2.8 Steam and Power Conversion Systems

2.8.1 Turbine-Generator System

Design Description

1.0 System Description

The turbine-generator system is a non-safety-related system that converts the energy of the steam produced in the steam generators into mechanical shaft power and then into electrical energy.

The flow of steam is directed from the steam generators to the turbine through the main steam system, turbine stop valves, and turbine control valves. After expanding through the turbine, which drives the main generator, exhaust steam is transported to the main condenser.

Turbine overspeed control is provided by two independent, redundant and diverse backup electrical turbine overspeed protection systems, in addition to the normal speed control function. The primary and backup overspeed protection systems are included to minimize the possibility of turbine rotor failure and turbine missile generation.

Turbine rotor components, and turbine stop and control valves, will be periodically tested to meet the manufacturer's turbine missile generation probability requirements.

2.0 Arrangement

2.1 The functional arrangement of the turbine-generator system is as described in the Design Description of Section 2.8.1, Table 2.8.1-1—Turbine-Generator System Equipment Mechanical Design and Table 2.8.1-2—Turbine-Generator System Equipment I&C and Electrical Design, and as shown in Figure 2.8.1-1—Turbine-Generator System Basic Configuration.

2.2 The axis of the turbine rotor shafts is positioned such that safety-related structures, except for two of the four Essential Service Water Buildings, are located outside the turbine missile low trajectory hazard zone. The low-trajectory hazard zone is defined as an area bounded by lines that are inclined at 25 degrees to the turbine wheel planes and pass through the end wheels of the low pressure stages.

2.3 Deleted.

2.4 Turbine rotor integrity is provided through the combined use of selected materials with suitable toughness, analyses, testing, and inspections.

2.5 The probability of turbine material and overspeed related failures resulting in external turbine missiles is less than $1x10^{-5}$ per turbine year.

3.0 I&C Design Features, Displays, and Controls

3.1 Controls on the PICS operator workstations in the main control room (MCR) trip the turbine-generator.

3.2 The turbine-generator has diverse and independent overspeed protection systems.

4.0 Electrical Power Design Features

4.1 Turbine stop valves and turbine control valves listed in Table 2.8.1-1 fail closed on loss of power.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.8.1-3 lists the turbine-generator system ITAAC.

Table 2.8.1-1—Turbine-Generator System Equipment Mechanical Design

Description	Tag Number(1)	Location	ASME Code Section III	Function	Seismic Category
Turbine Stop Valve 1 Turbine Stop Valve 2 Turbine Stop Valve 3 Turbine Stop Valve 4	30MAA11AA010 30MAA12AA020 30MAA13AA030 30MAA14AA040	Turbine Building	N/A	Close	N/A
Turbine Control Valve 1 Turbine Control Valve 2 Turbine Control Valve 3 Turbine Control Valve 4	30MAA11AA011 30MAA12AA012 30MAA13AA013 30MAA14AA014	Turbine Building	N/A	Close	N/A
Turbine-generator	N/A	Turbine Building	N/A	N/A	N/A

1. Equipment tag numbers are provided for information only and are not part of the certified design.

Table 2.8.1-2—Turbine-Generator System Equipment I&C and Electrical Design

Description	Tag Number(1)	Location	IEEE Class 1E	EQ –Harsh Env.	PACS
Overspeed Protection System	N/A	Turbine Building	N/A	N/A	N/A
Backup Overspeed Protection System	N/A	Turbine Building	N/A	N/A	N/A

1. Equipment tag numbers are provided for information only and are not part of the certified design.

2. The main steam relief control valves are capable of being positioned 40 percent open and capable of a linear variation between 40 and 100 percent open.

Table 2.8.1-3—Turbine-Generator System ITAAC
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	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
2.1	The functional arrangement of the turbine-generator system is as described in the Design Description of Section 2.8.1, Table 2.8.1-1 and Table 2.8.1-2, and as shown on Figure 2.8.1-1.	An inspection of the as-built turbine-generator system functional arrangement will be performed.	The turbine-generator system conforms to the functional arrangement as described in the Design Description of Section 2.8.1, Table 2.8.1-1 and Table 2.8.1-2, and as shown on Figure 2.8.1-1.
2.2	The axis of the turbine rotor shafts is positioned such that safety-related structures, except for two of the four Essential Service Water Buildings, are located outside the turbine missile low trajectory hazard zone. The low-trajectory hazard zone is defined as an area bounded by lines that are inclined at 25 degrees to the turbine wheel planes and pass through the end wheels of the low pressure stages.	An inspection of the as-built location of the axis of the turbine rotor shafts, with respect to safety-related structures will be performed.	Safety-related structures, except for two of the four Essential Service Water Buildings, are located outside the turbine missile low trajectory hazard zone.
2.3	Deleted.	Deleted.	Deleted.
2.4	Turbine rotor integrity is provided through the combined use of selected materials with suitable toughness, analyses, testing, and inspections.	A plant-specific analysis will be conducted of the as-built turbine rotor material property data, turbine rotor and blade design, and inspection and testing requirements.	A report exists and concludes that the as-built turbine rotor meets the requirements of the manufacturer's turbine missile probability analysis: 1. Turbine material property data, rotor and blade design analyses (including loading combinations, assumptions and warm-up time) demonstrating safety margin to withstand loadings from overspeed events, and 2. The results of inspection and testing, and the requirements for inservice inspection and testing.

Table 2.8.1-3—Turbine-Generator System ITAAC
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	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
2.5	The probability of turbine material and overspeed related failures resulting in external turbine missiles is less than $1x10^{-5}$ per turbine year.	A material and overspeed failures analysis will be performed on the as-built turbine design.	An analysis concludes that the probability of turbine material and overspeed related failures resulting in external turbine missiles is less than $1x10^{-5}$ per turbine year.
3.1	Controls on the PICS operator workstations in the MCR trip the turbine-generator.	Tests will be performed using controls on the PICS operator workstations in the MCR.	Controls on the PICS operator workstations in the MCR trip the turbine-generator.
3.2	The turbine-generator has diverse and independent overspeed protection systems.	a. An inspection and analysis will be performed on the as-built overspeed protection systems to verify that the turbine-generator has diverse and independent overspeed protection systems.	a. A report concludes that the turbine overspeed protection systems are diverse and independent by verifying: – Each system is designed and manufactured by a different vendor. – Software used to transform the analog speed signal into a digital signal is diverse between the two systems. – Components, process inputs and process outputs are not shared between the two systems. – The two systems are installed in separate cabinets. – The two systems are powered by separate power sources.
		b. Tests will be performed to verify the overspeed and backup overspeed protection systems trip the turbine within design limits.	b. Overspeed and backup overspeed turbine trips occur within the design limits for the systems listed in Table 2.8.1-2.

Table 2.8.1-3—Turbine-Generator System ITAAC
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	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
4.1	Turbine stop valves and turbine control valves as listed in Table 2.8.1-1 fail closed on loss of power.	Tests will be performed to verify that turbine stop valves and turbine control valves fail closed on loss of power.	Following loss of power, turbine stop valves and turbine control valves as listed in Table 2.8.1-1 fail closed.

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