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April 1, 1980

Docket No. 50-348

Director, Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attn: Mr. D. G. Eisenhut

Dear Mr. Eisenhut:

Alabama Power Company submits the enclosed response, as requested in enclosure two of your letter dated October 13, 1979, concerning Auxiliary Feedwater Systems.

If you have any further questions, please advise.

Sincerely yours,

F. L. Clayton, Jr.

FLC/RF:aw

Enclosure

cc: Mr. R. A. Thomas
Mr. G. F. Trowbridge

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ENCLOSURE

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

a. The reactor plant conditions which impose safety-related performance requirements on the design of the Auxiliary Feedwater System are as follows for the Joseph M. Farley Unit No. 1 plant.

(1) Loss of main feedwater with offsite power available
(2) Station blackout (i.e., loss of main feedwater without offsite power available)
(3) Loss of all AC Power
(4) Cooldown
(5) See note
(6) See note
(7) Feedline rupture
(8) Steamline rupture
(9) Loss of Coolant Accident (LOCA)

NOTE: The transient conditions resulting from a turbine trip with and without bypass and main steam isolation valve closure which impose safety-related performance requirements on the design of the AFWS are bounded by the transients and conditions resulting from events listed above.

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 transients, returning Tavg to its no-load value following a reactor trip; and cooling the reactor coolant system to the point at which RHR can be established. 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.

Question 2

Describe the analyses and assumptions and corresponding technical justification used with plant conditions 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

Analyses have been performed for the limiting transients which define the AFWS performance requirements. These analyses have been provided for review and have been approved in the Farley FSAR. Specifically, they include:

- Loss of Main Feedwater (Station Blackout)
- Rupture of a Main Feedwater Line
- Rupture of a Main Steam Line Inside Containment

In addition to the above analyses, calculations have been performed specifically for the Joseph M. Farley Unit No. 1 to determine the plant cooldown flow (storage capacity) requirements. The Loss of All AC Power is evaluated via a comparison to the transient results of a Blackout, assuming an available auxiliary pump having a diverse (non-AC) power supply. The LOCA analysis 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. The assumptions used in the Auxiliary Feedwater Design Verification are listed in Table 2-1.

Loss of Main Feedwater (Blackout)

A loss of feedwater, assuming a loss of power to the reactor coolant pumps, was performed in FSAR Section 15.2.8 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 and reactor coolant pumps are 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.

Rupture of Main Feedwater Line

The double ended rupture of a main feedwater pipe downstream of the main feedwater line check valve is analyzed in FSAR Section 15.4.2.2. Table 2-1 summarizes the assumptions used in this analysis. Reactor trip is assumed to occur when the unaffected steam generators are at the low level setpoint (adjusted for errors) and the faulted loop is assumed to be empty. This conservative assumption maximizes the stored heat prior to reactor trip and minimizes the ability of the steam generator to remove heat from the RCS following reactor trip due to a conservatively small total steam generator inventory. As in the loss of normal feedwater analysis, the initial power rating was assumed to be 102% of the ESD rating. The flow orifices in the Joseph M. Farley Unit No. 1 auxiliary feedwater system allow the delivery of 150 gpm to the two intact loops in 1 minute. At 10 minutes, the operator is assumed to have isolated the auxiliary feedwater from the break at which time the full 350 gpm requirement commences. The criteria listed in Table 1B-1 are met.

This analysis may establish the capacity of single pumps, establishes requirements for layout to preclude indefinite loss of auxiliary feedwater to the postulated break, and establishes train association requirements for equipment so that the AFWS can deliver the minimum flow required in 1 minute and 10 minutes assuming the worst single failure.

Rupture of a Main Steam Line Inside Containment

Because the steamline break transient is a cooldown, the AFWS is not needed to remove heat in the short term. Furthermore, addition of excessive auxiliary feedwater to the faulted steam generator will affect the peak containment pressure following a steamline break inside containment. This transient is performed at four power levels for several break sizes. Auxiliary feedwater is assumed to be initiated at the time of the break, independent of system actuation signals. The maximum flow is used for this analysis, considering pump runout. Table 2-1 summarizes the assumptions used in this analysis. At 30 minutes after the break, it is assumed that the operator has isolated the AFWS from the faulted steam generator which subsequently blows down to ambient pressure. The criteria stated in Table 1B-1 are met.

This transient establishes the maximum allowable auxiliary feedwater flow rate to a single faulted steam generator assuming all pumps operating, establishes the basis for runout protection, if needed, and establishes layout requirements so that the flow requirements may be met considering the worst single failure.

Plant Cooldown

Maximum and 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 the system. The auxiliary feedwater system partially cools the system to the point where the RHRS may complete the cooldown, i.e., 350°F in the RCS. Table 2-1 shows the assumptions used to determine the cooldown heat capacity of the auxiliary feedwater system.

The cooldown is assumed to commence at the maximum rated power, and maximum trip delays and decay heat source terms are assumed when the reactor is tripped. Primary metal, primary water, secondary system metal and secondary system water are all included in the stored heat to be removed by the AFWS. See Table 2-2 for the items constituting the sensible heat stored in the NSSS.

This operation is analyzed to establish minimum tank size requirements for auxiliary feedwater fluid source which are normally aligned.

Question 3

Verify that the AFW pumps in your plant will supply the necessary flow to the steam generator(s) as determined by items 1 and 2 above considering a single failure. Identify the margin in sizing the pump flow to allow for pump recirculation flow, seal leakage and pump wear.

RESPONSE

Flow rates for the design transients described in Response 2, requiring minimums low, have been met by the system for the worst single failure. The flows for those single failures considered are tabulated for the various transients in Table 3-1, including the following:

A. A/C Electrical Power Train Failure
B. Turbine Driven Pump Failure
C. Motor Driven Pump Failure

Operator intervention within 10 minutes is required in order to meet the minimum flow requirements on the Feedline Rupture.

The AFW pumps' design points for minimum flow were conservatively specified so that the design flow is produced at the maximum steam generator pressure developed when all main steam safety valves are wide open and fully relieving. System flow calculations verified pump acceptability by assuming pump performance degradation, due to wear, to be consistent with the limits of the Technical Specification.

AFW pump recirculation flow is through mini-flow orifices, back to the condensate storage tank. In all system flow analyses used to establish minimum flow, it is conservatively assumed that the mini-flow lines are open and operational. In addition, the mini-flow orifices are assumed to be worn and to pass 20% more flow, at a specified pressure drop, than a new orifice.

The AFW pumps have been provided with mechanical seals. Since the leakage characteristics of mechanical seals are a few drops per minute, no pump margin was added for seal leakage.

As stated in response to question 2, the upper bound for auxiliary feedwater flow is established by the steamline break transient. For this case operator, intervention is required within 30 minutes and no failures were assumed.

TABLE 1B-1

Criteria for Auxiliary Feedwater System Design Basis Conditions

Condition or Transient	Classification*	Criteria*	Additional Design Criteria
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.
Steamline Rupture	Condition IV	10CFR100 dose limits containment design pressure not exceeded	
Feedline Rupture	Condition IV	10CFR100 dose limits. RCS design pressure not exceeded	
Loss of all A/C Power	N/A	Note 1	Pressurizer does not fill with the turbine driven aux. feed pump feeding 2 SGs.
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	
Cooldown	N/A		100^{o}F/hr 547^{o}F to 350^{o}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.

TABLE 2-1

SUMMARY OF ASSUMPTIONS USED IN AFWS DESIGN VERIFICATION ANALYSES

	Transient	Loss of Feedwater (station blackout)	Cooldown	Main Feedline Break	Main Steamline Break (Containment)
a.	Max reactor power	102% of ESD rating (102% of 2774 MWt)	2713 MWt	102% of ESD rating (102% of 2774 MWt)	0, 30, 70, 102% of rated (% of 2660 MWt)
b.	Time delay from event to Rx trip	2 sec	2 sec	2 sec	variable
c.	AFWS actuation signal/time delay for AFWS flow	Low-low SG level 1 minute	NA	low-low SG level 1 minute	Assumed immediately 0 sec (no delay)
d.	SG water level at time of reactor trip	(lo-lo SG level) 0% NR span	NA	(lo SG level + steamfeed mismatch) 2 @ 20% NR span 1 @ tube sheet	N/A
e.	Initial SG inventory	60,700 lbm/SG (at trip)	100,800 lbm/SG @ 517°F	93,100 lbm/SG	consistent with power
	Rate of change before & after AFWS actuation	See FSAR Figure 15.2-31	N/A	turnaround 1600 sec.	N/A
	decay heat	FSAR Firure 15.1-6 ANS + 20%	FSAR Figure 15.1-6	FSAR Figure 15.1-6	FSAR Figure 15.1-6
f.	AFW pump design	1133 psia	1133 psia	1133 psia	N/A
g.	Minimum # of SGs which must receive AFW flow	2 of 3	N/A	2 of 3	N/A
h.	RC pump status	Tripped @ reactor trip	Tripped	Tripped @ reactor trip	All operating
i.	Maximum AFW temperature	120°F	100°F	120°F	equal to main feed temperature

TABLE 2-1
(Continued)

	Transient	Loss of Feedwater (station blackout)	Cooldown	Main Feedline Break	Main Steamline Break (containment)
j.	Operator action	none	N/A	10 min.	30 min.
k.	MFW purge volume/ temp.	100 ft^3/436.2^oF	450 ft^3/per loop 436.2^oF	330 ft^3/436.2^oF	150 ft^3/loop (for dryout time)
l.	Normal blowdown	none assumed	none assumed	none assumed	none assumed
m.	Sensible heat	see cooldown	Table 2-2	see cooldown	N/A
n.	Time at standby/ time to cooldown to RHR	2 hr/4 hr	2 hr/4 hr	2 hr/4 hr	N/A
o.	AFW flow rate	350 GPM - constant (min. requirement)	variable	150 gpm at 1 min increased to 350 gpm after 10 min (Min. requirement)	880 GPM (constant) to broken SG. (max. requirement)

TABLE 2-2

SUMMARY OF SENSIBLE HEAT SOURCES

Primary Water Sources (initially at rated power temperature and inventory)
- RCS fluid
- Pressurizer fluid (liquid and vapor)

Primary Metal Sources (initially at rated power temperature)
- Reactor coolant piping, pumps and reactor vessel
- Pressurizer
- Steam generator tube metal and tube sheet
- Steam generator metal below tube sheet
- Reactor vessel internals

Secondary Water Sources (initially at rated power temperature and inventory)
- Steam generator fluid (liquid and vapor)
- Main feedwater purge fluid between steam generator and AFWS piping.

Secondary Metal Sources (initially at rated power temperature)
- All steam generator metal above tube sheet, excluding tubes.

TABLE 3-1

AUXILIARY FEEDWATER FLOW[(1)] TO STEAM GENERATORS
FOLLOWING AN ACCIDENT/TRANSIENT WITH SELECTED SINGLE FAILURE - GPM

Single Failure

	Accident/Transient	Elec. Train Failure	TD Pump Failure	MD Pump Failure
		A	B	C
1.	Loss of Main FW	775	535	775
2.	Feedline Rupture	(2)	(2)	(2)
3.	Blackout	775	535	775
4.	Cooldown	775	535	775

NOTES:

(1) Items 1 thru 4 are minimum expected flows to intact loops.

(2) Ten minute operator action is required to isolate AFW flow to faulted loop. Prior to operator action, flow is 150 gpm to unfaulted loops; after operator action, flow is 350 gpm to unfaulted loops.