YANKEE ATOMIC ELECTRIC COMPANY

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FYR 81-98

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JUL 06 1981
U.S. NUCLEAR REGULATORY COMMISSION

June 30, 1981

United States Nuclear Regulatory Commission
Washington D. C. 20555

Attention: Mr. Dennis M. Crutchfield, Chief
Operating Reactors Branch #5
Division of Licensing

References:
(a) License No. DPR-3 (Docket No. 50-29)
(b) USNRC Trip Report and Meeting Summary, dated June 5, 1981, "Auxiliary Feedwater System Modification Public Meeting at Yankee Rowe."
(c) YAEC Letter to USNRC dated March 26, 1981 (FYR 81-52)
(d) YAEC Letter to USNRC dated September 12, 1979, (WYR 79-104)

Subject: Response to Action Items

Dear Sir:

This letter provides responses to the action items of Reference (b). The responses provide additional information and clarification on our modification to upgrade our existing emergency feedwater system (see Reference (c)).

We trust this information is satisfactory; however, if you have any questions, please contact us.

Very truly yours,

YANKEE ATOMIC ELECTRIC COMPANY

J. A. Kay

J. A. Kay
Senior Engineer - Licensing

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RESPONSE TO NRC ACTION ITEMS

Item 1:

The new AFW pumps do not currently have provision for protection from loss of suction. YAEC will evaluate and address this problem in a future submittal.

Responses:

The emergency feedwater system is a multiple pump system comprised of redundant and diverse flow paths (i.e. loss of one pumping configuration does not compromise the capability to deliver flow to the steam generators). Although the two new motor driven emergency feedwater (EFW) pumps share a common suction line from the primary water storage tank, a loss of pump suction due to failure of a manual valve (gate separating from drive stem) is highly unlikely, on the order of 3×10^{-5} per demand. Adequate surveillance measures as well as control room indications provide the necessary assurance that pump suction is maintained and that pump operating conditions can be identified quickly and remedial actions taken if necessary. The following provisions insure that suction is maintained to the pumps:

1. All the valves in the suction line to each pump that could cause a loss of suction to the pump are normally open valves that are locked in that position.

2. In accordance with plant technical specifications, prior to startup from cold shutdown, the flow path from the tank to the steam generators is verified by performing a flow test. Proper alignment of the valves is physically checked, and then verified by the flow test.

3. In accordance with proposed plant technical specifications (Reference (c)), the pump will be run, at least once every 31 days, while lined up to recirculate back to the supply tank. This test will verify the proper alignment of the suction valves, and the availability of pump suction.

4. In the control room, the operator has indication of pump motor amps, and flow to each steam generator through the normal path. The pump is started manually by the operator who monitors these two indications as soon as the pump is started. An abnormal amperage reading and no flow indication would alert the operator to a problem and the pump would be secured.

Based on the discussion above, the two new EFW pumps are adequately protected from damage due to a loss of suction. Also, there is more than adquate redundancy to insure that the emergency feed requirements are fulfilled.

Item 2:

YAEC will provide information on the control power sources and the seismic input used in the design of the new system in a future submittal.

Response:

The control power to the two new pumps is 125 volts d.c. from the sta'ion batteries. Control power for one pump is from no. 1 battery and no. 2 battery for the other pump.

The seismic input for the piping support designed was a static analysis at an acceleration of 5g.

Item 3:

YAEC will submit a description of the startup testing to be done before plant startup.

YAEC will perform a 48-hour flow test of the new pumps and the results will be reviewed by the NRC Resident Inspector prior to startup.

Response:

After the installation has been completed, the following testing will be performed prior to making the system operational:

1. Each pump will be run lined-up for continuous recirculation only to verify proper operation of the pump and to record initial readings.

2. Pump no. 2, which will normally be lined-up to the normal EFW path, will be run feeding each steam generator via the normal path to verify the flow path.

3. Pump no. 1, which will normally be lined-up to the alternate EFW path, will be run feeding each steam generator via the alternate path to verify the flow path.

4. Each pump will be run feeding all four steam generators through the EFW path it is normally lined-up to measure runout flow.

5. Pump no. 1 will be run feeding one steam generator through the cross-connect.

6. Each pump will be run feeding one steam generator with the discharge throttled to simulate design presure to verify design flow.

7. Each pump will be started on the associated emergency diesel generator to verify this capability.

8. Each pump will be run through a 48 hour endurance test similar to the test run on the steam driven EFW pump. Data will be gathered for submittal to the NRC based on the guidelines used for the steam driven pump. The results will be available for NRC Resident Inspector review prior to startup.

Through all of the tests described above, proper operation of the controls for the two pumps will be verified from both the local and remote stations. The same will be done for the new motor operated valves installed as part of this modification.

Item 4:

The new AFW pumps are not started automatically. YAEC will re-evaluate this decision and will address it in a future submittal.

Response:

Automatic initiation of the emergency feedwater system is not necessary for the Yankee system. This statement is based on (1) large steam generator water inventories supporting reasonable time periods for operator action to manually initiate emergency feedwater, (2) system reliability improvements to provide control room initiation capability for emergency feedwater, (3) improved valve alignments to eliminate operator actions, and (4) because of plant design features that make the plant response rather insensitive to a large variety of upset conditions.

System Design Features:

During steady-state power operation at Yankee, feedwater is supplied to four steam generators by the main feedwater system. The main feedwater system consists of three 2160 gpm motor driven pumps.

In the unlikely event that main feedwater flow is lost, the reactor protection system, in conjunction with a number of backup systems for supplying feedwater, acts to limit reactor coolant system heatup by maintaining a heat sink to remove core residual heat. Backup systems that are available for supplying feedwater to the steam generators include:

1) two new motor driven emergency feedwater pumps (>150 gpm each),

2) one steam driven emergency feedwater pump (> 80 gpm)

3) three charging pumps (total >100 gpm),

4) one train of safety injection (1 HPSI and 1 LPSI) (>100 gpm),

Besides the various alternatives for supplying feedwater to the steam generators, numerous flow paths also exist for injection purposes. The sources of water that are available for feedwater addition include:

1) Demineralized Water Storage Tank (30,000 gal.)

2) Primary Water Storage Tank (135,000 gal.)

3) Fire Water Storage Tank (350,000 gal.)

4) Safety Injection Tank (125,000 gal.)

The Yankee plant design includes features that make the system response rather insensitive to a large variety of upset conditions. Two important examples of these design features include:

- a relatively large pressurizer steam volume that has the capability of absorbing significant insurges without perturbing the system.
- a large steam generator liquid inventory relative to reactor power rating, providing extremely long steam generator dryout times.

These types of design features have led to a system that is slow to respond to some extreme perturbations. This feature of the Yankee plant design provides for extended operator response times for recognizing problems and taking corrective action. The extended response times available for many transients permit the operator to perform a complete assessment of the plant status before taking corrective actions. This is particularly true for loss of feedwater events.

Depending on the nature of the loss of feedwater event, operators at Yankee have from 40 to 90 minutes to manually initiate one of the backup feedwater systems outlined above. The actual time available for operator action depends upon the nature of the loss of feedwater event and whether main coolant pumps are running. Loss of feedwater events were evaluated to determine the response times required. A summary is given in Table 1. Three cases were analyzed assuming that offsite AC power was available to run the main coolant pumps. In these cases, power would also be available to run the main feedwater pumps: however, loss of feedwater flow is attributed to some other mechanism. In addition, one case was evaluated assuming loss of offsite power, resulting in loss of main feedwater and main coolant pumps. Operation of main coolant pumps has a significant impact on steam generator inventories. The magnitude of pump heat which must be dissipated using the steam generators is comparable to core decay heat. In all cases the plant was assumed to be operating at full power (600 MWt x (1.03) = 618 Mwt) and feedwater was assumed to be lost instantaneously. In reality, during a loss of feedwater event, the flow will not reduce to zero instantaneously but would take a finite time period to decrease as the pumps coast down and the feedwater lines clear out. Differences in dryout times between the cases with and without AC available are primarily attributed to:

1) the timing of reactor trip,

2) the availability of the main coolant pumps, and

3) the emergency feedwater sources used in the recovery.

With AC available, the rector trip would be delayed by approximately 18 seconds until steam generator level decreases to the low water level trip. Main Coolant pumps would continue to run until the main generator coastdown to 58 cycles following turbine trip. Following turbine trip, two of the four coolant pumps would coastdown with the generator. The two remaining MCPs are powered from an offsite power line and would continue to run. Operators are instructed through training and emergency procedures to either restart the MCP's that have tripped or trip the MCP's that continue to run. Either action results in preserving adequate heat transfer capability by utilizing the available inventory in all four steam generators. In the cases of either loss of offsite power or total loss of AC, a reactor trip would occur almost immediately as a result of loss of main coolant flow. An immediate trip on loss of main coolant flow coupled with loss of main coolant pump heat results in a slower depletion of steam generator inventory, providing an even greater time to initiate one of the backup sources of feedwater.

Dryout times for the cases evaluated are reported in Table 2. The most severe loss of feedwater event results when offsite AC power is available, reactor trip is on low steam generator water level, and the MCPs continue to run following trip. Steam generator dryout time is in excess of 40 minutes for this case. The details of this design case were reported in Reference (d). The backup feedwater source available in this case would be the two motor driven emergency feedwater pumps. Each pump has a capacity of 150 gpm and is capable of removing both decay heat and main coolant pump heat within 5 minutes after plant trip. Therefore, only one pump is required.

For the remaining cases steam generator dryout times are in excess of one hour. For the case of loss of offsite power or total loss of AC the steam generator dryout time is in the order of 90 minutes. Dryout time is more than doubled when AC is not available, because of the earlier reactor trip and absence of main coolant pump heat.

Under the extremely unlikely condition of total loss of all AC power, the primary means of supplying feedwater to the steam generators is by the steam driven emergency feedwater pump with a capacity of 80 gpm. This pump is capable of removing decay heat at 30 minutes following reactor trip. The capability of each of the backup sources for removing decay heat/main coolant pump heat is summarized in Table 3. Table 3 provides the times following a complete loss of feedwater when the various sources of emergency feedwater are capable of terminating steam generator inventory loss prior to dryout. Together with the steam generator dryout times, these results indicate that if the emergency feedwater system is initiated prior to steam generator dryout, enough capacity exists for recovery of level control. Dryout times given in Table 2 are a factor of 3 greater than most typical U-tube steam generators and about a factor of 30 greater than once through steam generators used in the industry. The longer steam generator dryout times are directly related to the conservative design features of the Yankee plant noted above.

Note further that steam generator dryout results in a degradation in primary to secondary heat transfer, which need not lead to core damage. Following complete loss of secondary cooling, when decay heat levels correspond to the extremely long dryout times, the core would heat up at the rate of 2-3°F/minute. It would take approxmately 60 minutes beyond steam generator dryout for the primary system to reach saturation. In the unlikely event that feedwater could not be restored in this time frame, primary system feed and bleed through the pressurizer PORV could be used as a method to remove core residual heat.

Reliability Consideration:

In NUREG-0610, "Generic Evaluation of Feedwater Transients and Small Break LOCA in Westinghouse-Designed Operating Plants," a reliability assessment was made on the Yankee Plant emergency feedwater system. This assessment was based on our original system configuration prior to this outage and was comprised of a single steam turbine pump, manually initiated at the pump, supported by two alternate and highly diversified flow paths, also manually initiated. The conclusions from this assessment placed the Yankee system in the medium reliability range, and directed certain recommendations at further improving overall reliability of the system. These recommendations recognized the reasonable time period for operator action (based on steam generator dryout) and keyed on providing pump initiation capability in the control room while retaining manual operation capability as backup.

With the additon of the two new motor driven pumps, we are now providing control room initiated capability for emergency feedwater injection. Furthermore, piping configurations, with associated valving, have been designed which do not require manual operator action to reposition valves to align flow paths on demand since the new design has properly lined up locked open valves. These modifications provide a substantial overall improvement in system reliability to deliver emergency feedwater to the steam generators.

Summary:

In summary, Yankee's unique design features significantly extend the time available for required operator responses following loss of main feedwater pump events under various conditions. Between 40 and 90 minutes is available for manual initiation of one of the many alternate methods of providing feedwater. With the exception of the steam driven emergency feedwater pump, which would be required only for total loss of AC (90 minutes available), the alternate methods of providing feedwater can all be remotely initiated from the control room.

Furthermore, the modifications being implemented provide a substantial overall improvement in system reliability. And because of the variety of methods available to provide feedwater to the steam generators and the time available for the operator to initiate any one of these systems, we feel that manual initiation of emergency feedwater is an effective and justified method for mitigating loss of feedwater events.

TABLE 1

SUMMARY OF
LOSS OF FEEDWATER EVENTS
ANALYZED FOR YANKEE ROWE

CASE 1 :	AC AVAILABLE
	REACTOR TRIP ON LOW SG WATER LEVEL (TIME 18 SECONDS)
	4 RCP's OPERATING
	STEAM BYPASS SYSTEM AVAILABLE
	ANS DECAY HEAT
CASE 2:	AC AVAILABLE
	REACTOR TRIP ON NORMAL SG LEVEL (TIME 0)
	4 RCP's OPERATING
	STEAM BYPASS SYSTEM AVAILABLE
	ANS DECAY HEAT
CASE 3:	AC AVAILABLE
	REACTOR TRIP ON LOW SG LEVEL (TIME 18 SECONDS)
	RCP's TRIPPED
	STEAM BYPASS SYSTEM AVAILABLE
	ANS DECAY HEAT
CASE 4:	AC NOT AVAILABLE
	REACTOR TRIP ON NORMAL SG WATER LEVEL (TIME 0)
	NO RCP's
	SECONDARY SAFETY VALVE CONTROL
	ANS DECAY HEAT

ALL CASES ASSUME A COMPLETE INSTANTANEOUS LOSS OF FEEDWATER FROM FULL POWER (600 MWT + 3% = 618 MWT)

CASE 1 WAS SUBMITTED IN WYR 79-104 SEPT. 12, 1979

TABLE 2

SUMMARY OF STEAM GENERATOR DRY-OUT TIMES FOR YANKEE ROWE*

CASE	DESCRIPTION	TIME TO SG DRYOUT FROM INITIATING EVENT**, MINUTES
1	AC AVAILABLE Rx TRIP ON LOW SG WATER LEVEL 4 RCP's OPERATING STEAM BYPASS SYSTEM AVAILABLE	41
2	AC AVAILABLE Rx TRIP ON NORMAL SG WATER LEVEL 4 RCP's OPERATING STEAM BYPASS SYSTEM AVAILABLE	62
3	AC AVAILABLE Rx TRIP ON LOW SG WATER LEVEL RCP's TRIPPED STEAM BYPASS SYSTEM AVAILABLE	70
4	AC NOT AVAILABLE Rx TRIP FROM NORMAL SG WATER LEVEL NO RCP's SECONDARY CODE SAFETY VALVE CONTROL	86

* WITHOUT FEEDWATER FROM ANY SOURCE.

** SG DRY-OUT INDICATES A DEGRADATION IN PRIMARY TO SECONDARY HEAT TRANSFER. FOLLOWING DRY-OUT THE CORE WILL HEAT UP AT 2-3°F/MINUTES. IT WILL TAKE ~ 60 MINUTES BEYOND DRY-OUT FOR PRIMARY SYSTEM TO REACH SATURATION. PRIMARY SYSTEM FEED AND BLEED CAN BE USED TO REMOVE ENERGY IF FEEDWATER CANNOT BE SUPPLIED.

TABLE 3

TIME FOLLOWING REACTOR TRIP
WHEN EMERGENCY FEEDWATER COOLING CAPACITY EQUALS
DECAY HEAT/RCP HEAT

FEEDWATER PUMP	CAPACITY GPM	TIME* TO BALANCE DECAY HEAT & PUMP HEAT (MIN)	TIME TO BALANCE DECAY HEAT (MIN)
STEAM DRIVEN	80	54, (90)	30
CHARGING PUMPS	100	36, (40)	17
NEW MOTOR DRIVEN	150	6, (16)	3

* ( ) DENOTES ASSUMPTION OF +20% UNCERTAINTY ON DECAY HEAT