Radiation Control and Monitoring System on the HTTR

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INTRODUCTION

The High Temperature Engineering Test Reactor (HTTR) is the first high temperature gas cooled reactor in Japan. The Japan Atomic Energy Research Institute (JAERI) started the construction of the HTTR in March 1991, and the first criticality was attained in November 1998. This reactor is a helium-gas-cooled and graphite-moderated reactor with thermal output of 30MW and the maximum temperature of outlet coolant reaches 950℃ at the high temperature test operation. The cutaway section of HTTR reactor building is illustrated in Figure 1 and major specifications of the HTTR are summarized in Table 1.

The radiation control and monitoring system on the HTTR is composed of the radiation monitoring system and the computer system. This system was designed with considering for measuring of radioactive gaseous elements, because it is difficult to search the leakage point of helium gas in the HTTR compared with water-cooled type reactor. The computer system is utilized for rapidly data processing and rationalization of radiation control works. The functions of the computer system are watching unusual data and machine troubles, calling in an emergency, presuming the cause of unusual radiation levels, etc.

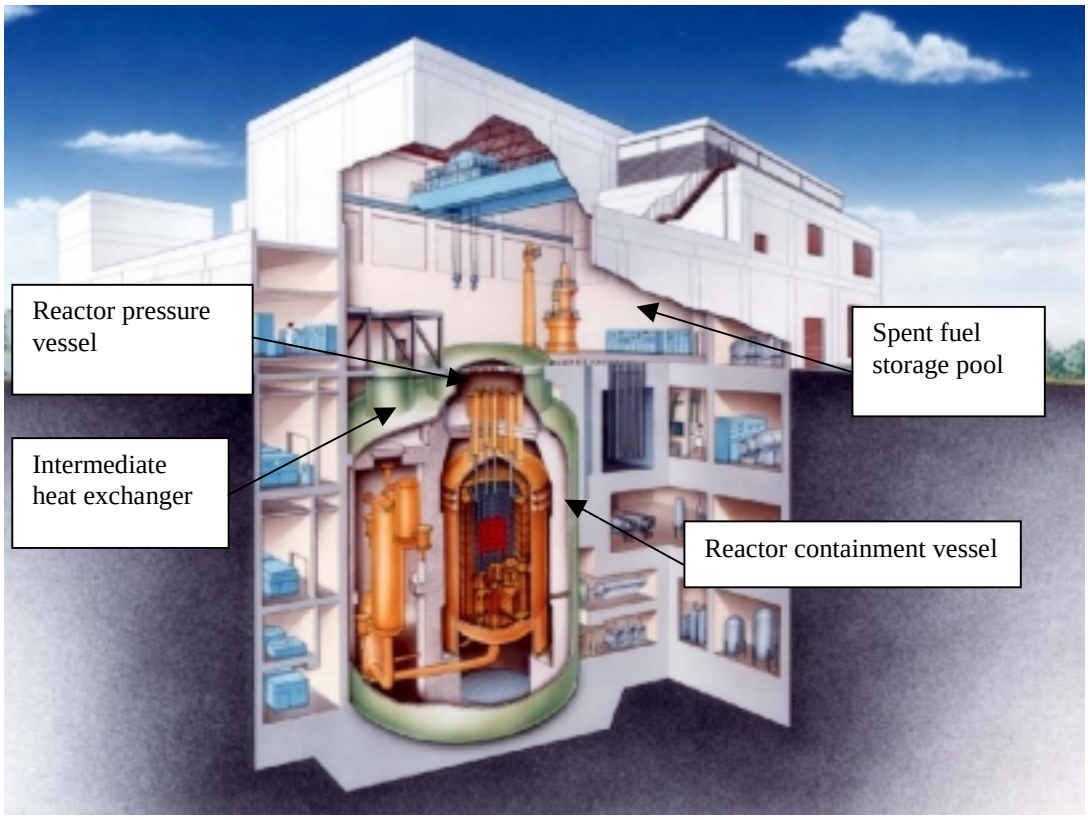

Figure 1 Cutaway of HTTR reactor building

Table 1 Major specifications of the HTTR

Thermal power	30MW
Coolant	Helium gas
Inlet gas temperature	395℃
Outlet gas temperature	850℃／950℃
Primary coolant pressure	4MPa
Core material	Graphite
Core height	2.9 m
Core diameter	2.3 m
Average power density	2.5MW/m^3
Fuel	Coated UO_2 particle
Uranium enrichment	3～10wt% (average 6wt%)

RADIATION MONITORING SYSTEM

The radiation monitoring system has six channels of effluent air monitoring equipment, eight channels of workplace air monitoring equipment and fourteen channels of dose rate monitoring equipment. Specifications of these monitoring equipments are shown in Table 2.

Table 2 Radiation monitoring equipments on the HTTR

Classification	System name	Kind of monitor	Number	Detector*)
Effluent monitors	Reactor building exhaust monitor	Dust monitor	1	Si
		Iodine monitor	1	NaI(Tl)
		β -ray gas monitor	1	Pl
		Tritium monitor	1	IC
		Tritium & carbon sampler	1	—
	Emergency exhaust monitor	Low range gas monitor	1	NaI(Tl)
		High range gas monitor	1	IC
Workplace air monitors	Reactor containment vessel monitor	Dust monitor	1	Si
		γ -ray gas monitor	1	NaI(Tl)
		Tritium monitor	1	IC
		Tritium & carbon sampler	1	—
	Reactor building duct monitor	Dust monitor	1	Si
		β -ray gas monitor	2	Pl
		γ -ray gas monitor	2	NaI(Tl)
		Tritium & carbon sampler	2	—
Area monitors	Reactor building area monitor	γ -ray area monitor	10	Si
	Reactor containment vessel area monitor	γ -ray area monitor	1	IC
		Neutron area monitor	1	BF_3
	Accident area monitor	γ -ray area monitor	2	IC
Access control monitors		Hand, foot & cloth monitor	3	Pl

*) Where, Pl : Plastic scintillator
IC : Ionization Chamber
NaI(Tl) : NaI(Tl) scintillator
Si : Silicon semiconductor
BF_3 : BF_3 proportional counter

(1) Effluent air monitoring equipments

There are two effluent lines in the reactor building, the stack line is using normally and the exhaust tube line is using in an emergency. If the primary coolant gas leaks and increases radioactive concentration in the Service Area (:air tight area in the reactor building) including the reactor containment vessel, the emergency air

purification system will be worked to purifying air contamination, and exhaust air will be emitted from the outlet of exhaust tube line. Effluents of each line are released from 80m height of the exhaust outlet with the stack. Schematic diagram of effluent air monitoring equipments are shown in Figure 2.

The dust monitor and the iodine monitor are employed for the monitoring of particulate radioactive materials. Sampling filters of these monitors can be changed at determined time automatically.

There are two different types of detector, a plastic scintillator and an ionization chamber of air flow type, are used to measure radioactive gaseous substances in the effluent air of the stack line. The former is used for rare gas monitoring because it has good sensitivity for β-ray. And the later is used as the tritium gas monitor which is applied high polymer membrane for selectively separation of hydrogen from the compound gaseous elements.

Besides, tritium and carbon-14 are absorbed into the liquid absorber of ethanol-amine after oxidized by cupper-oxide catalyst, and the absorbers are measured by liquid scintillation counter a month regularly.

The accident gas monitor consists of two types of detector, NaI(Tl) scintillation counter for low range concentration and ionization chamber for high range one, because it is too wide to cover the all range of concentration from the B.G level to accident level. The high range accident gas monitor has two different types of ionization chamber, one is enclosing Ar gas and the other is enclosing Xe gas, in order to obtain the average energy of radioactivity from the difference of sensitivity ratio between two detectors. The indicator of this monitor can show average energy, exposure rate, radioactive concentration in air, and release rate of radioactivity for evaluation of a public dose.

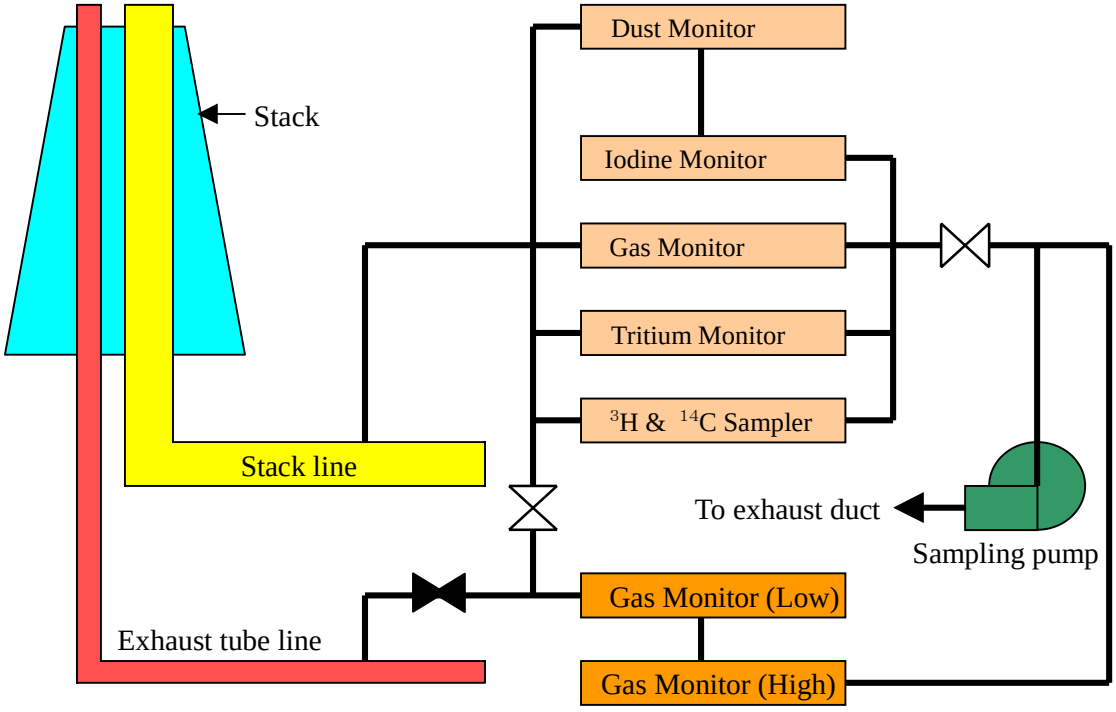

Figure 2 Schematic diagram of effluent air monitoring equipments

(2) Workplace air monitoring equipments

The types of monitor for working place air monitoring equipments are basically same as used for effluent air monitoring. Schematic diagram of workplace air monitoring equipments are shown in Figure 3 and Figure 4.

There are two systems of air monitoring equipments for workplace, one is for the reactor building (RB) and the other is for the reactor containment vessel (CV). Each equipment consists of gas and dust monitors. These monitors are constantly measuring radioactive contamination in air of working environment.

Usually, the monitors for the RB are sampling the air from all of sampling points. But when the value of indicator exceeded the alarm level, it automatically changes the sampling point to search the workplace of higher concentration of radioactivity.

Dust and gas monitors for the CV including area monitors placed in the CV have spot indicators at the inside and the outside of its entrance. When the workers are entering into the CV, they can verify the safety by confirming the value of spot indicator at the site.

The portable dust and gas monitors are available for the local monitoring, and they can be connected to computer system at any point of ten connector boxes placed in the RB and the CV.

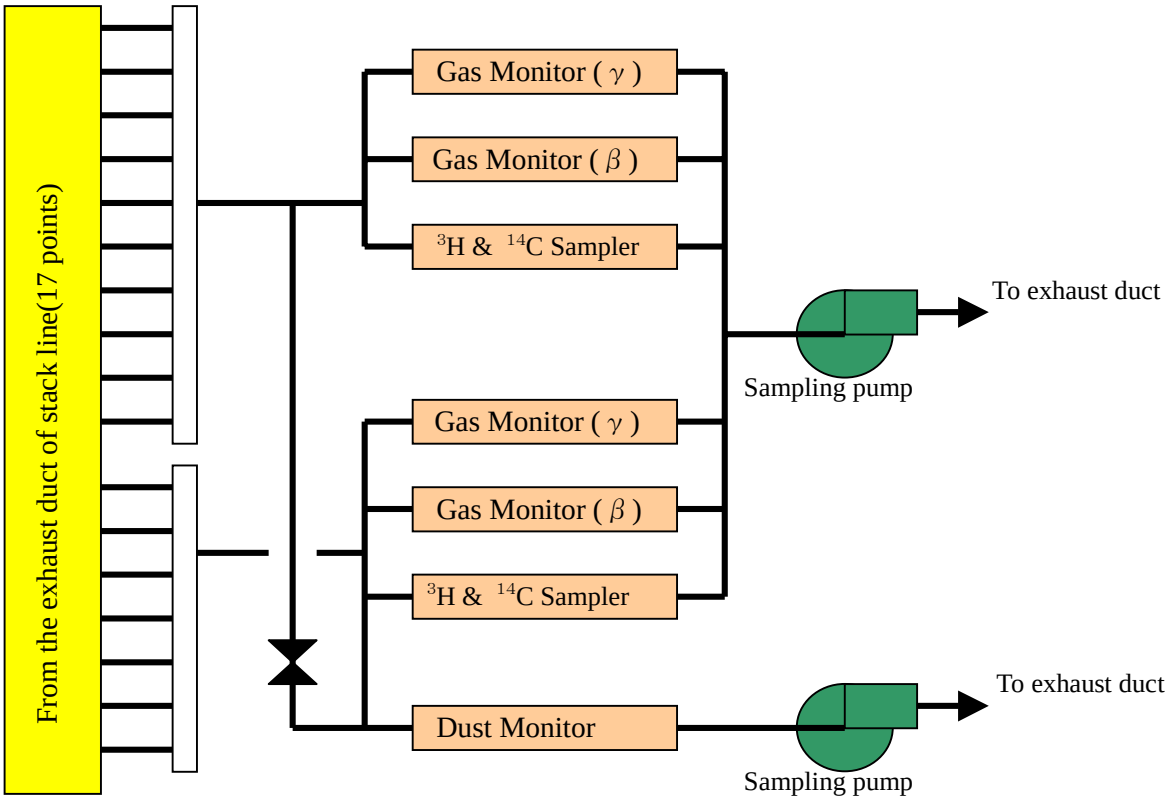

Figure 3 Schematic diagram of workplace air monitoring equipments for the reactor building

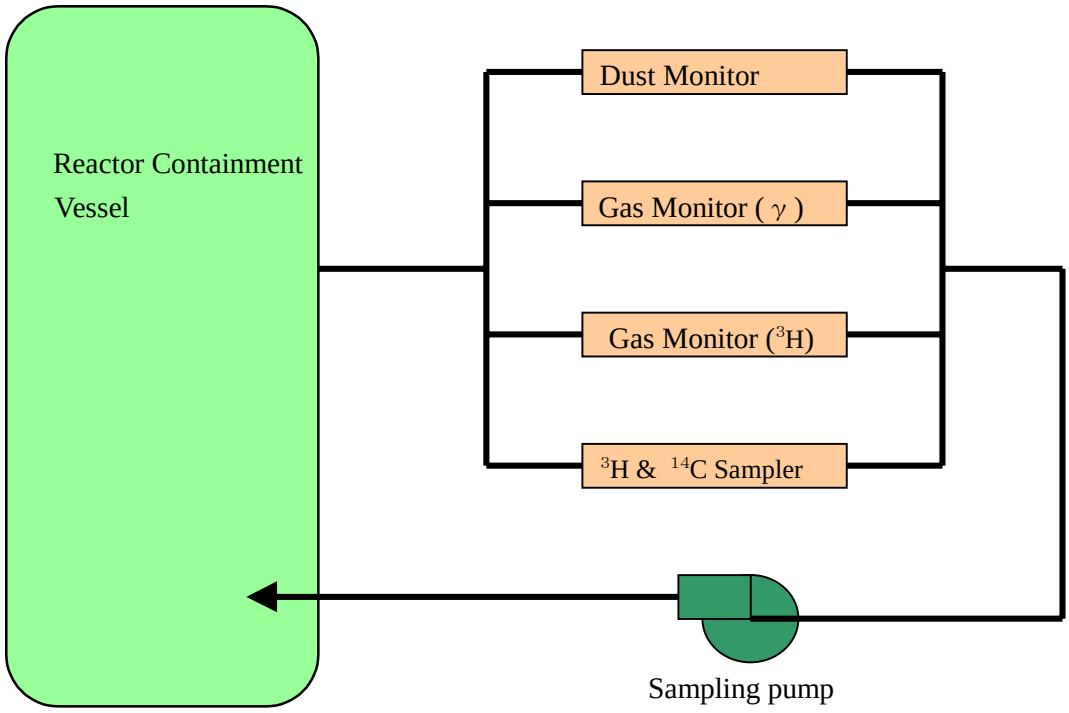

Figure 4 Schematic diagram of workplace air monitoring equipments for the reactor containment vessel

(3) Dose rate monitoring equipments

There are ten channels of gamma-ray area monitor using silicon semiconductor detector in the RB. And in the CV, there are two channels of accident gamma-ray area monitor, one channel of neutron area monitor using BF_3 proportional counter, and one channel of gamma-ray area monitor using ionization chamber because it is too severe environment about temperature and humidity to use the semiconductor. Each area monitor has the spot indicator at the monitoring place except the accident monitor. Usually, it indicates dose rate. If the value of indicator exceeded the alarm level, it shows the message, “Confirm Dose Rate” or “Escape immediately” by LED (Light Emitting Diode) panel, and makes the announcement over the speaker according to the dose rate level.

COMPUTER SYSTEM

The computer system is composed of two server computers and eleven client computers. It has installed the Windows NT as OS (Operation System) and connected with the LAN (Local Area Network) of the Oarai Research Establishment of the JAERI through the local router. Therefore the monitoring data can be watched at the other section of the Radiation Control Division. The outline of this system is shown in Figure 5.

Monitoring data and reactor process information are collected every ten seconds by the data collecting computer and saved into the server computer. These data can be shown on the client computers as a present monitoring view, a trend graph view of the monitor’s indication, and a working state view of the monitoring equipments mainly. The client computers also have the functions of start and stop of the sampling blower, changing the sampling lines and dust monitoring filters, automatic calibration of the rate meter modules, analyzing of temporally released radioactivity, and making the documents for radiation control works such as a record of released radioactivity, an alarm record of the monitors, a periodical record of indicated value of monitors, a dose equivalent record by APD (Alarm Pocket Dosimeter), etc.

(1) Automatic emergency call unit

In the out of working time, if the monitoring equipments gave the alarm or the computer system broke down, the automatic emergency call unit calls radiation control staff in turn to let them know the alarm message. The receiver has to input the code number to the phone and could hear the message. It will be continued to call until someone answers. The message is made up by combination of some alarms occurred in the fixed period from the first one. There are four kinds of alarm on the monitors, such as investigation level, low alarm level, high alarm level, and troubles. And it is possible to set the calling order of the staff according to the kind of alarms separately.

(2) Personal dosimeter checking gate and Personal dose data processing unit

The personal dosimeter checking gate applied a radio wave sending element (called PASSIVE INTEGRATED TRANSPONDER; registered trademark of the IDENTIFICATION DEVICES, INC. in the U.S.) has installed at the entrance of controlled areas for confirming of wearing the personal dosimeter with touch-free. When a person is passing through the gate, it sends the radio wave from the built-in antenna and reads the PIN (Personal Identification Number) in the radio wave returned from the element. And then, the name of persons who entered in the controlled areas is shown on the display at the entrance. If a person who has not worn the personal dosimeter passed through the gate, the unit announces, “You could not enter because you have not worn the personal dosimeter” to let that person know.

There are two hundreds of the APD prepared at the entrance of the controlled areas. If radiation exposure of workers were expected to exceed the detectable limit, they have to wear the APD during the radiation work. The data of individual dose equivalent are processed, and a record of radiation exposure of which every works and every divisions will be made automatically.

(3) Expert supporting unit

The staffs of radiation control are expected quickly dealing with urgency. This unit is installed the application soft wear produced by Gensym Co. named G2 for supporting of AI (Artificial Intelligence) development. The rules for presuming of the cause and the dealing way of the action to radiation control works could be easily revised by experiences on the operation. When the monitors gave the alarm, the expert supporting unit presumes the cause of unusual radiation levels and shows them how to do. If the dose rate increased, this unit can show the influence range of radiation at the area on the computer screen.

CONCLUSION

In the future, the JAERI has scheduled reactor performance test and full power operation. This system is expected to make radiation control works effectively and efficiently. It will be necessary to improve this system by knowledge obtained from the experiences accumulated under operation of the HTTR.

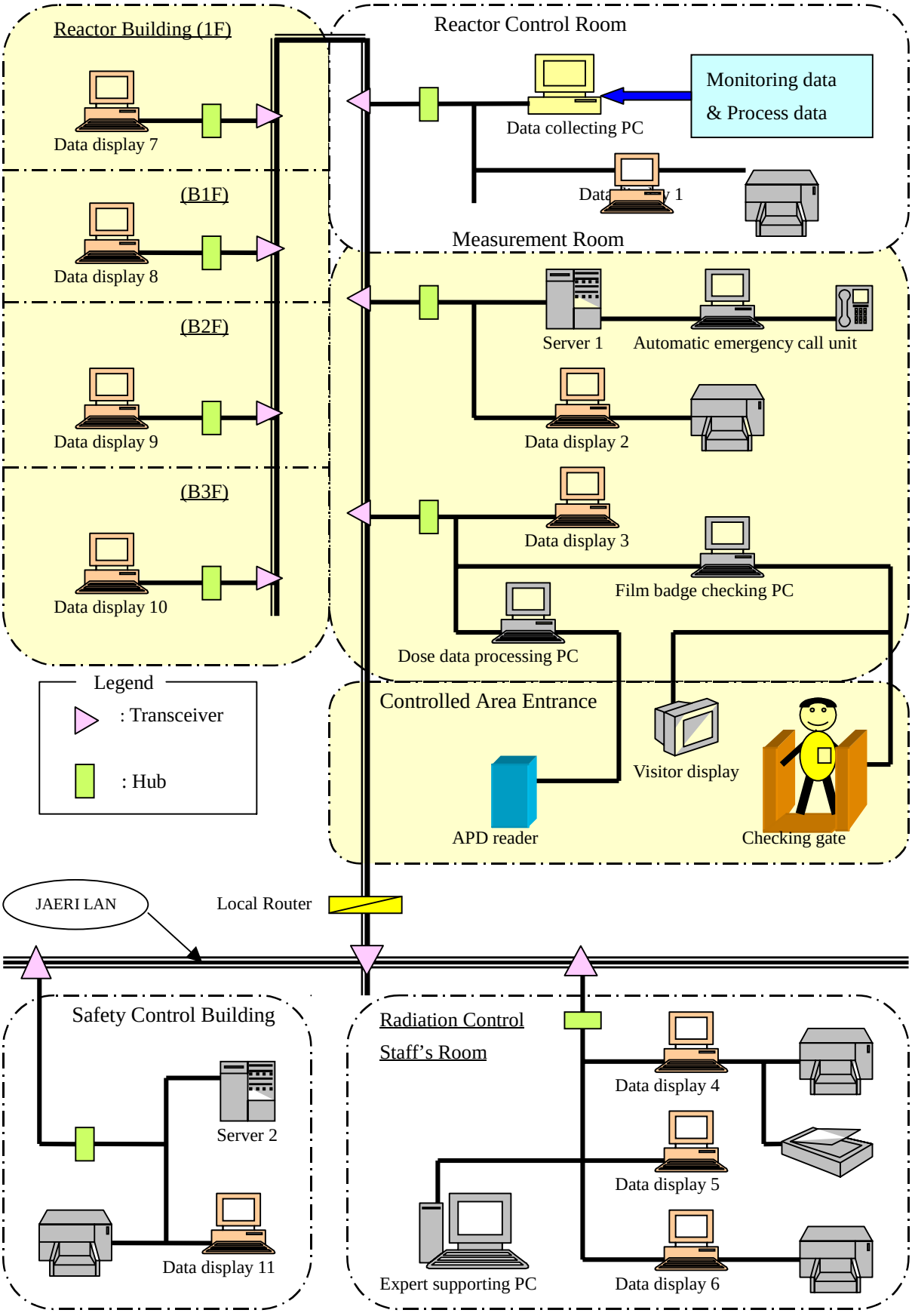

Figure 5 Radiation monitoring computer system on the HTTR