

Shutdown System Design for HANARO and CNS Trip

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1. Introduction

The cold neutron technology is to research the material structure in nano levels and the low energy dynamics in the meV ranges, which is only possible due to the unique scattering characteristics of cold neutrons with the wavelength range of 4~20 [1]. The HANARO cold neutron source (CNS) project was initiated in 2003. The basic design of the CNS system has been completed. This paper introduces a shutdown system design for the HANARO reactor and the CNS facility itself.

2. Cold Neutron Source System

The CNS, to be installed in the vertical hole of the reflector tank at the HANARO, is the facility in which thermal neutrons pass through liquid hydrogen at 20 K then they are moderated down to a cold neutron in the range of 0.1 and 10 meV.

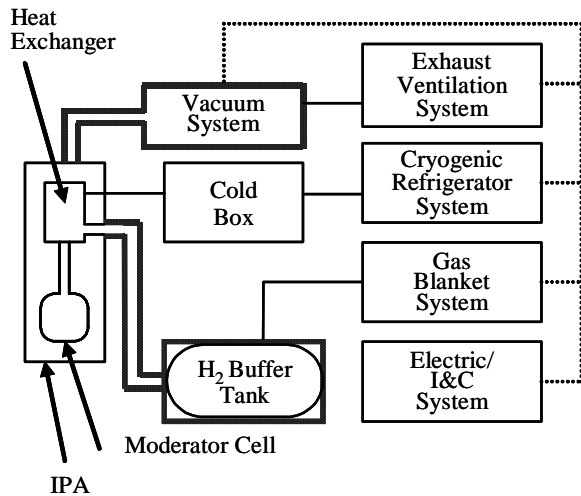


Figure 1. Schematic diagram of the CNS process.

Fig. 1 shows the schematic diagram of the CNS. The process system of the CNS consists of the IPA (In-Pool Assembly) including a moderator cell and a heat exchanger, the cryogenic refrigeration system, the gas blanket system, the vacuum system, the exhaust ventilation system, etc. The heat exchanger is installed to remove the heat from the moderator and the moderator cell heated by radiation. The moderator, in two phases, circulates in the thermo-siphon loop. The moderator cell and the heat exchanger are located in the vacuum chamber. The safety classification of the CNS

system is summarized in Table 1 based on the MOST rule 2002-21, "Safety class and the applicable standards to nuclear reactor facilities" that is a Korean version of ANSI N51.1-1983(R1988), "Nuclear safety criteria for the design of stationary pressurized water reactor plants". Three safety classes (SC-1, SC-2, SC-3) are established and are relied upon to accomplish the nuclear safety functions. A fourth safety class, Non-Nuclear Safety (NNS), is defined for the equipment, not included in the SC-1, SC-2 or SC-3 that is not required to accomplish the nuclear safety functions [2].

Table 1. Safety classification of the CNS system

System	Safety class	Quality class	Seismic class
IPA	SC-3	Q	I
Hydrogen	NNS	T	II
Vacuum	NNS	T	II
Gas Blanket	NNS	T or S	Non
Cryogenic Refrigerator	NNS	S	Non
Exhaust Ventilation	NNS	T	II or Non
I&C/Electric	NNS	T or S	Non

The Instrumentation and Control (I&C) system of the CNS consists of a control and monitoring system and a shutdown system [2]. The I&C system is designed to achieve the following objectives;

- Shutdown of the reactor and the CNS facility
- Accomplishment of safe and accurate control functions in the moderator thermo-siphon and process behavior
- Provision of sufficient and various monitoring and alarming functions
- Comprehensive support for start-up, operation, maintenance, and shutdown of the facilities
- Interface with the HANARO reactor system

The I&C system is classified as the NNS grade, as shown in Table 1, but it should have a high reliability, considering the importance of the dedicated safety function, which is to shut down the reactor in the case of some abnormal conditions in order to protect the components or systems of the CNS. Most of the control functions are accomplished by the main control computer system by an automatic control mode. A manual mode is also provided for an operational flexibility. An independent digital control system is used for the control and monitoring of the cryogenic refrigeration system. All the controllers and the Human

Machine Interface (HMI) systems are connected together by a redundant network system to compose an integrated system. The HMI system is a PC-based operator workstation using a general operating software. The HMI system is a PC-based operator workstation using a general operating software. Operation is performed in three locations, reactor control room, CNS instrumentation room in the reactor hall and an auxiliary control room in the CNS auxiliary building, to support the flexible operation policies. The start-up and shutdown operation of the CNS will be done by a CNS system engineering group from the CNS instrumentation room. But the normal operation is performed by the reactor operation group in the reactor control room. To support the maintenance activities, another operator station is installed in the CNS auxiliary building. Most functions are controlled with an automatic algorithm in the controller except for the start-up and shutdown.

3. Shutdown System Design

Main purpose of the shutdown system is to shut down not only the main devices to protect the CNS but also the reactor. The shutdown system is designed as the NNS system. It is based on the basic assumption that any dangerous condition for the reactor should not occur due to any events in the CNS including a hydrogen explosion in the vacuum chamber. The vacuum chamber will be designed to maintain its' physical integrity for all the design base events including an explosion, heating, and the static pressure of the water in the reactor pool. The shutdown system is also to protect the CNS facilities by a shutdown of the CNS system itself.

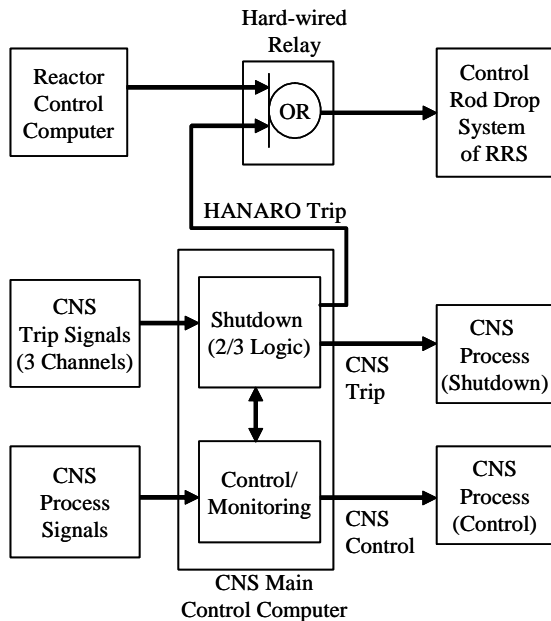


Figure 2. Block diagram of the shutdown system.

Fig. 2 shows a block diagram of the shutdown system. The shutdown signals are measured by 3 channels. The trip logic for the reactor trip and the CNS trip is composed of a '2 out-of 3' coincidence logic in the control computer system to improve the reliability of the shutdown function. The trip signals caused by the CNS facility are connected to the control absorber rod drop system belonging to the HANARO RRS (Reactor Regulating System), which is classified as a non-safety system. Fig. 3 shows the shutdown logic diagram for the HANARO trip and the CNS trip. The shutdown logic is designed by a fail-safe concept. The trip signals for the CNS shutdown are used for the shutdown of the main CNS facility. The trip parameters for the reactor trip and the CNS trip will be selected through a analysis of the operating conditions and the design limits of the components.

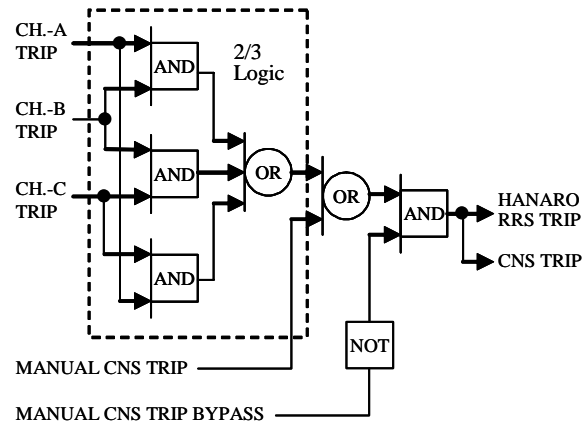


Figure 3. Logic diagram for shutdown.

4. Conclusion

The I&C system for the CNS consists of a control and monitoring system and a shutdown system. The shutdown system is classified as the NNS system. The shutdown logic for the HANARO trip and the CNS trip is designed to have a high reliability. The trip parameters will be selected in the detail design stage of the process system.

Acknowledgement

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References

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- [2] Y. K. Kim, et al., "Conceptual Design of Facilities and Systems for Cold Neutron Source in HANARO," KAERI/TR-2768/2004, Korea Atomic Energy Research Institute (2004).