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SUBJECT: Responds to NRC 800513 request for info concerning problem of low pressure turbine disc cracking.Forwards detailed responses to site specific questions.

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DUKE POWER COMPANY
POWER BUILDING
422 SOUTH CHURCH STREET, CHARLOTTE, N. C. 28242

June 16, 1980

WILLIAM O. PARKER, JR.
VICE PRESIDENT
STEAM PRODUCTION

TELEPHONE: AREA 704
373-4083

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. R. W. Reid, Chief
Operating Reactors Branch No. 4

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287

Dear Sir:

Your letter dated May 13, 1980, requested information from Duke Power Company concerning the problem of low pressure turbine disc cracking. The attached information is provided in response to those questions.

Very truly yours,

William O. Parker, Jr.

William O. Parker, Jr. By

FTP:scs

Attachment

A001
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1/1
ADD: Ltr Enc
W. Ross 1 1
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8006240465

DUKE POWER COMPANY
OCONEE NUCLEAR STATION
DOCKET NOS. 50-269, -270, -287

Response to Questions on Low Pressure Turbine Disc Cracking

Site Specific Questions

Question I:

Provide the following information for each LP turbine:

A. Turbine type
B. Number of hours of operation for each LP turbine at time of last turbine inspection or if not inspected, postulated to turbine inspection.
C. Number of turbine trips and overspeeds
D. For each disc:
    1. type of material including material specifications
    2. tensile properties data
    3. toughness properties data including Fracture Appearance Transition Temperature and Charpy upper steel energy and temperature
    4. keyway temperatures
    5. critical crack size and basis for the calculation
    6. calculated bore and keyway stress at operating design overspeed
    7. calculated K_{1c} data
    8. minimum yield strength specified for each disc

Response:

A. General Electric Type N2, 6 flow, Tandem compound, 38 "Last stage bucket length, 890 MW, double reheat MSR steam turbine.

B. The number of inservice hours on each turbine as of the last LP turbine inspection*:

Unit 1	Unit 2	Unit 3
2232.71 hours	4483.56 hours	3778.30 hours

Last inspection dates of each unit:

Between

11/21/79	11/04/78	04/28/79
02/27/80	12/29/78	10/30/79

C. The number of turbine trips and number of turbine overspeeds (test & actual) as of last LP turbine inspection and presently:

	Unit 1	Unit 2	Unit 3
No. of Trips	0	3	3
Overspeeds	0	1	0

*Inservice hours are to midnight 05/29/80.

D. General Electric Company has informed Duke Power Company that the answers to these questions involve data which is proprietary. Information was provided directly to the NRC during a meeting between General Electric and NRC representatives on April 21, 1980. According to General Electric, the NRC has indicated that this information is an acceptable reply to this question.

Question II:

Provide details of the results of any completed inservice inspection of LP turbine rotors, including areas examined, since issuance of an operating license. For each indication detected, provide details of the location of the indication, its orientation, size, and postulated cause.

Response:

An ultrasonic inspection was performed during the most recent refueling outage on all the shrunk-on wheels assembled on the LP-A and LP-B shafts of the Oconee Unit 2 turbine. The wheel bore region was inspected using the special ultrasonic test procedures developed by General Electric for inspecting assembled wheels. This test searches for radial-axial cracks in the vicinity of the wheel bore and keyway surfaces. The wheel bore ultrasonic inspection revealed no crack-like indications. In addition, a magnetic particle inspection was performed on the exposed surfaces of each wheel and no indications were found.

To date, wheels on the Oconee Units 1 and 3 turbines have not received an in-service ultrasonic inspection.

Question III:

Provide the nominal water chemistry conditions for each LP turbine and describe any condenser in leakages or other significant changes in water chemistry to this point in its operating life.

Response:

Steam samples are typically not regarded as being accurate or reliable. Low pressure steam at Oconee Nuclear Station is neither sampled nor analyzed. Oconee Nuclear Station's Once Through Steam Generators (OTSGs) are designed to convert the feedwater to steam without partitioning the chemical constituents between the fluid phases. Main (HP) steam chemistry conditions are identical to feedwater chemistry conditions.

Oconee Nuclear Station's Moisture Separator-Reheaters (MSRs) are designed to remove greater than 85% of the moisture from the saturated steam exhausting from the HP turbine. Partitioning of chemical constituents in the MSRs between the extracted moisture and the LP steam results in greater than 50-80% (chemical species dependent) of the dissolved solids remaining in the liquid fraction. Therefore, the concentration of chemical constituents in the LP steam is less than 20-50% of their respective concentration in feedwater. The nominal chemistry conditions of the feedwater are maintained less than the maximum permissible concentrations listed in the Feedwater Chemistry Specifications.

A. Feedwater Chemistry Specifications (Normal Power Operation)

Total Solids	10 ppb (max)
Cation Conductivity	0.5 μmho/cm (max)
Dissolved Oxygen as O_2	7 ppb (max)
Hydrazine as N_2H_4	1-25 ppb
Silica as SiO_2	20 ppb (max)
Total Iron as Fe	10 ppb (max)
Total Copper as Cu	2 ppb (max)
pH @ 77°F	9.3-9.6
Lead as Pb	1 ppb (max)

B. Condenser Inleakage Information

Condenser Cooling Water is obtained from Lake Keowee. There are no demineralizers or cooling towers installed. The following is a table of representative chemistry values:

Calcium	2.2 ppm
Magnesium	0.7 ppm
Sodium	1.7 ppm
Potassium	0.9 ppm
Bicarbonate Alkalinity	13.6 ppm
Sulfates	1.1 ppm
Chlorides	0.6 ppm
Phosphates	< 0.2 ppm
Nitrates	0.1 ppm
Free Carbon Dioxide	11.0 ppm
Silica	6.1 ppm
Total Iron	0.05 ppm
Manganese	0.12 ppm
pH	6.5-7.0

Condenser tubes are made of 304 stainless steel. During operation, tube leakage is detected by secondary chemical analyses for silica and cation conductivity; a maximum of 20 ppb and 0.5 µmho/cm respectively are allowed. A search for a tube leak occurs whenever either of these parameters begins to increase in the secondary system.

Condenser tubes were found to be failing from fatigue due to excessive amplitude of vibration. The condensers were modified in 1979, with intra-tube supports to reduce the vibrational effects.

Condenser Tube Leakage:

	Date	Remarks
Unit #1	November, 1974	2 tubes plugged
Unit #2	January, 1975	2 tubes plugged
	February, 1978	1 tube plugged
	April, 1979	124 tubes plugged (8 tubes leaking; 116 tubes plugged as a precaution)
	June, 1979	43 tubes plugged (5 tubes leaking; 38 tubes plugged as a precaution)
	July, 1979	60 tubes plugged (5 tubes leaking; 55 tubes plugged as a precaution)
	June, 1980	Eddy Current testing of condenser; some plugs removed, other tubes plugged due to EC indication. Total unit 2 tubes plugged as of June 1980-253
Unit #3	August, 1976	2 tubes plugged
	October, 1976	Identified cause of previous leakage as a broken bypass line support member causing steam to impinge directly on condenser tubes. Plugged approximately 150 tubes that were bent. (126 tubes leaking)
	February, 1977	1 tube plugged
	April, 1977	1 tube plugged
	May, 1977	3 tubes plugged
	December, 1977	1 tube plugged
	March, 1978	2 tubes plugged
	October, 1979	2 tubes plugged
	November, 1979	3 tubes plugged

C. Moisture Separator Drains

As stated earlier, the moisture separators at Oconee Nuclear Station extract 50-80% of the dissolved solids in the main steam from the LP steam with the liquid drains, representing 38-60% of the total dissolved solids in the feedwater (26.6% of the main steam is utilized for feedwater heater and reheater extractions prior to the MSRs). Oconee Nuclear Station has two moisture separators per unit designed to pump the drains forward with the feedwater. In 1979, the station began routinely routing one moisture separator drain (occasionally both) to the hotwell to reduce the final feedwater dissolved solids through condensate polishing.

Question IV:

If your plant has not been inspected, describe your proposed schedule and approach to ensure that turbine cracking does not exist in your turbine.

Response:

Duke Power Company has no future inspections planned specifically for the problem of disc cracking on any of the Oconee units. This is based on the lack of any indications of disc cracking from the inspection of the Unit 2 turbine, and the similarity in design and operation of the turbines in all three units. However, Duke Power will continue to evaluate the results of disc cracking inspections on other turbines, and if evidence deems that additional inspections are necessary, then these inspections will be performed.

Question V:

If your plant has been inspected and plans to return or has returned to power with cracks or other defects, provide your proposed schedule for the next turbine inspection and the basis for this inspection schedule, including postulated defect growth rate.

Response:

This question is not applicable as no evidence of disc cracking was found by the Unit 2 turbine inspection.

Question VI:

Indicate whether an analysis and evaluation regarding turbine missiles have been performed for your plant and provided to the Staff. If such an analysis and evaluation has been performed and reported, please provide appropriate references to the available documentation. In the event that such studies have not been made, consideration should be given to scheduling such an action.

Response:

An analysis and evaluation regarding turbine missiles has not been performed for the Oconee Nuclear Station. Duke Power Company plans to evaluate the results of disc cracking inspections on other turbines and will consider performing a turbine missile analysis as necessitated by the results of these inspections.

Generic Questions

Question I:

Describe what quality control and inspection procedures are used for the disk bore and keyway areas.

Response:

After the rough machined wheel/disk forging has been tempered, material is removed from surface locations to measure mechanical properties. The forging is then subjected to a 100% volumetric ultrasonic inspection. If the test results meet stringent acceptance standards, the forging is released for final machining. During final machining, attention is continually paid to the finish, contour and dimensions of every surface. For instance, the keyway depth, width, locations, radii, and surface finish for every wheel is checked for conformance to drawings. Quality control personnel assure that tolerances are maintained. Any deviation from accepted tolerances are reported to engineering for disposition.

Only coolants and lubricants approved by engineering are used in the manufacturing and assembly process. These coolants and lubricants have undergone extensive laboratory corrosion testing to insure their acceptability prior to their approval for use in manufacturing. Periodic sampling is done on all such fluids to verify that their chemistry is within acceptable limits. If required, corrective actions are taken to maintain the chemistry within limits.

After finish machining, each wheel is thoroughly cleaned and given a magnetic particle inspection of all surfaces. If acceptable, the buckets are assembled and the wheel is static balanced. After assembly on the shaft, each wheel is inspected and measurements are made to assure its proper location. The assembled rotor is then spun to 20% overspeed following a high speed balance. Finally, after a magnetic particle inspection of the buckets, the rotor is cleaned to prepare for shipment.

Question II:

Provide details of the General Electric repair/replacement procedures for faulty disks.

Response:

Stress corrosion cracks have not been observed to date in nuclear wheels manufactured by General Electric, and General Electric does not anticipate that removal or replacement of wheels will be required because of this phenomena. The water erosion which has been observed in the keyways of wheels on several non-reheat machines is being studied intensively. General Electric currently believes that the erosion process is self-limiting and should not require the replacement of any wheels.

Question III:

What immediate and long term actions are being taken by General Electric to minimize future "water cutting" problems with turbine disks? What actions are being recommended to utilities to minimize "water cutting" of disks.

Response:

No immediate actions are required to minimize water erosion because of the apparent self-limiting nature of the phenomena. However, if future inspections show an unexpected progression of the water erosion, appropriate operating restrictions and/or modifications will be recommended by General Electric.

Question IV:

Describe fabrication and heat treatment sequence for disks, including thermal exposure during shrinking operations.

Response:

The wheel/disk forgings are heat treated in the rough machined condition. The heat treatment consists of soaking at a temperature above the upper critical temperature with the time and temperature sufficient to insure complete austenitization throughout the forging followed by a quench in cold, vigorously circulated water for a sufficient time to insure complete transformation through the section. The forgings are heated uniformly to a tempering temperature below the lower critical temperature and held for a sufficient time to soften to the desired tensile range. After tempering, the forgings are still-air cooled to room temperature.

After final machining the wheels (disks) are uniformly heated in an electric furnace to a temperature below the embrittling range but sufficiently high to increase the wheel diameter enough to assemble on the shaft with the required shrink fit.