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April 15, 1980

Mr. T. A. Ippolito, Chief
Operating Reactors - Branch 3
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Unit 3
Response to Request for Information
Concerning Turbine Inspection
NRC Docket No. 50-249

Reference (a): T. A. Ippolito letter to D. L. Peoples dated April 7, 1980

Dear Mr. Ippolito:

Enclosed for your review are the Commonwealth Edison Company responses to the questions transmitted in reference (a).

Our justification for startup and operation with ultrasonic indications of water cutting in the turbine disk is also contained in the enclosed response and is based on indication depth found during inspection, projected crack growth rates for materials used in the disks, and calculated critical flaw sizes.

We are currently evaluating the applicability of any turbine missile analyses performed to date or the need to perform additional analyses. A completion schedule for this action is not available at this time, but will be provided with future submittals for our other Dresden and Quad Cities units.

Please address any additional questions you may have concerning this matter to this office.

Very truly yours,

D L Peoples

D. L. Peoples
Director of
Nuclear Licensing

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Attachment

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April 15, 1980

Response to letter from T.A. Ippolito to D.L. Peoples dated April 7, 1980 requesting information on the Dresden Unit 3 GE turbine inspection findings.

Reference 1: Minutes of March 20, 1980 meeting titled "NRC Meeting on Pilgrim #1 and Dresden #3 Wheel Inspections" by D.P. Timo, General Electric, March 26, 1980.

Reference 2: Minutes of January 9, 1980 meeting titled "Meeting with General Electric Related to Turbine Disc Cracks" by W.J. Ross, NRC, February 21, 1980.

1. Description of the turbine disc inspection procedure.

   A description of the General Electric wheel boresonic test method is contained in References 1 and 2.

2. Inspection results.

   Results of the inspections performed on the Dresden Unit 3 LP turbine wheels are presented in the response to Question II. of the "Request For Information Related To Turbine Discs".

3. Justification for returning to power with UT indications (i.e. water cutting).

   The evaluation of the indictions and justification for returning to power are presented in the response to Question V. of the "Request For Information Related To Turbine Discs."

4. Responses to the enclosed questions:

   I. Provide the following information for each LP turbine:

      A. Turbine type

         The Commonwealth Edison Company Dresden Unit 3 consists of one tandom compound six flow, four casings, non-reheat, condensing 1800 RPM General Electric Company turbine #170X364. Each of the three similar low pressure turbines is a double flow unit with 8 wheels at each end. Each wheel carries a single row of buckets. Steam from the high pressure turbine is sent through a moisture separator for removal of entrained water before entering the L.P. turbine.

B. Number of hours of operation for each LP turbine at time of last turbine inspection or if not inspected, postulated to turbine inspection

Unit 3 had 54, 103 hours of operation when it came down for its scheduled outage on February 2, 1980.

C. Number of turbine trips and overspeeds

There have been no recorded unscheduled turbine trips with resulting overspeed. All recorded overspeeds were initiated via scheduled tests. Eight tests were performed from 1975 through 1980. No information is currently available prior to 1975. The maximum recorded overspeeds were as follows:

Test of mechanical trip	1934 RPM (107.4%)
Test of back-up electrical trip	1966 RPM (109.2%)

D. For each disc containing an ultrasonic indication:

1. Type of material including material specifications.

   The disc material is Ni-CR-Mo-V alloy steel similar to but more restrictive than that defined by ASTM A471.

2. Tensile properties data.

   See Attachment A.

3. Toughness properties data including Fracture Appearance Transition Temperature and Charpy upper shelf energy and temperature.

   See Attachment A.

4. Keyway temperatures.

Disc No.	Keyway Temp., ^{o}F
2	333
5	225
6	193
7	163

5. Critical crack size and basis for the calculation.

   The calculated critical flaw sizes at 120% of normal operating speed are shown in the Table under Item V. of the Request For Information Related To Turbine Discs. The bases for estimating critical flaw size are as follows:

a. The lower bound of the scatterband of the correlation between K_{1C} and Excess Temperature is used.

b. Critical crack size (Acr) is obtained from the expression $K_{1C}=1.6\sigma\sqrt{5/8" + Acr}$ where 5/8" is the radial keyway depth.

This expression assumes a semi-elliptical surface crack at the keyway corner with a length four times its depth. It is applied to cracks which have sufficient depth to be beyond the influence of the keyway stress concentration.

c. The excess temperature is defined as T_e=wheel material temperature-FATT. The wheel material temperature used is room temperature (75°F), since little wheel material prewarming occurs during a cold start. It should be noted that the likelihood of reaching 10-20% overspeed during a cold start is very low. If the overspeed occurs due to loss of full load, the wheel material temperature will be considerably higher (approximately the temperatures listed in reply to question #I.D.4) and hence critical crack sizes will be correspondingly greater.

d. Estimated deep seated values of FATT are used. A fairly steep gradient of FATT occurs with radial distance from the bore surface, so that deep seated values of FATT may be on the order of 100°F higher than measured surface FATT's.

6. Calculated bore and keyway stress at operating design overspeed.

General Electric Company considers bore and keyway stress calculations to be proprietary and has not furnished this information. It is our understanding that General Electric and the Nuclear Regulatory Commission are having discussions on the draft "Request For Information Related To Turbine Discs" which may establish an acceptable means to satisfy the Commission's request.

7. Calculated K_{1C} data

The deep seated estimates of K_{1C} for the wheels with indications are shown in Attachment A. A discussion of the method of estimating K_{1C} is contained in Reference 1 starting at the bottom of page 2.

8. Minimum yield strength specified for each disc

General Electric Company considers the specified minimum yield strength for each disc to be proprietary and has not furnished this information. It is our understanding that General Electric and the Nuclear Regulatory Commission are having discussions on the draft "Request For Information Related To Turbine Discs" which may establish an acceptable means to satisfy the Commission's request.

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.

Unit 3 LP "A" inspection results:

The wheel bore ultrasonic inspection detected indications on the keyways of six wheels. In all cases, the indications were detected near the corners of the approximately rectangular keyways, although on some wheels indications were detected near only one of the two corners. Indications detected in the fifth and sixth stage low pressure wheels (both turbine and generator ends) extended axially from the upstream wheel hub faces to under the wheel webs (approximately 5" axial length). Indications in the second and seventh turbine end wheels were detected only under the upstream hubs (approximately 1 1/2" axial length). Results of the ultrasonic inspection are summarized below.

Wheel	Number of Indications (Corners)	Maximum Indication Depth (in)*	Approximate Axial Length (in)
2-TA	2	Less than .030	1 1/2
5-TA	2	.210 and .230	5
5-GA	2	.370 and .255	5
6-TA	1	Less than .030	5
6-GA	1	Less than .030	5
7-TA	2	Less than .030	1 1/2

*Relative to the keyway roof

The visual examination revealed an extensive amount of water erosion on the upstream side wheel webs and hubs. Water cut grooves were observed radially in-line with the wheel keyways. This water cutting was found to be most extensive on the third, fourth, fifth and sixth stage low pressure wheels. Using fiber optic equipment, the water cutting was tracked along the wheel hub faces to within approximately 1 1/2 from the keyways, at which location the narrower gap between adjacent wheels precludes inserting the probe any further. Based on available evidence, we believe that the water cut grooves do in fact extend into the keyways, and are the source of the keyway sonic indications.

No evidence of stress corrosion cracking was found by these examinations.

Unit 3 LP "B" inspection results:

The wheel bore ultrasonic test detected indications at the keyways of both the turbine and generator end fifth stage LP wheels. Indications were detected near both corners of the approximately rectangular keyway on the turbine end wheel. The indications extended axially approximately 5" from the upstream hub face, and had maximum radial depths (relative to the keyway roof) of approximately .170" and .270". An indication, having a maximum radial depth of approximately .230", was detected near the corner of the keyway on the generator end wheel. Again, this indication extended axially approximately 5" from the upstream hub face.

Considerable local moisture erosion was noted on the wheel hubs, including the fifth stage wheels. Such water cutting is not uncommon on non-reheat units. Moisture water cutting grooves were visible at the hub peripheries approximately in line with the keyway sonic indications. Fiber optics disclosed that these grooves extended radially inward from the hub periphery toward the keyway. Thus, it is likely that the keyway sonic indications are due to the existence of water cut grooves extending axially along the keyway corners.

No evidence of stress corrosion cracking was found by these examinations.

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

Technical Specifications limit reactor coolant water chemistry as follows:

a. At steaming rates less than 100,000 lb/hr conductivity shall not exceed 2 μmho/cm and chloride ion concentration shall not exceed 0.1 ppm.

b. At steaming rates greater than 100,000 lb/hr conductivity shall not exceed 5 μmho/cm and chloride ion concentration shall not exceed 0.5 ppm.

Unit 3 records dating back to 1974 indicate no deviation from these specifications.

c. For reactor startup, conductivity shall not exceed 10 µmho/cm and chloride ion concentration shall not exceed 0.1 ppm for the first 24 hours after placing the reactor in the power operating condition.

Reactor water is essentially pure water, i.e., conductivity typically less than 1.0 umho/cm and approximately 7.0 pH. Chloride ion concentration consistantly averages less than 30 ppb.

Full flow condensate demineralizer prevent significant changes in reactor water chemistry due to events such as minor condenser tube leaks.

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.

The rotors of L.P. turbines "A" and "B" were inspected using fiber optic and ultrasonic equipment in March of this year. The inspection results are given in the answer to question II. above.

L.P. "C" was not inspected during that outage. It is scheduled for an inspection during the next maintenance outage now planned for the Fall of 1981 (approximately 16.5 months of operation).

Based on all of the General Electric experience to date (See Reference 1), no stress corrosion cracks have been found. As discussed at the referenced meeting, the evidence shows that the keyway ultrasonic indications found to date are due to water cutting grooves. Because L.P."C" is of the same design as L.P. "A" and L.P. "B", and operates in the same steam environment, we would not expect to find water cutting indications any more serious than were found on the A and B rotors.

The justification for operating this rotor until the Fall of 1981 would thus follow the same analysis shown for L.P. "A" and L.P. "B" (See answer to question V. below).

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.

Startup of Dresden Unit 3 is presently scheduled for April 19, 1980. Commonwealth Edison intends to perform ultrasonic inspections of the LP-A and LP-B turbines during the refueling outage tentatively scheduled for the Spring of 1983. An evaluation of the effect of 33.0 additional operating months (24,000 hours) has been performed. Although stress corrosion cracking (SCC) has not been observed in the bore or keyway regions of General Electric LP turbine wheels, the evaluation makes use of propagation rates derived from SCC experience. The table presents the results of the evaluation.

Table: Effect on Water Cutting Indications of an Additional 33.0 Months of Running Time. Dresden Unit 3

Wheel No.	UT Indication (inches)	Growth[1] Rate (in./mo.)	Postulated Depth, A (inches)	Critical Flaw Size, Acr (inches)	A/Acr
2-TA	<.030	0.030	1.020	2.9	0.35
5-TA	0.230	0.005	0.395	1.4	0.28
5-GA	0.370	0.005	0.535	1.4	0.38
6-TA	<.030	<.003	0.129	2.6	0.05
6-GA	<.030	<.003	0.129	2.6	0.05
7-TA	<.030	<003	0.129	2.8	0.05
5-TB	0.270	0.005	0.435	2.2	0.20
5-GB	0.230	0.005	0.495	2.2	0.23

[1]Based on MED YS curve of "Turbine Crack Rate As Function Of Temp. & Materials" received from NRC

No correction factors have been added to the depth of the detected UT indications. The depths of water erosion grooves in the keyways used in the calculations are those measured near the ends of the keyways (under the hub portions of the wheels). Tangential stresses in this region are considerably lower than those which exist in the mid portion of the wheel under the web. At these latter locations the water erosion grooves are non-existant or more shallow than at the ends of the keyway.

The postulated-to-critical flaw ratios (A/Acr) are well below 0.50 in all cases and provide a large degree of conservatism against wheel burst during the next 33 months of operation. It should be emphasized that the indications detected in the keyways of these wheels are water erosion grooves rather than stress corrosion cracks. It has been conservatively assumed that stress corrosion cracks will be initiated immediately and that a stress corrosion crack growth mechanism is operative which we do not believe to be the case.

ATTACHMENT A

DRESDEN #3 TB. 170X364-LPA
WHEELS WITH WATER CUTTING

	Measured Mechanical Properties				Deep Seated	
Wheel	Tensile Strength (KSI)	.02% Yield Strength (KSI)	Room Temp. Charpy Energy (Ft-Lbs)	Meas. FATT (°F)	FATT (°F)	K_{1C} $KSI\sqrt{IN}$
2-TA	117/128	98/110	86	-110	<0	140
5-TA	135/138	121/123	110/112	-135	<+25	127
5-GA	134/136	120/122	89/91	-130	<+25	127
6-TA	125/130	107/114	82	- 95	<0	140
6-GA	126/131	111/114	81	- 90	<0	140
7-TA	122/125	107/110	103/106	- 95	<0	140

DRESDEN #3 TB. 170X364-LPB
WHEELS WITH WATER CUTTING

					Deep Seated	
Stage	T.S. (KSI)	.02% Y.S. (KSI)	RT CVN FT-lbs.	Meas. FATT °F	FATT °F	K_{1C} $KSI\sqrt{in}$
5-TB	131/135	116/121	92	-145	<0	140
5-GB	121	109/111	118	-125	<0	140

--All wheels are manufactured from NiCRMoV Steel

--K_{1C}: lower bound estimate of critical stress intensity factor