SDS No.2 Low Steam Generator Level and High/Low HTS Pressure Trip Instrumentation Improvement for Wolsong 1 NPP Refurbishment

Seog Hwan Jeong [a*], Jin Kwon Jeong[a], Jung Yang Lee[a], Seung Min Baek[a], Ho Won Lee[b]
[a]*Korea Power Engineering Company, Inc., 1045 Daedeok-daero, Yuseong-gu, Daejeon, 305-353*
[b]*Korea Hydro & Nuclear Power Co. Ltd, 260 Naah-li,Yangnam-myeon, Gyeongju-si,Gyeongsangbuk-do, 780-715*
[*]*shjeong1@kopec.co.kr*

1. Introduction

In Wolsong Nuclear Power Plant Unit 1 (Wolsong-1), the Shutdown System (SDS) #2 low steam generator (SG) level trip provides protection against secondary side failures and the high/low Heat Transport System (HTS) pressure trip provides protection against loss of heat sink / small LOCA. While the SDS #1 monitors SG #1 and #4 levels, and reactor outlet header (ROH) #1, #3, #5 and #7 pressures, the SDS #2 monitors the parameters for SG #2 and #3 levels, and ROH #1 and #5 pressures. This refurbishment is to add the instrumentation for SG #1 and #4 level parameters and ROH #3 and #7 pressure parameters to enhance the effective trip coverage, redundancy and diversity for SDS #2.

2. The Improvement and Results

In this section, the safety system requirements adopted to Wolsong-1 are provided, then the improvement made for SDS #2 refurbishment is described.

2.1 Safety Systems and Requirements

The safety systems - SDS #1, SDS #2, ECCS and Containment - are provided to limit any release of radioactivity due to the failures in the process systems. The SDS #2 employs an independent, triplicated logic system which senses the reactor trip conditions and opens fast-acting valves releasing pressurized helium to inject gadolinium nitrate solution into the moderator. This rapid reactor shutdown is an alternative to SDS #1 operation because of economic penalty associated with the relatively long shutdown period which follows SDS #2 operation.

The SDS #2 design, by applying three channel (G, H, J) and diverse safety system design, already meets Canadian Nuclear Safety Commission (CNSC) Regulatory Document R-8. The section 3.4.2 of R-8 document requires sufficient redundancy such that no failure of any single component of a shutdown system can result in impairment of that system to an extent that the system will not meet its minimum allowable performance standards under accident conditions. The section 3.5.1 also requires diverse design that is physically and operationally independent from each other, from process systems and from other special safety systems as far as practicable.

By supplying additional trip instrumentation for low SG level (SG #1 and #4) and high/low HTS pressure (ROH #3 and #7), the effective trip coverage, redundancy and diversity will be enhanced for Wolsong-1.

2.2 The Addition of Low SG Level Trip Parameter (BSI 68338)

There are four SGs in the HTS, two in each HT loop. If there is a break on the secondary side, all four SG levels will decrease. Level measurements from one SG in each loop (i.e. SG #2 in loop 1 and SG #3 in loop 2) are provided for the SDS #2 in the current design for Wolsong-1. After this refurbishment is accomplished, level measurements from each of four SGs are provided for SDS #2.

Three sets of taps for channels G, H, J on SG #1 and #4 are added, which are independent from those used for the level control of the regulating system. Each loop consists of level transmitter, A/I signals to Programmable Digital Comparator (PDC), indicating meter, isolated signal transmitter and power supplies. In addition, pilot solenoid valves and instrument isolating valves are provided for loop testing purposes. The transmitter, isolating valves and solenoid valves shall be located in instrument room R-106 instead of R-113 which is currently full of instrument, for refurbishment. The panels for relay, power, isolator, trip logic, PDC, etc. are located in the secondary control area (SCA). The indicating meter is located in the secondary control area (SCA) and the main control panel (MCP) redundantly. The SDS #2 design concept for channel G, H and J are identical each other. Figure 1 and Table 1 show channel G loop diagram for low SG level trip and the major components to be acquired for SDS #2 refurbishment.

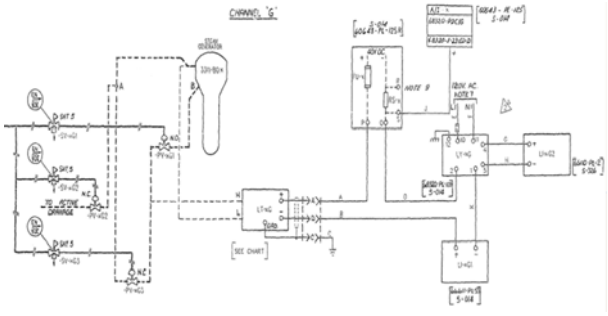

Figure 1. Loop Diagram for SDS #2 Low SG Level Trip

2.3 The Addition of High/Low HTS Pressure Trip Parameter (BSI 68333)

There are four ROHs in the HTS, two in each HT loop. If there is a loss of heat sink or small LOCA break, all four ROH pressures will increase or decrease. The pressure measurements from one ROH in each loop (i.e. ROH #1 in loop 1 and ROH #5 in loop 2) are provided in the current design for Wolsong-1 SDS #2. After this refurbishment is accomplished, the pressure measurement from each of four ROHs is provided for SDS #2. The improvement concept is same as low SG level trip addition except the instrument tubing duplication from HTS differential pressure parameters (BSI 68334) at ROH #3 and #7.

Table 1. Major Components for SDS #2 Refurbishment

Major Component	Low SG Level	Hi/Lo HTS Press
Nozzle for Level Measurement	12 ea	N/A
Transmitter	6 ea	6 ea
Isolated Signal Transmitter	6 ea	6 ea
Instrument Tube	As required	As required
Instrument Rack	3 set, integrated	
Valve	63 ea	24 ea
Vertical Indicator	3 ea	6 ea
Horizontal Indicator	3 ea	6 ea
Push Button	18 ea	12 ea

2.4 The Location for Transmitter Rack

The current SDS #2 transmitter rack is located at R-113 which is in containment and full of instrument, thus several options for rack room selection are analyzed.

One is S-031A which is outside containment near the SCA and is spacious. However, in case of the S-031A adoption for rack installment, it will require additional containment penetration for instrument tubing, zoning problem such as ventilation and drain provision, and operator's inconvenience for maintenance and testing because of a distant place between existing and newly added racks.

Another one is R-010 which is inside containment and is comparatively spacious. It has several advantages for maintenance and testing, and no further penetration and no radiation release outside containment are considered, even in the event of tube break. In the contrary, surrounded with R-010 are non-seismic evaluated pipes which require additional analysis and/or support structures.

Thus, R-106, which is inside containment, is finally selected for the appropriate one. However, the room R-106 shall be analyzed to accommodate maintenance and test inconvenience for operator, in addition to the seismic analysis for small sized pipes surrounded, furthermore.

2.5 MMI Consideration for Loop Numbers and MCP Instrument Arrangement

The current loop numbers for SG and ROH are assigned as loop 1 for SG #2 and loop 2 for SG #3 while loop 1 for ROH #1 and loop 2 for ROH #5.

By considering the human factor engineering, the loop numbers are reassigned to be consistent with component numbers, for example, loop 2 for SG #2 instead of SG #3. Therefore, all the tag numbers of instrument on the MCP, SCA, transmitter, valve, etc. for SDS #2 are reviewed and revised.

Besides, the instrument arrangement of SDS #2 MCP and SCA panel including current and newly added indicator and pushbutton is re-designed for operator. Figure 2 shows MCP arrangement design for SDS #2 refurbishment.

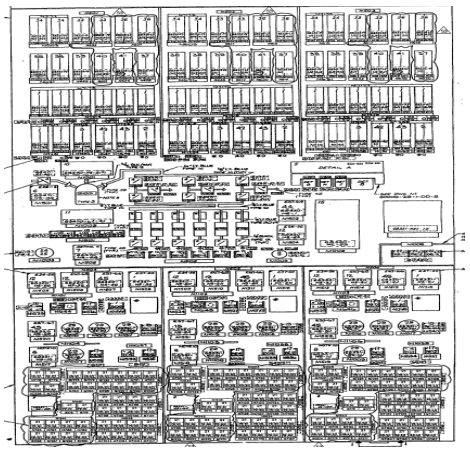

Figure 2. MCP Arrangement Display for SDS #2

3. Conclusions

This refurbishment can fully satisfy the purpose, which fulfills enlarging the effective trip coverage and maximizes the redundancy and diversity for shutdown systems by adding trip instrumentation loops, as well as optimal MMI and rack design considering human factor engineering.

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