GE Nuclear Energy

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Attention: Charles L. Miller, Director
Standardization and Non-Power Reactor Project Directorate

Subject: **Submittal of Responses to Additional Information as Requested in NRC Letter from Dino C. Scaletti, Dated January 26, 1990**

Enclosed are thirty four (34) copies of the Chapter 10 responses to the subject Responses to Request for Additional Information (RAI) on the Standard Safety Analysis Report (SSAR) for the Advanced Boiling Water Reactor (ABWR).

It is intended that GE will amend the SSAR with these responses in a future amendment.

Sincerely,

R C Mitchell

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cc: F. A. Ross (DOE)
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Question 430.59

Provide information on the following items that are to be submitted by March 31, 1989.(10.1)

a. Figure 10.1-2, Heat Balance for Guaranteed Reactor Rating

b. Figure 10.1-3, Heat Balance for Valves-Wide-Open

c. Table 10.1-1, Summary of Important Design Features and Performance Characteristics of the Steam and Power Conversion System, with regard to:

-- Condensate pumps: total head (ft) and motor hp.

-- Low pressure heaters: Stage pressure (psia) and duty per shell (Btu/hr) for heaters Nos. 1,2,3, and 4.

-- High pressure heaters: Stage pressure (psia) and duty per shell.

-- Low pressure turbine exhaust pressure to condenser.

Response 430.59

The above information was provided in Amendment 7. The low pressure turbine exhaust pressure to the condenser reported under item C is included on the heat balance Figure 10.1-2 and Figure 10.1-3.

Question 430.60

Specify the value for time "T" in Figure 10.2-2. (10.2)

Response 430.60

Figure 10.2-2 has been revised to indicate T(sec) = 0.0008 x % NBR Power.

Question 430.61

Provide a description of the bulk hydrogen storage facility mentioned in Section 10.2.2.2. (10.2)

Response 430.61

This is a project (site) Specific facility and is not within the scope of ABWR Standard Plant. For reference purposes, the standard design assumes a high pressure cylinder storage facility housed in a weather protected light structure having open top natural ventilation.

Question 430.62

Provide a description of the speed control unit, the load control unit and the flow control unit of the electrohydraulic (EHC) system. Your description should include how they perform their intended functions. Clarify whether the EHC system will fully cut off steam at 103 percent of rated turbine speed. (10.2)

Response 430.62

The main turbine EHC control system is now referred to as turbine digital control and monitoring (DCM) system. The DCM system, in conjunction with the reactor pressure control system, will provide manual and automatic control, protection and monitoring for the turbine-generator during normal operation of the unit. Specifically, the DCM will measure critical unit parameters, make and implement decisions, and regulate the position of the turbine main steam control valves to startup, load, unload and shutdown the unit. The system also includes built-in features to automatically protect the turbine-generator against abnormal operating conditions of overspeed, loss of oil, overheating, etc., which can be monitored and tested while the turbine-generator unit is in normal operation.

Triple-redundant digital control processors and protective logic circuitry is used to implement the closed loop control and protective functions necessary for safe operation of the turbine-generator. This redundant circuitry provides fault-tolerant operation of the turbine-generator unit for malfunctions within the control hardware, and allows on-line maintenance without need for shutting down the unit.

Inputs from redundant sensors are examined for validity and voted to protect against drift or other potential malfunctions. The voted inputs are provided to each of the three controllers where independent control calculations are performed. The controller outputs are also voted to eliminate control commands that may be erroneous to the component failure. Logic outputs are voted via two-out-of-three contact arrangements. Control action of the main control valve actuators is the result of the sum of the output currents from the triply redundant controllers. Process variable voting is thus extended to the triple coil servovalve with the first possible single failure being the mechanical servovalve itself.

The triply redundant architecture, with total independence between control channels (including input sensors and output drivers), therefore allows uninterrupted operation in the presence of one main channel malfunction. The triply redundant controllers of the DCM are identical, with the components of each being fully interchangeable. Any one controller can be shut down and removed from the system without affecting system operation. Individual power sources are provided for each controller. Furthermore, cabinet arrangement facilitates system maintenance by providing sufficient space for on-line component repair. The following sections describe the functions of the speed control function, the load control function, and the flow control function. Refer to Figure 20.3-41, simplified functional control diagram of the DCM.

1. Speed Control

   The governor speed control is fully coordinated with the trip system, and is capable of controlling speed accurately over the entire speed range from turbine gear to a speed high enough to test the protective overspeed trip devices.

   Multiple speed feedback signals are derived from redundant sensors mounted around a toothed wheel attached to the turbine shaft. A separate probe is provided for each of the triple redundant electronic governor channels, and the toothed wheel and the speed probes are both located at the turbine front standard.

   Each of the triplex speed control loops are used to control both speed and acceleration of the unit while off-line, and to provide correct regulation of the unit once it is synchronized to the system. Final control of the unit is determined by two-out-of-three vote from the three electronic governor channels.

   The speed control unit produces the speed error signal error signal which is fed to the load control unit where it is combined with other signals to control the steam admission valves. The speed error signal is derived by comparing the speed reference (desired speed) with the actual speed at steady state conditions.

The desired speed target may be selected manually from the operator interface in the main control room. Speed targets are provided for selecting steady state operation at the lower speed holds (where thermal soaking may be required) as well as for selecting rated speed. A separate selection is also provided that when enabled, overspeeds the turbine (at the selected acceleration rate) for purpose of testing the overspeed capabilities. The machine coasts down to rated speed when the selection is disabled. Discrete acceleration reference signals are also selected.

A function called the "wobbulator" is incorporated in the speed control unit to slowly vary turbine speed above and below the high speed hold. The wobbulator prevents the turbine from running at a constant speed near critical bucket resonances.

A governor "non-regulating" function is available as an option for operator selection. A frequency deadband is introduced within which no speed error is generated.

The speed control function also provides line speed matching capabilities for synchronizing the unit to the electrical grid system. Three methods of line speed matching are available:

(a) An automatic speed matcher is incorporated in the speed control function to simplify synchronization of the unit. If the following permissives have been satisfied, the automatic speed matcher will be enabled:

    a. Automatic speed matching selected
    b. Synchronous speed selected
    c. At speed target indicated
    d. Overspeed test not selected
    e. CIRCUIT BREAKER OPEN indicated

    When the automatic speed matcher is in operation, the circuit will adjust the turbine speed to the desired slip frequency until the circuit breaker has been closed. The automatic speed matcher can be removed from service at any time.

(b) Line speed matching may be performed by remote equipment. With the remote speed matcher, turbine speed is adjusted by the DCM according to increase and decrease pulses received from an automatic synchronization equipment. In this case, the slip frequency is established by the automatic synchronization system.

(c) Speed matching may also be performed manually by operation of increase/decrease selections at the operator interface in the main control room when the semi-automatic mode is selected.

2. Load Control Function

The basic purpose of the load control function is to accept input signals from other functions of the DCM system and to use these signals in conjunction with functions internal to the load control function to compute flow reference signals for the flow control function. Switching signals indicating operating conditions are also supplied to other parts of the DCM system.

The load control functions may be grouped as follows:

a.) Sensing functions are provided to detect and generate signals proportional to parameters that affect loading of the unit.

b.) Limiting Functions are provided to electrically constrain the flow reference signals in response to signals from the sensing circuits, from the speed control function, or from devices detecting the state of plant components.

c.) Computing functions are provided to generate flow reference signals for the valve stems, considering the desired load signal, the limiting functions, and the speed error signal from the speed control function.

d.) Logic functions are provided to ensure that necessary permissives have been satisfied prior to changes in mode of operation, to communicate status information between the load control function and other elements of the DCM system, and to provide switching signals to devices in the DCM system.

Since each of the described functions of the load control function may involve more than one of the basic generalized functions listed above, each description given below will involve discussion of the appropriate functions (sensing, limiting or computing) as well as the logic functions involved. The load control functions are:

a. Load Reference
b. Load Runbacks
c. Valve Position Limit
d. Load Setbacks
e. Control Valve Testing
f. Valve References

Load Reference

The Load Reference is a value corresponding approximately to current desired load. The load reference signal is also provided to the reactor pressure control system for calculation of the load demand error signal. The load demand error signal is an input to the reactor recirculation flow control system for automatic load following operations. The load control function changes the load reference at the selected loading rate towards the selected target load. The load reference may be changed by any of the following sources, by changing the target load: The target load being lowered or raised at the operator control interface in the main control room. Increase or decrease signals are generated by the automatic or manual speed match functions and may be received from a remote source when some remote form of operation has been selected. Certain abnormal conditions require that the load reference be run back in the decreasing load direction. These runbacks are discussed in the following section "load runbacks".

Load Runbacks

Logic is incorporated to reposition the load reference when certain abnormal operating conditions are detected. Runbacks must be initiated by a signal from the prior load unbalance, if the load reference signal exceeds a preset load limit, or by a signal from the plant computer system indicating that abnormal plant conditions require a reduction in load.

The load runback is enabled by a pulsed or continues-contact closure. Continues-contact closure will run the load set down from rated load toward 2% load in 45 seconds. The maximum rate of change of the load reduction is 133% per minute. The minimum pulse length is 225 milliseconds. Load increase demands are interrupted during load runbacks.

Load Position Limit

A valve position limit function is provided in the DCM to limit steady state opening of the controlling valves to limit steam flow. An additional feature is a runback of the load reference to a point 2% above the setting of the valve position limit such that when the limit is lifted, it does not allow a sudden load increase.

Load Setbacks

Four load setback inputs are available that will set the valve position limit signal back upon a contact closure from the plant computer. They can be used by the customer upon loss of circulating water pumps, low condenser vacuum, etc., to reduce load rapidly to a given level regardless of system frequency.

The four setbacks have separately adjustable valve position limit levels and setback rates to provide for various contingencies. Several signals from the customer's plant computer may be associated with each of the four variable rate load setbacks. These variable rate setbacks have a range of 0.5% per second to 10% per second. The setback levels have a range of essentially 0% to 100%.

When indication of a limiting condition is received, the setback signal reduces the valve position to the preselected limit level at the preselected rate. Simultaneously, signals are provided to the load reference function to run back the target load to slightly above the level of the appropriate limit. Should more than one setback be activated simultaneously, load will be set back to the lowest limit at the fastest rate. Again, this condition will be indicated on the operator interface. All customer-provided signals which initiate a setback must be cleared before normal conditions are re-established.

Control Valve Testing

Circuitry is provided to test each valve separately while the unit is operating under load. The tests are initiated from the operator interface in the main control room and cause each valve to close at constant rate to verify free operation.

Near the closed end position (approximately 90% closed), a signal is given to the fast closing devices in each valve actuator to verify that they are responding correctly. The motion of the valves during testing is displayed to the operator so that correct performance can be observed.

Valve References

A total of three valve reference signals are generated in the load control function to produce flow references for the #2 main stop valve, the control valves and intercept valves, respectively.

The flow reference for the #2 main stop valve is generated by adding the operator's warming bias signal with the speed error and passing the result to the flow control function as main stop valve #2 warming reference.

For the control valve reference, the speed error and the load reference are added. This resulting signal is subsequently combined with the steam flow demand signal from the reactor pressure control in a low-value selector to form the control valve flow reference signal passed on to the flow control function. Normally, the turbine flow reference signal is biased higher than the steam flow demand signal from the reactor pressure control system, and hence, the pressure control signal (steam flow demand) will pass through the low-value selector and becomes the control valve flow reference signal. The control valve flow reference signal is subtracted from the steam flow demand signal from the reactor pressure control system to form the bypass flow demand. When the main turbine cannot accept all the steam generated from the reactor, the excess steam is thus bypassed to the main condenser through turbine bypass valves.

The speed error, the load reference and appropriate bias values are added to form intercept valve flow reference for passing to the flow control function.

The regulation relative to the speed error for the valves sets are:

Main Stop Valve #2	5%, fixed,
Control Valves:	adjustable from 2.5% to 7.5%, set to 5%, at the factory.
Intercept Valves:	2%, fixed

With a regulation of 5% for the control valves (20% change in load reference per % change in speed error), a 5% increase in speed will fully cut off steam to the turbine. However, since the turbine bypass capacity is only 33%, the reactor pressure increase will result in a high power or high pressure scram to shut down the reactor.

3. Flow Control

The four turbine control valves, the three turbine steam bypass valves, three of the six intercept valves (CBIV), and the #2 main stop valve bypass are designed to operate on closed loop control. The remaining main stop valves, intercept valves and reheat stop valves will all operate on open loop control resulting in either a fully open or fully closed position.

The flow control function will determine, from the main stop valve, control valve and intercept valve flow references, the required sequence of valve strokes and instantaneous position of each valve and implement these positions through the associated valve position circuits. The reactor pressure control system, interfacing with the turbine load control function, will control the steam bypass valves.

Electro hydraulic servovalves are provided on all controlling valve actuators to convert the electrical control signals from the control system to precisely regulated flow of servofluid into valve actuators. The actuators, in turn, provide the mechanical forces to position the steam valves in response to the commands from the control system.

The actuators are equipped with triple coil sevovalves and three redundant linear position transducers (LVDT) for triple redundant valve position control. The positioning system is able to withstand a failure of any single element in the positioning system with less than 5% of full stroke steady state distortion of the valve position.

3.1 Main Stop Valve Positioning

The main stop valve (MSV) #2 has been position control for the full stroke of its internal bypass valve, foe use in chest and rotor warming. The actuator for this internal bypass valve is equipped with a two coil servovalve, a single position transducer, and a fast acting solenoid valve.

MSV #1, 3, and 4 are positioned either fully open or fully closed. These actuators are equipped with a solenoid test valve, a single position transducer, and a fast acting solenoid valve. Circuits and logic for positioning and testing of these stop valves are provided.

3.2 Control Valve Positioning

All four control valves are positioned continuously over their entire stroke. Each actuator is equipped with a three coil servovalve and three position transducers. All control valves will be closed fast simultaneously by power load unbalance circuit by energizing fast acting solenoid valves on each actuator. Each control valve is tested regularly with the help of its servovalve and fast acting solenoid valve. The positioning circuitry will withstand failure of a single channel. If two channels should fail, a fully open valve will remain open, whereas a partially open valve will go closed. The reactor transients associated with failure of control valves is analyzed in Chapter 15.

3.3 Intercept Valve Positioning

Combined Intercept Valve (CBIV) #1, 2, and 3 have continues positioning capability from the intercept flow valve reference developed by the load control function. The actuators are equipped with three coil servovalve and three position transducers, as well as fast acting solenoid valve for fast closing. CBIVs #4, 5, and 6 are positioned as "slaves" based on the position of "masters" CBIVs #1, 2, and 3 respectively. The actuators on slaved valves are equipped with one solenoid test valve, one fast acting solenoid valve, and one position transducer. While a master valve is being opened, its slave remains fully closed until the master valve is being opened, its slave remains fully closed until the master reaches the 90% open position at which time the slaved valve will be commanded to go fully open by actuation of its test solenoid valve. When the master valve is moving in the closed direction, its slave valve remains open until the master has reached the 50% open position at which time the slaved valve will be commanded closed by actuation of its test solenoid valve. Position signals are generated from position transducer feedback.

3.4 Bypass Valve Positioning

All three bypass valves are positioned continuously over their entire stroke by the reactor pressure control system. Each actuator is equipped with a three coil servovalve. The bypass valves will open in sequence, depending on the magnitude of the bypass steam flow demand signal. Each bypass valve is tested regularly with the help of its servovalve and fast acting solenoid valve. The positioning circuitry will withstand failure of a single channel. If two channels should fail, a fully open valve will remain open, whereas a partially open valve will go closed. Upon a turbine/generator trip, the bypass valve fast acting solenoid valve is energized, allowing fast opening of all bypass valves to minimize the pressure increase in the reactor pressure vessel.

Question 430.63

For the turbine overspeed protection system (described in Section 10.2.2.4), the SSAR referred to redundant electrical trip signals. Provide information on the power source associated with each of the trip circuits.(10.2)

Response 430.63

If the normal speed control system should fail, the overspeed trip devices must close the steam admission valves to prevent turbine overspeed. The mechanical trip overspeed mechanism operates at 110% of rated speed. Three speed signals independent of the normal speed control unit provide input to the electrical backup overspeed trip. Two out of three logic is employed in the electrical backup overspeed trip circuitry.

Electrical power required by the turbine digital control and monitor (DCM) system is provided by two separate uninterruptable power sources, the Vital Non-Class 1E 120 VAC busses (refer to Figure 8.3-6, Plant Vital CVCF Single Line Diagram). AC power from these two independent sources is provided to rectifiers which convert the 120VAC to 125 VDC. The rectifier outputs feed a high value gate. The high value gate output is the 125 VDC bus used to trip system and the various DCM subsystems. Circuit breakers and fuses are provided as necessary to protect the power distribution system from vulnerability to single point failures.

The electrical overspeed trip system (backup overspeed trip or BOUST) contains two "trip busses", one at 24 VDC (energized by redundant power supplies) and one at 125VDC (energized directly from the 125 VDC bus described above). The BOUST makes trip input to the hydraulic system from its 24 VDC bus with a "de-energize-to-trip" solenoid valve and from 125 VDC bus with an "energize-to-trip" solenoid valve.

The mechanical overspeed trip is powered entirely by spring force, energized at the time of turbine reset, and implements its trip command by "depressurization-to-trip."

Question 430.64

As presented in Section 10.2.2.4 of the ABWR SSAR, the closing time of the extraction nonreturn valves is less than 0.2 seconds, while it is 2 seconds at current BWR plants. Provide additional information on the design of these valves that supports the difference between the above closing time values. (10.2)

Response 430.64

Subsection 10.2.2.4 was in error and revised to indicate the closing time of the extraction nonreturn valves to be less than 2 seconds.

Question 430.65

Clarify whether at least one main stop valve, control valve, reheat intercept valve will be inspected at approximately 3-1/3 years by dismantling them, and whether visual and surface examinations will be conducted for the valve seats, disks and stems. (Note: The above is an acceptance criterion for SRP Section 10.2) (10.2)

Response 430.65

Subsection 10.2.3.6 will be revised to indicate that one valve of each type will be inspected after each fuel cycle or every 3-1/3 years, whichever is less. As stated in Subsection 10.2.3.6 Item 3 under the heading "The inservice inspection of valves important to overspeed protection," all main stop valves, main control valves, and CIVs inspections will be conducted for:

a. Wear of linkage 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

These inspections will be accomplished by disassembly of the valves. Subsection 10.2.3.6 will be revised to include a statement that the valves are to be dismantled and visual and surface examinations conducted of valve seats, disks, and stems.

Question 430.66

Identify preoperational and startup tests of the turbine generator in accordance with Regulatory Guide 1.68, "Initial Test programs for Water Cooled Power Plants," as an interface requirement. (10.2)

Response 430.66

The preoperational and startup tests of the turbine generator will be included in Section 14.2

Question 430.67

As stated in Section 10.3.2.1, "the four main steam lines are connected to a header upstream of the turbine stop valves...." However, according to Figure 10.3-2a, the main steam header is located downstream of the turbine stop valves. Identify whether the statement or figure is in error and revise the item in error so that the SSAR is consistent. (10.3)

Response 430.67

The main steam header upstream of the turbine stop valves referred to in Subsection 10.3.2.1 is shown on Figure 10.3-1. The line shown on Figure 10.3-2a downstream of the turbine stop valves is provided to equalize pressure upstream of the turbine control valves. The Subsection 10.3.2.1 text and Figure 10.3-1 are therefore consistent and do not need to be revised.

Question 430.68

Provide information on the leakage detection system for steam leakage from the MSSS in the event of a steam line break. Also provide information on the statement "safety feature designed into the MSSS" that will prevent radiation exposures in excess of the limits of 10 CFR Part 100 in the event of a break of a main steam line or any branch line (SSAR Section 10.3.3. (10.3))

Response 430.68

The leak detection system (LDS) is designed to monitor leakage from the main steam lines and from the branch steam line to RCIC. Upon detection of a leak in the main steam lines, LDS will automatically isolate the source of the leak by closing the MSIVs, both the inboard and outboard containment isolation valves. The specific variables which LDS monitors to isolate the main steam supply in the event of a steam line break are:

a. High radiation in the MSL tunnel area
b. High ambient temperature in the MSL tunnel area
c. High ambient temperature in the main turbine area
d. High flow in the main steam lines
e. Low pressure in the inlet steam line to the main turbine
f. Low pressure in the RCIC steam line
g. High flow in the RCIC steam line

Any of the above variables items (1) thru (5) will initiate closure of the MSIVs and isolate the main steam supply to the turbines. Either vcariable items (6) or (7) above will isolate the main steam line to RCIC turbine.

The safety features designed in the MSSS is the automatic closure of the containment isolation valves which isolate the source of the leak. This prevents release of radioactivity to the environment and minimize exposure to radiation.

Question 430.69

For the following items identified in SSAR Figure 10.3-1:

a. Deaerating steam to condenser
b. Offgas system
c. Steam jet air ejectors
d. Turbine gland sealing system
e. Reheater
f. Main steam bypass (turbine bypass)

Provide the following information:

a. Maximum steam flow (lbs/hr)
b. Type of shut-off valve(s)
c. Size, quality, design code. closure time, actuation mechanism and associated motive power of the valve(s).

Response 430.69

Figure 10.3-1 has been revised and shows the power cycle auxiliaries using main steam (all services other than the turbine bypass) divided into two groups such that the supply line to each group has one isolation valve.

The grouping of the steam supply services is made to facilitate the pipe routing. As an example the steam supply to the turbine gland seal system is grouped with the steam supply to reheaters A-1 and A-2. The turbine gland seal system and reheaters A-1 and A-2 are physically within close proximity of each other. Similarly, the steam supply to the condenser sparger, the steam jet air ejector, offgas system, and reheaters B-1 and B-2 are grouped together.

(a) The maximum steam flow for each steam service identified (except for the deaerating steam service to the condenser) are taken from the valves-wide-open (VWO) heat balance, Figure 10.1-3.

(i) Maximum deaerating steam flow to the condenser (this system is not shown on the heat balance) is approximately 20,000 lb/hr.

(ii) The steam supply flow to the offgas system is included in the steam supply flow shown on the heat balance to the steam jet air ejector. The total steam flow for the Steam Jet Air Ejector and the offgas system is 18,800 lb/hr as shown on Figure 10.1-3.

(iii) Turbine Gland Seal System steam flow is nominally 22,000 lb/hr at 198.95 psia and 1089 Btu/lb for the VWO condition as shown on Figure 10.1-3. The maximum design flow however is based on a gland clearance equal to twice the normal clearance, and is estimated in first approximation to be 45,000 lb/hr.

(iv) The steam supply flow to the four reheaters is 1,655,884 lb/hr as indicated on the VWO heat balance Figure 10.1-3.

(v) The turbine bypass steam flow is approximately 33% of the maximum guaranteed heat balance steam flow of 16,845,171 lb/hr shown on Figure 10.1-2. The total turbine bypass steam flow is therefore 5,615,057 lb/hr.

The steam flow for the two groups of services is calculated as follows:

a) Design steam flow for the supply line to reheaters A-1 and A-2 and the turbine gland seal steam is approximately 875,000 lb/hr derived by taking one-half of the total heat balance reheater steam of 1,655,884 lb/hr and adding 45,000 lb/hr for the turbine gland seal steam flow.

b) Design steam flow for the supply line to the condenser sparger, steam jet air ejector and offgas systems and reheaters B-1 and B-2 is approximately 850,000 lb/hr derived by taking one-half of the total heat balance reheater steam flow and adding the steam flow for the steam jet air ejector and offgas system steam flow. (The deaerating steam flow is not included in this total since deaerating using main steam only occurs during startup.)

(b) The main steam supply shutoff valves for the two steam supply lines (does not include turbine bypass) are to be power operated gate valves.

(c) Each of the two steam supply shutoff valves will be 16 inch diameter, quality group D, ANSI B16.1 design code, having a closure time of 2 seconds, and having air operators and spring closure mechanisms.

Note: Refer to response to question 430.84 for additional information on the turbine bypass valves.

Question 430.70

Provide information on the following items:(10.3)

Question 430.70a

Analysis for steam hammer and safety relief valve discharge loads and issues.

Response 430.70a

The acoustic loads due to turbine stop valve closure (TSVC-steam hammer) and safety relief valve discharge loads are analyzed using GE standard practices for the ABWR main steam (MS) and safety relief valve discharge line (SRVDL) piping systems. A discussion of these acoustic loads are discussed below.

Turbine Stop Valve Closure (TSVC)

Prior to turbine stop valve closure, saturated steam flows through each main steam line at nuclear boiler rated pressure and mass flow rate. Upon a closure signal, the turbine stop valves close rapidly and flow stops at the upstream side of these valves at the instant valve closure is achieved. A pressure wave is created and travels at sonic velocity toward the reactor vessel through each main steam line. Steam flow into each main steam line from the reactor vessel continues until the fluid compression wave reaches the reactor vessel nozzle. Repeated reflection of the pressure wave at the reactor vessel and stop valve ends of the main steam lines produce time varying pressures and velocities at each point along the main steam lines. The combination of fluid momentum changes, shear forces, and pressure differences cause forcing functions which vary with position and time, to act on the main steam piping system.

The analysis of the TSVC transient consists of a sequential time history of the fluid flow equation to generate a time history of the fluid properties at numerous locations along the pipe. The fluid transient properties are calculated based on the nuclear boiler rated steam flow rate and pressure.

The time history method of analysis is used to determine the piping system response to the TSVC transient. The force time histories are applied at locations on the piping system where fluid flow changes direction, thus causing momentary reactions. The resulting loads on the main steam line and at the attachment points are combined with other loads (e.g., pressure, thermal, and seismic).

SRVDL Acoustic Loads

An SRV lift results in a transient that produces momentary unbalanced forces acting on the piping system, for the period from opening of the SRV until a steady discharge flow from the RPV to the suppression pool is established. This period includes clearing of the water slug from the end of the discharge piping submerged in the suppression pool. Pressure waves traveling through the discharge piping following the relatively rapid opening of the SRV, cause the SRV discharge piping to respond. This in turn produces forces that act on the main steam and SRV piping.

The analysis of the relief valve discharge transient consists of a sequential time history solution of the fluid flow equation to generate a time history of the fluid properties at numerous locations along the pipe. The fluid transient properties are calculated based on the maximum set pressure specified in the main steam system specification and the value of the ASME B&PV Code flow rating increased by a factor to account for the conservative method of establishing the rating. Simultaneous discharge of all valves is considered to induce maximum stress in the piping. Reaction loads on the pipe are determined at each location corresponding to the position of an elbow. These loads are composed of pressure times area, momentum change, and fluid friction terms.

The time history method of analysis is used to determine the main steam and SRVDL piping system response to relief valve operation. The forces are applied at locations on the SRVDL piping system where fluid flow changes direction, thus causing momentary reactions. The resulting loads on the SRV, the main steam line, and the discharge piping are combined with other loads (e.g., pressure, thermal, and seismic).

Question 430.70b

Power source to the solenoid valves for the inboard and outboard main steam and isolation valves.

Response 430.70b

There are three solenoids per MSIV. The power sources are Division I and II essential power with the three solenoid for testing being either one or two.

For further details refer to Chapter 7 under leak detection and isolation.

Question 430.70c

Location of seismic interface restraint (e.g., interface of which buildings?)

Response 430.70c

The seismic interface restraint is outside the outboard MSIV's, but within the reactor building. (See Figure 5.1-3)

Question 430.70d

Route which the main steam lines, including the branch lines, pass up to the turbine stop valves.

Response 430.70d

The main steam line routing including branch lines up to the turbine stop valves inside the turbine building is shown on Figures 1.2-25, 1.2-26, and 1.2-28.

Question 430.70e

Specific design features provided to protect safety related portions of the main steam isolation valves, against externally and internally generated missiles and adverse natural phenomena such as floods, hurricanes and tornadoes.

Response 430.70e

The safety-related portion of the main steam lines can be found in Section 3.9. To summarize, the safety-related portion of main steam lines are located in a Seismic category I structure that protects it from external events (i.e., tornadoes, hurricanes, external missiles). For internal missiles protection features, see Section 3.5 for details.

Question 430.71

Describe provisions for operation of the main condenser with leaking condenser tubes. (10.4.1)

Response 430.71

The condenser is provided with leakage detection instrumentation in each hotwell outlet, each condenser tube sheet leak detection trough, and condensate is further monitored at the condensate pump discharge. The type of instrumentation to be utilized is site specific. The condensate cleanup system includes hollow fiber filters and deep bed demineralizers and will ensure the water quality is maintained up to the (site specific) design condenser leak rates. The leak detection instrumentation will allow the operator to identify the leaking tube bundle, initiate power reduction and faulty tube bundle drain down if required, and arrange for water box entry and leak repair at the earliest appropriate time.

Question 430.72

Provide the permissible cooling water inleakage rate and the allowed time of operation with inleakage. (10.4.1)

Response 430.72

The polishing system is sized to meet the chemistry requirements for continuous operation while operating continuously with a condenser leak of 0.001 gpm and to maintain water quality during an orderly unit shutdown (not longer than 8 hours) with a leak of 0.1 gpm until repairs can be made. The design is adequate to clean up the feed and condensate system during plant heatup and low power operation without limiting plant startup time. The number and sizing of the ion exchangers are such that the functional requirements are met while permitting the replacement of resin in one ion exchanger at a time. The ABWR Standard Plant design features facilitate replacement of ion exchange resin.

Question 430.73

Provide information on the following items:(10.4.1)

(a) Provisions incorporated into the main condenser design to preclude component or tube failure due to steam blowdown from the turbine bypass system.

(b) Worst possible flood level in the applicable buildings due to complete failure of main condenser and provisions for protecting safety related equipment located in the buildings against such flooding (note that ABWR SSAR Section 3.4 does not discuss the turbine building).

Response 430.73

(a) Specific provisions inside the condenser to preclude condenser tube damage due to turbine bypass steam impingement are to be defined by the condenser vendor for each project. Typically the provision inside the condenser consists of a horizontal perforated steam distribution pipe enclosed in a perforated guard pipe designed to protect the condenser internals from steam impingement. The perforated pipe and its guard pipe run the full length of the condenser and are supported above the condenser tube bundle.

(b) A circulating water system pipe, waterbox, or expansion joint failure, if not detected and isolated, would cause internal turbine building flooding up to slightly over grade level, with excess flood waters potentially spilling over on site. If a failure occurred within the condensate system (condenser shell side), the resulting flood level would be less than grade level due to the relatively small hotwell water inventory relative to the condenser pit capacity. In either event the flooding of the turbine building would not affect safety related equipment since no such equipment is located inside the turbine building and all plant safety related facilities are protected against site surface water intrusion.

Question 430.74

Discuss how the components of the main condenser evacuation system (MCES) conform to the guidelines of Regulatory Guide 1.26, 1.33. and 1.123 with respect to quality group classification and quality assurance programs.(10.4.2)

Response 430.74

The main condenser evacuation system is designed to Quality Group D as defined in Regulatory Guide 1.26. The condenser evacuation system is designed to meet the quality assurance requirements for design, construction, and operation according to the guidelines of Regulatory Guides 1.33 and 1.123.

Question 430.75

Provide the design pressure and normal operational absolute pressure for the MCES components that could contain potentially explosive gas mixtures. (10.4.2)

Response 430.75

The offgas portion of the MCES, that is downstream of the 2d stage steam jet air ejectors, is designed to withstand the effects of a hydrogen detonation. Design for extremely short duration (microsecond) loadings is outside the scope of normal industry design codes (ANSI B31.1 and ASME Section VIII). The design pressure is based on maximum detonation pressure increase factors varying from 2 to 170 for piping depending on layout. For components such as pressure vessels this increase is approximately 20. The appropriate increase factor is applied to the absolute operating pressure in each portion of the system to give the maximum static equivalent hydrogen detonation pressure. Once the system operating pressures, pipe diameters and layout are established, the detonation pressures for the piping and components can be established.

Question 430.76

Identify the radiation monitoring provisions for the mechanical vacuum pump exhaust. Is the exhaust filtered by charcoal absorber and HEPA filters prior to release? (10.4.2)

Response 430.76

The mechanical vacuum pump exhaust is monitored for radiation prior to discharge to the turbine building exhaust ventilation system. The turbine building ventilation exhaust is filtered by a moderate efficiency filter and monitored for radiation prior to discharge to the plant vent. Reference Figure 9.4-2a and Figure 10.4-1.

Question 430.77

Identify the number, location and functions (i.e., recording and annunciating alarm) performed by the hydrogen analyzers. Clarify whether they can withstand a hydrogen detonation. (10.4.2)

Response 430.77

Two parallel independent hydrogen analyzers are to be provided to measure the hydrogen content of the offgas process stream downstream of each offgas condenser. The hydrogen concentration analyzer signals are indicated and recorded in the main control room and the analyses provide for an independent alarm annunciation in case of high hydrogen concentration in the offgas process stream.

The hydrogen analyzers are designed to withstand a hydrogen detonation.

Question 430.78

Clarify whether the air ejectors are redundant in the sense that one of them is a standby. (10.4.2)

Response 430.78

The steam jet air ejector system consists of two 100% capacity, multiple element, multistage, steam jet air ejector (SJAE) units. Figure 10.4-1 is being revised to clearly indicate there are two sets of 1st and 2nd stage SJAEs and two intercondensers. One set of 1st and 2nd stage SJAEs and its intercondensers is normally in operation with the redundant set in standby.

Question 430.79

Identify the components and portions of the MCES that are designed to withstand a detonation in the system. (10.4.2)

Response 430.79

The SJAE discharge piping up to the offgas system equipment and interconnecting piping is designed for hydrogen detonation.

Question 430.80

Discuss how the design of the turbine gland sealing system (TGSS) conforms to the guidelines of Regulatory Guide 1.26 as it relates to the quality group classification for the system, and the Regulatory Guide 1.33 and 1.123 as they relate to the quality assurance program. (10.4.3)

Response 430.80

The turbine gland sealing system is designed to Quality Group D as defined in Regulatory Guide 1.26. The turbine gland sealing system is designed to meet the quality assurance requirements for design, construction, and operation according to guidelines of Regulatory guides 1.33 and 1.123.

Question 430.81

Provide a description of the exhauster blower provided for the TGSS. (10.4.3)

Response 430.81

The two exhauster blowers are 100% capacity, motor driven blowers having inlet and outlet butterfly isolation valves. The exhauster blower assembly is mounted directly on top of the gland steam condenser. One exhauster blower is in normal operation with the other on standby. The exhauster blower in operation maintains a slight vacuum in the gland steam condenser. The exhauster blower is designed to discharge the air-inleakage to the turbine building ventilation exhaust system which discharges to the plant vent.

Question 430.82

ABWR SSAR Subsection 10.4.3.1.2 states that the TGSS exhausts the noncombustible gases to the turbine building equipment vent system, however, Subsection 10.4.3.3. states that the TGSS exhausts the noncombustibles gases eventually to the main vent. Clarify how the TGSS exhausts are monitored. Also, clarify whether the main vent mentioned above is the plant vent referred to in SSAR Section 11.5. (10.4.3)

Response 430.82

The TGSS exhaust is monitored for radiation prior to discharge to the turbine building ventilation system. The turbine ventilation system exhausts to the plant vent. The main vent referred to in Section 11.5 is the plant vent. Subsections 10..4.3.1.2 and 10.4.3.3.3 will be revised to indicate the TGSS exhausts to the turbine building ventilation system which exhausts to the plant vent. Section 11.5 will be revised to substitute the "plant" vent for "main" vent to make the SSAR sections consistent.

Question 430.83

What is the source for the auxiliary steam? Justify why an advanced design will use essentially radioactivity free auxiliary steam (see SSAR Section 10.4.3.2.2) as a backup sealing source rather than as normal sealing source. Note that the use of a process steam supply for sealing purpose can result in significant operational radioactivity releases. (10.4.3)

Response 430.83

The source of auxiliary steam in the ABWR is a conventional plant start-up package boiler.

The ABWR turbine gland seal system design is fully conventional and proven except with respect to the generation of sealing steam for use during normal plant operation. In recent BWR plants, this steam evaporator that reboiling main steam or crossaround steam as heating fluid. In older BWR plants main steam or crossaround steam is used directly for gland sealing but this direct feed process has resulted in significant noble gas discharge to the environment, as well as in-plant contamination, where the type of fuel that was then used in these plants experienced abnormal levels of failures.

With modern BWR fuel, experience shows that failure rates are so low that gland sealing can safely be achieved using process steam directly. Yet, to be extra conservative and avoid any potential uncontrolled radioactivity releases without incurring the penalty of a sealing steam evaporator, the ABWR reference design generates this steam from the high pressure heater drain tanks using tank connections such that the incoming drains are routed via a liquid drain loop seal. Thus, only the minimal amount of cycle gases that may be dissolved in the condensed drains is allowed to enter the drain tanks. Sealing steam is taken from the drain tanks, through the tank vent, as the degassed drains are allowed to reboil at such a slow rate that no low volatility product can escape the liquid phase and contaminate the vented steam.

Through this process, relatively high purity sealing steam is generated for use during plant normal operation above approximately 50% load. During plant startup, sealing steam is provided directly by main steam but the long term average amount of radioactivity that may be released even with abnormally high levels of fuel failure is still quite small as plant startup radioactivity levels are relatively low and duration is relatively short. Finally, to permit continued plant operation even in the extremely unlikely presence of multiple fuel rod failures, the gland seal system includes a connection for supplying sealing steam from the plant auxiliary (startup) boiler.

Question 430.84

For turbine bypass system:(10.4.4)

(a) Provide figures which delineate the system and its components.

(b) Clarify whether the system includes pressure-reducer assemblies for the bypass valves to reduce steam pressure prior to steam discharge into the condenser.

Response 430.84

(a) Figures 10.4-10 and 10.4-11 have been added to delineate the system and its components.

(b) The detailed design will follow standard industry practice and reduce the pressure sequentially through orifices prior to entering the condenser. In addition, please note that the valves will be 9" globe type as shown in Figure 10.4-10 which also indicates the actuation mechanism and associated motive power.

Upon a turbine trip or generator load rejection, the start of the bypass valve flow is delayed no more than 0.1 seconds after the start of the main turbine stop or control valve fast closure. A minimum of 80% of the bypass system capacity is established within 0.3 seconds after the start of the stop or control valve closure.

The bypass system quality design codes are defined in Section 3.2.

Question 430.85

For the circulating water system: (10.4.5)

(a) Describe the function of the waterbox fill and drain subsystem mentioned in ABWR Subsection 10.4.5.2.1. Also, describe the "makeup water" shown in SSAR Figure 10.4-3.

(b) Provide the worst possible flood levels that can occur in the applicable plant buildings as a result of circulating water system failure and indicate how safety-related equipment located in the building is protected against such flooding.

Response 430.85

(a) The waterbox fill and drain subsystem performs the following two functions:

(i) Following circulating water system maintenance and/or inspection from the inside, the subsystem uses turbine service water outflow to completely refill any previously drained section of the circulating water system. Thus, the circulating water pump can be started without any difficult valve throttling being required and without risk of water hammer.

(ii) The fill and drain subsystem is also used to permit rapid draining of the series connected condenser water boxes by gravity flow into the circulating water sump. The sump is provided with a vertical wet pit centrifugal pump which can discharge the collected drains, via the turbine service water system discharge header, to the power cycle heat sink (cooling tower basin, where applicable).

Overall, the subsystem function is to permit expeditious draining and refill of the condenser tube side and, thus, contribute to the plant ability to respond to potential circulating water leaks with minimal loss of availability.

"Make-upwater" to the circulating water system is provided from the site water supply, as required to compensate for cooling tower evaporation and drift water losses. Makeup water flow rate is normally controlled automatically to maintain a constant level in the cooling tower basin.

(b) As noted in response to Question 430.73, the worst possible flood that can affect the turbine building would result in a flood level slightly higher than grade. Such a flood, however, would not impact any safety related equipment as no such equipment is located inside the turbine building and all plant safety related facilities are protected against external flooding.

Question 430.86

How is the remote manual motor-operated shutoff valve (gate valve F 282) powered? (10.4.7)

Response 430.86

From a non-safety grade bus.

Question 430.87

Describe the design features provided to protect the safety-related portion of the condensate and feedwater system from internally generated missiles.

Response 430.87

The portion of the feedwater system outboard of the outer feedwater stop valve and the condensate system are not safety-related. The portion of the feedwater system inboard of the outer feedwater stop valve is safety-related. See Section 3.5 for design features that protect the safety-related portion of the feedwater system from internally generated missiles.

Question 430.88

Provide a summary of the analysis of a postulated high energy pipe break for the feedwater piping in the steam tunnel including the design features provided (e.g., pipe whip restraint) for preventing adverse effects resulting from pipe whip, jet impingement and flooding.

Response 430.88

Leak before break (LBB) methodology will be used for the feedwater piping system; therefore, no high-energy pipe break can happen for the feedwater piping system. See Section 3.6 and Appendices 3E and 3F for details on design features provided.

Question 430.89

Provide information on the analysis that shows that the entire feedwater system piping can accommodate water hammer events and the means to prevent water hammer loads due to hydraulic transients (10.4.7)

Response 430.89

During normal power operation, water hammer is not a problem because variable speed feedwater pumps are used to vary feedwater flow for reactor water level control. Feedwater control valves that could rapidly interrupt feedwater flow, causing water hammer are not used foe normal operations.

During low power conditions (less than approximately 10% power), a slow acting low flow control valve is used to control reactor water level in conjunction with one variable speed motor driven pump. Features of the feedwater control system insure that there will not be large sudden changes in feedwater flow that could induce water hammer.

Question 430.90

Provide detailed information on the feedwater control valve and controller design including the feature s which ensure that the design will be stable and compatible with the system and the imposed operating conditions. (10.4.7)

Response 430.90

The feedwater control system (FWCS) is related but separate from the condensate and feedwater system. The FWCS design is described in Subsection 7.7.1.4. The FWCS was designed using control system techniques to assure adequate gain and phase margin for stability. Evaluations were then performed using plant dynamic analysis computer codes (e.g., REDYA) to confirm that the FWCS design satisfies all performance requirements, including stability specifications. Preliminary controller gains and compensator time constants have been established using these analytical tools to assure that the complete system will be stable for all operating conditions. These settings will be confirmed during plant power ascension testing, and adjustments can be made, if necessary, based on the test results.

Chapter 10 will be revised to reflect a modified condensate feedwater system design which does not have any feedwater control valves for power operation. The normal feedwater pumping configuration will have three adjustable speed motor driven feedpumps, which do not utilize feedwater control valves. The only modulating valve in the feedwater system is a low flow control valve for use at low power operating conditions. The low flow FWCS has been specifically designed to minimize cycling in feedwater nozzles. Since the emphasis is on minimizing feedwater flow variations, the low flow control valve will not be required to be highly responsive. The evaluations and testing described above have also been performed on the low flow feedwater control design. Therefore, there is no stability concern associated with the low flow feedwater control valve.

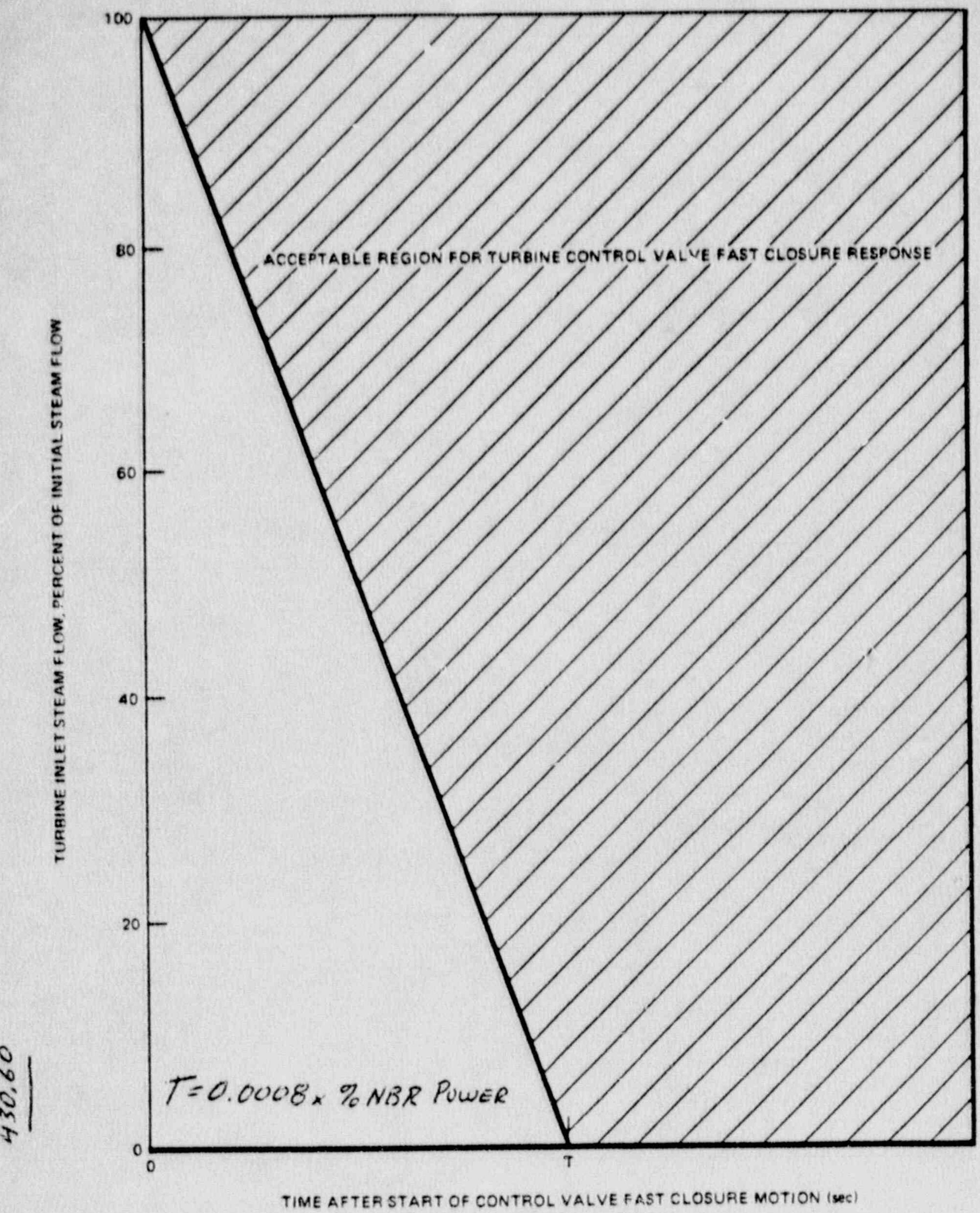

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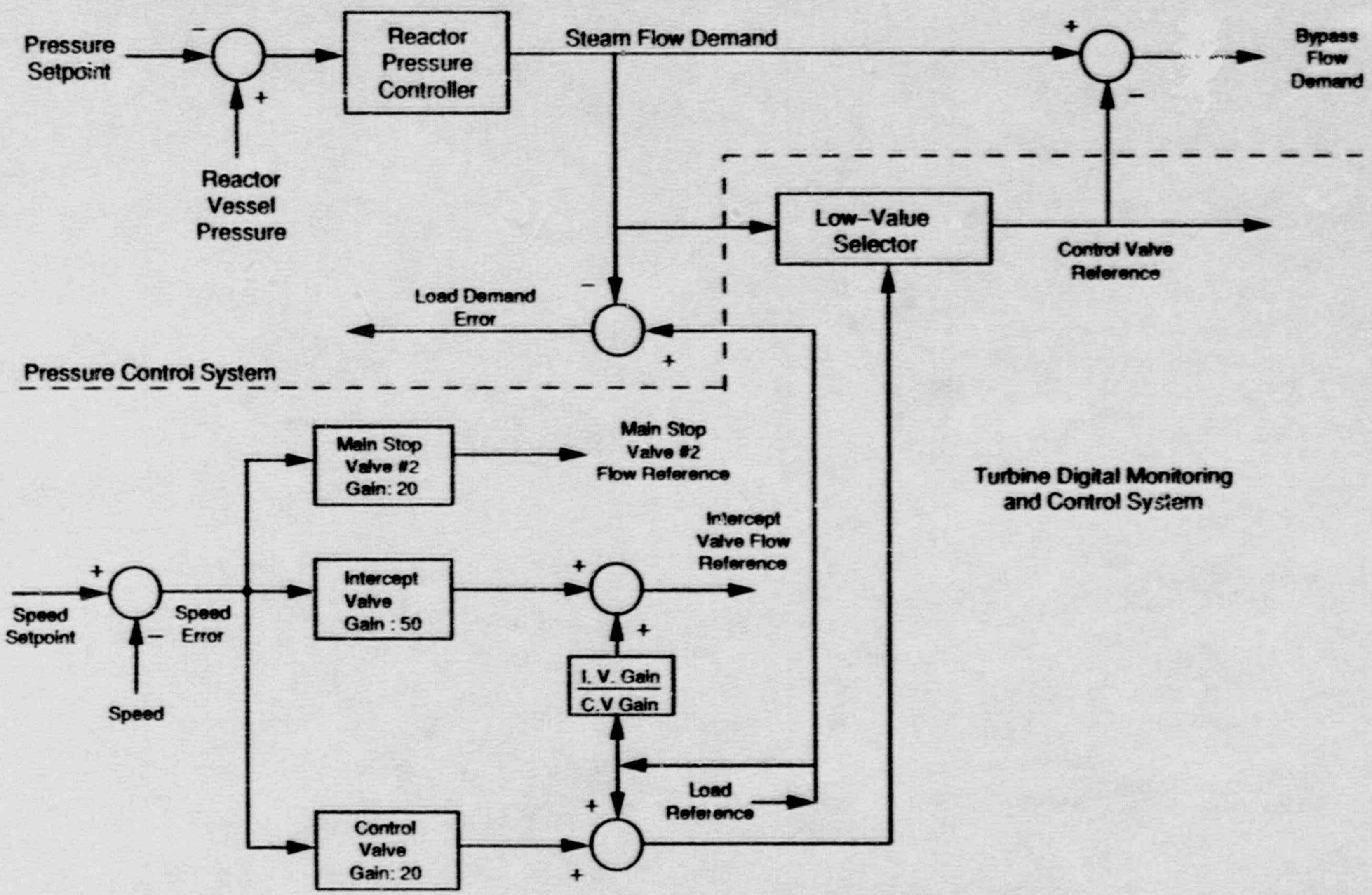
Figure 10.2-2 TURBINE CONTROL VALVE FAST CLOSURE CHARACTERISTIC

430.62



20.3-41

Figure ~~xyz~~. Simplified Functional Control Diagram of Turbine Digital Control and Monitoring System (Typical of One of Three Channels)

(3) Magnetic particle and ultrasonic examination

(4) Surface finish tests of slots for indication of a stress riser

<u>Bulk Hydrogen System</u> - The bulk hydrogen and CO_2 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 system consists of hydrogen supply piping with all the necessary valves, instrumentation, gas purity measuring equipment, hydrogen gas dryers, and bulk hydrogen storage unit.

Fires and explosions during filling and/or purging of the generator are prevented by inerting the generator with CO_2 so that a flammable mixture of hydrogen and oxygen cannot be produced. Unneeded hydrogen is vented outside through a flame arrestor.

10.2.2.3 Normal Operation

During normal operation, the main stop valves and CIVs 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.

10.2.2.4 Turbine Overspeed Protection System

In addition to the normal speed control function provided by the turbine control system, a separate turbine overspeed protection system is included. The turbine overspeed system is a highly reliable and redundant system which is classified as non-safety related.

Protection against turbine overspeed is provided by the mechanical overspeed trip and electrical backup overspeed trip. Redundancy is achieved by using two independent channels from the signal source to the output device. The sensing device, line and output device are of a different nature for each individual channel in order to increase reliability.

The overspeed sensing devices are located in the front bearing standard, and therefore are protected from the effects of missiles or pipe break. The hydraulic lines are fail safe, that is, if one were to be broken, loss of hydraulic pressure would result in a turbine trip. The electric trip signals are redundant. One circuit could be disabled by damage to the wiring, but the other system is fail safe, i.e., loss of signal results in a turbine trip. These features provide inherent protection against failure of the overspeed system caused by missiles or pipe whipping.

The electrical backup overspeed trip consists of independent circuits. Each circuit monitors a separate speed signal voltage and activates voltage comparators at various speed levels. The output of these circuits is used in tripping and monitoring of the turbine.

Two air relay dump valves are provided which actuate on turbine trip. The valves control air to the extraction nonreturn valves which limit contributions to turbine overspeed from steam and water in the extraction lines and feedwater heaters. The closing time of the extraction nonreturn valves is less than 2 seconds. 430.34

Upon loss of generator load, the electro-hydraulic control (EHC) system acts to prevent rotor speed from exceeding design overspeed. Refer to Table 10.2-1 for the description of the sequence of events following loss of turbine load. Failure of any single component will not result in rotor speed exceeding design overspeed (i.e. 120 percent of rated speed). The following component redundancies are employed to guard against overspeed:

(1) Main stop valves/Control valves

(2) Intermediate stop valves/Intercept valves (CIVs)

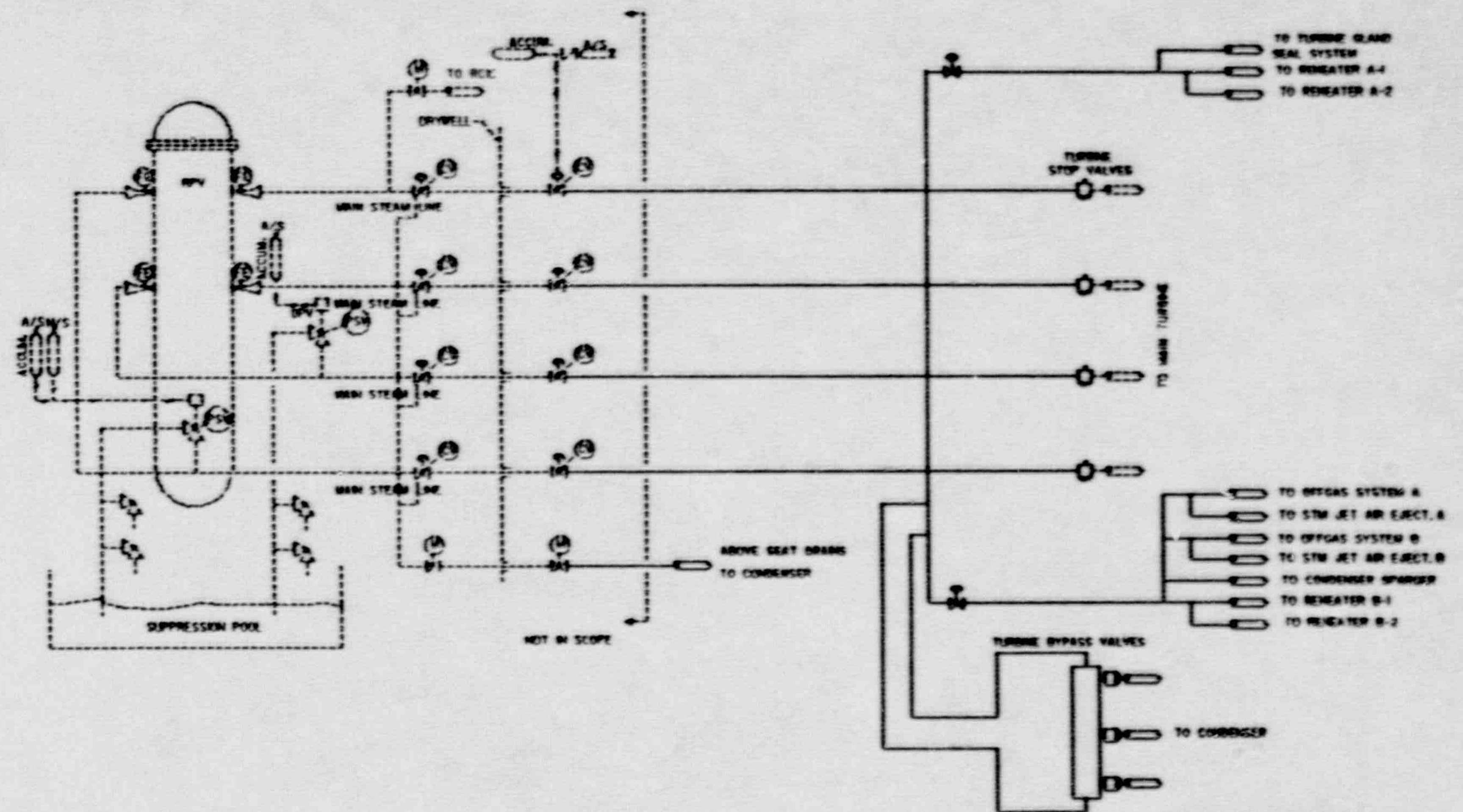
(3) Primary speed control/Backup speed control

(4) Fast acting solenoid valves/Emergency trip fluid system (ETS)

(5) Speed control/Overspeed trip/Backup overspeed trip

The main stop valves and control valves provide

450.69



ABWR TURBINE ISLAND DESIGN

MAIN STEAM SUPPLY SYSTEM DIAGRAM

Figure 10.3-1

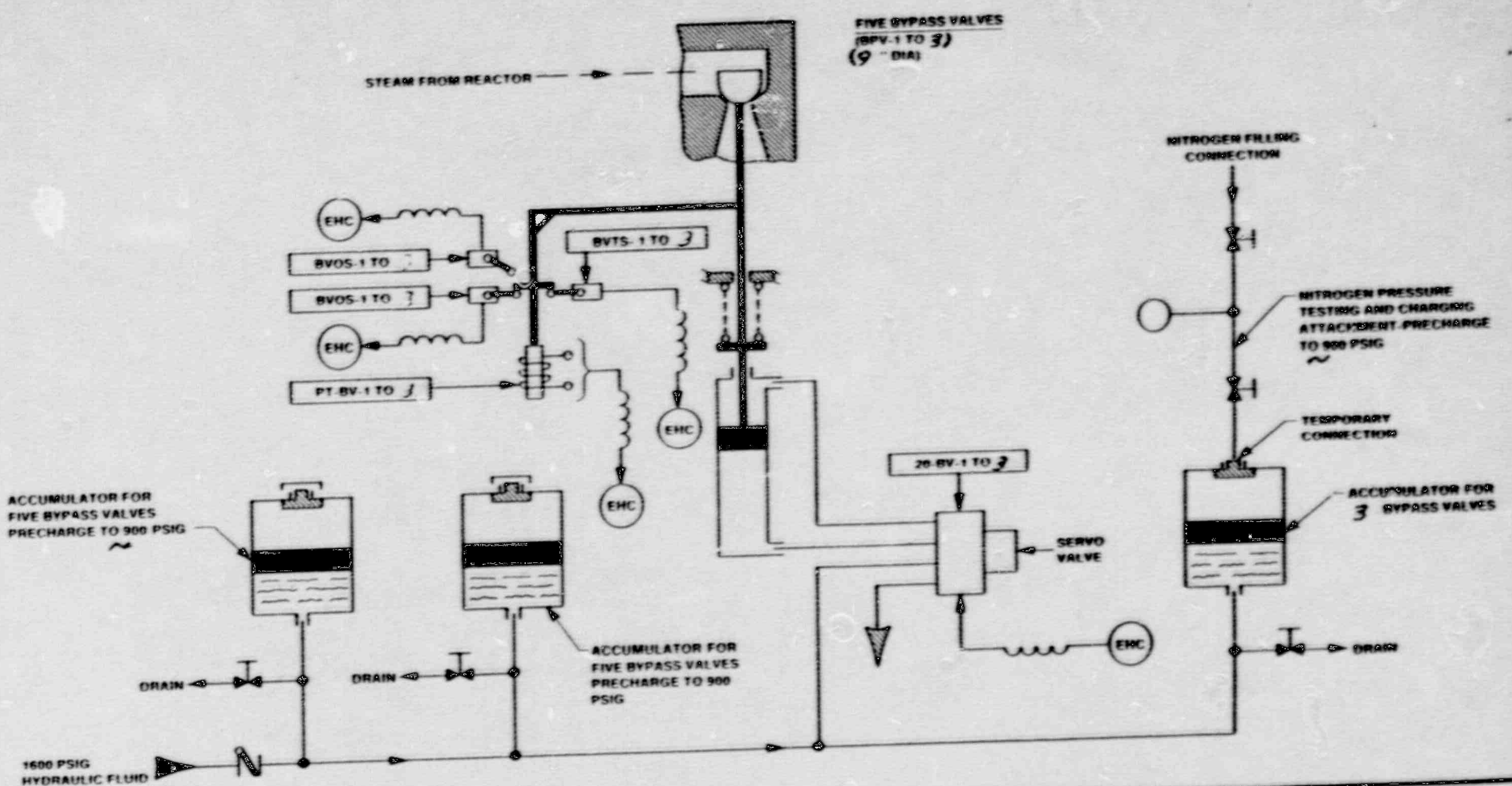


FIGURE 10.4-10

BYPASS VALVE CONTROL DIAGRAM
ELECTRO-HYDRAULIC CONTROL UNIT

430 84

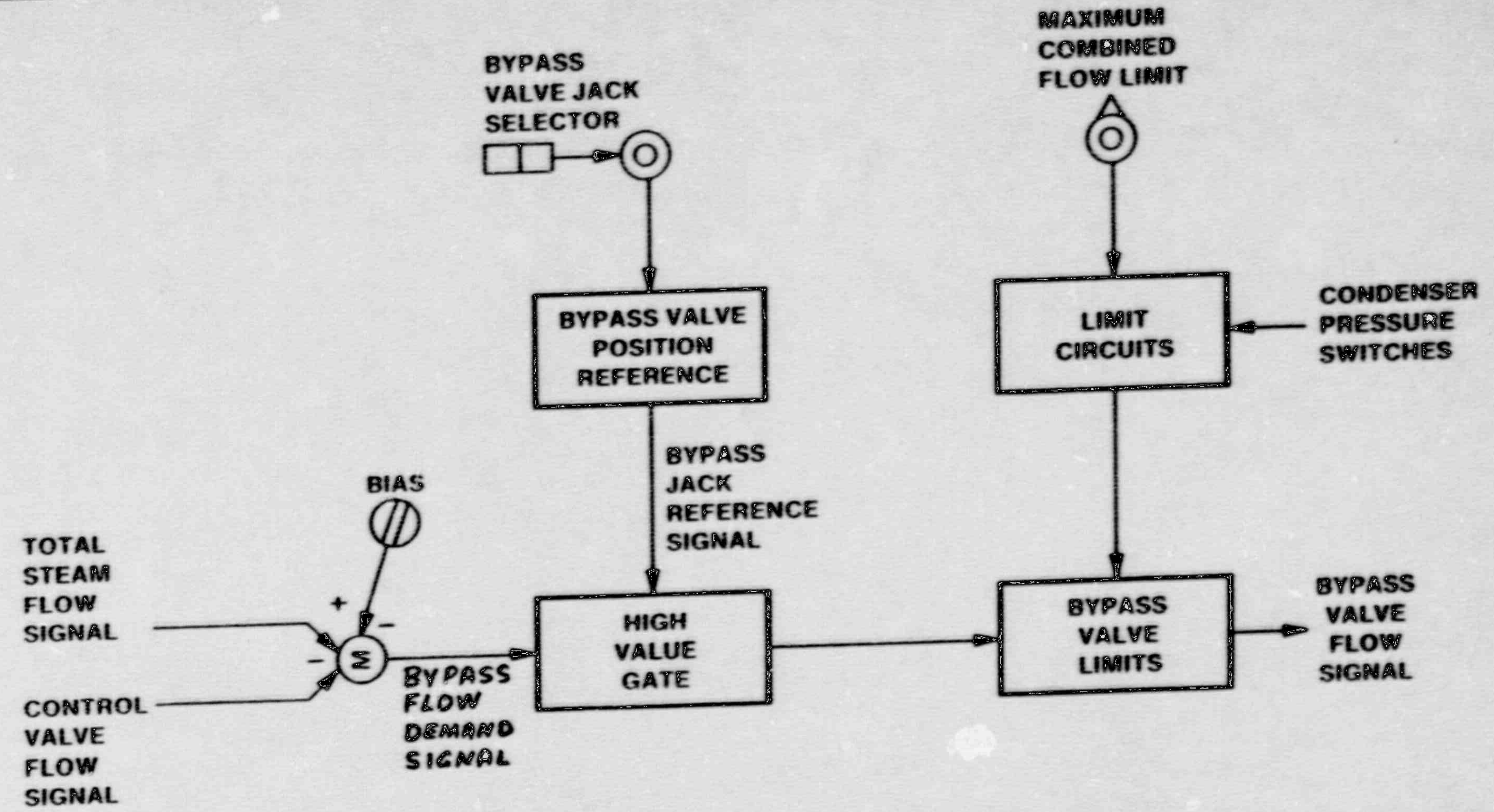


FIGURE 10.4-11

SIGNAL FLOW CHART FOR TURBINE
BYPASS CONTROL UNIT

430 84