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Operational Experience from the Experimental Fast Reactor JOYO

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OARAI ENGINEERING CENTER

POWER REACTOR AND NUCLEAR FUEL DEVELOPMENT CORPORATION

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Operational Experience from the Experimental Fast Reactor JOYO

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要　　旨

1981年6月7日から10日までの4日間，米国フロリダ州マイアミで米国原子力学会（ANS）の年会が開催され，そこに招待論文として発表した内容をまとめたものである。

この招待論文の案内では，各国の高速炉の運転経験をループ型対タンク型を運転者の立場からみるという注文がついていた。そこで筆者らは，「常陽」の臨界以降の運転経験の中からその議論に関係するトピクスをぬき出すとともに，運転経験の成果を要約して紹介した。

本報告書では，その年会の予稿集に掲載された当論文と口頭発表に使用したスライドの写しおよびその説明をまとめて報告する。なお，上記口頭発表を一部修正したものを，同年8月28日米国ACRSメンバーとの打合せに発表したので，それも合せて記載してある。

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1. まえがき

本報告は，各国の高速炉の運転経験をループ型対タンク型を運転者の立場からみるという注文のついた ANS 年会1セッションで，「常陽」の臨界以降の運転経験の中からその議論に関係するトピクスをぬき出し，運転経験の成果の要約と合わせて発表した際の，口頭発表に用いたスライドと説明をまとめたものである。

この ANS 年会は 1981 年 6 月に行なわれたものであるが，この報告の準備のため，高速実験炉部内で多くの議論を行ない，スライド作成にも多くの人が貢献されたので，記録として本報告を出すことにした。

なお，このスライドは，その後 8 月の米国 ACRS メンバーとの打合にも一部修正して使用され，その後も機会あるごとに利用されている。

この機会に，スライドの作成に直接たずさわった方々（中野　誠，砂押　博，原　広，田村政昭，田村誠司，引地貴義，鈴木利明，向坊隆一，平尾和則の各氏）に謝意を表わしたい。

2. ＡＮＳ年会予稿

(ANS Transactions, Vol. 38 P. 608 ～ 610)

3. Operational Experience from the "JOYO" Fast Breeder Reactor, *Shoji Nomoto, Yoshihiko Nara, Tohru Fukuda, Fumio Asakura, Hiroshi Taniyama (PNC-Japan)*

INTRODUCTION

The JOYO experimental fast reactor was designed to provide construction and operating experience for liquid-sodium-cooled fast breeder reactors (LMFBRs) in Japan. Since initial criticality in April 1977, the reactor system has undergone low-power physics tests, 50-MW(th) power operation, and 75-MW(th) power operation. The main core parameters of JOYO are summarized in Table I. As of early 1981, JOYO had operated for 9250 h and generated 430 500 MWh of thermal power. The entire reactor system and plant have also been subjected to two detail inspection and maintenance programs lasting three months each. Some of the operating experiences obtained since commissioning and initial criticality are discussed in this paper.

DISCUSSION

Experience obtained during the operation of JOYO is described below for some of the reactor and plant systems. Problem areas, together with methods for their resolution, are presented.

Sodium System Preheating

Sodium system preheating is one of the most important operational functions for sodium-cooled fast reactors, not only during initial commissioning, but also during normal plant outages for inspection and maintenance. Before initial sodium fill of JOYO, the double-walled primary cooling system and the reactor vessel were preheated using only the normal nitrogen gas circulating preheating system. It took ~15 days to attain a temperature of 150°C (302°F) from ambient conditions. The heatup speed was limited by the temperature differences between the reactor vessel and the core internals. During this procedure at JOYO, neither an in-vessel forced gas circulating system nor supplementary in-vessel heating methods were applied. The use of these methods should reduce the time to reach the sodium-filling temperature in future systems.

Shielding Performance

Radiation distribution measurements at JOYO have been conducted since initial low-power tests and through the 50- and 75-MW(th) power ascension and operation test programs. No major problem with shielding performance has been experienced at JOYO.

TABLE I

Main Core Parameters of JOYO

		MK-I		MK-II
		First	Second	
Reactor Output	MW(th)	50	75	100
Primary Coolant Flow Rate	t/h	2 200	2 200	2 200
Reactor Inlet Temperature	°C	370	370	370
Reactor Outlet Temperature	°C	435	470	500
Core Stack Length	cm	60	60	55
Core Volume (max.)	ℓ	294	304	231
Linear Heat Rate (max.)	W/cm	210	320	400
Fuel Pin Diameter	mm	6.3	6.3	5.5
$PuO_2/(PuO_2+UO_2)$	wt%	18	18	30
^{235}U Enrichment	wt%	23	23	12
Neutron Flux (max.)	$n/cm^2 \cdot s$	1.9×10^{15}	3.2×10^{15}	5.1×10^{15}
Neutron Flux (Core av.)	$n/cm^2 \cdot s$	1.1×10^{15}	1.9×10^{15}	2.6×10^{15}
Max. Excess Reactivity	% ΔK/K	~4.5	~4.5	~5.5
Control Rod Worth	% ΔK/K	Safty Rod 5.6~ Regulating Rod 2.8~	Safty Rod 5.6~ Regulating Rod 2.8~	9~
Max. Burnup (pin av.)	MWd/tonne	25 000	42 000	50 000
Operation Cycle		45 Days Operation 15 Days Stoppage		

Reactor Monitoring

Neutron flux monitors, sodium flowmeters, reactor outlet temperature thermocouples, and reactor sodium-level indicators are key JOYO instrumentation for the determination of reactor power and plant system performance. In addition, two fuel failure detection systems (cover gas system and a delayed neutron monitoring system), several kinds of noise and vibration analysis systems, sodium and cover gas purification monitoring systems, and piping system displacement measurement monitoring systems are used to provide advanced warning of operating anomalies. The utilization of all of these monitoring instruments supports the safe and stable operation of the reactor.

To date there have been no problems with the safety-related instrumentation during JOYO operations. Furthermore, no indication of any fuel failure has been experienced so far with the maximum (subassembly average) fuel burnup of 26 600 MWd/tonne.

Reactor Instrumentation

Two problems noted during JOYO operation to date have been (a) low neutron count at startup after long reactor shutdown periods, and (b) the long time required to confirm criticality for control rod calibration. To reduce these operational problems, an in-core or in-vessel neutron monitoring system is strongly recommended by the plant operators for future plants.

Thermal and Hydraulics

The thermal and hydraulic behavior of the reactor heat transport system are important in the design and efficient operation of the reactor plant. Some observations on the experience obtained at JOYO in this area are discussed.

Heat transport system thermal transient tests have been conducted to determine the magnitude of the thermal shock to which the reactor vessel, piping, and components are subjected. Scram transient tests have shown that coolant temperature changes following pump trips are smaller by a factor of 2 than the design values. Natural circulation characteristics of the reactor vessel and primary coolant system have been confirmed by tests.

Heating and Ventilating Systems

The operational experience at JOYO has indicated several problem areas with respect to the containment vessel heating and ventilating (H&V) system. The pressure containment vessel of JOYO is separated into two atmospheres: one is the air atmosphere in the above-floor area of containment, and the other is nitrogen gas atmosphere in the under-floor cells. Most of the primary sodium components are installed in the under-floor cells with steel liners covering the concrete areas. During the initial stage of commissioning, there were so many leaks through the steel liners that pressurization of the under-floor space was almost impossible. Many different methods were used to detect and locate the leakage spots. These leaks were sealed, and the system is operated at a negative differential pressure relative to the above-floor air atmosphere.

Another problem with the heating and ventilating system was the flow distribution of the nitrogen cooling gas in the under-floor compartments. Due to initial placement of the nitrogen gas ducts and the component locations, the cooling performance in some cells was not good. Modifications of cooling duct locations and the installation of small fans have been made. A third (and related) problem has been the heat removal performance of the H&V system itself. The problems with the pressurization control, and the flow distribution performance in the under-floor cells have already been solved, but the final cooling performance capability of the H&V system still requires resolution. According to test results for current 75-MW(th) operation, the total heat load in the cells amounts to 95% of the design heat load of the system for 100-MW(th) operation. Resolution of this problem will be made prior to 100-MW(th) operation, scheduled to begin in 1982.

REFUELING OPERATIONS

A JOYO operating duty cycle consists of ~45 days of power operation, followed by 15 days of refueling operations. The refueling sequence consists of the following activities: (a) removal of the concrete shield pit covers—2 days, (b) preparation of the in-vessel transfer machine—1.5 days, (c) in-vessel transfer from storage pot to transport pot—1 day, (d) fuel transport by ex-vessel handling machine—6 days, (e) in-vessel refueling between core and in-vessel storage rack—1.5 days, and (f) reseating of the concrete shield pit covers—2 days. The average number of fuel assemblies handled per cycle is between 3 and 6. The maximum handling capability is 15 assemblies per one sequence because of limitations of in-vessel sodium storage locations.

The JOYO refueling system consists of many single-function machines, and these machines have to be operated sequentially according to the flow of a subassembly into or out of the reactor. JOYO does not have an interim, ex-vessel sodium storage tank for new or spent fuel. Based on past JOYO experience, ex-vessel spent fuel storage in sodium (in- or ex-containment) is recommended to increase the efficiency of refueling operations.

Plant Maintenance

To satisfy licensing requirements and to gain experience, JOYO has undergone two major inspection and maintenance programs. During these periods, the in-containment under-floor atmosphere is changed from air to nitrogen (and vice versa) in 6 h. Oxygen meters and closed-circuit industrial television monitors are used to assure safe working conditions in the cells during the maintenance operations.

CONCLUSION

This paper has summarized some of the experience obtained during 4 yr of JOYO operation. Some problem areas, and the modifications required to the various systems, that were discovered in the course of the long testing, operation, and maintenance programs for JOYO were described. During this period, several research and development studies were also conducted at the Oarai Engineering Center to confirm the proper functioning of the JOYO plant systems.

Currently, the advanced MONJU prototype fast breeder power station is in the process of licensing and construction in the Tsuruga area of Japan. The MONJU is also a loop-type LMFBR and will generate 280 MW(e) of electrical power. Our experiences at JOYO are expected to feed back valuable information for the effective design and ultimate operation of this power station.

1. H. SAKATA, "Construction and Function Tests of Experimental Fast Reactor 'JOYO'," *J. At. Energy Soc. Jpn.*, **19**, 10 (1979).

2. S. NOMOTO et al., "Physics Measurements at the Startup of JOYO," IAEA-SM-244/8, International Atomic Energy Agency, Vienna (1980).

3. H. YAMAMOTO, "Reactor Physics Characteristics from Operational Testing of the JOYO Experimental Fast Reactor," ANS Topl. Mtg., Phoenix, Ariz. (1980).

3. ANS年会への口頭発表のスライドと説明

（1981．6．8発表）

OPERATIONAL EXPERIENCE FROM THE EXPERIMENTAL FAST REACTOR JOYO

PNC-TN941 82-217

POWER REACTOR AND NUCLEAR FUEL DEVELOPMENT CORPORATION

PNC N943 81-01

OPERATIONAL EXPERIENCE FROM THE EXPERMENTAL FAST REACTOR "JOYO"

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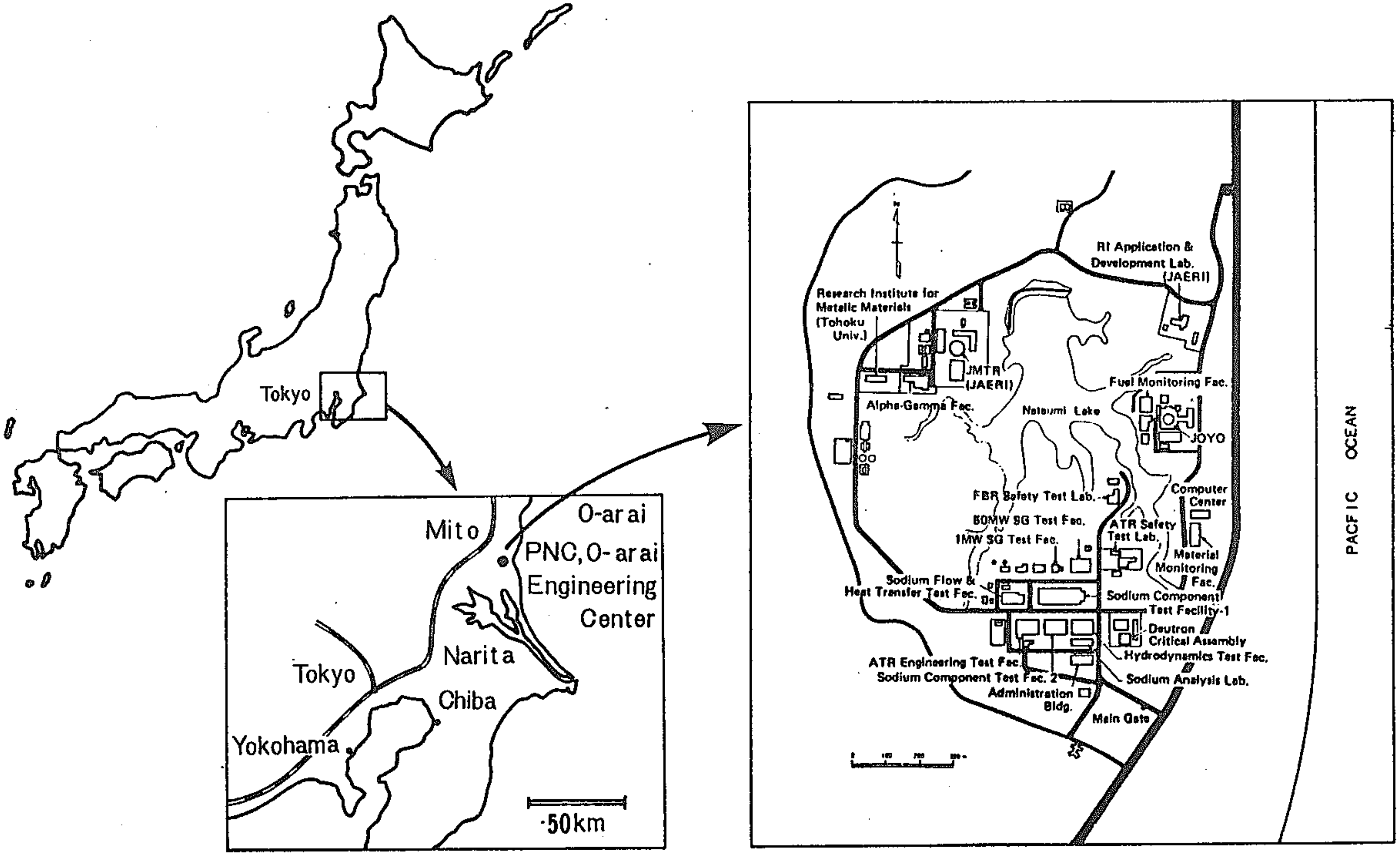

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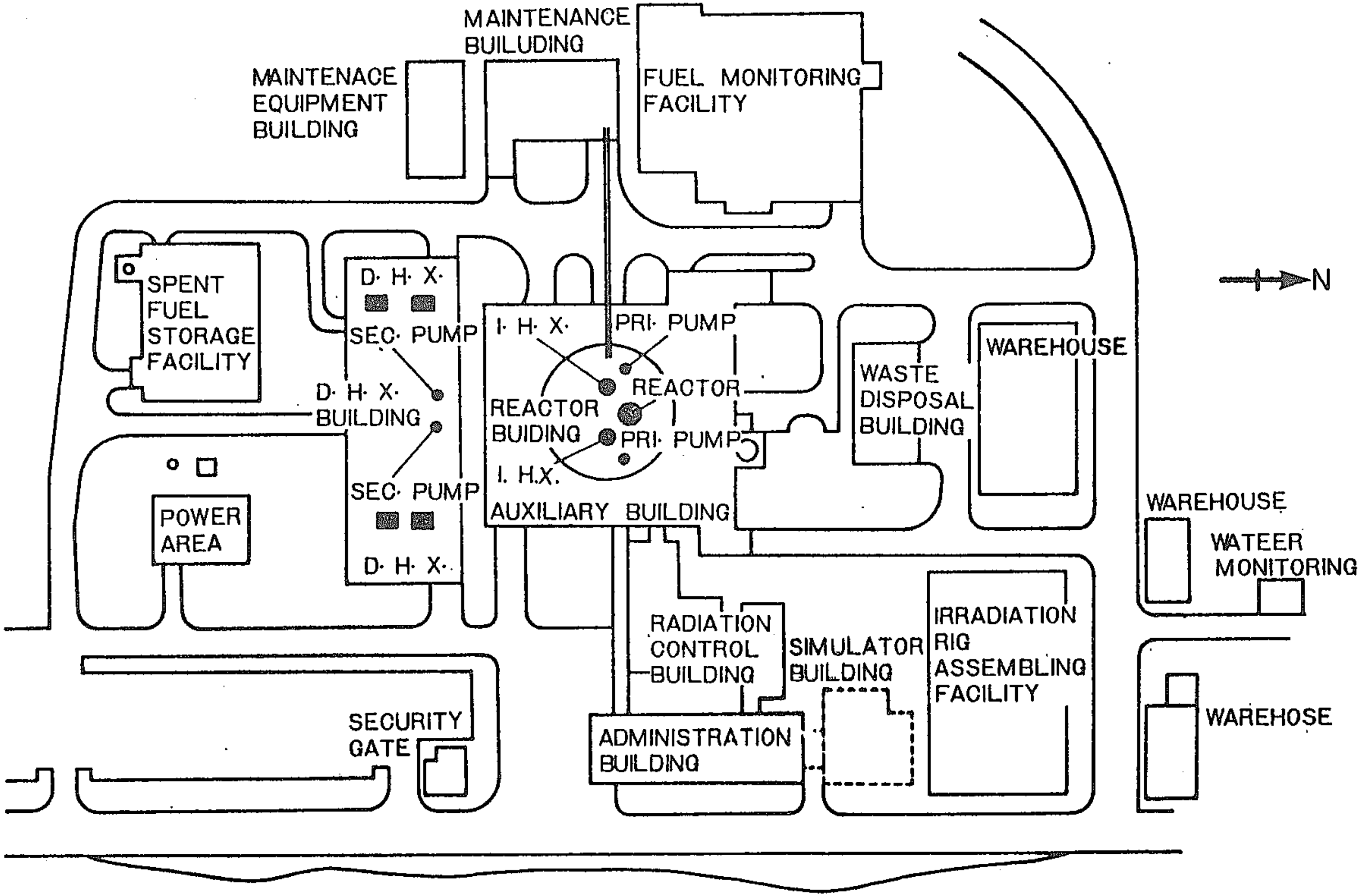

JOYO COMPLEX

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PROJECT OBJECTIVES OF EXPERIMENTAL FAST REACTOR JOYO

1. ACQUIRE TECHNOLOGICAL EXPERIENCE NECESSARY TO CONSTRUCT A PROTOTYPE LMFBR

2. PROVIDE AN IRRADIATION FACILITY FOR FUELS AND MATERIALS TESTING

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CONSTRUCTION AND MANUFACTURING MAIN PARTICIPANTS FOR JOYO

● PROJECT CONTOOL	PNC
● LEADING COMPANY	TOSHIBA
● FUEL	PNC
● CORE COMPONENT, CRD, CONTAINMENT AND OTHERS	TOSHIBA
● RV, PHTS AND OTHERS	HITACHI
● ROTATING PLUGS, SHTS AND OTHERS	MITSUBISHI
● FUEL HANDLING SYSTEM AND OTHERS	FUJI
● ARCHITECT	TAKENAKA

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MAIN PLANT PARAMETERS OF JOYO

● REACTOR TYPE	PU·U MIXED OXIDE FUELED SODIUM COOLED EXPERIMENTAL FAST REACTOR, LOOP TYPE (2 LOOPS)
● FUEL HANDLING SYSTEM	DOUBLE ROTATING PLUG, STRAIGHT MOVEMENT FHM, CASK CAR EVTM
● CORE	SINGLE ZONE HOMOGENEOUS
● HEAT REJECTION	AIR COOLER (4)
● PLANT CONTROL	MANUAL
● COOLANT FLOW CONTROL	CONSTANT FLOW
● REACTOR POWER	100 MWt RATED (75MWt WITH MK-I CORE)
● PHTS TEMPERATURE	REACTOR INLET/OUTLET 370°C/500°C AT RATED POWER
● SODIUM INVENTORY	PRIMARY 120t, SECONDARY 70t
● ASEISMIC DESIGN	150 GAL AT BASE (SCRAM LEVEL 150GAL AT OPERATION FLOOR)

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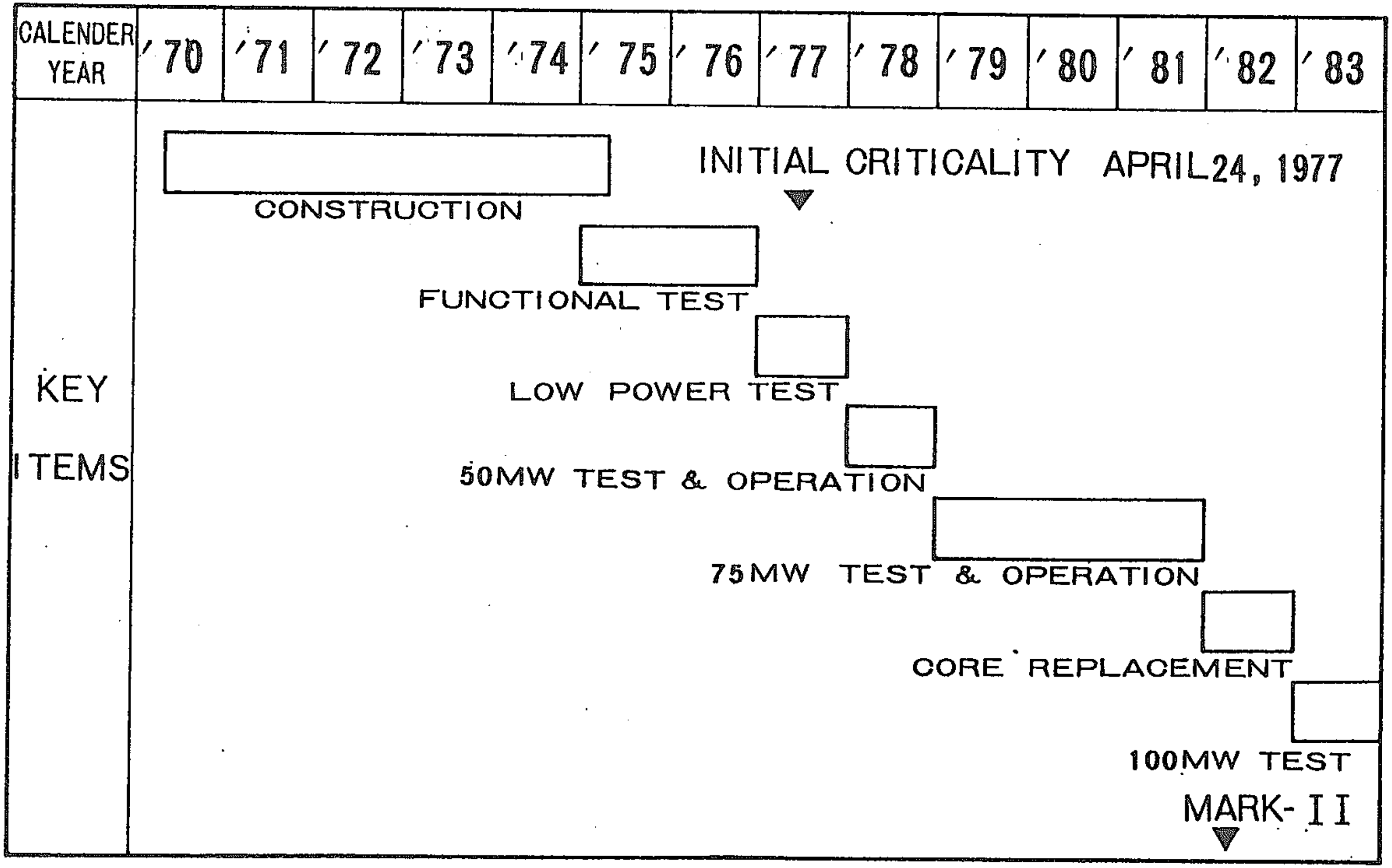

MASTER SCHEDULE OF JOYO

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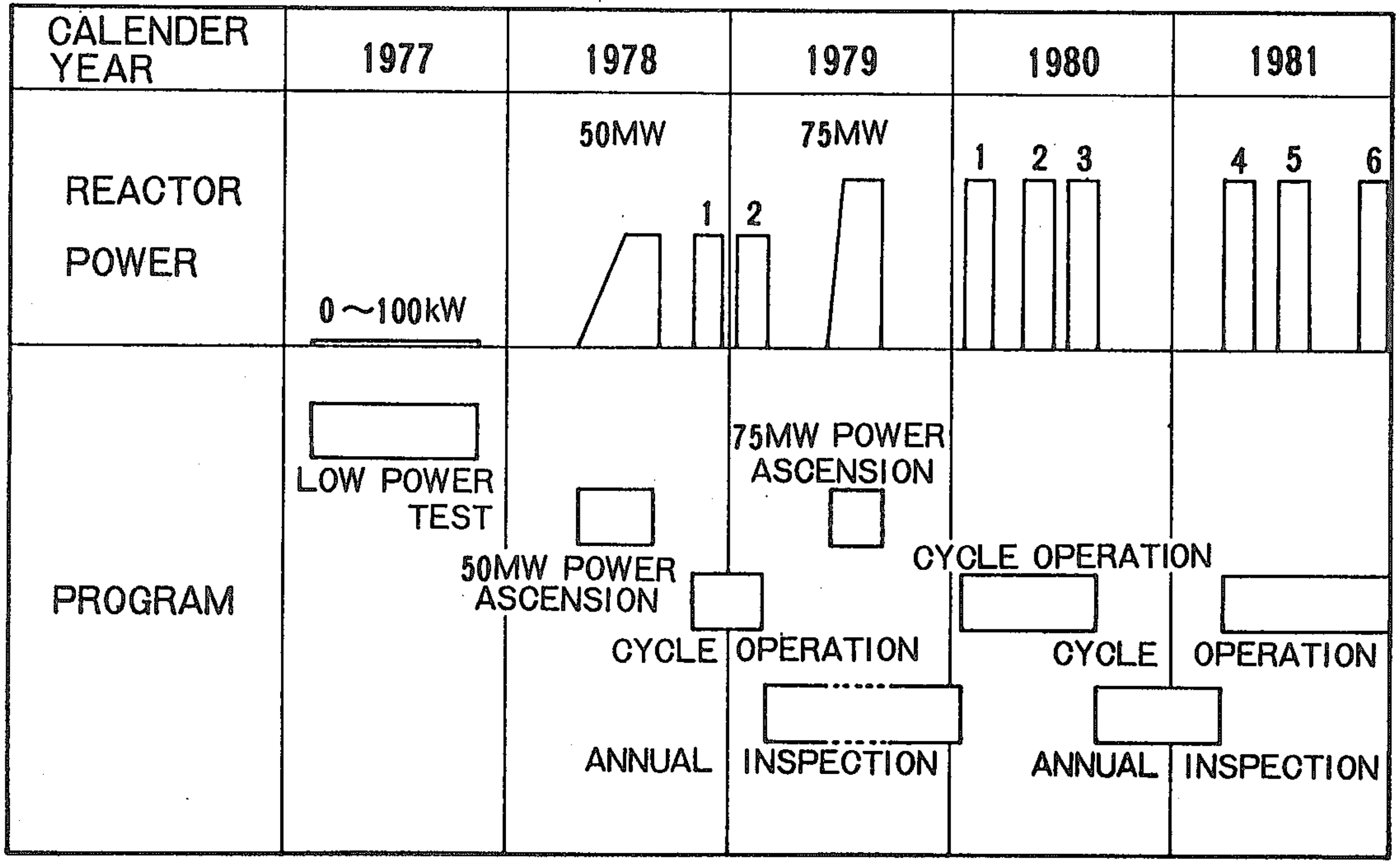

OPERATION HISTORY OF JOYO MARK-1 CORE

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MAIN RESULTS CONFIRMED THROUGH OPERATION

● CORE PHYSICS	AGREED WITH DESIGN WITHIN 10%
● CORE THERMAL-HYDRAULICS	AGREED WITH DESIGN WITHIN 5%
● REACTOR SHIELDING	ADEQUATE WITH DESIGN MARGIN
● PLANT PARAMETERS	AGREED WITH DESIGN WITHIN 5%
● PLANT DYNAMICS	STABLE WITH SUFFICIENT NEGATIVE FEEDBACK
● DESIGN FEATURES	SATISFACTORY
● OPERABILITY	SIMPLE AND RELIABLE
● MAINTAINABILITY	SATISFACTORY
● SODIUM/COVER GAS PURITY CONTOROL	SATISFACTORY
● CP ACCUMULATION	ACCEPTABLE (3 ~ 5 mrem/h ON ENTIRE PHTS)
● OCCUPATIONAL RADIATION EXPOSURE	13man·rem (0.7 man·rem/GWd)
● EARTHQUAKE EXPERIENCE	33 gal (MIYAGI-OKI EARTHQUAKE)

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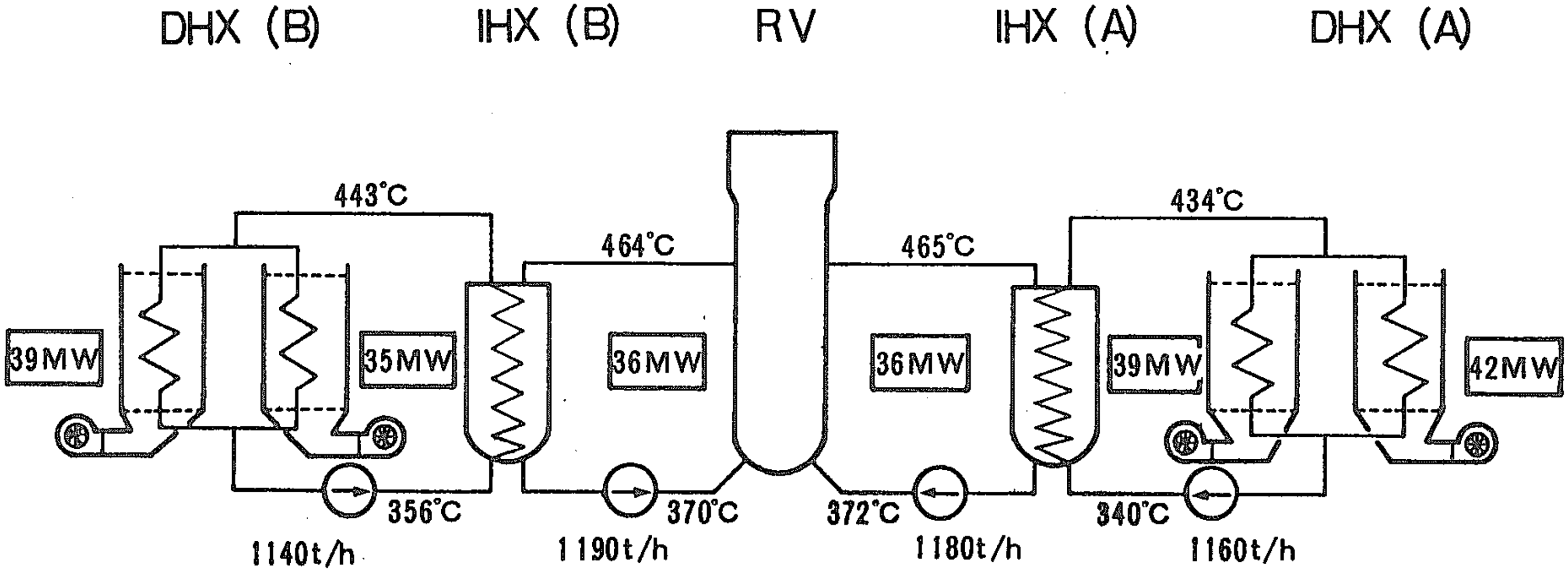

HEAT BALNCE OF JOYO (JULY 16,1979)

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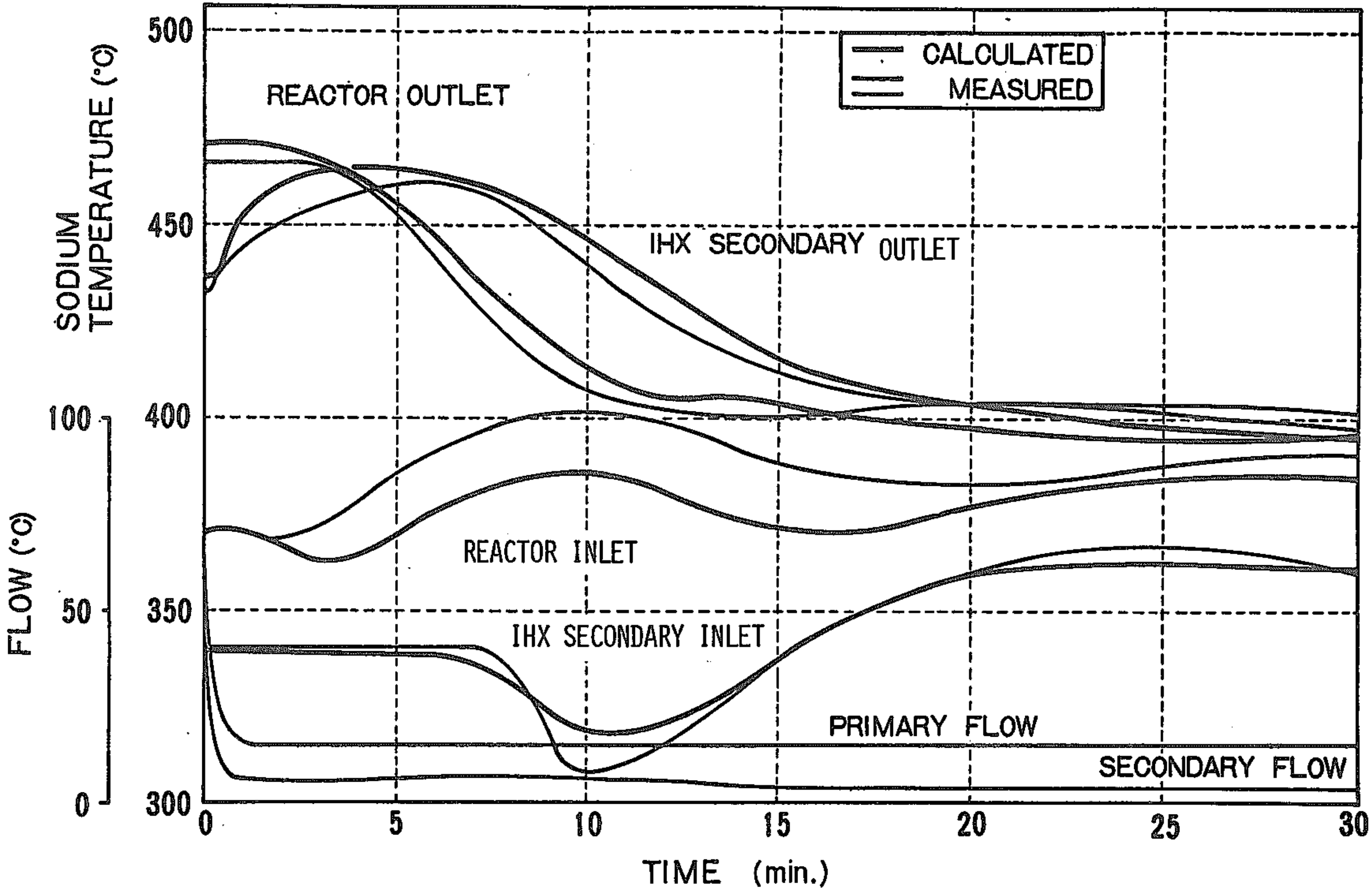

THERMAL TRANSIENT RESPONSE AFTER LOP FROM 75MW (A LOOP)

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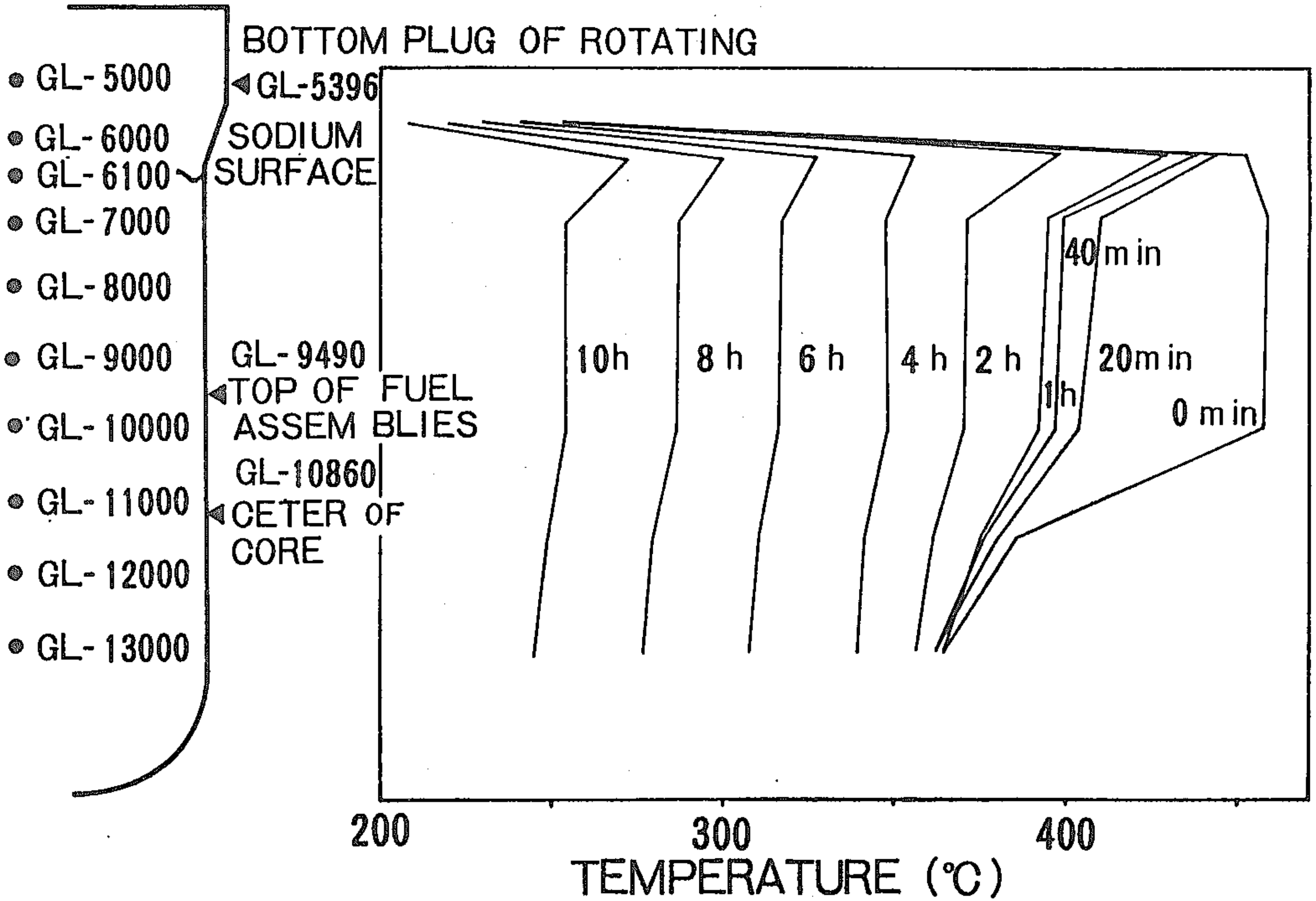

RV WALL TEMPERATURE CHANGES WITH TIME AFTER LOP FROM 75MW (AUGUST 13,1979)

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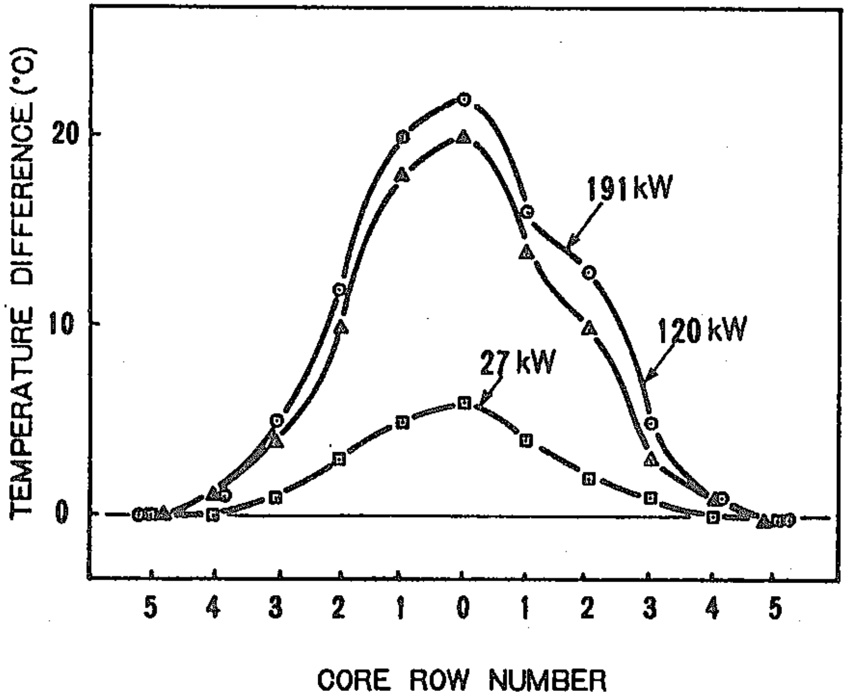
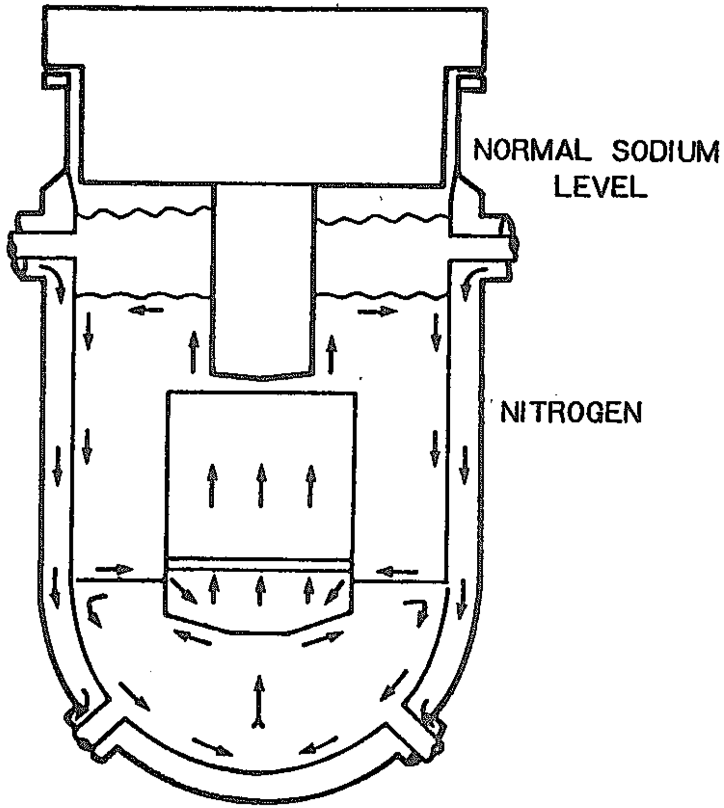


FUEL OUTLET SODIUM TEMPERATURE PROFILE AT STEADY STATE IN-VESSEL NATURAL CIRCULATION



NATURAL CIRCULATION PATH IN REACTOR VESSEL

IN-VESSEL NATURAL CIRCULATION TEST
(SEPTEMBER 13～16, 1978)

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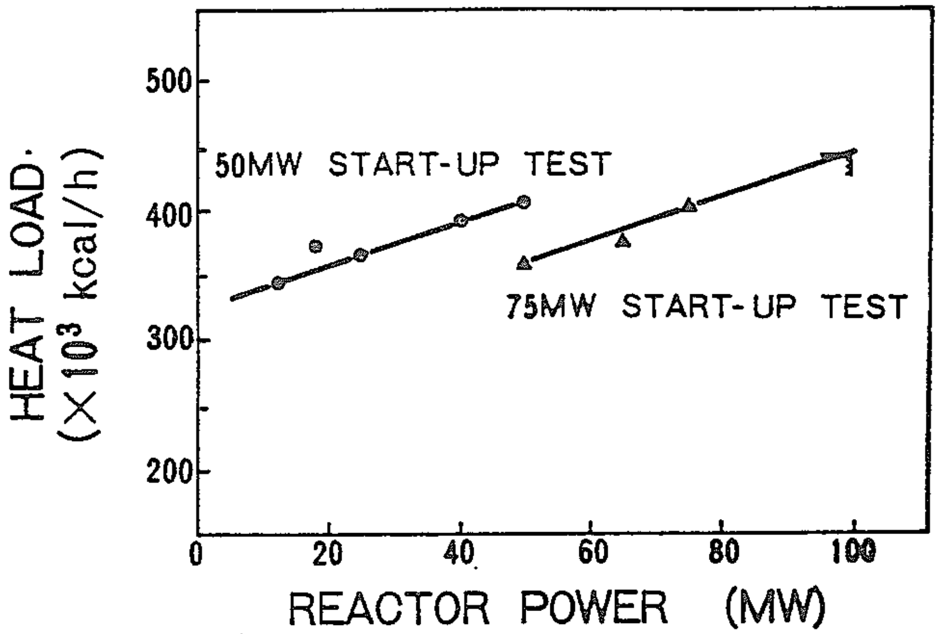

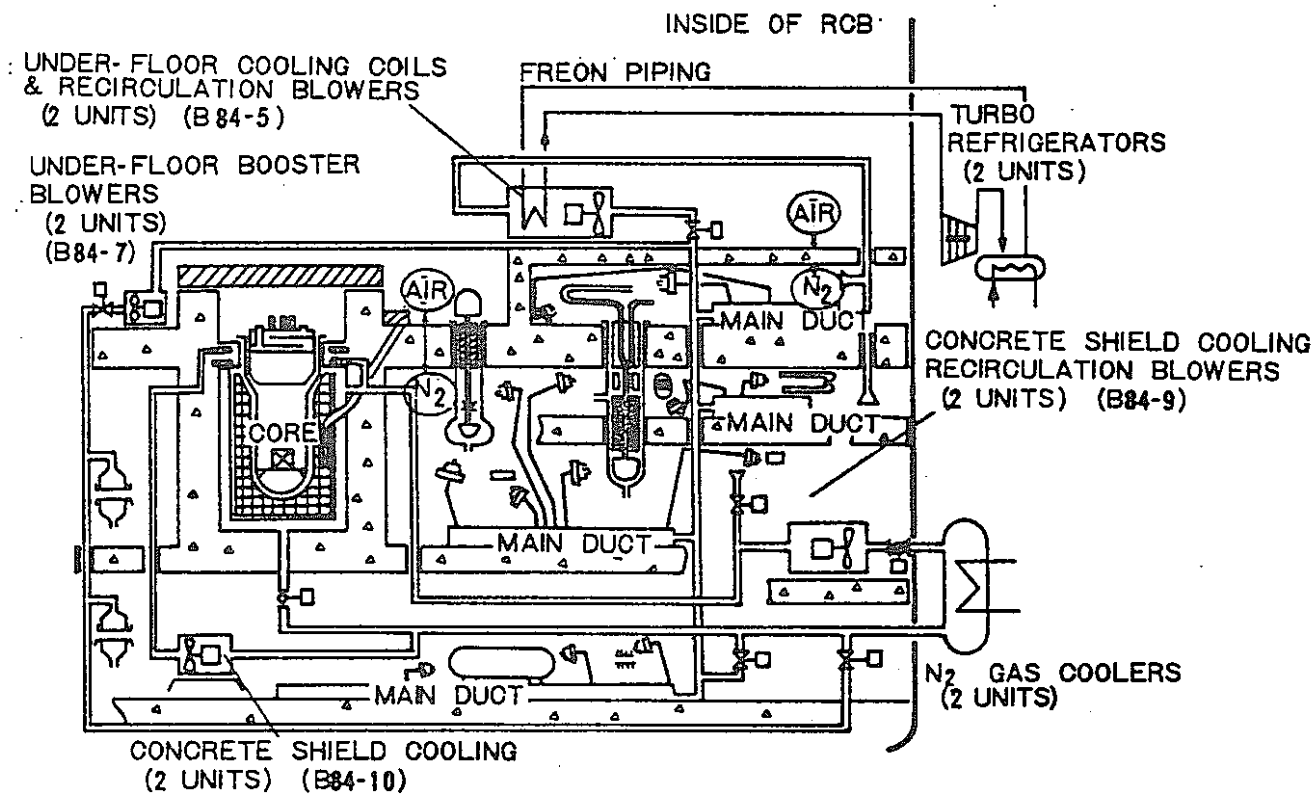

HEAT LOAD IN UNDER-FLOOR AREA OF JOYO

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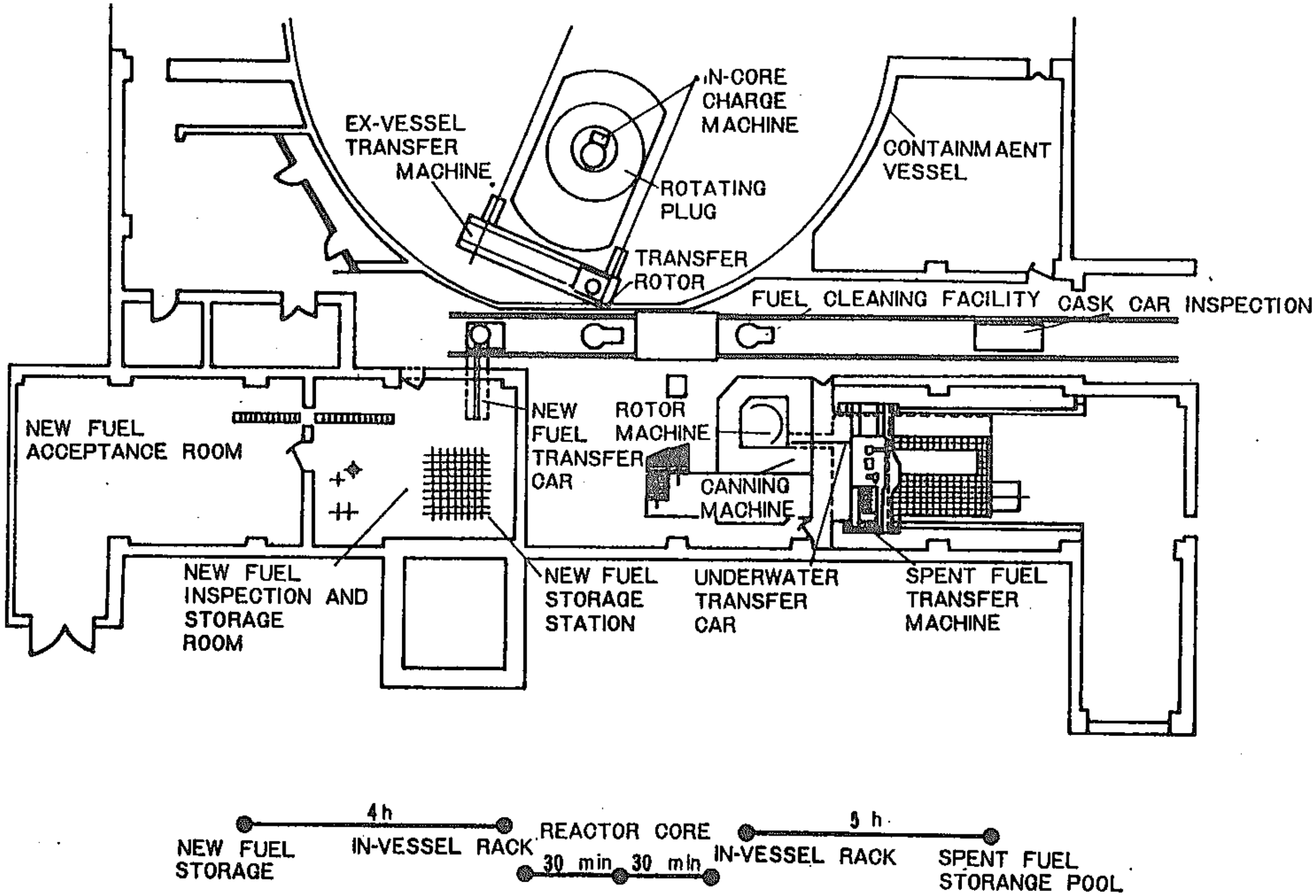

FUEL HANDLING SYSTEM AND TIME DURATION FOR FUEL HANDLING WORK

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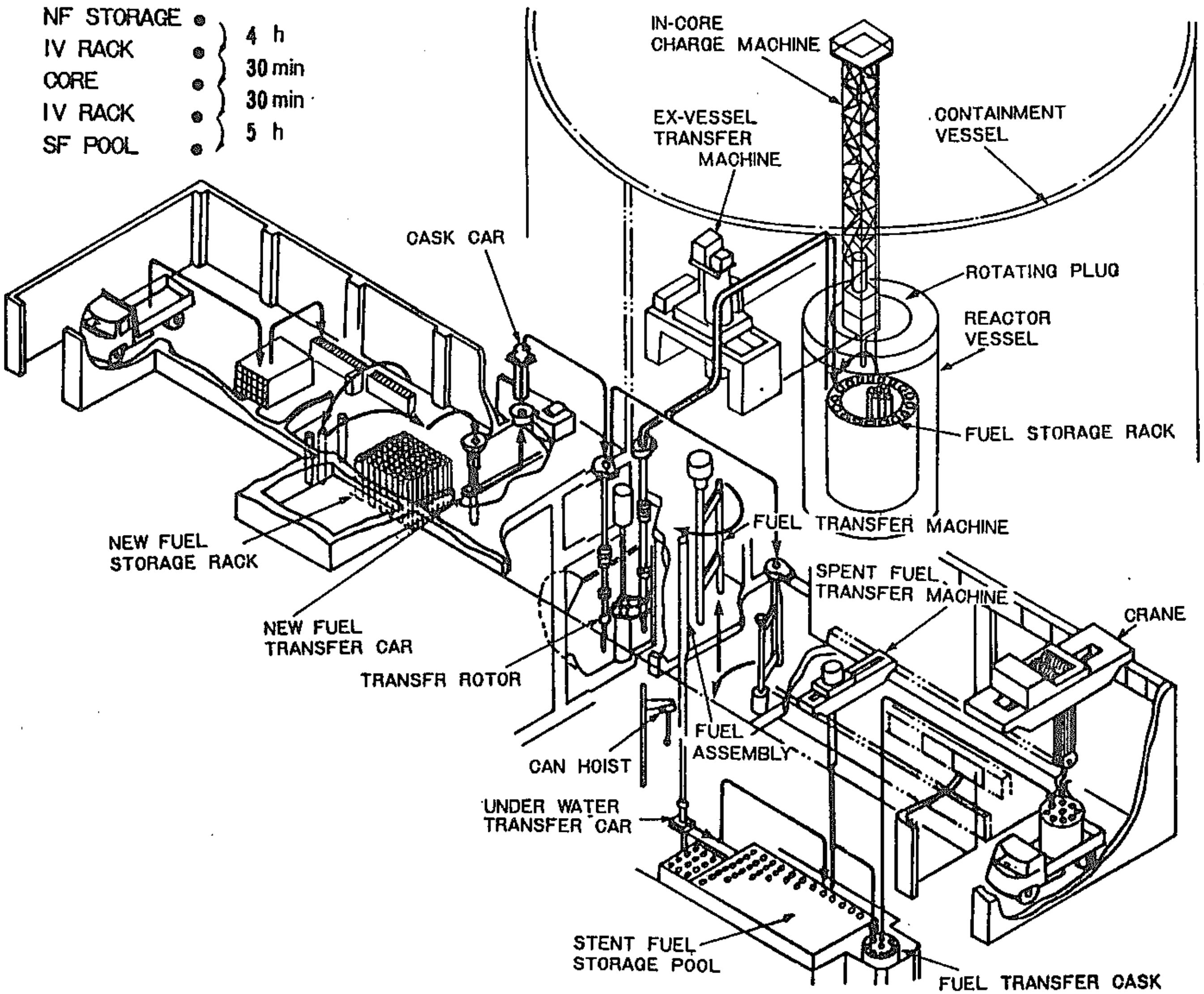

FUEL HANDLING SYSTEM OF JOYO

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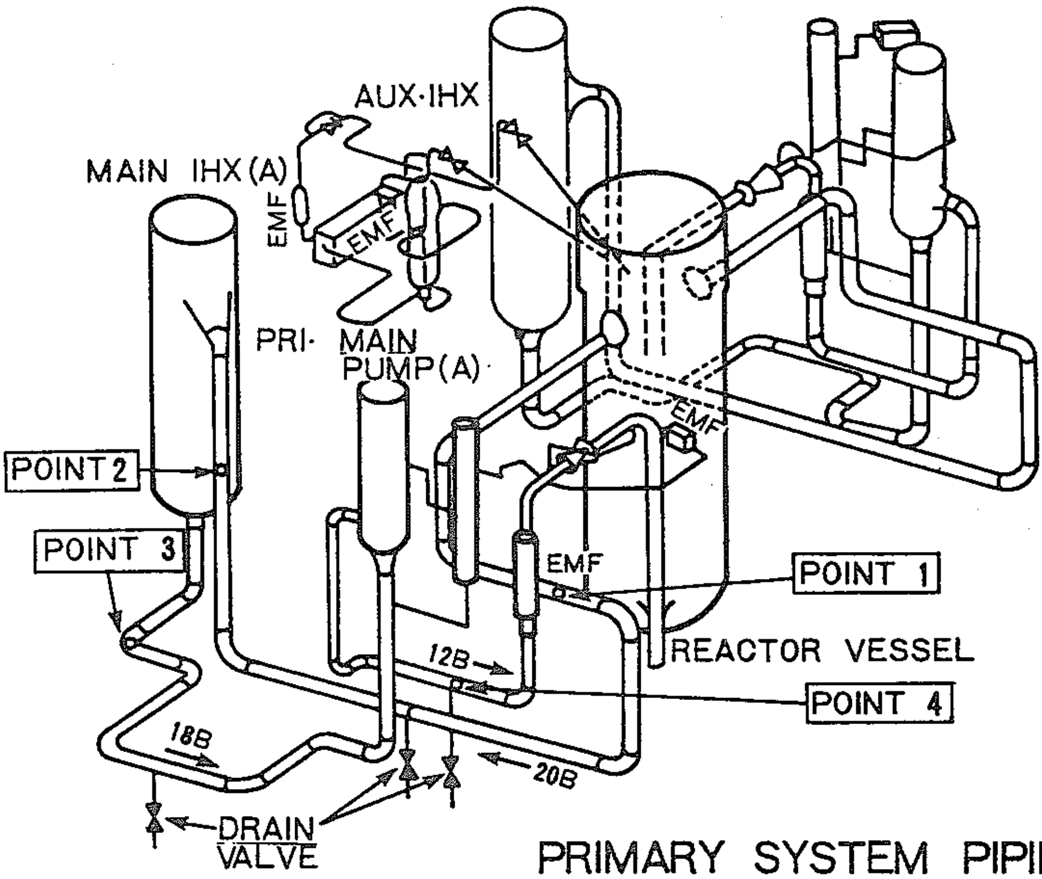
(AFTER DRAINING PRIMRY SODIUM)

PRIMARY PIPING	POINT NO.	2.4×10^3MWd (SEP.78)	6.7×10^3MWd (MAR.79)	8.9×10^3MWd (NOV.79)	1.8×10^4MWd (DEC.80)
HOT LEG	POINT 1	1.3mR/h	2.1mR/h	3.0mR/h	6.5mR/h
	POINT 2	0.4	2.5	0.75	3.2
COLD LEG	POINT 3	0.6	1.2	2.0	3.4
	POINT 4	0.65	1.5	2.0	5.6

DETECTOR: G-M TUBE TYPE SURVEYMETER



PRIMARY SYSTEM PIPING

GAMMA DOSE RATE AT SURFACE OF PRIMARY PIPING

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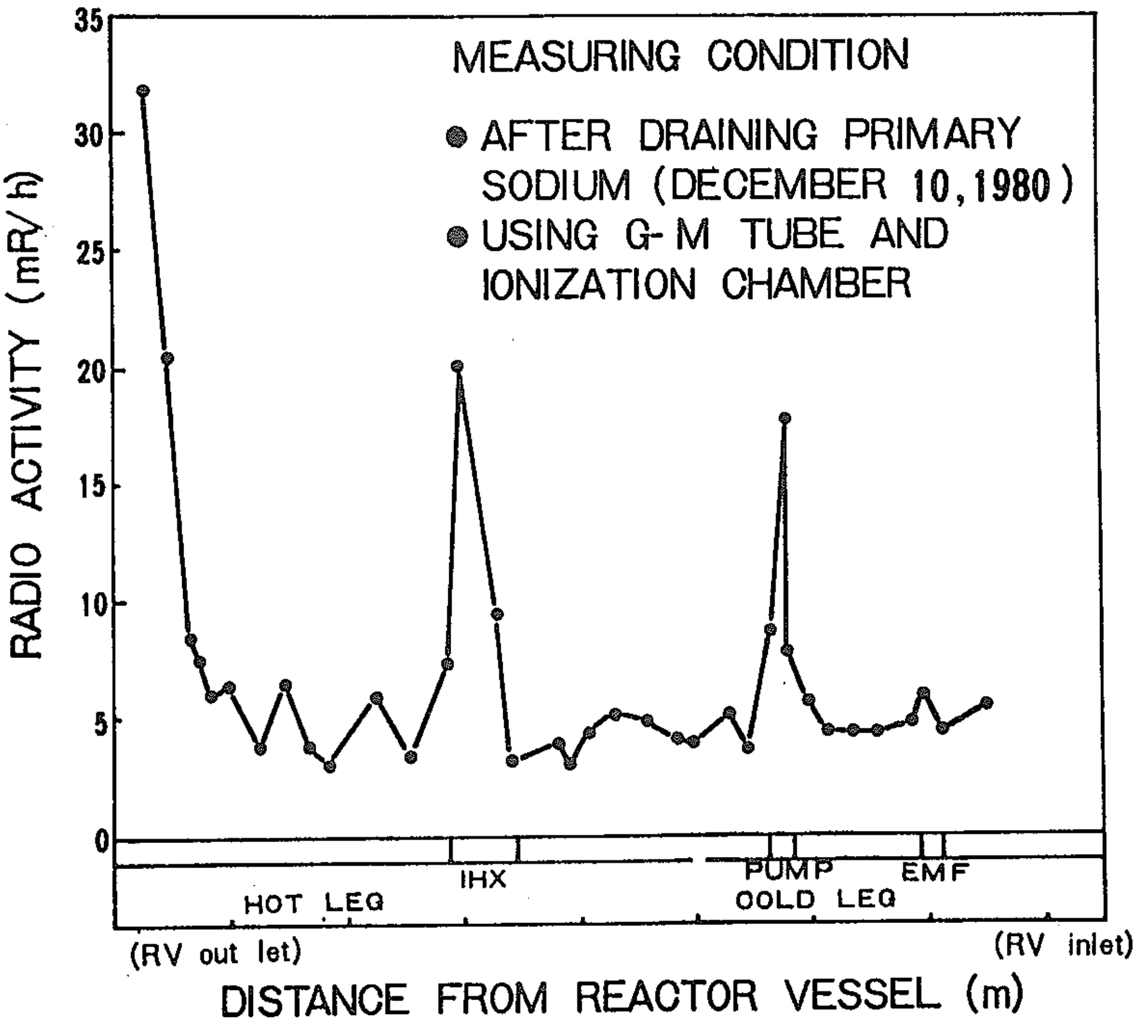

CP DISTRIBUTION ALONG PHTS OF JOYO CA LOOP

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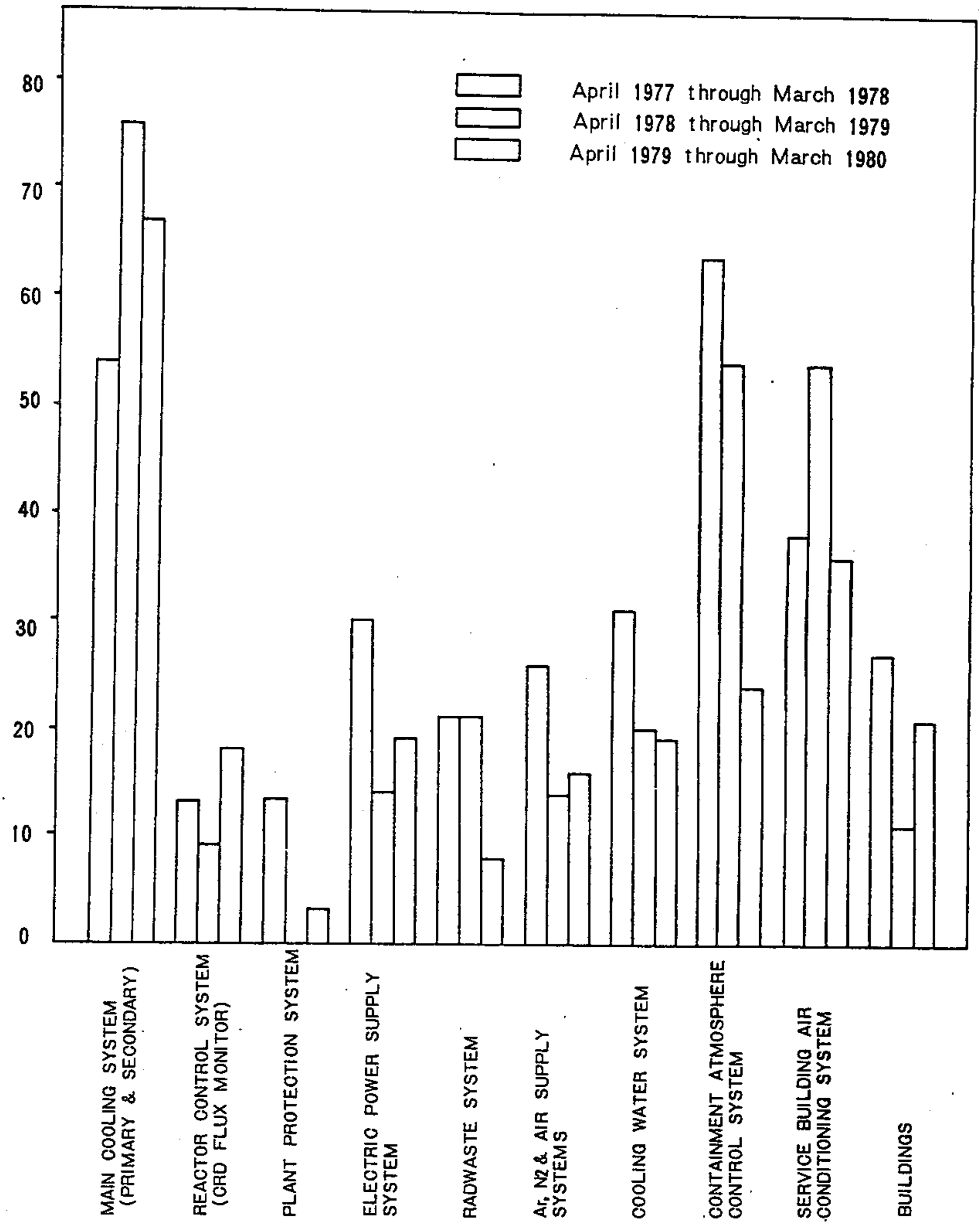

COMPARISON OF REPAIR FREQUENCY
OF EACH SYSTEM

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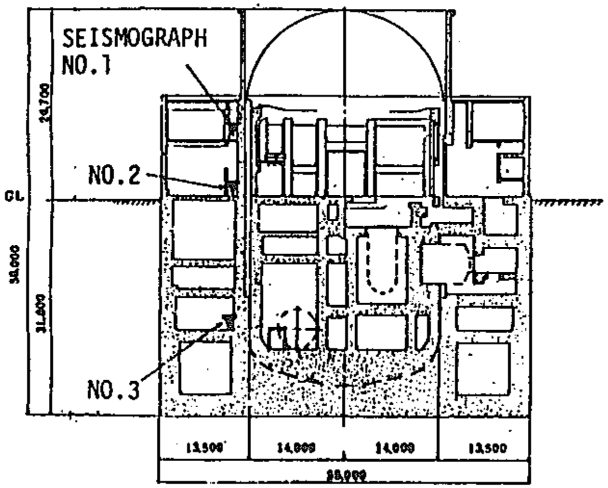
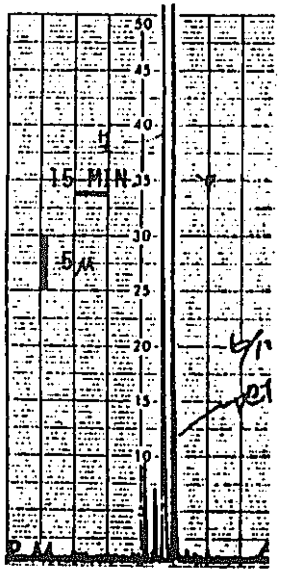
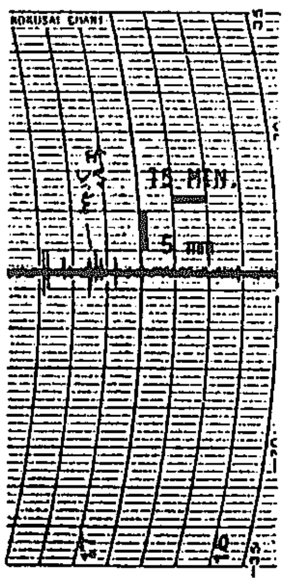
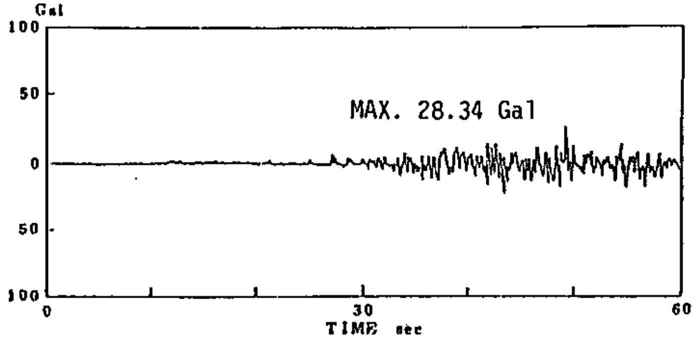


VIBRATION OF SECONDARY MAIN PUMP A

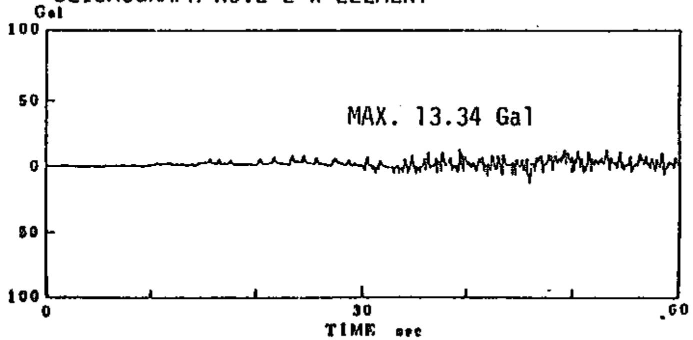


VIBRATION OF SODIUM SURFACE IN RV





SEISMOGRAPH NO.2 E-W ELEMENT



SEISMOGRAPH NO.2 U-D ELEMENT

MIYAGI-OKI EARTHQUAKE

DATE	JUNE 12, 1978 17:14
MAGNITUDE	7.4
EPICENTER	LONGITUDE 142°13′E
	LATITUDE 38°09′N
	DEPTH 30KM

IMPACT OF MIYAGI-OKI EARTHQUAKE ON JOYO

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CONCLUSION FROM OPERATIONAL EXPERIENCE OF JOYO (AS OF MAY 1981)

- ACCUMULATED OPERATION TIME
  - TOTAL PRIMARY PUMP OPERATION 30,774 h
  - TOTAL REACTOR OPERATION 10,492 h
- ACCUMULATED HEAT GENERATION 512,251 MWh
- FUEL IRRADIATION
  - MAXIMUM FUEL BURN UP ACHIEVED 31,000 MWd/t (CONTINUING)
  - NUMBER OF FUEL ASSEMBLIES DISCHARGED FROM RV 18 (CORE FUEL)
- NUMBER OF START UPS 211 (INCLUDING CRITICAL TEST)
- NUMBER OF FUEL ASSEMBLIES HANDLED 149
- NUMBER OF ANNUAL INSPECTIONS 2

OPERATION, MAINTENANCE, IRRADIATION AND TESTING EXPERIENCE HAS BEEN COMPLETELY SATISFACTORY TO DATE.

PNC N943 81-01

Operational Experience from the JOYO Fast Breeder Reactor

(Oral paper for ANS Annual Meeting at Miami in June, 1981)

(1) Cover

Good afternoon,Ladies and Gentlemen.

I'd like to present the operational experience of our experimental fast reactor JOYO. First of all I would like to thank Mr. Chairman for giving me a chance to make this presentation and to participate in this discussion on LMFBRs.

This discussion on the comparison of the loop versus the pool type from the operators view has many interesting features and shall give us valuable insights on the development of safe and economical large LMFBR plants for the future.

As you know, our experience of operation is limited only to a loop type fast reactor in Japan, so I'll show you the experience which could be effective for the subject.

(2) Contents

My presentation consists of three parts.

First, I'll introduce you to our plant and the pesent status of the reactor.

Second, I'll give you some highlights of JOYO operating experience concerning reactor type discussion.

Lastly, conclusions from our operational experience of JOYO to date will be given.

(3) Photo of JOYO

This is JOYO including the fuel monitoring facility. More than ten irradiated core fuel assemblies have been examined and tested there.

You can see the cylindrical reactor containment head here.

(4) Map around JOYO

JOYO is located in the PNC O-arai Engineering Center which is on the east-coast of Japan and 100 km or 70 miles north-east of Tokyo.

(5) JOYO Complex

The plant complex consists of many buildings such as the maintenance building, the spent fuel storage and the recently built irradiation rig assembling fucility.

One feature of the layout of JOYO is that the heat transportation is done in the north and south direction while fuel flows perpendiculor to it.

(6) Project Objectives of JOYO

The purposes of the JOYO project are first, to acquire technological experience necessary to construct and operate a prototype LMFBR, and second, to provide an irradiation facility for fuels and materials development.

(7) Industrial Participants of JOYO

In order to develop LMFBRs in Japan, the power supplying companies as well as the leading nuclear power plant suppliers joined the PNC project.

All of the design and fabrication of major components were done by domestic companies.

(8) Main Plant Parameters of JOYO

JOYO is a loop type reactor with two loops. The fuel handling system consists of a double rotating plug, a straight movement IVTM, a cask car type EVTM. Spent fuel storage is done in a water pool inside a can.

The rated power is 100 MWt while the present operation is at 75 MWt for the MK-I core. The generated heat is dissipated to the atmosphere through four air coolers.

The plant is controlled manually with constant coolant flow rate which gives the reactor outlet coolant temperature of 500°C or 930°F at rated power.

The primary coolant sodium inventory is 120 tons.

The plant is designed for a seismic criterion of 150 gals at the base.

(9) Master Schedule of JOYO

The JOYO construction was started in 1970.

The sodium was introduced into the system in 1976. The initial criticality was achieved in 1977 and power operation at 50 MWt began in 1978. Power was increased to 75 MWt in 1979, and the operation with MK-I core will be through the end of this year.

The operation at the rated power of 100 MWt with the MK-II core is scheduled to start in March 1983 after core replacement work planned next year.

(10) Operation History of JOYO MK-I Core

JOYO has been operated for four and a half years during which three 50 MWt and five 75 MWt operation cycles were completed.

During this period more than 100 tests were carried out in order to confirm the capability of this type of reactor.

(11) Main Results Confirmed Through Operation

The main results confirmed through operation to date are shown here.

The design features are satisfactory.

The operability is simple and reliable.

The maintainability is also satisfactory.

Corrosion product accumulation along the primary HTS is acceptable for necessary maintenance work. Total occupational radiation exposure to date is 13 man-rem corresponding to 0.7 man-rem / GWd.

(12) Heat Balance of JOYO (July 16,1979)

From here on, the slides will show you some highlights of operational experiences related to differences with reactor type descussion.

First,this figure shows the heat balance near rated power of MK-I core of JOYO. Forced circulation of each primary loop coolant flow makes respective heat transport capability maneuvable while some problems remain in measurement of process quantities typically shown in the secondary and tertiary systems.

(13) Thermal Transient Response After LOP

This figure, shows the temperature change of the sodium coolant at thermal transient conditions after a loss of power simulation test.

For example, the reactor vessel outlet temperature change rate is 10°C/min in maximum gradient. Including this, all of the thermal transient responses are not so severe and the maximum gradient values are one third to one teuth of the corresponding allowable values.

It is noteworthy that the secondary hot leg temperature peak after loss of power can be rather high, depending on the hot leg temperature change rate of the primary system.

(14) RV Wall Temperature Changes with Time after LOP

This figure shows the reactor vessel wall temperature change with time, also after loss of power.

We can see a tendency here, like a stratification phenomenon in the upper plenum of the reactor vessel which succeeds for about one hour after the loss of power.

(15) In-vessel Natural Circulation Test

We performed a series of tests in JOYO to confirm the decay heat removal capability by the in-vessel natural circulation of sodium using nitrogen gas cooling between the reactor vessel and its leak jacket.

Core fuel outlet sodium temperature profiles corresponding to power levels of approximately 30 to 200 kW in the tests are shown.

A series of tests of natural circulation capability of the main heat transport system is scheduled to be carried out at the end of this year. The detailed analyses for the tests are just under way.

(16) Heat Load in Under-floor Area of JOYO

A problem of the loop type reactor is the primary cell atmosphere conditioning system.

Several tests of the heat load of the system were performed at power operation of the reactor. The heat load was estimated to be 400 to 500 kW.

This figure below shows a schematic layout of the blow-out and suction headers of the system.

(17) Fuel Handling System of JOYO

This figure shows the path and the necessary time to handle the fuel assembly in JOYO.

The red line shows a route of new fuel from its storage through a transfer rotor and an EVTM to the fuel storage rack in the reactor vessel. It takes 4 hours including preheating time.

The orange line shows the route of spent fuel from fuel storage rack in the reactor vessel through EVTM, transfer rotor, fuel cleaning tank and canning machine into the spent fuel storage pool.

It takes 5 hours including sodium removal and canning time.

The necessary time to handle fuel assemblies is important the plant load factor,and depends on the system concept. And so, changes shall be made in this system for prototype reactor.

(18) Gamma Dose Rate at Surface of Primary Piping

Gamma dose rate along the primary piping from the reactor vessel through the lHX and pump back to the vessel has been measured, after sodium drainage, in order to define corrosion product accumulation in the system.

(19) CP Distribution along PHTS of JOYO

The recent results are shown in this graph where we can see the dose rates are several mR/h for hot and cold leg piping, and about 20 mR/h for the lHX and pump.

These figures have been gradually increasing, but are still low enough for access to the cells.

(20) Repair Frequency of Each System

This figure shows the comparison of repair frequency of each sub-system since the year 1977.

The main heat transport system including the secondary system shows the highest frequency. However instrumentation and small valves are the main causes of these repairs.

(21) Impact of MIYAGI-OKI Earthquake on JOYO

This shows some of the effects we have experienced with earthquakes at JOYO.

The largest one for JOYO under power operation is MIYAGI-offshore earthquake in 1978. The records during this occasion are shown in this figure. The upper right shows acceleration in the east-west element, to be a maximum of 28 gals, the right middle in the up-down element, at a maximum of 13 gals, on the seismograph No.2 which is placed at ground level.

Records shows that there were slight vibrations at the sodium level in the reactor vessel 1 about 5mm here, and at the secondary main pumps about 50 μm.

Since the earthquake was not so strong, below designed allowable level, the reactor did not scram.

(22) Conclusion from Operational Experience of JOYO

This summarizes the operational experience to date of the loop type experimental fast reactor JOYO.

Accumulated reactor operation time is 10,492 hours.

Number of start-ups is 211 including criticality test.

Number of fuel assemblies handled is 149.

Operation, maintenance, irradiation and testing experience of JOYO has been completely satisfactory.

Looking back, we had no FBR technology 15 years ago in Japan. Now we have achieved a 75 MWt energy source by FBR technology supplied 100% by domestic industries.

So we can say that 75 MWt has been gained for 15 years. And hopefully 750 MWt will be available to us in the next, 10 years.

This concludes my presentation. I hope this has contributed to the objective of this meeting.

Thank you.

4. ACRSメンバーとの打合せへの発表のスライドと説明

(1981. 8. 28 於東京 富国生命ビル)

スライドは，前項第3項のスライドを流用した。たゞし，下記2点を修正。

(1) Contents の第2節の3行目「Stratification in Reactor Vessel」を削除。

それにともない，スライドの13枚目（RV Wall Temperature Changes with Time after LOP from 75 MW」を削除。

(2) スライド最終ページの「Conclusion from Operational Experince of JOYO（As of May, 1981）」の内容を，時間のずれに応じて修正。

したがって，こゝには上記(2)の修正後のスライドのページのみ添付する。

CONCLUSION FROM OPERATIONAL EXPERIENCE OF JOYO (AS OF AUGUST 1981)

● ACCUMULATED OPERATION TIME		
-TOTAL PRIMARY PUMP OPERATION	33,912	h
-TOTAL REACTOR OPERATION	11,780	h
● ACCUMULATED HEAT GENERATION	598,345	MWh
● FUEL IRRADIATION		
-MAXIMUM FUEL BURN UP ACHIEVED	36,000	MWd/t (CONTINUING)
-NUMBER OF FUEL ASSEMBLIES DISCHARGED FROM RV	21	(CORE FUEL)
● NUMBER OF START UPS	225	(INCLUDING CRITICAL TEST)
● NUMBER OF FUEL ASSEMBLIES HANDLED	157	
● NUMBER OF ANNUAL INSPECTIONS	2	

OPERATION, MAINTENANCE, IRRADIATION AND TESTING EXPERIENCE HAS BEEN COMPLETELY SATISFACTORY TO DATE.

Operational Experience from the JOYO Fast Breeder Reactor
(Oral paper for Meeting with ACRS members in Tokyo, Aug.28, 1981)

(1) Cover

Good morning, Gentlemen.

First of all, I'd like to express my appreciation for having opportunity to speak about some operational experiences and test results related to safety of our experimental fast reactor JOYO.

(2) Contents

My presentation covers roughly three areas.

First, I'd like to introduce you to our plant and the present status of the reactor.

Second, I'd like to mention simply about the test results and some operating experiences which could concern with plant safety.

Lastly, conclusions from our operational experience of JOYO to date will be given.

(3) Map around JOYO

JOYO is located in the PNC O-arai Engineering Center which is on the east-coast of Japan and 100 km or 70 miles north-east of Tokyo.

(4) JOYO Complex (Photo)

The plant complex consists of many buildings such as the maintenance building, the spent fuel storage and the recently built irradiation rig assembling fucility.

One feature of the layout of JOYO is that the heat transportation is done in the north and south direction while fuel flows perpendiculor to it.

(5) Project Objectives of JOYO

The main purposes of the JOYO project are first,to acquire technological experience necessary to construct and operate a prototype LMFBR, and second, to provide an irradiation facility for fuels and materials development.

(6) Industrial Participants of JOYO

In order to develop LMFBRs in Japan, the power supplying companies as well as the leading nuclear power plant suppliers joined the PNC project.

All of the design and fabrication of major components were done by domestic companies.

(7) Main Plant Parameters of JOYO

JOYO is a loop type reactor with two loops. The fuel handling system consists of a double rotating plug, a straight movement IVTM, a cask car type EVTM. Spent fuel storage is done in a water pool inside a can.

The rated power is 100 MWt while the present operation is at 75 MWt for the MK-I core. The generated heat is dissipated to the atmosphere through four air coolers.

The plant is controlled manually with constant coolant flow rate which gives the reactor outlet coolant temperature of 500°C or 930°F at rated power.

The plant is designed for a seismic criterion of 150 gals at the base of the reactor building.

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The construction of JOYO was started in 1970.

The sodium was introduced into the system in 1976. The initial criticality was achieved in 1977 and power operation at 50 MWt began in 1978. Then the power was increased to 75 MWt in 1979, and the operation with MK-I core will be completed by the end of this year.

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Since the earthquake was not so strong, below designed allowable level, the reactor did not scram.

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Accumulated reactor operation time is 11,500 hours.

Number of start-ups is 220 including criticality test.

Number of fuel assemblies handled is 150.

Operation, maintenance, irradiation and testing experience of JOYO has been completely satisfactory.

These experiences have been reflecting to the prototype FBR plant MONJU.

Thank you.