



生态环境部核与辐射安全中心
Nuclear And Radiation Safety Center

Analysis of Occupational Exposure Status and Good Practices in Operating Nuclear Power Plants in China

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1. Overview on CISOE

1. Overview on CISOE



What is NSC

- A nonprofit affiliated institution to the Ministry of Ecology and Environment/ National Nuclear Safety Administration (MEE/ NNSA)
- The only public technical guarantee organization mainly focus on nuclear safety regulations and radiation protection management
- Provides overall and comprehensive science & technical support for nuclear and radiation safety regulations
- Also serves as the China' s nuclear and radiation safety centers on technical review, R&D and information exchange as well as the training base for kinds of regulators



The significance of establishment the CISOE

- **Understand the technical requirements and operation experience of occupational radiation protection management of nuclear industries**
- **Provide technical support for the regulatory authorities to implement unified management of occupational radiation**
- **Promote the development of systematic and information-based nuclear and radiation safety supervision in China**

Approved by the "nuclear and radiation safety supervision big data construction (phase I)" sub project of "ecological environment big data construction" of the Ministry of ecological environment

National code for management and use of occupational radiation exposure information system ([2019]100)



A hierarchical management network system at the national, provincial, and enterprise levels.

Achieve dynamic mastery of unit information, facility information, personnel information, and dose information

Achieve full coverage of personal dose data

2017.5

2018.3

2018.11

2019.1

2019.12

2024.12

- Strengthen the establishment and management of personal dose database of occupational exposure
- Establish the project implementation plan and build it according to the idea of "overall planning, hierarchical responsibility, based on the existing resources and integrating resources"

Complete the final acceptance of the project. The system is officially running.



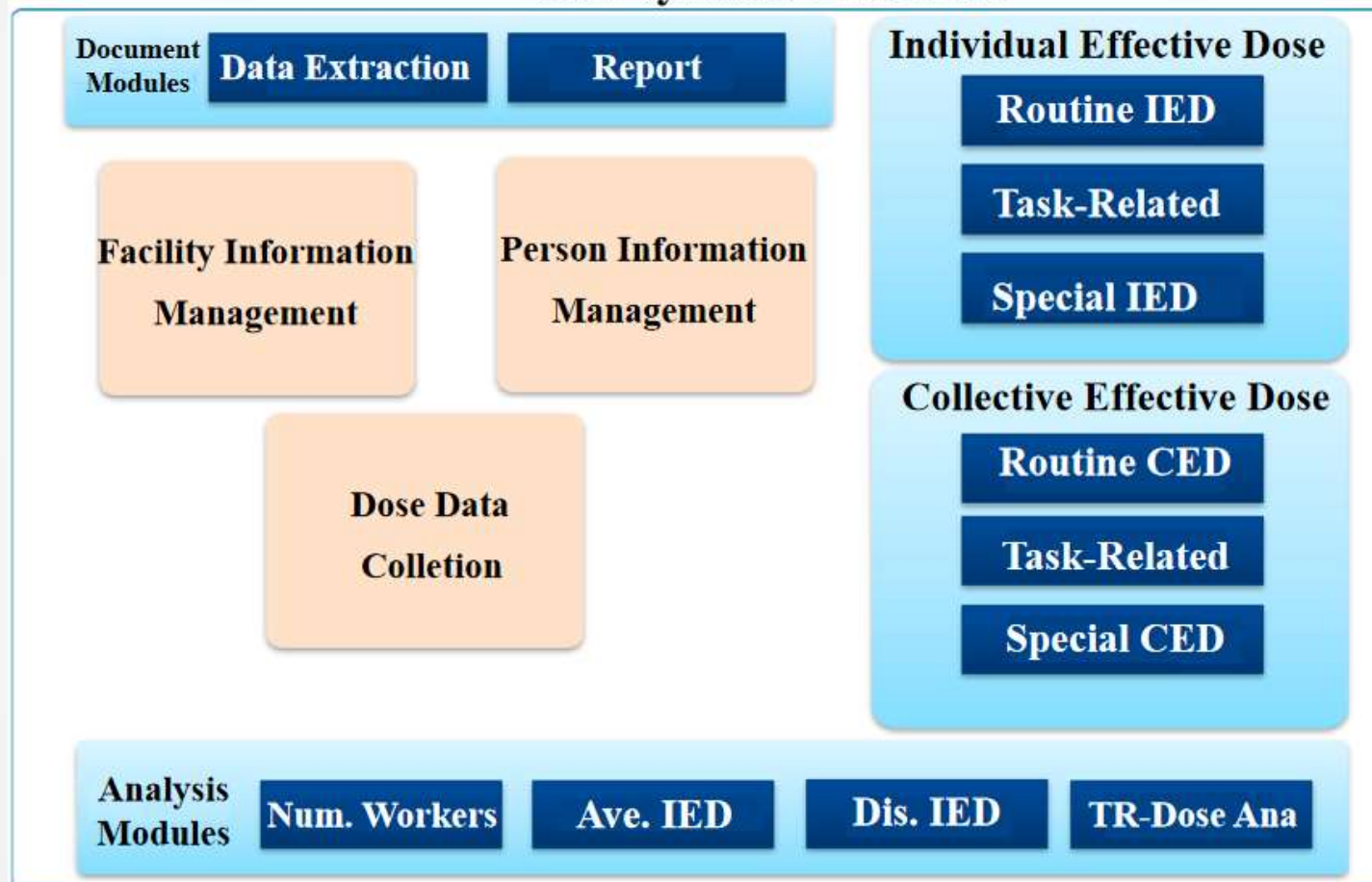
The first annual report on occupational exposure was issued



1. Overview on CISOE



Sub-systems of CISOE



1. Overview on CISOE



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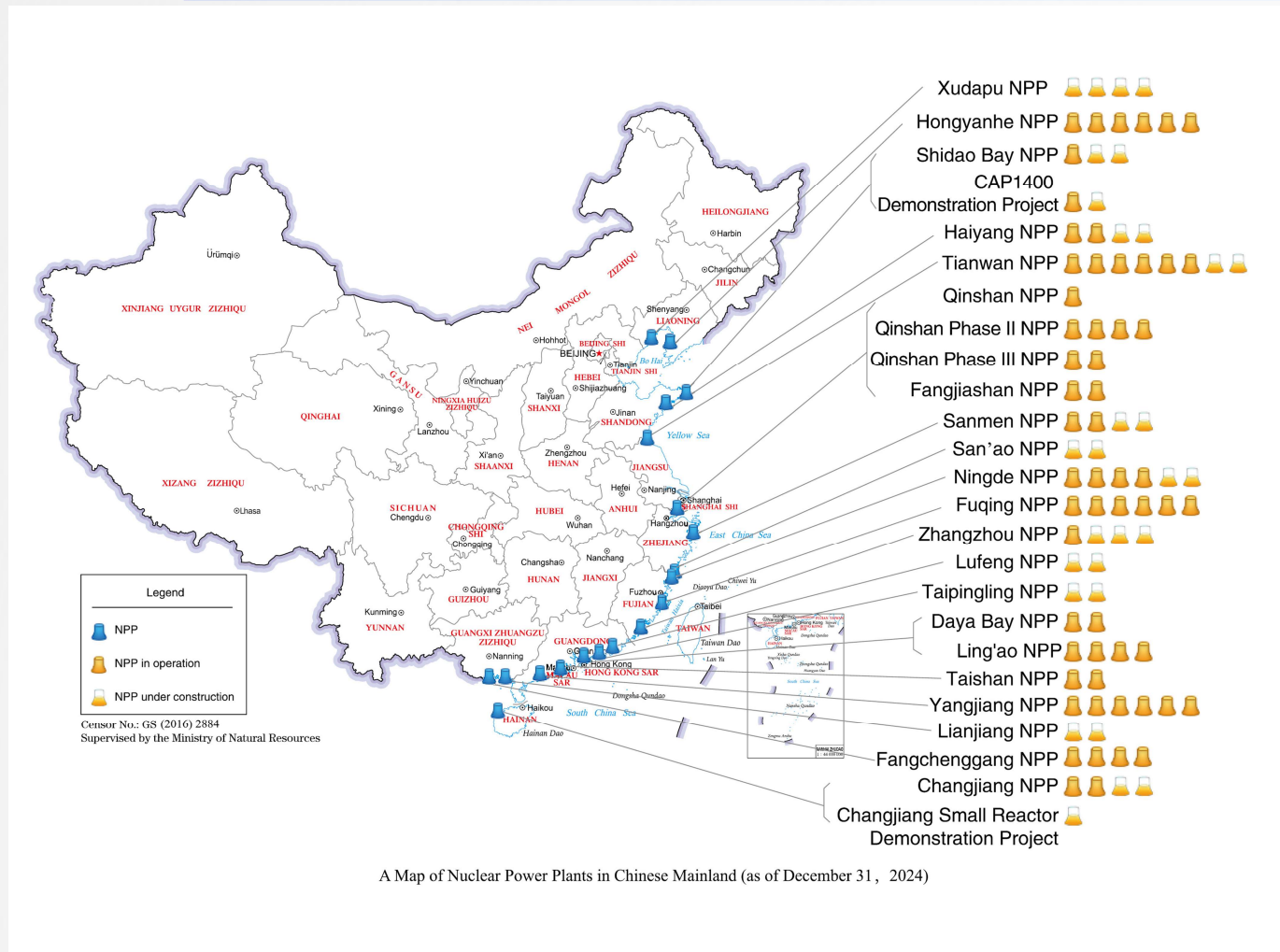


- **Centralized control, interconnection, real-time sharing and early warning of occupational exposure information can be realized**
- **National, provincial and enterprise hierarchical management network system has been established**
- **Operator information, facility information, personnel information and dose information (including routine, task-related and special monitoring) are included**
- **Personal dose data for nuclear facilities, uranium mining and metallurgy industries, nuclear technology utilization and radiation safety supervision have been covered**

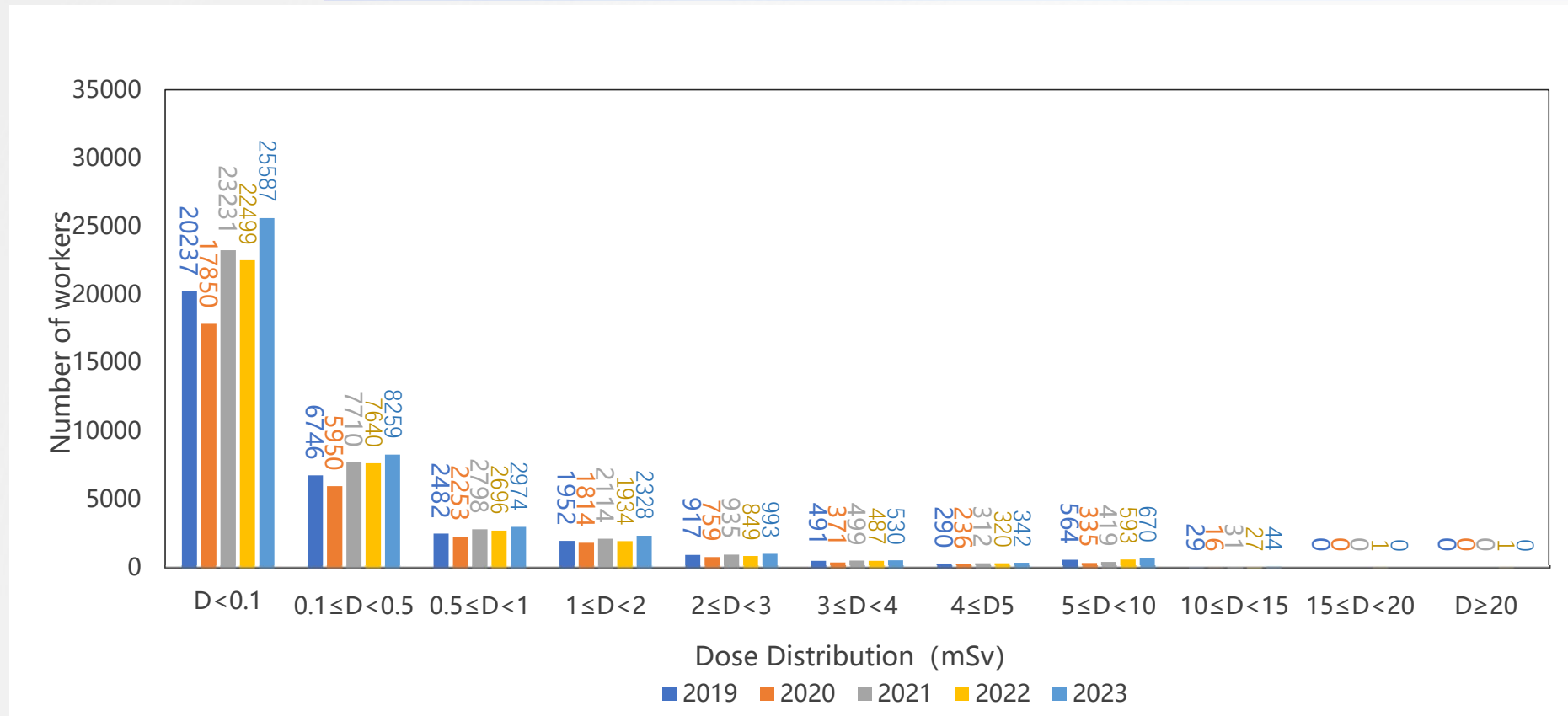


2. Management on Occupational Exposure

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Personal dose distribution in nuclear power plants from 2019 to 2023

2. Management on Occupational Exposure



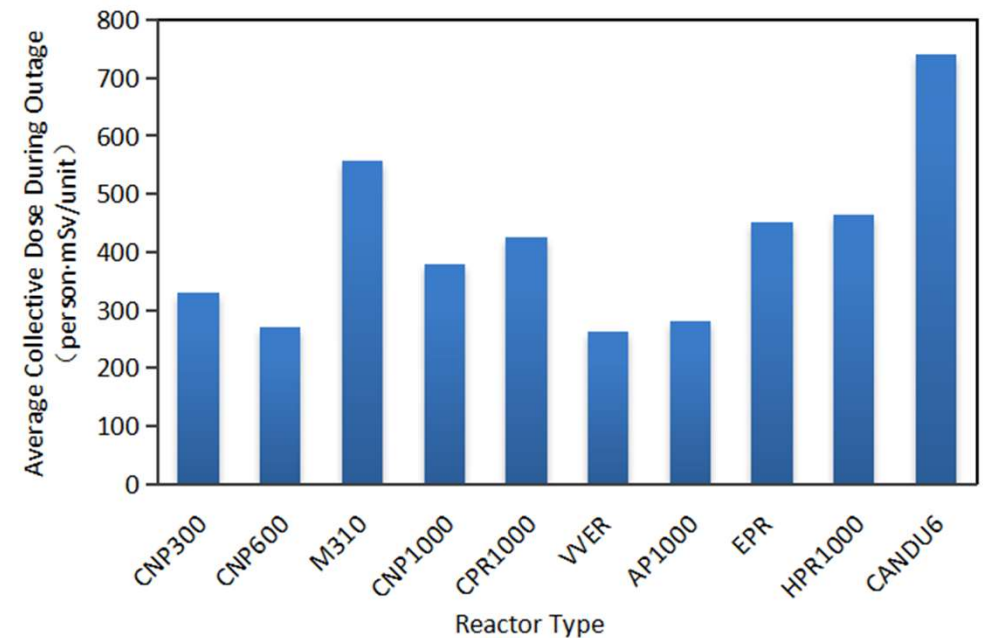
Collective dose statistics of different reactor operating units (2018-2024)

Reactor Type		No.of Units	Annual Average Collective Effective Dose	Average Collective Dose per GW-yr	3-Year Average Collective Effective Dose per Reactor(person·mSv/unit)				
			(person·mSv/unit)	(person·mSv/GWa)	2018-2020	2019-2021	2020-2022	2021-2023	2022-2024
CNP300	PWR	1	376	1456	398	272	292	347	351
CNP600	PWR	6	222	387	229	213	214	208	212
M310	PWR	4	547	649	500	435	463	592	643
CNP1000	PWR	8	334	370	293	279	308	355	407
CPR1000	PWR	20	360	393	368	378	328	346	355
VVER	PWR	4	210	224	211	229	188	203	196
AP1000	PWR	4	209	184	/	218	211	239	226
EPR	PWR	2	245	281	/	438	379	250	201
HPR1000	PWR	3	317	321	/	/	138	290	320
CANDU6	PHWR	2	478	755	346	352	525	635	621

2. Management on Occupational Exposure



- **Outage activities involve a large volume of work and a long duration, and the proportion of outage collective dose in the annual collective dose generally reaches over 80%.**
- **The statistical results of the average outage collective dose from the latest four outages (2018-2024) for units of different reactor types (a total of 53 units) are shown.**



Average planned outage collective dose (2018-2024) for different reactor types



3. Good practices in occupational exposure control

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a) Control of radiation source terms

- Oxidative Decontamination of the Primary Circuit System

- ◆ The activated corrosion products deposited in the primary circuit system are mainly ^{58}Co and ^{60}Co , while the radionuclides deposited on equipment and pipelines are generally $^{110\text{m}}\text{Ag}$.

- ◆ After oxidative decontamination, the total γ peak value of the unit **decreases by approximately 3-8 times**, with a significant decontamination effect.

- ◆ New units have a higher amount of corrosion-activated products, approximately 5-10 times higher than that of older units (after three fuel cycles). As the operating years increase, the radiation source term tends to stabilize.

3. Good practices in occupational exposure control



a) Control of radiation source terms

- Zinc injection technique

- ◆ Zinc injection into the reactor coolant system (RCS) of pressurized water reactors (PWRs) has demonstrated benefits for significantly reducing both radiation fields and primary water stress corrosion cracking (PWSCC).

- ◆ Sanmen NPP Unit 1-2 and Haiyang NPP Unit 1-2 have taken the program in their primary systems from the thermal testing phase.

- ◆ the collective dose in the first fuel cycle and the ^{58}Co peak value during oxidative operation are significantly lower than those of units without zinc injection. (the collective dose of Unit 2 of Sanmen NPP' s first outage was 183 person·mSv, setting the record for the lowest collective dose in the first outage. The ^{58}Co peak value during oxidative operation was about 5-10 times lower than that of units without zinc injection.)

3. Good practices in occupational exposure control



b) Individual Dose Control

- Application of Intelligent Management Technology

- ◆China General Nuclear Power Group (CGN) has widely applied automated or remote operation technologies in the in-service inspection of steam generators and pressurizers.

3. Good practices in occupational exposure control



b) Individual Dose Control

- Application of Intelligent Management Technology

- ◆China National Nuclear Corporation (CNNC) has achieved good practices in using 3D technology to eliminate radioactive hotspots and reduce radiation doses, as follows:

- 3D Mapping of Typical Hotspots in CNP600 Units (Qinshan NPP) :**

- A 3D mapping system for the distribution of radioactive hotspots in process systems is established, which provides 3D model display of radioactive hotspots, demonstration of hotspot flushing processes, and guidance for on-site shielding construction. It offers technical support for reducing radiation source terms, thereby lowering the collective dose of the power plant.

3. Good practices in occupational exposure control



b) Individual Dose Control

- Application of Intelligent Management Technology

- ◆China National Nuclear Corporation (CNNC) has achieved good practices in using 3D technology to eliminate radioactive hotspots and reduce radiation doses, as follows:

- Tianwan NPP has implemented whole-process refined management of radiation hotspots**, achieving comprehensive control throughout the lifecycle—from hotspot identification to resolution and experience feedback. As a result, the number of radiation hotspots has **decreased from 112 to 70, representing a reduction of 37.5%**.

3. Good practices in occupational exposure control



b) Individual Dose Control

- Adoption of Risk-Informed Technology

- ◆ Tianwan NPP implemented the pilot optimization of risk-informed in-service inspection on Units 1-2, a total of 36 components of the main pipeline and medium-pressure safety injection pipeline were exempted from automated ultrasonic testing, and more than 100 components of Class 2 and 3 nuclear pipelines were exempted from radiographic testing. It is estimated that the two units can cumulatively reduce the collective dose by approximately 14 person·mSv over a complete in-service inspection cycle (6 years).

3. Good practices in occupational exposure control



b) Individual Dose Control

- Collective Dose Control

- ◆ VVER and AP1000 reactor types demonstrate good performance in terms of collective dose. Due to their design advantages, the collective dose during outage is relatively low. For VVER and AP1000 units during outage, their normalized collective effective dose is only about 200 person·mSv/GWa, which is at a relatively low level.

3. Good practices in occupational exposure control



c) Information Exchange

- **Domestic exchange** : extensive exchanges have been carried out among domestic nuclear power groups to continuously advance the standardization of radiation protection management and technology in nuclear power plants. Various plants have conducted in-depth exchanges on their respective good practices, carried out experience feedback, planned subsequent work in the field, summarized and analyzed radiation protection data of each unit, systematically evaluated the radiation protection management performance of each plant and unit, and conducted internal benchmarking.

3. Good practices in occupational exposure control



c) Information Exchange

- **International Exchange:** the occupational exposure information of China's operating nuclear power units has been widely submitted and shared on information platforms of relevant international organizations and institutions such as UNSCEAR and IAEA. Through experience feedback and international exchanges, the level of occupational radiation protection has been continuously improved.



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