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SUBJECT: Forwards info requested in NRC 791031 ltr re auxiliary
 feedwater sys. Identifies plant transient & accident
 conditions considered in establishing auxiliary feedwater
 sys flow requirements.

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Mr. Darrell G. Eisenhut, Acting Director
Division of Operating Reactors
United States Nuclear Regulatory Commission
Washington, D. C. 20555

H. B. ROBINSON STEAM ELECTRIC PLANT UNIT 2
DOCKET NO. 50-261
LICENSE NO. DPR-23
AUXILIARY FEEDWATER SYSTEM

Dear Mr. Eisenhut:

In our letter of October 31, 1979, we indicated that the information requested in Enclosure 2 of your September 21, 1979 letter would be provided around April 30, 1980. In accordance with that commitment, the requested information is attached.

If you have any questions concerning this subject, please contact our staff.

Yours very truly,

E. E. Utley

Executive Vice President
Power Supply and Customer Services

JJS/jc (1443)
Attachment

cc: Mr. J. D. Neighbors (NRC)

1001
5/11

Question 1

a. Identify the plant transient and accident conditions considered in establishing AFWS flow requirements, including the following events:

- 1) Loss of Main Feed (LMFW)
- 2) LMFW w/loss of offsite AC power
- 3) LMFW w/loss of onsite and offsite AC power
- 4) Plant cooldown
- 5) Turbine trip with and without bypass
- 6) Main steam isolation valve closure
- 7) Main feed line break
- 8) Main steam line break
- 9) Small break LOCA
- 10) Other transient or accident conditions not listed above.

b. Describe the plant protection acceptance criteria and corresponding technical bases used for each initiating event identified above. The acceptance criteria should address plant limits such as:

- 1) Maximum RCS pressure (PORV or safety valve actuation)
- 2) Fuel temperature or damage limits (DNB, PCT, maximum fuel central temperature)
- 3) RCS cooling rate limit to avoid excessive coolant shrinkage
- 4) Minimum steam generator level to assure sufficient steam generator heat transfer surface to remove decay heat and/or cool down the primary system.

Response to 1.a

The Auxiliary Feedwater System serves as a backup system for supplying feedwater to the secondary side of the steam generators at times when the feedwater system is not available, thereby maintaining the heat sink capabilities of the steam generator. As an Engineered Safeguards System, the Auxiliary Feedwater System is directly relied upon to prevent core damage and system overpressurization in the event of transients such as a loss of normal feedwater or a secondary system pipe rupture, and to provide a means for plant cooldown following any plant transient.

Following a reactor trip, decay heat is dissipated by evaporating water in the steam generators and venting the generated steam either to the condensers through the steam dump or to the atmosphere through the steam generator safety valves or the power-operated relief valves. Steam generator water inventory must be maintained at a level sufficient to ensure adequate heat transfer and continuation of the decay heat removal process. The water level is maintained under these circumstances by the Auxiliary Feedwater System which delivers an emergency water supply to the steam generators. The Auxiliary Feedwater System must be capable of functioning for extended periods, allowing time either to restore normal feedwater flow or to proceed with an orderly cooldown of the plant to

the reactor coolant temperature where the Residual Heat Removal System can assume the burden of decay heat removal. The Auxiliary Feedwater System flow and the emergency water supply capacity must be sufficient to remove core decay heat, reactor coolant pump heat, and sensible heat during the plant cooldown. The Auxiliary Feedwater System can also be used to maintain the steam generator water levels above the tubes following a LOCA. In the latter function, the water head in the steam generators serves as a barrier to prevent leakage of fission products from the Reactor Coolant System into the secondary plant.

DESIGN CONDITIONS

The reactor plant conditions which impose safety-related performance requirements on the design of the Auxiliary Feedwater System are as follows for H.B. Robinson Unit No. 2

- Loss of Main Feedwater Transient
 - Loss of main feedwater with offsite power available
 - Station blackout (i.e., loss of main feedwater without offsite power available)
- Rupture of a Main Steam Line
- Loss of all AC Power
- Loss of Coolant Accident (LOCA)
- Cooldown

Loss of Main Feedwater Transients

The design loss of main feedwater transients are those caused by:

- Interruptions of the Main Feedwater System flow due to a malfunction in the feedwater or condensate system
- Loss of offsite power or blackout with the consequential shutdown of the system pumps, auxiliaries, and controls

Loss of main feedwater transients are characterized by a rapid reduction in steam generator water levels which results in a reactor trip, a turbine trip, and auxiliary feedwater actuation by the protection system logic. Following reactor trip from high power, the power quickly falls to decay heat levels. The water levels continue to decrease, progressively uncovering the steam generator tubes as decay heat is transferred and discharged in the form of steam either through the steam dump valves to the condenser or through the steam generator safety or power-operated relief valves to the atmosphere. The reactor coolant temperature

increases as the residual heat in excess of that dissipated through the steam generators is absorbed. With increased temperature, the volume of reactor coolant expands and begins filling the pressurizer. Without the addition of sufficient auxiliary feedwater, further expansion will result in water being discharged through the pressurizer safety and relief valves. If the temperature rise and the resulting volumetric expansion of the primary coolant are permitted to continue, then (1) pressurizer safety valve capacities may be exceeded causing over-pressurization of the Reactor Coolant System and/or (2) the continuing loss of fluid from the primary coolant system may result in bulk boiling in the Reactor Coolant System and eventually in core uncovering, loss of natural circulation, and core damage. If such a situation were ever to occur, the Emergency Core Cooling System would be ineffectual because the primary coolant system pressure exceeds the shutoff head of the safety injection pumps, the nitrogen over-pressure in the accumulator tanks, and the design pressure of the Residual Heat Removal Loop. Hence, the timely introduction of sufficient auxiliary feedwater is necessary to arrest the decrease in the steam generator water levels, to reverse the rise in reactor coolant temperature, to prevent the pressurizer from filling to a water solid condition, and eventually to establish stable hot standby conditions. Subsequently, a decision may be made to proceed with plant cooldown if the problem cannot be satisfactorily corrected.

The blackout transient differs from a simple loss of main feedwater in that emergency power sources must be relied upon to operate vital equipment. The loss of power to the electric driven condenser circulating water pumps results in a loss of condenser vacuum and condenser dump valves. Hence, steam formed by decay heat is relieved through the steam generator safety valves or the power-operated relief valves. The calculated transient is similar for both the loss of main feedwater and the blackout, except that reactor coolant pump heat input is not a consideration in the blackout transient following loss of power to the reactor coolant pump bus.

The station blackout transient serves as the basis for the minimum flow required for the smallest capacity single auxiliary feedwater pump for H.B. Robinson Unit No. 2. The pump is sized so that any single pump will provide sufficient flow against the steam generator safety valve set pressure (with 3% accumulation) to prevent water relief from the pressurizer. The same criterion is met for the loss of feedwater transient with the operation of any two pumps, where A/C power is assumed available.

Rupture of a Main Steam Line

Because the rupture of a main steam line may result in the complete blowdown of one steam generator, a partial loss of the plant heat sink is a concern. The main steamline rupture accident conditions are characterized initially by plant cooldown, and hence, auxiliary feedwater flow is not needed during the early stage of the transient to remove

decay heat from the Reactor Coolant System. Provisions must be made in the design of the auxiliary feedwater system to allow termination of flow to the faulted loop and to provide flow to the intact steam generators during the controlled cooldown following the steamline break accident.

Loss of All AC Power

The loss of all AC power is postulated as resulting from accident conditions wherein not only onsite and offsite AC power is lost but also AC emergency power is lost as an assumed common mode failure. Although this accident scenario is not a design basis for the H. B. Robinson Unit, several features are incorporated into the design to mitigate the effects of such a sequence. In the event of complete loss of AC power, the steam turbine driven auxiliary feedwater pump may be placed into service by manually opening one of the steam supply lines, in conjunction with the motor operated valves in the steam driven auxiliary feedwater pump discharge line.

Loss-of-Coolant Accident (LOCA)

The loss of coolant accidents do not impose on the auxiliary feedwater system any flow requirements in addition to those required by the other accidents addressed in this response. The following description of the small LOCA is provided here for the sake of completeness to explain the role of the auxiliary feedwater system in this transient.

Small LOCA's are characterized by relatively slow rates of decrease in reactor coolant system pressure and liquid volume. The principal contribution from the Auxiliary Feedwater System following such small LOCAs is basically the same as the system's function during hot shutdown or following spurious safety injection signal which trips the reactor. Maintaining a water level inventory in the secondary side of the steam generators provides a heat sink for removing decay heat and establishes the capability for providing a buoyancy head for natural circulation. The auxiliary feedwater system may be utilized to assist in a system cooldown and depressurization following a small LOCA while bringing the reactor to a cold shutdown condition.

Cooldown

The cooldown function performed by the Auxiliary Feedwater System is a partial one since the reactor coolant system is reduced from normal zero load temperatures to a hot leg temperature of approximately 350°F. The latter is the maximum temperature recommended for placing the Residual Heat Removal System (RHRS) into service. The RHR system completes the cooldown to cold shutdown conditions.

Cooldown may be required following expected transients, following an accident such as a main feedline break, or it may be a normal cooldown prior to refueling or performing reactor plant maintenance. If the reactor is tripped following extended operation at rated power level, the AFWS is capable of delivering sufficient AFW to remove decay heat

and reactor coolant pump (RCP) heat following reactor trip while maintaining the steam generator (SG) water level. Following transients or accidents, the recommended cooldown rate is consistent with expected needs and at the same time does not impose additional requirements on the capacities of the auxiliary feedwater pumps, considering a single failure. In any event, the process consists of being able to dissipate plant sensible heat in addition to the decay heat produced by the reactor core.

Response to 1.b

Table 1B-1 summarizes the criteria which are the general design bases for each event, discussed in the response to Question 1.a, above. Specific assumptions used in the analyses to verify that the design bases are met are discussed in response to Question 2.

The primary function of the Auxiliary Feedwater System is to provide sufficient heat removal capability for heatup accidents following reactor trip to remove the decay heat generated by the core and prevent system overpressurization. Other plant protection systems are designed to meet short term or pre-trip fuel failure criteria. The effects of excessive coolant shrinkage are bounded by the analysis of the rupture of a main steam pipe transient. The maximum flow requirements determined by other bases are incorporated into this analysis, resulting in no additional flow requirements.

TABLE 1B-1

Criteria for Auxiliary Feedwater System Design Basis Conditions

<u>Condition or Transient</u>	<u>Classification*</u>	<u>Criteria*</u>	<u>Additional Design Criteria</u>
Loss of Main Feedwater	Condition II	Peak RCS pressure not to exceed design pressure. No consequential fuel failures	
Station Blackout	Condition II	(same as LMFW)	Pressurizer does not fill with 1 single motor driven aux. feed pump feeding 2 SGs.
Loss of all A/C Power	N/A	Note 1	
Loss of Coolant	Condition III	10 CFR 100 dose limits 10 CFR 50 PCT limits	
	Condition IV	10 CFR 100 dose limits 10 CFR 50 PCT limits	
Cool down	N/A		100°F/hr 547°F to 350°F

*Ref: ANSI N18.2 (This information provided for those transients performed in the FSAR).

Note 1 Although this transient establishes the basis for AFW pump powered by a diverse power source, this is not evaluated relative to typical criteria since multiple failures must be assumed to postulate this transient.

Question 2

Describe the analyses and assumptions and corresponding technical justification used with plant condition considered in 1.a above including:

- a. Maximum reactor power (including instrument error allowance) at the time of the initiating transient or accident.
- b. Time delay from initiating event to reactor trip.
- c. Plant parameter(s) which initiates AFWS flow and time delay between initiating event and introduction of AFWS flow into steam generator(s).
- d. Minimum steam generator water level when initiating event occurs.
- e. Initial steam generator water inventory and depletion rate before and after AFWS flow commences -- identify reactor decay heat rate used.
- f. Maximum pressure at which steam is released from steam generator(s) and against which the AFW pump must develop sufficient head.
- g. Minimum number of steam generators that must receive AFW flow; e.g., 1 out of 2? 2 out of 4?
- h. RC flow condition -- continued operation of RC pumps or natural circulation.
- i. Maximum AFW inlet temperature.
- j. Following a postulated steam or feed line break, time delay assumed to isolate break and direct AFW flow to intact steam generator(s). AFW pump flow capacity allowance to accommodate the time delay and maintain minimum steam generator water level. Also identify credit taken for primary system heat removal due to blowdown.
- k. Volume and maximum temperature of water in main feed lines between steam generator(s) and AFWS connection to main feed line.
- l. Operating condition of steam generator normal blowdown following initiating event.
- m. Primary and secondary system water and metal sensible heat used for cooldown and AFW flow sizing.
- n. Time at hot standby and time to cooldown RCS to RHR system cut in temperature to size AFW water source inventory.

Response to 2

Analyses have been performed for the Loss of Main Feedwater and the loss of offsite AC power to the Station, the transients which define the AFWS performance requirements. These analyses have been provided for review and have been approved in the Applicant's FSAR.

In addition to the above analyses, calculations have been performed specifically for H.B. Robinson Unit 2 to determine the plant cooldown flow (storage capacity) requirements. The LOCA analysis, as discussed in response 1.b, incorporates the system flows requirements as defined by other transients, and therefore is not performed for the purpose of specifying AFWS flow requirements. Each of the analyses listed above are explained in further detail in the following sections of this response.

Loss of Main Feedwater (Blackout)

A loss of feedwater, assuming a loss of power to the reactor coolant pumps, was performed in FSAR Section 14.1.9 for the purpose of showing that for a station blackout transient, a single motor driven auxiliary feedwater pump delivering flow to two steam generators does not result in filling the pressurizer. Furthermore, the peak RCS pressure remains below the criterion for Condition II transients and no fuel failures occur (refer to Table 1B-1). Table 2-1 summarizes the assumptions used in this analysis. The transient analysis begins at the time of reactor trip. This can be done because the trip occurs on a steam generator level signal, hence the core power, temperatures and steam generator level at time of reactor trip do not depend on the event sequence prior to trip. Although the time from the loss of feedwater until the reactor trip occurs cannot be determined from this analysis, this delay is expected to be 20-30 seconds. The analysis assumes that the plant is initially operating at 102% (calorimetric error) of the Engineered Safeguards design (ESD) rating shown on the table, a very conservative assumption in defining decay heat and stored energy in the RCS. The reactor is assumed to be tripped on steam/feed mismatch coincident with low steam generator level, allowing for level uncertainty. The FSAR shows that there is a considerable margin with respect to filling the pressurizer. A loss of normal feedwater transient with the assumption that the two smallest auxiliary feedwater pumps operate with the reactor coolant pumps running results in even more margin.

This analysis establishes the capacity of the smallest single pump and also establishes train association of equipment so that this analysis remains valid assuming the most limiting single failure.

Plant Cooldown

Minimum flow requirements from the previously discussed transients meet the flow requirements of plant cooldown. This operation, however, defines the basis for tankage size, based on the required cooldown duration, maximum decay heat input and maximum stored heat in