6. Instrumentation and Control System

6.1 Instrumentation System

(1) Nuclear instrumentation system

The nuclear instrumentation system of the HTTR is composed of the wide range monitoring system (WRMS) and the power range monitoring system (PRMS).

The WRMS should be available as a post accident monitor under accident conditions such as rupture of the primary concentric hot gas duct. Therefore, the neutron detector for this system had to be developed in JAERI through an accelerated irradiation test at up to 600℃ in the JMTR. The WRMS is used to measure the neutron flux from 10^{-8}% to 30% of the rated power. Three fission chambers are installed in the permanent reflector blocks through the stand-pipe shown in Fig.Ⅱ.6.1.

The PRMS is used to measure the neutron flux from 0.1% to 120% of the rated power. The PRMS is also used as the sensor for the reactor power control system. It is difficult to monitor the whole reactor core because the temperature and neutron flux level in the reactor pressure vessel become very high in full power operation. Accordingly the detector of the PRMS is required to be located outside the reactor pressure vessel as shown in Fig.Ⅱ.6.1. Therefore, the detector has a high sensitivity so as to detect the neutron flux at a very low level.

(2) In-core temperature monitoring system

In order to monitor the core outlet temperature of the primary coolant, seven thermocouples are arranged in the hot plenum blocks below the reactor core as shown in Fig. Ⅱ.6.2. The N-type thermocouple (Nicrosil-Nisil) is selected because the temperature of the primary coolant in the hot plenum reaches about 1000℃ at the rated power operation. The coating materials for the N-type thermocouple have been developed in order to avoid carburization of sheath material by carbide deposits.

(3) Fuel Failure Detection System

The fuel failure detection system is composed of precipitators, a pre-amp, a control

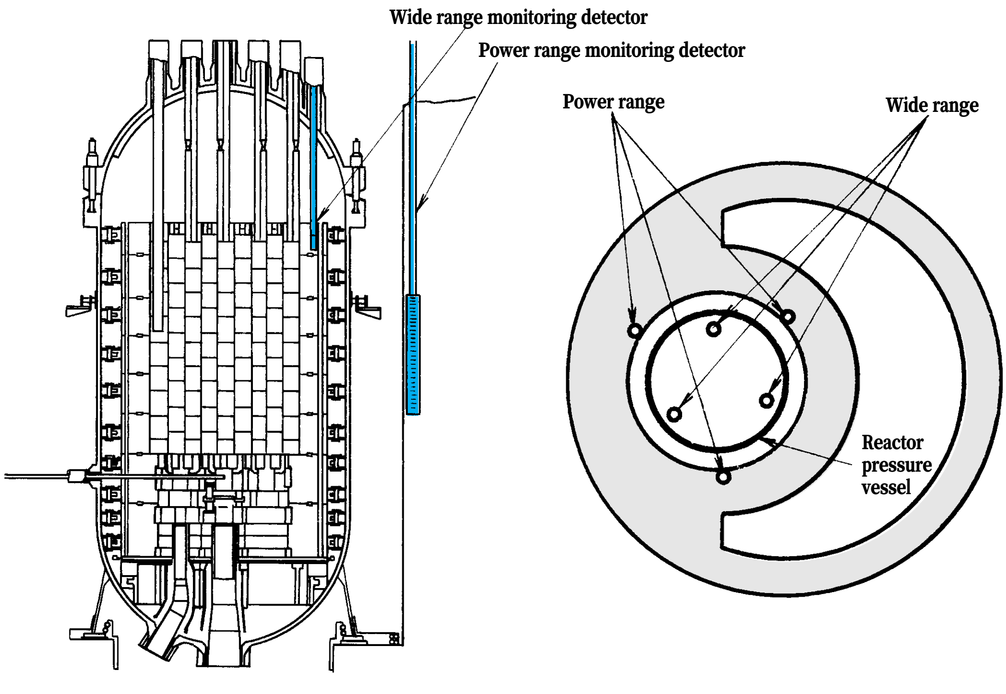

Fig. Ⅱ.6.1 Neutron detector arrangement.

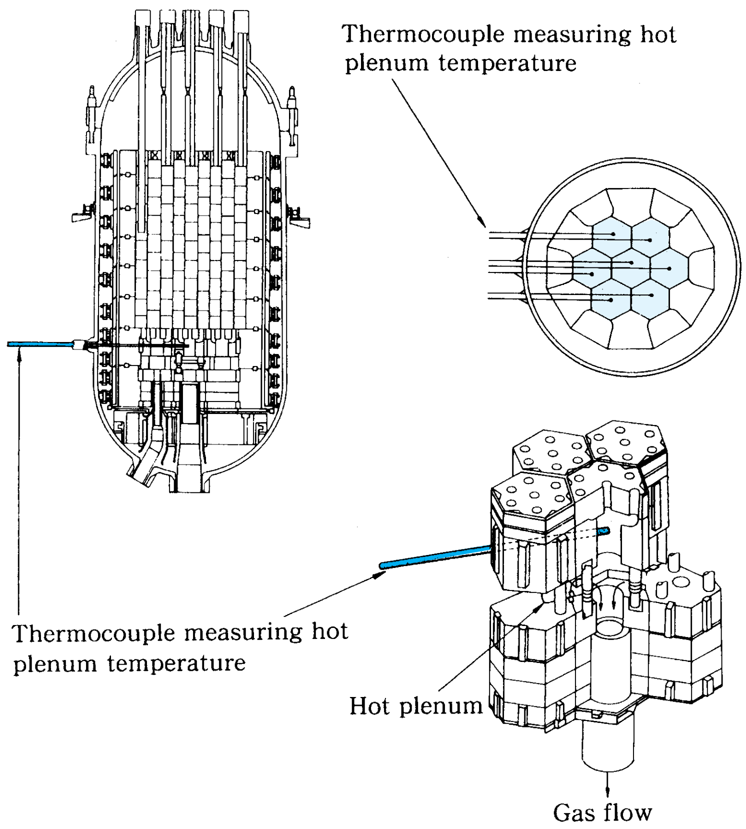

Fig. II.6.2 Thermocouple arrangement for core outlet temperature measurment.

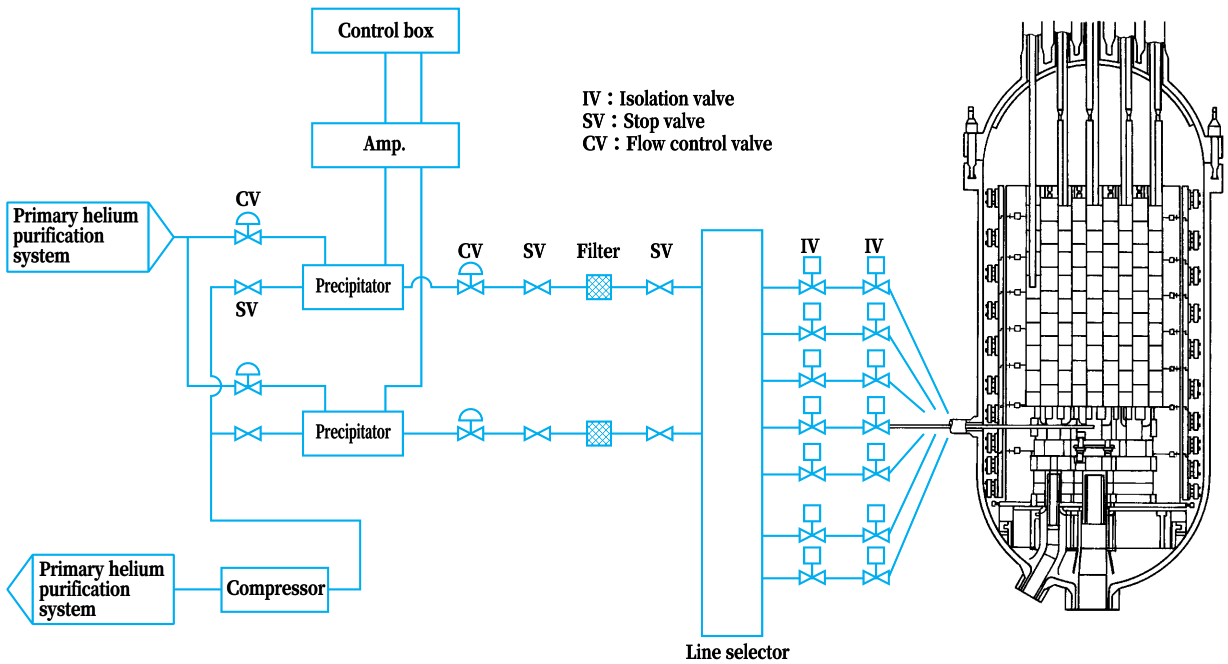

Fig. II.6.3 Fuel failure detection system.

box, etc. as shown in Fig. II.6.3. The precipitator is used in order to detect β rays radiated from the short-lived gaseous FPs such as ^{88}Kr, ^{89}Kr and ^{138}Xe from the failed fuel particles.

6.2 Reactor Control System

The reactor control system of the HTTR is designed to assure high stability and reasonably damped characteristics against the various disturbances during the operation. The reactor control system consists of the operational mode selector, the reactor power control, and plant control systems. The operational mode selector is designed to select several mode operations such as the rated power operation, the high temperature test operation, the safety demonstration test operation, the irradiation test operation and so on.

The reactor power control system consists of the power control and reactor outlet coolant temperature control devices. The reactor outlet coolant temperature control device is an upper one to give demand of reactor power to the power control device as shown in Fig. II.6.4.

The plant control system controls the plant

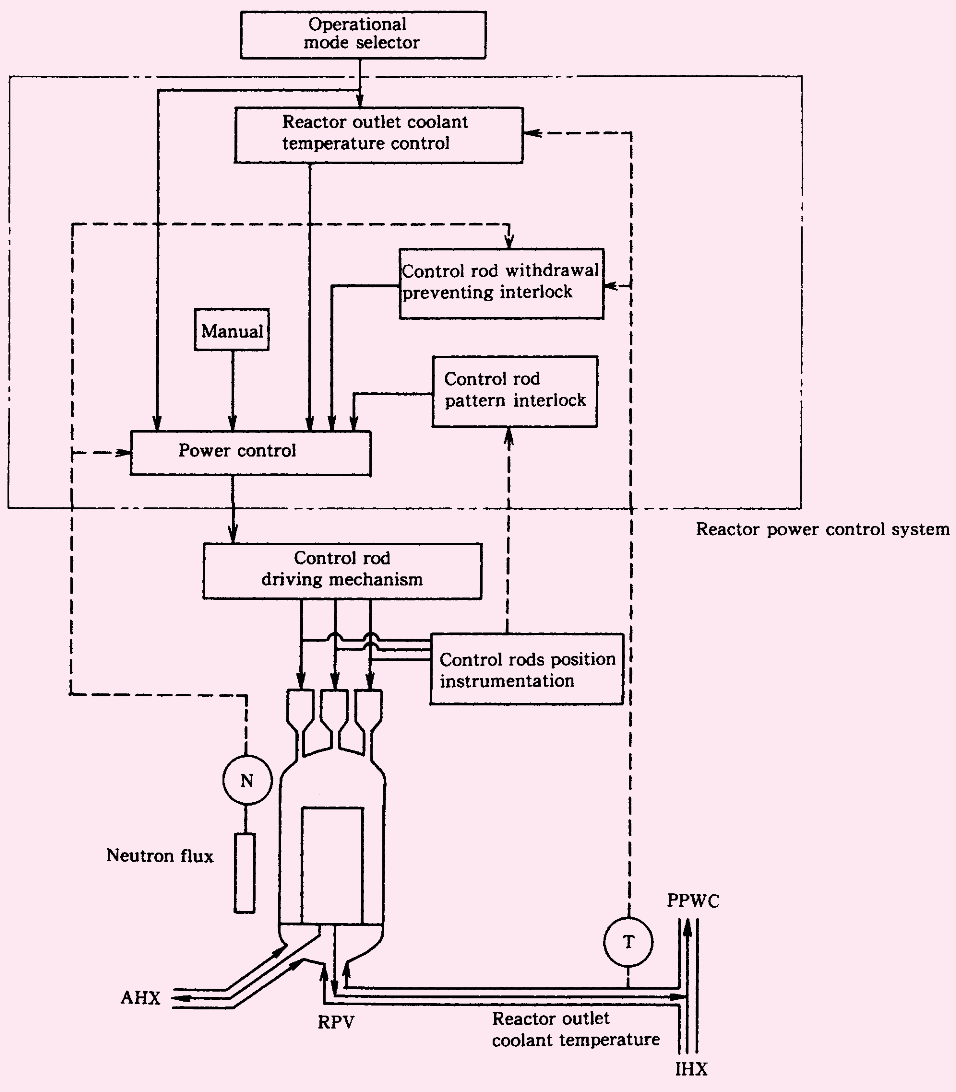

Fig. II.6.4 Schematic diagram of reactor control system.

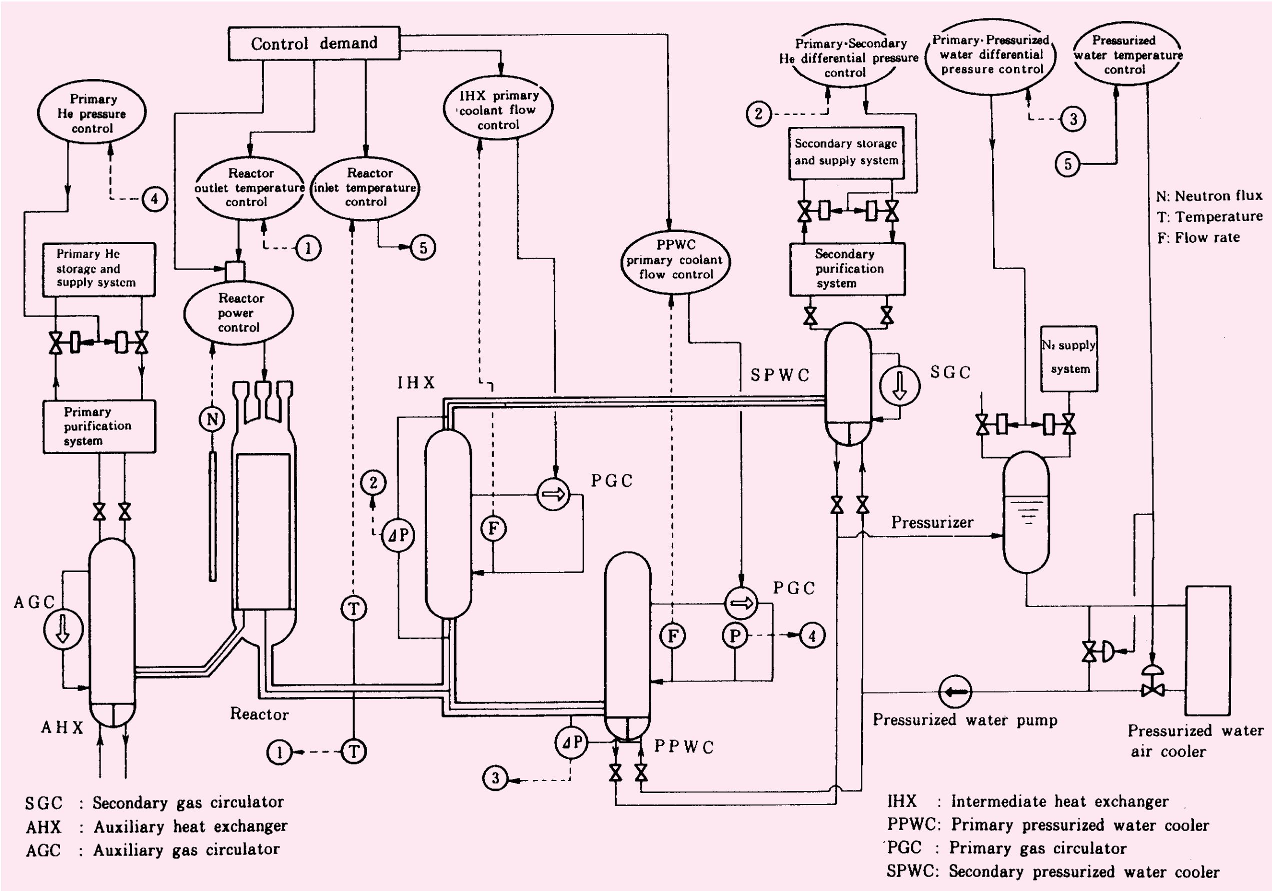

Fig. II.6.5 Schematic diagram of plant control system.

parameters such as the reactor inlet coolant temperature, the primary coolant pressure and differential pressure between the PCS and the PWCS or SHCS. The schematic diagram of plant control system is shown in Fig. II.6.5.

6.3 Safety Protection System

The safety protection system consists of the reactor protection and engineered safety features actuating systems. It is designed with 2-out-of-3 circuit logic and 2-trains. The signals in the safety protection system are listed in Table II.6.1. The reactor protection system of the HTTR automatically initiates a reactor scram by inserting the control rods. The engineered safety features actuating system of the HTTR is designed to arrest the release of the FP and to ensure the integrity of the core, the reactor coolant pressure boundary and the containment vessel boundary against unexpected conditions during abnormal operational transients and accidents such as a concentric hot gas duct rupture.

Table Ⅱ.6.1 Items of safety protection system.

Reactor scram signals in reactor protection system	
WRMS	high
PRMS	high
IHX primary coolant flow rate	low
PPWC He flow rate	low
Primary coolant radioactivity	high
IHX outlet primary coolant temperature	high
Reactor outlet temperature	high
Core differential pressure	low
PPWC pressurized water flow rate	low
Primary/pressurized water differential pressure	high
Primary/pressurized water differential pressure	low
Primary/secondary He differential pressure	large
Secondary He flow rate	low
Seismic acceleration	large
Manual	—

Engineered safety features	Signals	
CV isolation	CV pressure	high
	CV radioactivity	high
	Primary/pressurized water differential pressure	low
	Primary purification flow rate	high
	SA radioactivity	high
	Manual	—
ACS start-up	Reactor scram	—
	Manual	—
Auxiliary water isolation	Primary/auxiliary water differential pressure	low
	Manual	—