Introduction to Optimization in Occupational Radiation Protection for Nuclear Power Plants in China

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Nuclear and Radiation Safety Center (NSC) of MEP (NNSA)
What is NSC?

• A nonprofit affiliated institution to the Ministry of Environmental Protection / National Nuclear Safety Administration (MEP / NNSA);
• The only public technical guarantee organization mainly focus on nuclear safety regulations and radiation environment monitoring;
• Provides overall and comprehensive science & technical support for nuclear and radiation safety regulations;
• Up to now, NSC has 4 administrative divisions and 17 technical divisions with 504 staff.
Main Tasks

Nuclear & Radiation Safety

- Safety Review & Inspection
- Event Emergency Response & assessment
- Information services
- Technical consultation
- Regulation policy & Codes Research
- Science Research on Nuclear & radiation safety
Legislative and Regulation Framework

- Nuclear Safety Act?
- Nuclear Safety Regulations (HAF)
- Radiation Protection Criteria (GB)
- Radiation Protection Guides (HAD)
- Radiation Protection Technical Documents
- State Laws
- Administrative Regulations of the State Council
- National Standards
- Guiding Documents
- Reference Documents
Legislative System

- Nuclear Safety Law?
- Regulations on Surveillance and Control of Civilian Nuclear Installations, HAF001, 1986
- *Regulations on Safety for Nuclear Power Plant Design, HAF102, 1991*
- *Regulations on Safety for Nuclear Power Plant Operation, HAF103, 1991*
Full consideration should be given to radiation protection requirements, such as optimized facility deployment, installation shielding, in such a way to make the activities and occupancy time of persons within radiation areas as less as possible.

Taking necessary measures to reduce quantity and concentrations of radioactive materials within plant area.

Carrying out, on the part of operating nuclear facilities, assessment and analysis of radiation protection requirements and their implementation, making and implementing radiation protection programs to ensure the implementation of such programs and the verification of their goal achievement, and if necessary taking necessary corrective actions.

Radiation protection program shall be reviewed and amended in accordance with experiences gained.
<table>
<thead>
<tr>
<th>Name</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSS against Ionizing Radiation and for Safety of Radiation Sources</td>
<td>GB11871-2002</td>
</tr>
<tr>
<td>Rules for Operational Radiation Protection in NPP</td>
<td>EJ/T270-2005</td>
</tr>
<tr>
<td>Requirements of Radiation Protection Program for Decommissioning Operations of Nuclear Facilities</td>
<td>EJ/T1203-2006</td>
</tr>
<tr>
<td>Radiation Protection Design for NPP</td>
<td>HAD101/12-1990</td>
</tr>
<tr>
<td>Radiation Protection during Operation of NPP</td>
<td>HAD103/4-1990</td>
</tr>
</tbody>
</table>

Under the GB18871-2004, the principles and requirements of radiation protection are the same as the basic safety standards recommended by ICRP 60 Recommendations and BSS 115 issued by IAEA together with other international organizations.
Nuclear Power Plants in China
(Until June 31, 2013)
Average Collective Dose Per Reactor (M310)

Source: ISOE databases, WANO 2012 and Annual Reports of NNSA
Average Collective Dose Per Reactor (no M310)

Source: ISOE databases, WANO 2012 and Annual Reports of NNSA
Average Collective Dose Per Energy (M310)

Source: ISOE databases and Annual Reports of NNSA
Average Collective Dose Per Energy (no M310)

Source: ISOE databases and Annual Reports of NNSA
## Collective Dose for Operational NPPs
### (From 2004 to 2012)

<table>
<thead>
<tr>
<th>Plants</th>
<th>PWR</th>
<th>PHWR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M310</td>
<td>VVER</td>
</tr>
<tr>
<td>Units</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>man·Sv/unit</td>
<td>0.376</td>
<td>0.2323</td>
</tr>
<tr>
<td>man·mSv/GWh</td>
<td>0.1069</td>
<td>0.0344</td>
</tr>
</tbody>
</table>
Annual Average Individual Effective Dose

Source: Annual Reports of NNSA
Annual Maximum Individual Effective Dose

Source: Annual Reports of NNSA
## Individual Dose for Operational NPPs
(From 2004 to 2010)

<table>
<thead>
<tr>
<th>Plants</th>
<th>PWR</th>
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<tr>
<td></td>
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<td>VVER</td>
</tr>
<tr>
<td>Units</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Average (mSv/a)</td>
<td>0.366</td>
<td>0.191</td>
</tr>
<tr>
<td>Max (mSv)</td>
<td>12.169</td>
<td>3.460</td>
</tr>
</tbody>
</table>
Detailed Measures for Optimization

- Optimization process is dependent deeply on the different phase of nuclear power plants
- New plants at the design stage are affording more opportunities for eliminating hazards and engineered control
- Operational plants are often constrained in the control options available and plants undergoing clean up
- Decommissioning also need be considered in the design and operation stage
Detailed Practices for Operational Plants

◆ Control of the gaseous radioactive source, such as ventilation, negative pressure devices, individual positive pressure oxygen breathing apparatus

◆ Control of the corrosion product in coolant:
  ✓ Hydrogen Peroxide ($\text{H}_2\text{O}_2$) injection
  ✓ Maintaining proper pH level
  ✓ Increasing reactor coolant letdown flow rate (purification)
  ✓ Washing and decontamination
  ✓ Reducing the concentration of tritium in the coolant (limitation of )
Concentration of radioactive nuclides in reactor coolant changes after Hydrogen Peroxide (H$_2$O$_2$) Injection
ALARA Classification Management

Collective Dose (CD) Assessment

CD < 2 man·mSv

Yes

No ALARA Measures

No

ALARA Class 1

2 man·mSv ≤ CD < 5 man·mSv

Work preparation reviewed by RP staff; check list; ALARA action list

ALARA Class 2

5 man·mSv ≤ CD < 20 man·mSv

Work preparation reviewed by RP staff; check list; ALARA action list; RP control point; RP staff on-site supervision; On-site supervision list

ALARA Class 3

CD ≥ 20 man·mSv

Work preparation reviewed by RP staff; check list; ALARA action list; Preparation Meeting; RP control point; RP staff on-site supervision; On-site supervision list; ALARA work group
Detailed Measures for New Plants

- Zinc injection can reduce the concentration of corrosion product in the reactor coolant
- Reducing interval between each refueling and maintenance (namely from 12 months fuel cycle to 18 months fuel cycle)
Learning from Experience

◆ Lacking clear guidance from international and national standards, NNSA have a difficult task in assessing performance at nuclear plants.

◆ Same comparative activities that have assisted in reducing nuclear plant dose have also created a dilemma in the comparison of one plant to another.

◆ Information systems are very important for management of occupational exposure for contractors.
## Guideline values of control level for emergency

<table>
<thead>
<tr>
<th>Category</th>
<th>Emergency Task</th>
<th>Effective Dose (mSv)</th>
<th>External Exposure Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Undertaking actions of saving life or preventing core damage or radioactive material large release when core damage happened only when the expected benefits to others would clearly outweigh the risks to the emergency workers.</td>
<td>&gt;500</td>
<td>&gt;250</td>
</tr>
<tr>
<td></td>
<td>Preventing core damage or radioactive material large release.</td>
<td>&lt;500</td>
<td>&lt;250</td>
</tr>
<tr>
<td>2</td>
<td>Avoiding to avert a large collective dose or preventing the development of severe or catastrophic accidents; Recovery safety systems of reactor</td>
<td>&lt;100</td>
<td>&lt;50</td>
</tr>
<tr>
<td>3</td>
<td>Short term recovery operation; Implementing emergent protection action</td>
<td>&lt;50</td>
<td>&lt;25</td>
</tr>
<tr>
<td>4</td>
<td>Long term recovery operation; Work without directly relevant to accident</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>
Thank you for your attention!