ISSF 2010: Session 6

Integrity Inspection of Dry Storage Casks and Spent Fuels at Fukushima Daiichi Nuclear Power Station

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Yumiko Kumano

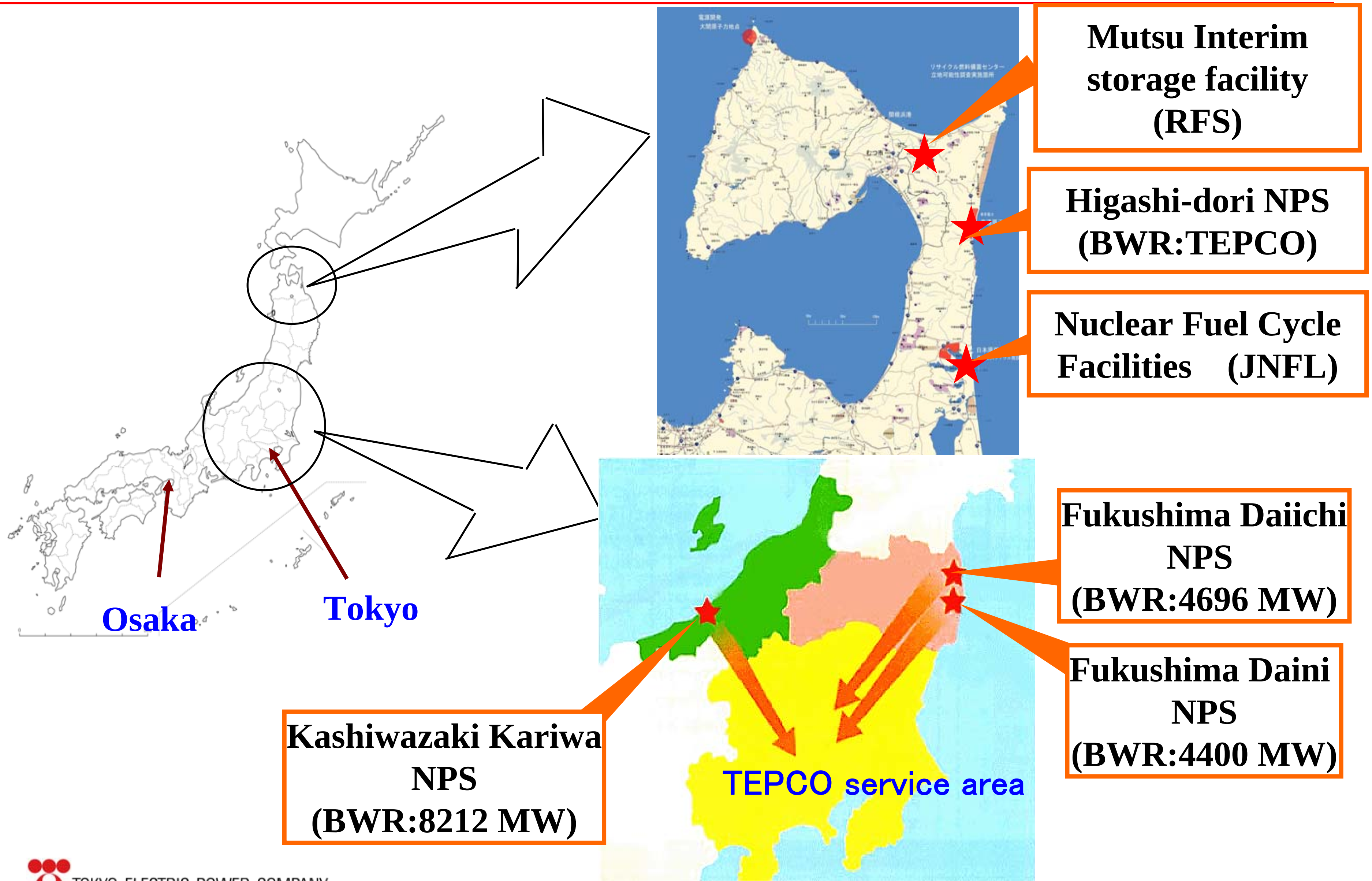
Tokyo Electric Power Company

TEPCO TOKYO ELECTRIC POWER COMPANY

Introduction

- **In Japan, currently 54 nuclear power plants are in operation.**
- **The general strategy for the management of spent fuels is "to store spent fuels safely until being reprocessed".**
- **Japanese utilities are coping with safe storage of spent fuels / operation of Rokkasho reprocessing facility.**

Site Location



Storage Status of Spent Fuel at TEPCO's NPSs

	Number of NPPs	Storage amount (ton-U) (as of Mar/2010)	Storage capacity (ton-U)	Occupancy (%)
Fukushima-Daiichi	6	1,760	2,100	84%
Fukushima-Daini	4	1,060	1,360	78%
Kashiwazaki-Kariwa	7	2,190	2,910	75%
Total	17	5,010	6,370	

Measures for increasing Storage Capacity

	Already done	Additional measures
Fukushima-Daiichi Unit 1-6	✓Increase in the capacity of spent fuel pools by re-racking ✓Installation of common spent fuel pool ✓Installation of dry cask storage facility	Installation of additional dry casks
Fukushima-Daini Unit 1-4	✓Increase in the capacity of spent fuel pools by re-racking	—
Kashiwazaki-Kariwa Unit 1-7	✓Increase in the capacity of spent fuel pools by re-racking	Increase in a fuel pool capacity * at Unit 5

TEPCO’s Decision for Further Storage

In order to increase the flexibility for coping with increasing amount of the spent fuels, TEPCO decided to construct <u>an off-site interim spent fuel storage facility.</u>

Establishment of RFS, Recyclable-Fuel Storage Company (a joint company with JAPC)

RFS will begin operation of the Japanese first off-site interim spent fuel storage facility at Mutsu in 2012.

Outline of Mutsu Facility

- **Final Storage Capacity : 5,000tU**
- **Storage Period : up to 50 years**
- **Construction Schedule :**

  First building: 3,000 tU capacity

  ⇨License for operation was permitted on 13/May/2010

  ⇨Construction began on 31/Aug./2010

  Second building: 2,000tU capacity
- **Cask Type: Dry metal dual-purpose cask**
- **Main Equipment & Devices:**

  -Equipment for carrying in, storing and carrying out fuels :

  -Metal Casks

  -Storage buildings

  -Metal cask handling equipment, etc.

  -No equipment for opening lids and surveying inside casks

Outline of Mutsu Facility (2)

Role sharing :

- **RFS**
  - **Responsible for designing/builiding/operating Mutsu storage facility for up to 50 years**
- **TEPCO,JAPC**
  - **Responsible for loading spent fuels in metal casks**
  - **Responsible for transporting casks before / after storage at RFS facility**
  - **Responsible for accumulation of data about a long-term storage of spent fuels under dry conditions**

    (Japanese authority made a demand for periodical investigations of dry casks in order to accumulate knowledge on a long-term storage in the safety assessment guideline for off-site interims storage facilities.)

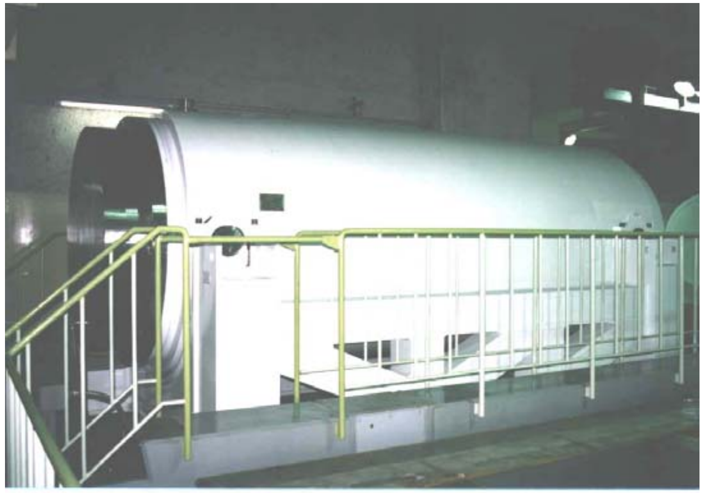
Storage Status of Spent Fuel at Fukushima-Daiichi NPS

- **Approx. 700 spent fuel assemblies are generated every year.**

  ⇨Stored in spent fuel pools / dry casks

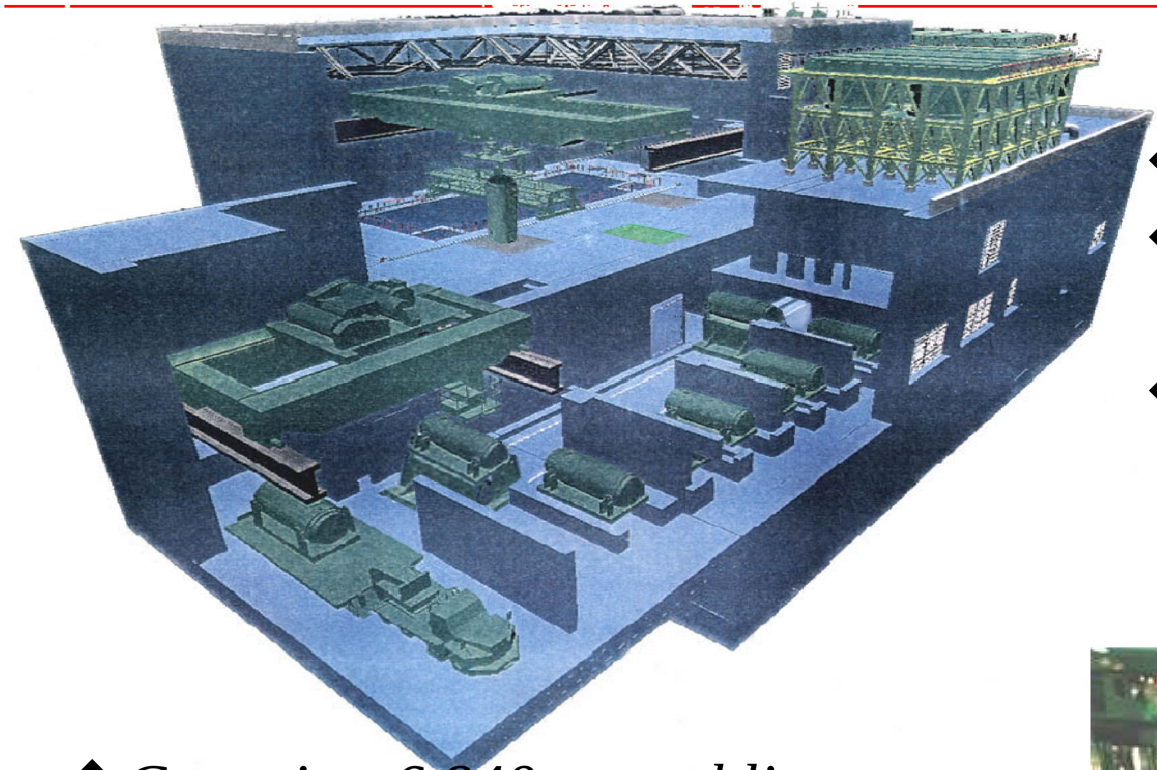
Storage Status of spent fuel (as of Mar. 2010)
(Assemblies)

Storage method	Storage Amount	Capacity (existing facilities)
Spent fuel pool at each reactor unit	3,450	8,310
Dry cask	408	408
Common pool	6,291	6,840
Total	10,149	15,558



Approx. 450% of the total core capacity of 6 plants

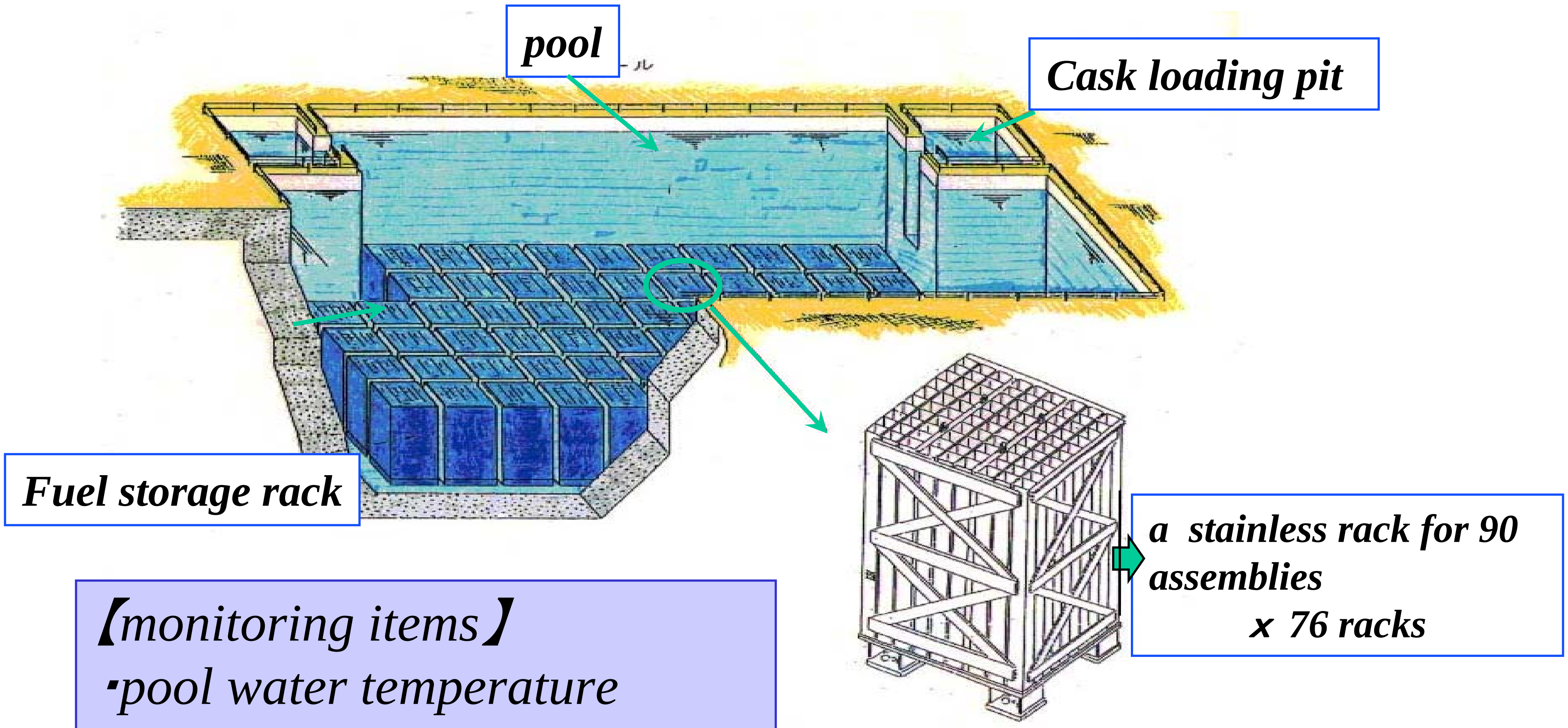
Outline of Common Spent Fuel Storage Pool (1)



◆*In operation since 1997*
◆*A large-scale pool*
12m x 29m x 11m(depth)
◆*fuels more than 19-month cooling*

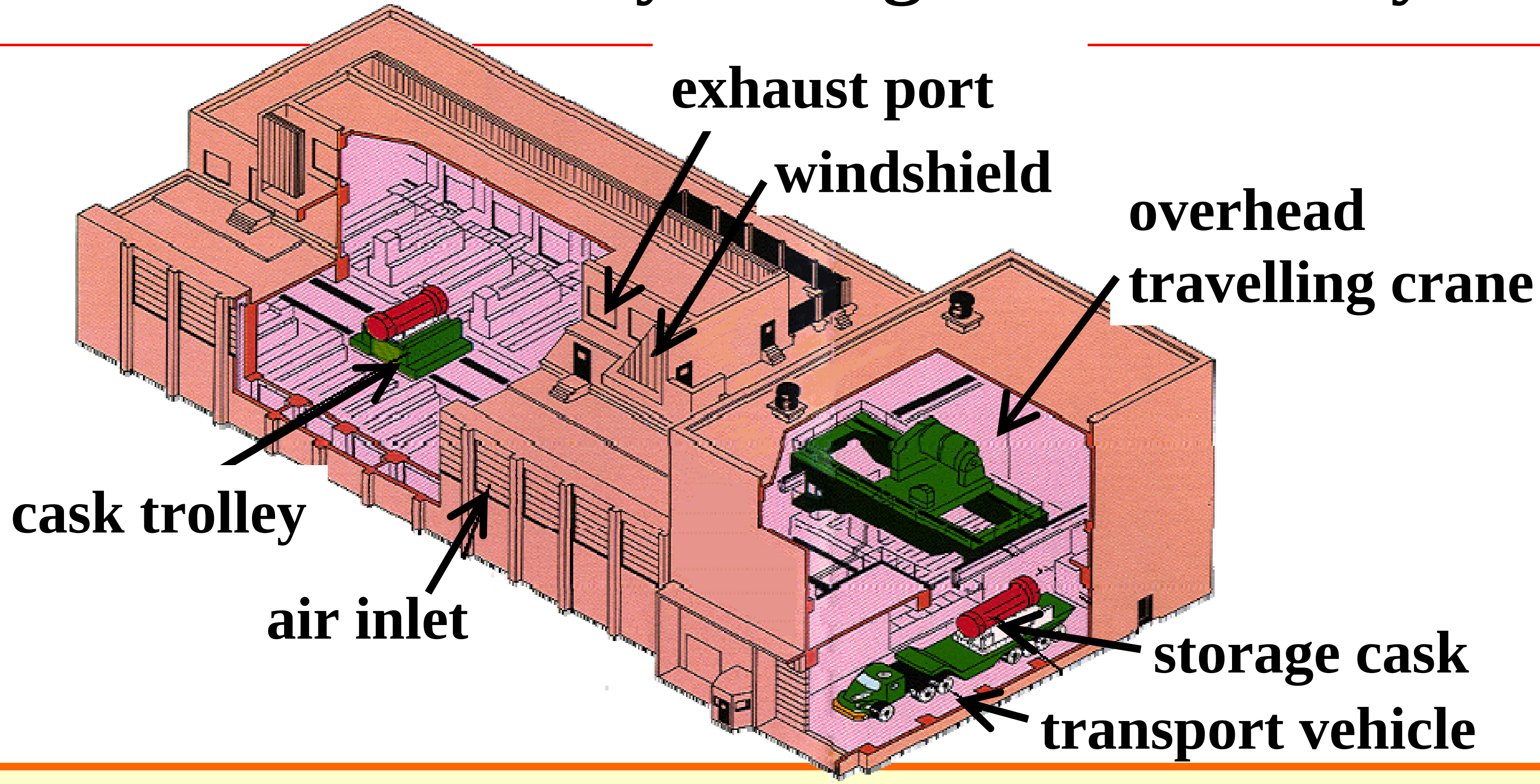
◆*Capacity: 6,840 assemblies*
⇨*corresponds to 200% of total core capacity*
◆*Storage amount: 6,291 assemblies*
⇨*corresponds to 90% of the pool capacity*

Outline of Common Spent Fuel Storage Pool (2)



【monitoring items】
- pool water temperature
- water level of the pool
- area radiation in the building
- radioactivity in the air dust

Outline of Dry Storage Cask Facility



◆*Originally designed for transport casks*

→ *Modified the license in 1994 / dry cask storage since 1995*

◆*Permission for the storage of 20 casks*

-9 dry casks are in operation,11 casks are to be installed.

◆*Efficient use of existing building→Casks are laid down in horizontal*

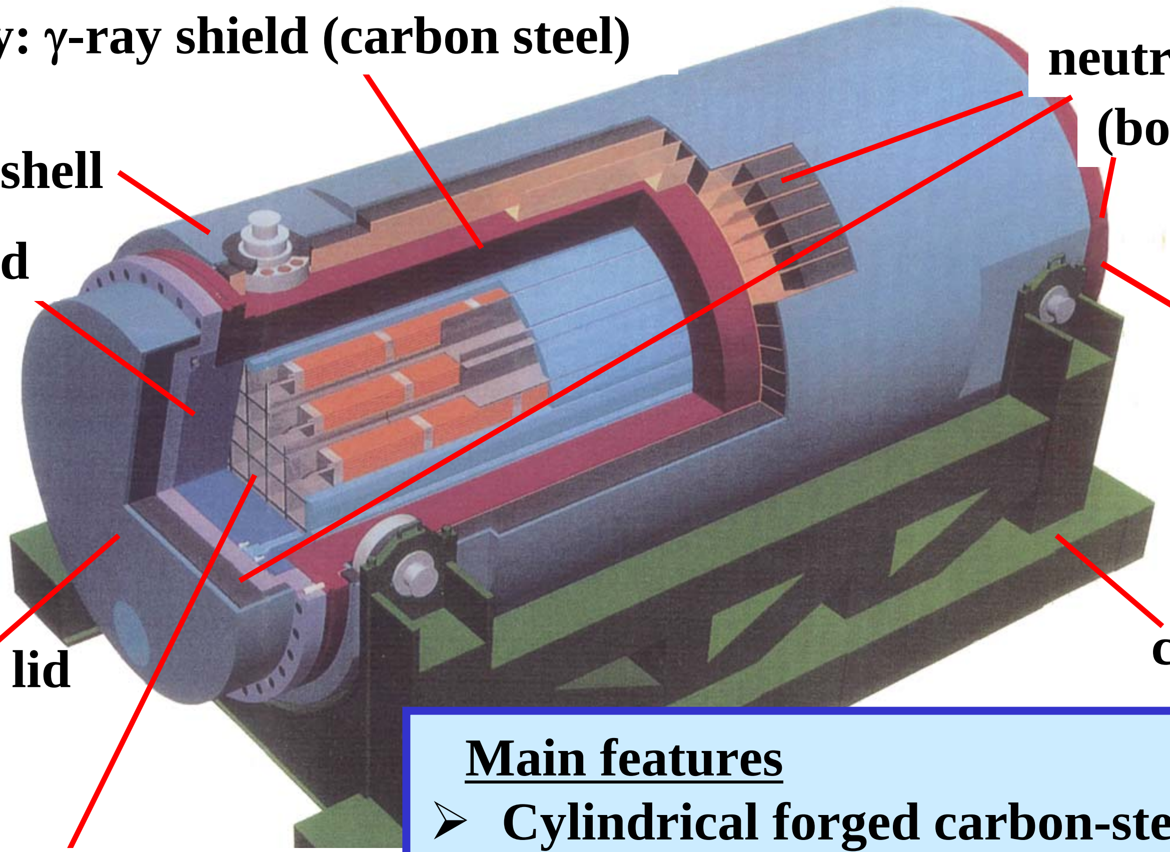
◆ *Natural-convection cooling*

Specification of Dry Casks

	Large type	Medium type	
Weight (t)	115	96	
Length (m)	5.6	5.6	
Diameter (m)	2.4	2.2	
Assemblies in a cask	52	37	
Number of casks	5	2	2
Fuel type	8 x 8	8 x 8	New 8 x 8
Cooling-off period (years)	> 7	> 7	> 5
Average burn-up (MWD/T)	<24,000	<24,000	<29,000

Additional 11casks are being prepared for installation.

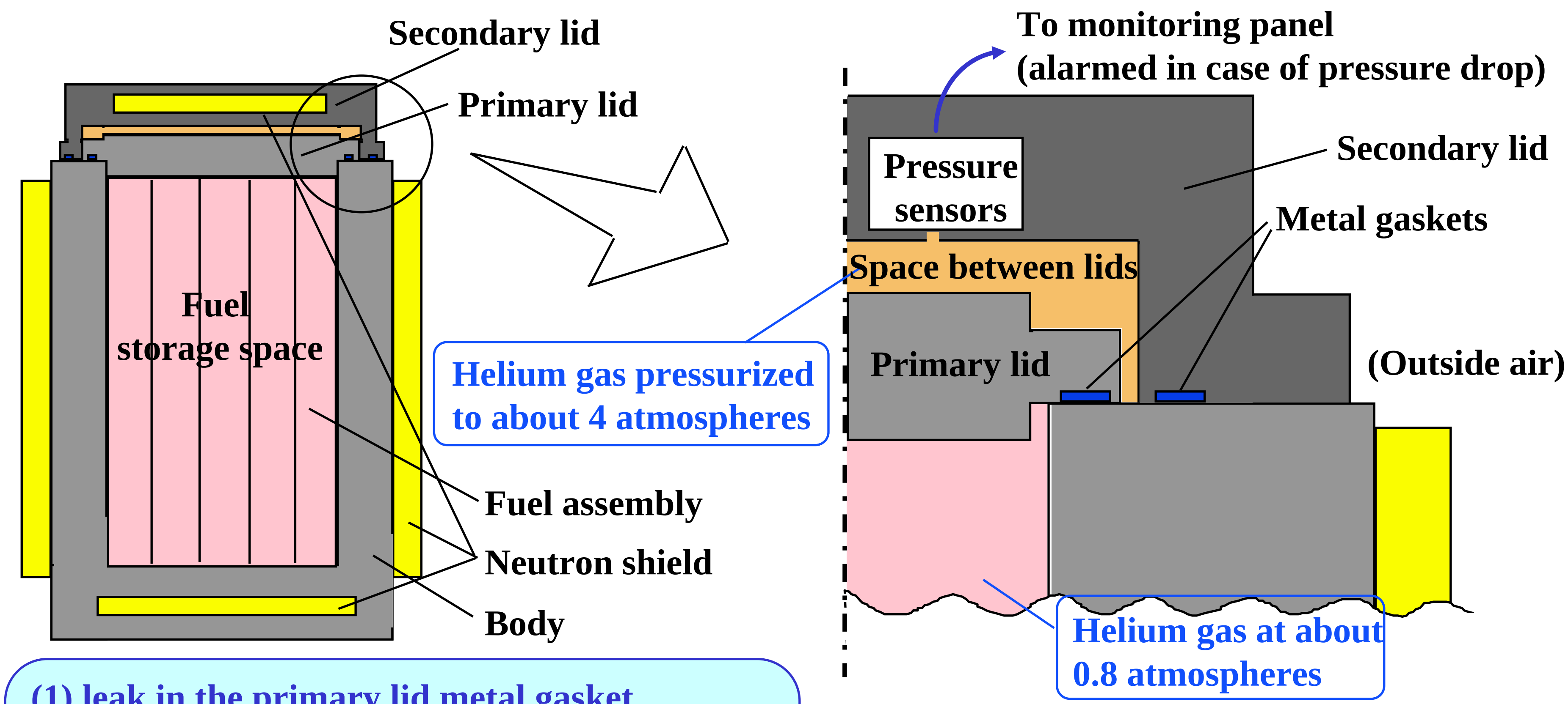
Structure of Dry Cask



<u>Main features</u>

- Cylindrical forged carbon-steel casks
- Similarity with transport casks
- Enhanced sealing/ monitoring functions
- Inner gas substituted with helium
- Steel for γ-ray shield/ resin for neutron shield
- Borated-aluminum alloy basket for sub-criticality

Design Features Concerning Containment



(1) leak in the primary lid metal gasket

Space between lids —Helium gas→ Fuel storage space

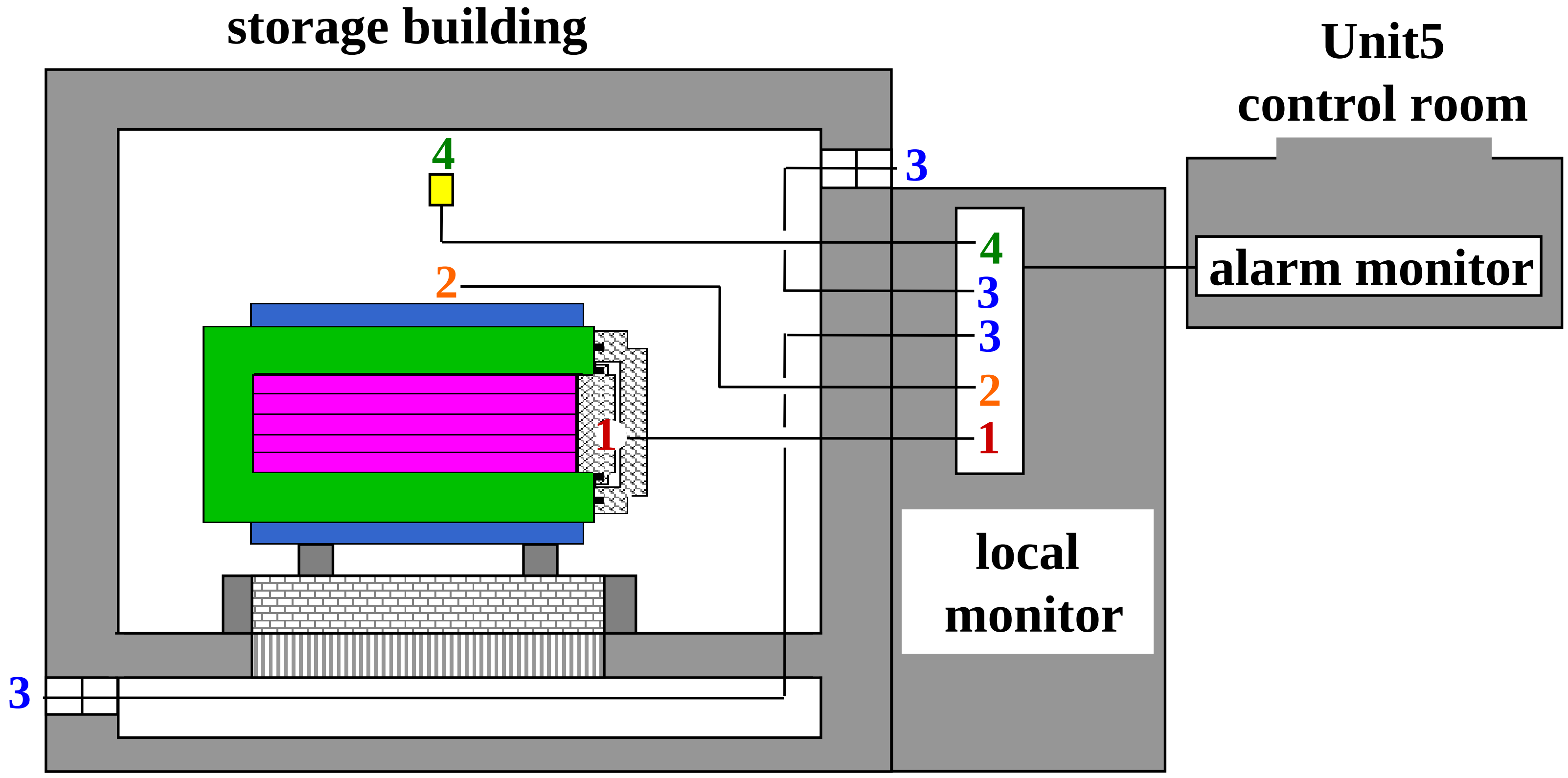
(2) leak in the secondary lid metal gasket

Space between lids —Helium gas→ Outside air

→ Alarmed in case of pressure drop

Even if a leak in a metal gasket occurs, no radioactive material inside the cask (in the spent fuel storage space) is released outside the cask.

Monitoring System at Normal Conditions



1. pressure between primary /secondary lids

2. surface temperature

3. inlet and outlet air temperature / temperature difference

4. area radiation in the building

Outline of Integrity Inspections

Time Series

- **1995:Start of operation**
- **2000:First inspection after 5-year storage**
- **2005: Second inspection after 10-year storage**

Target

- **A cask was selected as the test target which contained the maximum heat source inside the cask.**

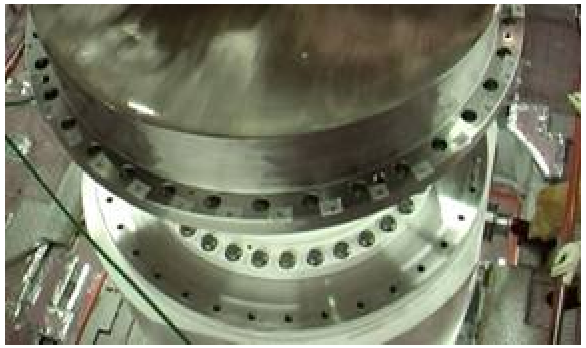
(Estimated temperature of fuel cladding:90-140 degrees C)

Inspection Items

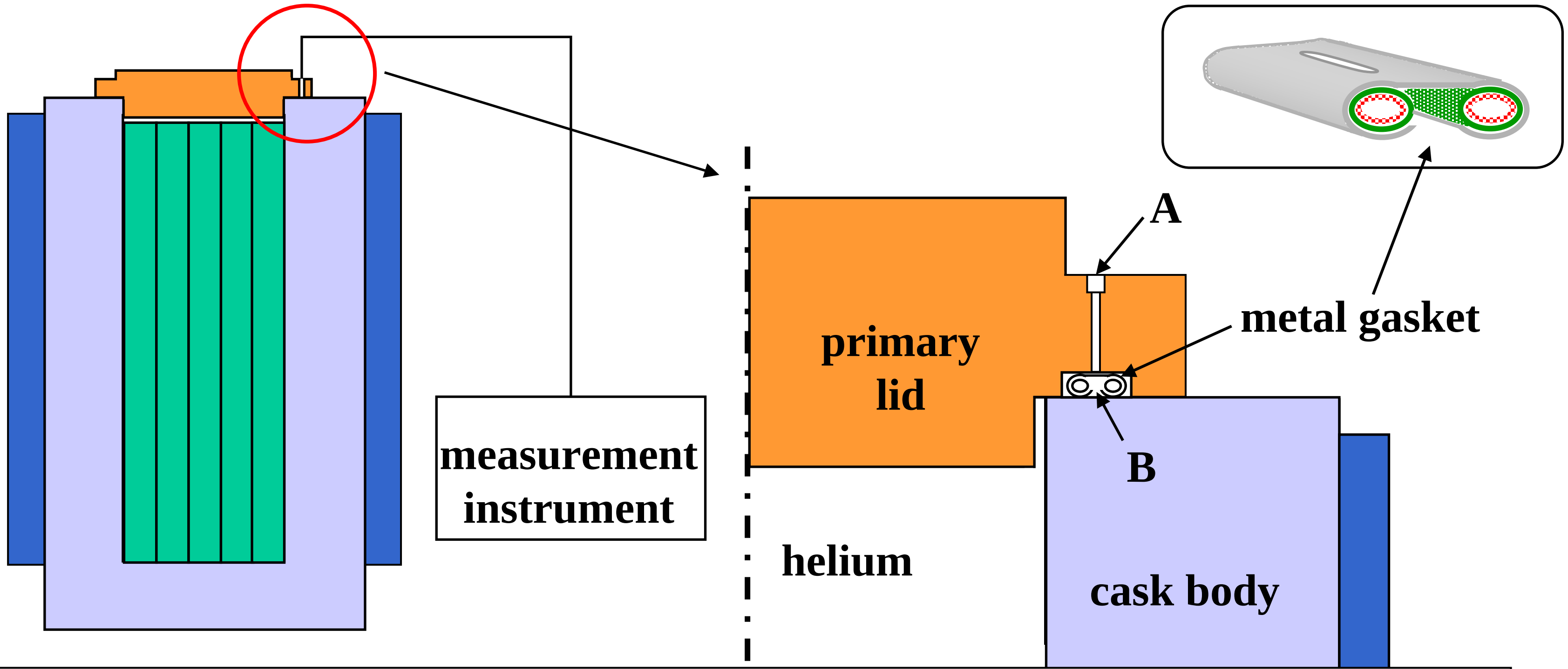
- **Gas sampling in order to detect Kr-85**
- **Visual inspection of sealing parts**
- **Leak test of the primary lid**
- **Visual inspection of fuel cladding for two bundles**

Procedure of the Inspections

1)Transportation of a cask from the cask storage building to a reactor building
2) Leak test of the secondary lid
3) Secondary lid opening / visual inspection
4) Leak test of the primary lid
5) Inner gas sampling for Kr-85 detection
6) Reflood / removal of bolts
7) Transportation into fuel pool
8) Primary lid opening / visual inspection
9) Lift up of a fuel bundle / visual inspection



Leak Test for a Primary Lid



【PROCEDURE】

1. A flexible pipe is connected to a detection hole (A).
2. The other end of the pipe is connected to the measurement instrument.
3. Helium among the doubled layer of a metal gasket (B) is vacuumed by a vacuum pump which is installed in the measurement instrument.
4. Flow rate of helium gas passing through the metal gasket is measured.
5. The measured amount is converted into leak rate.

Result of the Investigation in 2000
(1) sealing performance

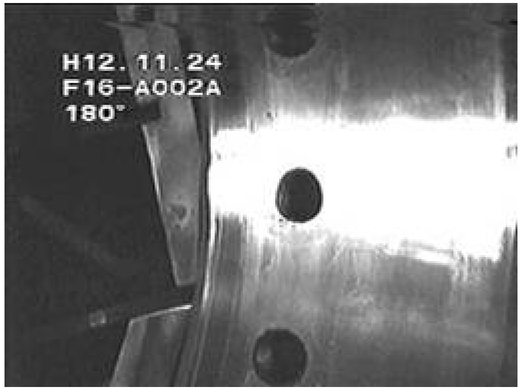
➢ **Leak test for the primary lid**

measured value: 5.3×10^{-8} Pa・m^3/s

required criteria: <1×10^{-6} Pa・m^3/s

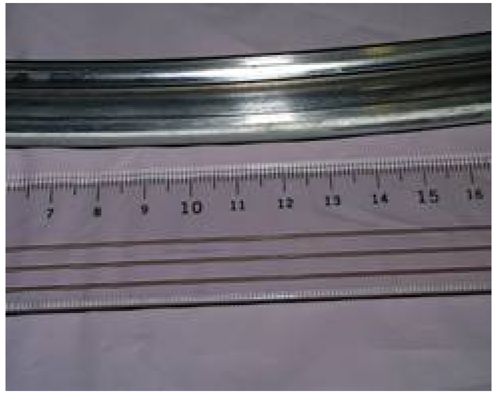
⇨No problem found in the confinement performance

➢ **Visual inspection of the primary lid**



←Flange surface of the cask

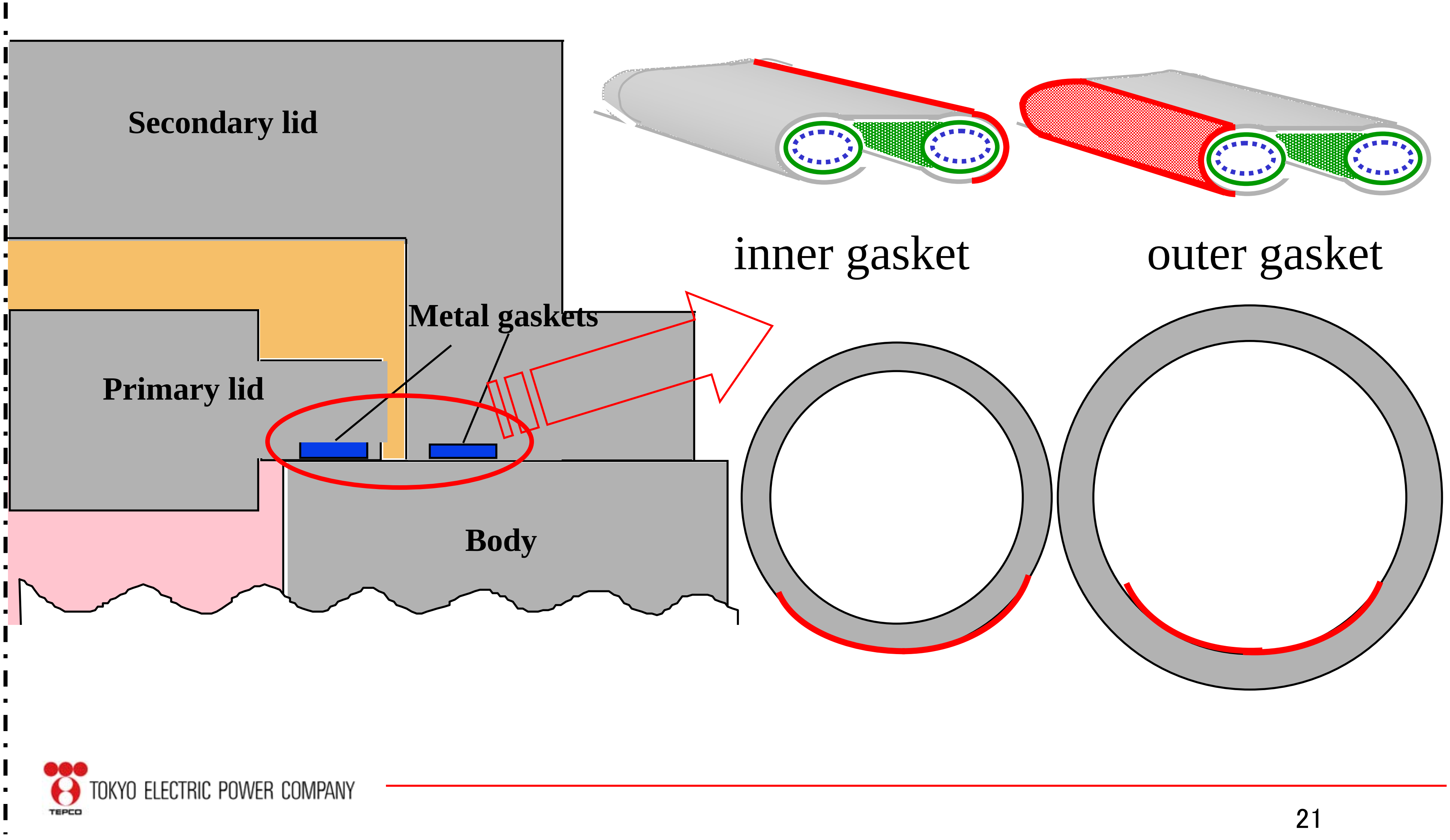
Metal gasket of the primary lid →



⇨Nothing abnormal occurred on confinement, but white coloring was observed on the gasket's surface due to residual water.

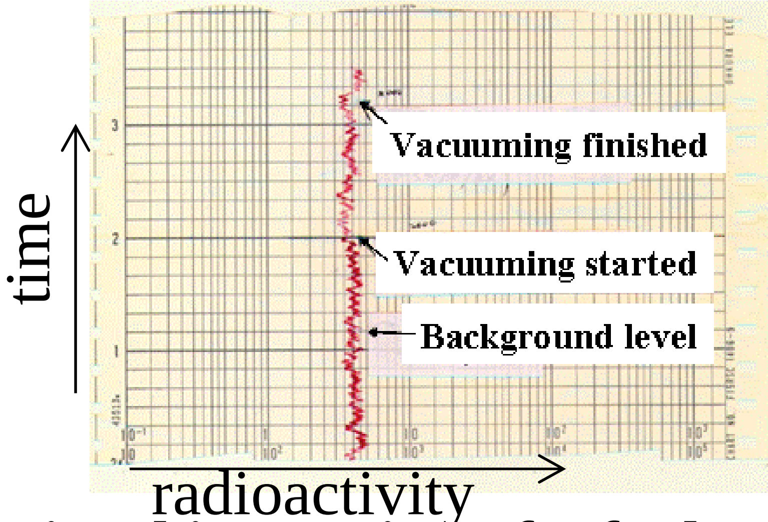
- **All metal gaskets were replaced.**
- **Procedure manual was updated so that residual water could be completely removed.**

Schematic Figure of the Whitened Region observed at the Investigation in 2000



Result of the Investigation in 2000
(2) integrity of fuel cladding

➢ Inner gas sampling for measuring Kr-85 concentration



⇨No leak of Kr-85 from the spent fuel was observed based on the measurement of radioactivity of the sampled gas.

➢ Visual inspection of a fuel assembly

17/Nov/1995

22/Nov/2000

⇨No signal of any defect was observed.

Target: New 8X8 BWR assembly (approx.32 GWd/t)

Result of the Investigation in 2005
(1) sealing performance

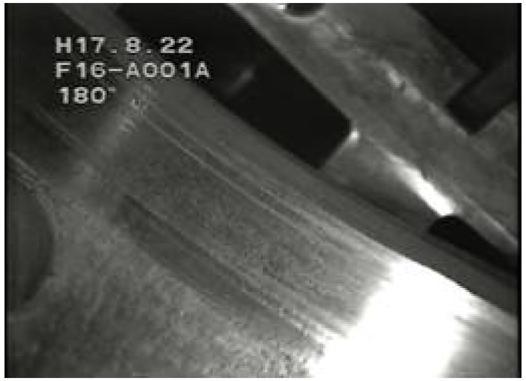
- **<u>Leak test for the primary lid after five-year use since 2001</u>**

measured value: 1.6×10^{-7} Pa･m³/s

required criteria: <1×10^{-6} Pa･m³/s

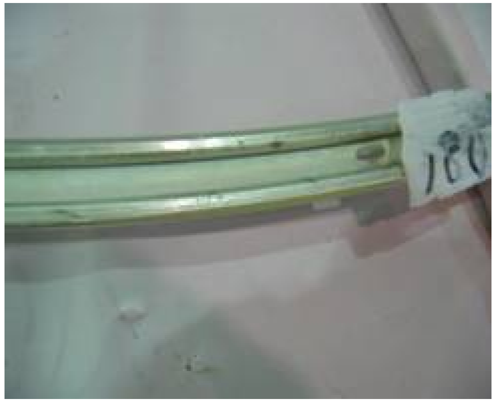
⇨No problem found in the confinement performance

- **<u>Visual inspection of the primary lid</u>**



←Flange surface of the cask

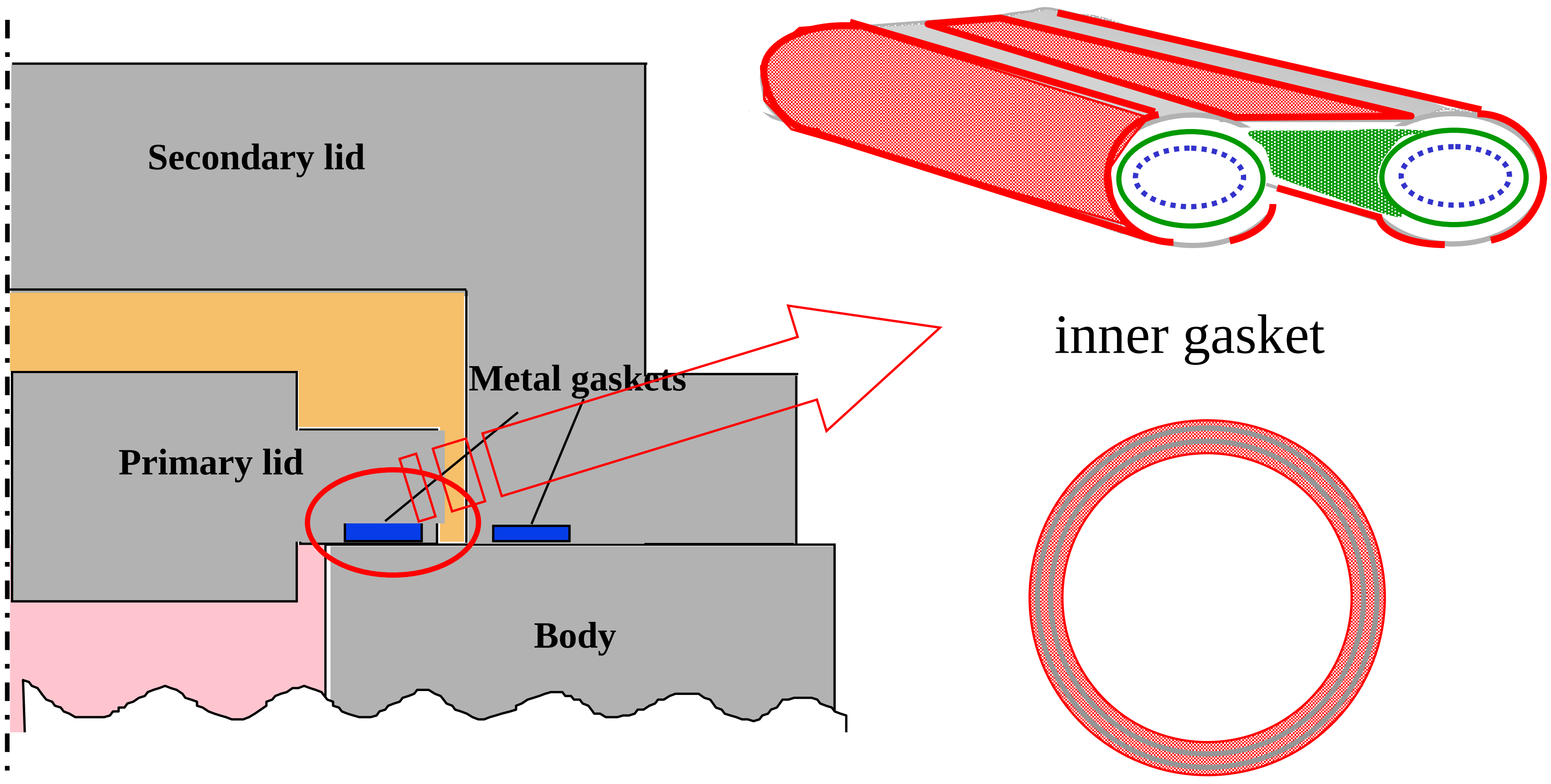
Metal gasket of the primary lid →



⇨Nothing abnormal occurred on confinement, but white color change was observed on the surface of the gasket due to immersion to reactor pool water for several days before opening the primary lid.

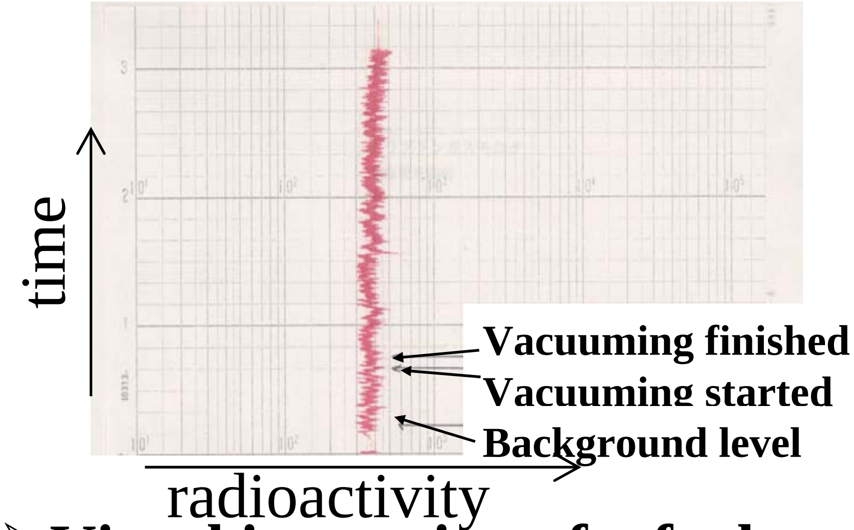
- **Procedure manual will be additionally updated in order to reduce the immersion duration.**

Schematic Figure of the Whitened Region observed at the Investigation in 2005



Result of the Investigation in 2005
(2) integrity of fuel cladding

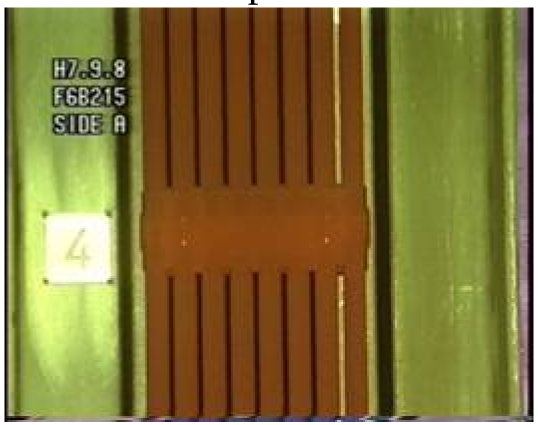
➢Inner gas sampling for measuring Kr-85 concentration



➩No leak of Kr-85 from the spent fuel was observed based on the measurement of radioactivity of the sampled gas.

➢Visual inspection of a fuel assembly

8/Sep/1995



23/Aug/2005

➩No signal of any defect was observed.

Target: 8X8 BWR assembly (approx.28 GWd/t)

Conclusions

- Integrity of storage casks and fuel bundles was carefully investigated after 5- and 10- year storage in dry condition.
- The result did not indicate any significance of defect / degradation of the system.
- Our procedure manual was updated in order to reflect the lesson learned from these investigations.
- Next investigation will be held in a few years.
- These knowledge and data will be accumulated to support future transport after storage, etc.