GE Nuclear Energy

General Electric Company
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Chet Poslusny, Senior Project Manager
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of the Nuclear Reactor Regulation

Subject: Submittal Supporting Accelerated ABWR Review Schedule - **Revised LCO 3.7.5**

Dear Chet:

Enclosed is a SSAR markup of the revised LCO 3.7.5, Main Turbine Bypass System.

Please provide a copy of this transmittal to George Thomas.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

cc: Norman Fletcher (DOE)
Cal Tang (GE)

210014

JF93-163

3.7 PLANT SYSTEMS

3.7.6 5 Main Turbine Bypass System

LCO 3.7.6 5 The Main Turbine Bypass System shall be OPERABLE.

[OR

LCO 3.2.2, "MINIMUM CRITICAL POWER RATIO (MCPR)," limits for an inoperable Main Turbine Bypass System, as specified in the [COLR], are made applicable.]

APPLICABILITY: THERMAL POWER ≥ ~~25%~~ 40 RTP.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. [Requirements of the LCO not met or Main Turbine Bypass System inoperable.]	A.1 [Satisfy the requirements of the LCO or restore Main Turbine Bypass System to OPERABLE status.]	2 hours
B. Required Action and associated Completion Time not met.	B.1 Reduce THERMAL POWER to < ~~25%~~ 40 RTP.	4 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.7.6 5.1	~~Verify one complete cycle of each main turbine bypass valve.~~ Perform bypass valve opening test to approximately 10% position for each turbine bypass valve.	31 days

indicates change

(continued)

SURVEILLANCE REQUIREMENTS (continued)

	SURVEILLANCE	FREQUENCY
SR 3.7.6.2 (5)	Perform a system functional test.	[18] months
SR 3.7.6.3 (5)	Verify the TURBINE BYPASS SYSTEM RESPONSE TIME is within limits.	[18] months

REFUELING INTERVAL

BASES

ACTIONS (continued)

B.1

If the Main Turbine Bypass System cannot be restored to OPERABLE status or the MCPR limits for an inoperable Main Turbine Bypass System are not applied, THERMAL POWER must be reduced to < 25% 40 RTP. As discussed in the Applicability section, operation at < 25% 40 RTP results in sufficient margin to the required limits, and the Main Turbine Bypass System is not required to protect fuel integrity during the feedwater controller failure, maximum demand event. The 4 hour Completion Time is reasonable, based on operating experience, to reach the required unit conditions from full power conditions in an orderly manner and without challenging unit systems.

SURVEILLANCE REQUIREMENTS

SR 3.7.6 5.1

~~Cycling~~ Opening each main turbine bypass valve ~~through one complete cycle of full travel~~ to its 10% position (approximately) demonstrates that the valves are mechanically OPERABLE and will function when required. The 31 day Frequency is based on ~~engineering judgment, is consistent with the procedural controls governing valve operation, and ensures correct valve positions. Therefore, the Frequency is acceptable from a reliability standpoint.~~ a reliability analysis (Ref 3).

SR 3.7.6 5.2

The Main Turbine Bypass System is required to actuate automatically to perform its design function. This SR demonstrates that, with the required system initiation signals, the valves will actuate to their required position. The ~~[18] month~~ REFUELING INTERVAL Frequency is based on the need to perform this Surveillance under the conditions that apply during a unit outage and because of the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown the ~~[18] month~~ REFUELING INTERVAL Frequency, which is based on the refueling cycle, is acceptable from a reliability standpoint.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.7.6.3 (5)

This SR ensures that the TURBINE BYPASS SYSTEM RESPONSE TIME is in compliance with the assumptions of the appropriate safety analysis. The response time limits are specified in [unit specific documentation]. The [18] month REFUELING INTERVAL Frequency is based on the need to perform this Surveillance under the conditions that apply during a unit outage and because of the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown the [18] month REFUELING INTERVAL Frequency, which is based on the refueling cycle, is acceptable from a reliability standpoint and is also based upon the reliability analysis of Ref. 3.

REFERENCES

1. ABWR FSAR SSAR, Section [7.7.1.5] 8.
2. ABWR FSAR SSAR, Section [15.1.2] Chapter 15.
3. [ ]

ABWR Main Turbine Bypass Valve Failure Rate

The ABWR has three main turbine bypass valves (BPVs) with the capacity to dump 33% of reactor steam directly to the main condenser. In event of a turbine trip at modest power, less than 33%, the BPVs will open quickly to dump steam before a reactor scram can occur because of high reactor pressure.

If a turbine trip occurs at high power, even fast action of the bypass valves will not avoid reactor scram. However, the proper BPV function will limit the pressure rise in the reactor. The hydraulic fluid loop showing the fast acting solenoid valve (FASV) and its connection to the BPV is shown in Figure 1. The FASV is the key to fast opening of BPVs.

The number of safety related demands on the bypass valves and the FASV will depend on the number of turbine trips for which operability of the BPVs is assumed. That analysis included only one transient in which it was assumed that the BPVs would function properly. The transient is described in SSAR Section 15.1.2, Feedwater Controller Failure -- Maximum Demand; and the estimated frequency is less than once in 10,000 years. However, the event is analyzed as a moderate frequency event (once in 20 years), which overestimates its importance by a factor of 500.

Bypass valves of current BWRs in the U.S. are tested monthly in a test that includes slow stroking for 90% of valve travel followed by rapid stroke for the final 10% of travel. This monthly test frequency has no technical basis and was established on the basis of other turbine valve testing. Because of the 11% power capability of a single bypass valve in the ABWR plant, it is desirable to test the full stroke and fast travel of bypass valves only during plant shutdown, approximately every two years, to minimize disturbance to the electrical grid and to minimize potential challenges to the plant safety systems. At shutdown the total valve stroke time can be measured. The valves can be stroked slowly during plant operation over partial travel (such as 10%) to assure that they are not bound and will open on demand. Such a test will have little impact on operation.

The circuit to cause fast opening of the BPV is attached as Figure 2. The fault tolerant, solid state digital controller components are checked frequently by the self-check circuits. They are also combined in 2-out-of-3 logic so there will be a very low probability of failures of the controller that lead to inadvertent opening of the fast acting solenoid valves (FASVs). Because of the high reliability of this circuit, the main contributor to failure of the FASV to perform its desired function will be the FASV itself.

The referenced IEEE Standard gives failure rates for much nuclear plant equipment, including solenoid valves. The "all modes" failure rate for solenoid valves is 1.32E-6/h, but this is primarily for "catastrophic" (spurious open or spurious close) failures, 0.95E-6/h. The failure rate for "degraded" performance is 0.37E-6/h. A demand failure rate of 1.08E-6/d is also given in IEEE 500-1984.

The demand failure rate for solenoid valves is very low, and demand failure rates are generally not time dependent. Therefore, it will be assumed to be independent of test frequency. It is pessimistic to assume that the time dependent failure rate is dominant, in which case the failure rate will be proportional to the test interval. For such a pessimistic approach, the average failure probability during a time interval T is given as

$$\bar{\lambda} = \lambda T/2 = 0.37E\text{-}6 \times T/2 =$$

$$0.185E\text{-}6 \times T \text{ (hours)} = 1.35E\text{-}4 \times T \text{ (months)}$$

Test Interval T (months) =	1	3	6	12	24
Failure Probability	= 1.35E-4	4E-4	8.1E-4	1.6E-3	3.2E-3
Valve failures/year During FWC Maximum Demand Failure	= 2.0E-5	6.1E-5	1.2E-4	2.4E-4	4.9E-4

The valve failures per year are based on three valves in the plant and on the assumed 0.05 safety related turbine trips per year. To summarize the table, at a current test frequency of monthly for the FASV, less than one bypass valve failure in 50,000 years would be expected during failure of the feedwater controller resulting in maximum FW demand. (This failure could result in reactor overpressure, if bypass capability with the other valves were lower than power level.) If the test frequency were once per six months, one failure per 16,000 years could be expected. A 24-month interval between tests would result in the expectation of one failure per 2,000 years.

The determination of test frequency for turbine bypass valve testing should be based on the acceptable frequency of valve failure during the transient caused by FWC failure and leading to maximum flow demand. If one turbine trip causing reactor overpressure in 2,000 years is acceptable, a 24-month test interval can be justified.

Consideration was given to the probability that accumulator failure would preclude rapid BPV action when needed. The accumulators are precharged with nitrogen to 900 psig with the hydraulic system pump off. When the pump operates, system pressure climbs to 1600 psig. This pressure is maintained by the operating pump, and a standby pump will automatically start if system pressure drops to a preset value, indicating failure of the operating pump. If the accumulator leaks nitrogen, without being detected, and subsequently the operating pump fails and the standby pump fails to start, or starts and fails to run, the plant would be vulnerable to the FWC maximum demand event, with its assumed 0.05/year probability.

The probabilities of the above sequence are as follows:

- Accumulator leaks in 2 years: 1.7E-5/h x 8760 x 2 h = 0.30

- Operating pump fails to run 3 months (assume that pump switches to standby after 3 months):

  7.4E-6/h x 8760 h/4 = 1.63E-2

- Standby pump fails to start or starts & fails to run for one month (failed pump could be repaired in one month):

  1.3E-3 + 7.4E-6 x 8760 / 12 = (1.3 + 5.4) E-3 = 6.7E-3

- Demand for BPV operation, FWC maximum demand: 0.05/year

- Total event probability:

  0.30 x 1.63E-2 x 6.7E-3 x 0.05 = 1.6E-6/year

The probability of this sequence of events is so low, even when the event frequency is overestimated by a factor of 500, it need not be considered. It will have no impact on the frequency of BPV testing.

Reference: IEEE Std. 500-1984, "IEEE Guide to the Collection and Presentation of Electrical, Electronic, and Sensing Component Reliability Data for Nuclear Power Generating Stations", Dec 13, 1983

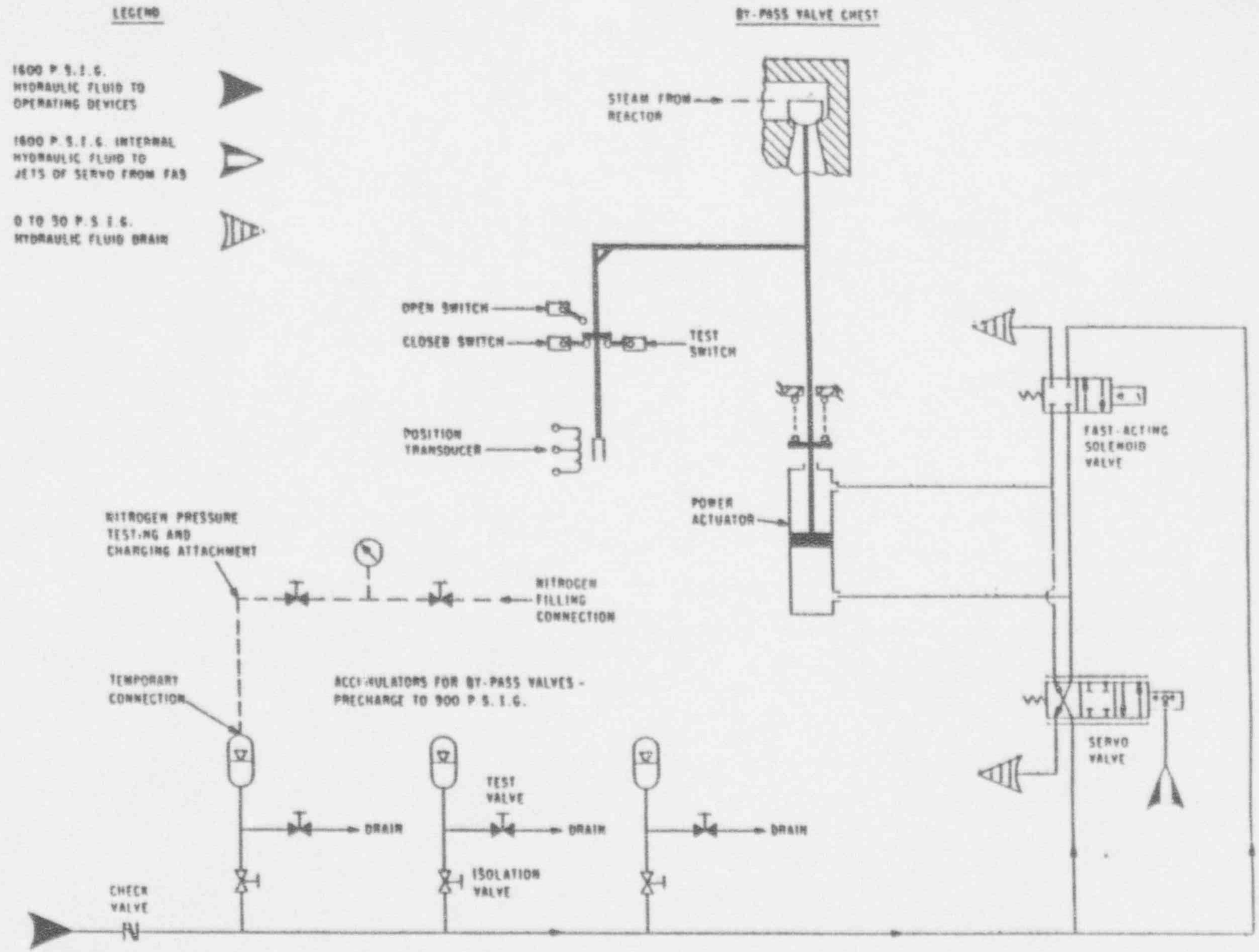

Figure 1. Turbine Bypass Valve Hydraulic Fluid Control Loop

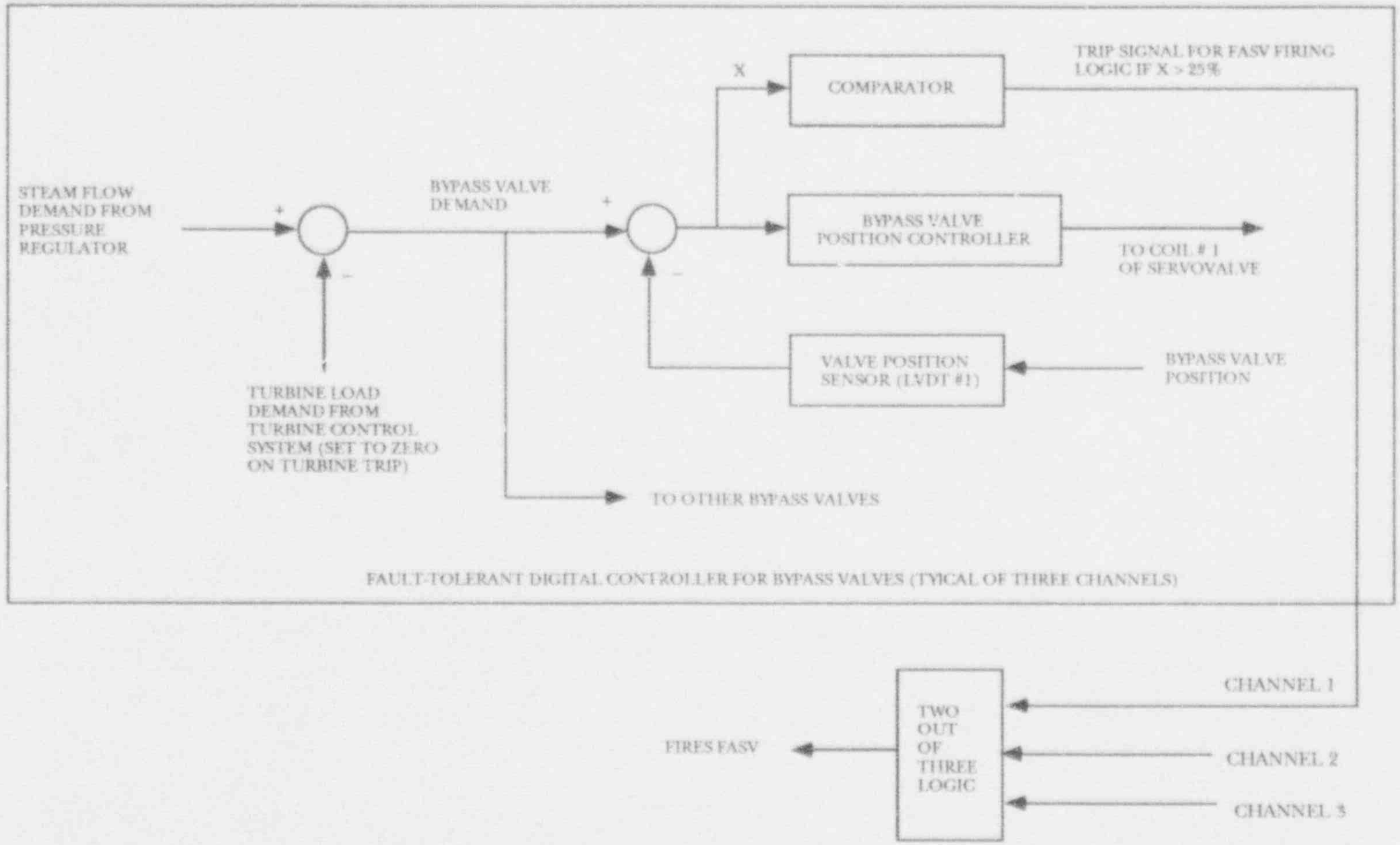

FIGURE 2. TURBINE BYPASS VALVE FAST ACTING SOLENOID VALVE CONTROL CIRCUIT