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Qualified Indication and Alarm System – PAMI Design

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1. Introduction

Instrumentation and control systems are designed in full digital system for human interfaces and high reliability. In Shin-Kori 3 and 4, the instrumentation and control systems utilize the standardized platform for both safety system and non-safety system. Qualified Indication and Alarm System – Post Accident Monitoring Instrumentation (QIAS-P) is safety related system that displays the variables for accident monitoring. QIAS-P performs the core condition monitoring of saturation margin calculation, reactor vessel monitoring, and core exit temperature calculation. In addition to the core condition monitoring, it monitors post accident variables. In this paper, the design of QIAS-P is described.

2. System Design

In this section the QIAS-P system is described. The description includes system inputs and display outputs. The selection of the variables for the system is described.

2.1 System Function

The indicators and recorders for accident monitoring were dedicated for each variable in the conventional control room. Thus there were many indicators and recorders for the accident monitoring. Among these accident monitoring instruments, the variables related to the safety were gathered and displayed at the dedicated display of the QIAS-P. The QIAS-P is a redundant system in Channels A and B; each QIAS-P interfaces with dedicated Flat Panel Displays (FPD) in the main control room (MCR). The main function of QIAS-P is to monitor the inadequate core cooling condition and post accident variable monitoring. The inadequate core cooling monitoring is required as part of Three Mile Island action items [1]. For inadequate core cooling monitoring, it receives inputs from heated junction thermocouple (HJTC), core exit thermocouples (CET) and Pressurizer pressure and RCS temperature. Individual CET temperatures are displayed at each location along with highest CET temperature in each core quadrant and a representative CET temperature. The CET saturation margin is calculated based on the representative CET temperature. The reactor vessel level is calculated based on eight sensor locations of heated and unheated thermocouple outputs. The HJTC calculates the difference in temperature between the heated and unheated thermocouples. When water surrounds the heated thermocouples, the voltage difference between a HJTC pair becomes low. If the heated thermocouple is uncovered, the temperature of the heated thermocouple increases resulting in an increase in differential temperature between the heated and unheated thermocouple pair. When the differential temperature rises above a predetermined setpoint or the unheated thermocouple temperature rises above a predetermined setpoint, coolant level is below this HJTC position.

The Saturation temperature is calculated from the Pressurizer Pressure input. The Saturation Pressure is calculated from the maximum temperature input. The temperature saturation margin is the difference between saturation temperature and the maximum temperature input. The pressure saturation margin is the difference between saturation pressure and the pressure input. The temperature and pressure saturation margins are calculated for each major temperature location: RTDs in the Reactor Coolant System (RCS); maximum of the top three unheated HJTC thermocouples in the upper head; and the representative CET temperature. The minimum of the RCS and upper head saturation margin is also calculated to give the operator the best indication to monitor possible saturation conditions.

In addition to core cooling monitoring, the QIAS-P displays variables of RCS conditions and containment conditions for post accident monitoring. The RCS pressure, Pressurizer level, logarithmic power level, RCS temperature, steam generator level and pressure are monitored for RCS conditions. The containment radiation level, containment pressure, hydrogen density, auxiliary feed water storage tank level and containment isolation valve positions are monitored.

2.2 Variable Display

The QIAS-P receives and processes post accident monitoring variables specified in the RG 1.97. The variables to be monitored are selected according to usage and need in the plant Emergency Response Guidelines [3]. They are assigned design and qualification Category 1, 2, or 3 and classified as Type A, B, C, D, or E. QIAS-P is safety related system such that only category 1 variables are displayed. The variable classification is defined based on their role during the accident. The category is classified based on the importance of the variable display. The minimum

set of variables is described in the RG 1.97 guidelines depending on the type of the reactor. The design was such that the variables specified on the guidelines are processed for post accident monitoring.

The display design is based on the human factor guidelines. The symbols and legend and its color scheme is determined based on human factor guidelines. The display for the saturation margin monitor is shown at the Figure. 1. It describes the saturation margin conditions for each parameter along with graphical view. Figure 2 shows the containment isolation displays of the system. The display shows the on/off status of the valves with different symbol depending on the valve type.

Fig. 1. Display of Saturation Margin of QIAS-P

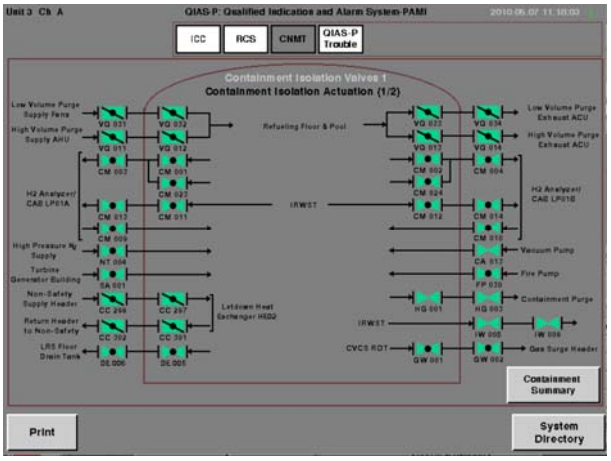

Fig. 2. Display of Containment Isolation Valves of QIAS-P

2.3System Design and implementation

The system receives its input signal for HJTC sensors, CETs, and RCS temperatures directly from field. The input signals that are shared with other safety system such as PPS come from APC-S (Auxiliary Process Cabinet-Safety). The valve status signals come to the system via safety channel network AF100. The system consists of PLCs (Programmable Logic Controller) with input and output devices and flat panel display for operator display and maintenance panel. The PLC processes input signals for HJTC, CET, RCS temperature. The input signals for the status display goes to flat panel display (QIAS-P Display and MTP) through the safety network. The system configuration of the QIAS-P and the input, output signal interfaces are shown at Figure 1. Portions of the input signals of HJTC and CET are isolated and sent to the Diverse Indication System against common mode failure. The QIAS-P is classified as safety related system and designed in accordance with related standards [2].

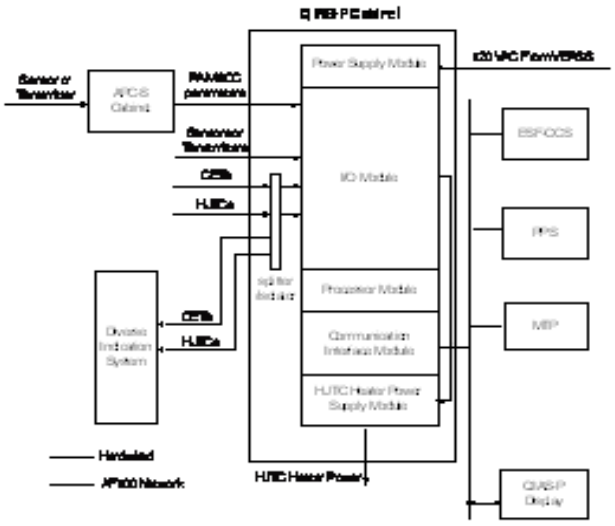

Fig.3. System Configuration and Interfaces of QIAS-P

3. Conclusions

QIAS-P has been described along with the display pages of the system. The QIAS-P is designed to monitor the core cooling conditions of saturation margin and reactor vessel level, and to monitor the variables for RCS and containment variables for the post accident conditions. The variables to be monitored are specified in the Regulatory Guide 1.97. The QIAS-P provides the safety grade signals for the post accident monitoring at one display. This will enhance the operator action for the accident conditions by providing relevant displays of reliable qualified variables at one display.

REFERENCES

[1] NUREG-0737, Section II.F.2, Instrumentation for Detection of Inadequate Core Cooling, November 1980.
[2] USNRC Reg. Guide 1.97, Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident, Rev.03, May 1983.
[3] IEEE 7-4.3.2, IEEE Standard Criteria for Digital Computer in Safety Systems of Nuclear Power Generating Stations, 1993