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Evaluation of Atmospheric Dump Valve and Turbine Bypass Valve Capacities for YGN 3

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Abstract

The Atmospheric Dump Valve (ADV) and Turbine Bypass Valve (TBV) capacity test was performed at 30% power level during the YGN 3 Power Ascension Test period. In this test, several plant data were measured to calculate the ADV and TBV capacity considering that critical condition was developed through the ADV and TBV. The test results show that the test acceptance criteria are met.

1. Introduction

The purpose of this paper is to provide an evaluation of capacity test results for the Atmospheric Dump Valves and Turbine Bypass Valves for Yonggwang Nuclear Power Plant Unit 3 (YGN 3). This evaluation establishes whether each capacity of ADV's and TBV's meets the required acceptance criteria.

2. Test Descriptions

2.1 Test Objectives

(1) To verify whether the capacity of each ADV upstream of the Main Steam Isolation Valves (MSIV) meets test acceptance criteria or not.
(2) To verify whether the capacity of each TBV meets test acceptance criterion or not.
(3) To verify whether the TBV capacity to the condenser meets test acceptance criterion or not.
(4) To verify whether the TBV capacity to atmosphere meets test acceptance criterion or not.
(5) To verify whether the total capacity of the TBV controlled by the Steam Bypass Control System(SBCS) meets test acceptance criterion or not.

2.2 Test Acceptance Criteria

(1) The capacity of each ADV upstream of the MSIV is greater than or equal to 6% of the total main steam flow to be encountered at full power operation.
(2) The maximum capacity of each ADV upstream of the MSIV is less than 11% of the total main steam flow to be encountered at full power operation.
(3) The maximum capacity of each TBV is less than 11% of the total main steam

flow to be encountered at full power operation.

(4) The TBV capacity to condenser is greater than or equal to 40% of the total main steam flow to be encountered at full power operation.

(5) The TBV capacity to the atmosphere is greater than or equal to 15% of the total main steam flow to be encountered at full power operation.

(6) The sum of all eight TBV capacities is greater than or equal to 55% of the total main steam flow to be encountered at full power operation.

2.3 Initial Test Conditions

(1) Reactor power was stable at power plateau(50%).

(2) RCS cold leg temperature was stable and within the range of 296 ℃ ± 1 ℃.

(3) Pressurizer pressure was stable and within the range of 158 ± 2 Kg/cm^2.

(4) Pressurizer level was stable and at the programmed level.

(5) Steam generator level was stable and within the normal operating range.

(6) NSSS control systems(FWCS, SBCS, PPCS, and PLCS) were in automatic maintaining parameters.

(7) Control Element Drive Mechanism Control System was in manual sequential.

(8) Condensate storage tank inventory was sufficient.

2.4 Description of Test Methods

Reactor power was slowly decreased to approximately 30% from initial power plateau condition (50%) and turbine power was decreased to match reactor power. The reactor was stabilized at approximately 30%±0.2% reactor power as the monitoring point. Turbine-Generator(TG) load and Steam Generator(SG) blowdown were stable and to remain unchanged for the remainder of the test. Main feedwater flow, SG pressure, and steam header pressure were taken to establish a baseline data at 30% power for five minutes after stabilization.

While maintaining turbine power constant, the first valve(TBV) to be tested was slowly opened as reactor power was slowly increased by approximately 1.5% to allow the steam flow increased. Once reactor power was stabilized, data was taken for five minutes. This incremental stepping was done for one TBV in order to obtain a typical flow characteristic curve. This stepping was continued until the valve to be tested was fully open. After SG level and pressure, main feedwater flow, reactor power, and cold leg temperature(T_{cold}) were stabilized, data were taken for five minutes.

The next valve to be tested was slowly opened as the valve tested previously was slowly closed to establish the steam flow capability of each TBV and ADV while reactor power was maintained constant and SG pressure was maintained within ±1 Kg/cm^2 of present value. Once one valve was fully closed or opened, reactor power was increased or decreased as necessary until another valve was fully opened or closed. After the next valve to be tested was fully opened, stabilized data were then acquired for five minutes. The process continued to swap TBV's and ADV's and gather full open stabilized data for each valve until the final valve to be tested.

While maintaining turbine power constant, an ADV was slowly opened to gather its typical flow characteristic curve as the reactor power was increased by approximately 2.5% increment. When conditions were stabilized, stabilized data were taken for five minutes. This process continued until the final ADV was fully opened.

2.5 Capacity Calculation

The acceptance criteria are specified in terms of the valve capacities at full rated power conditions but the actual capacities are measured at different conditions. Therefore, the measured capacity for each valve has to be corrected to get the capacity at full rated power conditions.

The fomula utilizes a choke flow equation and provides for capacity correction if turbine load changes from the initial value.

$$S_v = [MF(final) - MF(initial) + Turbine\ Load\ Correction] \times [\frac{P_1(h_{g2}-185)}{P_2(h_{g1}-185)}]$$

Where,

S_v = Steam flow through valve at full power conditions, Kg/hr

$MF(final)$ = Total feedwater flow with valve open, Kg/hr

$MF(initial)$ = Total feedwater flow with all valves closed, Kg/hr

Turbine Load Correction = Correction utilized if TG megawatt load changes during test from the initial value

P_1 = Calculated valve inlet pressure at full power conditions as follows:

TBV-1001 = 1022 psia
TBV-1002 = 1022 psia
TBV-1003 = 1016 psia
TBV-1004 = 1016 psia
TBV-1005 = 1006 psia
TBV-1006 = 996 psia
TBV-1007 = 1002 psia
TBV-1008 = 999 psia

P_2 = Calculated valve inlet pressure using average steam header pressure(SG pressure for ADV's) measured during test minus head loss correction

h_{g1} = Enthalpy of saturated steam at pressure P_1

h_{g2} = Enthalpy of saturated steam at pressure P_2

185 = A constant

3. Test Results

3.1 Atmospheric Dump Valves

Valve Number	Acceptance Criteria	100% Rated Capacity(%)	Remarks
SG-178	≥6%, <11%	8.34	Acceptance criteria were met
SG-179	≥6%, <11%	8.10	〃
SG-184	≥6%, <11%	8.07	〃
SG-185	≥6%, <11%	8.15	〃

3.2 Turbine Bypass Valves

Valve Number	Acceptance Criterion	100% Rated Capacity(%)			Remarks
		1st Test	2nd Test	3rd Test	
SG-1001	<11%	4.72	5.43	9.46	The acceptance criterion was met at all tests
SG-1002	<11%	5.57	6.85	*	〃
SG-1003	<11%	5.11	5.13	*	〃
SG-1004	<11%	7.35	8.72	*	〃
SG-1005	<11%	6.16	6.87	*	〃
SG-1006#	<11%	2.40	4.70	*	〃
Total to Condenser	≥40%	31.31	37.70	41.73	The acceptance criterion was not met at the 1st and the 2nd tests, but was met at the 3rd test
SG-1007	<11%	9.17	*	*	The acceptance criterion was met at the 1st test
SG-1008	<11%	8.99	*	*	〃
Total to Atmosphere	≥15%	18.16	*	*	〃
Total	≥55%	49.47	55.86	59.89	The acceptance criterion was not met at the 1st test, but was met at the 2nd and the 3rd tests

* Test was not done because the acceptance criterion was met at the previous test.

\# At the first test it appeared to have very low capacity. The second test was performed after replacing cage.

4 Conclusions

(1) The test results meet the test acceptance criteria. Therefore, ADV's and TBV's are suitable for their intended use and functions specified in Ref. 3.4.

(2) The formula incorporating head loss and turbine load correction is appropriate for the capacity calculation at full rated power conditions..

References

(1) Power Ascension Test Procedure for ADV & Steam Bypass Valve Capacity, 3S-I-521-01 Rev. 00

(2) YGN 3&4 FSAR, Sections 10.3.2.2.6 and 14.2.12.5.19