

## 10.2 Turbine Generator

The information in this section of the reference ABWR DCD, including all subsections, tables and figures, is incorporated by reference with the following departures and supplements.

[STP DEP 1.1-2 \(Figure 10.2-4\)](#)

STP DEP 10.2-1 [\(Figure 10.2-4\)](#)

STP DEP 10.2-2

STP DEP 10.2-3

STP DEP 10.2-4

STD DEP T1 2.4-2

STD DEP Admin (Figure 10.2-1)

### 10.2.1.2 Power Generation Design Bases

STP DEP 10.2-2

**Power Generation Design Basis Three**—~~The T-G is designed to accept a sudden loss of full load without exceeding design overspeed~~ with sufficient margin to the overspeed trip.

**Power Generation Design Basis Five**—~~The failure of any single component will not cause the rotor speed to exceed the design speed~~ Emergency Overspeed (EOS).

STP DEP 10.2-3

**Power Generation Design Basis Six**—~~The T-G is designed to support the plant availability goals by utilizing 2/3 or 2/4 coincident trip logic for all but the vibration trips (which are at least 2/2 per bearing). Similarly, all turbine control functions which are required for power generation will use at least dual redundant controllers and triply redundant control inputs.~~ Turbine control functions required for turbine protection possess sufficient redundancy such that failure of a single component input does not compromise the integrity of the turbine protection system.

### 10.2.2.1 General Description

STP DEP 10.2-1

*The turbine-generator consists of an 188.5 rad/s (1800 RPM) turbine, moisture separator/reheaters, generator, exciter, controls, and associated subsystems.*

*The turbine consists of a double-flow, high-pressure unit, and three double flow low-pressure units in tandem. The high-pressure unit has ~~a single stage of steam~~ extraction points for reheater reheating steam and high pressure feedwater heating. Moisture*

separation and reheating of the high-pressure turbine exhaust steam is performed by ~~four~~ two combined moisture separator/reheaters (MSRs). ~~Two MSRs are~~ A MSR is located on each side of the T-G centerline. The steam passes through the low-pressure turbines, each with four extraction points for the four low-pressure stages of feedwater heating, and exhausts into the main condenser. In addition to the moisture separators in the external MSRs, ~~the turbines are designed to separate water from the steam and drain it to the next lowest extraction point feedwater heater~~ turbine steam path has provisions for removing some additional moisture and routing it to extraction lines.

The generator is a direct driven, three-phase, 60 Hz, 188.5 rad/s (1800 RPM) synchronous generator with a water-cooled ~~stator~~ armature winding and hydrogen cooled rotor.

The turbine-generator uses a digital monitoring and control system which, in coordination with the turbine Steam Bypass and Pressure Control System, controls the turbine speed, load, and flow for startup and normal operations. The control system operates the turbine stop valves, control valves, and combined intermediate stop and intercept valves (CIVs). T-G supervisory instrumentation is provided for operational analysis and malfunction diagnosis.

Automatic control functions are programmed to protect the Nuclear Steam Supply System through appropriate corrective actions (Section 7.7).

T-G accessories include the bearing lubrication oil system, electrohydraulic control (EHC) system, turbine hydraulic system, turning gear, hydrogen gas control system, ~~and CO2 system~~, seal oil system, stator cooling water system, exhaust hood spray system, turbine gland sealing system, MSR reheater heating steam system and turbine supervisory instrument (TSI) system.

STD DEP Admin

The T-G unit and associated piping, valves, and ~~controls~~ instruments are located completely within the Turbine Building. ~~There are no safety-related systems or components.~~ The safety-related instruments located within the Turbine Building with the exception of are the safety-related Reactor Protection System (RPS) sensors on the T-G unit. ~~The safety-related switches or transducers used to detect fast closure of the turbine main stop and control valves and closure of the main stop valves and the Leak Detection and Isolation System (LDS) sensors used to detect~~ and high high main condenser back shell pressure, low main steam header pressure, and main steam line leakage. ~~The safety-related instrumentation is~~ are fail safe, hence any local failure associated with the T-G unit will not adversely affect any safety-related equipment. Failure of T-G equipment cannot preclude safe shutdown of the reactor.

STD DEP T1 2.4-2

The Turbine Building contains the safety-related electrical switchgear and trip breakers for the condensate pumps for the mitigation of a postulated feedwater line break in accordance with ~~the ABWR Licensing Topical Report NEDO 33372, "Feedwater Line~~

~~Break Advanced Boiling Water Reactor (ABWR) Containment Analysis.” dated August September 2007 Subsection 8.3.1.1.1.~~

### 10.2.2.2 Component Description

#### STP DEP 10.2-3

~~The main stop valves are operated in an open closed mode by either by the emergency trip, fast acting valve for tripping turbine overspeed protection system in response to a turbine trip signal, by a test solenoid valve, or by the fast acting solenoid valve used for periodic testing or by a small solenoid valve for testing. The disks are totally unbalanced and cannot open against full differential pressure. A bypass is provided to pressurize the below seat areas of the four valves. Springs are designed to close the main stop valve in approximately 0.20 second under the emergency conditions listed in Subsection 10.2.2.5.~~

#### STP DEP 10.2-1

**Moisture Separator Reheaters**—~~Four~~**Two** horizontal cylindrical-shell, combined moisture separator/reheaters (MSRs) are installed in the steam path between the high and low pressure turbines. The MSRs serve to dry and reheat the HP turbine steam exhaust (crossaround steam), before it enters the low-pressure turbines. This improves cycle efficiency and reduces moisture-related erosion and corrosion in the low-pressure turbines. Crossaround steam is piped into the bottom of the MSR. Moisture is removed in chevron-type moisture separators, and is drained to the moisture separator drain tank and from there to the heater drain tank appropriate stage of feedwater heating. ~~The dry crossaround steam next passes upward across the reheater which is supplied with main steam. Finally, the crossaround steam is routed to the combined intermediate valves (CIVs), which are located just upstream of the low pressure turbines inlet nozzles. The reheaters drain, via drain tanks, to the forward pumped heater drain system, which discharges to the reactor feedwater pump suction. Safety valves are provided on the MSR for overpressure protection. The steam next passes upward across the two reheater stages. Heating steam to the first reheater stage is supplied by extraction steam and heating steam to the second reheater stage is supplied with main steam. Reheated steam is routed to the intermediate stop and intercept valves, which are located just upstream of the low-pressure turbine inlet nozzles. Relief valves are provided on the MSR for overpressure protection.~~

#### STP DEP 10.2-1

**Combined-Intermediate Stop and Intercept Valves**—~~Two combined intermediate valves (CIVs) are provided for each LP turbine, one in each steam supply line, called the hot reheat line. The CIV consists of two valves—the intercept valve and the intermediate stop valve, which share a common casing. Although they utilize a common casing, these valves have entirely separate operating mechanisms and controls. The function of the CIVs is to protect the turbine against overspeed from steam and water energy stored between the main stop and control valves and the CIVs. One CIV is located on each side of each LP turbine.—Hydraulically operated intermediate stop and intercept valves are provided in each hot reheat line just~~

upstream of the Low Pressure (LP) inlet. Upon loss of load, the intercept valves first close then throttle steam to the LP turbine, as required to control speed. The intermediate stop valves close on a turbine trip. The intermediate stop and intercept valves are designed to rapidly close to control turbine overspeed.

~~Steam from the MSRs enters the single inlet of each valve casing, passes through the permanent basket strainer, past the intercept valve and stop valve disks, and enters the LP turbine through a single inlet these valves. The CIVs which are located as close to the LP turbine as possible to limit the amount of uncontrolled steam available for overspeeding the turbine. Upon loss of load, the intercept valve first closes then throttles steam to the LP turbine, as required to control speed and maintain synchronization. #is These valves are capable of opening against full system pressure. The intermediate stop valves close only if the intercept valves fail to operate properly. These valves are capable of opening against a pressure differential of approximately 15% of the maximum expected system pressure. The intermediate stop valve and intercept valve and are designed to close in approximately 0.2 second.~~

STP DEP 10.2-1

**Low-Pressure Turbines**—~~Each LP turbine receives steam from two CIV hot reheat lines. The steam is expanded expands axially across several stages of stationary and moving buckets blades. Turbine stages are numbered consecutively, starting with the first HP turbine stage. Extraction steam from the LP turbines supplies the first four stages of feedwater heating. A fifth extraction stage may be provided to remove moisture and protect the last stage buckets from erosion induced by water droplets. This extraction is drained directly to the condenser.~~

STP DEP 10.2-1

**Extraction Non-return Valves**—~~Upon loss of load, the steam contained downstream of the turbine extractions could flow back into the turbine, across the remaining turbine stages, and into the condenser. Associated condensate could flash to steam under this condition and contribute to the backflow of steam or could be entrained with the steam flow and damage the turbines. Extraction nNon-return valves are installed in the employed in selected extraction lines to the first, second, third and, if required, fourth stage of turbine extractions to guard against this backflow and the resulting potential damage due to water entrainment or overspeed condition. minimize the potential for overspeeding.~~

STP DEP 10.2-1

**Generator**—~~The generator is a direct-driven, three-phase, 60 Hz, 188.5 rad/s (1800 RPM), four-pole synchronous generator with water-cooled stator and hydrogen cooled rotor.~~

~~The rotor is manufactured from a one-piece forging and includes layers of field windings embedded in milled slots. The windings are held radially by steel slot wedges at the rotor outside diameter. The wedge material maintains its mechanical properties at elevated temperature. The magnetic field is generated by DC power which is fed to~~

the windings through collector rings located outboard of the main generator bearings. The rotor body and shaft is machined from a ~~single~~, solid steel forging. Detailed examinations include:

- (1) material property checks on test specimens taken from the forging;
- (2) photomicrographs for examination of microstructure;
- (3) magnetic particle and ultrasonic examination;
- (4) ~~surface finish tests of slots for indication of a stress riser~~ residual stress measurement at vendor factory test.

#### STP DEP 1.1-2

#### STP DEP 10.2-4

**Bulk Hydrogen System**—The bulk hydrogen and CO<sub>2</sub> system is illustrated on Figure 10.2-4. The hydrogen system is designed to provide the necessary flow and pressure at the main generator for purging carbon dioxide during startup and supply makeup hydrogen for generator leakage during normal operation.

The bulk hydrogen system utilizes the guidelines given in EPRI report NP-5283-SR-A with respect to these portions of the guidelines involving hydrogen that do not deal specifically with the HWC system. Specifically, the bulk hydrogen system piping and components will be located to reduce risk from their failures. A single bulk hydrogen storage facility will be used to store hydrogen compressed gas cylinders for STP 3 & 4. The bulk hydrogen storage is located outside ~~but near~~ the Turbine Building and at least 100m from any safety-related building. The hydrogen lines are provided with a pressure reducing station that limits the maximum flow to less than 100 standard cubic meters per minute before entering the Turbine Building. Equipment and controls used to mitigate the consequences of a hydrogen fire/explosion will be designed to be accessible and remain functional during the postulated postaccident condition. The design features and/or administrative controls shall be provided to ensure that the hydrogen supply is isolated when normal building ventilation is lost.

### 10.2.2.3 Normal Operation

#### STP DEP 10.2-1

During normal operation, the main stop valves ~~and CIVs~~, intermediate stop valves and intercept valves are wide open. Operation of the T-G is under the control of the Electro-Hydraulic Control (EHC) System. The EHC System is comprised of three basic subsystems: the speed control unit, the load control unit, and the flow control unit. The normal function of the EHC System is to generate the position signals for the four main stop valves, four main control valves, and six ~~CIVs~~ intermediate stop valves and intercept valves.

#### 10.2.2.4 Turbine Overspeed Protection System

The information in this subsection of the reference ABWR DCD is replaced in its entirety with the following information.

##### STP DEP 10.2-3

The normal speed control system comprises a first line of defense against turbine overspeed. This system includes the main steam control valves, intermediate steam intercept valves, extraction system non-return valves, and fast-acting valve-closing functions within the EHC system. The normal speed control unit utilizes three speed signals. Loss of any two of these speed signals initiates a turbine trip via the Emergency Trip System (ETS). An increase in speed above setpoint tends to close the control and intercept valves in proportion to the speed increase. Rapid turbine accelerations resulting from a sudden loss of load at higher power levels normally initiate the fast-acting solenoids via the speed control system to rapidly close the control and intercept valves irrespective of the current turbine speed. The normal speed control system is designed to limit peak overspeed resulting from a loss of full load, to at least 1% below the overspeed trip set point. Typically, this peak speed is in a range of 106-109% of rated speed, and the overspeed trip set point is typically close to 110% of rated speed. All turbine steam control and intercept valves are fully testable during normal operation. The fast closing feature, provided by action of the fast-acting solenoids, is testable during normal operation.

If the normal speed control should fail, the overspeed trip devices close the steam admission valves including the main and intermediate stop valves. This turbine overspeed protection system comprises the second line of defense against turbine overspeed. It is redundant, highly reliable and diverse in design and implementation from the normal speed control system and protection system. This overspeed protection system is designed to ensure that even with failure of the normal speed control system, the resulting turbine speed does not exceed 120% of rated speed. In addition, the components and circuits comprising the turbine overspeed protection system are testable when the turbine is in operation.

The overspeed trip system is electrical, redundant ~~and diverse~~ and consists of the Primary and Emergency overspeed trip functions. Reliability is achieved by using two sets of redundant speed sensing probes, which input to the independent ~~and diverse~~ Primary and Emergency Trip modules in the control system. For additional reliability, two-out-of-three logic is employed in both the Primary and Emergency overspeed trip circuitry. Either trip module can de-energize the trip solenoids of the electro-hydraulic Emergency Trip Device (ETD). ~~The ETD is configured in a two-out-of-three tripping mode (i.e., if any two trip solenoids are de-energized the emergency trip fluid system is de-pressurized) rapidly closing all steam inlet valves.~~ The ETD is composed of two independent trip solenoid valves, each with two normally energized solenoid operated pilot valves. The solenoid operated pilot valves de-energize in response to detection of an overspeed condition by the turbine speed control logic. De-energization of both solenoid operated pilot valves is necessary to cause the spool in their respective trip solenoid valve to reposition, which depressurizes the emergency trip fluid system, rapidly closing all steam inlet valves. Accordingly, the repositioning of only one of the



~~two trip solenoid valves is necessary to trip the main turbine.~~ A single component failure does not compromise trip protection, and does not result in a turbine trip. Each trip solenoid valve in the ETD is testable while the turbine is in operation.

The overspeed sensing devices are located in the turbine front bearing standard, and are therefore protected from the effects of missiles or pipe breakage. The hydraulic lines are fail-safe; if one were to be broken, loss of hydraulic pressure would result in a turbine trip. The ETD's ~~are is~~ also fail-safe. Each trip solenoid transfers to the trip state on a loss of control power, resulting in a turbine trip. These features provide inherent protection against failure of the overspeed protection system caused by low trajectory missiles or postulated piping failures.

The Primary and Emergency electrical overspeed trip modules each consist of three independent ~~and diverse~~ circuits. Each circuit monitors a separate speed signal and activates trip logic at specific speed levels ~~based on software/hardware voted inputs and outputs for Primary functions and firmware based protection with hardware voted inputs and outputs for Emergency functions. This arrangement provides diversity in overspeed protection.~~

Each turbine extraction line is reviewed for potential energy and contribution to overspeed. The number and type of extraction non-return valves required for each extraction line are specified based on the enthalpy and mass of steam and water in the extraction line and Feedwater heater. Higher energy lines are provided with power-assisted closed non-return valves, controlled by air relay dump valves, which in turn, are activated by the emergency trip fluid system. The air relay dump valves, actuated on a turbine trip, dump air from the extraction non-return valve actuators to provide rapid closing. The closing time of the extraction non-return valves is sufficient to minimize steam contribution to the turbine overspeed event.

The following component diversities are employed to guard against excessive overspeed:

- (1) Main stop valves/control valves
- (2) Intermediate stop valves/intercept valves
- (3) Normal speed control/primary overspeed control/emergency overspeed control
- (4) Fast-acting solenoid valves/emergency trip fluid system (emergency trip device)
- (5) Speed control signals/primary overspeed trip/emergency overspeed trip

The main stop valves and control valves provide full redundancy and diversity in that these valves are in series and have independent control signals and operating mechanisms. Closure of all four stop valves or all four control valves effectively shuts off all main steam flow to the HP turbine. The intermediate stop and intercept valves are also fully redundant and diverse in that they are in series and have independent

control signals and operating mechanisms. Closure of either valve or both valves in each of the six sets of intermediate stop and intercept valves effectively shuts off steam flow to the three LP turbines. This arrangement is such that failure of a single valve to close does not result in a maximum speed in excess of design limits.

### 10.2.2.5 Turbine Protection System

STP DEP 10.2-3

*In addition to the overspeed trip signals discussed, the ETS closes the main stop and control valves and the ~~CIVs~~ intermediate stop and intercept valves to shut down the turbine on the following signals.*

- (1) Emergency trip pushbutton in control room
- (2) Moisture Separator high level
- (3) High condenser pressure
- (4) Low lube oil pressure
- (5) LP turbine exhaust hood high temperature
- (6) High reactor water level
- (7) Thrust bearing wear
- ~~(8) Overspeed (electrical and mechanical)~~
- (9) ~~Manual Emergency trip handle on at front standard~~
- (10) Loss of stator coolant ~~(if runback fails)~~
- (11) Low hydraulic fluid pressure
- (12) ~~Any Selected~~ generator trip
- (13) Loss of EHC electrical power
- (14) Excessive turbine shaft vibration
- (15) Loss of two speed signals-either Normal Speed Control or Emergency Overspeed ~~Control Trip~~
- (16) Loss of two pressure control channels

*All of the above trip signals except generator trips, loss of power, and vibration and manual trips use ~~2/3 or 2/4~~ two-out-of-three coincident trip logic.*



*When the ETS is activated, it overrides all operating signals and trips the main stop and control valves, and ~~combined~~ intermediate stop and intercept ~~by way of their~~ disk/dump valves.*

### **10.2.2.6 Turbine-Generator Supervisory Instruments**

#### STP DEP 10.2-1

*Although the turbine is not readily accessible during operation, the turbine supervisory instrumentation is sufficient to detect any potential malfunction. The turbine supervisory instrumentation includes monitoring of the following:*

*(13) ~~Exciter~~ Collector air temperatures*

### **10.2.2.7 Testing**

#### STP DEP 10.2-3

*The ~~electrical and mechanical~~ Primary and Emergency overspeed trip circuits and devices can be tested remotely at shut down, rated speed and under load, by means of controls ~~on the EHC test panel~~ in the Main Control Room (~~MCR~~). Operation of the overspeed protection devices under controlled, ~~overspeed~~ speed conditions is checked at startup and after each refueling or major maintenance outage. In some cases, operation of the overspeed protection devices can be tested just prior to shutdown, thus negating the need to test overspeed protection devices during subsequent startup, if no maintenance is performed affecting the overspeed trip circuits and devices.*

*During refueling, or maintenance shutdowns, coinciding with the in-service inspection schedule required by Section XI of the ASME Code for reactor components, at intervals defined in Subsection 10.2.3.76, at least one main steam stop valve, one turbine control valve, one intermediate stop valve, and one intercept valve are dismantled to conduct visual and surface examinations of valve seats, disks and stems. If unacceptable flaws or excessive corrosion is found in a valve, all other valves of that type are dismantled and inspected. Valve bushings are inspected and cleaned, and bore diameters checked for proper clearance.*

*Main stop valves and turbine control valves, intercept valves and intermediate stop valves are exercised ~~at least once within each calendar~~ quarterly (or as required by the missile probability analysis) by closing each valve and observing the remote valve position indicator for fully CLOSED position status. This test also verifies operation of the fast close function of each main steam stop, turbine control, intercept and intermediate stop valve during the last few percent of valve stem travel.*

*Access to required areas outside of the turbine shielding is provided on the turbine floor under operating conditions.*

Provisions for testing each of the following devices while the unit is operating are included:

- (1) Main stop valves and control valves
- (2) Turbine bypass valves
- (3) Low pressure turbine ~~combined~~ intermediate stop and intercept valves (CIVs)
- (4) ~~Overspeed governor~~ Emergency trip devices
- (5) Turbine extraction nonreturn valves
- (6) ~~Condenser vacuum trip system~~ Lubricating oil pumps Not Used
- (7) ~~Thrust bearing wear detector~~ Control fluid pumps Not Used
- (8) ~~Remote trip solenoids~~ Power load unbalance circuits Not Used
- (9) Lubricating oil pumps
- (10) Control fluid pumps

### 10.2.3.1 Materials Selection

STP DEP 10.2-2

~~Since actual levels of FATT and Charpy V notch energy vary depending upon the size of the part, and the location within the part, etc., these variations are taken into account in accepting specific forgings for use in turbines for nuclear application. The fracture appearance transition temperature (50% FATT), as obtained from Charpy tests performed in accordance with specification ASTM A 370, will be no higher than 17.8°C for low pressure turbine disks. The Charpy V notch energy at the minimum operating temperature of each low pressure disk in the tangential direction should be at least 81.4 Nm.~~

Low-pressure turbine wheel (disc) forgings are made from vacuum treated Ni-Cr-Mo-V alloy steel forgings. The fracture appearance transition temperature (50% FATT), as obtained from Charpy tests performed in accordance with ASTM A-370, will be no higher than 0°F for low-pressure turbine wheel (disc) forgings. The Cv energy at the minimum operating temperature will be at least 60 ft-lbs for a low-pressure turbine wheel (disc) forging. A minimum of three Cv specimens will be tested in accordance with specification ASTM A-370 to determine this energy level. The determination of FATT is used in lieu of nil-ductility transition temperature methods.

Large integral rotors are also made from vacuum treated Ni-Cr-Mo-V alloy steel forgings. Their larger size limits the achievable properties. The fracture appearance transition temperature (50% FATT), as obtained from Charpy tests performed in accordance with ASTM A-370, will be no higher than +40+30°F for large integral forgings. The Cv energy at the minimum operating temperature will be at least 45 ft-

lbs for a large integral rotor forging. A minimum of three Cv specimens will be tested in accordance with specification ASTM A-370 to determine this energy level.

Current turbine designs utilize rotors produced from large integral forgings. Future turbine designs may include fabricated rotors produced from multiple wrought components. Acceptable material properties will be consistent with component size and fabrication method.

### 10.2.3.2 Fracture Toughness

STP DEP 10.2-2

Stress calculations include components due to centrifugal loads, interference fit, and thermal gradients where applicable. The ratio of material fracture toughness, K<sub>IC</sub> (as derived from material tests on each major part or rotor), to the maximum tangential stress intensity at speeds from normal to 115% of rated speed design overspeed is at least  $40 \text{ mm}^{1/2}$  2 at minimum operating temperature. The fracture toughness (K<sub>IC</sub>) value is determined using a value of deep-seated FATT based on the measured FATT values from trepan specimens, and a correlation factor obtained from historical integral rotor test data.

~~Adequate material fracture toughness needed to maintain this ratio is assured by destructive tests on material samples using correlation methods which are as conservative, or more so, than those presented in Reference. However, this method of obtaining fracture toughness, K<sub>IC</sub>, will be used only on materials which exhibit a well-defined Charpy energy and fracture appearance transition curve and strain rate insensitive. The COL applicant will provide the test data and the calculated toughness curve to the NRC staff for review. (See Subsection for COL license information.)~~

~~Turbine operating procedures are employed to preclude brittle fracture at startup by ensuring that metal temperatures are (a) adequately above the FATT, and (b) as defined above, sufficient to maintain the fracture toughness to tangential stress ratio at or above 10.~~

Sufficient warmup time is specified in the turbine operating instruction to assure that toughness will be adequate to prevent brittle fracture during startup. Sufficient warm-up time is specified in the turbine operating instructions to ensure that the above ratio of fracture toughness to stress intensity is maintained during all phases of anticipated turbine operation.

### 10.2.3.3 High Temperature Properties

STP DEP 10.2-2

The operating temperatures of both the high-pressure and the low pressure rotors are below the stress rupture range. Therefore, creep-rupture is not a significant failure mechanism.

### 10.2.3.4 Turbine Design

STP DEP 10.2-2

*The turbine assembly is designed to withstand normal conditions and anticipated transients, including those resulting in turbine trip, without loss of structural integrity. The design of the turbine assembly meets the following criteria:*

- (1) *Turbine shaft bearings are designed to retain their structural integrity under normal operating loads and anticipated transients, including those leading to turbine trips.*
- (2) *The multitude of natural critical frequencies of the turbine shaft assemblies existing between zero speed and 20% overspeed are controlled in the design and operation so as to cause no distress to the unit during operation.*
- (3) *~~The maximum tangential stress resulting from centrifugal forces, interference fit, and thermal gradients does not exceed 0.75 of the yield strength of the materials at 115% of rated speed.~~ The turbine rotor average tangential stress (excluding stresses in the blade/wheel region) at design overspeed resulting from centrifugal forces, interference fit (as applicable), and thermal gradients does not exceed 0.75 of the minimum specified yield strength of the material.*
- (4) *The design overspeed of the turbine is at least 5% above the highest anticipated speed resulting from a loss of load. The basis for the assumed design overspeed will be submitted to the NRC staff for review. (See Subsection [10.2.5.2](#) for COL license information.)*
- (5) *~~The turbine disk design will facilitate inservice inspection of all high stress regions. The turbine rotor design is based on using solid forged monoblock rotors rather than shrunk-on disks.~~*

### 10.2.3.5 Preservice Inspection

STP DEP 10.2-1

*The pre-service inspection procedures and acceptance criteria are as follows.*

- (1) *Forgings are rough-machined with minimum stock allowance prior to heat treatment.*
- (2) *Each finished machined rotor is subjected to ~~100% volumetric (ultrasonic), and~~ surface visual examinations, using established acceptance criteria. These criteria are more restrictive than those specified for Class 1 components in the ASME Boiler and Pressure Vessel Code, Sections III and V, and include the requirement that subsurface sonic indications are either removed or evaluated to ensure that they will not grow to a size which will compromise the integrity of the unit during its service life. Forgings undergo 100% volumetric (ultrasonic) examination subject to established inspection methods and acceptance criteria that are equivalent or more restrictive than*

those specified for Class I components in ASME Code Sections III and V. Subsurface sonic indications are not accepted if found to compromise the integrity of the unit during its service life. Rotor forgings may be bored to remove defects, obtain material for testing and to conduct bore sonic inspection.

- (3) ~~All finished~~ Finished machined surfaces rotors are also subjected to a surface and visual examination. Specific portions, including any bores, keyways, or drilled holes, are subject to magnetic particle test. ~~with no flaw indications permissible~~ Surface indications are evaluated and removed if found to compromise the integrity of the unit during its service life. All flaw indications in keyways and drilled holes are removed.
- (4) ~~Each fully bucketed~~ bladed turbine rotor assembly is factory spin- tested at the highest anticipated speed resulting from a loss of load 20% overspeed.

*Additional preservice inspections include air leakage tests performed to determine that the hydrogen cooling system is tight before hydrogen is introduced into the generator casing. The hydrogen purity is tested in the generator after hydrogen has been introduced. The generator windings and all motors are megger tested. Vibration tests are performed on all motor-driven equipment. Hydrostatic tests are performed on all coolers. ~~All piping is pressure tested for leaks. Motor operated valves are factory leak tested and in place tested once installed~~ Required piping is pressure-tested for leaks.*

### 10.2.3.6 Inservice Inspection

STP DEP 10.2-1

*The inservice inspection program for the turbine assembly includes ~~the disassembly of the turbine and~~ complete inspection of all normally inaccessible parts, such as couplings, coupling bolts, turbine shafts, ~~low pressure turbine buckets, low pressure and high pressure~~ turbine blades and turbine rotors. During plant shutdown (coinciding with the inservice inspection schedule for ASME Section III components, as required by the ASME Boiler and Pressure Vessel Code, Section XI), turbine inspection is performed in sections during the refueling outages so that ~~in 10 years~~ a total inspection has been completed at least once within the time period recommended by the manufacturer.*

The recommended maintenance and inspection program plan for the turbine assembly, valves and controls ensures that the annual turbine generator missile probabilities are maintained at or below the acceptable level (See Subsection 10.2.1).

*This inspection consists of visual, ~~and~~, surface and volumetric examinations as indicated below.*

- (1) Visual, magnetic particle, and ultrasonic examination of all accessible surfaces of rotors.

- (2) ~~Visual, and surface~~ magnetic particle, or liquid penetrant examination of examination of all low pressure buckets turbine blades.
- (3) ~~100% visual~~ Visual and magnetic particle examination of couplings and coupling bolts.

The inservice inspection of valves important to overspeed protection includes the following:

- (1) All main stop valves, control valves, extraction nonreturn valves, intermediate stop, and intercept valves and CIVs will be are tested under load. Test controls installed on in the main control room turbine panel permit full stroking of the stop valves, control valves, and CIVs intermediate stop and intercept valves. Valve position indication is provided on the panel in the main control room. Some load reduction is may be necessary before testing main stop and control valves, intermediate and intercept valves-CIVs. Extraction nonreturn valves are tested by equalizing air pressure across the air cylinder. Movement of the valve arm is observed upon action of the spring closure mechanism. by the main control room valve position indication.
- (2) Main stop valves, control valves, extraction nonreturn valves, and intermediate stop and intercept valves will be are tested in accordance with the BWROG turbine surveillance test program, as required by the turbine missile probability analysis by closing each valve and observing by the main control room valve position indication or that # the valves move smoothly to a fully closed position. Closure of each main stop valve, control valve and CIV intermediate and intercept valve during test will be is verified by direct observation of the main control room valve motion-position indication. This test also verifies the fast closure function during the last portion of the valve travel.

Tightness tests of the main stop and control valves are performed at least once per maintenance cycle by checking the coastdown characteristics of the turbine from no load with each set of four valves closed alternately, or using warm-up steam as an indicator with the valves closed.

- (3) All main stop valves, main control valves, and intermediate stop and intercept valves are disassembled and visually will be inspected once during the first three refueling or extended maintenance shutdowns. Subsequent inspections will be are scheduled by the GOL applicant in accordance with the recommendations of the BWROG turbine surveillance test program as required by the turbine missile probability analysis. The inspections will be conducted for:
  - (a) Wear of linkages and stem packings.
  - (b) Erosion of valve seats and stems,



- (c) Deposits on stems and other valve parts which could interfere with valve operation,
- (d) Distortions, misalignment or cracks.

Inspection of all valves of one functional type (i.e., stop, control, intercept) are ~~will be conducted if any unusual condition is discovered~~ for any detrimental, unusual condition (as defined by the turbine valve in-service inspection program) if one is discovered during the inspection of any single valve.

## 10.2.4 Evaluation

~~STP DEP 10.2-1~~

~~The connection between the low pressure turbine exhaust hood and the condenser is made by means of a rubber or stainless steel expansion joint.~~

STP DEP 3.5-1

The probability of a turbine missile striking any component has been determined to be less than  $1 \times 10^{-7}$  per year (subsection 3.5.1.1.1.3), which meets the guidelines of Regulatory Guide 1.115 for not considering turbine missile damage to specific components. Refer to subsection 3.5.1.1.1.3 for a discussion of compliance with Standard Review Plan 3.5.1.3 and the guidelines of Regulatory Guide 1.115. Thus failure of T-G and associated equipment cannot preclude the safe shutdown of the reactor.

## 10.2.5 COL License Information

### 10.2.5.1 Low Pressure Turbine Disk Fracture Toughness

The following site-specific supplement addresses COL License Information Item 10.1.

In accordance with 10 CFR 50.71(e), STPNOC will update the FSAR to identify the turbine material property data that supports the material properties used in the turbine rotor design specified in Subsection 10.2.3.2, after procurement and prior to initial fuel load (COM 10.2-1). Operating procedures to assure sufficient turbine warm-up time as required by subsection 10.2.3.2, are prepared in accordance with the guidelines in FSAR Section 13.5. ~~the Plant Operating Procedure Development Plan in accordance with Licensing Topical Report NEDO-33297 "Advanced Boiling Water Reactor (ABWR) Procedures Development Plan," dated January 2007.~~

### 10.2.5.2 Turbine Design Overspeed

The following site-specific supplement addresses COL License Information Item 10.2.

The highest anticipated speed resulting from loss of load is normally in the range of 106-109% of rated speed. Turbine components are designed such that calculated stresses do not exceed the minimum material strength at 120% of rated speed. Turbine rotors are spun to a speed of 120% rated as part of factory balance verification. This is approximately 10% above the highest anticipated speed resulting from loss of load.

### 10.2.5.3 Turbine Inservice Test and Inspection

The following site-specific supplement addresses COL License Information Item 10.3.

Turbine inservice test and inspection requirements are discussed in subsection 10.2.3.6.

### 10.2.6 References

The following standard supplement adds the following references.

- 10.2-3     Electric Power Research Institute, "Guidelines for Permanent BWR Hydrogen Water Chemistry Installations – 1987." EPRI NP-5283-SR-A, September 1987.
- 10.2-4     USNRC, "Safety Evaluation Report Relating to the Operation of Hope Creek Generating Station", NUREG-1048, Supplement No. 6, July 1986

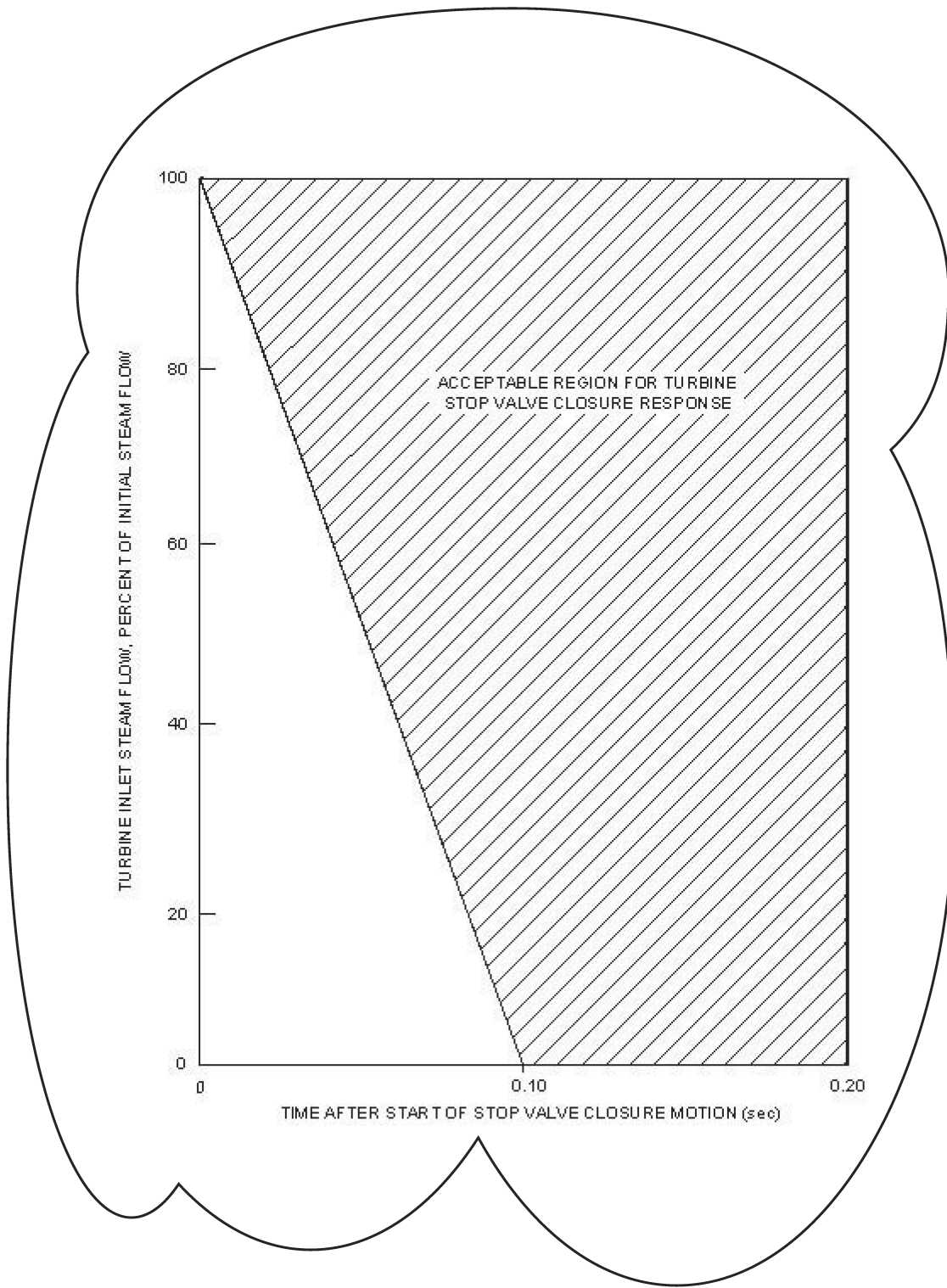
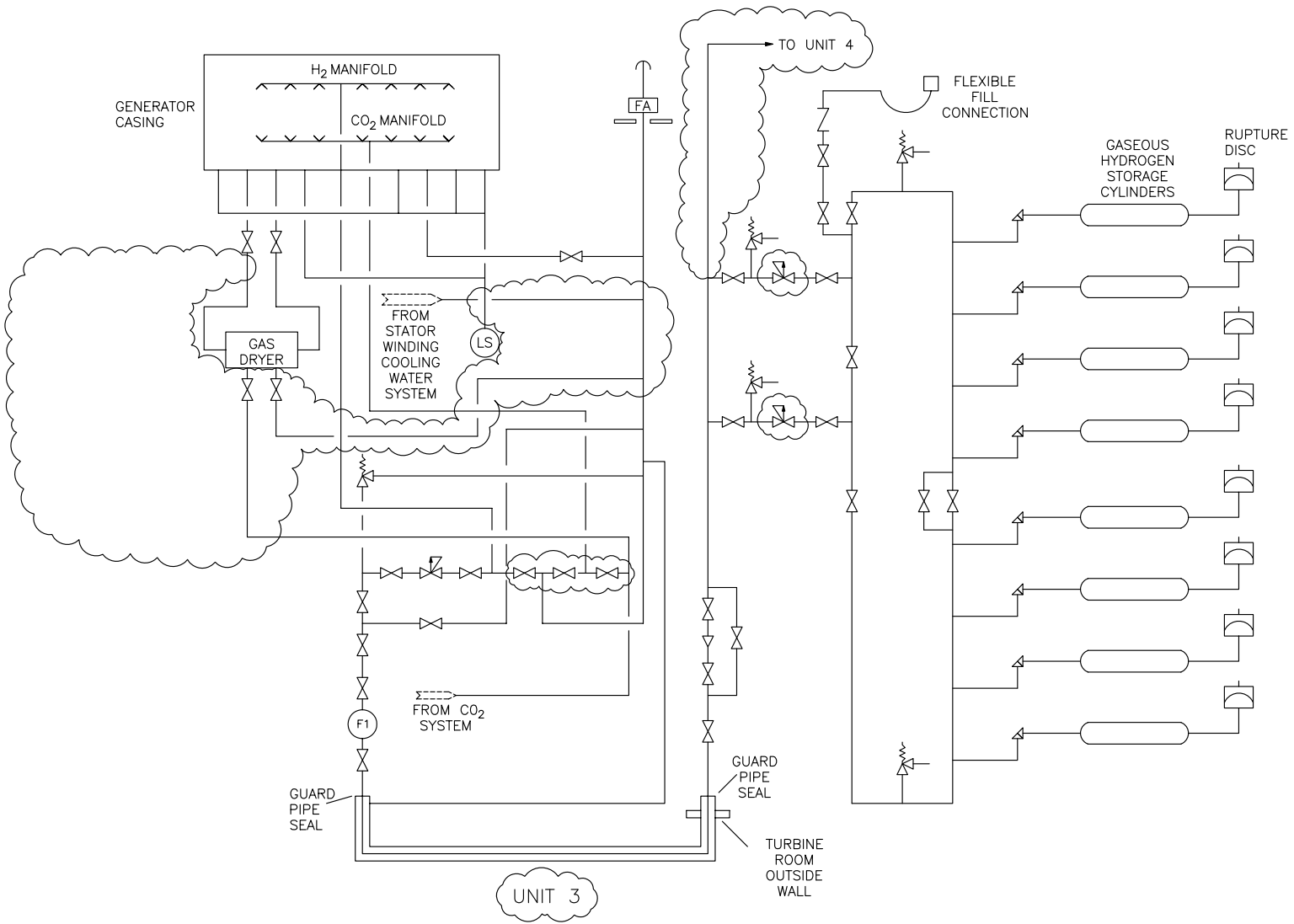


Figure 10.2-1 Turbine Stop Valve Closure Characteristic



**Figure 10.2-4 Generator Hydrogen and CO<sub>2</sub> System**