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# 8 STEAM DUMP AND BYPASS CONTROL SYSTEM (SDBCS)

**Learning Objectives:**

1. List the purposes of the Steam Dump and Bypass Control System (SDBCS).
2. Briefly describe how each purpose is accomplished.
3. List the input signals to the SDBCS.
4. Describe how over-pressurization of the condenser is prevented.

## 8.1 Introduction

The SDBCS exists to remove excess energy from the reactor coolant system (RCS) by dumping steam to the atmosphere and/or bypassing main steam flow around the turbine directly to the condenser. Operational conditions that can result in excessive RCS energy are:

1. Load rejection or turbine trip,
2. Reactor trip,
3. Reactor start-up or
4. Plant cooldown.

A load rejection is a complete or partial loss of electrical power generation. It is desirable to immediately reload the turbine generator following a load rejection in order to restore the unit output to normal. Since electrical generation is proportional to turbine steam flow, a load rejection results in excessive RCS energy. If this excessive energy is not removed, a high pressurizer pressure trip will result and the ability to immediately reload the turbine will be lost.

When the reactor trips, the turbine also trips. The tripping of the turbine drops the heat removal from the RCS to 0. If the reactor trips from 100% power steam generator pressure approaches a value that corresponds to saturation pressure for 572°F. This pressure is in excess of 1200 psia and would lift all of the main steam safety valves. Therefore, the SDBCS is designed to remove this excessive energy and restore RCS temperature to the no load value of 532°F following a reactor trip.

Thus far, only upset conditions that cause excessive RCS energy have been discussed. However, during a reactor start-up, reactor power is increased while turbine power (normal heat removal) remains at a value of zero. This increase in reactor power causes excessive RCS energy that is removed by the SDBCS. Excessive RCS energy during a reactor startup is required for two reasons. First, as the SDBCS removes energy, a constant steam flow (for a given power level) is established. In order to maintain steam generator level, an increase in feedwater flow is required. If the power escalation is performed in a slow orderly fashion, manual control of feed water is easier. Also, the escalation of reactor power to a pre-determined value (8-10%) provides sufficient energy for turbine warmup, roll to synchronous speed, and initial loading. As the turbine is loaded, the SDBCS valves will close and energy removal from the RCS will remain constant until turbine load exceeds reactor power.

The final function of the system involves the removal of excess energy during a plant cooldown. During this evolution, RCS temperature is reduced to the shutdown cooling initiation point by bypassing steam to the condenser or dumping steam to the atmosphere.

Over-pressurization of the condenser is prevented by rupture diaphragms on the Low Pressure Turbine Exhaust Hoods which rupture at 5 psig.

### 8.2 SDBCS Components

In order to accomplish the functions previously discussed, the SDBCS controls six valves that are divided into two groups. The first group is the bypass group consisting of four valves. These valves bypass main steam flow around the turbine. The bypass valves have a total capacity of 40% of rated steam flow, and are connected to the main steam header downstream of the main steam isolation valves. The second group of valves are called the dump valves and release steam directly to the atmosphere. The two dump valves have a total capacity of 5% of rated steam flow, and are connected to the main steam headers upstream of the main steam safety valves. Each of the dump valves has an associated isolation valve located between the dump valve and the main steam header.

The total steam flow handling capacity allows the SDBCS to control secondary steam pressure without requiring operation of the main steam safety valves. The bypass valve operation is sequenced to prevent abrupt changes in RCS heat removal. In the event of a loss of condenser vacuum, the turbine bypass valves close automatically. The atmospheric dump valves are designed to remove reactor decay heat when the condenser is not available. The SDBCS valves are designed to withstand a maximum steam pressure of 1000 psig at 580°F.

## 8.3 SDBCS Operations

### 8.3.1 Load Rejection

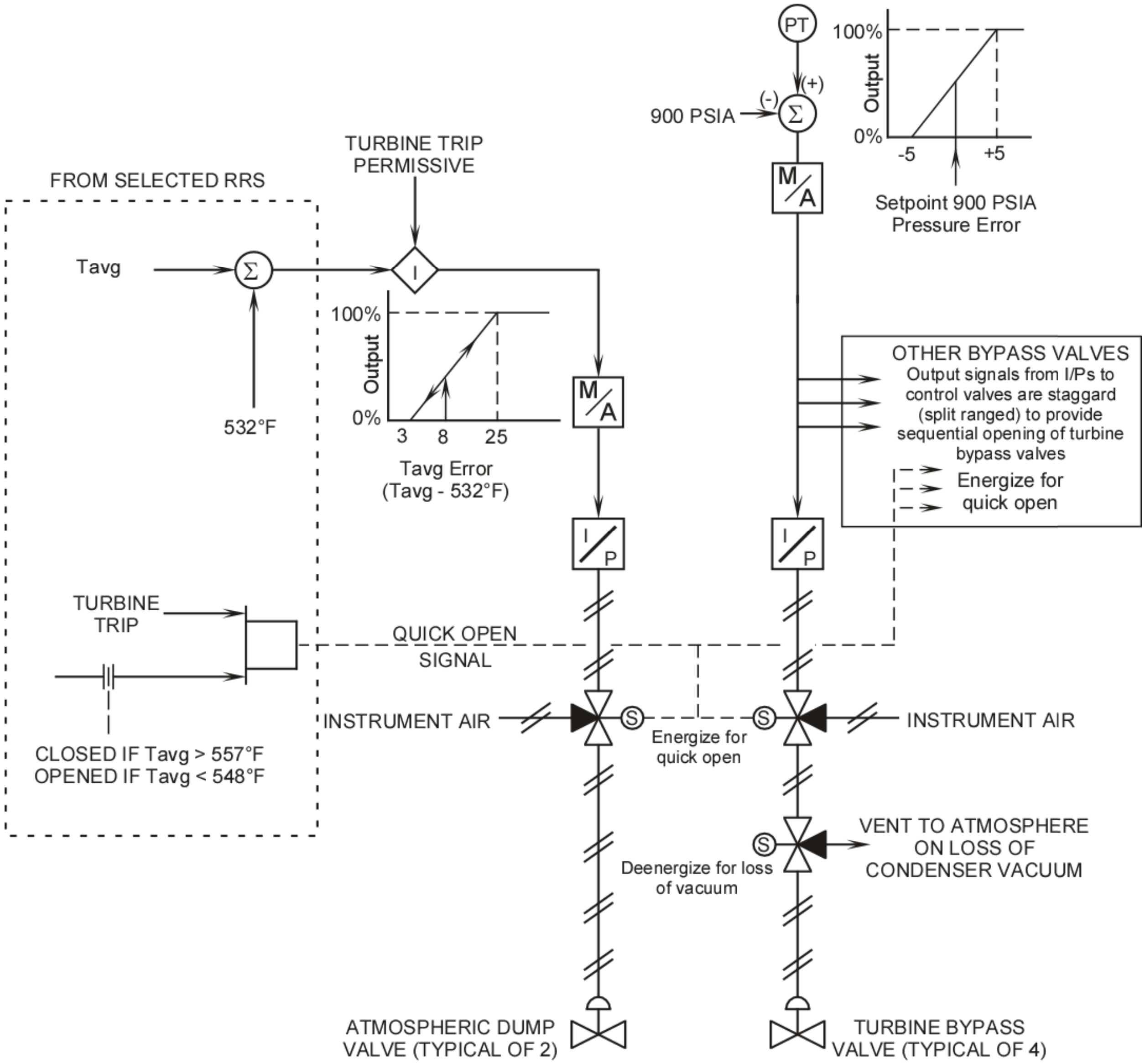


Figure 8-1 Steam Dump and Bypass Control System

Assume the unit is operating at full electric output and the control element assemblies (CEAs) are in the automatic sequential mode of operation. For some unknown reason, electrical load is reduced by 40%. When the step change in electrical load occurs, the turbine control valves will close to prevent a turbine overspeed condition. As the turbine control valves close, steam flow decreases rapidly which leads to an increase in steam pressure. The bypass valves will be sequentially opened as steam pressure increases (depending on the amount of pressure increase). When steam pressure exceeds 895 psia, the bypass valves begin to open. The bypass valve pressure controller generates an output signal proportional to secondary pressure over the range of 895 to 905 psia (for a setpoint of 900 psia). Meanwhile, the CEAs are being inserted by the Reactor Regulating System (RRS) due to the mismatch between reactor and turbine power. As the CEAs add negative reactivity, reactor power is reduced. With the SDBCS valves open, the reduction in reactor power causes a reduction in steam pressure. As steam pressure decreases, the pressure error gets smaller and the bypass valves start to close. These actions will continue until the RRS restores $T_{avg}$ to the proper value for the corresponding power (turbine load).

### 8.3.2 Turbine Trip

The steam dump controller generates a suppressed range signal, $T_{avg}$ error, which is proportional to actual $T_{avg}$ minus 532°F. Upon receipt of a turbine trip, the dump controller signal opens the atmospheric steam dump valves. The position of the SDBCS valves is proportional to the signals applied to them, which provides a controlled discharge of excess pressure. The magnitude of the programmed $T_{avg}$ error signal is directly proportional to the amount of heat energy stored in the reactor coolant.

When the reactor is operating at approximately 8% power ($T_{avg}$ ~535°F), the programmed $T_{avg}$ signal magnitude is minimum. At 63% power ($T_{avg}$ ~ 557°F) the programmed $T_{avg}$ error signal magnitude is maximum. When the turbine trips while reactor power is between 8% and 63%, the programmed $T_{avg}$ error signal is applied through the main control circuits to the current to pneumatic signal (I/P) converters, resulting in a similar response of the system with the CEA interface as discussed in section 8.3.1.

When the main turbine trips while the reactor is operating above 63% power, the RRS supplies a Quick Open (QO) signal to energize the solenoid dump valves. When the solenoid valves are energized, the pneumatic signals from the current to pneumatic converters are isolated and a higher air pressure from the instrument air system is applied to the dump valve actuators through the solenoid valves. This causes the dump valves to rapidly move to their fully open position.

The release of secondary steam flow to the atmosphere through the steam dump valves following a reactor trip causes $T_{avg}$ to decrease. Once $T_{avg}$ drops below approximately 548°F, the solenoid valves are deenergized (QO signal cleared), allowing the programmed $T_{avg}$ error signal to assume control of dump valve position. The programmed $T_{avg}$ error signal continues to vary directly with $T_{avg}$. As $T_{avg}$ decreases toward 535°F, the steam dump valves move proportionately toward their shut position. Once $T_{avg}$ drops below 535°F, the dump valves are fully shut. Should $T_{avg}$ begin to increase above 535°F, the dump valve controls hold the valves shut until $T_{avg}$ reaches 540°F, at which time the dump valves are reopened by an amount corresponding to the strength of the programmed $T_{avg}$ error signal.

The programmed $T_{avg}$ error signal continues to position the valves as previously described. The automatic positioning of the steam dump valves is referred to as modulating the valves. When the controller is in manual, the positioning of the dump valves is controlled by manually adjusting the amount of current applied to the converters.

### 8.3.3 Reactor Trip

If a load rejection occurs which is in excess of the capacity of the SDBCS, the resulting temperature and pressure transient will cause a reactor trip. When the reactor trips, a turbine trip signal is generated, closing all the turbine control valves. If $T_{avg}$ is above 557°F with a turbine trip present, a quick open signal is generated.

The actuation of the SDBCS valves following a reactor trip causes $T_{avg}$ to decrease. Once $T_{avg}$ drops below 548°F, the solenoid valves are de-energized (QO signal cleared), allowing the programmed $T_{avg}$ error signal to assume control for the position of the SDBCS valves. The $T_{avg}$ error signal continues to vary directly with $T_{avg}$. As $T_{avg}$ decreases toward 535°F, the steam dump valves are modulated toward the closed position. Once $T_{avg}$ decreases below 535°F, the steam dump valves are fully closed. Should $T_{avg}$ begin to increase, and again go above 535°F, the steam dump controls hold the dump valves closed until $T_{avg}$ reaches 540°F. This 5°F deadband allows the bypass valves (if available) to control the heat removal based on pressure, which minimizes the amount of secondary inventory lost to the atmosphere. If $T_{avg}$ reaches 540°F, the steam dump controls reopen the dump valves by an amount corresponding to the strength of the $T_{avg}$ error signal.

The automatic positioning of the valves is referred to as modulating the valves. At the end of the transient, steam pressure should equal about 900 psia which corresponds to an average RCS temperature of 532°F.

### 8.3.4 Startup

Before the reactor can be taken critical, the RCS is heated up to no load temperature by the operation of the reactor coolant pumps. As the pumps add heat energy to the steam generators, steam pressure increases. When steam pressure tries to exceed the SDBCS setpoint of 900 psia, an error signal will be generated. The error signal will cause the bypass valves to open and will maintain steam pressure at 900 psia. As reactor power is escalated, $T_{avg}$ increases. The increase in temperature tries to raise steam pressure, however, the error signal from the pressure controller increases. The increase in the error signal will cause the bypass valves to open further and steam pressure will remain at 900 psia.

As the turbine is loaded, steam flow increases and steam pressure tries to decrease. The decrease in steam pressure will be sensed by the SDBCS and the pressure error signal to the bypass valves will decrease. The decrease will continue until the SDBCS valves are fully closed and all the steam flow is being directed through the turbine. In the event of a loss of condenser vacuum, the turbine bypass valves close automatically and the atmospheric steam dump valves open, exhausting steam to the atmosphere and maintaining temperature between 535°F and 540°F.

### 8.3.5 Plant Cooldown

When the reactor is shutdown; and being maintained in a hot shutdown condition, the steam dump and bypass controllers remain at their normal setpoints. In order to decrease RCS temperature, steam from the steam generators is dumped to the condenser. The operator takes manual control of the steam pressure controller and increases the output of the controller. The output is routed to the I/P converter and the bypass valve(s) will achieve the desired position. Remember that the rate of RCS cooldown is limited by plant technical specifications. RCS temperature is reduced by manual operation of the SDBCS valves until the proper temperature is obtained for shutdown cooling system operations.

## 8.4 Summary

The purpose of the SDBCS is to remove excess energy from the RCS by dumping steam to the atmosphere and/or bypassing steam to the main condenser. Excess energy can be caused during load rejections, turbine trips, reactor trips, reactor start-up or plant cooldowns.

The system consists of six valves. Four valves are bypass valves and have a total capacity of 40% of rated steam flow. Two valves are dump valves and have a total capacity of 5% of rated steam flow.

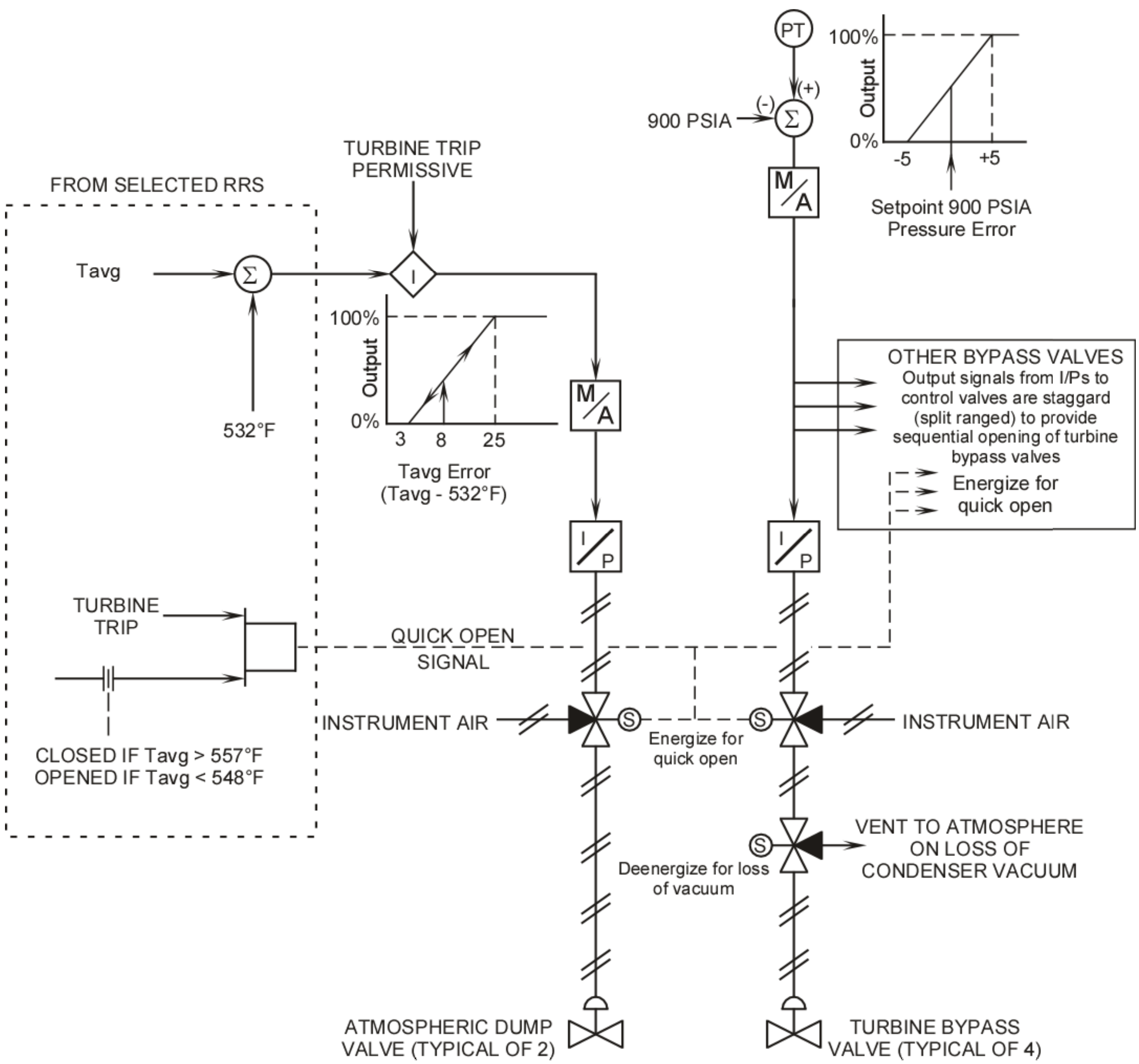


**Figure 8-1 Steam Dump and Bypass Control System**