PACIFIC GAS AND ELECTRIC COMPANY

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January 10, 1975

Mr. Karl R. Goller
Assistant Director for Operating Reactors
Directorate of Licensing
Office of Regulation
U. S. Atomic Energy Commission
Washington, D.C. 20545

Re: Docket No. 50-133

Dear Mr. Goller:

On November 27, 1974 the Company submitted Abnormal Occurrence Report No. DPR-7/74-4 covering the failure of some of the reactor feedwater sparger hold-down U-bolts. At the time of the report, two broken U-bolts were undergoing laboratory examination and the feedwater sparger repairs were in progress. The purpose of this report is to describe the U-bolt failure mechanism determined from this examination and the corrective feedwater sparger repairs.

BACKGROUND

The reactor feedwater sparger consists of a continuous section of oval cross section pipe located around the inside of the vessel at an elevation below the top of the core chimney. The sparger is supplied with water from one inlet nozzle. The sparger has holes ½ inch in diameter near the bottom on both sides to distribute the feedwater uniformly in the vessel. The sparger is supported by eight gusset type brackets around the inside diameter of the reactor vessel wall and was originally designed to be held in place with U-bolts mounted on each bracket. The U-bolts, which were fabricated from ½ inch diameter SA-276 Type 304 austenetic stainless steel, fit around the sparger and were held in place with nuts on both sides of the support bracket. The nuts were tack welded to the bracket. The general arrangement of the sparger is shown in Figure 20 of the Final Safety Analysis Report.

On November 17, 1974, while the reactor was shut down for a regularly scheduled refueling outage, it was noted that the sparger had moved 1½ to 2 inches away from the nozzle and that some of the U-bolts were broken. A close examination showed that six of the U-bolts had broken through on one or both legs (refer to Figure No. 1). The bolts from the 22° and 157° positions, considering the feedwater nozzle as the 0° position, were sent to the Vallecitos Nuclear Center for metallographic examination to identify the failure mechanism. These bolts were broken through on both legs just above the nut on the top of the support bracket.

RESULTS OF THE METALLOGRAPHIC EXAMINATION

Examination procedures consisted of visual, visible dye penetrant, scanning electron microscopy, metallography and hardness. The examination showed that the U-bolt failure was caused by high cycle fatigue. The basis for this conclusion is as follows:

1. Electron microscope examination of the broken bolts showed that the fracture mode was transgranular cleavage. Transgranular cleavage is the type of fracture associated with high cycle fatigue.

2. Metallographic examination of the fracture surfaces showed a completely transgranular mode of failure. The transgranular mode of propagation and the absence of plastic deformation associated with the fracture indicated that the most likely failure mechanism was high cycle fatigue. The material was verified to be solution annealed with a Rockwell Hardness in the range of 93 to 95. This is normal for commercial bar stock of this material.

3. A longitudinal section through the slightly worn area where the 157° bolt contacted the side of the sparger revealed essentially no cold working. This indicates that the source of wear was gentle and probably occurred over a long period of time.

POSTULATED FAILURE MECHANISM

It is postulated that the U-bolts vibrated in resonance with input from a source such as the feedwater pump or recirculation flow. It is further postulated that the sparger itself was not vibrating or that the vibration amplitude was very low. This is based on the following findings:

1. Visual examination of the underside of the sparger showed no unusual wear marks. If the sparger were vibrating it would be expected that grooves or chatter marks would be worn into the bottom of the sparger from contact with the sparger support brackets.

2. Visual examination of the thermal sleeve-sparger junction showed this area to be in excellent condition. If the sparger were vibrating significantly it would be expected that cracks would be created at this junction.

CORRECTIVE REPAIRS

Corrective repairs were performed under water using specially designed tools. All of the U-bolts and associated nuts were removed from the sparger support brackets. There are no lost or unaccounted for parts in the reactor vessel. The basic tools used in this phase of the repair were a commercial hydraulic bolt cutter and nut cracker modified by the plant staff for this particular application.

The sparger was then recentered using a commercial hydraulic jack with special fixtures built at the plant so that the sparger could be jacked against two of the sparger support brackets. The force required to move the sparger back in place was calculated to be less than 2000 pounds.

After the sparger was recentered, the feedwater line inside of the drywell was examined by the visible dye penetrant method. No relevant indications were found. The feedwater nozzle was also examined by radiography. This examination showed that the thermal sleeve which attaches to the sparger was in its proper position. The end of the thermal sleeve appeared to be normal in all respects.

Redesigned sparger restraints were installed at each sparger support bracket. These restraints are substantially stronger in design and clamp tightly around the sparger. They are not directly attached to the sparger support brackets as were the original U-bolts. The nuts which bolt the restraints to the sparger were tightened to 40 foot pounds and secured by staking to prevent them from working loose. Legs from the restraints are designed to engage the wall bracket to limit any sparger movement away from the feedwater nozzle due to hydraulic forces, while allowing the sparger to move as a result of thermal growth (see Figure 2).

The new restraint design should not be susceptible to the same types of vibration problems that were postulated for the original U-bolt design. The reason for this is that the new restraints are held in firm contact with the sparger. The new restraints were fabricated in the plant from solution annealed ASTM A-276 Type 304 stainless steel bar and flat stock.

Twenty-three days elapsed from the time the sparger problem was first discovered (November 17, 1974) until the corrective repairs were completed (December 9, 1974). All of the repair work to the sparger was performed by plant personnel working from the refueling platform on the reactor extension tank to minimize radiation exposure. The total accumulated exposure to perform the repair work is estimated to be only 6.5 man-rem. All special tools and the new restraints were built by plant personnel. Engineering support was provided by General Electric Company's Nuclear Engineering Division (San Jose) and Vallecitos Nuclear Center and the Company's Department of Engineering Research.

FUTURE INSPECTION PROGRAM

During the 1975 and 1976 regularly scheduled refueling and maintenance outages a thorough visual inspection of the feedwater sparger, all support brackets and all sparger restraints will be made. In addition, each restraint will be checked to assure that it is still clamped tightly to the sparger. During the 1976 outage one of the restraints will be removed and replaced by a new restraint of similar design. The removed restraint will be subjected to a thorough examination by the Company's Department of Engineering Research. Future inspection programs will be based upon the results of these examinations.

Very truly yours,

Philip A. Crane, Jr.

Philip A. Crane, Jr.

cc: Mr. R. H. Engelken, Director
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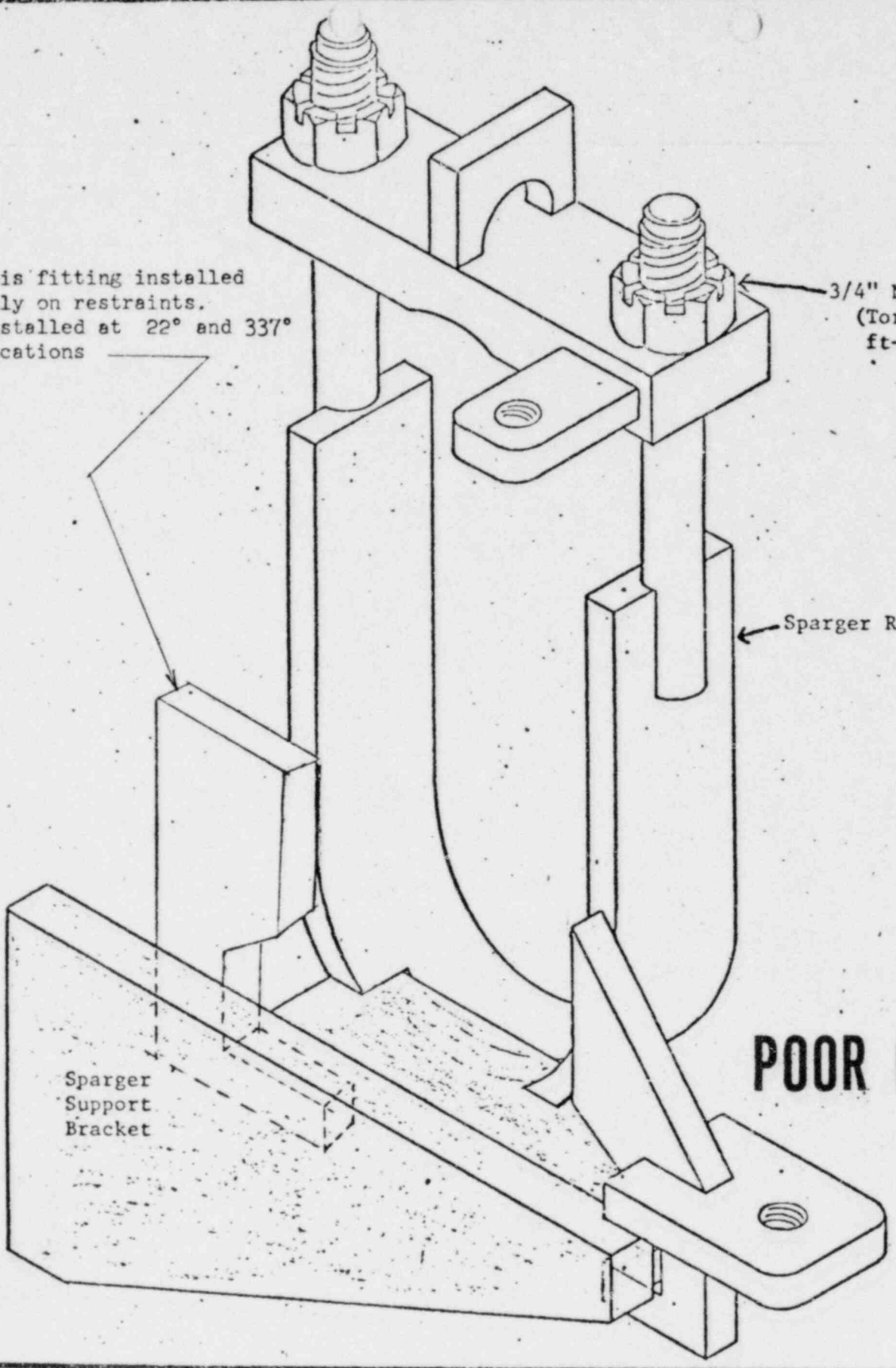

Figure No. 2 - Basic Redesigned Feedwater Sparger Restraint

(Illustrative Only)

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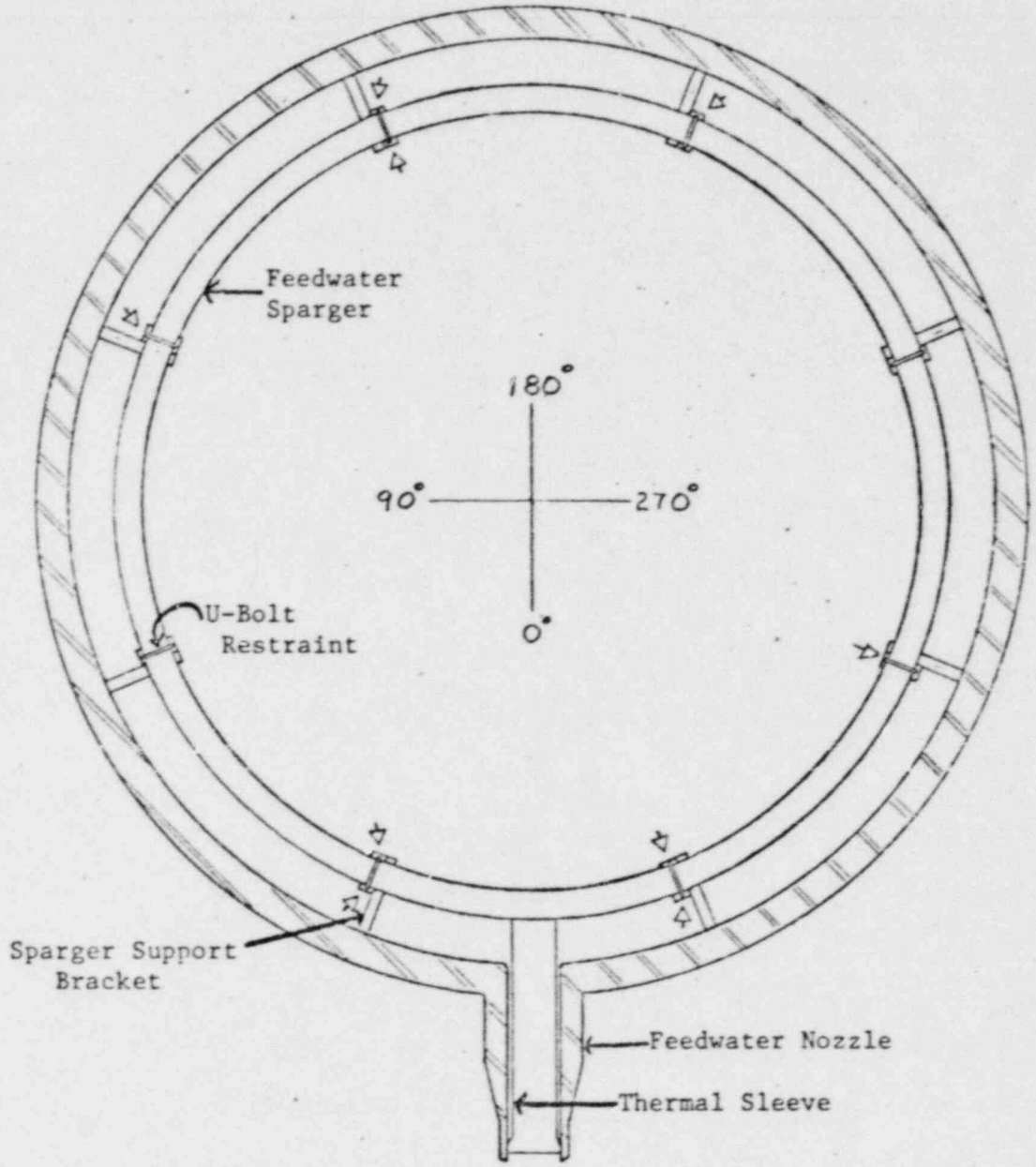
DATE	SCALE
1-3-75	None



Arrow (⇩) indicates broken U-Bolt

Figure No. 1 - Feedwater Sparger Plan
View Showing Location of Failed U-Bolts

(Illustrative Only)

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