SMUD
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September 4, 1980

Mr. Thomas M. Novak, Assistant Director
for Operating Reactors
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Docket 50-312
Rancho Seco Nuclear Generating
Station, Unit 1

Dear Mr. Novak:

In your letter of July 1, 1980 (received July 8, 1980) you requested a response to a set of questions on fuel assembly holddown springs. The District's response to these questions is provided in the attachment.

Sincerely,

John J. Mattimoe

John J. Mattimoe
Assistant General Manager
and Chief Engineer

Attachment

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FUEL ASSEMBLY RETAINER HOLD-DOWN SPRINGS QUESTIONS

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

Response 1. The District has examined 253 of the 341 fuel assemblies onsite (177 in core and 164 in the spent fuel pool). A summary of these examinations is provided below. During these examinations, no damage to the retainer springs was observed.

Twenty-two of the fuel assemblies examined contained Burnable Poison Rod Assemblies (BPRA's). Because the BPRA's partially obscured the retainer springs, our inspectors were not able to satisfactorily examine the springs in the 110 fuel assemblies which contain BPRA's. There is presently no capability at Rancho Seco 1 for removing and storing the BPRA's to facilitate the examination of these fuel assemblies.

Based on the observations made during these inspections, it was judged that a high level of confidence exists in the fact that the fuel assemblies in the core are free from retainer spring damage. Consequently, it was not deemed necessary to pursue the examination of the fuel assemblies which contain BPRA's.

Summary of Retainer Spring Examination

Incore Examinations - Core verification tapes.

Batch 1	13 FAS (EOC-4 Tape)
Batch 2	5 FAS (EOC-3 Tape)
Batch 3	60 FAS (EOC-3 Tape)
Batch 4	56 FAS (2 Exams, EOC-3/EOC-4 Tapes)
Batch 5	56 FAS (2 Exams, EOC-3/EOC-4 Tapes)
Batch 6	52 FAS (EOC-4 Tape)
	242 FAS

No Fuel Assy was observed to have spring damage.

S.F.P. Examinations

Batch 1	None examined due to BPRA's.
Batch 2	16 (14 w/BPRA's)
Batch 3	60 (8 w/BPRA's)
	76 (22 w/BPRA's)

Summary of Retainer Spring Examination (cont)

Total Examination

Batch 1	13
Batch 2	16
Batch 3	60
Batch 4	56
Batch 6	52
	253

Question 2.a.

Assume the holddown spring is broken, provide an estimate of the flow conditions under which the assemblies would be leviated. (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 margin.

Response 2.a.

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.

The broken springs observed to date are characterized by breaks within ¼ coil of the top or bottom transition point. Two springs have contained breaks at both top and bottom. The single exception to this pattern occurred at Davis Besse. Here, one spring was broken at the lower transition and again approximately 1/3 coil towards the spring mid-coil. The broken piece was wedged between the dead coil and the upper coils. From the test results, it is estimated that this spring would have retained approximately 100 pounds holddown force without the wedged piece (which should increase holddown).

Thus, this test encompasses the observed spring breaks. 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 retaining 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 distribution 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 1510 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 assembly, taking credit for only the wet weight (no spring force) is 58 pounds. The net force on 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 accomodate 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 accomodate all possible three pump operation. Due to the demonstrated conservatism shown for 3 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.

Question 2.b.

Part 1: "Have any loose parts (i.e. broken springs, pieces of cladding) been observed anywhere in the primary system?"

Response 2.b. During the EOC 3/BOC 4 refueling, the spacer grids of several fuel assemblies were torn. As a consequence, small pieces of spacer grid material fell into the lower vessel internals. It was estimated that at the end-of-refueling, all but 3 in^2 of grid material was recovered. The material was distributed in at least 7 pieces, the longest being 0.5" by 1.2".

Parts 2 & 3: 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 2.b. Loose parts monitoring at Rancho Seco is performed using an Atomics International Vibration and Loose Parts Monitoring (VLPM) System. Eight Endevco accelerometers (Model 2276) are attached to the Primary System. Two accelerometers monitor the lower vessel, two monitor the upper vessel, two monitor the OTSG tube sheet and two monitor the OTSG inlet. Large amplitude vibrations, in the 28 KHZ range, activates an audio recorder. The recording can later be analyzed to provide an indication of the location of the vibration to within 10 feet. The rated sensitivity of the loose parts monitor is based on the magnitude of the impact of the loose part on the vessel or pipe wall and the subsequent acoustic transmission through water or metal to the accelerometer. The minimum impulse detectable is 0.05 ft-lbs. Vibrations which results in 2g acceleration are also detectable.

Characterization of the noise generated by broken springs is dependent upon several factors relative to the physical nature of the break and the location of the affected spring. The VLPM is designed primarily to detect "loud" noises associated with major component movement. Therefore, it is unlikely that noises associated with the movement of a fuel assembly or due to spring pieces "wiggling" in place could be detected. However, if the spring were to loosen to the point that large pieces could be dislodged and transported to the steam generator head; detection might be possible, as in the Crystal River 3 experience with the Burnable Poison Rod Array movement.

Since the initial notification of the retainer spring problem, the shift supervisors have been monitoring the VLPM each shift to provide familiarity with the "nominal" acoustic noises. Thus, any "qualitative" change in noise could serve as a basis for performing a thorough spectrum analysis. In addition, a monthly surveillance program has been in place which provides for the performance of a detailed spectrum analysis of the VLPM noise monitors. This data provides baseline information on the nominal noise levels for comparison purposes.

Question 2.c.

Have there been any excore or in-core neutron detector indications of leviated 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 utilitized to detect loose assemblies by either nuclear or mechanical monitoring devices?

Response 2.c.

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 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 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 transit time). Thus, even this hypothetical reactivity insertion does not significantly affect the steady state and transient safety analysis; the potential reactivity insertion from a small number of spring failures, if lifting were to occur, is shown to be of no consequence.

Question 2.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 posulated worst-case effects of a laterally displaced assembly?

Question 2.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.

Question 2.e.(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 otherise support the response to question 2.e.(i).

Response 2.(d) & (e)

As discussed in response to question 2(a), fuel assemblies with broken holddown springs would not be predicted to lift-off during normal operation. Furthermore, there have been no indications that any of these assemblies did lift-off. Three fuel assemblies containing broken holddown springs were visually examined. No evidence of lift or of wear from lift or lateral displacement was found; no fuel assembly damage of any kind was found.

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 than 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 lead-in surfaces of the guide blocks such that 0.4 inches or later 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. They were run in the Control Rod Drive Line Test facility (Alliance Research Center), which is a single fuel assembly test loop simulating reactor flow, temperature and pressure. A displacement transducer was used in determining fuel assembly lift. 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 for a lifted assembly.

Question 3.

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

Response 3.

The cause of the holddown spring failures was 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.

Corrective action consisted of replacing the springs from this heat of material. Replacement springs were made to a current specification which controls grain size to obtain uniform fine grains to provide increased fatigue resistance.