UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

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April 20, 1982

MEMORANDUM FOR: D. W. Moeller, Chairman
TMI-1 Subcommittee

FROM: for Richard Major, Senior Staff Engineer

SUBJECT: TMI-1 STEAM GENERATOR TUBE PROBLEM AND PROPOSED REPAIRS

Attached to a copy of the April 7, 1982 Daily Staff Notes (enclosed) is a News Release from GPU Nuclear. The news release discusses the suspected cause of the Unit 1 Steam Generator tube degradation problem, which has caused defects in approximately one-third of the tubes in the steam generators. The news release also discusses a proposed plan to repair the tubes. GPU estimates the repairs will take until October of 1982; however, the NRC Staff has not reviewed the proposed fix.

The most likely cause of the tube defects is chemically assisted intergranular attack. The corrosive agent is suspected to be sodium thiosulfate which was used as an additive to the containment spray water to scrub iodine from the containment air in the event of an accident. (This additive is no longer used; its use was determined to be unnecessary.) The sodium thiosulfate entered the primary system through the leakage of two valves down stream of the sodium thiosulfate tank during testing of the containment spray pumps. The sulfate entered the borated water storage tank used as the source of makeup water to the primary system and from there into the primary loop.

So far, most of the corrosion has been detected in the top few inches of the tube sheet region (top two feet) of the steam generator tubes. Water level in the steam generators was allowed to drop to this level and the dissolved sulfur and air atmosphere contributed to cause the corrosion in the top of the tube sheet region of the tubes. Inspection of the reactor internals and fuel is scheduled for the near future. GPU's preferred method of repairing the tubes is to expand and reseal the tube walls at a location within the tube sheet below the area of the defects.

I will keep the Committee informed as additional information becomes available.

Enclosure:
As stated

cc: ACRS Members
ACRS Fellows and Staff
Metal Components Consultants
TMI Consultants

A191

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News Release

ATTACHMENT

GPU Nuclear

Public Information Services

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For Further Information
Contact: Doug Bedell, David Osterhout

For Release: Immediately

Date: April 7, 1982
#45-82

PLANS FOR REPAIRING STEAM GENERATOR TUBES AT TMI UNIT 1

Middletown, PA -- GPU Nuclear Corporation today announced plans for a $25 million program to repair 8,000 to 10,000 steam generator tubes at Three Mile Island Unit 1 that have been damaged by corrosion. The repairs are expected to be completed by late summer or early fall of this year, which would permit the return of Unit 1 to service before the end of the year.

The repairs involve a technique of expanding and resealing the tube walls at points below where corrosion attacked the tubes. The work will be done using remote-controlled equipment that will expand the tube walls either hydraulically or mechanically to create a new seal. Other repair options that were considered, and are under continuing evaluation, are plugging or sleeving the damaged tubes. The tube expansion method appears to be the optimum repair technique in terms of scheduling, cost and plant performance.

The cost of the repairs, including related studies and allowance for contingencies, is estimated at $25 million. The funds have been made available from Unit 1's 1982 funding of $94 million by realigning the work planned for the year.

Officials of GPU Nuclear briefed officials of the Nuclear Regulatory Commission staff on their plans for repairing the TMI-1 steam generators at a meeting today at the NRC's offices in Bethesda, Md.

The tube expansion repair method is feasible because of the specific nature and location of the corrosion in the TMI-1 steam generator tubes. The corrosion is located almost entirely in the upper ends of the tubes of the two

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generators, in the portion of the tubes where the upper one to one-and-a-half inch of the 56-foot long tubes was expanded -- or "rolled" -- to hold them tightly in place within the tube sheets. The tube sheets are two-foot thick blocks of steel containing holes for the 15,500 tubes in each of the steam generators.

In pressurized water reactor systems, the steam generators are where the plant's radioactive "primary system" and its non-radioactive "secondary system" pass each other to exchange heat. Hot radioactive water from the nuclear reactor passes through the steam generator tubes and causes water on the secondary side of the tubes to flash to steam. That steam turns the plant's turbine-generator to generate electricity.

The planned tube repairs at TMI-1 are not expected to require a change in existing technical specifications for Unit 1. Leakage, if any, from the tubes following the repairs is expected to be minor and within prescribed operational limits for Unit 1. Performance of the repaired steam generators is expected to be as reliable as the original design.

Studies that have been made of the steam generators since the discovery of small leaks in Unit 1 tubes last November have developed a probable explanation for how the corrosion occurred.

GPU Nuclear officials are proceeding on the basis of that explanation, which is still being refined and verified by further testing, that a species of sulfur -- most likely sodium thiosulfate -- was the active corrosive agent. The corrosion apparently occurred through a complex interaction of equipment test sequences, materials properties, stresses and chemical conditions that occurred during the latter part of the three-year period in which Unit 1 has not been operating.

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The steam generator corrosion at TMI-1 is different from that typically encountered in other nuclear plants in that the corrosion proceeded from the inside -- or primary side -- of the steam generator tubes and worked outward, indicating that a corrosive agent or agents were in the primary reactor coolant water.

The most likely manner in which small amounts of the prime suspected corrosive agent -- sodium thiosulfate -- entered the primary system water is by leakage through valves downstream of the sodium thiosulfate tank during testing of the Unit 1 containment building spray pumps, and from there into the borated water storage tank at Unit 1. (Sodium thiosulfate was required to be available for injection into Unit 1 spray water to capture iodine from air and water in the containment building in the event of an accident in the containment building.)

Makeup water from the borated water storage tank was injected into the reactor coolant system during September, 1981 when Unit 1 was brought -- using non-nuclear heat -- to operating temperature and pressure during hot functional testing of the plant. It is believed that sulfur in the amount of less than 1 part per million entered the reactor coolant system at that point. At operating temperature, the chemical form of the sulfate compound was changed to one which upon subsequent cooldown would be corrosive in combination with the "right" conditions of stress, metal structure and chemistry of the reactor system water.

No evidence of corrosion was detected during the hot functional testing. However, the type of corrosion that occurred in the TMI-1 steam generators -- which is known as chemically assisted intergranular attack (IGA) -- can proceed quickly if an aggressive contaminant is present and other specific conditions, as noted above, all exist.

Such conditions apparently did exist when the water level in the Unit 1 steam generators was decreased somewhat following cooldown after the hot functional testing was completed. Concentrations of corrosive sulfur developed in the

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"dry-out region" at the top of the generators and likely induced cracks in 8,000 to 10,000 tubes. The affected tubes are located predominately near the outer edge of the tube "bundles". About 140 tubes actually leaked during early low-pressure testing of the generators, and they are being plugged, along with 19 other tubes from which sections were removed for laboratory analysis.

Cracking apparently stopped either because chemistry changes expected to take place at the lower temperature produced a less aggressive form of sulfur or because the environment in the "dry-out region" was improved when the water level was increased in the steam generators.

Two other possibilities for the injection of sulfur into the reactor coolant system were investigated and found to be less likely than the introduction of sodium thiosulfate. They were the accidental injection of 3000 milliliters of sulfuric acid into the reactor makeup system in October, 1979, and the possible contamination of the reactor coolant system by oil in March, 1979. The sulfuric acid is not believed to have reached the reactor coolant itself; if it did, however, the sulfur in sulfuric acid is in the form of sulfate, which is not an aggressive species with the inconel metal of the tubes. If oil was the source, the quantity of sulfur available through that means is felt to be too low to have caused the corrosive attack.

Using the tube expansion repair technique, the affected tubes will be expanded -- or "rolled" again -- below the area of corrosion so that a tight seal will be restored between the tube walls and the holes in the tube sheet. There will, however, be additional plugging of tubes where tests show leakage at higher test pressures or indications of corrosion below the upper tube sheet.

The repair operation will begin after the tube expansion technique is fully tested and qualified for the Unit 1 application.

Because of the fairly unique "primary to secondary" nature of the corrosion, GPU Nuclear officials also plan to lift the head from the Unit 1 reactor to inspect internal components of the reactor itself for any evidence of corrosion. The inspection program will involve removal of at least two of the 177 fuel assemblies in the reactor. That operation will begin shortly.

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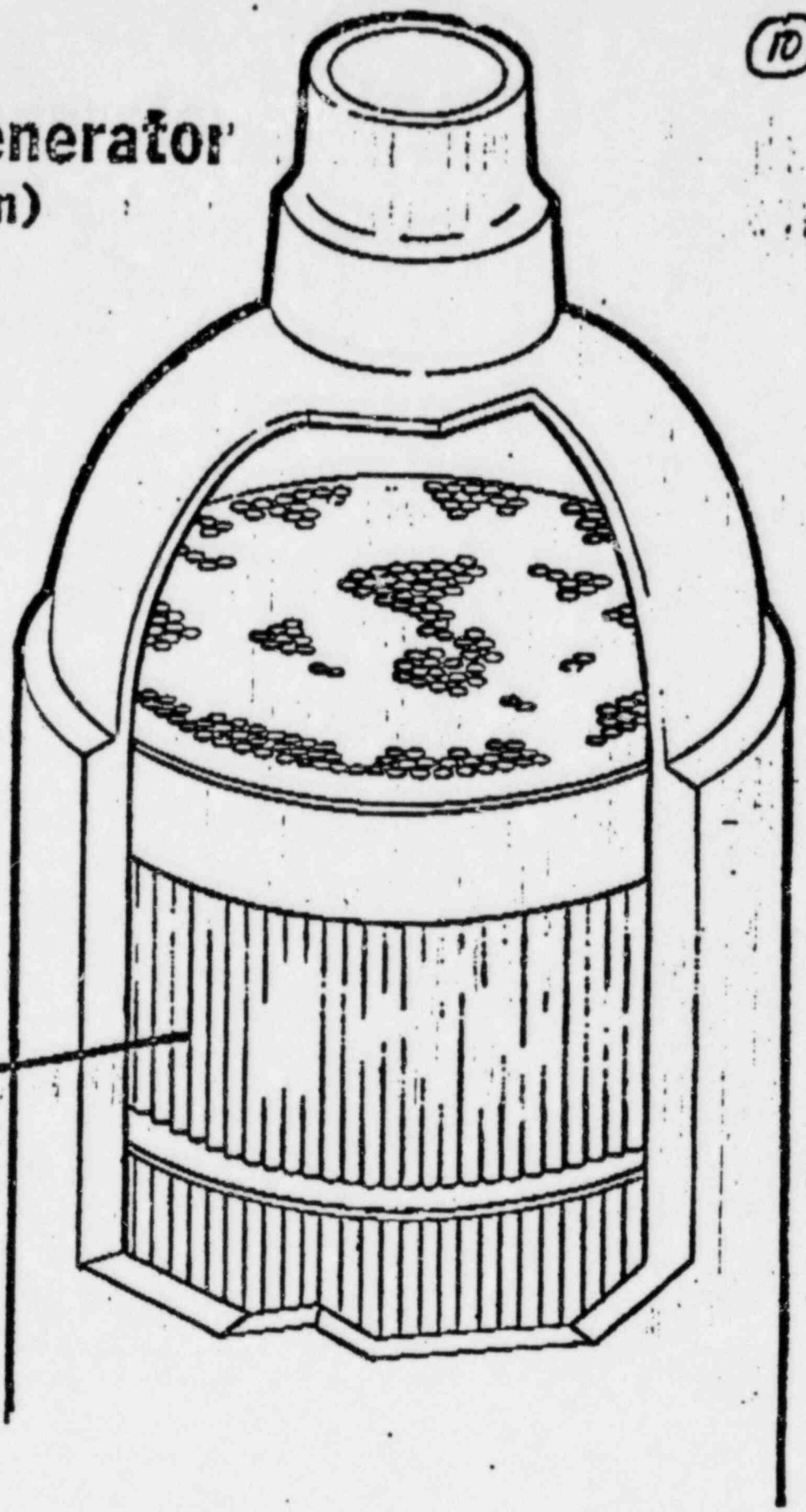
Steam Generator
(Top Section)



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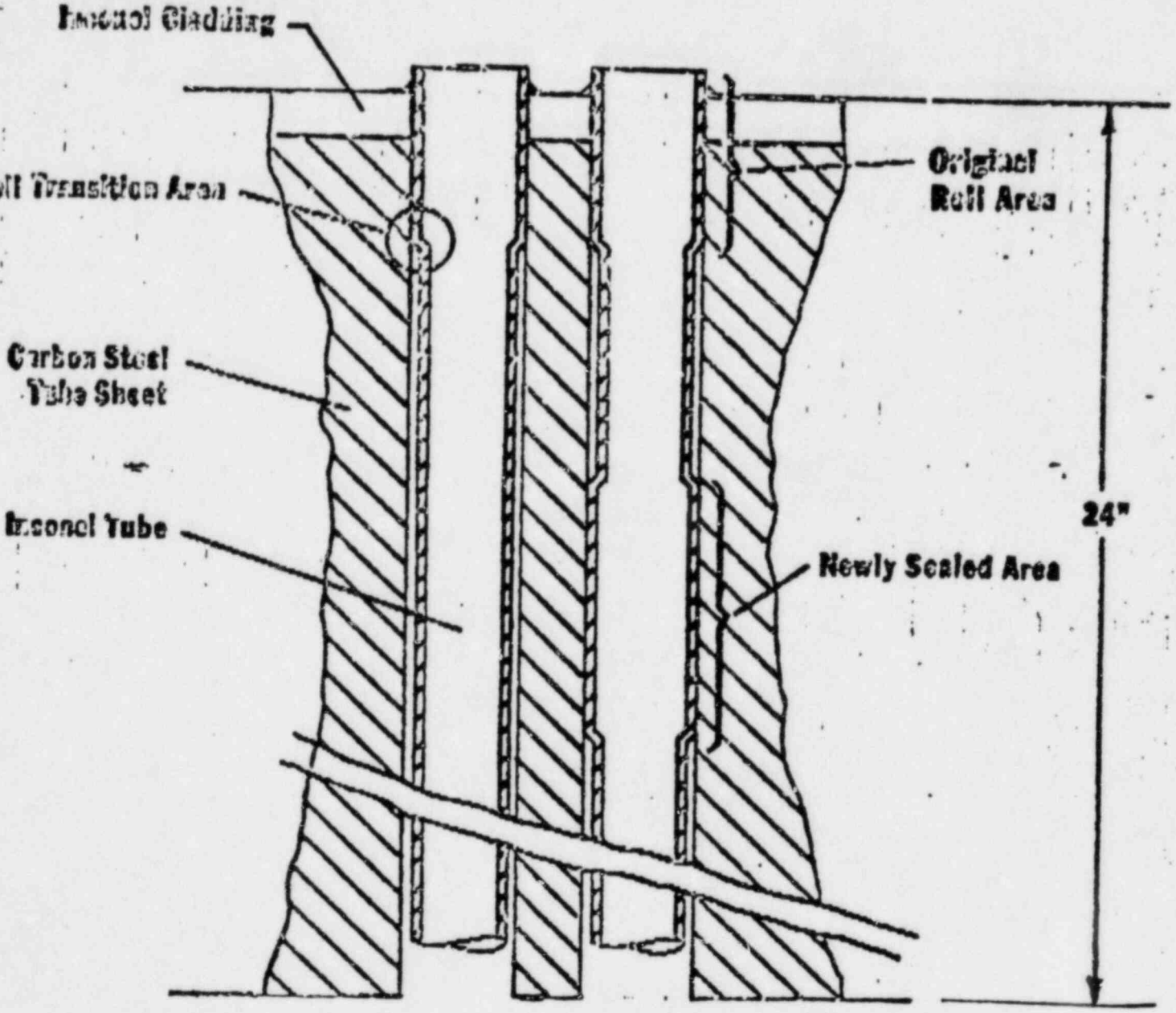
UNIT 1 STEAM GENERATOR TUBE SHEET AREA



STEAM GENERATOR TUBE as Fabricated

STEAM GENERATOR TUBE Showing Repair (Newly Sealed Area)

(NOT TO SCALE)