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ISOE INFORMATION SHEET

Experience of 1st Annual Inspection Outage in an ABWR

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Kashiwazaki-Kariwa unit No.6, the world's first advanced boiling water reactor (ABWR) of The Tokyo Electric Power Co. (TEPCO), implemented the 1st annual inspection from November 1997 to January 1998 after a stable operation of 378 days. The first inspection, which included numerous inspections and testing, was completed successfully within the short period of 61 days, in spite of the 6 days of year's end and the New Year holidays included. The entire dose equivalent during the inspection outage was 0.3 person-Sv and the volume of radioactive waste generated was approximately 50 drums ($10m^3$). Information in this paper was provided by TEPCO.

1. Features of ABWR

The ABWR key features in the aspects of operation and maintenance are as follows.

(1) Reactor Internal pump (RIP)
Eliminating the conventional external recirculation loops equipped with the recirculation pump and jet pumps, the recirculation pumps are installed directly to the reactor pressure vessel. This reactor recirculation system with internal pumps provides the following advantages.

- Reduction in radiation rate and ISI process by elimination of recirculation piping
- Reduced risk of reactor water leakage by the application of the wet motor module with no shaft seal.
- Reduced station power due to lower recirculation system power capacity

(2) Fine motion control rod drive (FMCRD) mechanism
Replacing the conventional hydraulic control rod drive mechanism, the FMCRD is equipped with motor driven system for normal operation and hydraulic control unit (HCU) in response to a scram. The FMCRD, therefore, provides the following advantages;

- Easy reactivity compensation with motor driven system capable of fine motion
- Shorter start-up period due to automatic gang operation
- Simplified hydraulic system of 2CRD/1HCU (hydraulic control unit)
- Eliminated scram discharge volumes and vessels

- Installation of split housing allows concentrating the maintenance parts to the spool piece and thereby providing a maintenance-free unit design. This reduces the exposure dose and shortens the inspection outage period.

(3) Reinforced concrete containment vessel (RCCV)
The RCCV allows a larger selection of configurations. The cylindrical containment vessel provides a compact layout with adequate working areas inside it.

(4) Totally digitalized ABWR main control panels
Provided with the state-of-the-art technologies such as digital instrumentation/control technology, optical data transmission technology, and power electronic technology, the instrumentation/control system provides the following features;

- User-friendly man/machine interface
- Compact main console for monitoring and operation
- Large display panel allows all operators to monitor important operational information.
- Extended automatic operation including control rod operation further reduces operator load.
- Improved recognition as alarms are displayed according to the level of their importance.
- Digitalization provides improved controllability, reliability, and maintainability

(5) Large capacity/high efficiency turbine system
Turbine with a 52-inch last stage blade, moisture separating reheater and heater drain pump-up system improves the thermal efficiency.

2. Outline of the first annual inspection

The major inspections of the 1st annual inspection outage are described below.

(1) Reactor related items

- RIP;	2 units (Motors replaced with spare units)
- FMCRD;	
Main body;	3 units (replaced with spare units)
Motor;	21 units (replaced with spare units)
Spool piece;	21 units (replaced with spare units)
- Neutron source removal;	5 units
- Power range neutron monitor replacement;	7 units
- Start-up range neutron monitor replacement;	1 unit
- Refueling;	180 fuel bundles
- Steam safety relief valve;	18 units
- Reactor seawater pump;	6 units

(2) Turbine related items

- Main turbine;	4 casings (1 high pressure, 3 low pressure)
- Moisture separator heaters;	2 units
- Main valves (all)	
Main stop valves;	4 units
Control valves;	4 units
Combined intercept valves;	6 sets
Turbine bypass valves;	3 units
- Generator internal inspection;	1 unit

(3) Seawater intake/channels related items

- Intake; 3 systems
- Turbine auxiliary seawater channels 3 systems
- Reactor auxiliary seawater channels 3 systems

3. Actual inspection process

Table-1 outlines the reactor and turbine related inspection processes during the 1st annual inspection of unit-6.

The reactor related critical process consists of works on the operation floor and in the lower dry well. Operation floor inspection includes the removal and installation of the RIP impeller shafts, which is specific to ABWR, and neutron source removal. Regarding the lower dry well inspection, replacement of main bodies, motor units (M/U), and spool pieces (S/P) of the FMCRD is critical. The replacement process for the motor units and spool pieces is enabled within the lower dry well. Therefore, it may be carried out along with the fuel reshuffling and loading on the operation floor. The reactor related process during this annual inspection was enabled with a time margin since the overhaul of the main turbine unit (all casing; 1 high pressure one & 3 low pressure ones) was critical (mostly 2-shift work) in the entire process.

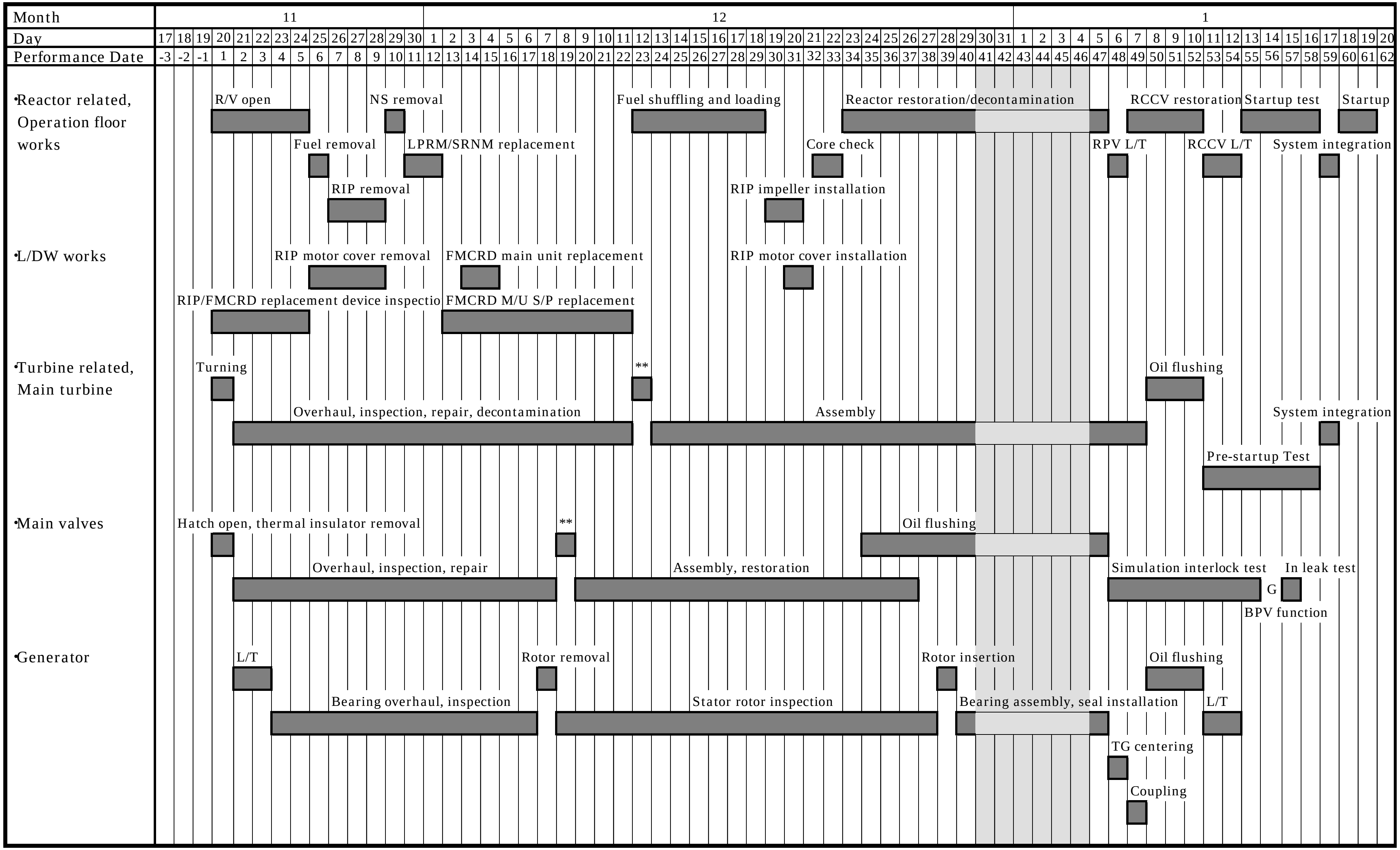
4. Exposure doses and radioactive waste volume generated

Table-2 shows the dose equivalent in each related work during the 1st annual inspection of Unit-6. The entire dose equivalent was 0.3 person-Sv, considered ordinary as the 1st inspection outage.

From an individual aspect, the dose equivalent in the CRD related process was reduced due to the installation of an FMCRD which prevented the reactor water from penetrating into the CRD housing. The dose equivalent in the internal pump related process did not reduce from that recorded in the first annual inspection of a conventional plant. Here, however, the major dose portion is the dose during the motor removal and installation processes. Since the measures to reduce this dose were studied, future reduction is expected. Also, unlike conventional PLR pumps, a long term dose equivalent increase is considered to be minimal due to the complete pump inspection, external loop valve inspection, and hardly any dose increase by ISI. Regarding the other processes, study for dose reduction shall be promoted based on the experience gained from the 1st annual inspection.

The volume of radioactive waste produced during the 1st annual inspection of Unit-6 was approximately 50 drums, being half the 100 drums suggested at its development. The recent successful plant management is reflected in this record.

Table 1. Process of the First Annual Inspection



** : Inspection by authority.

Table 2. Dose Equivalent in Each Process during 1st annual inspection outage

(Unit: person-mSv)

	Process	Unit-6	Unit-3
1	RIP (PLR)	50.22	31.63
2	Cleaning and decontamination	42.39	47.86
3	RPV	28.38	22.00
4	Inspection	27.49	7.59
5	Others	25.73	25.09
6	Valves	24.67	38.82
7	CUW	17.70	26.84
8	ISI	17.51	19.69
9	Instrumentation	13.09	28.65
10	SRV	9.16	2.64
11	RHR	8.65	16.15
12	Radiation control	7.43	8.58
13	Turbine main unit	6.44	1.03
14	CRD	5.96	15.23
	Others	15.61	27.80
Total		300.43	319.60