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THERMAL SHIELD COOLING TUBE SURVEILLANCE B, C, D, AND K REACTORS

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AUTHOR

C. E. Bonham
Reactor Design
Design Engineering
Facilities Engineering

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R. S. Peterson
R. S. Peterson

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THERMAL SHIELD COOLING TUBE SURVEILLANCE
B, C, D, AND K REACTORS

November 19, 1964

Prepared by
C. E. Bonham
Reactor Design Operation
Design Engineering Sub-Section
Facilities Engineering Section

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Verified By D. Hanson, 4-21-94

Approved by

R. S. Peterson
R. S. Peterson, Supervisor
Reactor Design Operation

Approved by

H. W. Heacock
H. W. Heacock, Manager
Design Engineering Sub-Section

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THERMAL SHIELD COOLING TUBE SURVEILLANCE
B, C, D, AND K REACTORS

INTRODUCTION

The top thermal shields of the Hanford reactors were formed by placing single layers of large cast iron blocks on the top of the graphite stacks. Accumulative distortion of the graphite stack is causing several inches of variation in the elevation of the originally level top thermal shields. The integrity of the top thermal shield cooling tubes is of concern because of the high axial and bending stresses they are subjected to from the shield variations in addition to the normal service conditions common also to the side and bottom thermal shields. Concern for possible deteriorating condition of the top cooling tubes has increased with the discovery of a leaking cooling tube at the C Reactor.

SUMMARY

The cooling tubes of the top thermal shields are subjected to increasing severity of service caused by conformance of the top thermal shields to the increasing distortion of the graphite. Information of the present condition of the cooling tubes and continued surveillance of their condition is required for evaluation of their continued serviceability. In accordance with the priorities and steps outlined in the program memorandum for graphite oriented problems(1), the following is submitted to the Manufacturing Section.

It is proposed that the Manufacturing Section incorporate surveillance programs in their Equipment Maintenance Standards for B, C, D, KE and KW Reactors to monitor the condition of the top thermal shield cooling tubes. The surveillance should consist of current inspection of representative cooling tubes in each reactor and re-inspection of the same cooling tubes on a periodic basis as discussed below.

Improved eddy current techniques(2,3) of field testing small tubes are considered to be adaptable to the copper tubes in C Reactor and the stainless steel tubes in the other reactors. The proposed test method results in permanent chart records of the probed tubes that can be analyzed for varying wall thickness, intergranular corrosion, bends, cracks or other defects. The test method proved very successful on heat exchangers at N Reactor.

- (1) HW-82887, Program Memorandum -- Rod Serviceability Program, R. F. Corlett, June 18, 1964.
- (2) HW-SA-3245, Nondestructive Testing of Nuclear Steam Generators After Installation, L. J. Chockie, October 21, 1963.
- (3) HW-81780, An Improved Eddy Current Tubing Test, H. L. Libby, May 7, 1964.

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The testing and analysis of data can be accomplished by qualified personnel from Physical Testing, Hanford Laboratories, on a work order basis.

Facilities Engineering Section will if requested prepare the required design changes for full tube entry and will direct Physical Testing in adaptation of present equipment for the stainless steel tubes and development of new equipment for the copper tubes.

Information from the surveillance program will be used by Facilities Engineering Section and the Research and Engineering Section for continuing evaluation of the serviceability of the thermal shield cooling tubes and determining rate of deterioration for effective planning of modifications or changes in the mode of operation.

DISCUSSION

The top thermal shields are single layers of cast iron blocks eight or ten inches thick placed directly over the graphite. Cooling is provided by tubes embedded in slots with lead caulking. The cooling tubes enter the reactor through penetrations of the front biological shield, extend along the slots of the thermal shield and leave the reactor by penetrations of the rear biological shield. Graphite distortion in the form of expansion and contraction in the vertical orientation results in an accumulative effect on the top of the stack. The thermal shield resting on the graphite reflects the full amount of vertical stack distortion and the cooling tubes are subjected to flexures and loads from articulation of the thermal shield at the joints between the blocks as shown on Figure 1.

The cooling tubes are of materials that would be expected to give more than adequate service life under the rather mild corrosion conditions of the coolant at the normal shield temperatures. However, the stress conditions that are more prevalent for the top thermal shield cooling tubes and of higher intensities because of graphite distortion can result in tube failures from stress corrosion cracking or simple rupture. Loss of cooling effectiveness is also possible as a result of stress conditions that reduce the tube surface contact with the lead caulking and consequently reduce heat transfer from the cast iron. Knowledge of the present condition of the cooling tubes and continued assessment of their potential failure by leakage or reduction in heat transfer is required for effective planning of corrective adjustments or modifications such as fringe poisoning.

The top and bottom thermal shield cooling tubes for C Reactor are of 3/4 inch copper tubing with a 0.090 inch wall thickness giving an inside diameter of about 0.57 inch. There are two tubes in each slot of the top and bottom thermal shield, one over the other as shown on Figure 1. The fittings on the ends of the top thermal shield cooling tubes permit full access to the tube inside diameter after removal of the header connectors. One top thermal

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FIGURE 1
TOP THERMAL SHIELD CROSS-SECTIONS

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shield cooling tube at C Reactor has developed a leak. Although the point of failure would be expected to be either at the start of the lead caulking or at a joint between two blocks, the leak was determined by use of a sonic leak detector to be several inches away from such a point. Cause of failure has not been determined.

The side thermal shield cooling tubes for C Reactor are of stainless steel tubing of 1.05 inch outside diameter and 0.120 inch wall giving an inside diameter of about 0.81 inch. End fittings for header connectors are butt welded on the cooling tubes and have reduced inside diameter of about 0.48 inches.

All of the thermal shield cooling tubes for the K Reactors are of 3/4 inch stainless steel pipe, Schedule 40, giving an inside diameter of about 0.82 inches. The required tube length was obtained by butt welding two lengths of pipe together with full penetration welds and some weld protrusion can be expected on the inside diameter. Tube fittings were also butt welded to the pipe ends to provide means of attaching header connectors. The end fittings have reduced inside diameters of 0.48 inches that restrict entry to the cooling tubes.

The thermal shield cooling tubes for B and D Reactors are also of 3/4 inch stainless steel pipe, Schedule 40, giving an inside diameter of about 0.82 inches. The end fittings are attached by pipe threads that would permit full entry to the cooling tube. Auger inserts were originally installed in the tube bores at each end. The augers were later considered unnecessary and many were removed. However, a large number were stuck and left in place rather than possibly damaging the cooling tube during auger removal.

COOLING TUBE SURVEILLANCE

The top thermal shield cooling tubes are of primary concern and as a minimum, the following tubes should be selected for initial determination of condition by eddy current test and re-inspected on a yearly basis or greater frequency as determined from the findings.

B, D Reactors -- 55, 61, 67, 73

C Reactor -- 55, 61, 67, 73, 79, 85, 91 Upper and Lower

K Reactors -- 45, 51, 57, 63, 69, 70, 76, 82, 88, 94

The numbers refer to process channel columns in vertical line with the selected cooling tubes. The tubes were selected adjacent to vertical channel positions because of possible damage during channel enlargement or maintenance and because of the increased information that may be gained from observations of the leaded slots. The initial quantity was based on obtaining adequate tube condition information for determining continued surveillance requirements.

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In addition, at the time of access to the vertical rod channels, observations should be made of the visible leaded surface of cooling tube positions on each side of the channel for sign of lead protrusion above the cast iron surface or other sign of shift in tube position in the slots.

SURVEILLANCE METHODS

Removal of samples from the cooling tubes or sample tubes to enable laboratory inspection and determination of tube conditions is not practical because tube replacement methods have not been developed for the original permanent embedded type of installation. The cooling tubes are accessible only at their ends and inspections must be accomplished on the long tubes by methods that are applicable to the small inside diameter (see Figure 2).

A non-destructive eddy current method of inspecting small stainless steel tubes from their inside proved very effective for assessing the condition of thousands of heat exchanger tubes at N Reactor (see Figure 3). The test method and test equipment were developed by the Hanford Laboratories to inspect the tubes under field conditions after the discovery of leaking tubes made assessment of the installed tube condition necessary. A probe assembly was blown into each tube with a few pounds of air pressure and then withdrawn at a uniform rate by cable. The test signals were recorded and analyzed by new techniques that enabled distinguishing and isolating harmful defects from normal background or non-harmful tube variations.

Monitoring of the thermal shield cooling tubes could be accomplished in a similar manner. Special probes for the specific size tube involved would be blown down the inside of the selected surveillance tubes. The probe would then be withdrawn at a uniform rate and the test signals fed to equipment that electrically splits the signal into quadrature components. The two voltage vectors are then recorded on a two channel strip chart recorder such that the signal from any point in the tube can be determined in both amplitude and phase at any future time for interpreting the test results and later comparing with subsequent re-inspections. An oscilloscope is also used for direct operator observation of the test signals enabling ready differentiation of major defects from non-harmful tube conditions. Closer analysis of the recorded test data will enable distinguishing corroded areas of varying depth from the outside or inside surface as well as cracks, holes, kinks, and possibly poor contact areas in the lead.

Degree of accuracy of the eddy current test has some dependence on the ability of sizing the probe for close fit in the tube with minimum wobble. Some end fitting adaptation will be required on the cooling tubes with restrictive entries that are selected as surveillance tubes (see Figure 4). Sludge in the tubes is also detrimental to probe effectiveness and the test tubes will require some cleaning. Any butt weld protrusion at the midpoint of the K tubes will require broaching or the test scan will have to be made from both ends.

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Physical Testing, HL, has eddy current test equipment that is suitable for inspecting the stainless steel cooling tubes upon fabrication of specifically sized probes. Eddy current testing of copper material requires a different test frequency and suitable equipment would have to be built with three to four month fabrication time probable at a cost of approximately \$4,000.

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FIGURE 2
THERMAL SHIELD COOLING TUBE ENTRIES

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FIGURE 3
EDDY CURRENT TESTER ARRANGEMENT

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PRESENT END FITTING

NEW END FITTING AND ADAPTER

FIGURE 4
TYPICAL COOLING TUBE MODIFICATION FOR
SURVEILLANCE TUBES WITH RESTRICTIVE ENTRIES

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