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Safety Analysis for Enlargement of Allowance Band of Main Steam Safety Valve Opening Setpoint of Wolsong Unit 1

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1. Introduction

Safety analysis was performed to enlarge the opening setpoint allowance band of the main steam safety valves (MSSVs) of the Wolsong unit one(WSNPP-1) from ±1% to ±3%[1] by using the CATHENA code[2]. The target events were selected to be the two most secondary system pressurization events – Loss of Class IV Power (LOCL4) and Loss of Condenser Vacuum (LOCV). In actual analysis, additional safety margin of 1% was added for conservatism, therefore the allowance band of ±4% was used.

2. MSSV of WSNPP-1

A total 16 spring-loaded MSSVs (4 per each Steam Generator(SG) in Fig 1) are provided in WSNPP-1 for the protection of over pressurization of secondary side of SG. Each MSSV of all SGs has a different opening setpoint – 5.01, 5.03, 5.06, 5.09 MPa(g) each[3].

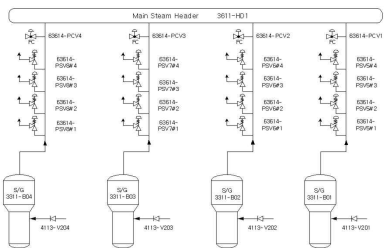


Fig.1 Simple Diagram of MSSV of WSNPP-1.

3. Availability Test of MSSV in WSNPP-1

All MSSVs have been tested periodically with respect to the availability to open in the allowance band of ±1% based on the above each opening setpoints. WSNPP-1 tried to enlarge the allowance band from 1% to 3% which is consistent with the requirement of ASME NC-7513[4] and the domestic licensing instance of PWR plants.

4. Safety Analysis for the Enlarged Allowance Band

To evaluate the enlarged allowance band of MSSV opening setpoint in the view of plant safety, the deterministic safety analysis method was used for the limiting Design Basis Accident (DBA) events with regard to secondary side pressurization, which make the MSSVs open. Among many DBAs of CANDU-6 type plant, LOCL4 and LOCV was selected. LOCL4 is the loss of flow in the primary side due to the loss of power to the Primary Heat Transport System (PHTS) pumps, causing the pressurization of both primary and secondary system leading to the opening of MSSVs. And following LOCV, turbine trips and all Condenser Steam Discharge Valve (CSDVs) close, which brings about the rapid pressurization of secondary side of all SGs, therefore MSSVs must be opened to protect the over-pressurization.

Thermal hydraulic safety analysis code of Canadian Algorithm for THErmalhydraulic Network Analysis (CATHENA) was used as a safety analysis.

5. Opening Model of MSSV in CATHENA

The assessment was performed against two safety criteria: i) fuel integrity and ii) pressure boundary integrity. For the assessment of fuel integrity, MSSVs start to be opened at the lowest opening setpoint with allowance of -3% and uncertainty -1%, which makes the dryout on the fuel sheath occur early due to the early depressurization of both primary and secondary system. On the other hand, for the assessment of pressure boundary integrity, MSSVs start to be opened at the highest opening setpoint with allowance of 3% and 1% uncertainty, which gives the highest peak pressure of both primary and secondary system from the delayed opening of MSSVs(Fig.2).

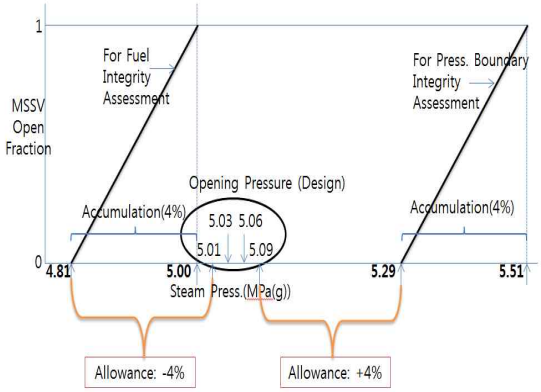


Fig.2 Diagram for MSSV Opening Model in CATHENA

6. Acceptance Criteria

Acceptance criterias for this assessment are same as those applied to WSNPP-1 Final Safety Analysis Report (FSAR) Ch.15 as following Table 1. From Canadian Nuclear Safety Commission (CNSC) R-77[6], pressure boundary integrity criteria should be applied differently according to the applied shutdown system (SDS1 or SDS2), and available number of Liquid Relief

Valve(LRV)s. 11.9MPa(a) and 13MPa(a) are values of 110% and 120% of primary system design pressure, respectively and 5.68MPa(a) is a value of 110% of secondary system design pressure.

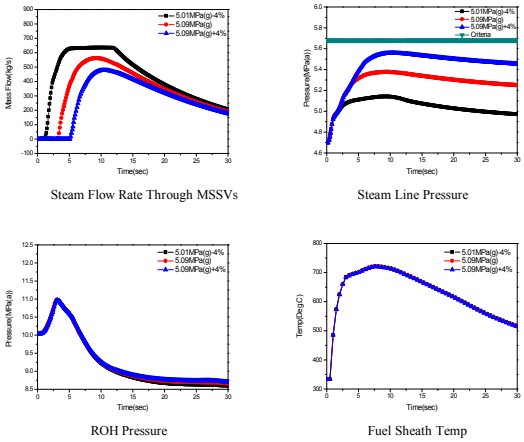
Table.1 Acceptance Criteria for Fuel and Pressure Boundary Integrity

Fuel Integrity			Fuel Sheath Temp. < 800℃
Pressure Boundary Integrity	Primary	Tripped by SDS1	ROH Pres. < 11.9MPa(a)
		Tripped by SDS2	ROH Pres. < 13.0MPa(a)
	secondary	Tripped by either of SDS1/SDS2	Steam Pres. < 5.68MPa(a)

7. Analysis Results

A. LOCL4

Analysis results for the event of LOCL4 are shown in Fig.3 and Table2.



Steam Flow Rate Through MSSVs | Steam Line Pressure

ROH Pressure | Fuel Sheath Temp

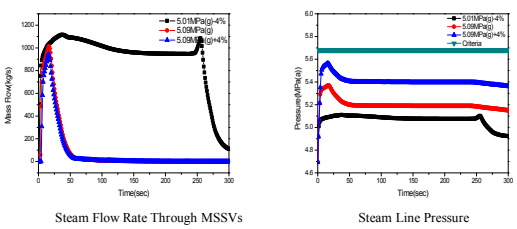
Fig 3. Analysis Results for LOCL4, 103%FP

Table 2. Analysis Results for LOCL4, 103% FP

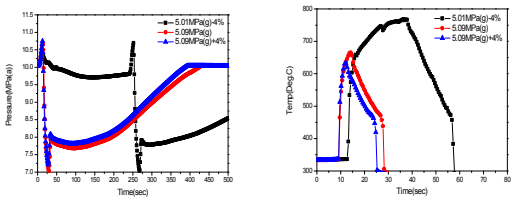
Tripped By	Available LRVs	Allowance	ROH Press. (MPa(a))	Steam Press. (MPa(a))	Sheath Temp. (℃)
SDS-1	2	5.09+4%	10.97	5.56	
		5.01-4%	10.98	5.14	
	4	5.09+4%	10.98	5.56	721
		5.01-4%	10.99	5.14	721
SDS-2	0	5.09+4%	12.02	5.58	
		5.01-4%	12.00	5.17	
	4	5.09+4%	11.73	5.57	737
		5.01-4%	11.67	5.16	741

B. LOCV

Analysis results for the event of LOCV are shown in Fig.4 and Table3.



Steam Flow Rate Through MSSVs | Steam Line Pressure



ROH Pressure | Fuel Sheath Temp

Fig 4. Analysis Results for LOCV, 103%FP

Table 3. Analysis Results for LOCV, 103%FP

Tripped By	Available LRVs	Allowance	ROH Press. (MPa(a))	Steam Press. (MPa(a))	Sheath Temp. (℃)
SDS-1	2	5.09+4%	10.75	5.57	
		5.01-4%	10.69	5.11	
	4	5.09+4%	10.74	5.57	564
		5.01-4%	10.46	5.13	712
SDS-2	0	5.09+4%	11.55	5.61	
		5.01-4%	11.39	5.14	
	4	5.09+4%	10.89	5.58	636
		5.01-4%	10.48	5.13	765

8. Conclusion

Safety analysis was performed with CATHENA code to evaluate the safety affection with the enlargement of allowance band of MSSV opening setpoint of WSNPP-1

Analysis results for both LOCL4 and LOCV tell that the enlarged allowance would bring no harm to the safety of the plant in the view of fuel integrity and pressure boundary integrity. Therefore, the new allowance band of MSSVs will be applied into the Technical Specification of WSNPP-1

REFERENCES

[1] WSNPP-1 FSAR Ch.15
[2] B.N. Hanna, "CATHENA MOD-3.5d/Rev.2 Input Reference", 53-112020-UM- 001, Aug. 2005, AECL
[3] WSNPP-1 Design Manual – DM-59-36100
[4] ASME Boiler & Pressure Vessel Code, Section-III, NC-7513, 2010.
[5] Model Report, 59RF-03500-AR-011, CATHENA Secondary Side Model, 2008
[6] AECB Regulatory Document R-77, "Overpressure P rotection Requirements for Primary Heat Transport Syst ems in CANDU Power Reactors Fitted with Two Shutd own Systems," October 1987.