The Concept of Training System for Newly Established Operator in Embarking State

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Rosatom Central Institute for Continuing Education&Training
1. WWER Technology in a nutshell
2. Training of NPP operating personnel
3. Training solutions for recipient countries
**WWER Technology – History of Implementation**

- **AES-2006**
  (WWER-1200, 60 years lifetime, 90% capacity factor)

- **WWER-TOI**
  (WWER-1300, Typical Optimized Informative-advanced project)

- **AES-92**
  (WWER-1000)

- **AES-91**
  (WWER-1000)

**WEST:** PWR

**Russia:** WWER

**1. WWER in a nutshell**

**Water Cooled Water Moderated Energy Reactor**
At present more than 50 nuclear power plant units with WWER-type reactors are being operated around the world:

- Finland 2
- Czech Republic 6
- Armenia 1
- Bulgaria 2
- Hungary 4
- Iran 1
- China 2
- India 1
- Slovakia 6
- Ukraine 15
- Russia 17

1. WWER in a nutshell
Currently Rosatom has negotiations over construction of 23 nuclear power units overseas. Nine power units are under construction in Russia.
# WWER vs PWR

## TABLE V-1. Fuel Features

<table>
<thead>
<tr>
<th>Reactor type</th>
<th>Fuel material</th>
<th>Fuel rod cladding&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Typical Assembly</th>
<th>Enrichment</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGR</td>
<td>UO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Stainless steel</td>
<td>Circular array of pins in graphite sleeve</td>
<td>2 - 4%</td>
</tr>
<tr>
<td>BWR</td>
<td>UO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Zircaloy-2</td>
<td>Square array</td>
<td>Up to 4.95%</td>
</tr>
<tr>
<td>Magnox</td>
<td>U metal</td>
<td>Magnox alloy</td>
<td>-</td>
<td>Natural</td>
</tr>
<tr>
<td>RBMK</td>
<td>UO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>E110, E635</td>
<td>Circular array</td>
<td>Up to 2.8%</td>
</tr>
<tr>
<td>PHWR</td>
<td>UO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Zircaloy-4</td>
<td>Circular bundle</td>
<td>Natural</td>
</tr>
<tr>
<td>PWR</td>
<td>UO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Zircaloy-4</td>
<td>Square array</td>
<td>Up to 4.95%</td>
</tr>
<tr>
<td>WWER</td>
<td>UO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>E110, E635</td>
<td>Hexagonal array</td>
<td>Up to 4.95%</td>
</tr>
</tbody>
</table>

<sup>a</sup> Zircaloy-2 and -4 are alloys of zirconium with about 1.5% tin as the main alloying element. Magnox alloy is magnesium with about 1% aluminium or zirconium. Both E110 and E635 are alloys of zirconium with about 1% niobium.

### Find difference!

1. WWER in a nutshell
Extensive tests and over 20 years experience proved safe operation of cladding made of 1% Nb zirconium alloy E110 at temperature below 350 °C. That value has been detected the lowest temperature for structural changes in material. Below 350 °C there is no evidence of plastic deformation or any other mechanical phenomena. To improve plastic deformation resistance the E365 alloy (1% Nb, 1.5% Sn, 0.5%Fe) was introduced in 2000. Test results demonstrate that Zr1%Nb alloy in VVERs is more resistant to oxidation than Zircaloy (ZrSn alloy) in PWR.

1. WWER in a nutshell

WWER – THE LOWEST OCCUPATIONAL EXPOSURE LEVEL

WWER - 0.51 (2011 average annual collective dose)
0.54 (3-year rolling average for 2009-2011)

PWR - 0.65
0.69

BWR - 1.18
1.3

PHWR/CANDU - 1.18
1.44

All reactor types, incl. GCR and LWGR - 0.76
0.82

data from “Twenty-first Annual Report of the ISOE Programme 2011”
E&T Path for the Position of Control–Room Operator (in Russia)

University Specialization

«Nuclear Power Plants and Facilities»

Fields of professional competences:
- Management
- NPP structure & design
- Commissioning & maintenance

4 yrs - Bachelor degree
2 yrs - Master degree
5.5 yrs – Specialist

The specific of Russia is that, compared to western education system, there is a university specialty “nuclear power plant and facilities” especially focusing the staffing of Nuclear Power Plants.
NPP Personnel Development: Required On-The-Job Experience

2. Training of NPP operating personnel
WWER NPP Staffing

2. Training of NPP operating personnel

- Staffing Coefficient (persons/MWel):
  - **Total**
  - **Operating personnel**

- Job distribution (Russian NPP):
  - **Craftsmen**: 18%
  - **Technicians**: 39%
  - **Engineers**: 43%
## Number of construction workers and fitters by years for two units NPP

Example for Novovoronezh NPP-2 (by design documentation)

<table>
<thead>
<tr>
<th>Jobs</th>
<th>1 yr</th>
<th>2 yr</th>
<th>3 yr</th>
<th>4 yr</th>
<th>5 yr</th>
<th>6 yr</th>
<th>7 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction workers</td>
<td>1085</td>
<td>2374</td>
<td>5341</td>
<td>5178</td>
<td>1625</td>
<td>209</td>
<td>10</td>
</tr>
<tr>
<td>Tele-equipment fitters</td>
<td>193</td>
<td>397</td>
<td>1451</td>
<td>1783</td>
<td>695</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Ventilation equipment</td>
<td>35</td>
<td>51</td>
<td>106</td>
<td>64</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>installers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction electricians</td>
<td>283</td>
<td>1440</td>
<td>1700</td>
<td>600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation workers</td>
<td>7</td>
<td>82</td>
<td>182</td>
<td>228</td>
<td>184</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL:</td>
<td>1085</td>
<td>2609</td>
<td>6154</td>
<td>8357</td>
<td>5400</td>
<td>1700</td>
<td>46</td>
</tr>
</tbody>
</table>
Role of a Training Centre in NPP Startup in Newcomer Country

1. TC construction
2. 1-st concrete at NPP
3. FSS start up
4. Fuel load
5. NPP construction

-5 - 0 Years

Number of TC trainees:
- 300
- 900
- 4000

Operating personnel:
- Key personnel
- Technicians
- Training construction workers and fitters
- Outreach and vocational guidance

3. Training solutions for newcomers
Stages of NPP Personnel Training: the case of recipient country

Recipient Country: Russia

Training Profiles:
- Reactor Island
- Turbine Island
- Electrical Equipment Shop
- Automation & Control Shop
- Water-Chemistry Shop
- Commissioning / maintenance

Theoretical training & Simulator based training (CICET, NV-TC)

Probation at the reference NPP

Probation at the NPP under construction

FSS Start-up

Comissioning

Training of construction workers

Completing TC

First concrete at the NPP site

Yrs

0

-1

-3

-5

Russian Language Courses & University education (MEPhI, etc)

University education (EVN-EPU,... & Russian Language Courses)

Key Personnel

Recipient Country

Work under supervision of Russian specialists

Acceptance of NPP

First Criticality

Training of fitters

3. Training solutions for newcomers
Configuration of the Consortium to Support the HRD Programme for NPP Staffing in Recipient Country
Stages of NPP Personnel Training: the case of recipient country

<table>
<thead>
<tr>
<th>Stages of Training</th>
<th>Field Operator</th>
<th>Senior Field Operator</th>
<th>Control Room Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>Admission for independent work</td>
<td>Shadow training</td>
<td></td>
</tr>
<tr>
<td>2 year</td>
<td>Admission for independent work</td>
<td>Shadow training</td>
<td>Licensing</td>
</tr>
<tr>
<td>3 year</td>
<td>Admission for independent work</td>
<td>Shadow training</td>
<td></td>
</tr>
</tbody>
</table>

- **Direction of foreign NPP under construction**
  - Examination
  - On-the-job training
  - Practical training
  - Theory

- **Training Center of foreign NPP under construction**
  - Examination
  - On-the-job training
  - Practical training
  - Theory

- **Concern Rosenergoatom**
  - Examination
  - On-the-job training

- **Branches of CICE&T at NPPs**
  - Practical training
  - Special issues on operation

- **Atomtehenergo**
  - Practical training
  - Special issues on operation

- **Central Institute for Continuing Education and Training**
  - General issues on operation
  - General issues on safety

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Graduates of Russian, national universities and professionals from recipient country labor market

3. Training solutions for newcomers
Staffing and Scheduling for VN NPP (2 units)

<table>
<thead>
<tr>
<th>No of people / Yrs</th>
<th>-5</th>
<th>-4</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>National staff</td>
<td>48</td>
<td>128</td>
<td>248</td>
<td>408</td>
<td>608</td>
<td>1176</td>
<td>1176</td>
<td>1176</td>
<td>1176</td>
</tr>
<tr>
<td>Russian operating staff</td>
<td>50</td>
<td>80</td>
<td>120</td>
<td>160</td>
<td>200</td>
<td>200</td>
<td>120</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Russian instructors</td>
<td>5</td>
<td>15</td>
<td>30</td>
<td>55</td>
<td>55</td>
<td>30</td>
<td>15</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Russian staff - total</td>
<td>55</td>
<td>95</td>
<td>150</td>
<td>215</td>
<td>255</td>
<td>230</td>
<td>135</td>
<td>65</td>
<td>0</td>
</tr>
</tbody>
</table>

3.HRD for newcomers

![Graph showing staffing and scheduling](image-url)
Thank You for Your Attention!
Welcome to Rosatom CICET

http://rosatom-cicet.ru/

http://rosatom-cicet.ru/?page_id=98
Nuclear Engineering Education in Russia
The main source of human resources for Russian Nuclear Sector is National Nuclear Research University MEPhI and the Consortium of universities supported by Rosatom.

The share of Consortium universities graduates’ in Rosatom graduate employment – 90%

Universities supported by Rosatom:
1. NNRU MEPhI
2. ISPU
3. MGSU
4. MSTU
5. MPEI
6. MISIS
7. NSTU
8. Lobachevsky UNN
9. Mendeleyev UCTR
10. SPSU
11. SPbSPU
12. TPU
13. UrFU

- 13 leading universities of Russia including a National University and 9 research universities
- Over 300,000 students and 50,000 lecturers in 23 cities of 19 regions of Russia, including all closed cities
- 56 scientific and educational centers with leading enterprises of the sphere

NNRU MEPhI unites:
11 universities and 13 colleges
Around 35,000 students
Over 2000 lecturers
Over 1600 professors and associate professors
Over 500,000 m² academic area
60 higher education majors
45 secondary education majors

Moscow Eng Phys.Inst
Tomsk Politech
Establishment of an international campus in Obninsk based on Obninsk branch of NRNU MEPhI and CICE&T

START: 2010

Advance training of foreign specialists on the programmes of Russian nuclear education

<table>
<thead>
<tr>
<th>Country</th>
<th>2010</th>
<th>Vietnam</th>
<th>Jordan</th>
<th>Mongolia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vietnam</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jordan</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mongolia</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>42</strong></td>
<td><strong>99</strong></td>
<td><strong>50</strong></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>

2011

Expanding the pool of countries-recipients of Russian nuclear education

<table>
<thead>
<tr>
<th>Country</th>
<th>Vietnam</th>
<th>Turkey</th>
<th>Kazakhstan</th>
<th>Jordan</th>
<th>Mongolia</th>
<th><strong>Total:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vietnam</td>
<td>99</td>
<td>50</td>
<td>20</td>
<td>10</td>
<td>9</td>
<td><strong>188</strong></td>
</tr>
</tbody>
</table>

2012

Formation of the interuniversity cooperation programme

<table>
<thead>
<tr>
<th>Country</th>
<th>Vietnam</th>
<th>Turkey</th>
<th>Mongolia</th>
<th>Kazakhstan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vietnam</td>
<td>169</td>
<td>126</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Jordan</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mongolia</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>344</strong></td>
<td><strong>1100</strong> foreign specialists</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2016

Implementation of a system of Russian nuclear education export in 25 countries

- Promoting Consortium of Rosatom’s reference universities in international education market.
- Opening of International Nuclear Education Centers in the universities
- Nuclear power engineering training in the Obninsk International Center

Programmes of international cooperation in education and knowledge transfer:

- ENEN-RU project «Cooperation infrastructure development in the field of nuclear education» (Rosatom-Euratom agreement)
- Educational programmes of IAEA, WNU
- Working group on formation EurAsEC Cooperation Council
- Cooperation programmes with foreign universities (Turkey, Vietnam)
Potential market in Asia-Pacific

Potential market is estimated as 80 WWER units by 2030
Scheme of Professional Education at Far-Eastern Federal University (FEFU)

Professional education including special practical training and special courses at ROSATOM's enterprises and academic institutions including the use of 'Distant-education’ technologies.

Year 1  Year 2  Year 3  Year 4

FEFU
Natural science and basic engineering education
Cross-culture education
Management
BS in Nuclear Engineering

General structure of the BS programme (numers stand for credit units, 1 credit unit – 36 academic hours).

Distribution of NPP oriented disciplines in professional cycle (totally 55 credit units).
Simulator training in the Far Eastern Federal University (Sept 2013)

http://rosatom-cicet.ru/?p=159