Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

June 23, 1980

Mr. T. A. Ippolito, Chief
Operating Reactors - Branch 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Quad Cities Station Units 1 and 2
Response to Request for Information
Concerning Turbine Disks
NRC Docket Nos. 50-237/249 and 50-254/265

References (a): T. A. Ippolito letter to D. L. Peoples dated May 16, 1980.

(b): D. L. Peoples letter to T. A. Ippolito dated April 15, 1980.

Dear Mr. Ippolito:

Reference (a) requested information concerning turbine disk design and previous inspection results for Dresden Units 2 and 3 and Quad Cities Units 1 and 2. Our response to this request is contained in Attachments 1, 2, and 3 for Dresden Unit 2, Quad Cities Unit 1, and Quad Cities Unit 2, respectively. Our response to these questions for Dresden Unit 3 was previously provided by Reference (b).

Please address any questions concerning this matter to this office.

One (1) signed original and fifty-nine (59) copies of this transmittal are provided for your use.

Very truly yours,

Robert F. Janecek

Robert F. Janecek
Nuclear Licensing Administrator
Boiling Water Reactors

Attachment

SUBSCRIBED and SWORN to
before me this 23rd, day
of June, 1980

Notary Public

A001 S/1

ADD: L E
W ROSS 1 1
W HAZELTON 1 1
H WALKER 1 1

4672A

8006250 277

Attachment 1

Dresden Station, Unit 2
Response to May 16, 1980 Letter From
T.A. Ippolito Requesting Information Related To
Turbine Discs

Site Specific General Questions

I. Provide the following information for each LP turbine:

A. Turbine Type

The Commonwealth Edison Company Dresden Unit 2 turbine consists of one tandom compound six flow, four casings, non-reheat, condensing 1800 RPM General Electric Company turbine #170X326. 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. Steam is exhausted from the three L.P. turbines into a three section condenser.

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 2 will have approximately 69,717 hours of operation before it is inspected in January, 1981. At that time at least one of the LP turbines will be U.T. inspected.

C. Number of turbine trips and overspeeds.

No unscheduled turbine trips with overspeed have been recorded. All of the recorded trips with overspeed were due to planned tests of the overspeed protection system. No information is available prior to 1973. From 1973 to 1980 there were 15 recorded tests. The maximum speed recorded during tests of the mechanical trip system was 1911 RPM. The maximum recorded overspeed during tests of the back-up electrical trip was 1984 RPM.

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 temperatures
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_{Ic} data
8. Minimum yield strength specified for each disc

Answers to these questions involve data which is proprietary to the General Electric Company. Information was provided directly to the NRC during a meeting between General Electric and NRC representives on April 21, 1980. General Electric has informed us that the information provided at that meeting is an acceptable reply to this 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.

Unit 2 has not been inspected so this question is not applicable.

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 umho/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 umho/cm and chloride ion concentration shall not exceed 0.5 ppm.

A chloride result of 0.19 ppm and 0.15 ppm occured on Unit 2 on 6-25-78. This occured after a reactor scram. The time in which the 0.10 ppm Technical Specifications limit was exceeded was approximately six hours.

c. For reactor startup, conductivity shall not exceed 10 umho/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 ultrasonic inspections performed to date of General Electric low pressure turbines have not found cracking of the disc keyway or bore regions. Ultrasonic indications attributed to water cutting have been found in the keyways of certain discs of a minority of the inspected low pressure turbines. While there is no experience with cracking, the possibility of water cutting is a concern which requires evaluation. At least one of the low pressure turbines of Dresden Unit 2 will be ultrasonically inspected in the disc keyway and bore regions during the outage scheduled for January, 1981.

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.

Unit 2 has not been inspected so this question is not applicable.

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.

An assessment of the applicability of an existing turbine missile analysis is being performed at the present time. The results of this review will be reported by July 15, 1980.

Generic Question:

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

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, location, 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 ensure 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.

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

Stress corrosion cracks have not been observed to date in nuclear wheels manufactured by General Electric, and we do 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. We currently believe that the erosion process is self-limiting and should not require the replacement of any wheels.

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?

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.

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

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 ensure complete austenitization throughout the forging followed by a quench in cold vigorously circulated water for a sufficient time to ensure complete transformation through the section. The forgings are heated uniformly to a tempering temperature below the low 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.

<u>Attachment 2</u>

Quad Cities Station, Unit 1
Response to May 16, 1980 Letter From
T.A. Ippolito Requesting Information Related To
Turbine Discs

<u>Site Specific General Questions</u>

I. Provide the following information for each LP turbine:

A. Turbine Type

The Commonwealth Edison Company Quad Cities Unit 1 turbine consists of one tandom compound six flow, four casings, non-reheat, condensing 1800 RPM General Electric Company turbine No.-170X370. 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. Steam is exhausted from the three L.P. turbines into a three section condenser.

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 1, LPA is scheduled for inspection in September, 1980, when it will have operated approximately 58,000 hours. The other two LP turbines are tentatively scheduled for September, 1982 inspections.

C. Number of turbine trips and overspeeds

No unscheduled turbine trips with overspeed have been recorded. There have been 23 recorded trips with overspeed which were due to planned tests of the overspeed protection system.

The maximum overspeed recorded was 1985 RPM.

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 temperatures
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_{Ic} data
8. Minimum yield strength specified for each disc

Answers to these questions involve data which is proprietary to the General Electric Company. Information was provided directly to the NRC during a meeting between General Electric and NRC representives on April 21, 1980. General Electric has informed us that the information provided at that meeting is an acceptable reply to this 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.

Unit 1 has not been inspected so this question is not applicable.

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.

The station does not perform chemical analysis of turbine water. However, the quality of the steam is dependent on the condition of the reactor water. Listed below are the nomimal water chemistry condition's in the Unit 1 reactor water.

Equivalent 1-131	4.00e-02 uci/ml
Gross Beta (B)	7.0e-1 uci/ml
Conductivity	0.2 umho/cm
Turbidity	0.1 JTU
Chlorides	20 ppb
Silica	0.10 ppm
Dissolved Oxygen	190-200 ppb

There have been two cases for Unit 1 in which the chemistry exceeded Technical Specification limits for conductivity. They are:

4-6-73 conductivity reached 23.5 umho/cm, pH of 4.6 caused by an air and resin injection into the Unit 1 reactor by the clean-up system.

9-21-79 During Unit 1 start-up conductivity reached 20.0 umho, chlorides of .18 ppm. This was caused by high conductivity in the reactor water prior to start-up.

It should be noted that the duration of time that the reactor water exceeded 10 umho/cm was on the order of a few hours. During relatively frequent condenser tube leaks conductivity in the reactor seldom exceeds 1 to 2 umho/cm before corrective action is initiated to plug the condenser 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 ultrasonic inspections performed to date of General Electric low pressure turbines have not found cracking of the disc keyway or bore regions. Ultrasonic indications attributed to water cutting have been found in the keyways of certain discs of a minority of the inspected low pressure turbines. While there is no experience with cracking, the possibiltiy of water cutting is a concern which requires evaluation. The low pressure turbines of Quad Cities Units 1 will be ultrasonically inspected in the disc keyway and bore regions according to the following tentative schedule:

LP-A	LP-B	LP-C
September, 1980	Fall, 1982	Fall 1982

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.

Unit 2 has not been inspected so this question is not applicable.

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.

An assessment of the applicability of an existing turbine missile analysis is being performed at the present time. The results of this review will be reported by July 15, 1980.

Generic Question:

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

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, location, 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 ensure 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.

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

Stress corrosion cracks have not been observed to date in nuclear wheels manufactured by General Electric, and we do 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. We currently believe that the erosion process is self-limiting and should not require the replacement of any wheels.

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?

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.

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

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 ensure complete austenitization throughout the forging followed by a quench in cold vigorously circulated water for a sufficient time to ensure complete transformation through the section. The forgings are heated uniformly to a tempering temperature below the low 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.

<u>Attachment 3</u>

Quad Cities Station, Unit 2
Response to May 16, 1980 Letter From
T.A. Ippolito Requesting Information Related To
Turbine Discs

Site Specific General Questions

I. Provide the following information for each LP turbine:

A. Turbine Type

The Commonwealth Edison Company Quad Cities Unit 2 turbine consists of one tandom compound six flow, four casings, non-reheat, condensing 1800 RPM General Electric Company turbine No.-170X378. 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. Steam is exhausted from the three L.P. turbines into a three section condenser.

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 2, LPB and LPC are scheduled for inspection in September, 1981, when they will have operated approximately 56,790 hours. The other LP turbine is tentatively scheduled for a Spring 1983 inspection.

C. Number of turbine trips and overspeeds

No unscheduled turbine trips with overspeed have been recorded. There have been 22 recorded trips with overspeed which were due to planned tests of the overspeed protection system.

The maximum overspeed recorded was 1977 RPM.

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 temperatures
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_{Ic} data
8. Minimum yield strength specified for each disc

Answers to these questions involve data which is proprietary to the General Electric Company. Information was provided directly to the NRC during a meeting between General Electric and NRC representives on April 21, 1980. General Electric has informed us that the information provided at that meeting is an acceptable reply to this 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.

Unit 2 has not been inspected so this question is not applicable.

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.

The station does not perform chemical analysis of turbine water. However, the quality of the steam is dependent on the condition of the reactor water. Listed below are the nominal water chemistry condition's in the Unit 1 reactor water.

Equivalent 1-131	3.00e-02 uci/ml
Gross Beta (B)	7.0e-1 uci/ml
Conductivity	0.4 umho/cm
Turbidity	0.06 JTU
Chlorides	20 ppb
Silica	0.16 ppm
Dissolved Oxygen	190-200 ppb

There have been three cases for Unit 2 in which the chemistry exceeded Technical Specification limits for conductivity. They are:

6-9-74 Conductivity reached 40.5 umho/cm and a pH of 3.9. this was caused by an air and resin injection into the Unit 2 reactor.

9-25-74 During unit start-up Unit 2 conductivity reached 13.5 umho/cm, a pH of 4.7 and chlorides of <.03ppm. This was caused by poor quality hotwell water.

4-27-80 During Unit 2 start-up conductivity reached 13.0 umho/cm and clorides of .064 ppm. This was caused by a condenser tube leak along with poor quality reactor water prior to start-up.

It should be noted that the duration of time that the reactor water exceeded 10 umho/cm was on the order of a few hours. During relatively frequent condenser tube leaks conductivity in the reactor seldom exceeds 1 to 2 umho/cm before corrective action is initiated to plug the condenser 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 ultrasonic inspections performed to date of General Electric low pressure turbines have not found cracking of the disc keyway or bore regions. Ultrasonic indications attributed to water cutting have been found in the keyways of certain discs of a minority of the inspected low pressure turbines. While there is no experience with cracking, the possibiltiy of water cutting is a concern which requires evaluation. The low pressure turbines of Quad Cities Units 2 will be ultrasonically inspected in the disc keyway and bore regions according to the following tentative schedule:

LP-A	LP-B	LP-C
Spring 1983	Sept. 1981	Sept. 1981

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.

Unit 2 has not been inspected so this question is not applicable.

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.

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