

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



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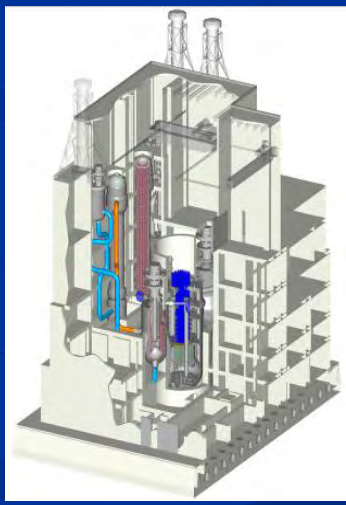
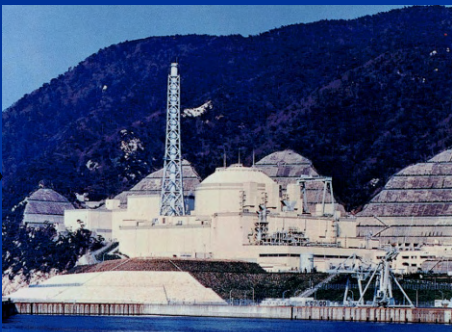


Introduction

Human Development towards the new FBR Age

Japan has been progressing development of FBR and is now aiming at starting operation of a demonstration FBR around 2025 in the Fast Reactor Cycle Technology Development Project called the **FaCT Project**.

To prepare such as the new FBR age, INITC (International Nuclear Information Training Center) has been working on human development included abroad via various kinds of educational trainings using Monju.



2005

2015

≈2025



Educational Training Activities by INITC

The educational training activities by INITC are divided into two types as follows:

● Domestic Educational Training Program

1) FBR Engineering Educational Training

- For young engineers/researchers engaged in Monju especially

2) Student Educational Training

- ◆ Tsuruga Summer Institute on Nuclear Energy for mainly graduated students in Fukui University, also involved in Kansai, Chubu and Kanto area's universities.
- ◆ Environmental Energy Education for under high schools in local community

● International Educational Training Program

- ◆ International Sodium Handling Training Course
- ◆ International Reactor Plant Safety Course for Asian Nations



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

The FBR Engineer Educational Training was remarkably improved by taking following main remedies based on the teachings obtained from the accident.

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





Training Goal of Each FBR Engineer

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.

Target	Training Goal Point
<p>Monju Operator</p>	<ul style="list-style-type: none"> ● Operational Technology ● Sodium Handling Technologies including knowledge (sodium properties and features) ● FBR Basic Knowledge
<p>Monju Maintenance Engineer</p>	<ul style="list-style-type: none"> ● Maintenance Technologies peculiar to Monju and conventional technologies ● Sodium Handling Technologies ● FBR Basic Knowledge
<p>FBR Engineer</p>	<ul style="list-style-type: none"> ● FBR Plant System Engineering Technologies ● Sodium Knowledge



Establishment of Training Framework

For achieving each engineer's training goal, the **Educational Training Framework** categorized into the 4 kinds of technical trainings was established newly.

Training Framework	Course Number	Target Point for Learning
Sodium Handling Technical Training	6 courses	Learning <u>various kinds of sodium handling technologies</u> including <u>knowledge</u> regarding sodium
Maintenance Technical Training	7 courses	Learning <u>four kinds of maintenance technologies peculiar to Monju</u> components and four types of conventional maintenance technologies
FBR Operation Technical Training	8 courses	Learning operation technologies for <u>normal and abnormal operation modes</u> by using a operation training simulator
FBR Plant System Engineering Training	5 courses	Learning <u>fundamental and advanced</u> FBR plant engineering technologies based on their carrier



Strengthening Sodium Handling Technical Training

New Construction of FRTF

For carrying out high quality educational training relate to both **Sodium Handling** and **Maintenance Technologies**, the Fast Reactor Training Facility (FRTF) was newly built near Monju in March 2000.



<Overview of FRTF>



Technical Subjects which should be Learned

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

Based on the technical subjects which should be learned to master sodium handling technology, the following **6 training courses** were established.

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



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 six kinds of Sodium Physical Properties
 - ✓ Density
 - ✓ Melting point
 - ✓ Kinetic Viscosity
 - ✓ Specific Heat
 - ✓ Thermal Conductivity
 - ✓ Surface Tension



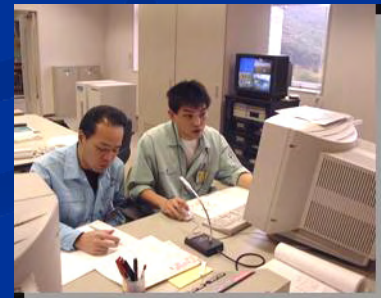
Sodium Loop Operation

<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
- Charging and Draining Operations
- Purification Operation (Measurement of Sodium Impurities Concentration)





Sodium Handling Skills Against Sodium Leak

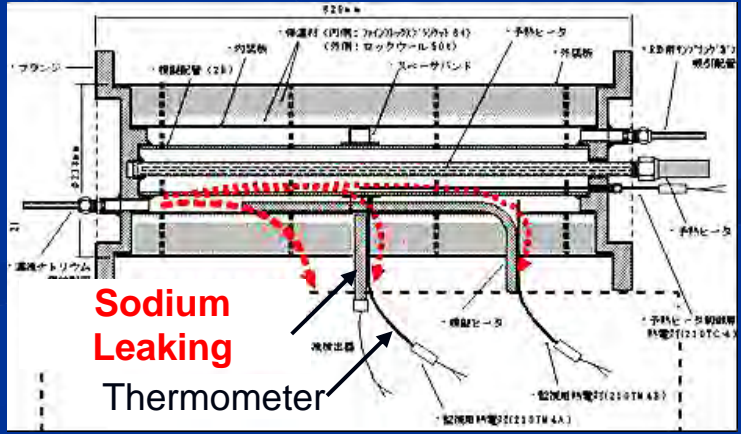
One of Remedies as for Strengthening Sodium Handling Technology
⇒ **Development of “Sodium Leak Response Course”**

- This course was started from June 2001 and is the **only training course available worldwide.**
- An **imitation leaking pipe** has a space between inside-rod and outer insulator, and sodium is charged into that space.
- And then, the charged sodium leaks through the gap between insulator and sodium leak detectors, thermocouples and electrical heaters from the inside space.



[Sodium Piping Leakage Condition]

- Leak Amount [2kg]
- Sodium Temp. [500°C]
- Leak Rate [100kg/h(Monju≈170kg/h)]



<Imitation Sodium Leak Pipe>



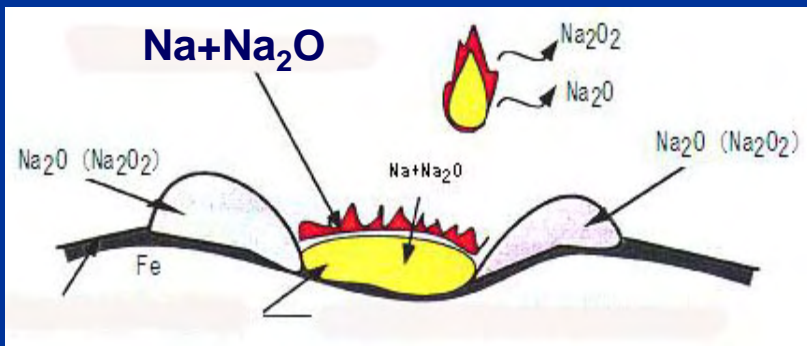
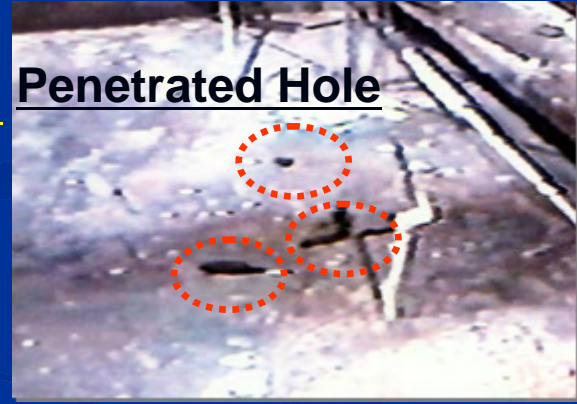
- ◆ This “Sodium Leak Response Training Course” is the **only training course available worldwide** which is very useful for the trainees who has **never seen a sodium leak scene**.
- ◆ Additionally, this course contains **not only watching a sodium leak scene** but also a **dismantling work** of the leaked pipe.
- ◆ Trainees can observe the **residual sodium compounds** in insulator and are able to experience the waste processing work of sodium compounds.



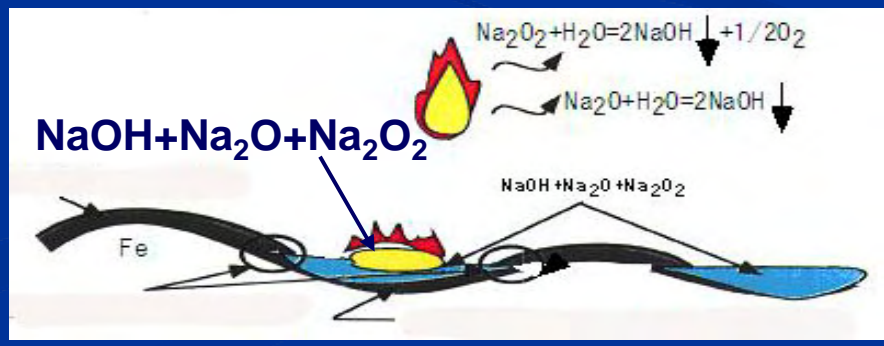


Other Remedy ⇒ Prevailing New Knowledge regarding Sodium Corrosion

- From the viewpoint of investigation of technical knowledge, a reappearance experiment simulated the Monju leak accident was conducted in 1996.
- At that time, an unexpected phenomenon in design that some holes penetrated the liner plate was occurred.
- This phenomenon was caused by **Molten Salt Type Corrosion** which occurs under humid environment. Under such as that condition, **sodium peroxide (Na₂O₂)** which is a **strong oxidizer** is dominant, and liner plate is corroded so quickly.
- While, since the actual field condition was low humidity, in such a case is **Na-Fe Double Oxidization Type Corrosion** which has not strong corrosive power.
- By studying the result, it was revealed that humidity plays a key role which corrosion type occurs.
- This new knowledge has been prevailing via a lecture.



<Na-Fe Double Oxidization Type Corrosion>



<Molten Salt Type Corrosion>



Sodium Handling Skills in Maintenance Work

Before engaging sodium handling work at Monju, all workers have to attend the **Sodium Handling Internal License Course** and 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>

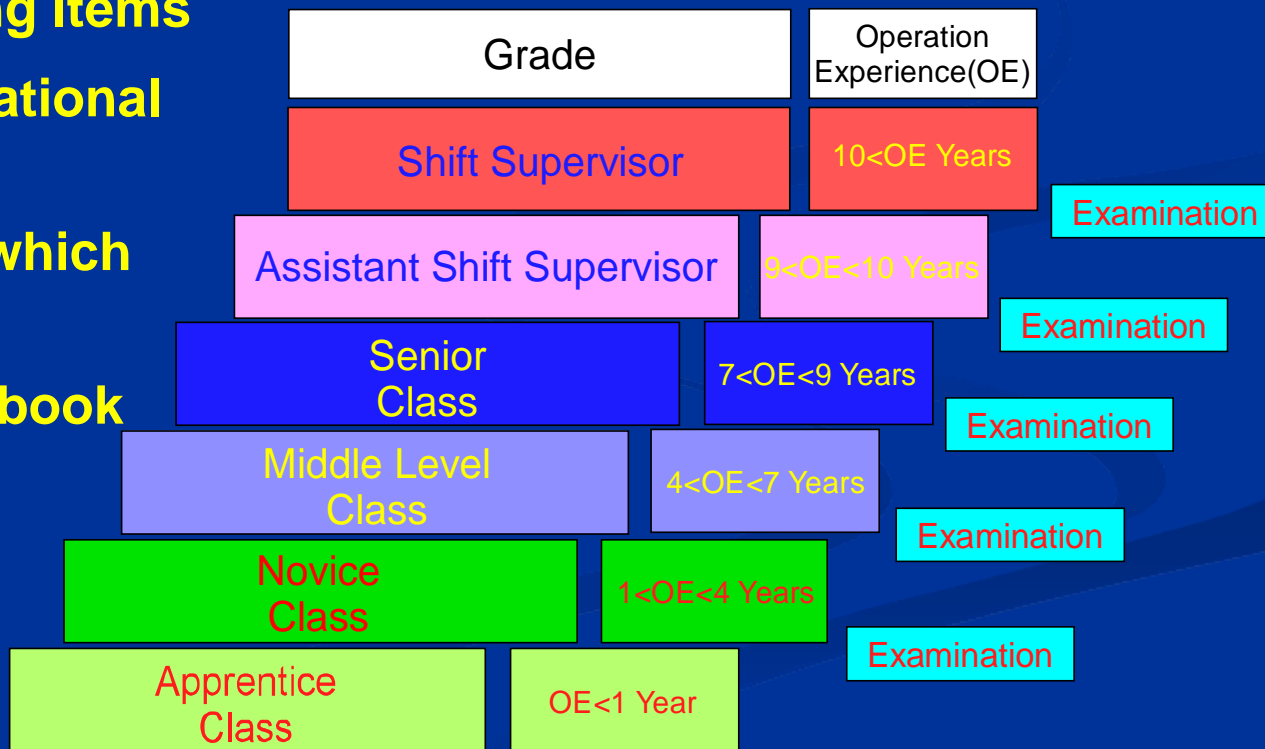


Upgrading FBR Operation Technical Training

Establishment of Educational Training Guidance

- ◆ Monju operators are classified into 6 grads.
- ◆ 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 Textbook

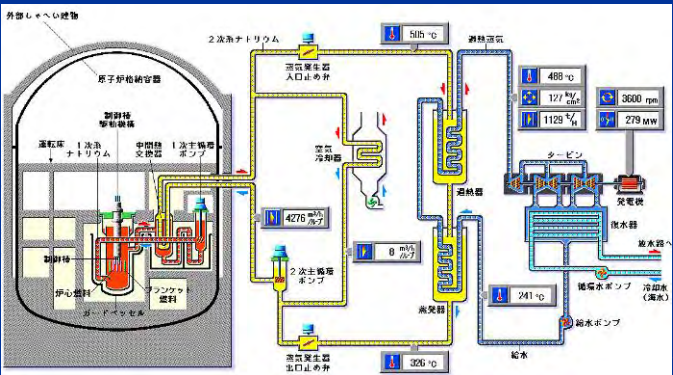


<Monju Operator Grades>



Training by Monju Advanced Reactor Simulator (MARS)

- ◆ **MARS is a Full Scope Type Simulator**, which faithfully duplicates all main control panels and partial local panels, which are located in a central control room.
- ◆ MARS has three types computer systems: dynamic computer; process computer for controlling interlock actions; process linkage control unit and can **offer real time behaviors** under normal and abnormal conditions.
- ◆ A total of **73 training cases for normal mode** and **320 cases for off-normal mode operation** are available.
- ◆ Additionally, MARS satisfies the plant simulation accuracy required by ANSI/ANS-3.5-1985 (Nuclear Power Plant Simulator).



<MARS Overview & System Scope>



One of Remedies as for Upgrading FBR Operation Training
⇒ Remodeling of MARS (Supplement of Synthetic Sodium Leak Monitoring System)

- ◆ Since Monju provided the **Synthetic Sodium Leak Monitoring System** in order to confirm a sodium leak accident quickly and exactly, the same system was introduced to the MARS as an extra system.
- ◆ This system is linked to MARS's computer system and can **automatically display a virtual graphic** of small or large leaks scale, calculated by MARS.



Large Leak



Small Leak



No Leak



<Synthetic Sodium Leak Monitoring System>

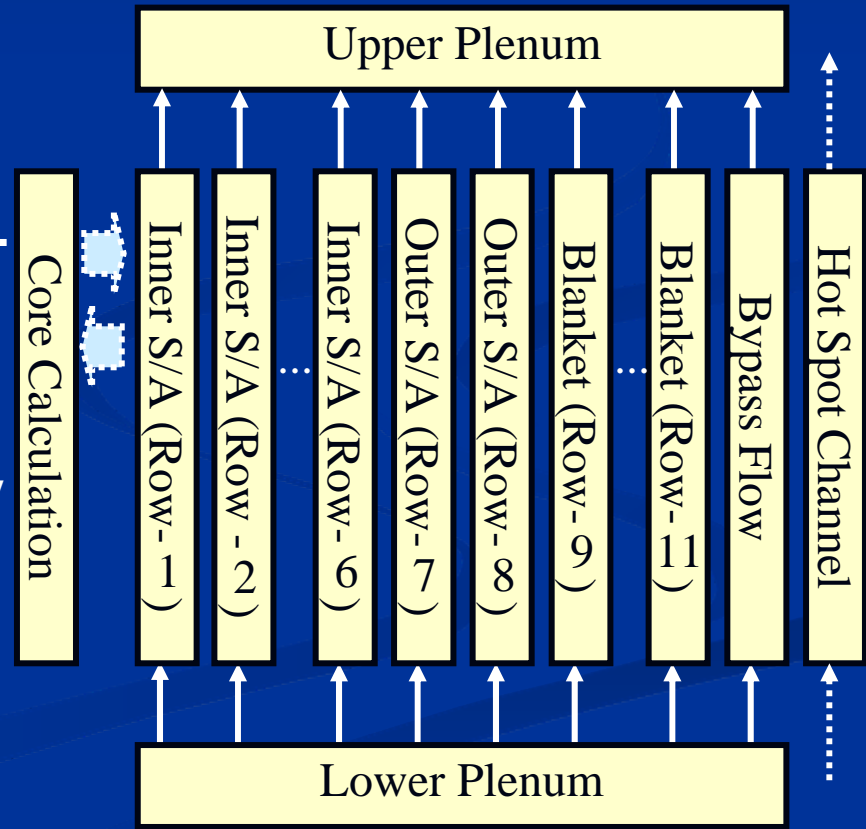


Other Remedy ⇒ Improvement of Core Calculation Accuracy

To perform the training for the severe accident, such as a loss of coolant accident (LOCA), a loss of heat removal system (LOHRS), etc., it is indispensable to improve core dynamic characteristic analysis accuracy.

Remodeling Contents

- ◆ Core model was remodeled from a Single Channel to a Multi Channel which consists of 11 representative channels of 6 inner core S/As, 2 outer core S/As and 3 blanket core channels and 2 plenums, etc.
- ◆ Two plenums and each channel are concatenated with momentum equations and friction factors for calculation of pressure drop at each S/A that is given by the in-water tests.
- ◆ In addition, reactor power is calculated based on one point prompt jump approximation of reactor kinetics with six energy groups of delayed neutron.





Other Remedy ⇒ 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.



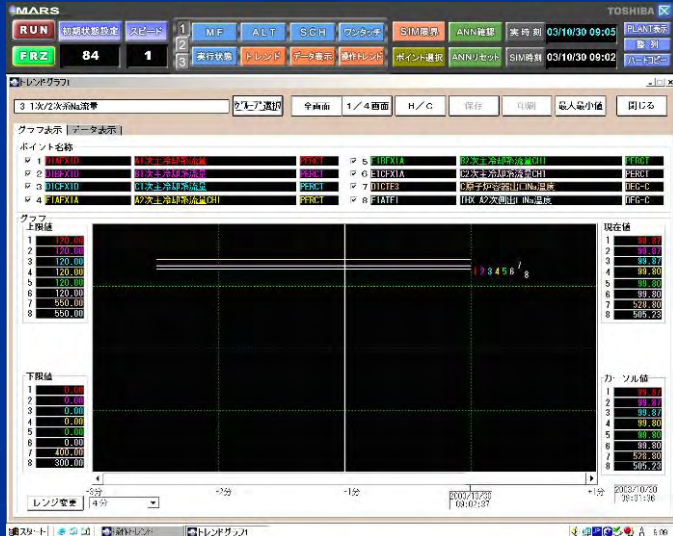
<Malfunction Data Scene>



<Console Panel >



<Initial Condition Setting Data Scene>

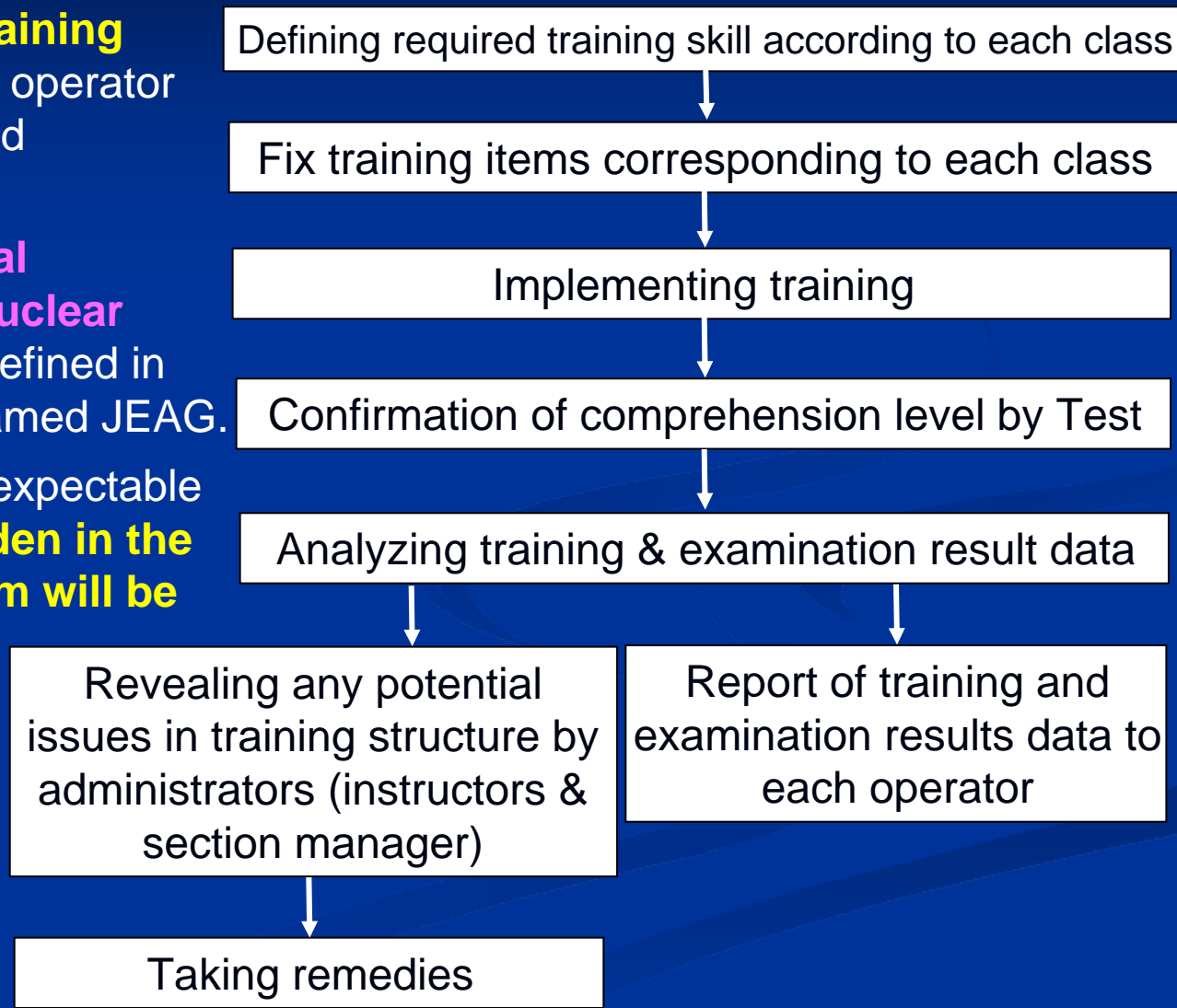


<Analog Trend Data Scene>



Other Remedy ⇒ Introduction of Systematic Approach Training (SAT)

- Monju is now preparing to introduce **Systematic Approach Training (SAT)** in order to carry out operator training more efficiently and systematically.
- The SAT is an **Educational Evaluation System for Nuclear Power Plant Operators** defined in the Japanese guidance named JEAG.
- By applying the SAT, it is expectable that **potential issues hidden in the present education system will be revealed.**
- Also, the **training results can be grasped quantitatively.**





5. Establishment of FBR Plant System Engineering Training

- As one of remedies for more enhancing FBR Engineering Educational Training, **FBR Plant System Engineering Training Course** was newly established.
- This training contains a total of five courses which are divided into **one Basic Course** and **four Advanced Courses**.
- Trainees can learn manifold FBR plant system engineering **step by step** based on their knowledge level.

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



2. Student Educational Training

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

1. Tsuruga Summer Institute on Nuclear Energy

- ◆ Organizing: Sponsorship by three institutes (Fukui University, Wakasawan Energy Research Center and JAEA) and as **one of collaborative activities** based on a **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, English Debate and Monju Discussion**





2. Environmental Energy Education for under High School Students

- ◆ JAEA supports **Environmental Energy Education** for under high school students as one of 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.

Nuclear Lesson



Human Development in Nuclear Field (Employment)



Energy Environmental Education



Science Education Support



Science School



Various Kinds of Science Events



3. International Educational Training Program

- 1. International Sodium Handling Training Course**
- 2. International Reactor Plant Safety Course for Asian Nations**



1. International Sodium Handling Training Course

- ◆ 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.





2. 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, seismic design, etc.; **4 Exercises; 10 Sight Tours, Discussion**





Open of CEA-JAEA Collaboration Website

CEA-JAEA Collaboration Website regarding education and training field has been just opened newly. The address is as follows:

<http://www.cea-jaea-collaboration.net/>

The screenshot shows a web browser window with the following elements:

- Browser Title Bar:** CEA-JAEA Collaboration Web-site - Windows Internet Explorer
- Address Bar:** http://www.cea-jaea-collaboration.net/
- Navigation Bar:** Includes menu items like 'ファイル(E)', '編集(E)', '表示(V)', 'お気に入り(A)', 'ツール(T)', 'ヘルプ(H)', and search engines like Google and Yahoo!
- Website Header:**
 - Left: CEA logo
 - Center: TRAINING AND EDUCATION
 - Right: JAEA logo
- Navigation Menu:**
 - *Common Contents*
 - *Home
 - *Event & News
 - *Archive
 - *Sodium PocketBook
 - *Literature
 - *Training Facility
 - *Contact
- Main Content Area:**
 - Center: Large graphic with 'CEA-JAEA Collaboration Web-Site' text and logos of CEA and JAEA.
 - Text: 'Very welcome to our CEA and JAEA collaboration site. This site is given on the various kinds of individual information concerning both institutes' activities on educational training relating to fast breeder Reactor (FBR) technology, such as: event & news; training facility; training courses; etc. Please contact us if you have any questions about our site contents. Thank you!'
 - Images: Two photographs showing industrial facilities, one labeled 'cea' and the other 'JAEA'.
 - Buttons: 'French Version' and 'English Version' with a 'DESTINATION MONJU' logo.
- Left Sidebar (CEA Information):**
 - CEA Information
 - French Sodium School
 - School Activities
 - Goals
 - Means
 - Program
 - International Cooperation
 - French Sodium School Facility
 - SUPERFENNEC
 - KALINA / VAUTOUR
 - MININANET
 - FONTANA
- Right Sidebar (JAEA Information):**
 - JAEA Information
 - Training Facility
 - Sodium Handling Training Facility
 - Maintenance Training Facility
 - Monju Advanced Reactor Simulator
 - Training Category
 - Training Outline
 - Training Schedule



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!

