ARKANSAS POWER & LIGHT COMPANY
POST OFFICE BOX 551 LITTLE ROCK, ARKANSAS 72203 (501) 371-4000

August 27, 1980

1-080-20

Director of Nuclear Reactor Regulation
ATTN: Mr. T. M. Novak
Operating Reactors
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Fuel Assembly Holddown Springs
(File: 4135)

Gentlemen:

In response to your letter of July 1, 1980, the following is provided concerning fuel assembly holddown spring failures.

1. (If the reactor is down for refueling and the reactor vessel head is off) Examine all fuel assembly holddown springs in the core and in the spent fuel pool and report the number and extent of damage on the springs and affected assembly components.

   (Alt.) (If the reactor is operating.) Review video tapes of the core from the last refueling and examine all assemblies in the spent fuel pools. Report the number and extent of damage on the springs and affected assembly components.

Response:

Video tapes of the core from the last refueling have been reviewed. Also, assemblies in the spent fuel pool have been examined. No damage to the springs or assembly components was noted.

2. Provide a discussion of the safety significance of operating with one or more broken springs in the core. Your discussion should include, but not necessarily be limited to the following:

A. Assume the holddown spring is broken, provide an estimate of the flow conditions under which the assemblies would be levitated. (Provide the value of the force required to lift the assembly, the flow conditions under which that force would be supplied, the number of coolant pumps that would be in operation under such conditions, and the schedule of reactor operations under which such conditions might have been achieved.) Contrarily, demonstrate the margin between the assembly weight and the calculated maximum applied lift off force, if there is such a margin.

Response:

A break occurring in a holddown spring will result in a decrease in holddown force which is a function of the location of the break and the degree to which the coils become misaligned. To quantify this decrease, tests were run on springs cut at typical break locations. The test fixture was an upper end fitting complete with guide tube nuts, a holddown spider and a simulation of the upper grid plate pads.

Two springs were prepared for the test: one cut at the location of the transition from the dead coil to active coil, the second was cut at a location ¼ coil towards the mid-coil of the spring. A series of six tests were run using the two springs. Each was tested with: 1) no breaks, 2) one break at the upper location, and 3) breaks at both upper and lower locations. The retained holddown force (at 100% power, BOL) exceeded 300 pounds for three of the four break configurations. Only the configuration with two breaks, each ¼ coil from the transition, resulted in a significant loss. The retained holddown force for this extreme configuration was 64 pounds.

Based upon these results, it can be concluded that a broken spring is likely to retain from 64 to 500 pounds holddown force. The break most frequently observed would provide a retained holddown force near the upper end of this range.

It is significant to note that each of the broken holddown springs observed to date has held the spring spider against the remaining plugs. This pinned condition is only possible due to some retained preload on the spring. Springs in this condition are expected to develop a minimum of 100 pounds retained holddown force when extrapolated to operating conditions due to additional preload from the reactor internals.

The flow of coolant water through the core during normal operation produces large hydraulic forces on the fuel assemblies. The actual forces imposed during operation will depend on the total flow through the core and the distributuion of coolant flow to the various assemblies. The total mass flow is a function of the coolant temperature and the number of reactor coolant pumps (1-4) in operation. The flow distribution is affected by (1) the power distribution, (2) the assembly geometry (i.e., control rod, orifice rod, BPR, open guide tube), and (3) the location within the core (peripheral/interior).

Counteracting these large hydraulic forces are the fuel assembly weight (approximately 1,510 lbs. in air), the supplemental force supplied by the preloaded holddown spring and frictional forces exerted by the reactor internals and adjacent fuel assemblies. The holddown spring is sized to provide a minimum force under the most adverse conditions (coolant temperature, irradiation exposure, dimension tolerances, etc.), without consideration of frictional forces. The force required to lift a fuel assembly is assumed, for this evaluation, to be equal to the weight of the fuel assembly in water (that is, it is assumed that there is no holddown force available from the holddown spring or from frictional forces).

Based on a nominal system flow rate of 114% of design (where the design rate is 352,000 GPM) the maximum net lift force on any assembly is +58 pounds. That is, the net vertical (upward) force on the fuel assemblies in control rod locations varies between -143 pounds to -236 pounds indicating that all of these assemblies have significant margin to lift even if no credit is taken for the spring's holddown force. Of the core locations not occupied by control rods 52 have a net positive lift force with no spring force considered. Recalling that all broken springs observed to date have retained at least 100 pounds holddown force it can be concluded that no fuel assembly lift would be predicted for normal operation with broken holddown springs.

The hydraulic forces on the fuel assembly generally increase with decreasing temperature. The phenomenon is due to the increased fluid density at the reduced temperature. Therefore, the most severe lift condition is the lowest temperature at which four reactor coolant pumps are in operation. The holddown spring is sized to accommodate this limiting condition--the fourth pump startup.

The maximum net lift force at the fourth pump startup temperature of 500°F is +134 pounds. For this condition all control rod locations maintain positive holddown without the benefit of the spring force. Lift forces on assemblies in control rod locations vary from -62 pounds to -163 pounds. Assuming a minimum retained holddown force of 100 pounds for a broken spring, only 20 assemblies would be predicted to lift for this extreme temperature condition; however, lifting under this transient condition is not a significant concern and will not cause significant fuel assembly wear or damage.

Due to the increase in holddown requirements with decreasing temperature, transients which cause an overcooling of the primary system are the most limiting with respect to fuel assembly lift. Such transients will, in general, be terminated before reaching a condition analyzed for the fourth reactor coolant pump startup. However, if the primary coolant temperature were to go below 500°F and all four reactor coolant pumps were inadvertently left on, the required holddown force would continue to increase at a rate of approximately 120 lbs. for each 100°F the primary coolant temperature drops below 500°F. Without the force from holddown springs, a significant number of fuel assemblies would be expected to lift under this condition; however, lifting under these transient conditions is not a significant concern and will not cause significant fuel assembly wear or fuel damage.

Operation with less than four reactor coolant pumps is expected to produce no fuel assembly lift regardless of the spring holddown force available. The maximum net lift force (with no credit for spring force) for three pump operation at 100°F is -73 pounds, indicating significant margin to lift. This temperature was chosen for the evaluation to conservatively accommodate all possible three pump operation. Due to the demonstrated conservatism shown for three pump operation no evaluation of 1 or 2 pump operation is required; fuel assembly lift will not occur for these pump operating conditions regardless of the spring force available.

B. Have any loose assembly parts (i.e., broken springs, pieces of cladding) been observed anywhere in the primary system? Describe your methods for loose part detection. Are there installed noise detectors capable of detection of broken springs, pieces of cladding, or vibrating assemblies?

Response:

No loose parts have been observed in the primary system. Attached is a description of the loose parts monitor system. The installed detectors are capable of detecting the items mentioned.

C. Have there been any excore or in-core neutron detector indications of levitated assemblies? Describe the expected reactivity effects that would result from lift-off or reseating of assemblies with broken hold-down springs. What efforts are being utilized to detect loose assemblies by either nuclear or mechanical monitoring devices?

Response:

There have been no indications of leviatated assemblies. Normal steady state operation with lifted fuel assemblies does not represent a safety concern. If a lifted assembly were to reseat during operation a small increase in core reactivity

Due to the increase in holddown requirements with decreasing temperature, transients which cause an overcooling of the primary system are the most limiting with respect to fuel assembly lift. Such transients will, in general, be terminated before reaching a condition analyzed for the fourth reactor coolant pump startup. However, if the primary coolant temperature were to go below 500°F and all four reactor coolant pumps were inadvertently left on, the required holddown force would continue to increase at a rate of approximately 120 lbs. for each 100°F the primary coolant temperature drops below 500°F. Without the force from holddown springs, a significant number of fuel assemblies would be expected to lift under this condition; however, lifting under these transient conditions is not a significant concern and will not cause significant fuel assembly wear or fuel damage.

Operation with less than four reactor coolant pumps is expected to produce no fuel assembly lift regardless of the spring holddown force available. The maximum net lift force (with no credit for spring force) for three pump operation at 100°F is -73 pounds, indicating significant margin to lift. This temperature was chosen for the evaluation to conservatively accommodate all possible three pump operation. Due to the demonstrated conservatism shown for three pump operation no evaluation of 1 or 2 pump operation is required; fuel assembly lift will not occur for these pump operating conditions regardless of the spring force available.

B. Have any loose assembly parts (i.e., broken springs, pieces of cladding) been observed anywhere in the primary system? Describe your methods for loose part detection. Are there installed noise detectors capable of detection of broken springs, pieces of cladding, or vibrating assemblies?

Response:

No loose parts have been observed in the primary system. Attached is a description of the loose parts monitor system. The installed detectors are capable of detecting the items mentioned.

C. Have there been any excore or in-core neutron detector indications of levitated assemblies? Describe the expected reactivity effects that would result from lift-off or reseating of assemblies with broken hold-down springs. What efforts are being utilized to detect loose assemblies by either nuclear or mechanical monitoring devices?

Response:

There have been no indications of leviatated assemblies. Normal steady state operation with lifted fuel assemblies does not represent a safety concern. If a lifted assembly were to reseat during operation a small increase in core reactivity would occur due to the relative motion between the fuel assembly and a partially inserted control rod. Conservative calculations have predicted that a fuel assembly lifting 1.5 inches (the maximum possible) would change the core reactivity .002%$\Delta k/k$ at hot full power (HFP) and .006%$\Delta k/k$ at hot zero power. The limiting reactivity insertion would occur if the fuel assemblies in all 61 control rod locations were lifted the maximum distance. As discussed in the response to question 2(a), assemblies in control rod locations retain positive holddown during normal operation even with no spring force. Thus, this limiting maximum reactivity insertion of only 0.1%$\Delta k/k$ at HFP is predicted. The resulting transient would, at worst, be characterized by a small, rapid increase in neutron power tripping the plant on high flux in the first few seconds of the transient. The transient would also result in a small increase in reactor coolant system pressure with no change in core inlet temperature for approximately 10 seconds (one loop transient time). Thus, even this hypothetical reactivity insertion does not significantly affect the steady state and transient safety anaysis; the potential reactivity insertion from a small number of spring failures, if lifting were to occur, is shown to be of no consequence.

Neutron noise analysis has been performed this cycle by Oak Ridge with no anomalies noted.

D. Have there been any observed indications of lateral repositioning of loose assemblies? Describe the methods used to detect lateral assembly motion. Describe the degree of lateral repositioning that is physically (dimensionally) possible after lift-off. What are the postulated worst-case effects of a laterally displaced assembly?

E. (i) Describe the degree of "worst-case" mechanical damage that would be expected as a result of movement of a "loose" assembly (one with a broken spring) against adjacent assemblies, core baffle, or other core components.

(ii) Discuss the results of flow tests or other experiments that have provided measurements of axial or lateral vibratory motion of an assembly after lift-off or that would otherwise support the response to Q2.E(i).

Response to D. and E.:

There has been no observation of lateral repositioning of loose assemblies.

A fuel assembly suddenly experiencing a loss of holddown could move upward a maximum of 1.5 inches, with a corresponding impact energy level of less that 50 ft-lbs. This level of impact is far below the energy necessary to damage the fuel assemblies. For example, LOCA analysis has shown that the fuel assembly can withstand impact energies in the range of 500 ft-lbs. Thus, gross impact of fuel assemblies can be eliminated as a cause for concern, but there is the possibility of lower level vibrations which could cause some wear. Also, there is the possibility of spacer grid mismatch due to lifting of one assembly while its neighbor remains seated. The fuel assembly can lift up to 1.5 inches at beginning of life whereas 1.2 inches lift will result in the spacer grids outside strips no longer matching up. Long term operation under this condition would, at worst, result in damage to some peripheral fuel rods. There is no possibility of damage resulting in non-insertion of control rods since the guide tubes are protected by two rows of fuel rods.

Horizontal vibration of the fuel assembly while in the lifted condition may be more pronounced at the lower end fitting since it may not be held tightly by the grid pads. Lateral motion in which two adjacent assemblies contact at the lower end fitting is possible and could cause wear on the lower end fitting. However, the lower end fitting has thick cross sections which can withstand significant wear without loss of function. Peripheral assemblies might contact the core baffle plates, but again wear would not be a significant problem. The lower end fitting of a fuel assembly which is postulated to lift 1½ inches can raise up onto the chamfered leadin surfaces of the guide blocks such that 0.4 inches or lateral repositioning could theoretically occur. However, lateral repositioning is nominally limited to the clearances between the lifted assembly and adjacent seated assemblies or baffle plates which are 0.05 inches and 0.1 inches respectively.

The upper end fitting will remain closely aligned by the upper grid pads at all times. Lateral vibration would not be expected to increase. For this reason upper end fitting wear or control component wear would not be expected to be any greater than the low levels experienced during normal operation.

There have been several tests run to determine the flow required to cause fuel assembly lift. These tests also provide an indication of assembly vibration levels in the lifted condition. During these tests, the holddown spring remains uncompressed since the maximum loop flow is incapable of lifting the assembly with the spring compressed. The flow is increased in small increments until the assembly lifts at which point the flow is then varied to determine the lift velocity as accurately as possible. There has been no indication of vertical oscillation of the assembly during these tests. Also, the fuel assemblies were examined after each test and no evidence of impact or wear has been found. These results indicate that severe vibration will not result from a lifted assembly.

3. Provide a description of the cause of the failures and corrective action to reduce the likelihood of future failures at your facility.

Response:

No failures have been detected at ANO-1, therefore, no corrective action is necessary.

The cause of the holddown spring failures has been determined by B&W to be an improper material condition characterized by a coarse outer grain structure. Coarse grain structure is indicative of less fatigue resistance. The coarse grain material precipitated fatigue crack initiation. The mechanism of failure was then fatigue propagation followed by the secondary effects of stress corrosion cracking and final fracture.

Very truly yours,

David C. Trimble

David C. Trimble
Manager, Licensing

DCT:MAS:nak

Attachment

VIBRATION AND LOOSE PARTS MONITOR SYSTEM

The Vibration and Loose Parts Monitor (V&LPM) provides continuous vibration and loose parts monitoring at four locations of the reactor primary system. These locations correspond to probable loose parts collection points. The metal-to-metal impacts of loose parts in the reactor coolant system produces ringing noises which are enhanced by natural system resonances in the 1 to 10K Hz range. The system components are generally excellent conductors of acoustic waves in this frequency range so that impact noises can be readily detected by the installed piezo electric accelerometer sensors.

The locations for the four accelerometers are in the lower reactor vessel region, upper reactor vessel region, and OTSG reactor coolant inlet region. The Channel #1A, Lower Vessel, accelerometer is positioned on in-core instrument guide tube number 2, two feet from the vessel bottom inside the primary shield wall. Channel #1B, is a redundant Lower Vessel accelerometer and is located on guide tube #10. The Channel #2, Upper Vessel, accelerometer is located on the control rod protection shroud lower flange, between attachment bolts. Channels #3A and #4A, OTSG A and B respectively, accelerometers are bolted directly to the steam generator at the tube sheet level adjacent to the Steam Generator Vessel support near the secondary shield wall. Channels #3B and #4B are redundant channels and are diametrically opposed to the A channels. Channel #5 & #6, Reactor Internals yields core dynamic information via an input from a buffered NI power signal originating from Cabinet C42 and C43 respectively.

During NSS operation each V&LPM channel exhibits its own unique frequency spectrum. This frequency signature, or normal background, results from sources such as primary flow turbulance, reactor coolant pump vibrations, feedwater and steam flow turbulances, structural response of NSS components, and other localized noise sources, including airborne noises from fans and other equipment.

Each channel signal can be connected to strip charts, audio output, cassett tape unit, X-Y plotter, or a spectrum analyzer for diagnosis of any alarms or for surveillance checks of the system signatures.