中国核能电力股份有限公司
China National Nuclear Power Co., Ltd.

追求卓越 超越自我

Monitoring of Tritium Internal Exposure Doses In TQNPP

Wang Kongzhao, CNNO,China

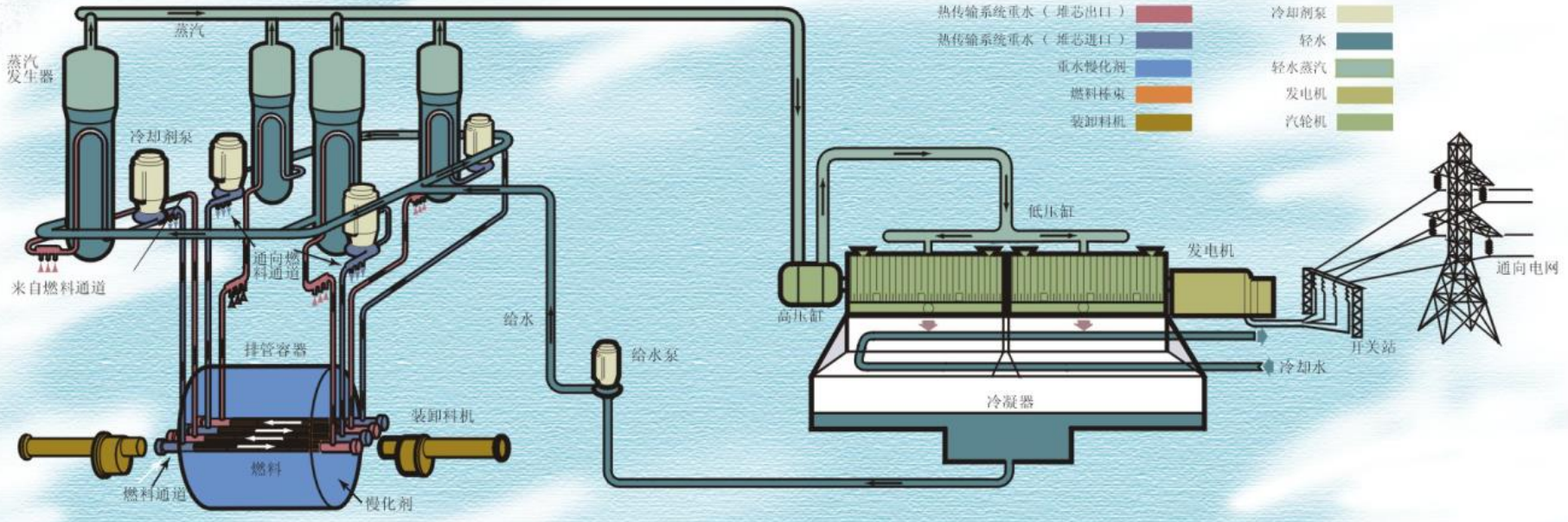
23 Oct. 2019

1. Qinshan Nuclear Power Base

1. Qinshan Nuclear Power Base

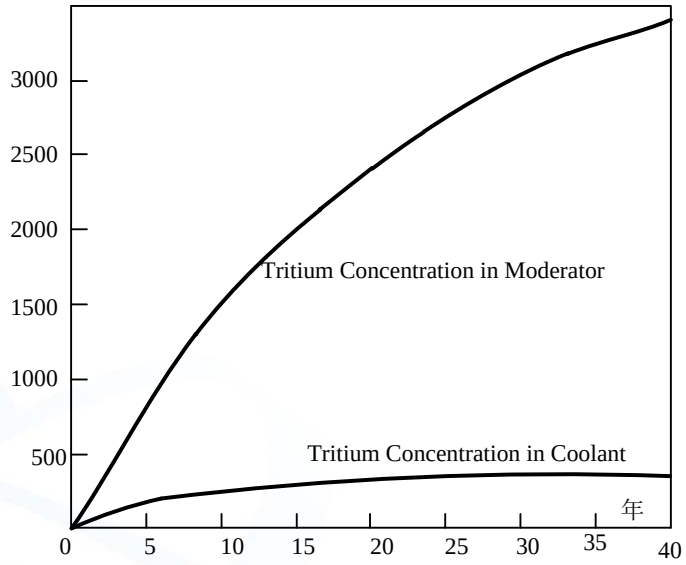
Unit	Construction	Commercial Operation	Capacity(MW)
Q1-1	Mar.20,1985	Apr. 01,1994	350
Q2-1	Jun.02,1996	Apr. 15,2002	650
Q2-2	Apr.01,1997	May.03,2004	650
Q3-1	Jun.08,1998	Dec.31,2002	728
Q3-2	Sep.25,1998	Jul.24,2003	728
Q2-3	Apr.28,2006	Oct.25,2010	660
Q2-4	Jan.28,2007	Dec.30,2011	660
QF-1	Dec.26,2008	Dec.15,2014	1089
QF-2	Jul.17,2009	Feb.12,2015	1089

2. Third Qinshan Nuclear Power Plant



Coolant: **~200T** heavy water; Moderator: **~260T** heavy water

3. Tritium



$$n + {}_{1}^{2}H \rightarrow {}_{1}^{3}H + \gamma$$

1.04×10^{3}TBq/y in Coolant

5.40×10^{4}TBq/y in Moderator

HTO and TDO can cause internal exposure by inhale and by skin penetration. Generally, when exposed without any protection, tritium intake by inhale and by skin penetration will be **2:1**.

According to the operation experience of heavy water reactors around the world, the internal tritium exposure dose takes **20%-40%** of CRE in the heavy water reactor plant.

4. Tritium Internal Dose Monitoring

LSC:
PerkinElmer Tricarb 2900TR/2910TR

Scintillation Solution:
PerkinElmer Ultima GOLD LLT （10L）

Urine Sample Direct Analysis:
Urine Sample(2ml) + Scintillation Solution(10ml) darkened for 30 min, measured directly by LSC.

Routine Monitoring:

Workers who have the tritium internal exposure risk.

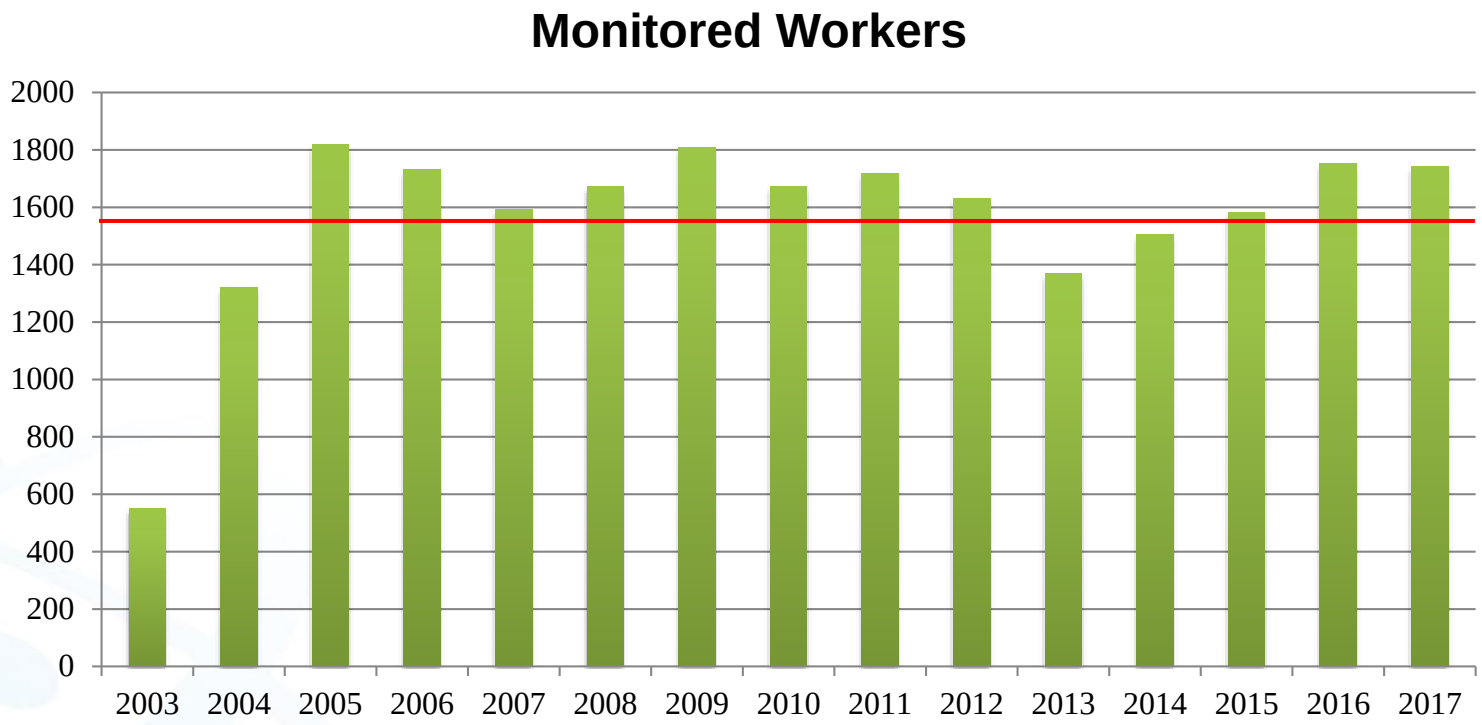
Monitoring Period:

14 days and 30 days

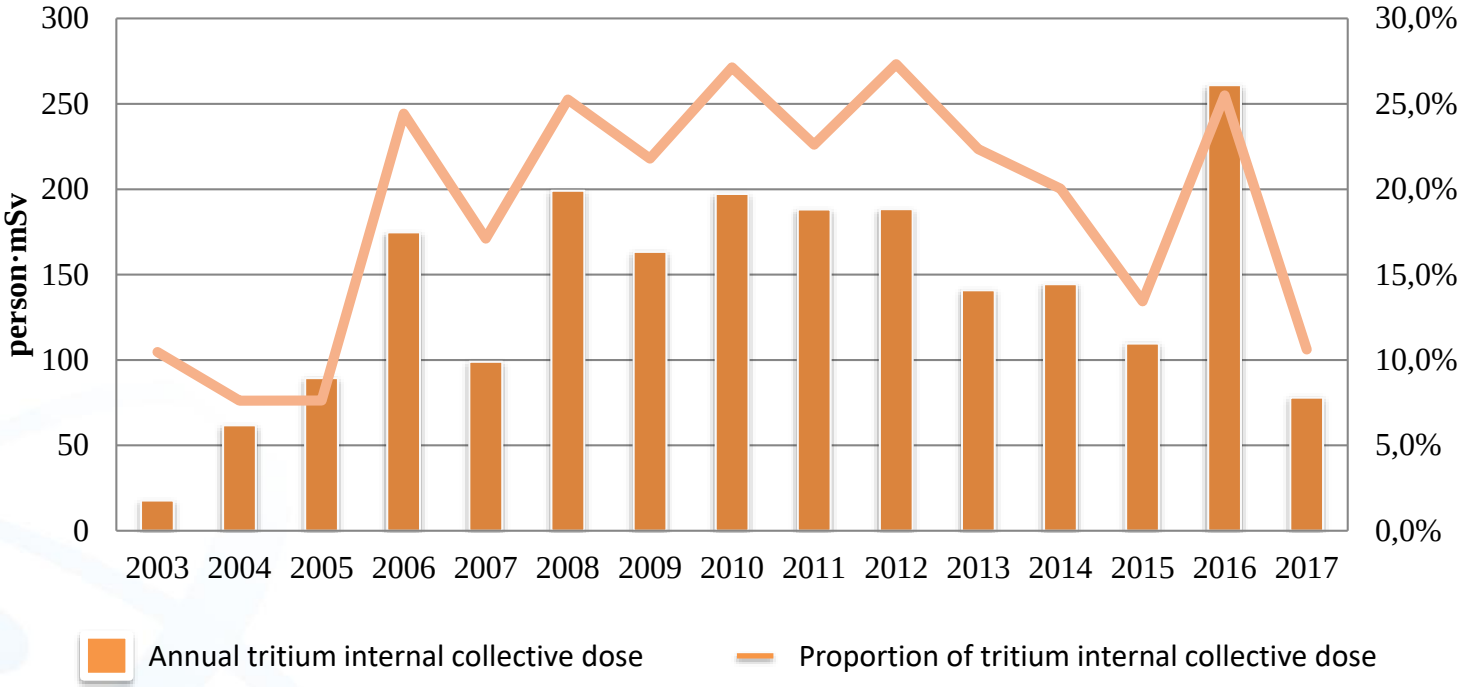
$$\mathrm{E} = \frac{(C_i + C_{i+1})\ (t_{i+1} - t_i)}{2} \times 4.8 \times 10^{-5} \times 110\%$$

$$\mathrm{E} = \frac{4.8 \times 10^{-5} C_n}{\ln 2/10} \times 110\% = 7.6 \times 10^{-4} C_n$$

4. Tritium Internal Dose Monitoring



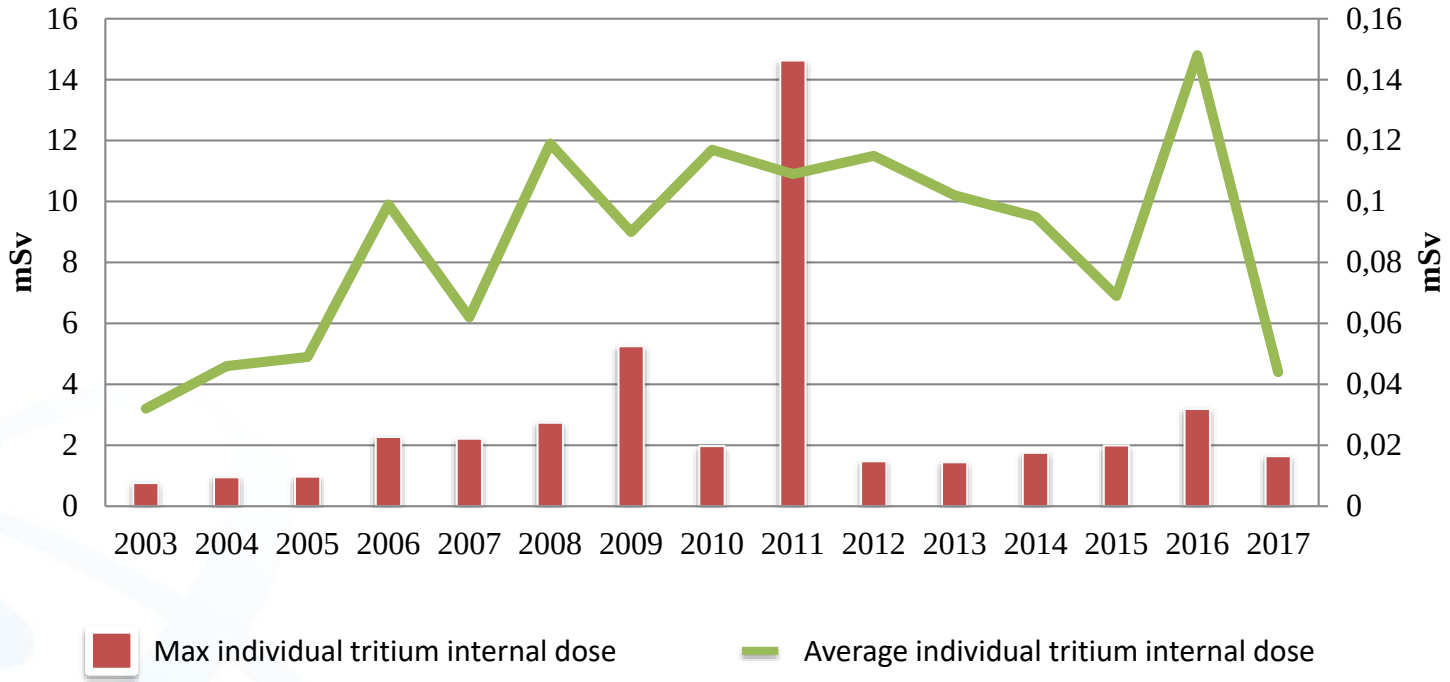
4. Tritium Internal Dose Monitoring



4. Tritium Internal Dose Monitoring

Since 2004, the average annual collective dose of tritium internal exposure has been **149.62 person·mSv**, accounting for **19.07%** of the total annual collective dose. The collective dose of tritium internal exposure is closely related to the tritium concentration in the moderator and coolant, operating conditions of units, and tritium-related workload. As running time increases, the collective dose of tritium internal exposure grows with the tritium concentrations in the moderator and coolant. Since 2008, radiation protection technical and management measures in plant have been increasingly optimized to protect against tritium internal exposure. The trend of a continuous increase in tritium internal exposure collective dose has been controlled and is currently stable. Since the second half of 2012, plant started a special ALARA project to reduce the collective dose, focusing on the high radiation risk activities, encouraging the frontline workers' involvement to optimize the work process, to develop the more effective protection measures internal exposure, to implement timely detection and response procedures for heavy-water leakage. Based on these policies, the collective dose of tritium internal exposure has decreased each year.

4. Tritium Internal Dose Monitoring

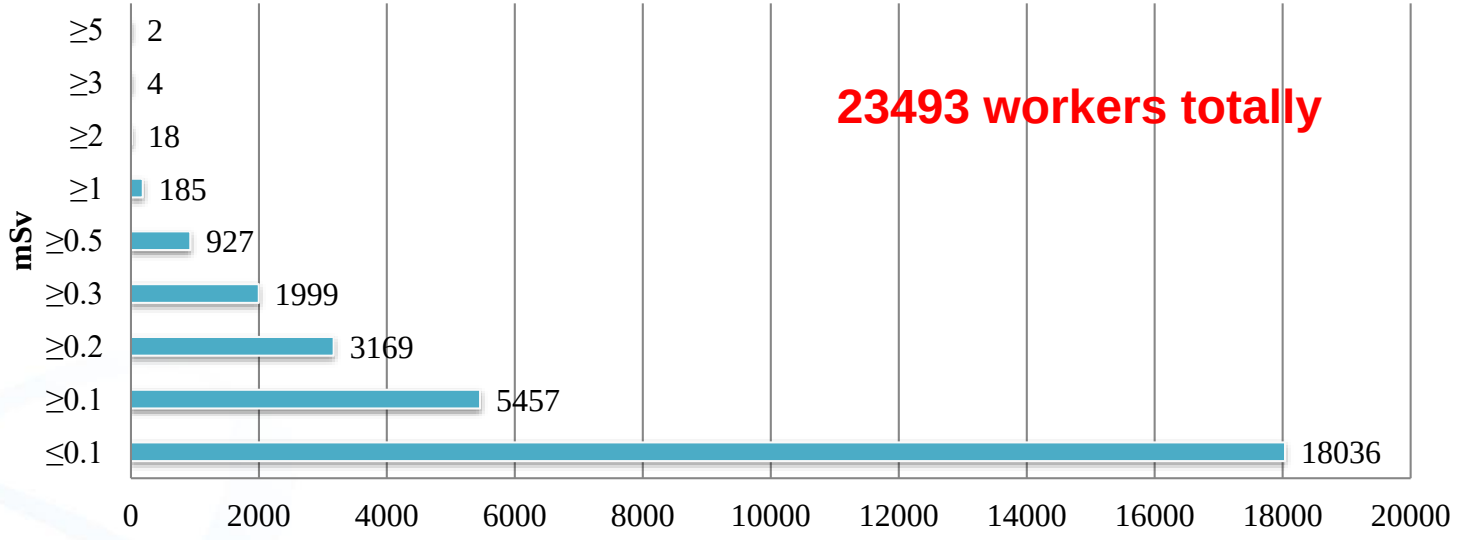


4. Tritium Internal Dose Monitoring

Since 2003, the annual average personal internal exposure dose has been **less than 0.16 mSv**. A total number of workers whose annual personal internal exposure doses exceeded 2 mSv, of which **5 workers' internal exposure doses in a single intake exceeded 2 mSv**.

2011, an unexpected tritium intake event was occurred when the work group were cutting and wielding heavy water pipes. A wielder received **14.53mSv** tritium internal exposure dose.

4. Tritium Internal Dose Monitoring

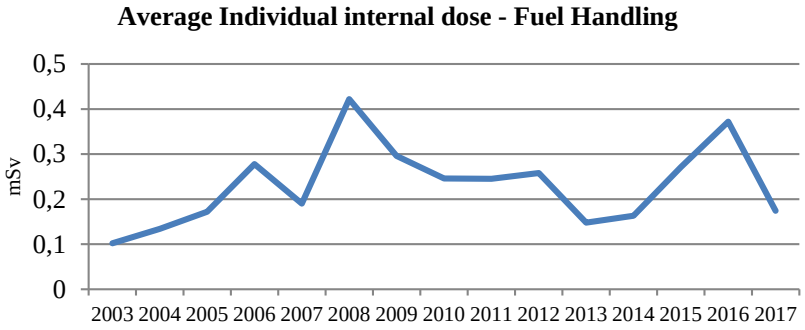


Number of monitored workers from 2003 to 2017

4. Tritium Internal Dose Monitoring

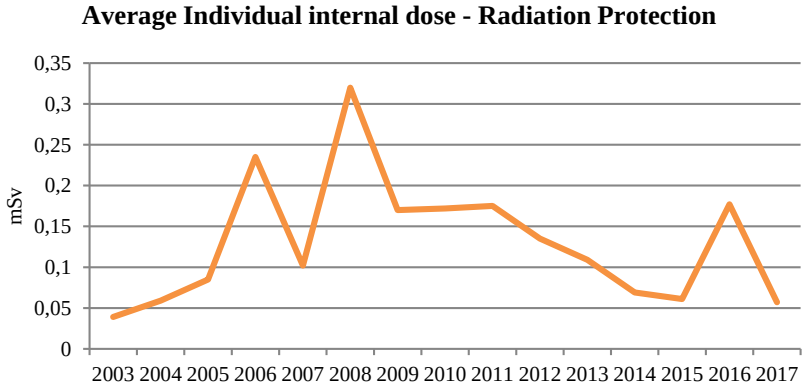
Category	Worker Number	Average Internal Collective Dose(person-mSv)	Average Individual Internal Dose(mSv)
Maintenance	852	64.22	0.08
Fuel Handling	122	29.37	0.24
Radiation Protection	146	19.68	0.14
Operation	246	6.63	0.03
Engineering	225	8.07	0.03

4. Tritium Internal Dose Monitoring

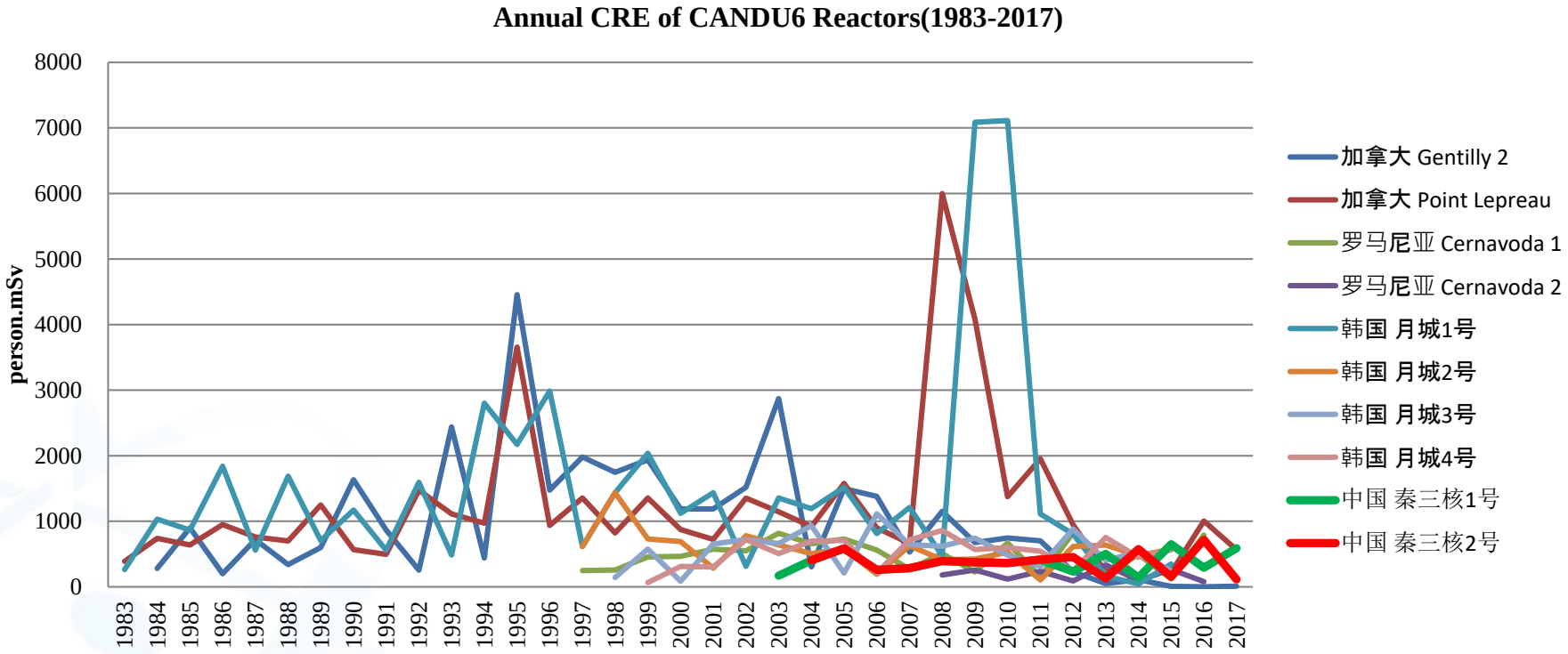


Fuel Handling is unique to heavy-water reactor plants. Fuel handling operators are facing the highest radioactive risk in the heavy water reactor plant. In TQNPP, the average annual individual dose of fuel handling operators is **2.85mSv**, and the average annual tritium internal individual dose is **0.24mSv**.

Regardless of whether the reactor units were being overhauled or operating normally, the radiation protection personnel had a relatively balanced workload throughout the year. Radiation protection personnel may **be exposed to plant-wide radiation** because their coworkers and workplaces are distributed across the plant, and their work is related to the entire plant.



5. Conclusion



中国核能电力股份有限公司
China National Nuclear Power Co., Ltd.

中国核电 国家名片