Central File

INDIANA & MICHIGAN POWER COMPANY

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September 5, 1979
AEP:NRC:00221B

Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74

Mr. J. G. Keppler, Regional Director
Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
Region III
799 Roosevelt Avenue
Glen Ellyn, Illinois 60137

Dear Mr. Keppler:

The attachment to this letter contains the second progress report on the feedwater line data collection program in Unit No. 2 of the Donald C. Cook Nuclear Power Plant. The data collection program was described in our AEP:NRC:00221 submittal dated June 15, 1979. This progress report is submitted in accordance with the commitment made in our AEP:NRC:00216 submittal dated June 15, 1979. Our first progress report was transmitted to you on August 3, 1979 via our AEP:NRC:00221A submittal.

The AEPSC interprets 10 CFR 170.22 as requiring that no fee accompany this submittal.

Very truly yours,

John E. Dolan

John E. Dolan
Vice President

JED/emc
Attachment

cc: R. C. Callen
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SEP 10 1979

Progress Report - II

Feedwater Line Data Collection Program

Introduction

The following is the second progress report on the investigation of the feedwater pipe cracking problem at Donald C. Cook Nuclear Plant, Units 1 and 2. The American Electric Power Company has joined the Feedwater Cracking Owners' Group which to date represents six utilities with a similar problem. Westinghouse has agreed to render technical assistance to determine the cause of the cracking problem on a generic basis. The generic program includes system vibration, water hammer loadings, thermal hydraulic modeling, operating transients, chemistry and design modifications. The organization and plans of the Owners Group were discussed with the staff in a meeting August 8, 1979. In addition to the Westinghouse work, the American Electric Power Service Corporation is doing confirmatory work in the analysis of the Cook Plant data. We are also investigating possible modifications to the feedwater system.

Herein, we will discuss the status of the work being done by ourselves and Westinghouse.

System Evaluation

System Vibration

Operating experience indicates that during normal operation a steam generator might have vibration with a ten mil amplitude with frequencies in the two to ten Hertz range. These frequencies are in the same range as "typical" feedwater lines. To determine if feedwater lines were being excited to the point of causing damage, an analytical investigation was undertaken by Westinghouse.

AEP Unit 2 feedwater line 1 model was chosen as typical, and an analysis was run with sinusoidal input motion at the SG Nozzle of ± 10 mils along the axis of the inlet leg of the feedwater line. Input frequencies in the range of 2 to 10 Hz were used and system nonlinearities were included.

Maximum stress results from the analysis were 200 psi. This is caused by system response to the input motion which shows some small amplification. The conclusion to be drawn is that steam generator vibrations are not the cause of the cracking.

Plant Operation

Feedpipe cracking is related to the thermal transients and stratified feedwater conditions in the nozzle feedpipe weld region during zero and low power operation.

Waterhammer Loads

Westinghouse is developing a preliminary set of forcing functions in their waterhammer program for the following four categories of interest:

(1) Acoustic (classical), pipe break
(2) Acoustic (classical), valve operation
(3) Bubble collapse, slugging
(4) Bubble collapse, snapping

Although initial operation of Cook - 1 was without "J" tubes, Unit 2 has always had "J" tubes. Therefore, we believe that waterhammer is not the cause of the cracking problem.

Thermal Hydraulic Test

Westinghouse has completed the design for a full scale model test to meet the following objectives:

1) To determine if any leakage occurs at the slip fit interface between the feedwater nozzle and the thermal sleeve.

2) To determine the temperature profile of the feedwater inlet pipe, feedwater nozzle, and thermal sleeve due to the interaction of hot and cold water.

3) To determine if flow reversal occurs from the feedring back to the feedwater nozzle.

4) To investigate thermal stratification in the feedwater line and feedwater nozzle.

A preliminary test specification providing objectives, equipment, functional requirements and test procedure has been completed and all long lead time items have been ordered. Assembly of the test components with delivery of long lead time items was scheduled for 9/26/79. The assembly and preliminary testing of the model is expected to be completed 10/1/79. This testing delay of approximately one month is primarily due to the necessity of going to a full scale model.

A meeting has been scheduled with EPRI and GE to discuss GE's experience with pipe cracking. To be discussed are the testing and results found to date by GE, and Westinghouse's observations from on-site testing.

Analysis of Feedwater Nozzle/Pipe Junction

Westinghouse has completed their three-dimensional finite element models for the nozzle followed by an elbow and a straight pipe. The first configuration is similar to the D.C. Cook nozzle/elbow connection. General verification runs are in progress to determine the accuracy of the model.

A number of theoretical steady-state runs have been made assuming sharp stratification of the flow in the nozzle ie. the transition between the hot and cold temperatures occur at a point. Runs were made for the following stratification of flow in the nozzle:

1. Hot/cold junction 90^{o} from the top of the pipe
2. Hot/cold junction 45^{o} from the top of the pipe
3. Hot/cold junction 15^{o} from the top of the pipe

A hot temperature of $547^{o}F$ and a cold temperature of $70^{o}F$ was considered. Even though these runs are steady state, the change in stress distribution between one stratification level and another causes significant local stress variations. Preliminary unchecked results of the above variation shows that the maximum stress ranged from 70 ksi for case 1 to 150 ksi for case 3. Although these test runs are academic, since the actual circumferential temperature variation is in reality more gradual and therefore stresses are much lower, they do point out that the stress level is more dependent on how the circumferential temperature gradient is manifested rather than just the top to bottom temperature difference. Our experimental data generally exhibit the same trend. Sharp circumferential

temperature gradients in the upper portion of the elbow yielded higher stresses than equivalent or even sharper gradients in the lower portion of the elbow.

Westinghouse has begun examining test data from D.C. Cook and H.B. Robinson in order to define a transient case to be run.

A temperature striping evaluation of the feedwater piping has been completed. Striping refers to the application of a cyclically varying fluid temperature on the inside surface of the pipe wall. The output of the analysis consists of temperature distributions through the wall as a function of the following variables:

film coefficient

cycle period of water temperature fluctuations

wall thickness of pipe

material properties of carbon steel and Inconel

From this, data plots of allowable number of cycles for crack initiation versus the above properties are produced. This will serve as a guide as to what frequency and magnitude of temperature variation to look for in the site and model test data.

Chemistry

Dissolved oxygen concentrations in the condensate storage tank and feedwater have been significantly reduced as a result of locating and eliminating oxygen in-leakage to the secondary system. The dissolved oxygen concentrations have been kept within the Westinghouse specifications of $<$5PPB and $<$100PPB for the feedwater and condensate storage tank respectively.

DESIGN MODIFICATION

The design modifications being considered by Westinghouse fall into two categories: Operation/System and Mechanical. The following system modifications have been evaluated to determine their adequacy. The application of any method must await resolution of the cause of observed cracking.

Modification 1: Main feedwater heated, auxiliary feedwater introduced into steam generator through separate auxiliary feedwater nozzle.

The main feedwater is heated to the desired temperature by one or two stages of feedwater heating with steam extracted from the main steam header. Cold auxiliary feedwater, introduced through a separate nozzle, serves as a backup feedwater system and functions as an Engineered Safeguards System.

Modification 2: Main feedwater heated, auxiliary feedwater system used only for Engineered Safeguards System function.

In this arrangement, the auxiliary feedwater system is used, for example, to maintain steam generator level following a reactor trip, but not during long term hot shutdown operation. The number of temperature cycles due to introduction of cold auxiliary feedwater is greatly reduced, although not completely eliminated.

Modification 3: Main and auxiliary feedwater heated

Main and auxiliary feedwater are both heated prior to introduction into the steam generator through the main steam generator nozzle. Adequate steam should be available from reactor coolant pump heat and core decay heat.'

In addition to the above, increasing the aux. feed flow has been considered to eliminate the observed stratification. However, leakage of flow past the feedwater valves must be eliminated before the effects of higher flow can be evaluated. Analysis of our experimental data shows that for the D.C. Cook feedwater line stratification is not totally eliminated until flows in excess of 250,000 lb/hr are reached.

We have embarked on a detailed design program to implement modification 2. Subject to the final determination of the cause of the feedwater line crack, we plan on implementing modification 2. Experimental measurements taken when the difference between RCS and auxiliary feedwater temperatures was 200°F less than at full RCS temperature showed a significant decrease in stress. Thus heating the feedwater is expected to reduce resulting stresses.

Various mechanical design changes have also been considered and preliminary evaluation completed. These include:

1. Designs to provide thermal sleeve protection and minimize bypass leakage.
2. Separate auxiliary feedwater nozzle on the steam generator (used in conjunction with the system modifications described above).
3. Flow splitter/swirl vane designs (these have been evaluated as to their effect on the flow model test).
4. Use of alternate materials or cladding of the feedwater piping near the steam generator.

We are presently investigating the possible design of a thermal sleeve. Discussions on its design are being held with Westinghouse.

Test Data Reduction

Westinghouse has played back all the FM tapes of the D.C. Cook feedwater test onto strip charts. Selected data sets have been examined to identify stratified temperature conditions along the pipes. A plot of temperature vs. time for each thermocouple during the entire test period has been made. These plots indicate the degree of stratification and the number of stratification cycles the pipes undergo during a normal startup. Though the frequency and amplitude of the stratification cycles during hot-standby is dependent on the operator and how often he injects auxiliary feedwater, our analysis of the experimental data reveals that approximately 3 - 4 temperature cycles will occur each hour following criticallity and continuing until the steam generator is on main feedwater.

Westinghouse has also completed FM tape playbacks for the test at the Robinson and Ginna plants. Westinghouse has reported similarities beyween the temperature stratification trends at all these plants.