10.4.4 Turbine Bypass System

The turbine bypass system (TBS) discharges main steam from the steam generators (SG) directly to the main condenser in a controlled manner, bypassing the turbine. This process minimizes transient effects on the reactor coolant system (RCS) during plant startup, hot shutdown and cooldown; and step load reductions in generator load. The TBS is also referred to as the steam dump system.

10.4.4.1 Design Bases

The TBS performs no safety-related function and therefore has no nuclear safety-related design basis.

The TBS is designed to meet the following functional criteria:

- Combined capacity of the TBS is sufficient so that, considering reactor trip (RT), this system alone is sufficient to prevent actuation of a main steam relief train (MSRT) or main steam safety valve (MSSV) following a turbine trip (TT) or full load rejection.
- The TBS dump valves automatically open when steam generation exceeds the consumption limit of the turbine.
- With one turbine bypass valve out of service, 50 percent of SG capacity can be dumped to the main condenser.
- Steam to the turbine can be bypassed to the main condenser during plant startup and also can be bypassed to permit a normal cooldown of the RCS from a hot shutdown condition to a point consistent with the initiation of the residual heat removal system (RHRS).

10.4.4.2 System Description

10.4.4.2.1 General Description

The TBS is part of the main steam supply system (MSSS). A turbine bypass to the main condenser is included for operational flexibility. The system consists of a manifold connected to the main steam lines upstream of the turbine stop valves and of lines from the manifold with regulating valves to each condenser shell. Refer to Section 10.3 for information on the design and operation of the MSSS with respect to the TBS. The TBS is shown on Figure 10.3-1 in Section 10.3.

The TBS is located in the Turbine Building and consists of six valves that dump steam to the three condenser shells. The dump valves automatically open when steam generation exceeds consumption by the turbine.

10.4.4.2.2 Component Description

Table 3.2.2-1 provides the seismic design and other design classifications for components in the TBS. Section 3.2 describes how the guidance of RG 1.26 is implemented for the U.S. EPR.

Bypass Valves

The turbine bypass valves are designed to codes and standards consistent with the design of the main steam line piping in the Turbine Building. Turbine bypass valves and actuators are designed to Turbine Building environmental conditions and fail closed on loss of electrical signal or actuating fluid.

Piping

Piping upstream of turbine bypass valves is designed to codes and standards consistent with the design of the Turbine Building main steam line piping. A drain pot is provided in the turbine bypass valve header because the valves are normally closed and are located at a piping low point that can collect condensate during normal operation.

10.4.4.2.3 System Operation

Normal Operation

During power operation, the TBS is normally not used. During mild pressure transients, the turbine bypass valves help prevent opening of the main steam relief isolation valves (MSRIV) and main steam safety valves (MSSV). In the case of an imbalance between core power and turbine load, excess steam is dumped to the main condenser via the TBS.

Shutdown

MSSS shutdown coincides with unit shutdown. Unit load is reduced to no-load and the turbine and reactor are shut down. During normal shutdown, steam generated in the SGs is dumped to the main condenser through the turbine bypass valves. Steam flow is a function of the power supplied by the reactor coolant pumps (RCP) and core decay heat. The SG water inventories are maintained by the startup and shutdown feedwater system described in Section 10.4.7.

Cooldown from no-load to the point of residual heat removal (RHR) connection is performed by gradually reducing the main steam pressure. The turbine bypass flow is regulated automatically to the desired cooldown rate. Once the RHRS is connected, heat transfer from the reactor is via the RHRS per Section 5.4.7. At this point, the turbine bypass and MSSS may be taken out of service and the SGs isolated.

If the TBS is unavailable, the cooldown is accomplished with either the MSRTs or MSSVs.

Abnormal Operation

Loss of External Load

Subsequent to a loss of external load, the turbine trips and is followed by reactor shutdown. Steam is automatically dumped to the main condenser through the TBS, or if TBS is unavailable to the atmosphere via the MSRTs. Once conditions have stabilized, the unit is maintained in hot shutdown conditions or cooled down using the TBS or MSRTs.

Loss of Condenser Vacuum

Loss of condenser vacuum causes the TBS to become unavailable for service. Chapter 15 describes the evaluation of anticipated operational occurrences.

Increased Steam Flow with MSIV Failure to Close

This event is initiated by a failure or function error of the turbine or turbine bypass controls, resulting in a sudden increase in steam flow. Also, one MSIV is postulated not to close upon receiving a main steam isolation signal. This event is enveloped by the main steam line break (MSLB) event. Once conditions have stabilized, heat removal takes place via the MSRTs.

Accident Conditions

A failure of the TBS piping is within the main steam line break outside containment event. Refer to Chapter 15 for a description of accident analyses. This includes an evaluation of a MSLB and steam generator tube rupture.

10.4.4.3 Safety Evaluation

The TBS performs no safety-related functions and is not required to operate during or after an accident.

The design of the TBS satisfies general design criteria (GDC 4), regarding the environmental effects of a TBS failure on essential equipment.

- There is no safety-related equipment in the vicinity of the TBS. All high energy lines of the TBS are located in the Turbine Building. Therefore, TBS piping failures would not affect any safety-related equipment. Since there are no safety-related systems to be effected by a TBS pipe-break, NUREG-0800 BTP 3-3 (Reference 1) and BTP 3-4 (Reference 2) are not applicable to the TBS. The general subject of pipe failures is discussed in Section 3.6.1 and Section 3.6.2.

- The design of the TBS satisfies GDC 34, relating to providing a system of heat removal that has the capability of shutting down the plant during normal operation.
- The combined capacity of the turbine bypass valves is such that with consideration of a RT, the TBS alone is sufficient to prevent actuation of a MSRT or MSSV following a TT or full load rejection. Although the TBS is not safety related, the use of the TBS for heat removal minimizes the use and challenges to the safety-related MSRTs and MSSVs.

10.4.4.4 Inspection and Testing Requirements

The TBS components are inspected and tested as part of the initial plant startup. Refer to Section 14.2 (test abstract #061) for initial plant startup test program. System piping and valves are accessible for inspection. Operational testing and inservice inspection can be performed.

10.4.4.5 Instrumentation Requirements

The turbine bypass valves automatically modulate to maintain variable main steam pressure as determined by the reactor controls. The turbine bypass valves close and are prevented from opening on high condenser backpressure or high hot well level. The turbine bypass valves automatically open when steam generation exceeds demand by the turbine. Refer to Section 7.7.2 for a description of instrumentation and control systems used to implement non-safety-related functions, including main steam pressure control.

10.4.4.6 References

1. NUREG-0800, BTP 3-3, “Protection Against Postulated Piping Failures in Fluid Systems Outside Containment,” Rev. 3, U.S. Nuclear Regulatory Commission, 2007.
2. NUREG-0800, BTP 3-4, “Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment,” Rev. 2, U.S. Nuclear Regulatory Commission, 2007.

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