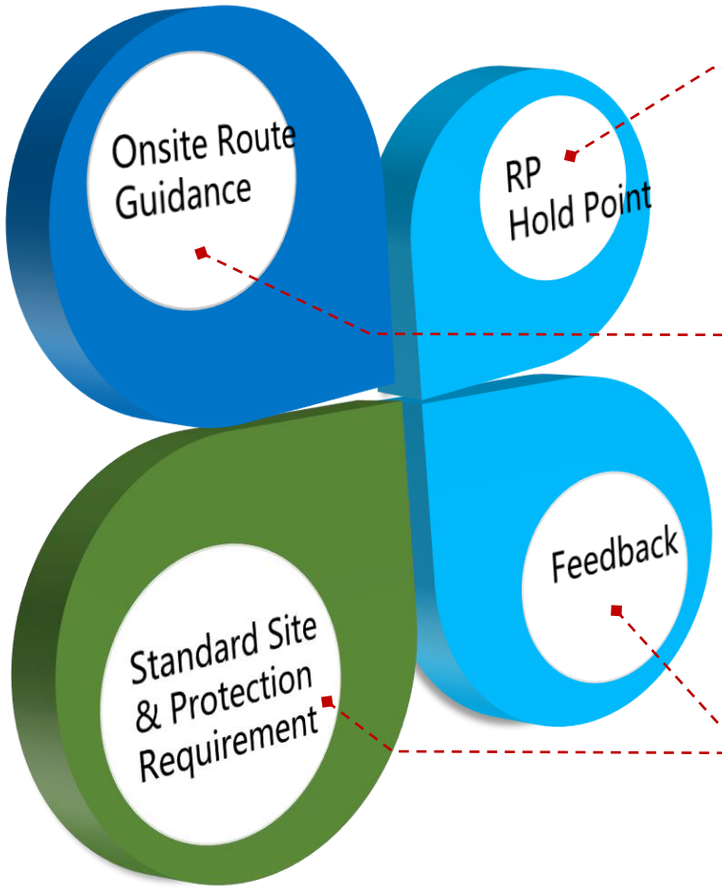
Training materials contain two major parts, 36 modules. Maintenance teams are categorized into 11 parts and each has a specialized training menu. In the first half of 2019, 3432 person-times of outage-enhancing training were conducted.

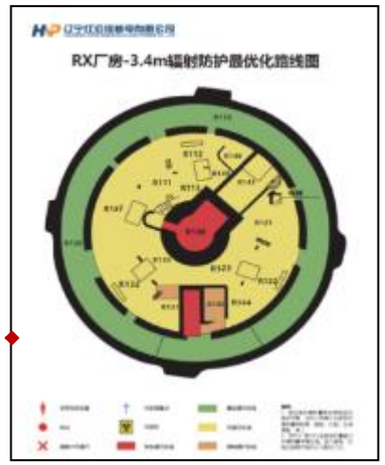
General part		
1	TY1	TY1a-General Admission Authorization
2		TY1b-RCA access and basic protective articles
3		TY1c-Tools, instruments, materials
4		TY1d-Information & risk notification
5		TY1e-Additional protective articles
6		TY1f-External exposure protection
7		TY1g-Abnomality response
8	TY2	TY2a-Reward and punishment regulations
9	TY3	TY3a-Experience feedback
10	TY4	TY4a-Risk classification and risk control manual
11	TY5	TY5a- Contaminated worksite management
12	TY6	TY6a-Non-radioactive material measurement
13	TY7	TY7a-Radioactive material transportation and storage
14	HM	HM1-Personnel behavior and typical violation – operation staff
15		HM2-Personnel behavior and typical violation – chemistry staff
16		HM3-Personnel behavior and typical violation—service staff
17		HM4-Personnel behavior and typical violation - maintenance staff
18	NB	New employee, small contractor

Specialized part		
1	AQ	Safety supervisor
2	GC	Work supervisor
3	DG	Main Equipment
4	PMC	PMC fuel
5	FW1	General service
6	FW2	Insulation & scaffold
7	FW3	Solid waste
8	RQ	Container
9	FM	Valve
10		TSD
11	YB	R & C
12	DQ	Electrical
13	ZJ	Main rotating Machine
14		General rotating equipment
15	TS	TS1-Radioinspection in RCA
16		TS2-Radioinspection outside RCA
17	XZ	Equipment testing
18		On-service equipment inspection

Maintenance teams		Training menu
大盖+容器	MRV	TY1-TY7、HM4、NB、DG、RQ、YB
燃料	MFA	TY1-TY7、HM4、NB、PMC
阀门+BOSS	Valve	TY1-TY7、HM4、NB、FM
转动主设备	Main rotate	TY1-TY7、HM4、NB、ZJ1
一般转动设备	General rotate	TY1-TY7、HM3、NB、ZJ2
控制区探伤	RT	TY1-TY7、HM3、NB、TS1
在役检查	Inspection	TY1-TY7、HM3、NB、XZ
保温、脚手架	Insulation & scaffold	TY1-TY7、HM3、NB、FW2
现场通用服务	General service	TY1-TY7、HM3、NB、FW1
新人	New employee	TY1-TY7、HM1-HM4、NB
大修现场通用	General	TY1-TY7、HM4、NB

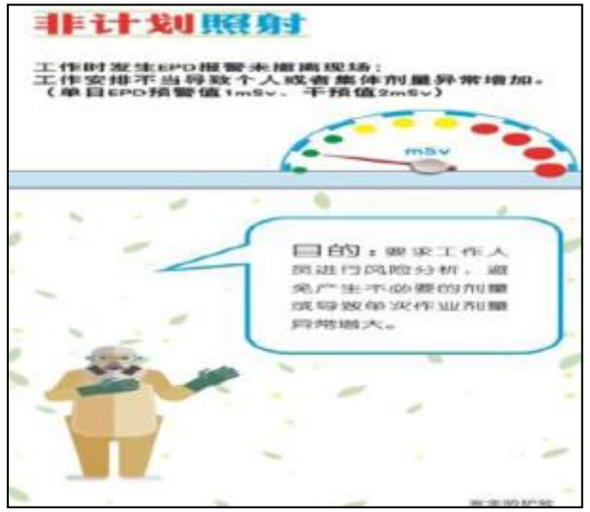
The Promoting of Skills & Awareness—2. Accurate communication/notification of safety information
技能、意识提升—2. 风险信息准确告知





- **The Promoting of Skills & Awareness—2. Accurate communication/notification of safety information**
  技能、意识提升—2. 风险信息准确告知

宣传



The Promoting of Skills & Awareness—3. Onsite survey & immediate training program
窗口及工序优化—3. 即时抽查与培训

Onsite survey

To check the RP skill of personnel and enhance their awareness of protection

Immediate training

According to the survey result the unqualified personnel will be provided with immediate training to enhance their awareness of radiation safety

The onsite survey/training program covered more than 500 employees or contractors in each outage.

The Promoting of Skills & Awareness—4. Smart plant program
窗口及工序优化—4. 智慧电厂

人员剂量实时监测和控制

Personnel dose real-time monitoring

工作现场实时视频监控

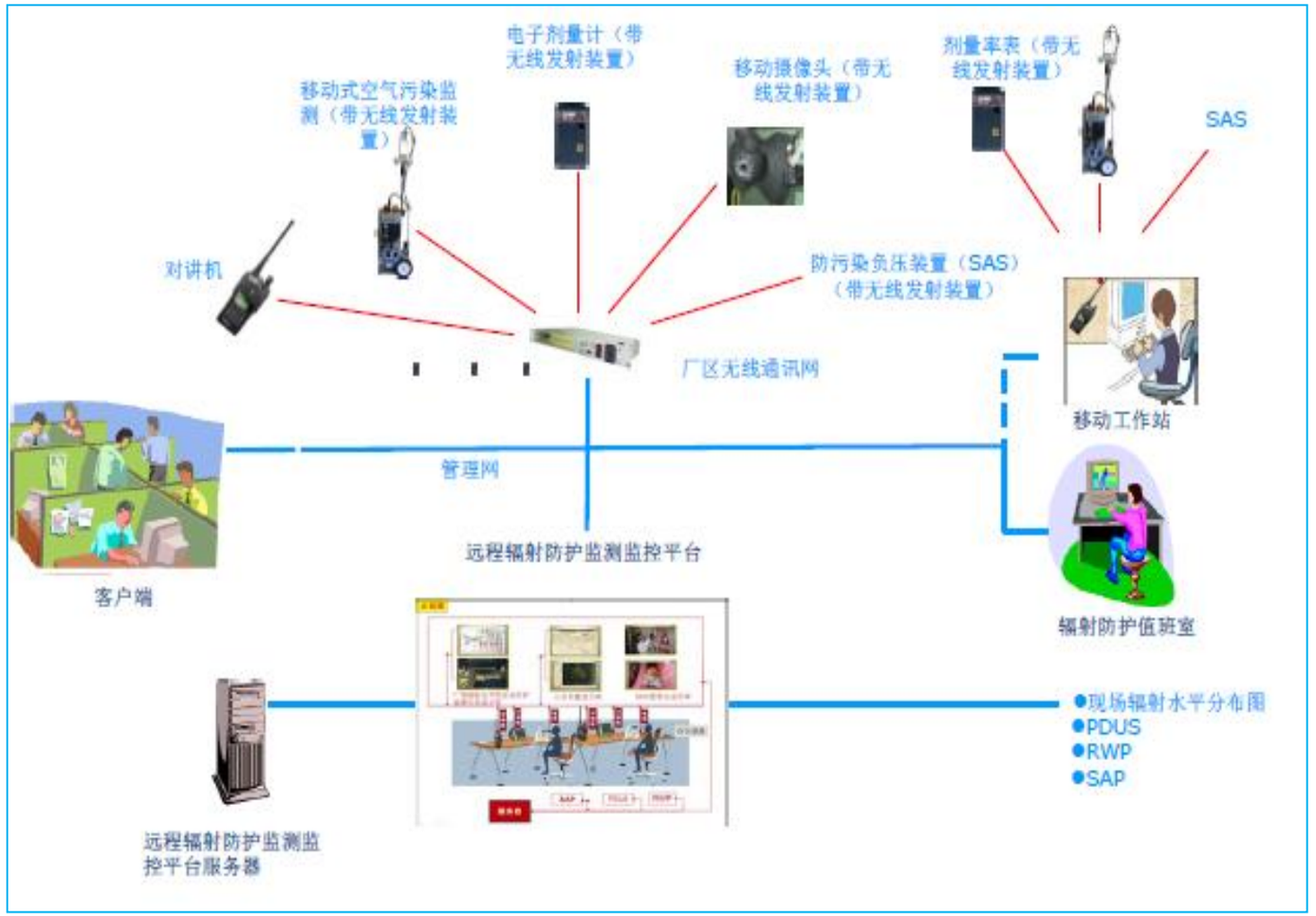
Real-time video monitoring on work site

现场辐射水平和安全状态连续监测

Radiation levels continuous monitoring

辐射防护数据无线传输

Wireless transmission of RP data



The Promoting of Skills & Awareness—5. Good practice promotion
窗口及工序优化—5. 剂量优化良好实践正向引导

Good Practice Classification	
A	By taking various optimization and improvement actions, reducing the collective dose of an maintenance task by more than 30% and 1mSv.
B	By taking various optimization and improvement actions, reducing the collective dose of an maintenance task by more than 20% and 0.5mSv.
C	By taking various optimization and improvement actions, reducing the collective dose of an maintenance task by 0.1mSv.

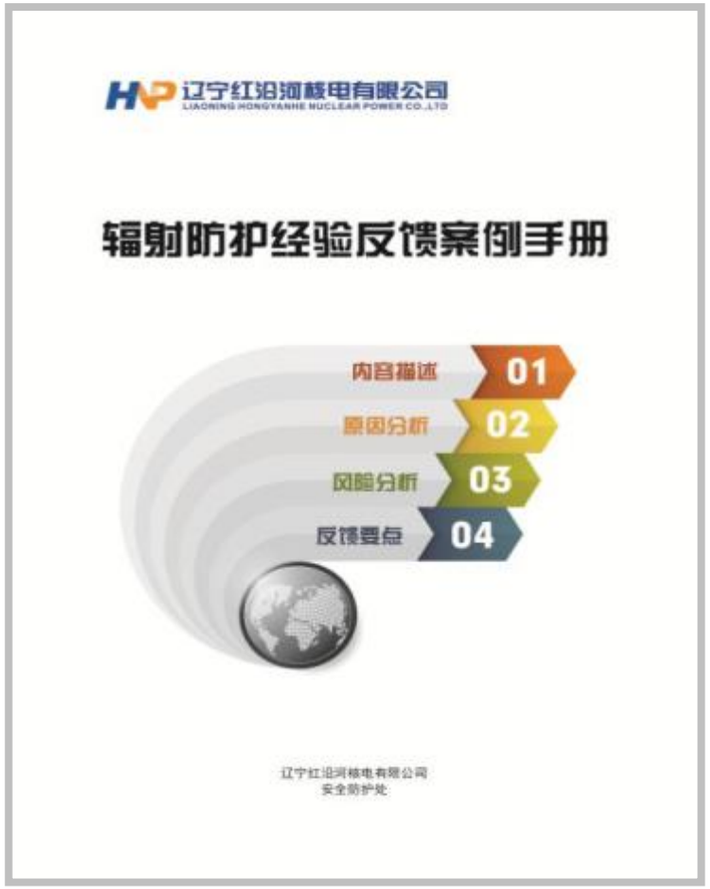
1. Good practice will be rewarded in various manners
2. Collective dose before optimization - collective dose after optimization = optimization value
3. Data must be traceable and reliable
4. Evidence of all good practice must be provided
5. Recommended optimization areas include hot spot removal, hot spot shielding, outline optimization, scheduling, processes, tools, personnel behavior control, training, drills, etc.

Good practices are complied into books and manuals

序号	实践描述	专业	安全员	实践进展情况			实践收益	
				不适用	待执行	已完成	优化的剂量	其他
1	阀座研磨专用固定支架	静机	赵刚、李帅					
19	RCV气动阀解体专用托架小车	转机	姬亚瑞、邱于里					
27	RCV001EX、002/003RF保温改造	服务	姜福智、张雷					
55	射线探伤语音报警器的使用	技术	徐浩博、罗琦					

Good practices implementation are followed by the maintenance depts. and safety dept.

The Promoting of Skills & Awareness—6. Experience feedback handbook
窗口及工序优化—6. 经验反馈手册



More than 190 RP relevant experience feedback listed in the handbook .

The Promoting of Skills & Awareness—7. The ‘Four Entering’ of experience feedback
窗口及工序优化—7. 经验反馈“四进”

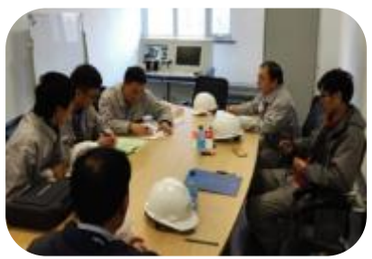
Entering Field 3760

To place the experience feedback information board in the field and to notice on field workers

Four Entering

Entering Meetings 1323

To introduce and discuss experience feedback in operation meeting, pre-shift meeting and pre-job brief.



Entering the Procedure 831

To write important experience feedback into procedures

Entering Working Schedule 1570

To introduce outage experience feedback into the outage main schedule

The Promoting of Skills & Awareness—8. Publicity activities
窗口及工序优化—8. 宣传活动

RP Monitoring Meter Day

RP Skill Competition

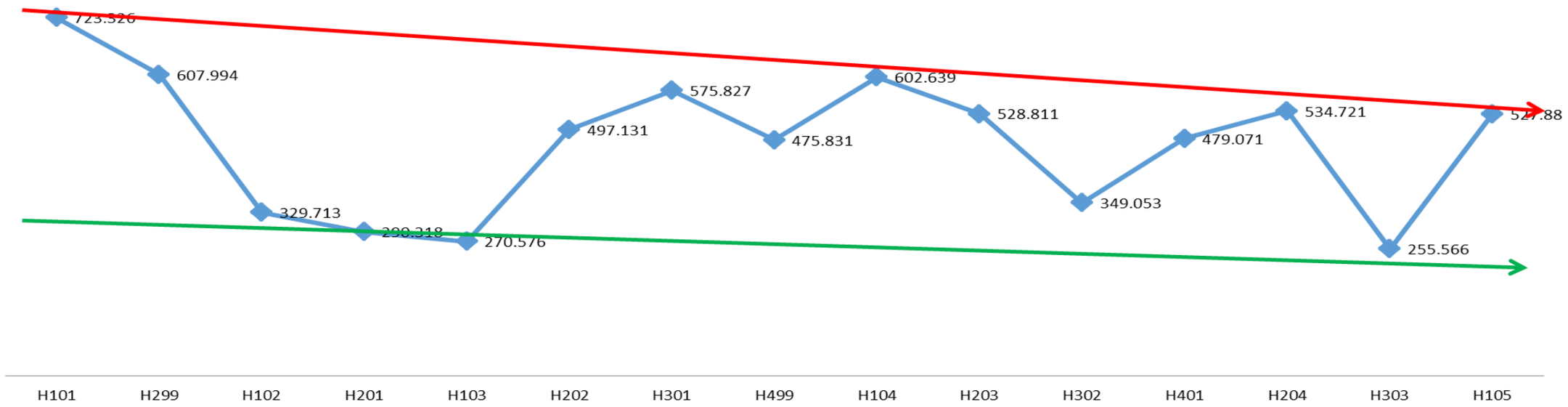
3 总结 Summary

Outage collective dose

大修集体剂量

Through the practice of the five-dimensional model, outage collective dose presents 2 trends.

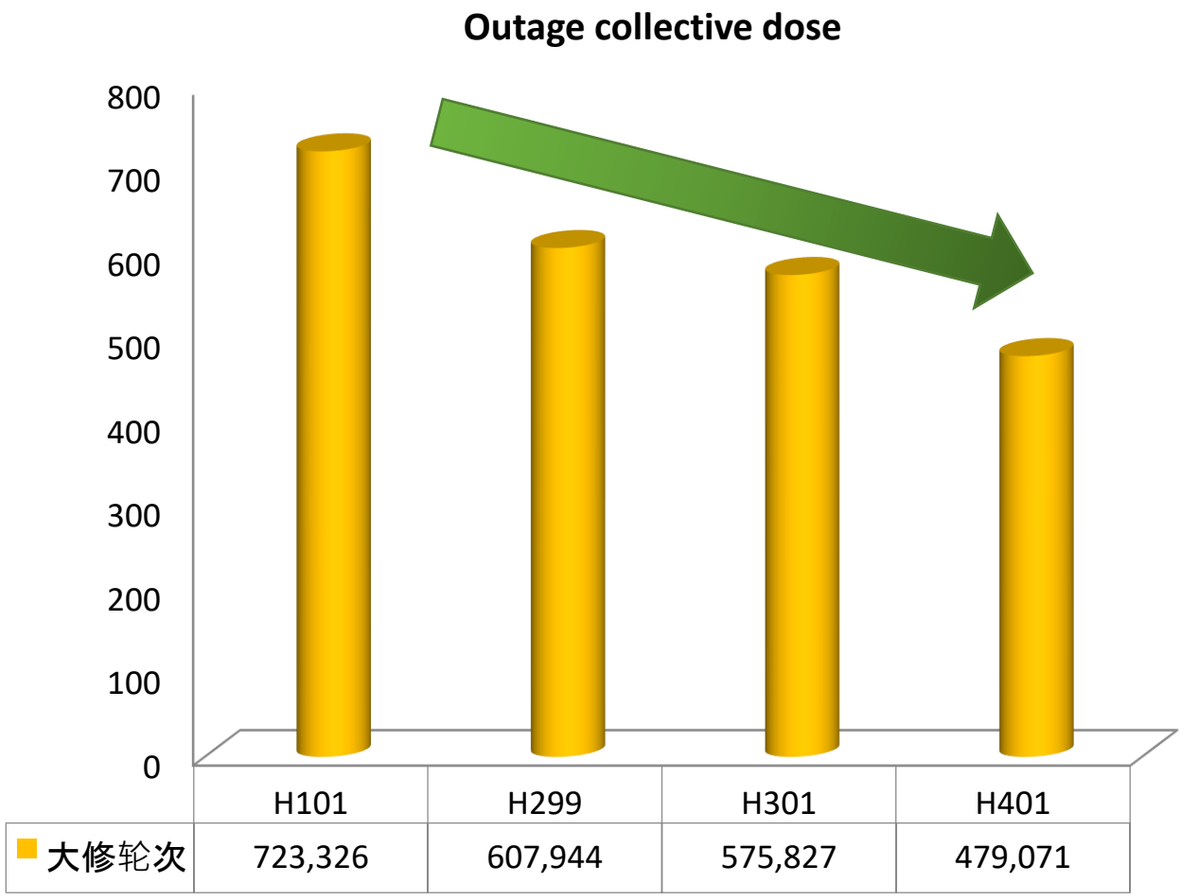
- The upper limit of the collective dose is gradually decreasing.
- The lower limit of collective dose has repeatedly reached new low level.



10-year outage collective dose

十年大修集体剂量

Through the practice of the five-dimension model, the collective dose of "10-year outage" is continuously optimized. Outage H401 created the optimal value of "10-year outage" collective dose in CGN.



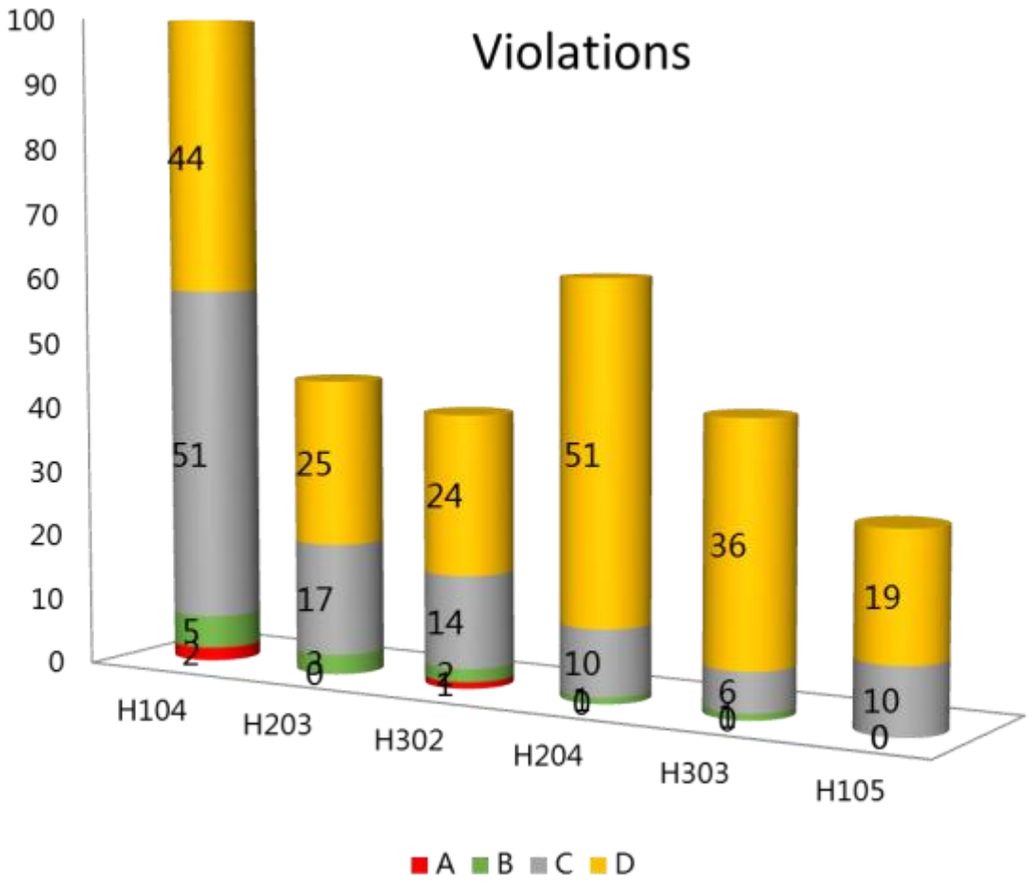
Benefits in radiation risk control

辐射风险管控收益

HYH unit 1 in 2018 reached the excellent level of WANO PWR annual CRE index.

Outage collective dose has repeatedly reached the top quarter of CGN's annual outages.

Violation number continuously decreases.



The practice of optimization brings not only economic and health benefits, but also respect for life.

对最优化的实践，带来的不仅是经济收益、健康收益，更是对生命的尊重。

Administrative level attention

管理层关注

More departments’ participation

更多部门参与

More communication within the industry

行业内更多交流

Thanks for Your Attention