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IAEA IWG-LMNPP

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Reliability Test for Reactor Internals Rejuvenation Technology

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1A

Items to be presented

- ① Plant Life Management in Japan**
- ② What is NUPEC ?**
- ③ What is Reliability Tests for Rejuvenation
of Reactor Internals?**
- ④ Outline of Each Test**



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Plant Life Management in Japan

- *Operating plants in Japan*

- Total 50 units (27 BWRs, 22 PWRs, 1 GCR)
- Over 30 years old : 1 unit(GCR) Over 25 years old: 3 units
- Over 20 years old : 9 units Over 15 years old: 9 units
- Over 10 years old : 10 units

- *Critical components and structures*

- Reactor pressure vessel & Reactor internals
- Reactor coolant piping, pump, & pressurizer
- Steam generator
- Electrical cables
- Reactor containment
- Concrete structures



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Countermeasures to Aging Degradation

- The MITI has issued a report summarizing the approach against plant aging degradation on April 1996.

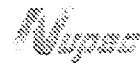
- *Enhanced Periodical Inspection*
- *Improved Guidelines for Aged Plant*
- *Self-imposed Maintenance*
- *Technological Development*
 - » Methods for thermal aging monitoring
 - » Nondestructive diagnosis methods
 - » Reactor internals repair & replacement
 - » Surface metallurgical improvement technique
 - » Improved evaluation methods for embrittlement due to neutron irradiation, fatigue considering environmental conditions, and thermal aging





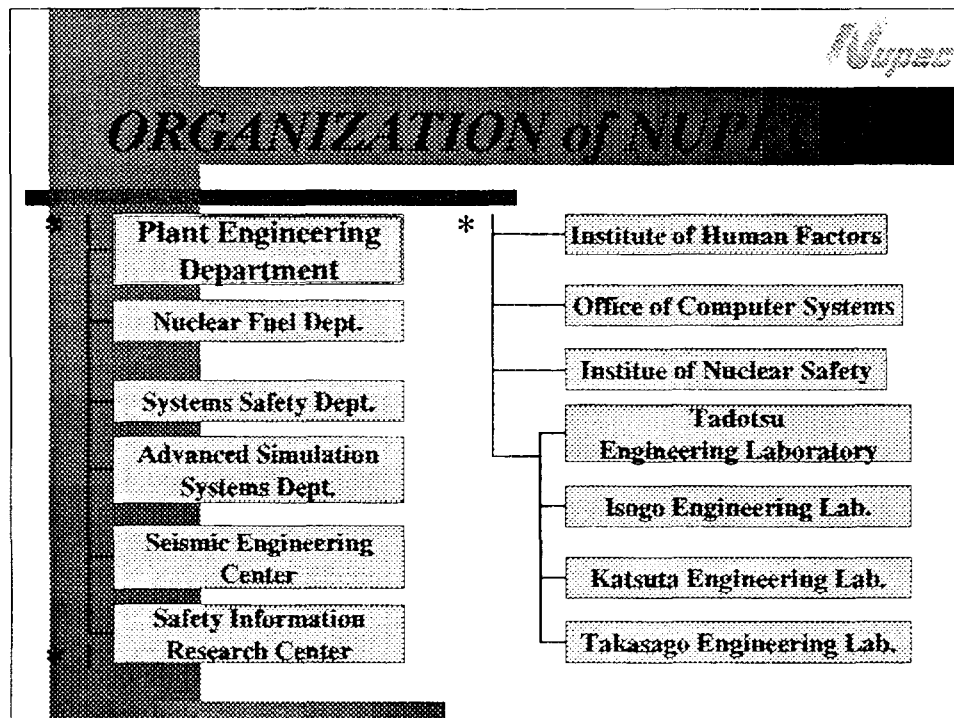
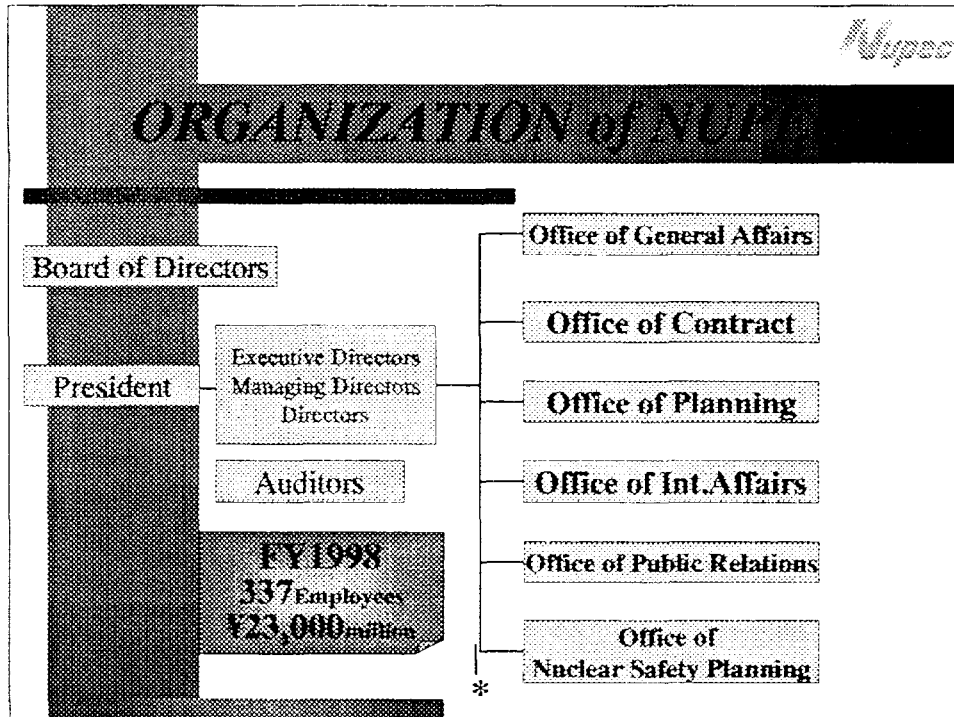
The History of NUPEC

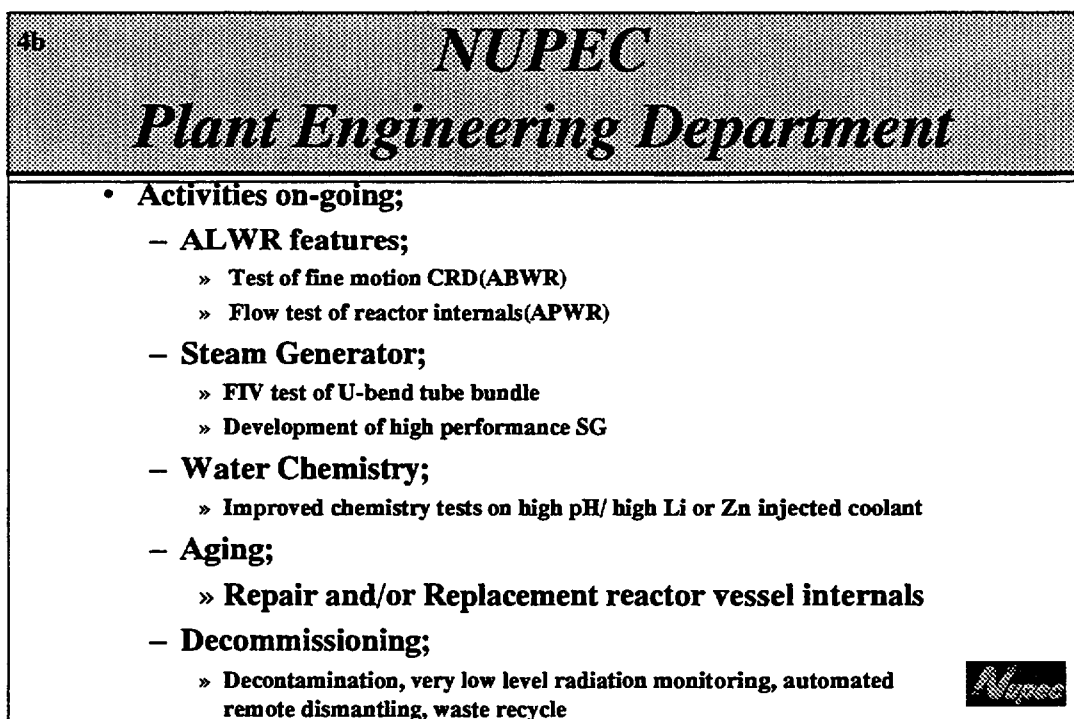
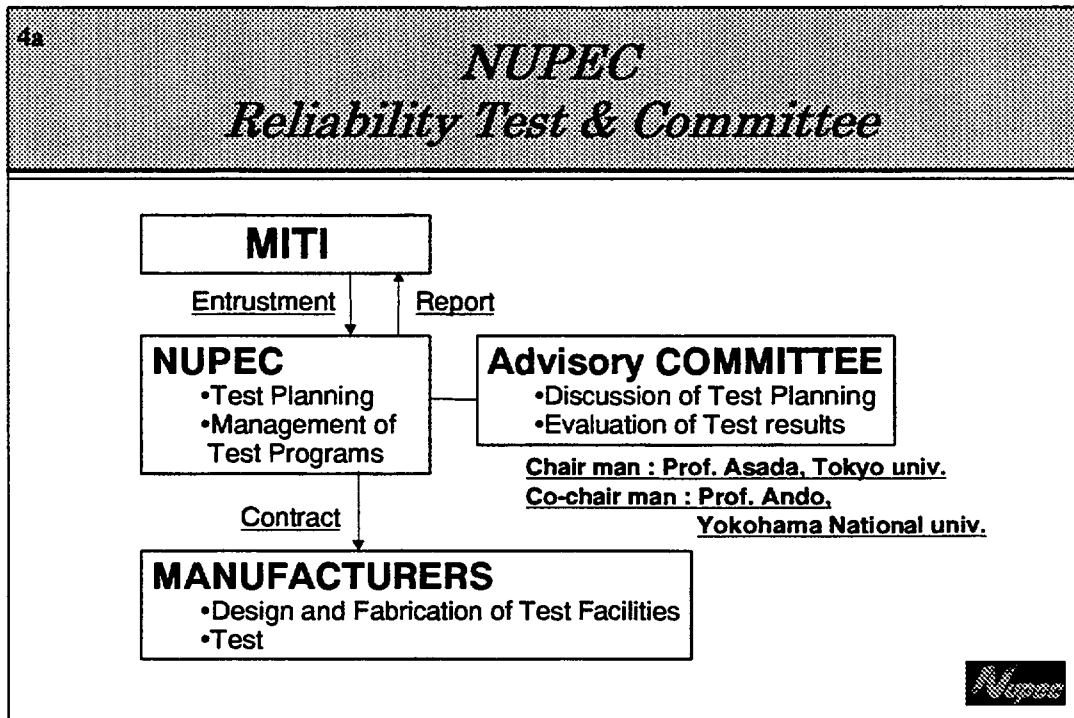
- Established on April 1976
 - Initial Objective
 - Verification Test of Nuclear Power Components using Large Scale Mockup Models
- Expansion of the Projects
 - Technical Development
 - Support for Administration
 - Safety Analysis
 - Safety Information for PA, etc.



Outline of the NUPEC Projects

- Seismic Engineering
- Plant Engineering & Components
- Nuclear Fuel
- Severe Accident
- Safety Analysis
- Safety Information
- Human Factor
- Public Relations
- International Affairs & Cooperation





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Reliability Test for Reactor Internals Rejuvenation Technology (1)

- ***Objectives***
 - To establish countermeasures against aging degradation of reactor vessel & internals
- ***Test Contents***
 - To verify reliability of the 6 replacement methods for
 - » In-core monitor housing (BWR)
 - » Core shroud (BWR)
 - » CR Drive housing/stub tube (BWR)
 - » Jet pump riser brace (BWR)
 - » Core Barrel (PWR)
 - » Bottom Mounted Instrumentation Adaptor (PWR)



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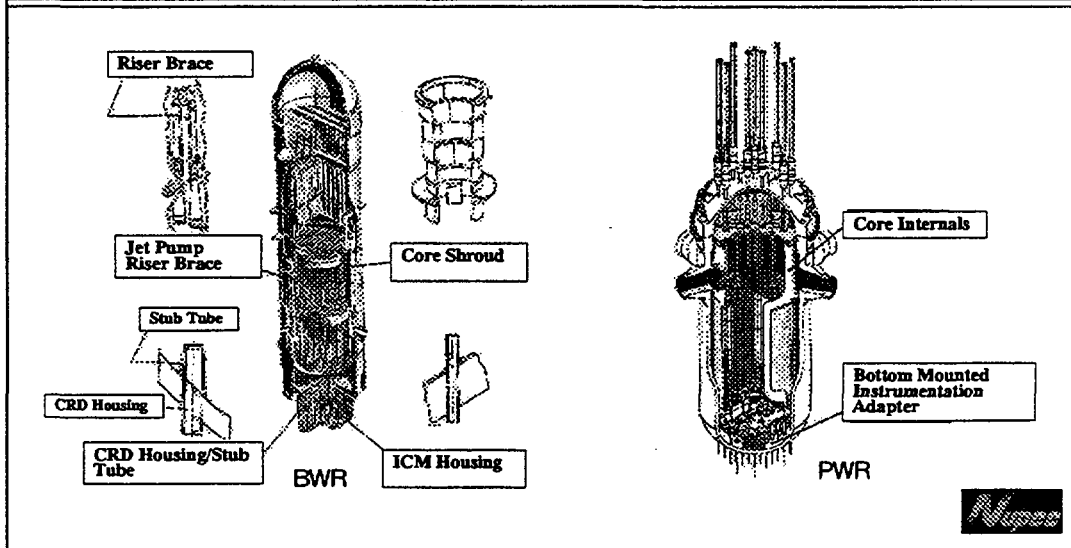
Reliability Test for Reactor Internals Rejuvenation Technology (2)

- ***Key Points of the Tests***
 - To demonstrate adequacy and reliability of the developed replacement methods
 - To verify structural integrity of the replacement components and/or sections
 - To go a long way towards getting public acceptance
 - To examine test results as a prior consultation for the MITI construction permit
 - The tests are performed with underwater automated devices using full scale mockup models.



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Components for the Nuclear Plant Rejuvenation Technology

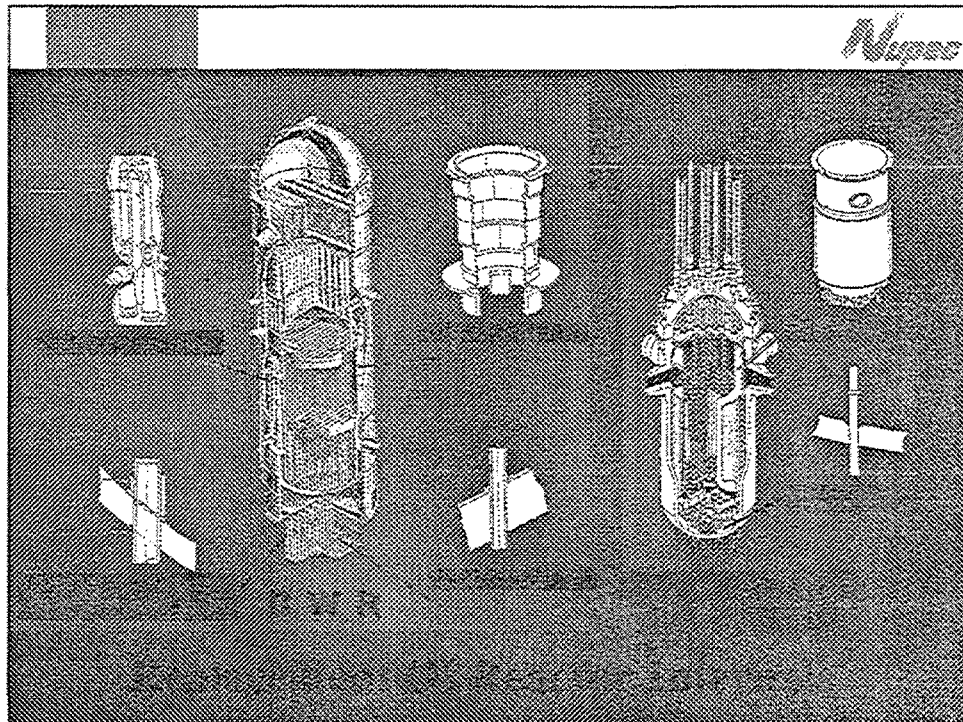


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Schedules for the Reliability Tests

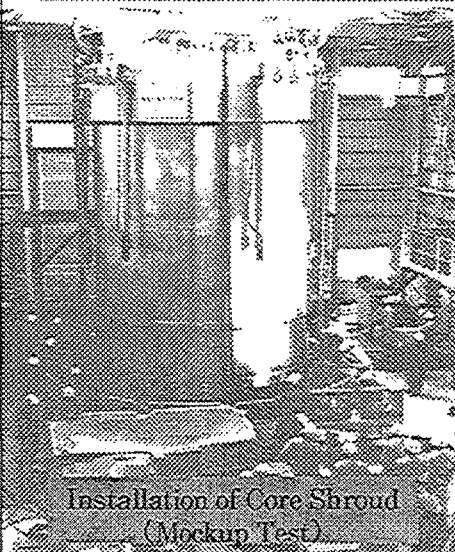
JFY	1995	1996	1997	1998	1999	2000	2001	2002
Plan and Design								
Manufacturing and Installation								
Tests								
ICM housing								
Core Shroud								
CRD Hsg. /Stub								
J/P riser brace								
Core Barrel								
BMI Adaptor								
Evaluation								







Test Results



Installation of Core Shroud
(Mockup Test)

- 1995
started the test plan
- 1996
ICM Housing Rep. Method
1997 Fukushima Daiichi Unit #4
ICM Housing Replacement
- 1997
Core Shroud Rep. Method
1998 Fukushima Daiichi Unit #3
Core Shroud Replacement
- 1998
CRD Housing/Stub Tube
Replacement Method

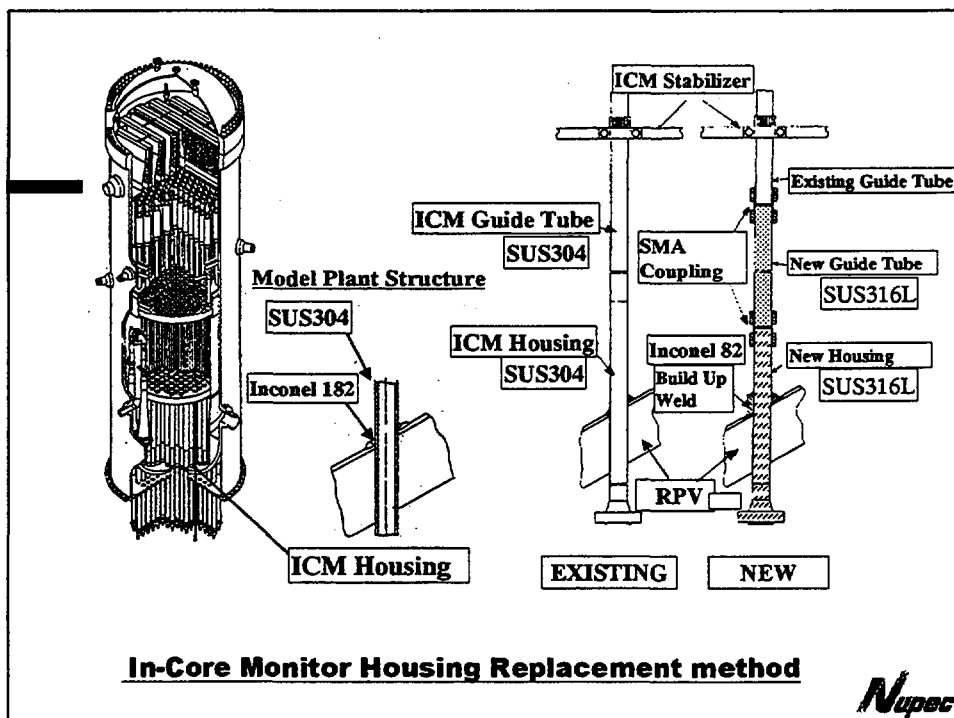


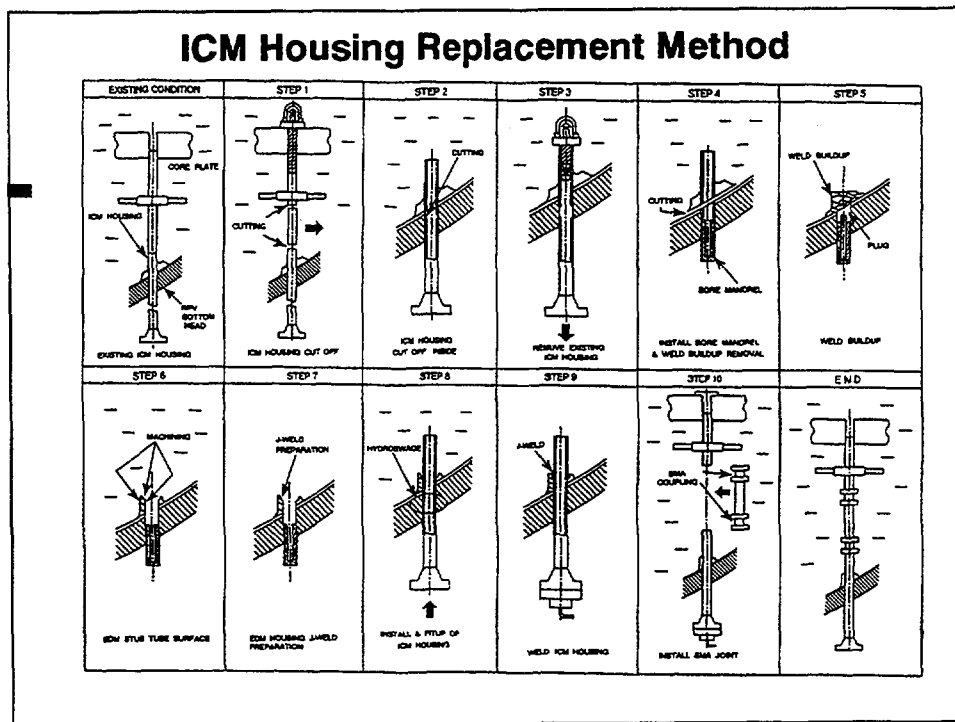
Nuclear Power Plant Rejuvenation Technology Reliability Test - Status -

◆ STATUS;

- Mockup test of replacement technology for In-Core Monitor housing executed in 1996
- Mockup test of replacement technology for Core Shroud executed in 1997
- Mockup test of replacement technology for CRD Housing/Stub Tube executing in 1998

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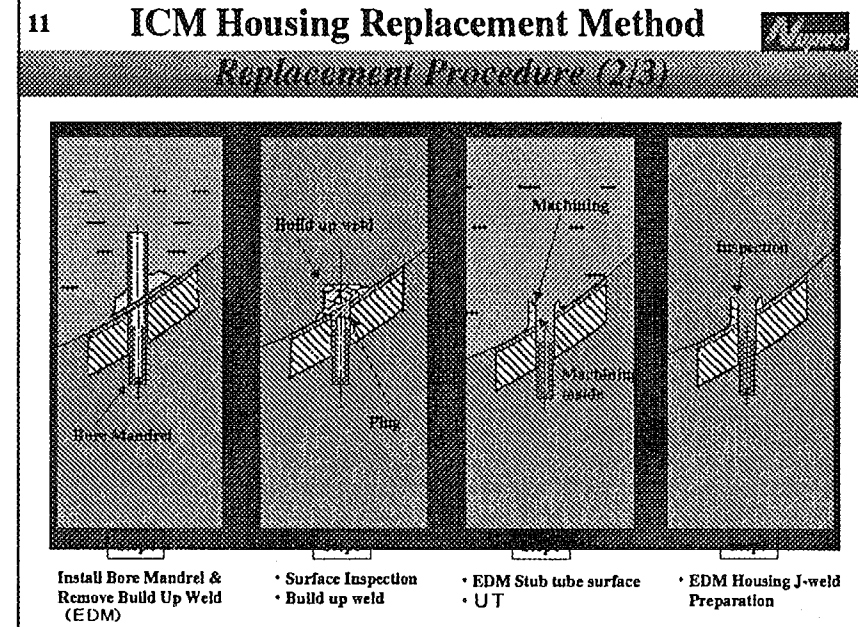
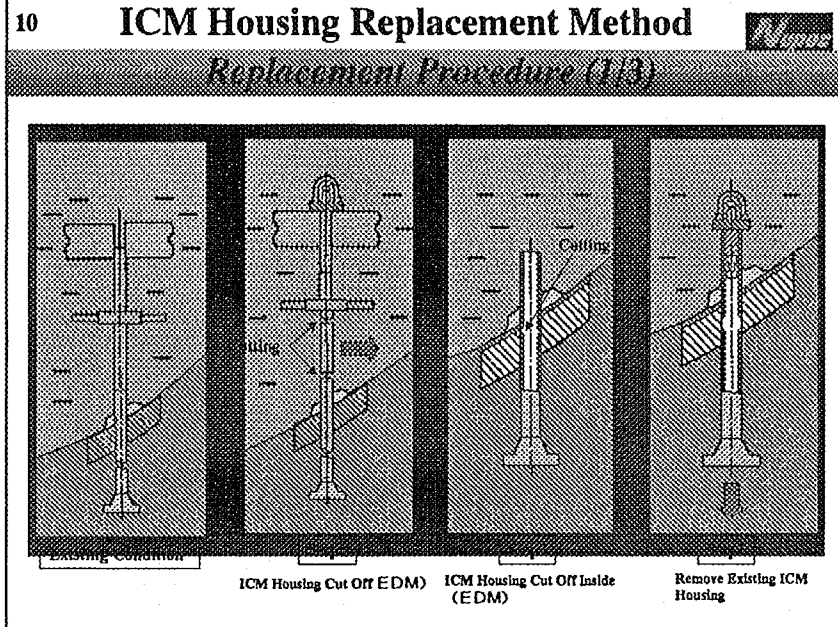
Nuclear Power Plant Rejuvenation Technology Reliability Test - Test Results and Evaluation -

◆ In-Core Monitor (ICM) Housing

◆ PROCEDURE RELIABILITY;

Reliability of the following steps have been verified

- Measuring of vessel overlay thickness
- Buildup weld
- Machining of new buildup
- Housing weld(J weld)
- UT of buildup/J weld section
- PT of buildup/J weld section
- Shape memory alloy coupling joint



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ICM Housing Replacement Method
Replacement Procedure (3/3)

Step 8

- Install & Fit up of ICM Housing

Step 9

- Weld ICM Housing
- UT

Step 10

- Install SMA Joint

End

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ICM Housing Replacement Method
Pictures after the Test

After J-Welding

SMA Coupling



Nuclear Power Plant Rejuvenation Technology Reliability Test - Test Results -

◆ STRUCTURAL INTEGRITY

Evaluations listed bellow show good results

- Quality of Welding (Build up and Housing J weld)
- Resistance to SCC of welding area
- Residual Stress of welding
- Effect of welding thermal input to Bottom Head Low Alloy
- Performance and Quality of SMA coupling

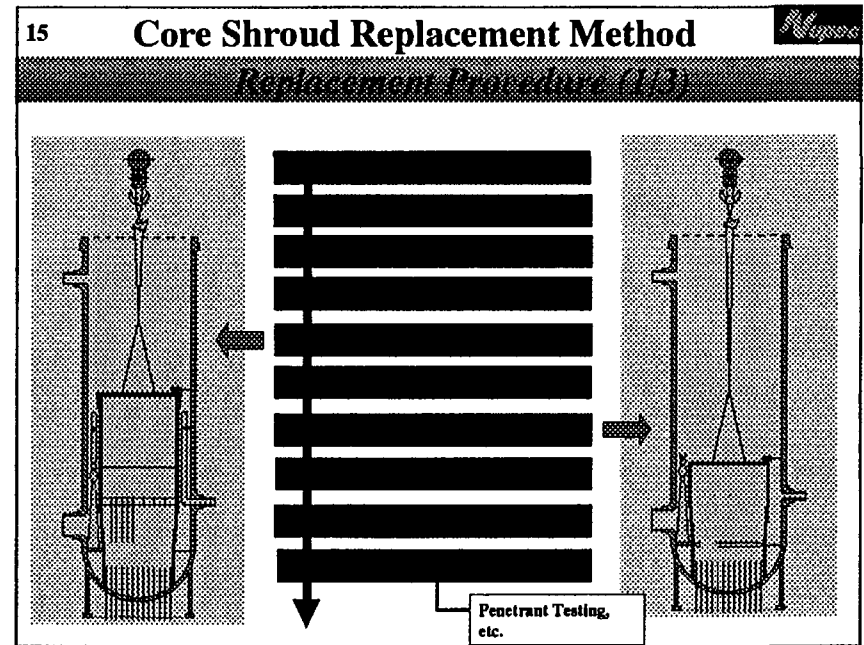
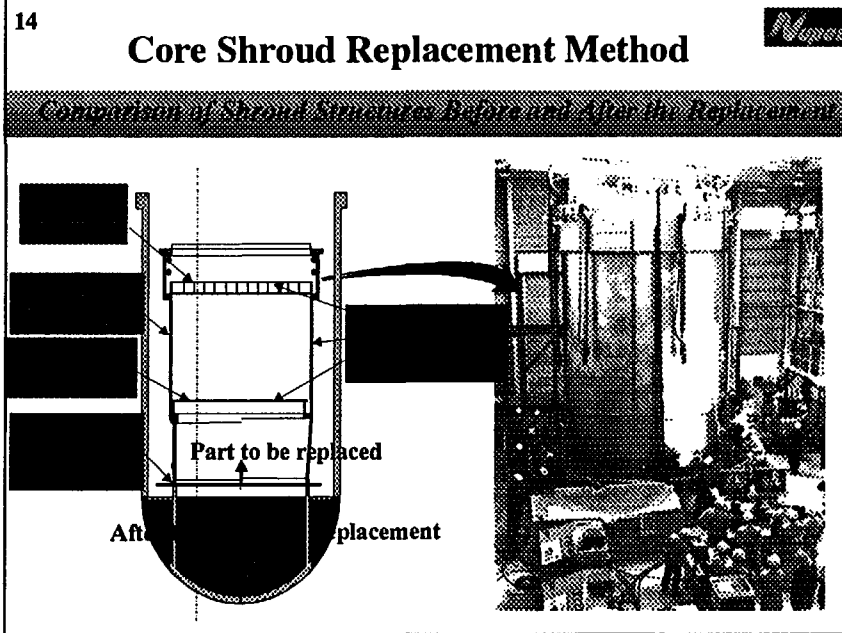
◆ STRESS ANALISYS

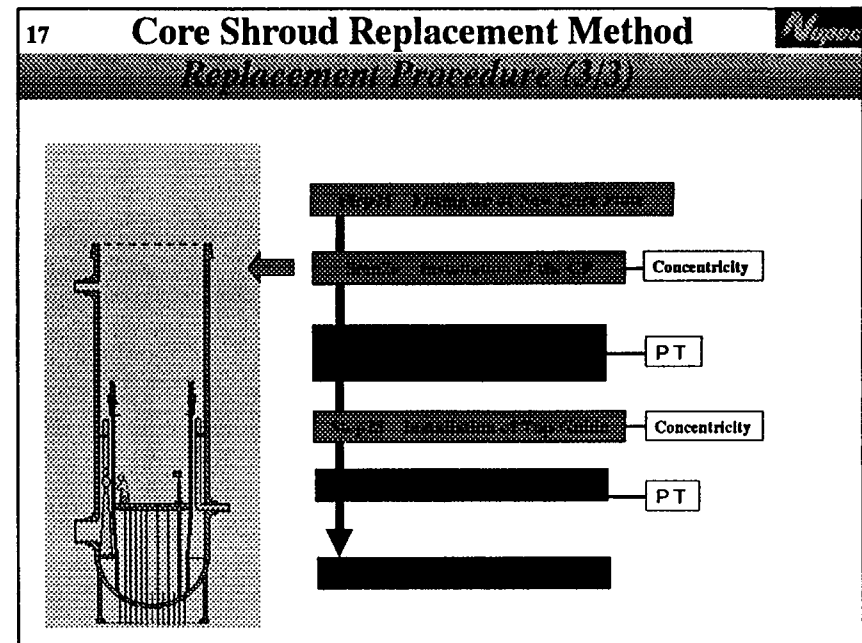
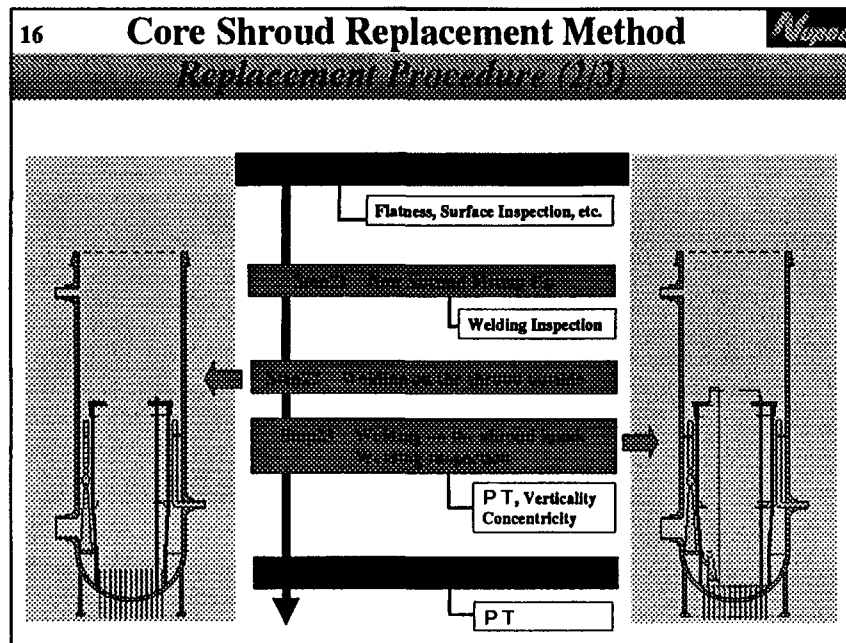
- Stress analysis shows that new structure meets
Japanese Design Criteria (MITI 501)

◆ APLICABILITY TO ACTURAL PLANTS

- This method can be applied to other similar plants which has a
different structure/material compared to mockup model plant

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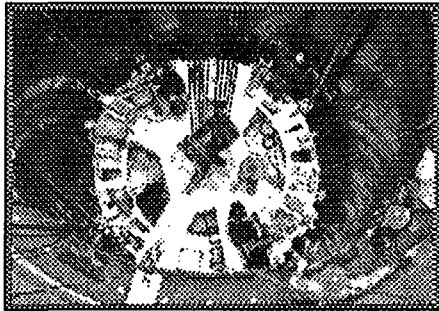


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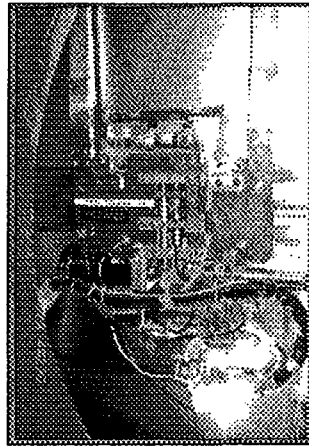
Core Shroud Replacement Method

Nepco

Pictures(1)



Fitting Up of New Core Shroud



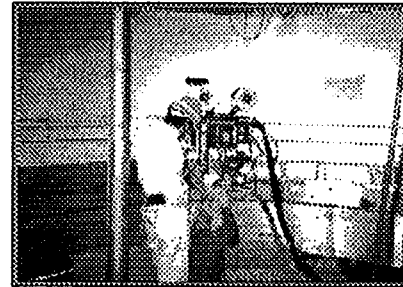
Welding on the outside

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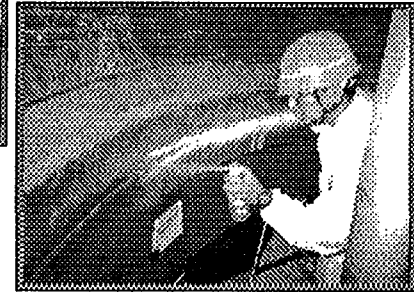
Core Shroud Replacement Method

Nepco

Pictures(2)



Welding Preparation on the inside



PT on the Inside Welding

S3

Evaluation of Procedure Reliability of the Replacement Method

- Full Size Test Vessel (BWR 800MWe class)
- Examine Remote process of the method
 - ☐ Shroud Fit-Up
 - Root Gap
 - Alignment
 - ☐ Shroud Installation Welding
 - Welding Condition, Test (VT,PT), Quality of welding
 - Alignment
 - ☐ Core Plate / Top Guide Installation
 - Alignment



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Application of the Test Results

◆ Replacement Technology for In-Core Monitor Housing

- ➔ Fukushima Dai-ichi Unit No.4 (784 MWe BWR, 14yrs old)
- ➔ The replacement started last December, finished this January.

◆ Replacement Technology for Core Shroud

- ➔ Fukushima Dai-ichi Unit No.3 (784 MWe BWR, 17yrs old)
- ➔ The replacement started last July, and finished this Spring.

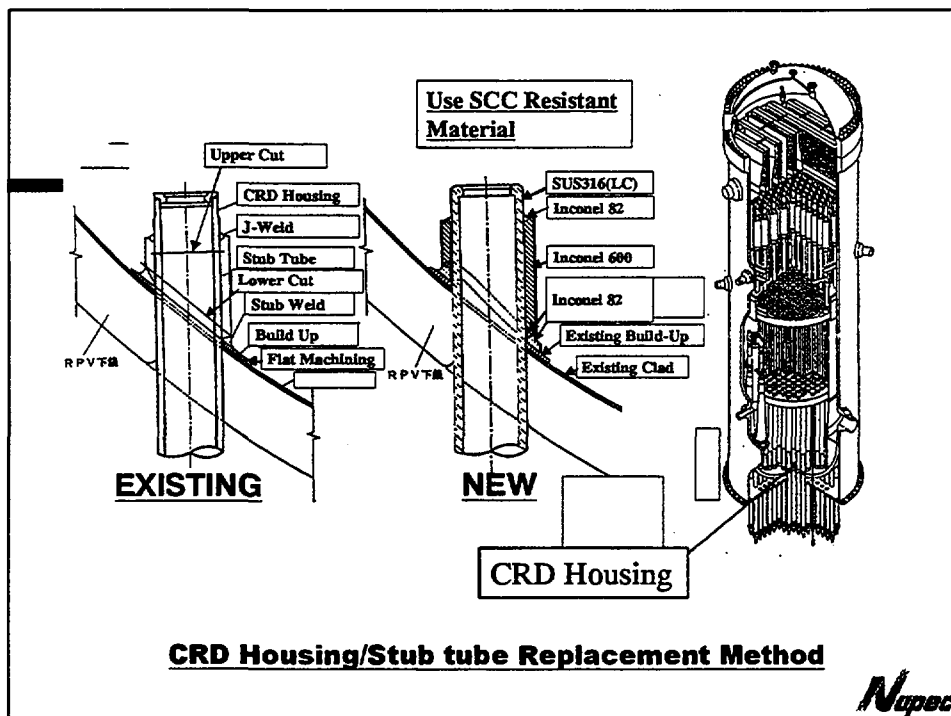


**Nupec Nuclear Power Plant Rejuvenation
Technology Reliability Test
- Executing Test -**

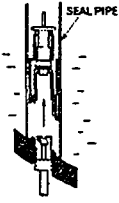
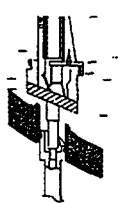
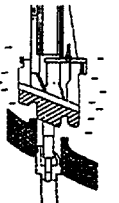
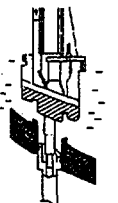
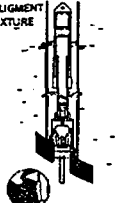
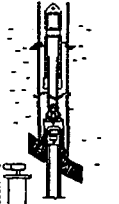
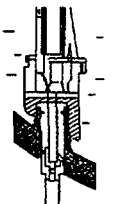
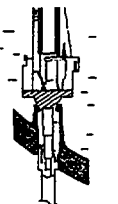
◆ CRD Housing / Stub tube

- Mockup Test will finish This year (1998)
- Mockup Test Contents
 - Buildup weld
 - Stub Tube 3D weld
 - Housing weld(J weld)
 - PT of Stub Tube section
 - (Test sequence does not include the same process as ICM Housing Replacement)

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CRD Housing/Stub tube Replacement Method

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6
					
INSTALL SEAL PIPE CUT CRD HOUSING AND STUB TUBE BY EDM	EDM MACHINE EXISTING WELD BUILDUP DRAIN RPV PT INSPECT EDM SURFACE	INSTALL WATER PROTECTION TOOL BUILDUP WELD ON EXISTING INCONEL BUTTING SURFACE	FLOOD RPV EDM MACHINE WELD BUILDUP UT INSPECT WELD BUILDUP	EDM MACHINE WELD PREPARATION PT INSPECT WELD PREPARATION OF BUILDUP	INSTALL STUB TUBE ON BUILDUP WELD PREPARATION
STEP 7	STEP 8	STEP 9	STEP 10	STEP 11	STEP 12
					
WELD STUB TUBE ON BUILDUP (S-D WELD) PT INSPECT STUB TUBE INSIDE SURFACE	EDM MACHINE STUB TUBE OUTSIDE	EDM MACHINE STUB TUBE A-WELD PREPARATION	INSPECT STUB TUBE (UT, PT)	POSITION CRD HOUSING IN BOTTOM HEAD	WELD CRD HOUSING TO STUB TUBE (A-WELD) INSPECT A-WELD (UT, PT)

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PWR Core Barrel Replacement Method

- **Background**

- Damage of Baffle Former Bolt due to IASCC
- One of the permanent solutions to the aging degradation of PWR reactor internals
- Effective for a large number of damage bolts
- NUPEC started the test plan in 1997.
- Full scale mock up test will be performed in 1999.



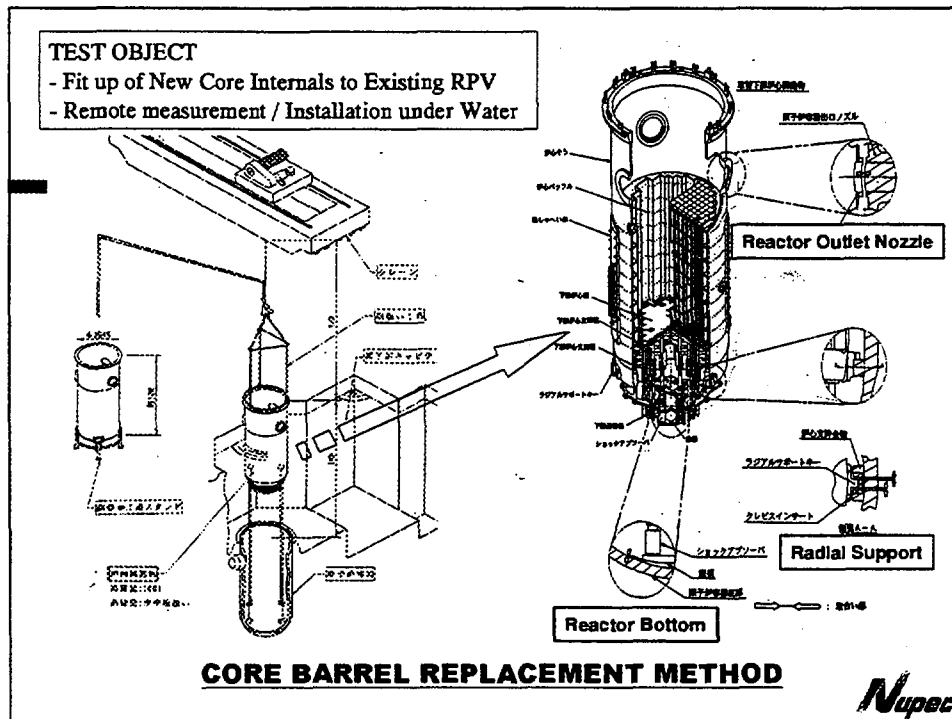
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PWR Core Barrel Replacement Method

- **Outline of the Method**

- Clearances between RPV and new CB
 - » Gaps at Outlet Nozzles
 - » Gaps at Radial Support
 - » Gap at RPV Bottom
- Instrumentation and Installation with remote control under water
- Accuracy ; 1/10 mm (CB is 10m long & 4m dia.)





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Subsequent Efforts

- Two tests are planned.
 - Bottom Mounted Instrumentation (BMI) Adapter (PWR) in 2000
 - Jet Pump Riser Brace (BWR)



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Conclusions

- ◆ Six methods to rejuvenate reactor internals have been presented.
- ◆ Two of the methods have already been applied to the actual plants.
- ◆ NUPEC activities concerned with countermeasures for the aging degradation have been successful in Japan.

