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MIRAGLIA,F. Licensing Branch 3

SUBJECT: Forwards list of attendees & handouts from util 810915 meeting w/NRC re final design for feedwater ring mods & basis for not repeating feedwater hammer test & procedure for feedwater ring/auxiliary piping integrity test.

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TELEPHONE
(213) 572-1401

September 16, 1981

Director, Office of Nuclear Reactor Regulation
Attention: Mr. Frank Miraglia, Branch Chief
Licensing Branch No. 3
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Subject: Docket Nos. 50-361 and 50-362
San Onofre Nuclear Generating Station
Units 2 and 3

SCE's letter of September 3, 1981 provided preliminary details of the San Onofre Units 2 and 3 Steam Generator feedwater ring modifications. The letter also indicated that SCE would provide the final design details for the modifications and a detailed discussion of the basis for not repeating the feedwater hammer test.

Consistent with that commitment, SCE met with the NRC staff on September 16, 1981 in Bethesda, Maryland to discuss the final design and the basis for not repeating the feedwater hammer test. Enclosure I provides seven (7) copies of the meeting attendance and meeting handouts which were provided to the NRC staff during the September 16, 1981 meeting (NRC Mail Code B028).

SCE indicated during the meeting that the damage suffered by the feedwater ring did not compromise its capability to deliver necessary auxiliary feedwater flow for decay heat removal and that the damage was not a safety concern. SCE further stated that it would not be necessary to repeat a water hammer test because the feedwater hammer test conducted in March of 1981 resulted in acceptable water hammer consequences for external piping and that the proposed modifications which include: (1) increased venting, (2) addition of a mechanical O-Ring seal, (3) stronger supports and vent for feedwater junction box and (4) replacing the schedule 40 feedwater ring piping with schedule 120 piping would preclude damage to the feedwater ring.

The NRC staff indicated that it was their position that a test should be performed to demonstrate the adequacy of the steam generator feedwater ring and auxiliary feedwater piping to withstand automatic introduction of auxiliary feedwater. Consistent with the NRC position and clarification provided during the meeting, Enclosure II provides seven (7) copies of the test procedure for verifying the adequacy of the feedwater ring and auxiliary feedwater piping (NRC Mail Code B028). This test procedure will be incorporated as part of another test involving initiation or simulated initiation of automatic auxiliary feedwater.

In response to an NRC concern, SCE indicated during the meeting that operational guidance was provided to operators in procedures relative to maintaining steam generator level above the bottom of the feedwater ring during manual auxiliary feedwater operation modes (i.e., from cold shutdown to hot standby) and that the procedures would be reviewed to verify the operational guidance. SCE has reviewed these procedures and those involved in taking the plant from hot standby to minimum load to assure that they contain the required guidance. The following are examples of the procedures involved and reviewed.

Procedure No.	Title
S023-5-1.3	Plant Startup from Cold Shutdown to Hot Standby.
S023-5-1.4	Plant Shutdown from Minimum Load to Hot Standby.
S023-5-1.5	Plant Shutdown from Hot Standby to Cold Shutdown.
S023-2-4	Plant Startup from Hot Standby to Minimum Load.

If you have any questions or comments regarding the enclosed information, please let me know.

Very truly yours,

K P Baskin

Enclosures

ENCLOSURE I

Attendees

September 16, 1981 meeting - San Onofre Units 2 and 3 Steam Generator Feedwater Ring Modifications

Name	Organization
H. Rood	NRC
W. D. Bennett	CE
R. L. Phelps	SCE
M. L. Merlo	SCE
J. E. Mahlmeister	Bechtel
F. R. Nandy	SCE SONGS 2&3 Licensing
R. S. Turk	CE
A. J. Rudyk	CE
S. MacKay	NRC
B. Mann	NRC

SEPTEMBER 16, 1981

MEETING AGENDA
SAN ONOFRE UNITS 2 & 3 FEEDWATER RING MODIFICATIONS

INTRODUCTION	F. NANDY
STEAM GENERATOR FEEDWATER RING DAMAGE MECHANISM	W. BENNETT
STEAM GENERATOR FEEDWATER RING MODIFICATIONS	F. NANDY
JUSTIFICATION FOR NOT REPEATING FEEDWATER HAMMER TEST	F. NANDY/M. MERLO

------- DISCUSSION/QUESTIONS -------

SUMMARY	F. NANDY

FEEDWATER RING DAMAGE MECHANISM

<u>MECHANISM</u>

SUDDENLY APPLIED DIFFERENTIAL PRESSURE AS A RESULT OF FULL AUXILIARY FEEDWATER FLOW BEING INJECTED INTO A FEEDWATER RING THAT WAS EFFECTIVELY DRAINED.

<u>OTHER CONTRIBUTING FACTORS</u>

- OVALITY
- VARIATION IN PIPE THICKNESS
- HOLES IN PIPE (J-TUBES)
- UNBALANCED ΔP LOADING

SAN ONOFRE 2 STEAM GENERATOR
FEEDWATER SPARGER DAMAGE MECHANISM

The description of damage based on visual examination of the north steam generator described several types of damage. The three principal modes were:

(1) Collapse of the feedwater sparger ring between the distribution box and the first set of U-bolt supports, in both the 90° and the 270° leg of pipe.

(2) Failure of the distributor box supports, in the form of bolt shear for the lower support and axial buckling for the upper support.

(3) Failure of the U-bolts (4) at both sparger supports in the 270° leg of pipe (tensile failure) and stretching of the U-bolts at the 90° position support.

Based on the observed deformations, measurements taken and the results of preliminary calculations, the following is CE's assessment of the damage mechanism:

An external pressure differential which was "suddenly" applied to the sparger, as a result of rapid steam condensation occurring inside the sparger, was the principal cause of sparger damage. Other factors which reduced the load carrying capacity of the 12 inch schedule 40 pipe were ovality, variation in thickness, the holes in both the top and bottom of the pipe and the unbalanced differential pressure loading across the back of the feedwater distributor box.

The unbalanced pressure loading was responsible for the failure of the distributor box supports. The failure of the U-bolts was probably due to a combination of loads induced by distortion of the collapsed sparger and reactions to the unbalanced pressure loading.

Theoretically, a round, unperforated pipe of nominal 12 inch schedule 40 geometry (O.D. = 12.75 in., t = 0.406 in.), made of SA-106 B Carbon Steel can withstand approximately 2000 psi of static external pressure without collapsing. However, a suddenly applied load of 1000 psi is equivalent to a static load of 2000 psi. To confirm this, CE performed dynamic elastic-plastic analysis on the pipe of interest for several values of differential pressure. Results indicate that 750 psi of suddenly applied (0.0002 seconds) pressure was insufficient to cause instability but 1000 psi of suddenly applied pressure did result in an unstable progressive deformation of the pipe.

The presence of 78 two-inch diameter holes periodically spaced in both the top and bottom of the sparger pipe (bottom holes are capped), provide preferential locations for two of the four plastic hinges required to form before the pipe can collapse. This is substantiated by observing the principal collapse modes of the damaged pipe in the north SONGS 2

steam generator. CE has calculated that the reduction in required collapse pressure, due to the holes in the pipe, is between 10 to 22%.

The degree of ovality in the pipe has a significant effect on the pipe's ability to withstand collapse. Measurements from the undamaged portion of the north steam generator sparger as well as the entire south steam generator sparger show an ovality of approximately 2% in the pipe. According to studies found in the literature based on experimental data, a 2% ovality will result in a reduction of required collapse pressure of approximately 25%.

While there is a variation in pipe thickness around the circumference due to the sparger forming process, the average thicknesses are nominal or greater based on field measurements. CE's experience, based on external pressure collapse testing of steam generator tubing with smaller ratios of bend radius to tube diameter and greater thickness variation than the feedwater sparger, is that there is no significant difference between collapse pressures of bent piping and straight piping. Therefore, the effect of thickness variation in the sparger piping is not considered to have been a factor in the sparger collapse.

The significance of the unbalanced differential pressure loading on the feedwater distributor box is obvious with regard to the box supports but difficult to quantify with regard to the sparger collapse. The immediate effect of the load was to shear the four bolts in the lower bracket and then to simultaneously buckle the upper support bracket and pivot the box about the upper connection point. These motions caused the sparger assembly to translate (note the sheared bottom pipe caps at the sparger brackets) and to twist (not the final position of the distribution box). In order to load the sparger, however, reactions to the translational and torsional components of the unbalanced pressure loading must be developed at the sparger supports. The failure of the U-bolts is a measure of the inability to completely develop these reactions. In addition, there is evidence that the feedwater nozzle thermal liner carried a portion of the unbalanced pressure loading. Finally, it is not possible to relate the time sequence between the application of external pressure on the sparger and the unbalanced pressure load reactions. Thus the unbalanced pressure loading probably inhanced the collapse of the sparger but the degree cannot be quantified.

In summary, a suddenly applied external differential pressure on the sparger ring is the principal cause of sparger damage. Other factors which reduce the load carrying capacity of the sparger against collapse are: (1) a 2% ovality in the as formed sparger ring, (2) the holes in the pipe, both top and bottom and (3) the unbalanced pressure loading on the feedwater distribution box. Considering all the above and allowing for some variation in the quantification of the various factors involved, it is concluded that a dynamically applied external pressure differential of between 500 psi and 800 psi was sufficient to collapse the feedwater sparger pipe.

FEEDWATER SPARGER BUCKLING CONSIDERATIONS

DAMAGE MECHANISM: SUDDENLY APPLIED DIFFERENTIAL PRESSURE

FACTORS WHICH REDUCE THE LOAD CARRYING CAPACITY OF THE PIPE:

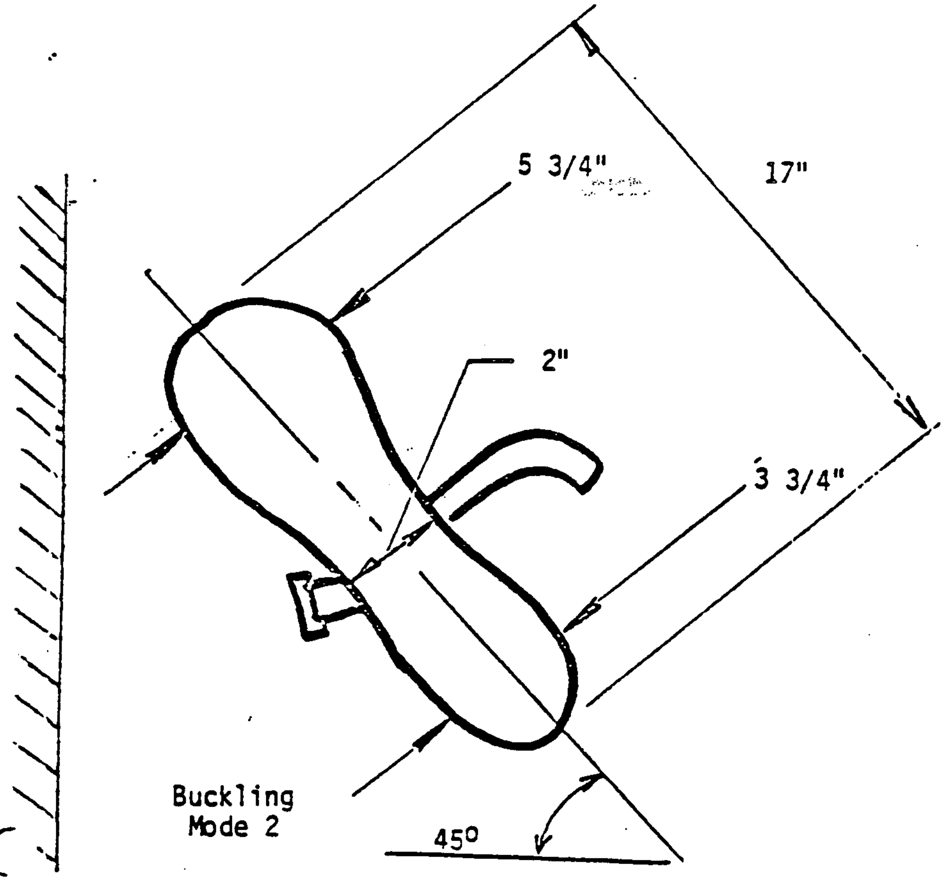
(A) OVALITY

(B) VARIATION IN THICKNESS

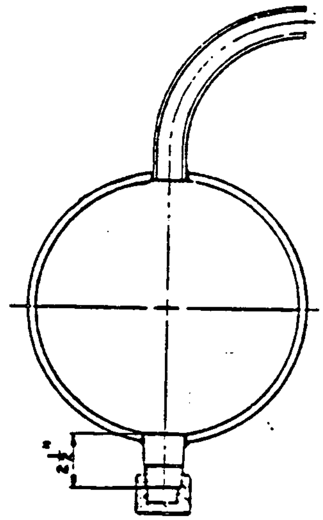
(C) HOLES IN THE PIPE

(D) UNBALANCED Δ P LOADING

FEEDWATER SPARGER COLLAPSE MODE

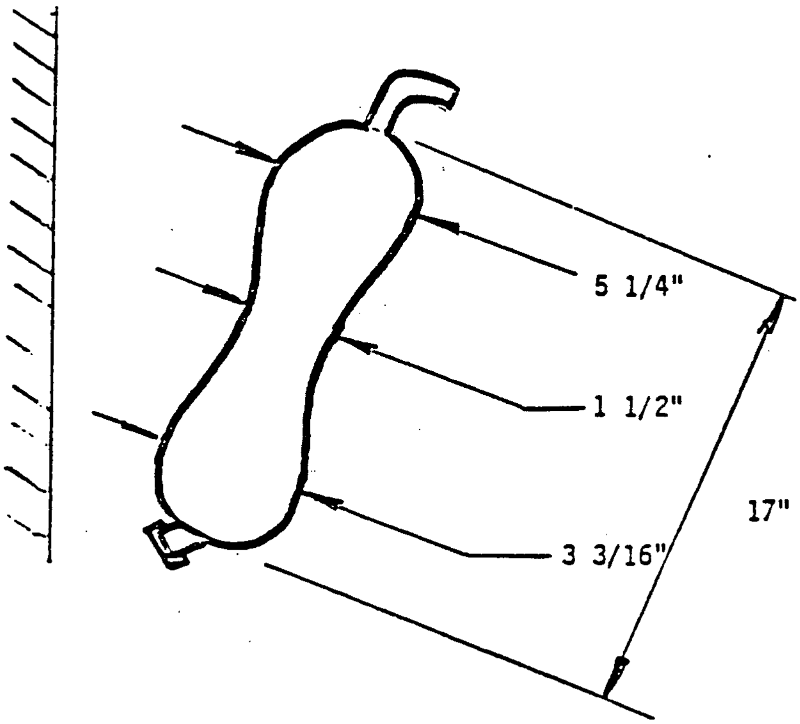


Buckling Mode 2

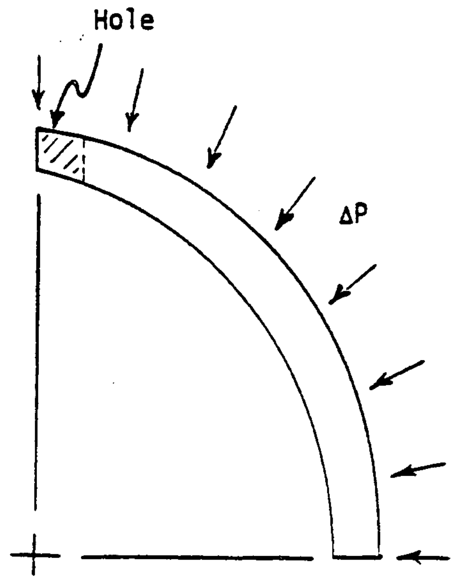


SECTION VIEW

TYPICAL 76 PLACES

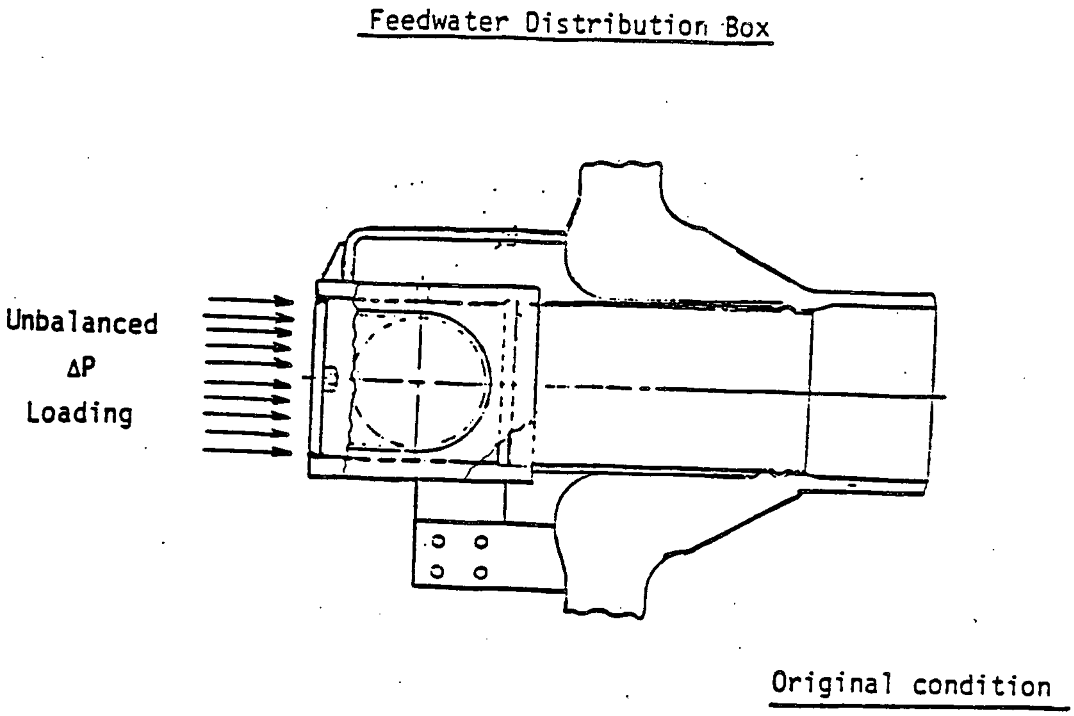


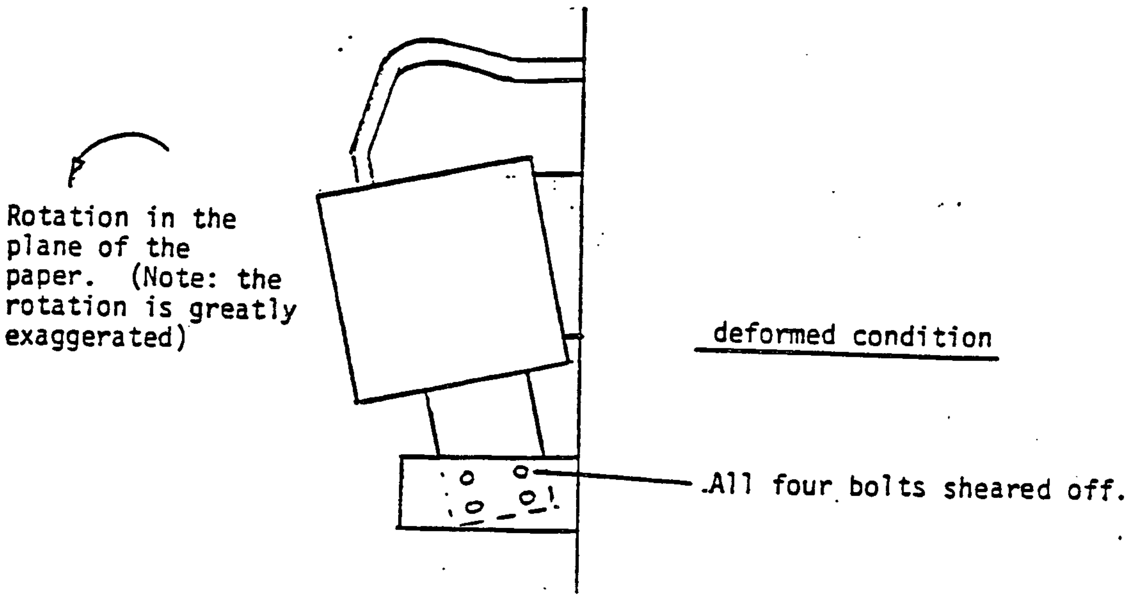
BUCKLING MODE 1



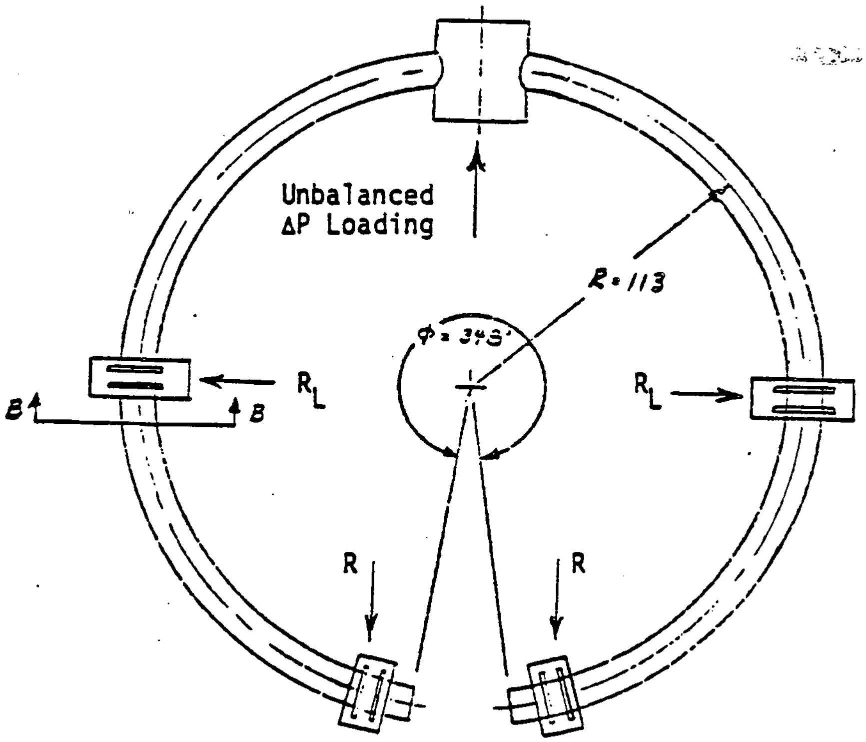
ELASTIC - PLASTIC ANALYSIS MODEL

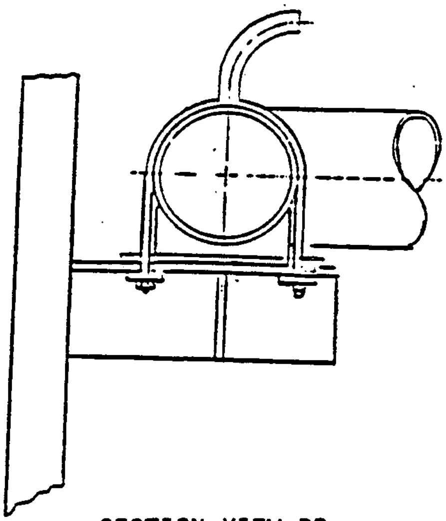
FEEDWATER DISTRIBUTOR BOX
SUPPORTS AND LOADING





FEEDWATER SPARGER SUPPORTS AND SUPPORT LOADING





SECTION VIEW BB

FEEDWATER RING MODIFICATIONS

INCREASE VENTING (40 3½ INCH J-TUBES)

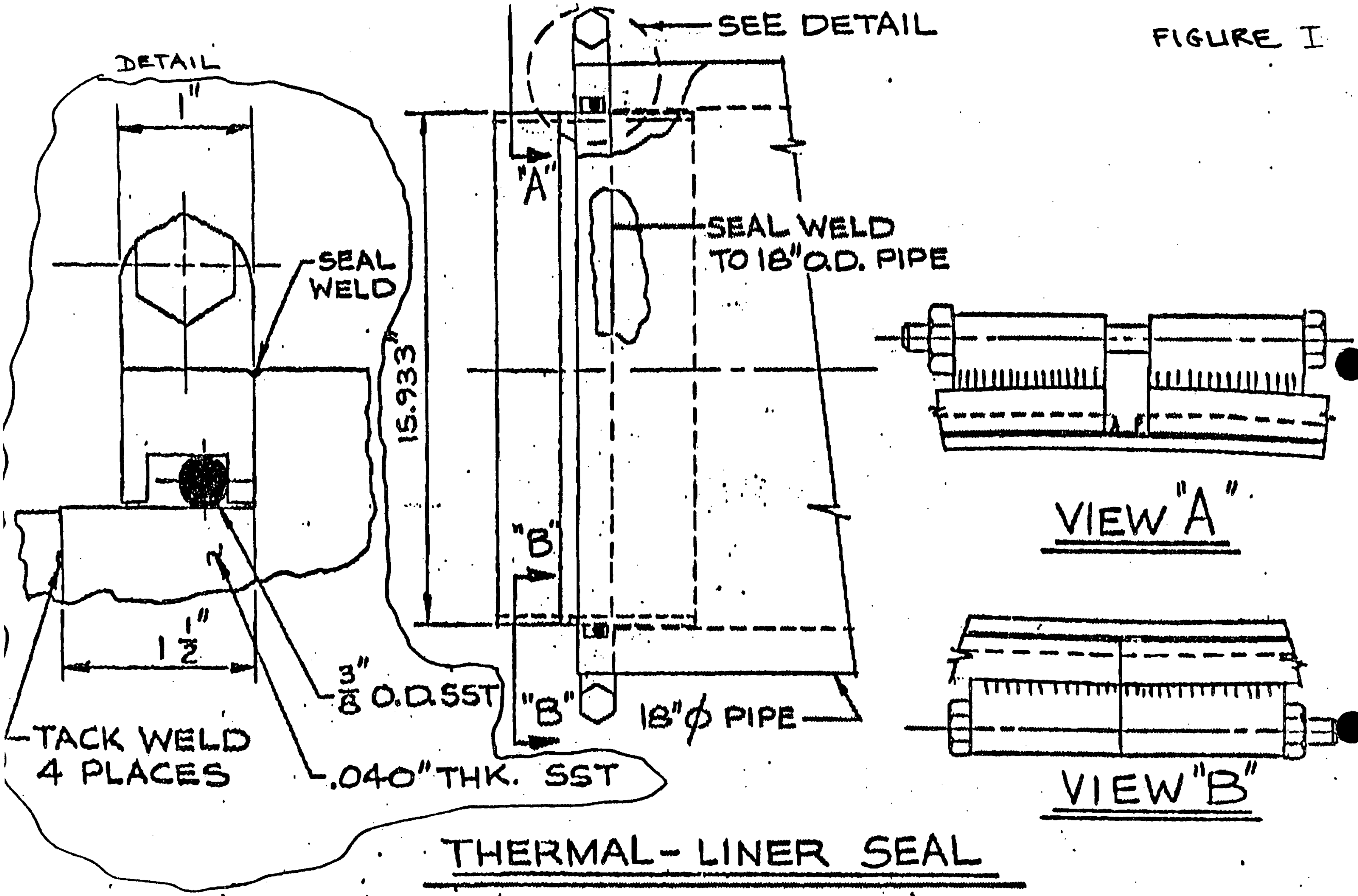
ADD MECHANICAL O-RING SEAL (FIGURE I)

MODIFY FEED WATER DISTRIBUTION BOX (FIGURE II)

- STRONGER SUPPORTS CAPABLE OF WITHSTANDING LARGER COMPRESSIVE LOADS
- ADD 6.6 SQ. INCH VENT

REPLACE FEEDWATER RING WITH SCHEDULE 120 PIPE

FIGURE I



THERMAL - LINER SEAL

DRAFT

FEEDWATER DISTRIBUTION BOX MODIFICATIONS

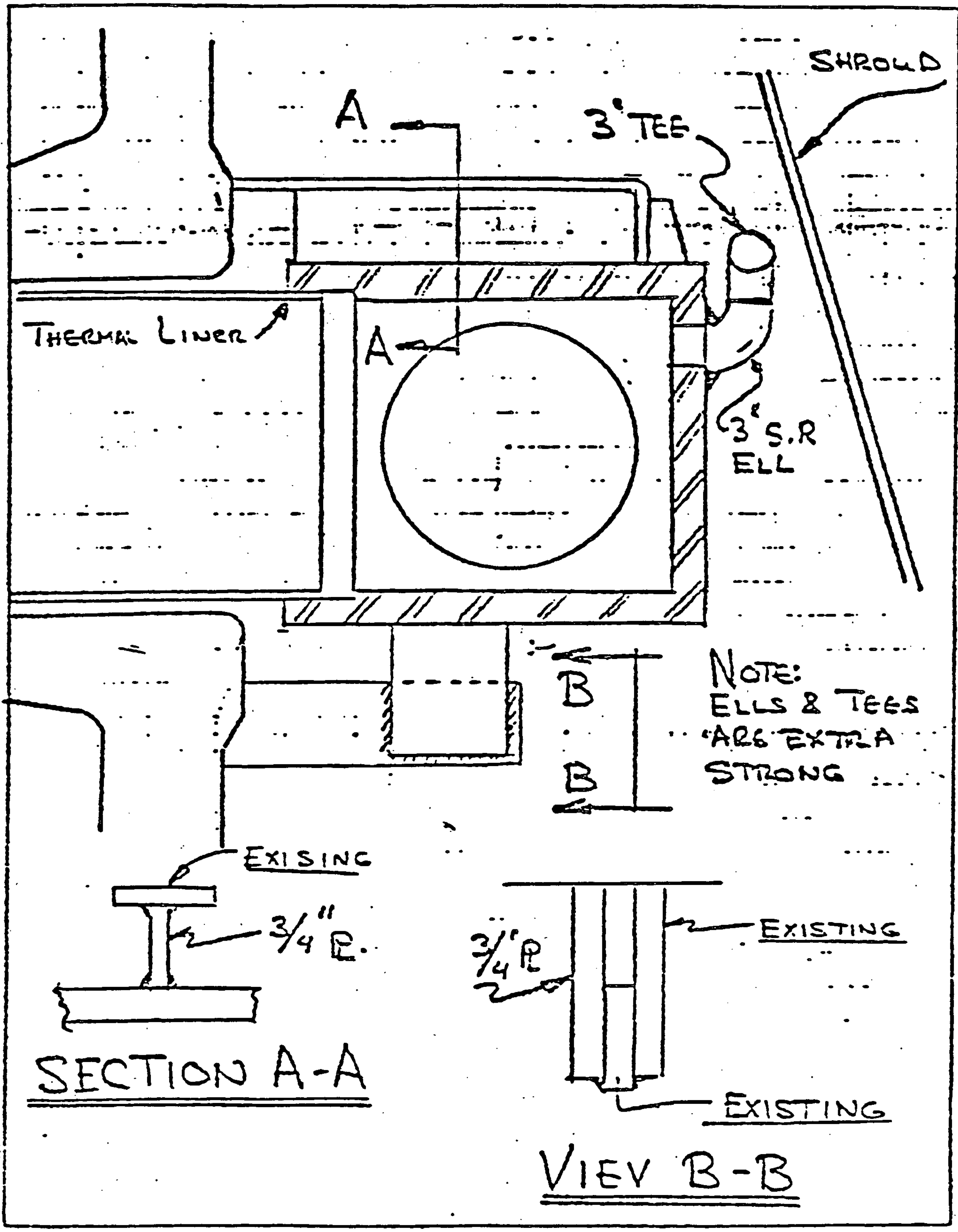


FIGURE II

JUSTIFICATION FOR NOT REPEATING FEEDWATER HAMMER TEST

DAMAGE TO FEEDWATER RING WAS NEVER A SAFETY CONCERN

TEST OF MARCH 1981 SUBJECTED THE FEEDWATER PIPING TO WATERHAMMER CONDITIONS FAR WORSE THAN THOSE EXPECTED DURING THE LIFE OF THE PLANT AND IT ENVELOPED THE POSSIBLE AUXILIARY FEEDWATER OPERATING CONDITIONS THAT HAVE BEEN POSTULATED TO GENERATE WATER HAMMER

TEST OF MARCH 1981 RESULTED IN ACCEPTABLE WATER HAMMER CONSEQUENCES FOR EXTERNAL PIPING

DAMAGE TO FEEDWATER RING WAS NOT DUE TO WATERHAMMER. DAMAGE WAS DUE TO A SUDDEN DIFFERENTIAL PRESSURE

EVEN THOUGH THE FEEDWATER RING WAS DAMAGED, AUXILIARY FEEDWATER FLOW WAS DELIVERED FOR APPROXIMATELY ONE WEEK WITHOUT ANY OBSERVED ANOMALIES (I.E. VIBRATION, NOISE OR FLOW INSTABILITIES)

INSPECTION OF DAMAGED FEEDWATER RING DEMONSTRATED THAT IT WAS CAPABLE OF PROVIDING MAXIMUM AUXILIARY FEEDWATER FLOW

FIGURES III & IV SHOW THAT THE FEED WATER PIPE IMMIDIEATELY ADJACENT TO THE JUNCTION BOX CONTAINING 4 J-TUBES (2 ON EACH SIDE) WAS UNAFFECTED. ONLY THESE 4 J-TUBES ARE NECESSARY TO PROVIDE REQUIRED AUXILIARY FEEDWATER FLOW FOR DECAY HEAT REMOVAL

MODIFICATIONS TO THE FEEDWATER RING THAT HAVE BEEN DESCRIBED ARE BEING MADE TO ENHANCE PLANT AVAILABILITY BY PRECLUDING ANY POSSIBLE FEEDWATER RING DAMAGE/REPAIR

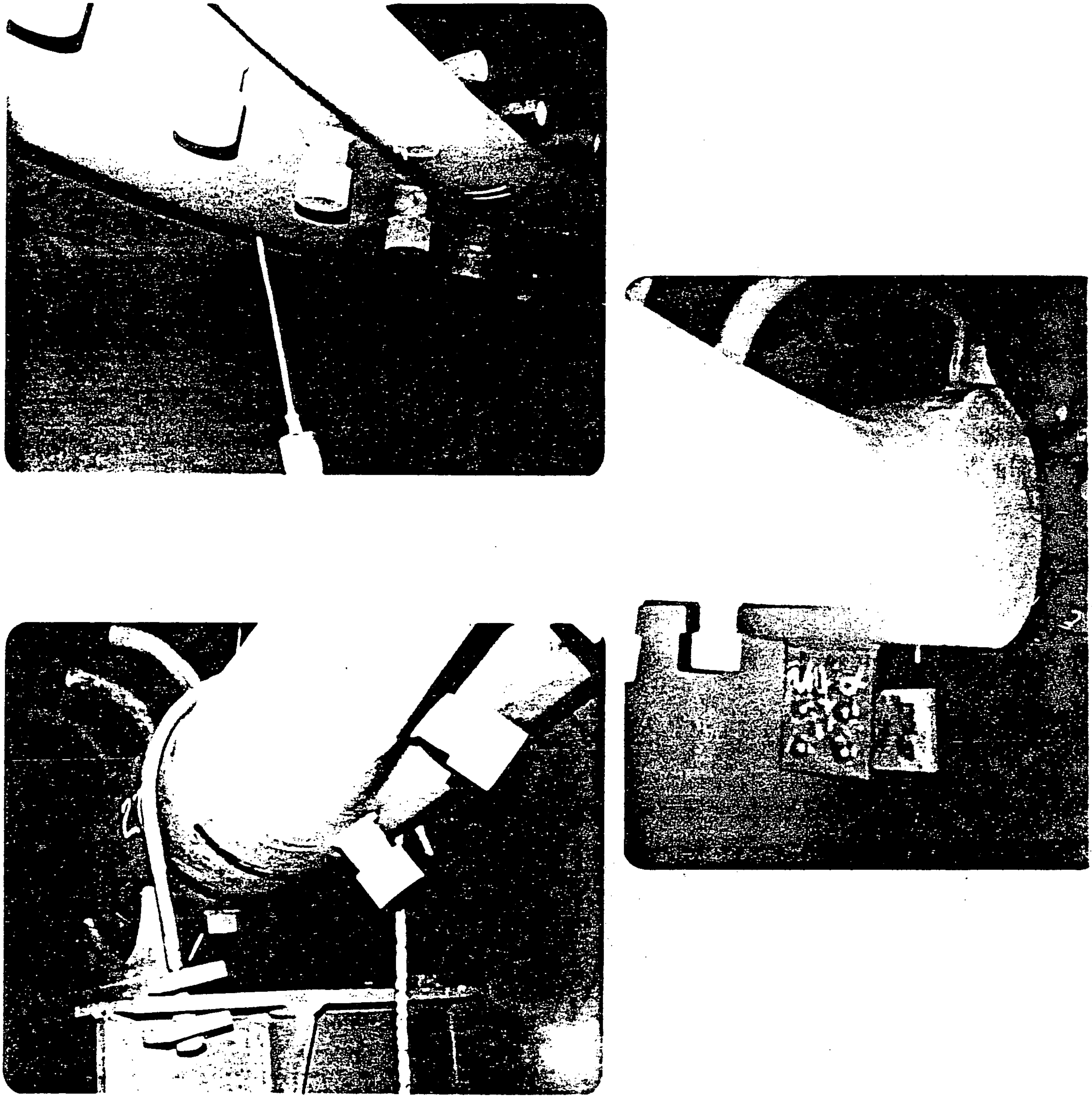


FIGURE III

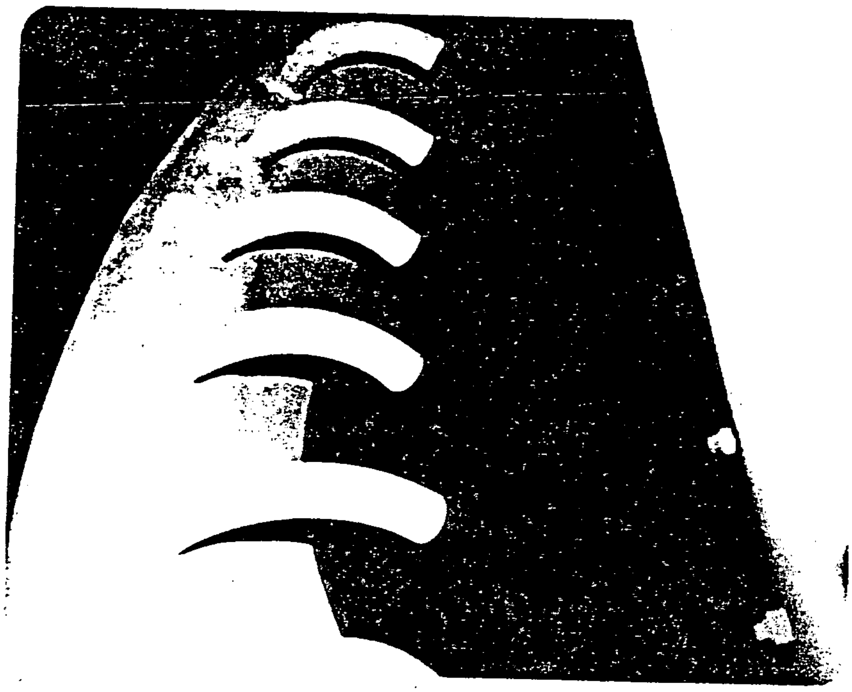


FIGURE IV

SUMMARY

- FEEDWATER RING DAMAGE WAS NOT A SAFETY CONCERN
- ACCEPTABLE FEEDWATER HAMMER CONSEQUENCES WERE ALREADY DEMONSTRATED IN MARCH 1981
- MODIFICATIONS WILL PRECLUDE FUTURE FEEDWATER RING DAMAGE
- THEREFORE A SECOND FEEDWATER HAMMER TEST WILL NOT BE REPEATED

ENCLOSURE II

STEAM GENERATOR FEEDWATER RING/AUXILIARY FEEDWATER PIPING INTEGRITY TEST

OBJECTIVE

To demonstrate the adequacy of the steam generator feedwater ring and auxiliary feedwater piping to withstand the introduction of auxiliary feedwater following exposure to a steam environment.

PREREQUISITES

a) Auxiliary feedwater system is available.

b) Main steam system is available.

c) Appropriate ac and dc power sources are available.

TEST METHOD

a) Lower the steam generator water level to below the feedwater ring without feedwater flow.

b) Initiate or simulate initiation of automatic auxiliary feedwater flow to reflood the steam generator.

ACCEPTANCE CRITERIA

a) No significant noise or vibrations are observed during test.

b) Visual inspection indicates that the integrity of feedwater piping supports and feedwater ring have not been violated.*

* Visual inspection of the feedwater ring, piping and supports will occur at the first convenient time (i.e., first cold shutdown) during the test program.