- Vibration characterization and monitoring system (induced from and on mechanichal components) including:

  Loose part monitoring
  Piping's vibrational status monitoring
  Pressure fluid leak monitoring

The conception of new reactors involve the consideration of mechanical failure in systems and components that degrade the systems functionality;
It is important to define monitoring systems able to detect the failure early by means of the correlation between the incipient anomalous functioning and the mechanical vibrations in systems and components.

RECENT DEVELOPMENT OF NUCLEAR POWER IN JAPAN AND INSTRUMENTATION AND CONTROL SYSTEM AND CONTROL ROOM EQUIPMENT FOR ADVANCED LIGHT WATER REACTORS

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Abstract

This paper was provided for the 13th IAEA/IWG-NPPCI Meeting and aims to introduce an outline of recent development of nuclear power in Japan and some topics in the field of nuclear power plant control and instrumentation.
Forty units of nuclear power plants are in operation in Japan and five units of BWRs and six PWRs are under construction. Construction of prototype FBR Monju have almost completed and construction of High-Temperature Engineering Test Reactor, HTTR, started in March 1991. In parallel of those, extensive effort has been carried out to develop the third generation LWRs which are called Advanced BWR(ABWR) and Advanced PWR(APWR). Two Advanced BWRs are under safety review for construction.
Instrumentation and control system of these Advanced LWRs adopts integrated digital I & C system, optical multiplexing signal transmission, fault tolerant control system and software logic for reactor protection and safety systems and enhances plant control performance and provides human-friendly operation and maintenance environments. Main control room of these Advanced LWRs, comprised with large display panels and advanced console, has special futures such as one-man sit-down operation, human friendly man-machine interface, high level automation in operation and maintenance.

1. Operation and Construction of Nuclear Power Plants

Forty nuclear power plants are in operation in Japan and the total electric generating capacity of these power plants is 31,645 MWe. The share of nuclear generated electricity was about 26% of the total generated electricity in 1990. Average annual availability factor of these plants was 73.0% in 1990.

In addition to these operating NPPs, five units of BWRs (4,702MWe in total), six PWRs (6,189MWe in total) and one FBR (280MWe) are under construction, and a BWR(825MWe) and two units of Advanced BWRs (2712MWe in total) are under the safety review.

The construction period of the NPP including a period of the commissioning test was remarkably shortened since several years ago and most NPPs have come into commercial operation for around 55 months.

Experimental LMFBR JOYO has been operated satisfactorily since 1977 and the prototype FBR MONJU (280MWe) has been almost completed and the first criticality will be achieved in October 1992.

The construction of a HTGR named High-Temperature Engineering Test Reactor(HTTR) started on 15th March in this year. The outlet helium temperature of the reactor is 950 C and the reactor is intended to use for various studies for utilization of nuclear heat in the non-electric field.

In addition to such environment of nuclear energy development, Japanese new long term energy policy was decided on 5th June 1990 by the Advisory Committee for Energy[1]. The committee report emphasizes the active development of nuclear power which has an advantage from the global environment preservation point of view. The report also says that nuclear power capacity is to increase from the 28,900MW of fiscal 1988 to 50,500MW in 2000 and 72,500MW for 2010. This represents the installation of 40 units of the 1000MW class nuclear power plants in the coming 20 years. As the results of this, 473 billion kWh electricity (about 43% of the total electricity demand) will be generated by the nuclear power in the fiscal year 2010.

2. I & C and Control Room Systems of Advanced Light Water Reactors

As the research and development activities and progress of the technologies in the field of nuclear power plant control and instrumentation in Japan has been reported widely in the last meeting[2], this report focuses on the I & C and control room systems for the Advanced Light Water Reactors, ABWR and APWR.

Advanced LWRs, ABWR and APWR, were developed as the third generation of nuclear power plants in Japan. Construction of one of them, Kashiwazaki-6 ABWR will start in the beginning of autumn in this year and is expected to come into commercial operation in July 1996. Construction of Kashiwazaki-7 starts in the next year and into commercial operation in July 1997.

The ABWR and APWR have many advanced operating performances and safety features such as 1) Enhancement of inherent safety features by use of new structure and arrangement of the reactor components, e.g. installation of reactor core at lower position in the vessel (PWR) and use of integrated in-vessel recirculation pumps (BWR), 2) Improvement of plant availability by advanced fuel/core design and improvement of maintainability of the plant, 3) Improvement of the plant operability, 4) Reduction of

radiation dose of workers, 5) Reduction of radioactive waste, and 6) Reduction of construction and operating costs.

I & C system have been also improved remarkably for these ALWRs. Integrated digital I & C system with optical multiplexing signal transmission was fully adopted to the ALWRs. Fault tolerant system structure was also used for the reactor control system. Conceptual schematic diagrams of I & C systems for the ABWR and APWR are shown in Fig. 1 and Fig.2 [3].

Automatic sequential operation and control functions have been provided for the almost all necessary operations for the plant start-up, shutdown, normal operations and even for the transient operations such as post scram operations immediately after turbine trip. Comparison of automated operation between conventional and ABWR is shown in Table 1 [4].

Microprocessor based software logic systems have been developed and are used in the ALWRs for the reactor protection and safety systems without hard-wired backup systems.
The verification and validation of the prototype software safety logic systems had been carried out by the NUPEC(Nuclear Power Engineering Centre) since 1987 including the accelerated aging tests for the plant life. The V & V was completed in the end of March of this year.

The new I & C systems will enhance plant control performance very much and provide human-friendly operating and maintenance environments.

In the field of control room system development for the ABWR and APWR, extensive studies have been also carried out in the various area such as the investigation of behavior, characteristics and capabilities of operators and operating crews using full scope training simulators, creating new control room concept and development of relating equipment and systems, and test of acceptability of the new control room system to the operators.

In the case of ABWR, for example, the design and manufacturing of the prototype control room system for ABWR started in 1987, evaluations of the system initiated in 1989 and completed in the end of 1990.

Figure 3 shows the first generation of control panels for the first 8 units of BWR of which construction started in the 1970's, Fig. 4 shows the second generation panels for the second 7 units since Fukushima II-3, and Fig. 5(a) and (b) show two kinds of experimentally manufactured control panels for the ABWR [5].
Fig. 6 to Fig. 8 show the progress of control panel design of the Japanese PWRs [6].

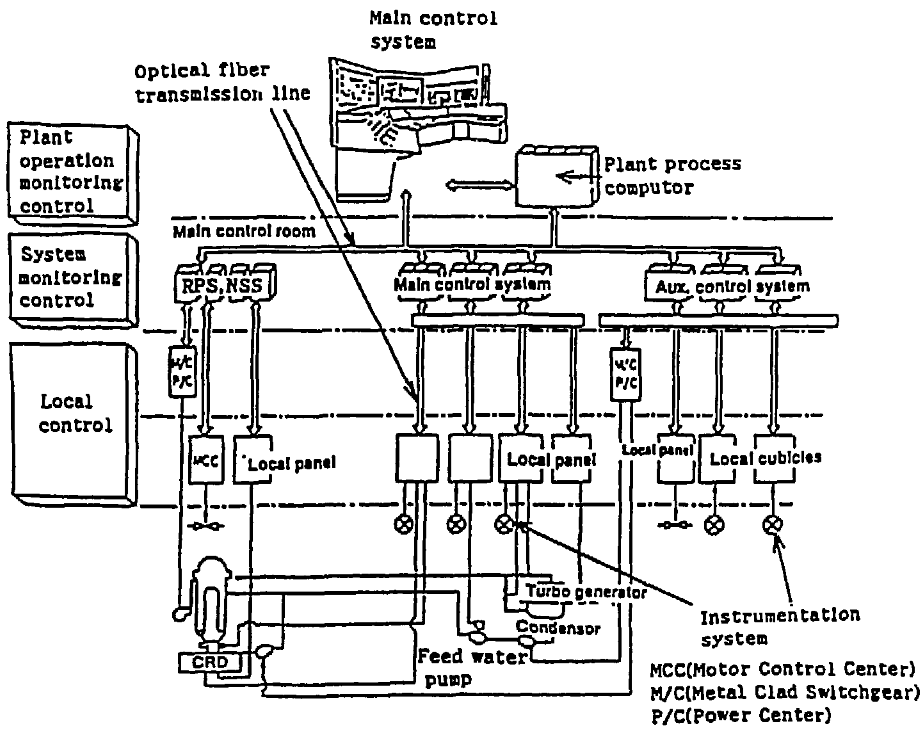

FIG. 1. Conceptual diagram of the I&C system for the ABWR.

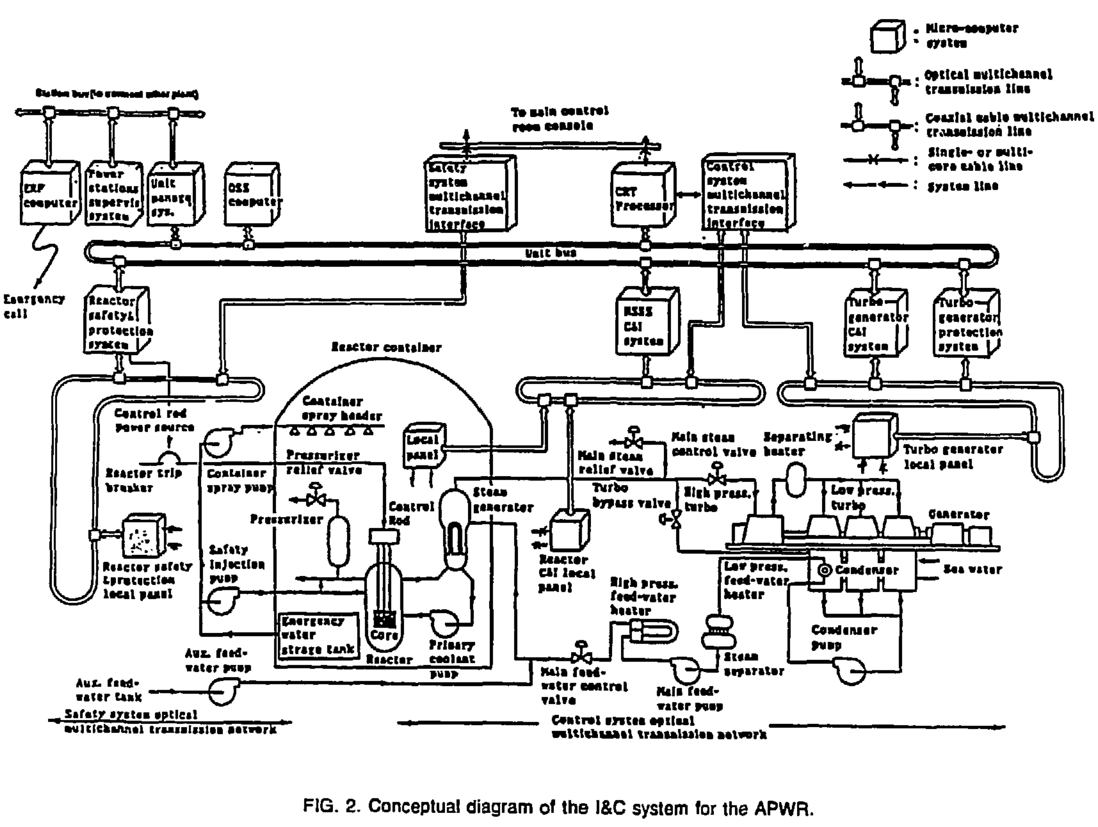

FIG. 2. Conceptual diagram of the I&C system for the APWR.

Table 1 Comparison of Automated Operation

	Major operations		Conventional Type	Second Generation Type	ABWR Type
Start-up	Reactor System	Switching of reactor mode SW	M	OG+M	OG+M
		Reactor de-aration	M	OG+M	OG+A(S)
		Withdrawal of control rod	M	M	A(F)
		Switching of IRM range	M	M	-
	Turbine System	Start-up turbine gland seal steam	M	OG+M	OG+A(S)
		Start-up of air extractor and off-gas system	M	OG+M	OG+A(S)
		Start-up of feedwater and condenser pump	M	OG+M	OG+A(S)
		Switching of reactor feedwater pump	M	A(F)	A(F)
	Main Turbine/ Generator	Warming of control valve	M	A(F)	A(F)
		Increase of pressure setpoint	M	A(F)	A(F)
		Increase of turbine speed	M	A(F)	A(F)
		Generator synchronization	M	A(F)	A(F)
Survellance Test	Emergency core cooling system		M	OG+M	OG+M
	Turbine system		M	OG+M	OG+M
Immediately After Scram	Switching of reactor mode switch		M	M	M
	Turbine trip		M	M	A(I)
	Turbine-driven reactor feedwater pump trip		M	M	A(I)
	Switching of turbine gland seal steam		M	M	A(S)
Emergency	Scram and start-up of emergency core cooling system		A(I)	A(I)	A(I)
	Start-up of containment cooling system		M	M	A(S)
	Mode switching of residual heat removing system		M	M	A(S)

M :Manual: Each equipment is to be operated manually.

A(S):Sequential automatic operation: A series of operations of fixed pattern is to be operated sequentially by mode SW.

A(F):Feed-back loop controlled operation: After receiving the manual start-up command,equipment is to be controlled continuously or descretely under feed-back loop.

A(I):Automatic operation by logic interlock:Action predetermined by logic interlock is automatically caried out,once certain conditions are satisfied.

OG :Operation guide: Process computer judges operational timing and operation permitting conditions and generates the operational message.

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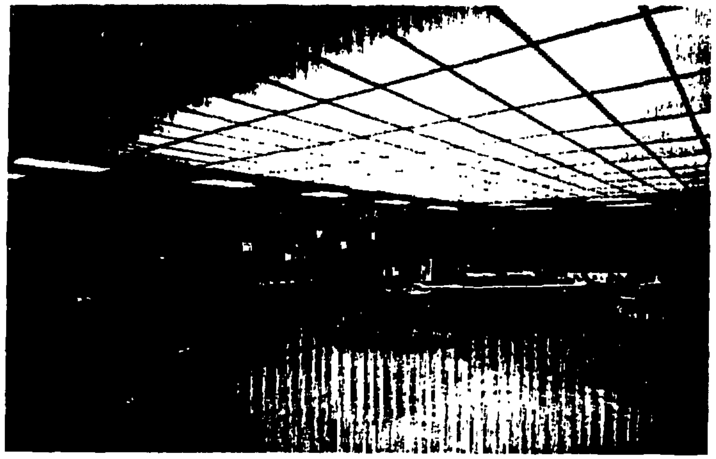


FIG. 3. First generation control panels for BWRs.

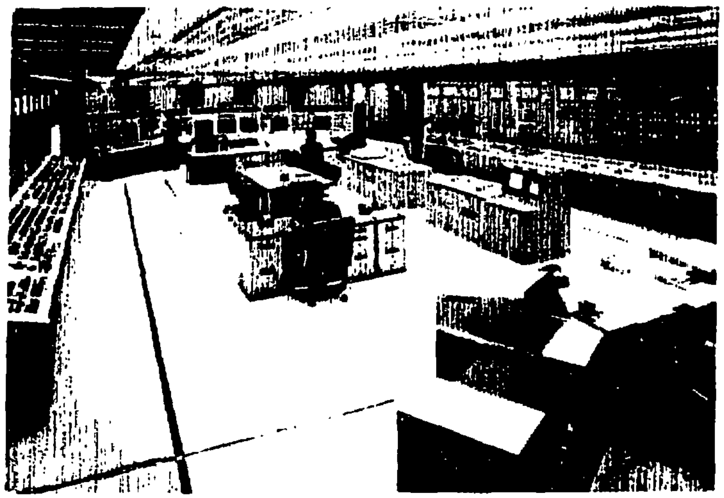
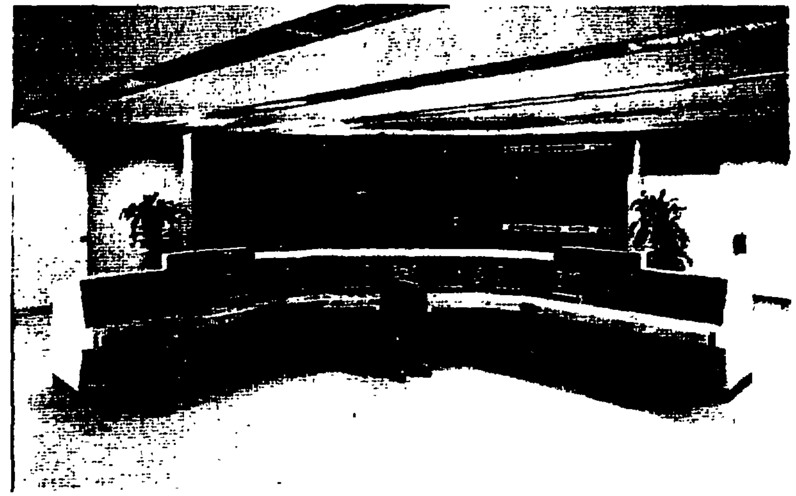


FIG. 4. Second generation control panels for BWRs.



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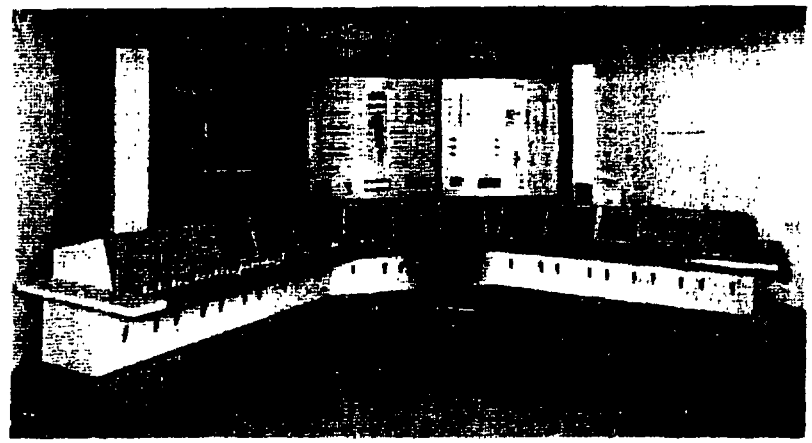

(b) NUCAMM-90

FIG. 5. Prototype control panels for ABWRs.

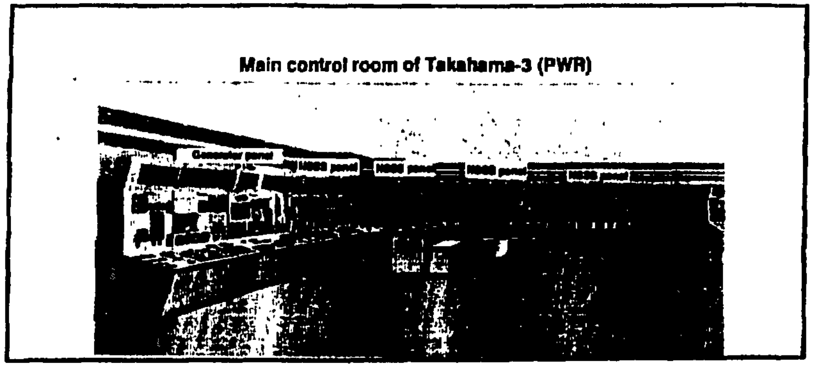

FIG. 6. Main control room of Takahama-3 PWR.

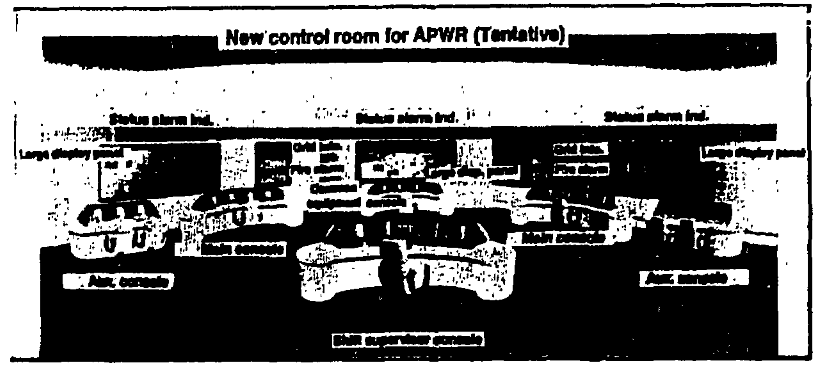

FIG. 8. New APWR control room.

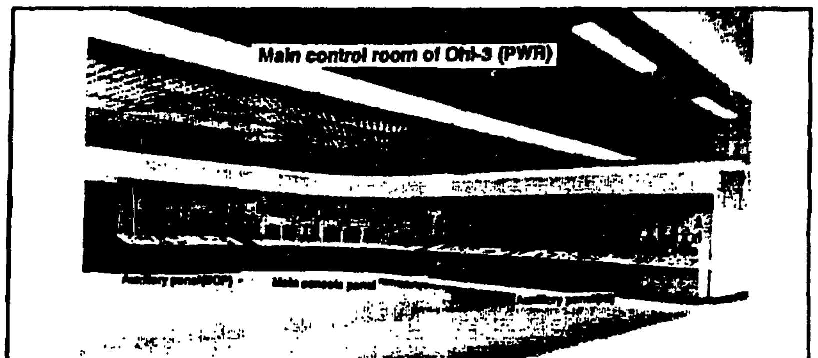

FIG. 7. Main control room of Ohi-3 PWR.

Principal design requirements for the control panels for the advanced LWR are;

- An operator should be able to perform all of the primary monitoring and control functions.
- Enhancement of automation level in normal, transient and even in accident conditions.
- Essential information shall be monitored in common by the entire operating crew.

The ABWR control panels[4],[5],[7] *comprises a compact console,* large display panels and enhanced operator support functions.

Large display panel on the left shows Plant Integrated Alarm which includes first hit display for 4 major events and around 40 annunciators. The central display panel provides Plant Mimic and about 100 system level annunciators in the upper part of the mimic. These panels are composed of LED display hardware panels *driven by dedicated redundant micro-processors to prevent the* effect of process computer failure. Large display panel on the right indicates plant variable information on the 100 inches screen.

Operator console has seven VDUs with touch screen controls, fifteen 10 inches colour Liquid Crystal Displays(LCD), which are connected with redundant micro-processors, and some hardware switches.

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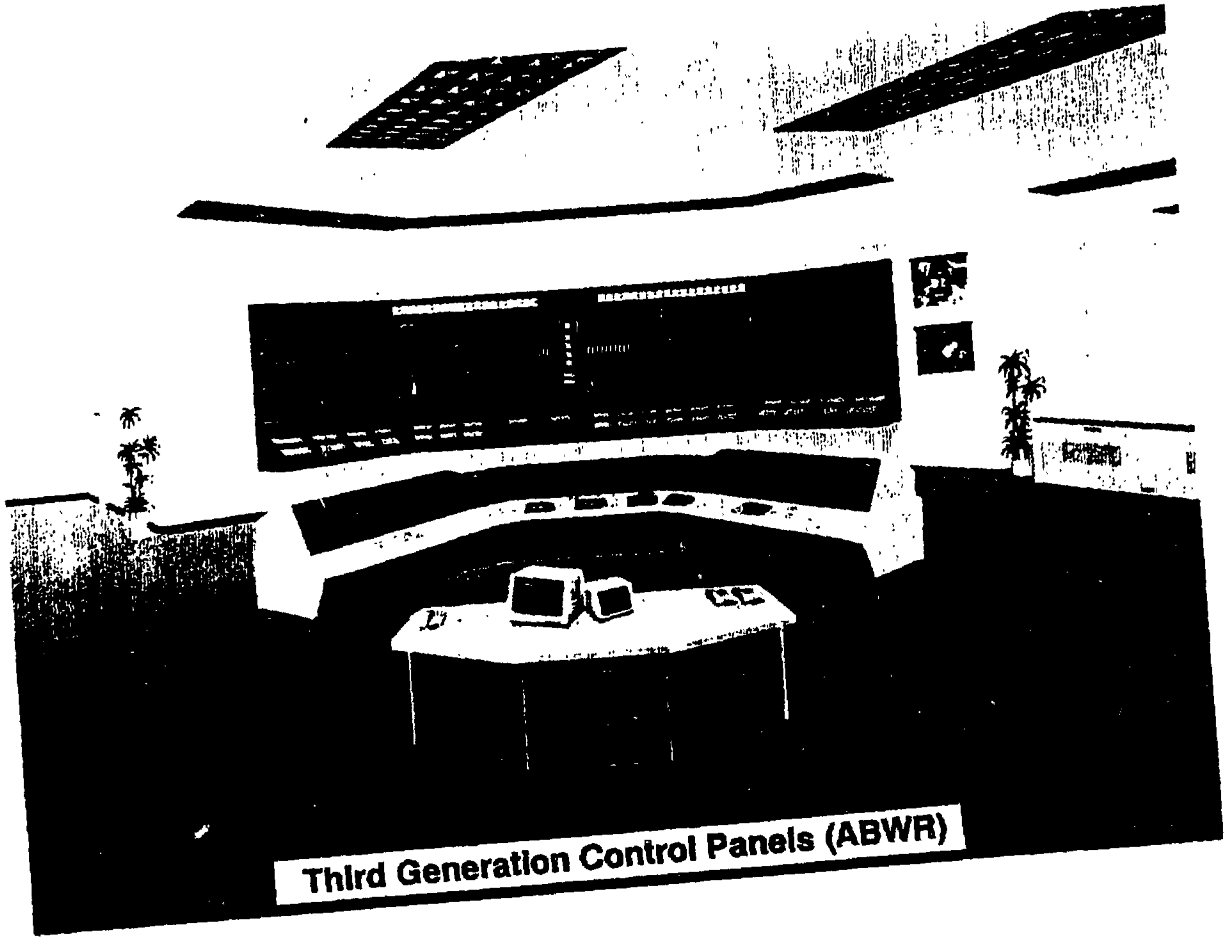

Third Generation Control Panels (ABWR)

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Almost all plant operations and control are carried out using touch screen controls except implementation of safety functions. Some hardware push buttons, e. g. mode switches and safety switches, are provided on the console desk and subroutines in the automatic sequential operations can be executed using these push buttons.

Operator support functions using plant diagnosis functions and artificial intelligence has been fully integrated in the control room system.

Centralizing plant information processing and control functions are also integrated for planning, operation, maintenance and management of the plant.

Final manufacturing design for these advanced control rooms are being carried out in cooperation between utilities and manufacturers.

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4) IWAKI, K., "Control Room Design and Automation in the Advanced BWR(ABWR), International Symposium on Balancing Automation and Human Action in Nuclear Power Plants, IAEA-SM-315 132, Munich, July 1990(1990)E.

5) *Photographes are prepared by The Tokyo Electric Power Co. Inc.*

6) Photographes are prepared by The Kansai Electric Power Co. Inc.

7) *Descriptive Material for K-6/7 Plant Man-Machine Interface,* provided by Toshiba Corp., March 7, 1991

NUCLEAR POWER PLANT CONTROL AND INSTRUMENTATION IN THE NETHERLANDS: STATUS AND DEVELOPMENTS

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Abstract

This article has been prepared for the regular IAEA/IWG-NPPCI-meeting in May 1991. It is provides an outline of the status of and prospects for nuclear energy in the Netherlands and a brief description of topics given specific attention by the authorities. It also gives an overview of recent developments and aims related to I & C in nuclear power stations.

Introduction

The Dutch nuclear power programme started relatively early with the construction of two power stations, which came into operation in 1970 and 1974. However, further growth was delayed by factors such as the use of national natural gas resources, negative public and political attitudes and, later, nuclear accidents such as TMI and Chernobyl. Today, around 6 % of the electricity is supplied by local nuclear power plants. An extension of the nuclear power programme is not expected in the short term. For example the new power plant planned for at the North Sea Coast near Rotterdam (Maasvlakte) will be coal-fired. The environmental effects of coal firing compared with coal gasification has given rise to a technical debate. The construction of more nuclear power stations is not on the agenda at the moment.

Nuclear installations in the Netherlands

The nuclear installations in the Netherlands comprise the following:

- The NPP Borssele, a Siemens/KWU, 450 MWe PWR, which has been in operation since 1974.
- The 60 MWe NPP Dodewaard, a BWR, based on natural convection, and engineered and constructed by General Electric; this plant was built to gain experience in research and into generation of electricity.
- Several smaller research reactors which are not generating electricity: the High Flux Reactor from the European Joint Reactor Center, the Low Flux Reactor (ECN), both in Petten, and the IRI reactor from the Delft University of Technology.

Waste storage facilities, to be located in Borssele and managed by Covra, are at the design stage.

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