Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 7-8, 2015

Design of the Control System for Engineered Safety Features of KIJANG Research Reactor

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1. Introduction

The KIJANG Research Reactor (KJRR), which started on the 1st of April 2012, is an open pool type reactor with 15 MW of thermal power. The main goals of KJRR are to self-sufficiently supply radioisotopes (RI), improve the production capacity in Neutron Transmutation Doping (NTD), and conduct research on reactor-related technologies [1].

The purpose of this paper is to design an effective control system for the Engineered Safety Features (ESF) of KJRR such as the Safety Residual Heat Removal System (SRHRS) pumps and Siphon Break Valve (SBV) without an Engineered Safety Features-Component Control System (ESF-CCS).

This control system is called a "local motor starter", because this system controls motors in the SRHRS pumps and SBVs by receiving the signal from Reactor Protection System (RPS) and Alternate Protection System (APS) when the differential pressure or pool level reach the set points.

In this paper, the design concepts and requirements of the local motor starter based on the design features of KJRR is proposed.

2. Technical Background

There are various ESFs including the Confinement Isolation Damper (CID), SRHRS pump, and SBV in KJRR.

If an abnormal release of radioactivity is detected, CIDs installed in the supply and exhaust ducts penetrating the building boundary wall are closed automatically by the RPS to confine the contaminated air within the reactor building.

When the Primary Cooling System (PCS) pumps stop either normally or abnormally, the SRHRS pumps provide an adequate downward flow through the reactor core to eliminate the residual core heat.

SBVs for the reactor outlet PCS pipes and the reactor inlet PCS pipes are installed to guarantee pool water inventory during a Loss of Coolant Accident (LOCA).

ESF-CCS, which is a kind of instrumentation and control system, was designed to control all safety-related systems including an ESF for the consequential mitigation of an accident in a power plant. However, a local motor starter that individually controls SRHRS pumps and SBVs is needed in KJRR, because an ESF-CCS that integrally controls the ESF does not exist.

There are some differences between an ESF-CCS and local motor starter. An ESF-CCS is composed of various digital components, conducts 2 out-of 4 logic by receiving the signals from each channel of the RPS, and determines whether or not the ESF is operating. On the other hand, the local motor starter consists of simple analog relay circuits and only operates the SRHRS pumps and SBVs through RPS actuation signals.

3. Design Requirement

The local motor starter shall open and close the Motor Operated Valve (MOV) type SBVs by receiving a 24V DC signal from the RPS and should operate SRHRS pumps within a limited time.

If SBVs are an integral type, the same voltage power shall be provided. However, in the case of a conventional type, a variety of voltages shall be provided for motors (460V AC), space heaters (120V AC), and so on. Therefore, a conventional type should transform the normal electric power (Class IV) into the rated voltage power for each component of the SBVs.

If SRHRS pumps and SBVs use Alternating Current (AC) motors, a starting torque of several hundred percent at the rated voltage occurs when the AC motors start to operate. This starting torque has a bad influence on the other circuits and equipment, causing a momentary voltage drop. To decrease the starting torque and optimize the Class 1E power loads, the local motor starter should provide a reduced voltage starting function for AC motors.

The local motor starter shall be equipped with circuit breakers for the breaking of the fault current and overcurrent protective relays for the overcurrent protection.

The shape of local motor starter shall be adhered to the SRHRS pumps and SBVs or be individually separated to enable a remote control.

Proven techniques should be used for the local motor starter to conduct safety-related functions through the proper inspections including an Equipment Qualification (EQ) corresponding to safety class 3, seismic category I, quality class Q, and electric class 1E.

4. Actual Design

An ESF including SRHRS pumps and SBVs in KJRR receives 1E class uninterruptible power and consists of two independent trains to satisfy the requirements of a single failure criterion and diversity.

The 1E class Uninterruptible Power Supply (UPS) systems of KJRR (125V DC and 120V AC) are independently triplicated to ensure the redundancy of RPS [1,2].

To maintain the principal design concepts of the independence and diversity in terms of the power supply plan, each train is connected to 2 out of 3 different channels of the UPS.

The safety class inverters and distribution panels are additionally designed for the DC uninterruptible power supply of AC motors in the SRHRS pumps and SBVs.

Figure 1 shows the concept of the power supply plan for the SRHRS pumps and SBVs using the local motor starters in KJRR. As shown in the figure 1, the local motor starters control the SRHRS pumps and SBVs by receiving 125V DC uninterruptible power from the batteries and a 24V DC control signal from the RPS and APS.

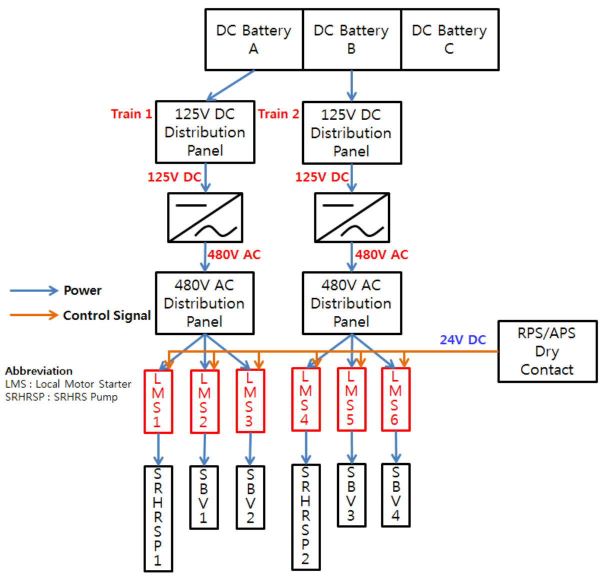

Fig. 1. Schematic diagram of the power supply plan for SRHRS pumps and SBVs using the local motor starter in KJRR.

In comparison with the power plants, the local motor starter in KJRR is made up of simple analog relays, because this equipment simply performs the starting of SRHRS pumps and the opening and closing of SBVs without any calculations.

The local motor starter for the SRHRS pumps needs only one relay for the on/off control, and the local motor starter for SBVs needs one more relay for the forward/reverse rotation. Figure 2 illustrates the composition of the local motor starter for the SBVs in KJRR.

As shown in figure 2, the 480/120V AC transformer is added to the local motor starter of a conventional type SBVs for the power supply of a space heater. In addition, special starting methods such as the Y-Delta, soft starter, and so on are considered for the reduced voltage starting function to decrease the starting torque.

The local motor starter is physically separated from the controlled systems and applies a remote control. The installation position shall be selected in consideration of the importance of the system, distance from the controlled systems, radiation effect, and accessibility.

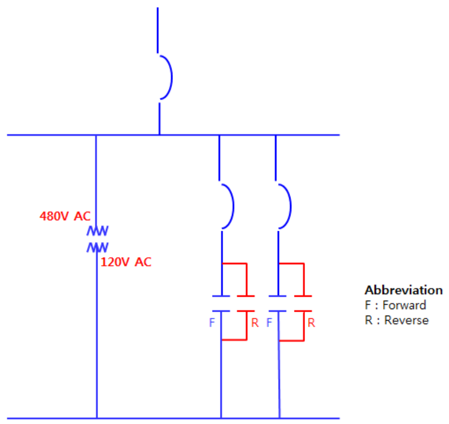

Fig. 2. Block diagram of the local motor starter for SBVs in KJRR.

5. Conclusions

An ESF is a safety system that mitigates consequences of the Anticipated Operational Occurrence (AOO) and Design Basis Accident (DBA). Various ESFs have been designed for the decay heat removal and limitation of release of radioactive materials in a KJRR [3].

An effective method for individual control of various ESFs is essentially needed, because an ESF-CCS for the integral control is not designed for a KJRR. This paper proposes the design concepts and requirements for a control system of an ESF using a motor such as the SRHRS pumps and SBVs.

The results of this paper are able to be used for the development of control systems for research reactors similar to KJRR. The precondition for such application is to have a few ESFs and conduct simple logic. The proposed control system called a local motor starter is being designed, and a manufacture of the actual systems is expected in the foreseeable future.

REFERENCES

[1] Hagtae Kim, Jun-Yeon Kim, Seung-Gyu Doo, Yong-Su Cho, Conceptual Design of Electrical System for KJRR, Transactions of the Korean Nuclear Society Spring Meeting, May 29-30, 2014.

[2] Hagtae Kim, Jun-Yeon Kim, Hong-Jun Park, Analysis of the Design Requirement for the Electrical System of KIJANG Research Reactor, Publications of the Korea Academia-Industrial Cooperation Society Fall Meeting, November 28-29, 2014.

[3] Hagtae Kim, Jun-Yeon Kim, Hee-Taek Chae, Kye-Hong Lee, Tae-Hyun Kwon, Jee-Young Kim, Yong-Hwan Yoo, Ju-Yeon Sim, So-Young Kim, Yong-Su Cho, A Study on the Power Supply Plan for Major System and Equipment of KIJANG Research Reactor, Korea Atomic Energy Research Institute Technical Report, KAERI/TR-5731/2014, 2014.