Human Development in Japan and Abroad Using Monju towards Next-Generation Age

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Introduction

Human Development towards the new FBR Age

◆ Aiming at starting commercial operation of a demonstration FBR around 2025 in the Fast Reactor Cycle Technology Development Project called the FaCT Project.

◆ Reflecting Monju Operation and Experiences to the FaCT Project.

◆ Human Development included Abroad via Various Kinds of Educational Trainings Using Monju by INITC

FBR Cycle Feasibility Study
FaCT Project
Demonstration FBR

2005
2015
≈2025
1. FBR Engineer Educational Training

- Strengthening Sodium Handling Technical Training
- Upgrading FBR Operation Technical Training
- New Establishment of FBR Plant System Engineering Training
Improvement of FBR Engineer Educational Training after Accident

◆ Poor Education and Training before the accident
◆ Taking main 4 kinds of Remedies

1. Establishment of Educational Training Framework which consists of 4 kinds of technical trainings

2. Strengthening Sodium Handling Technical Training by new construction of Fast Reactor Training Facility (FRTF) and new establishment of 7 kinds of handling training courses

3. Upgrading FBR Operation Technical Training by remodeling Monju Advanced Reactor Simulator (MARS) and improving training contents.

4. Establishment of FBR Plant System Engineering Training Courses which consists of fundamental and advanced courses
Establishment of Training Framework

- Training Framework which defines the Basic Policy of Educational Training
- Categorizing into the **4 kinds of Technical Trainings**

<table>
<thead>
<tr>
<th>Training Framework</th>
<th>Course Number</th>
<th>Target Point for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Handling Technical Training</td>
<td>6 courses</td>
<td>Learning various kinds of sodium handling technologies including knowledge regarding sodium</td>
</tr>
<tr>
<td>Maintenance Technical Training</td>
<td>7 courses</td>
<td>Learning four kinds of maintenance technologies peculiar to Monju components and four types of conventional maintenance technologies</td>
</tr>
<tr>
<td>FBR Operation Technical Training</td>
<td>8 courses</td>
<td>Learning operation technologies for normal and abnormal operation modes by using a operation training simulator</td>
</tr>
<tr>
<td>FBR Plant System Engineering Training</td>
<td>5 courses</td>
<td>Learning fundamental and advanced FBR plant engineering technologies based on their carrier</td>
</tr>
</tbody>
</table>
Before the accident, No Training Facility

As the first remedy, the Fast Reactor Training Facility (FRTF) which consists of Sodium Handling and Maintenance Training Facilities was built newly beside Monju in May, 2000.
To systematically master sodium handling technology, the following items are listed up as the technical subjects which should be learned.

- Sodium General Knowledge
- Sodium Physical and Chemical Properties
- Sodium Loop Operation Techniques (Sodium Charge and Drain operations)
- Sodium Purification Control Technique
- Sodium Corrosion Mechanism
- Treatment Skill for Sodium Compounds
- Response and Treatment Skills against Sodium Piping Leak
Establishment of Sodium Handling Training Courses

- The Sodium Technical Subjects are categorized into **4 Groups**.
- Establishing **6 Training Courses** based on 4 groups.

<table>
<thead>
<tr>
<th>Group Category</th>
<th>Training Courses</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Properties</td>
<td>① Sodium Beginner Course</td>
<td>1 Day</td>
</tr>
<tr>
<td></td>
<td>② Sodium Expert Course</td>
<td>2 Days</td>
</tr>
<tr>
<td>Sodium Loop Operation</td>
<td>③ Sodium Loop Operation Course (Charge, Drain and Purification Operations)</td>
<td>3 Days</td>
</tr>
<tr>
<td>Sodium Handling Skills Against Sodium Leak</td>
<td>④ Sodium Leak Response Course</td>
<td>2 Days</td>
</tr>
<tr>
<td></td>
<td>⑤ Sodium Fire Fighting Course</td>
<td>1 Day</td>
</tr>
<tr>
<td>Sodium Handling Skills in Maintenance Work</td>
<td>⑥ Sodium Handling Internal License Course</td>
<td>1 Day</td>
</tr>
</tbody>
</table>
Sodium Properties

<Main Lecture>

- Basic Knowledge regarding Sodium
- Chemical and Physical Properties of Sodium
- Reasons of Using Sodium as a Coolant of FBR
- Sodium Corrosion & Sodium Purification Control

<Main Exercise>

- Observation of Small Scale Sodium Combustion
- Measurement of 6 kinds of Sodium Physical Properties
  - Density
  - Melting point
  - Kinetic Viscosity
  - Specific Heat
  - Thermal Conductivity
  - Surface Tension
Sodium Loop Operation

<Main Lecture Contents>
- Specification & Design Philosophy of Monju Cooling System
- Function & Characteristic of Monju Sodium Components
- Corrosion by Sodium and Impurities in Sodium
- Sodium Purification Control Operation

<Main Exercise Contents>
- Loop Preheating
- Charge and Drain Operations
- Purification Control Operation (Measurement of Sodium Impurities Concentration)
Sodium Handling Skills Against Sodium Leak

Distinctive Course for Strengthening Sodium Handling Technology
⇒ Development of “Sodium Leak Response Course”

- Starting as the **Only Training Course Available Worldwide** from June 2001.
- An **Imitation Leak Pipe** which has a space between inside-rod and outer insulator.
- The **Charged Sodium Leaks through the Gap** between insulator and sodium leak detectors, thermocouples and electrical heaters.

[Sodium Piping Leakage Condition]
- Leak Amount [2kg]
- Sodium Temperature [500°C]
- Leak Rate [100kg/h (Monju≈170kg/h)]
This course is very **Useful Training** for the trainee who has **Never Seen a Sodium Leak Scene**.

**Not Only Watching a Sodium Leak Scene but also a Dismantling Work of the leaked pipe.**

**Observing Residual Sodium Compounds in Insulator**

**Experience of the Waste Processing Work**
**Reappearance Experiment Simulated the Monju Leak Accident in 1996**

**Occurrence of an Unexpected Phenomenon in Design that Some Holes Penetrated the Liner Plate by the Leaked Sodium**

**Two Types of Corrosion: Molten Salt Type Corrosion and Na-Fe Double Oxidization Type Corrosion**

**Strong Corrosive Power of Molten Salt Type Corrosion occurring under Humid Environment due to the cause of Sodium Peroxide ($\text{Na}_2\text{O}_2$) which is a Strong Oxidizer**

**Actual Corrosion Type occurred at the Monju Accident is Na-Fe Double Oxidization Type Corrosion which has not strong corrosive power.**

**Humidity Plays a Key Role.**

**Chemical Reactions:**

- **Molten Salt Type Corrosion:**
  \[
  \text{Na} + \text{Na}_2\text{O} \rightarrow \text{Na}_2\text{O}_2 + \text{NaOH}
  \]

- **Na-Fe Double Oxidization Type Corrosion:**
  \[
  \text{Na}_2\text{O}_2 + \text{H}_2\text{O} = 2\text{NaOH} + 1/2\text{O}_2
  \]

**Equations:**

- **NaOH + Na$_2$O + Na$_2$O$_2$**
- **Na$_2$O$_2$ + H$_2$O = 2NaOH + 1/2O$_2$
Before engaging sodium handling work at Monju, all workers have to attend the Sodium Handling Internal License Course and have to Pass the Examination (>60 points). (680 persons / as of October, 2009)

**<Main Lecture Contents>**

- Feature & Chemical Property of Sodium Combustion
- Cleaning Treatment Method of Sodium Compounds
- Mechanism of Sodium Spontaneous Combustion
- Notes on Sodium Handling Working
- Examination for Completion

**<Main Exercise Contents>**

- Sodium Wiping Work
- Observation of Sodium-Water Chemical Reaction
- Observation of Sodium Spontaneous Combustion
- Treatment Work of Sodium Compounds

**<Certificate of Completion>**
Monju operators are classified into 6 grades.

The Educational Training Guidance defined the following items was established after the Monju leak accident.

- Educational Training Items
- Frequency of Educational Training
- Training Contents which should be learned
- Preparation of Training Material

<Monju Operator Grades>
Training by Monju Advanced Reactor Simulator (MARS)

◆ Full Scope Type Simulator

◆ Offering Plant Behaviors under normal and abnormal with Real Time

◆ Enabling 73 Training Cases for Normal Mode Operation and 320 Cases for Off-Normal Mode Operation

◆ MARS Satisfies the Plant Simulation Accuracy Required by ANSI/ANS-3.5-1985 (Nuclear Power Plant Simulator).
For Upgrading FBR Operation Training

⇒ Remodeling of MARS (Supplement of Synthetic Sodium Leak Monitoring System)

◆ To Discover and to Confirm a Sodium Leak Accident Quickly and Exactly

◆ Link to MARS’s Computer System

◆ Display Automatically a Virtual Graphic of Small or Large Leaks Scale calculated by MARS

< Synthetic Sodium Leak Monitoring System >
Other Remodeling ⇒ Improvement of Core Calculation Accuracy

For Future Sevier Accident Training (LOCA, LOHRS, etc.), Indispensable Improving Core Dynamic Characteristic Analysis Accuracy

Remodeling Contents

◆ From a Single Channel to Multi Channel which consists of 11 Representative Channels

◆ Concatenating Two Plenums and Each Channel with Momentum Equations and Friction Factors for Calculation of Pressure Drop at each S/A

Other Remodeling ⇒ Improvement of Man-Machine Interface

Man-machine interface between instructor console and each control panels including local panels have been improved, and consequently, operability of the instructor console has become very good.
Now Preparing introduction Systematic Approach Training (SAT)

Educational Evaluation System for Nuclear Power Plant Operators defined in the Japanese guidance named JEAG.

Expectable that Potential Issues Hidden in the Present Education System will be Revealed.

Grasping the Training Results Quantitatively.

For More Upgrading Operator Training (For Future) ⇒ Introduction of Systematic Approach Training (SAT)

Defining required training skill according to each class

Fix training items corresponding to each class

Implementing training

Confirmation of comprehension level by Test

Analyzing training & examination result data

Revealing any potential issues in training structure by administrators (instructors & section manager)

Report of training and examination results data to each operator

Taking remedies

<Summary Evaluation Flow of SAT>
Establishment of FBR Plant System Engineering Training

- For Improving Poor Education and Training before the Accident
- **One Basic Course** covers All FBR Fundamental Technologies via 12 Lectures
- **Four Advanced Courses divided into 4 Groups**
- Learning **Step by Step** based on their knowledge level

<table>
<thead>
<tr>
<th>Categories</th>
<th>Training Courses</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>FBR Basic Course</td>
<td>Covers basic manifold FBR system engineering technologies via 12 lectures</td>
<td>lectures 3 Days</td>
</tr>
<tr>
<td>FBR Advanced Course-1</td>
<td>Covers system design, safety design &amp; assessment and plant application license</td>
<td>2 Days</td>
</tr>
<tr>
<td>FBR Advanced Course-2</td>
<td>Covers core characteristic, core shielding &amp; radiation source and fuel design, etc.</td>
<td>2 Days</td>
</tr>
<tr>
<td>FBR Advanced Course-3</td>
<td>Covers core structure &amp; material designs, fuel handling system and sodium components &amp; feature</td>
<td>2 Days</td>
</tr>
<tr>
<td>FBR Advanced Course-4</td>
<td>Covers plant operation experience, radiation control and radioactive waste treatment</td>
<td>2 Days</td>
</tr>
</tbody>
</table>
2. Student Educational Training

1. Tsuruga Summer Institute on Nuclear Energy
2. Environmental Energy Education for under High School Students
Tsuruga Summer Institute on Nuclear Energy

Organizing: Sponsorship by 3 Institutes (Fukui University, Wakasawan Energy Research Center and JAEA) and as One of Collaborative Activities based on a Technical Cooperation Agreement with CEA, France.

Target: Graduate Students mainly from a total of about Ten Universities in Kansai, Chubu, Hokuriku, Kanto areas including Fukui prefecture

Training Duration and Capacity: 1 week / 40 students

Contents: 4 Lectures, 3 Exercises, 5 Sight Tours, 5 Open Speeches, including English Debate and Monju Discussion
JAEA supports **Environmental Energy Education** for under high school students as one of collaborative activities for enhancing **Symbiotic between Local Community and Nuclear Energy including Monju**.

- **Learning Items:** Environment, Energy, Extensive Nuclear Science Field
- **Participants:** About **7,000 students from 2007 to as of Sep., 2009**.
3. International Educational Training Program

1. International Sodium Handling Training Course

2. International Reactor Plant Safety Course for Asian Nations
Sponsor: Nuclear Research Exchanging Program sponsored by MEXT
Past Participants: China Institute of Atomic Energy and Sandia National Laboratories of U.S.A.
Training Duration and Capacity: 10 weeks / 5 trainees
Contents: 10 Lectures & 12 Exercises regarding such as sodium properties, sodium loop operation, sodium corrosion, sodium leak, compounds treatment, etc., in addition, FBR engineering technologies.
International Reactor Plant Safety Course for Asian Nations

◆ Sponsor: Nuclear Instructor Development Program sponsored by MEXT
◆ Participants: 8 Asian Countries (China, Indonesia, Thailand, Philippines, Malaysia, Bangladesh, Sri Lanka)
◆ Training Duration and Capacity: 4 weeks / 10 trainees x 2 times /year
◆ Contents: 20 Lectures covering nuclear safety design principal, safety measures, safety assessment, seismic design, quality assurance, etc.; 4 Exercises; 10 Sight Tours; Discussion
Open of CEA-JAEA Collaboration Website

CEA-JAEA Collaboration Website regarding education and training field will be opened newly today. The address is as follows:

http://www.cea-jaea-collaboration.net/
Conclusion

- After Monju accident, the **FBR Engineer Educational Training** was drastically improved based on the teachings obtained from the accident.
  - **Strengthening Sodium Handling Training**: 1) Construction of the FRTF; 2) Development of sodium leak response course which is the only training course available worldwide, 3) Prevailing new knowledge concerning sodium corrosion, etc.
  - **Upgrading FBR Operation Training**: 1) Supplement of synthetic sodium leak monitoring system, 2) Improvement of reactor core calculation, etc.

- The **Student Educational Training** contributes to **progress symbiotic between local community and nuclear energy** including “Monju” from 2007, and about 7,000 students have jointed as of September, 2009.

- The **International Educational Training** provides two types of training courses were started from 2006: The **International Sodium Handling Course** by participation of China and U.S.A.; the **Reactor Plant Safety Course** by joint of 8 countries in Asia.

- The variety of those training activities mentioned above can be expected to contribute to the development of nuclear human resource in Japan and abroad towards the next-generation age.
Thank You for Your Attention!
Appendix
Multiple Sodium Training Cell

Sodium Fire Fighting Training Course, Sodium Leak Response Training Course, Sodium Handling Internal License Course, etc., are held in this cell. The cell provides an exhaust system which can trap sodium compounds of 95% more by high performance HEPA filters.
Before establishing the **Educational Training Framework for FBR Engineer Educational Training**, the goal of each FBR engineer was defined as the following in order to perform its training effectively.

<table>
<thead>
<tr>
<th>Target</th>
<th>Training Goal Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monju Operator</td>
<td>● <strong>Operational Technology</strong></td>
</tr>
<tr>
<td></td>
<td>● <strong>Sodium Handling Technologies</strong> including knowledge (sodium properties and features)</td>
</tr>
<tr>
<td></td>
<td>● <strong>FBR Basic Knowledge</strong></td>
</tr>
<tr>
<td>Monju Maintenance Engineer</td>
<td>● <strong>Maintenance Technologies</strong> peculiar to Monju and conventional technologies</td>
</tr>
<tr>
<td></td>
<td>● <strong>Sodium Handling Technologies</strong></td>
</tr>
<tr>
<td></td>
<td>● <strong>FBR Basic Knowledge</strong></td>
</tr>
<tr>
<td>FBR Engineer</td>
<td>● <strong>FBR Plant System Engineering Technologies</strong></td>
</tr>
<tr>
<td></td>
<td>● <strong>Sodium Knowledge</strong></td>
</tr>
</tbody>
</table>