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Docket No. 50-255

APR 30 1980

Mr. David P. Hoffman
Nuclear Licensing Administrator
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

Dear Mr. Hoffman:

The Commission has issued the enclosed Amendment No. 56 to Provisional Operating License No. DPR-20 for the Palisades Plant. This amendment is in response to your request dated April 11, 1980, as supplemented by letter dated April 16, 1980.

This amendment incorporates a new License Condition (Paragraph 3.G) into License DPR-20 to allow performance of a feedwater line water hammer test.

During our review of your application, we found it necessary to modify your proposed license amendment. We have discussed these changes with your representative and we have mutually agreed upon them.

Copies of our Safety Evaluation supporting the license amendment and the Notice of Issuance are also enclosed. In addition, we are enclosing our Safety Evaluation Report and our Consultant's Report relating to steam generator water hammer. These reports document the completion of our review of this generic issue for the Palisades Plant.

Sincerely,
Original signed:
Dennis M. Crutchfield for
Dennis L. Ziemann, Chief
Operating Reactors Branch #2
Division of Operating Reactors

Enclosures:
1. Amendment No. 56 to License No. DPR-20
2. Safety Evaluation
3. Notice
4. Safety Evaluation Report - Steam Generator Water Hammer
5. Consultant's Report (EG&G Idaho, Inc.), dated February 1980

cc w/enclosures:
See next page

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DATE		4/ /80	4/30/80		
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SURNAME		HSmith:ah	RDSilver		
DATE		4/23/80	4/23/80	4/ /80	

NRC FORM 318 (9-76) NRCM 0240 ★ U.S. GOVERNMENT PRINTING OFFICE: 1978 - 265 - 769

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

April 30, 1980

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Mr. David P. Hoffman
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cc w/enclosures:
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Plant Manager
Covert, Michigan 49043

William J. Scanlon, Esquire
2034 Pauline Boulevard
Ann Arbor, Michigan 48103

*W/cy of CPCo incoming dtd. 4/11/80

Water hammer test Prelim/Final

William O. Miller, Chief
License Fee Management Branch, ADM

Date: 4/30/80
Amended Form Date: _____

FACILITY AMENDMENT CLASSIFICATION - DOCKET NO(S). 50-255

Licensee: Consumers Power Co.

Plant Name and Unit(s): Palisades

License No(s): DPR-20 Mail Control No: 8004150474

Request Dated: 4-11-80 Fee Remitted: Yes ✓ No ____

Assigned TAC No: 8041

Licensee's Fee Classification: Class I ___, II ___, III ✓, IV ___, V ___, VI ___, None ___. $4000

Amendment No. 56 Date of Issuance 4/30/80

☒ 1. This request has been reviewed by DOR/DPM in accordance with Section 170.22 of Part 170 and is properly categorized.

☐ 2. This request is incorrectly classified and should be properly categorized as Class ____. Justification for classification or reclassification: _____

☐ 3. Additional information is required to properly categorize the request:

☐ 4. This request is a Class ____ type of action and is exempt from fees because it:

(a) ___ was filed by a nonprofit educational institution,

(b) ___ was filed by a Government agency and is not for a power reactor,

(c) ___ is for a Class ___ (can only be a I, II, or III) amendment which results from a written Commission request dated _____ for the application and the amendment is to simplify or clarify license or technical specifications, has only minor safety significance, and is being issued for the convenience of the Commission, or

(d) ___ other (state reason therefor): _____

HS 4/21/80
R. Silver

Dennis M. Crutchfield
Division of Operating Reactors/Project Management

☐ The above request has been reviewed and is exempt from fees.

Attached: Incoming + LA

William O. Miller, Chief
License Fee Management Branch

Date

LFMB 6/78

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

CONSUMERS POWER COMPANY

DOCKET NO. 50-255

PALISADES PLANT

AMENDMENT TO PROVISIONAL OPERATING LICENSE

Amendment No. 56
License No. DPR-20

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Consumers Power Company (the licensee) dated April 11, 1980, as supplemented by letter dated April 16, 1980, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, Provisional Operating License No. DPR-20 is hereby amended by adding a new Paragraph 3.G to read as follows:

"G. The licensee may proceed with the feedwater line water hammer test as identified in the Commission's staff Safety Evaluation supporting Amendment No. 56 to License No. DPR-20, dated April 30, 1980. This test shall be conducted as specified in the Palisades Plant Special Test Procedure T-130 or a revision to the subject procedure. This license condition is only applicable during startup testing at the beginning of Cycle 4."

3. This license amendment is effective as of the date of its issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Dennis M. Crutchfield

for Dennis L. Ziemann, Chief
Operating Reactors Branch #2
Division of Operating Reactors

Date of Issuance: April 30, 1980

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 56 TO PROVISIONAL OPERATING LICENSE NO. DPR20

CONSUMERS POWER COMPANY

PALISADES PLANT

DOCKET NO. 50-255

1.0 INTRODUCTION

By letter dated April 11, 1980, Consumers Power Company (the licensee) requested an amendment to the Provisional Operating License No. DPR-20 for the Palisades Plant to permit performance of a test for water hammer. Additional information was submitted by letter dated April 16, 1980.

2.0 DISCUSSION AND BACKGROUND

The purpose of this test is to determine whether water hammer will be induced by the introduction of cold auxiliary feedwater into a steam filled feedwater line at flow rates greater than 150 gallons per minute (gpm). The licensee has been limiting auxiliary feedwater flow administratively to 150 gpm as a precaution against steam generator water hammer. However, the licensee now wishes to raise this limit to provide a greater margin in the inventory of cooling water in the steam generators after a plant trip. With the present instrumentation and flow rate limit, when a plant trip occurs, the water level drops below the range of the level instrumentation and the level remains unknown until sufficient auxiliary feedwater is pumped in to recover the water level indication. By increasing the flow of auxiliary feedwater, the level will be recovered more quickly; and, thus, the period of "blind" operation will be reduced. The results of this test will be used to determine the new auxiliary feedwater flow limit that will be employed.

The Palisades Plant Review Committee reviewed procedure T-130 for this test and concluded that an unreviewed safety question could result from the performance of this test, i.e., there is a greater probability of a water hammer occurring, as a result of the test, than there would be if no test were performed. This in turn might increase the probability of damage to the feedwater piping. However, the Committee evaluated the possible consequences of a water hammer and concluded that this operation does not involve a significant hazards consideration with respect to performance of the test or potential impact on the health and safety of the public.

3.0 EVALUATION

We have reviewed the licensee's request for license amendment dated April 11, 1980, the attached water hammer test procedure T-130 Revision Zero and the additional information submitted by letter dated April 16, 1980.

The test will be performed in two major steps; one at 200 pounds per square inch (psig) pressure in the steam generator and the second at 900 psig. Auxiliary feedwater flow rates of 150 gpm and 300 gpm will be introduced at 200 psig and flow rates of 200 gpm through 400 gpm may be tested at 900 psig.

By performing the test in this manner the probability of a feedwater line break will not be significantly increased. Although the probability of a water hammer occurring at the first test point, 200 psig, may be greater than at 900 psig, the magnitude would be lower because the differential pressure (DP) driving the water slug would be only about 200 psid instead of 800 to 900 psid. With this decreased DP, the probability of a pipe break due to water hammer would be significantly reduced. Furthermore, if the test at 200 psig results in water hammer, the test will not be continued without further evaluation.

Even if a water hammer were to occur at full pressure, the consequences would not be likely to cause a feedwater line break. There has been only one instance in the United States, Indian Point, Unit 2, where a feedwater line was broken by steam generator water hammer. The line broke as a result of repeated water hammer and would not have broken from a single blow. If a water hammer were to occur during the full pressure test, the same test conditions would not be repeated to allow additional water hammer.

Although we have concluded that the probability of a feedwater line break will not be significantly increased by the performance of this test, we have considered the consequences of such a break during the performance of this test. In terms of potential radiation doses to the public and operating personnel, the consequences would be far less than those previously considered in the Final Safety Analysis Report. Because the plant has been shutdown since September 7, 1979, the level of radioactivity in the secondary coolant is only 10^{-7} μCi/gm or less. This is at least a factor of one million below the authorized limit of 0.1 μCi/gm given in the Technical Specifications for the operating license. Potential radiation doses are, therefore, significantly reduced. Furthermore, the primary coolant activity is only 2×10^{-2} μCi/gm. This is a factor of ten thousand below that allowed by the Technical Specifications and provides an additional margin of safety in the event that some steam generator tube leakage might occur.

In the unlikely event of a feedwater line break, it is our judgement that the operating crew will be prepared for such an event and no one would be injured. The situation would be well understood and completely controlled.

Although it is not very likely, we have also considered the consequences of the disablement of the auxiliary feedwater system during this test. Because the plant has been shut down since September, the reactor core decay heat level is so low that auxiliary feedwater would not be needed to cool the core or cooldown the plant. The core can be cooled by any one of the following systems: (a) normal makeup and letdown, (b) water inventory from the steam generators, (c) high pressure safety injection and power operated relief valves, and (d) low pressure safety injection. Therefore, even if the auxiliary feedwater system were completely disabled during this test, there would still be adequate and redundant means available for cooling the core.

4.0 SUMMARY

We have reviewed the test procedures that the licensee will use to perform a test for steam generator water hammer. We have considered the probability of causing a rupture in the feedwater line as a result of this testing and the consequences of such a rupture. We have found that the probability of a feedwater line rupture would not be significantly increased and that the consequences of such a rupture under the planned test conditions would be far less than those previously considered in the Final Safety Analysis Report.

Based on these findings we have concluded that the performance of test T-130A, Revision Zero does not involve a significant hazards consideration and that the licensee may proceed with this test during startup testing at the beginning of Cycle 4. We found it necessary to modify the licensee's proposed license amendment. We discussed these changes with the licensee and we have mutually agreed upon them.

5.0 ENVIRONMENTAL CONSIDERATION

We have determined that the amendment does not authorize a change in effluent types or total amounts nor an increase in power level and will not result in any significant environmental impact. Having made this determination, we have further concluded that the amendment involves an action which is insignificant from the standpoint of environmental impact and pursuant to 10 CFR §51.5(d)(4) that an environmental impact statement or negative declaration and environmental impact appraisal need not be prepared in connection with the issuance of this amendment.

6.0 CONCLUSION

We have concluded, based on the considerations discussed above, that: (1) because the amendment does not involve a significant increase in the probability or consequences of accidents previously considered and does not involve a significant decrease in a safety margin, the amendment does not involve a significant hazards consideration, (2) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (3) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

Date: April 30, 1980

NUCLEAR REGULATORY COMMISSION
SAFETY EVALUATION REPORT
STEAM GENERATOR WATER HAMMER
PALISADES PLANT
DOCKET NO. 50-255

1.0 INTRODUCTION

Steam generator water hammer has occurred in certain nuclear power plants as a result of the rapid condensation of steam in a steam generator feedwater line and the consequent acceleration of a slug of water which upon impact within the piping system causes undue stresses in the piping and its support system. The significance of these events varies from plant to plant. Since a total loss of feedwater could affect the ability of the plant to cool down after a reactor shutdown, the NRC is concerned about these events occurring, even though an event with potentially serious consequences is unlikely to happen.

Because of the continuing occurrence of water hammer events, the NRC, in September 1977, informed all PWR licensees that water hammer events due to the rapid condensation of steam in the feedwater lines of steam generators represented a safety concern and that further actions by licensees for Westinghouse and Combustion Engineering designed nuclear steam supply systems are warranted to assure that an acceptably low risk to public safety due to such events is maintained. Accordingly, these licensees were requested to submit proposed hardware and/or procedural modifications, if any, which would be necessary to assure that the feedwater lines and feedrings remain filled with water during normal as well as transient operating conditions. At the same time, the NRC provided each PWR licensee with a copy of its consultant's report, "An Evaluation of PWR Steam Generator Water Hammer," NUREG-0291.

A steam generator water hammer event has not occurred at the Palisades Plant. Operation of the plant began in 1971 and in January of 1977 precautionary procedures were adopted to avoid possible steam generator water hammer by limiting the flow of auxiliary feedwater to each steam generator to 100 gallons per minute (gpm). This limit was raised to 150 gpm per steam generator in October 1978. Because of the unique geometry of the feedwater piping at the Palisades Plant that provides the potential for a severe steam generator water hammer, it is considered prudent to require this licensee to limit the flow of auxiliary feedwater to either those values previously experienced at the Palisades Plant during repeated normal operations or those values experienced during special steam generator water hammer tests to be performed at the Palisades Plant.

2.0 EVALUATION

Our consultant, EG&G Idaho, Inc., prepared the attached evaluation of steam generator water hammer at the Palisades Plant as part of our technical assistance program. (Letter from J.A. Dearien, EG&G, to R.E. Tiller, DOE, dated February 27, 1980.) We have reviewed this report together with the licensee's submittals listed under item 4.0.

Our consultant concluded that based on its review of the Palisades Plant operating history and the present mode of operation (with limited auxiliary feedwater flow) the potential for damaging steam generator water hammer is sufficiently low to permit continued operation of this facility. We concur with our consultant's conclusion.

The licensee in its letters of November 19, 1979, and January 21, 1980, indicated that planned modifications to the auxiliary feedwater system will provide for (1) the automatic initiation of auxiliary feedwater flow, and (2) the control of flow to each steam generator to within a predetermined amount using an automatic flow controller. The licensee is planning to perform tests for steam generator water hammer at the Palisades Plant. It proposes to test with auxiliary feedwater flow rates up to 400 gpm in order to establish a safe range of allowable flow rates.

We have reviewed the licensee's plans for the automatic operation of the auxiliary feedwater system; and we have concluded that such operation, including automatic initiation and flow limitation, could reduce the potential for the occurrence of steam generator water hammer. However, increasing the auxiliary feedwater flow limit above 150 gpm might increase the potential for steam generator water hammer. We have reviewed the licensee's test procedures titled "Feedwater Line Water Hammer Test" T-130 Revision Zero and have found that the successful performance of this test would provide an adequate basis for establishing a safe range for the control of auxiliary feedwater flow with regard to steam generator water hammer.

3.0 CONCLUSION

Based on our knowledge of water hammer phenomena, and our review of the licensee's responses and the enclosed evaluation report, we concur with our consultant's conclusion that the potential for damaging steam generator water hammer is sufficiently low to permit continued operation of this facility. However, even though steam generator water hammer is not likely to occur, the licensee should be vigilant and monitor for water hammers that might impose significant stresses on the piping systems or their supports. We will continue to monitor reports from

this licensee for indications of possible water hammer. If such indications appear in the future, this matter will be reexamined and may result in additional requirements to reduce the probability of steam generator water hammer at this facility.

Based on our review of the licensee's plans for automatic initiation and automatic limitation of auxiliary feedwater flow, we have found that these measures will tend to reduce the probability of occurrence of a steam generator water hammer. Our review of the procedures for a feedwater line water hammer test shows that the successful performance of this test would provide an adequate basis for establishing a safe range for the control of auxiliary feedwater flow. These modifications and procedures are, therefore, acceptable to the staff for the purpose of reducing the potential for steam generator water hammer.

We, therefore, find that steam generator water hammer at Palisades Plant presents no undue risk to the health and safety of the public.

4.0 REFERENCES

4.1 W.E. Bennett, Waterhammer in Steam Generator Feedwater Lines, Westinghouse Technical Bulletin, NSD-TB-75-7, June 10, 1975.

4.2 R.B. Sewell, (CPC) "Palisades Plant," letter to DRL (NRC), July 16, 1975.

4.3 J.B. Block, et al, An Evaluation of PWR Steam Generator Water Hammer, Creare, Inc., NUREG-0291, December 1976.

4.4 Nuclear Services Corporation, Evaluation of Auxiliary Feedwater and Water Hammer Potential at Palisades Plant, CPC-01-07, February 24, 1977.

4.5 A. Schwencer (NRC) letter to D. Bixel (CPC), "Steam Generator Water Hammer" dated September 2, 1977.

4.6 D.P. Hoffman, (CPC) "Feedwater Line Water Hammer," letter to A. Schwencer, (NRC) January 24, 1978.

4.7 D.P. Hoffman, (CPC) "Palisades Plant - Feedwater Line Water Hammer," letter to D.L. Ziemann (NRC), August 9, 1978.

4.8 D.L. Ziemann, (NRC), "Docket 50-255," letter to D. Bixel (CPC), September 22, 1978.

4.9 R.B. DeWitt, (CPC), "Palisades Plant, - Additional Information Pertaining to NRC List dated May 4, 1979," letter to D.L. Ziemann (NRC), May 10, 1979.

4.10 NRC Staff, Water Hammer in Nuclear Power Plants, NUREG-0582 July 1979.

4.11 D.L. Ziemann (NRC) letter to D. Bixel (CPC) "Steam Generator Water Hammer" dated September 12, 1979.

4.12 S.R. Frost, (CPC), "Palisades Plant - Steam Generator Water Hammer Response," letter to D.L. Ziemann (NRC), November 19, 1979.

4.13 R.W. Huston (CPC) letter to Director, NRR, Attn: D.L. Ziemann "Automatic Initiation of Auxiliary Feedwater System dated January 21, 1980.

4.14 Feedwater Line Water Hammer Test T-130 Revision Zero

Date: April 30, 1980

STEAM GENERATOR WATER HAMMER TECHNICAL EVALUATION

PALISADES PLANT

February 1980

EG&G Idaho, Inc.

CONTENTS

TABLES

I. INTRODUCTION

A review of the Palisades Plant feedwater system was performed. The purpose of this review was to assess the susceptibility of the feedwater system to water hammer during operating transients that could result in conditions conducive to water hammer. Steam-water slugging in the steam generator feedrings and adjacent feedwater piping, generally referred to as steam generator water hammer, was considered in this review. The Palisades Plant is one of these facilities which has bottom discharge steam generator feedwater spargers. Further, there have been no reported incidents of steam generator water hammer.[1,2] Unusual features related to feedwater piping include a horizontal run of 28 feet before entering the steam generator and a 2 feet downward 'jog' inside the steam generator before teeing into the sparger.

The information for this evaluation was obtained from: 1) discussions with the licensee, 2) licensee submittals to NRC[1,5,6,7,8], 3) the Palisades Plant "Final Safety Analysis Report"[9], 4) "An Evaluation of PWR Steam Generator Water Hammer" NUREG-0291[3], 5) "Westinghouse Technical Bulletin, NSD-TB-75-7"[4], and 6) NRC correspondence and reports.[10,11]

A review of Palisades Plant steam generator water hammer experience is presented in Section II. The means to reduce the potential for water hammer at this facility are presented in Section III. Section IV presents a description of the feedwater system including a description of the feedwater piping and sparger. Section V presents a description and tabulation of available operating transients and situations that could result in conditions conducive to water hammer. Conclusions are presented in Section VI concerning the susceptibility of the Palisades Plant feedwater system to steam generator water hammer.

II. WATER HAMMER EXPERIENCE

There have been no reported steam generator water hammer incidents at the Palisades Plant during its period of operation.[1,2] Available information[1,2,5] indicates that there were 33 events (28 loss-of-feedwater and 5 loss-of-offsite power events) over the operating period of the Palisades Plant when feedwater sparger uncovery was likely and conditions conducive to steam generator water hammer existed. Of the total of 33 incidents, 13 events occurred prior to any administrative controls relative to feedwater admission and sparger recovery limitations and included 7 loss-of-feedwater events where sparger uncovery and substantial or complete drainage were definitely known to have occurred. Although such conditions are normally considered conducive to steam generator water hammer, none occurred.

III. MEANS TO REDUCE THE POTENTIAL FOR WATER HAMMER

Based on past experience at other plants,[3] steam generator water hammer would be most likely to occur during startup, shutdown, and low power situations when feedwater is under manual control and the flow rates are insufficient to maintain uncovered feedrings full of water. To avoid admission of steam and possibly slugging during these operational conditions, feedrings with bottom discharge must remain covered with water.[3] As a means to reduce the potential for damaging steam generator water hammer at the Palisades Plant, administrative controls were established and are currently in effect that require operators to maintain specified steam generator feedwater flow rates, delay times, and level control in the steam generator.

Initially, based on a consultant's report,[5] administrative procedures were adopted to limit steam generator feedwater flow rate to 100 gpm effective January 10, 1977. In August 1978, in order to meet anticipated decay heat removal requirements,[5] an increase to 150 gpm was proposed[7] and approved[10] effective October 4, 1978. The consultant's recommendations were based on a series of 7 loss-of-feedwater events in 1972 that resulted in the feedwater spargers inside the steam generators being uncovered (see Section V).

The administrative controls currently in force[10] for the use of the 150-gpm feedwater flow limit are defined as follows:

"The sparger has been uncovered for at least 15 minutes.

The trip occurred at greater than 85% power.

The steam generator level is maintained at least two feet below the sparger center line.

We interpret this to mean that a reflood rate no greater than 150 gpm may be employed while the steam generator level is more

than two feet below the sparger center line; that a rate no greater than 100 gpm may be employed while the steam generator is within two feet below the center line of the sparger; and that the reflooding rate would be unlimited provided the sparger is full of water."

The probability of steam generator water hammer was considered to be acceptably low for normal operations and plant trip situations while operating the main feedwater and auxiliary feedwater systems in the above manner.[10] From an operational viewpoint and to minimize operator error, higher AFW flow rates and simplification of existing administrative controls are certainly desirable. However, the extent of the available operating experience,[1,2] the basis of the consultants report,[5] the lack of any of the recommended features[3,4] incorporated in the feedwater piping, and the lack of any special tests which establishes the absence of water hammer preclude such considerations at this time. Based on operating experience available, it is concluded that existing administrative controls are an effective means to reduce the potential for steam generator water hammer and should be retained.

IV. FEEDWATER SYSTEM DESCRIPTION AND OPERATION

This section gives a brief description of both main and auxiliary feedwater systems and the attendant operation of each for the Palisades Plant. A description of the feedwater piping arrangement and the feedwater sparger is included.

1. MAIN FEEDWATER SYSTEM

For the main feedwater (MFW) system, condensate from the condenser hot well is pumped by two half-capacity, electric motor-driven condensate pumps through the air ejector and gland steam condensers, then through two parallel trains of five stages of low-pressure feed water heaters to the suction of two half-capacity, turbine-driven MFW pumps. The MFW is next pumped through two parallel sets of feedwater regulating valves and single stage high-pressure feedwater heaters and then to each of the steam generators. The main feedwater line and sparger are filled with 419^{o}F water at full load conditions. Steam for the MFW pump turbine drivers is normally taken from the main turbine crossover piping. A cross-connection to the main steam system provides automatic backup steam for plant low load operation.

Both MFW pumps are used to furnish the feedwater flow rate required at unit loads greater than 50%. The system is designed to permit operation with one feed pump under all modes at reduced unit load. Each pump is rated at 13,500 gpm with a total developed head (TDH) of 2640 feet at 5000 rpm. Each turbine driver and pump must be set up locally and brought up to speed before the driver can be controlled from the main control room. If MFW pump suction pressure falls below a preset critical value, the pump will be automatically tripped. The turbine drivers will also be tripped from thrust-bearing failure, low turbine exhaust vacuum, reverse rotation, excessive vibration, and loss of a condensate pump (trip of a preselected turbine driver).

The MFW controls maintain steam generator downcomer level within acceptable limits by positioning the feed water regulating valves supplying each steam generator. The speed of the turbine-driven main feedwater pumps will also be controlled by the feedwater controls. MFW pump speed control is by automatic or manual means. Automatic control of MFW is provided when the plant is above 15% power. Steam flow, feedwater flow and downcomer level are used in a three-element controller on each steam generator to maintain preset water level during steady-state and transient operation. Manual control of MFW flow may be assumed by the operator at any time.

At normal operating conditions on receipt of a reactor/turbine trip signal, the turbine driver speed is ramped down from about 5000 rpm to about 3200 rpm within 60 seconds The attendant MFW pump head is thus reduced from about 2300 feet to about 1000 feet (350 psi). As a result of main steam isolation caused by the turbine trip, the steam generator pressure rises from 700 to 900 psi which is the set-point of the steam dump and turbine by-pass valves. Since the MFW pump is pumping against a back pressure that is in excess of the developed pump head, no MFW flow enters the steam generator. The MFW pumps are then manually tripped and AFW is promptly initiated typically within 1-1/2 minutes of the turbine trip. The feedwater temperature gradually decreases to that of the AFW stored condensate in the condensate storage tank (CST).

In the event of a design basis accident (DBA), the main feed pumps will be tripped from low-condensate header pressure which will result from shedding of the condensate pumps from their supply buses. The motor-driven auxiliary feed pump will be available for service at the operator's discretion.

2. AUXILIARY FEEDWATER SYSTEM

The auxiliary feedwater (AFW) system provides unheated water to the steam generators during plant startup and shutdown operations and when the main feedwater (MFW) system pumps are isolated. Two AFW

pumps are provided (one of which is redundant). One electric motor-driven and one steam turbine-driven pump take suction from the 125,000 gallon CST. In the event of a loss or depletion of the CST water supply, the backup water supply from the fire system can be utilized by starting one of the fire pumps.

Each AFW pump has a capacity of 415 gpm with a TDH of 2730 feet. On start-up, the motor-driven AFW pump operates to provide feedwater to the steam generators until sufficient steam can be generated to operate the MFW pump turbine drivers. The level in the steam generators is maintained by remotely adjusting the AFW control valves in each respective steam generator auxiliary feed header. The AFW system also supplies water to the steam generators to remove decay heat during the initial phase of primary system cooldown. For any condition during which MFW to the steam generators is interrupted and the reactor is tripped, sufficient feedwater flow is maintained by the motor-driven or the turbine-driven AFW pumps to remove decay heat from the primary system.

The condensate pumps may be used to pump water through the normal feedwater train to the steam generators in the event of a failure of the AFW piping system. The steam generator pressure may be relieved by the steam dump system to accommodate this mode of operation.

In the event of a steam line break, the main feedwater pumps are inoperative. The turbine and motor driven AFW pumps are available to be used to maintain shutdown cooling flow to one intact loop steam generator. The AFW needed for the various plant operating conditions is such that one pump can supply all of the necessary water requirements.

3. FEEDWATER PIPING AND SPARGER DESCRIPTION

The MFW lines are 18-in. diameter and AFW lines are 6-in. diameter. Both are Schedule 80, seamless carbon steel, ASTM A-106, Grade B, and are designed to meet the requirements of ANSI B31.1.

The MFW check valves are located on a horizontal run at elevation 603 ft-0 in. approximately 11 feet outside of containment penetrations seven and eight. The AFW branch connections tee into the MFW lines just downstream of the check valves and outside of the containment. The AFW check valves are immediately upstream of the branch connection (injection location).

The MFW lines run parallel, approximately 11 feet apart in an east-southeast direction through the containment penetrations, and continue in the same direction for approximately 35 feet. The lines then drop to elevation 601 ft-0 in.. The "A" line turns 90 degrees to the south-southwest and the "B" line turns 90 degrees to the north-northeast. Each runs horizontally through straightening vanes, and flow elements, for a total length of approximately 46 ft.-6 in. Both lines turn 90 degrees upward and rise to an elevation of 653 ft.-9 5/8 in. They then both turn 90 degrees to the east-southeast and run horizontally for 20 feet. The "A" line turns 90 degrees to the north-northeast and the "B" line turns 90 degrees to the south-southwest, and they both run horizontally for approximately eight feet to the steam generator nozzles. After passing through the steam generator walls, the pipe "jogs" two feet downward to connect to a ring-shaped feedwater sparger. The sparger feedring is 100 inches in diameter and has bottom discharge. The spargers (one per steam generator) are 12-inch, Schedule 40, pipe and are located in the downcomer annulus at the approximate level of the top of the tube bundle. There are 68 bottom discharge orifices (on each sparger) which are formed by welding on 5-inch long, 1-1/4-inch diameter, Schedule 40, pipe nipples.

As described, the feedwater piping arrangement contains neither of the two recommendations[3,4] to prevent or abate water hammer influences, e.g., a pipe loop seal nor a short horizontal pipe run preceding the feedwater nozzle through the steam generator wall. The Palisades Plant has the longest known run of horizontal pipe length of any operating PWR facility, i.e., 28 feet. As visualized in a horizontal plane or plan view, this section of feedwater piping is "L"

shaped with a 'short-leg' nearest the steam generator 8 feet long and a 'long-leg' 20 feet in length before turning 90 degrees downward in the upstream direction.

V. OPERATING EXPERIENCE AND WATER HAMMER SUSCEPTIBILITY

The conditions considered most conducive to steam generator water hammer occur when the steam generator feedrings are uncovered and steam enters the feedrings and attached horizontal feedwater piping.[3] Steam-water slugging and subsequent water hammer may occur when incoming feedwater mixes with the steam in the piping and rapid condensation occurs.[3] The conditions can be avoided by keeping the feedrings and associated piping full of water. This can be accomplished by 1) keeping the water levels in the steam generators above the feedrings or 2) supplying feedwater at a higher flow rate than the rate at which feedwater drains through the discharge holes on the bottom of uncovered feedrings. The drop or "shrinkage" in steam generator water level and subsequent feedring uncovery is the result of interrupted reactor power production causing the collapse of steam voids within the secondary side of the steam generators. A similar situation would also be experienced during events such as loss of main feedwater, loss of offsite power, steam line break, or loss-of-coolant accident.

The expected water level behavior immediately following a loss of feedwater or loss of off-site power is not altered by recovery rates. Auxiliary feedwater is manually initiated following the trip. Actual steam generator level recovery is controlled by response time of the operator and feed flow - steam flow mismatch prior to the trip. The normal steam generator water level in the downcomer is 72 inches above the sparger center line (65% of narrow range). The steam generator low water level setpoint is at the sparger center line (24.7% of narrow range). The zero percent narrow range tap is located 44 inches below the sparger centerline. Slow recovery rates were realized after the imposition of the 100-gpm feedwater flow limit and as such reflect conditions realized for prevention of steam generator water hammer. Later, the 100-gpm recovery flow rate was found to be marginally acceptable to remove decay heat and reestablish water level, and 150-gpm recovery rates as given in Section III were instituted.

Tables I and II identify situations concerning ...s of feedwater which have resulted during the operational period since and including the year 1972.[2] These situations reflect conditions in which the sparger was uncovered in one or both steam generators and significant or complete drainage occurred as typified in Table III. Such conditions are normally expected and considered conducive to steam generator water hammer prior to the establishment of administrative controls relative to feedwater admission beginning January 10, 1977. Those events thereafter basically reflect the effectiveness of the existing administrative controls.

It is apparent from the review of feedring uncovery events that it is not possible to avoid drainage of the feedrings and adjacent piping by keeping the feedrings covered with water. The uncovery time not only varies among the events but between the A and B steam generators. Complete drainage of the feedrings and adjacent piping has likely occurred. The time required for complete drainage is unknown, but is probably on the order of a few minutes. As shown in Table III, one or both feedrings have been uncovered on four occasions for periods of 21 to 113 minutes which should be ample time for drainage.

As mentioned at the beginning of this section, the alternative to continuous coverage of the feedrings with water is to maintain sufficient feedwater flow through uncovered feedrings to keep the feedrings full of water. To do this, the main feedwater flow required for Palisades Plant is roughly calculated to be 2000 gpm per steam generator. As such, based on the design main feedwater flow of about 13,500 gpm per steam generator, the flow required to keep the feedrings full of water is about 15% of design flow. The feedrings, if uncovered, would not be kept full of water below power levels of about 15% of full power, and the AFW system is not capable of keeping the piping and sparger full.

Auxiliary feedwater flow is administratively limited to less than 150 gpm or 100 gpm per stream generator as explained in Section III. Plant experience during a number of complete loss of main feedwater events in Tables I, II and III have shown that this flow is adequate for reactor coolant pump and decay heat removal provided both steam generators are in service. Although steam generator narrow range level indication has, at times, been lost following a complete loss of main feedwater event, adequate removal of heat from the primary system was always maintained while feeding at the administrative limit.

The influence of the 2-foot "jog" downward of the feedwater piping inside the steam generators (before teeing into the sparger) is not firmly established. A consultants' report[5] indicated no apparent influence either for prevention or inducement of steam generator water hammer.

As indicated previously, water hammer would be most likely during startup, shutdown, and low power operation since feedring uncovery events are frequent due to manual feedwater control and feedwater flow requirements are insufficient to keep the feedrings full of water. However, the experience at this facility indicates an apparently low susceptibility to water hammer under conditions normally considered conducive to steam generator water hammer. Prior to instituting administrative controls on feedwater admission, there were 13 loss-of-feedwater events that covered a broad spectrum of plant operating conditions from low power (start-up and hot stand-by) to high power levels (93%). The reason for the Palisades Plant low susceptibility is presently unknown and undetermined.

VI. CONCLUSIONS

We have reviewed the operating history of the Palisades plant pertinent to steam generator water hammer and the related operational and procedural characteristics of the feedwater system. The review has shown that conditions conducive to steam generator water hammer have occurred at the Palisades plant but no water hammer events have been observed. The conditions are encountered during normal operating transients and during startup and shutdown operations. Such conditions would also be expected in the future during the normal and accident operating situations addressed in the review. Based on this review and the present mode of plant operation, we have concluded that the potential for damaging steam generator water hammer is sufficiently low to permit continued operation of this facility.

VII. REFERENCES

1. R. B . Sewell, (CPC) "Palisades Plant," letter to DRL (NRC), July 16, 1975.

2. S. R. Frost, (CPC), "Palisades Plant - Steam Generator Water Hammer Response," ltr. to D. L. Zieman (NRC), November 19, 1979.

3. J. B. Block, et al, An Evaluation of PWR Steam Generator Water Hammer, Creare, Inc., NUREG-0291, December 1976.

4. W. E. Bennett, Waterhammer in Steam Generator Feedwater Lines, Westinghouse Technical Bulletin, NSD-TB-75-7, June 10, 1975.

5. Nuclear Services Corporation, Evaluation of Auxiliary Feedwater and Water Hammer Potential at Palisades Plant, CPC-01-07, February 24, 1977.

6. D. P. Hoffman, (CPC) "Feedwater Line Water Hammer," letter to A. Schwencer (NRC), January 24, 1978.

7. D. P. Hoffman, (CPC), "Palisades Plant, - Feedwater Line Water Hammer," letter to D. L. Zieman (NRC), August 9, 1978.

8. R. B. DeWitt, (CPC), "Palisades Plant, - Additional Information Pertaining to NRC List Dated May 4, 1979," letter to D. L. Zieman (NRC), May 10, 1979.

9. Final Safety Analysis Report, Consumers Power Company, Palisades Plant, Docket 50-255.

10. D. L. Zieman, (NRC), "Docket 50-255," letter to D. Bixel (CPC), September 22, 1978.

11. NRC Staff, Water Hammer in Nuclear Power Plants, NUREG-0582, July 1979.

TABLE I

PALISADES PLANT TRIPS DUE TO LOSS OF FEEDWATER

Trip Number	Date	Power Level	Cause
72-01	1-11-72	5%	Feedwater pump trip due to sharp increase in desand. Operator manually opened the rag valve fully. (See Event 72-04.)
72-03	1-12-72	5%	Feedwater pump trip due to oscillations in suction pressure. Low suction pressure trip. (See Event 72-04.)
72-04	1-13-72	Hot Standby	Feedwater pump trip due to low suction pressure. Fine mesh start-up strainer had been left in the suction.
72-06	2-03-72	20%	Feedwater reg valve failure.
72-10	3-27-72	60%	Feedwater pump trip due to high vibration. Oil filter change out procedure induced air into oil system.
72-14	4-14-72	15%	Feedwater reg valve failure.
72-20	7-31-72	18%	Defective feedwater pump vibration sensor caused a pump trip.
72-23	12-21-72	82%	Inadvertent closing of feedwater reg valve.
75-04	6-30-75	20%	Feedwater pump trip, rapid demand in feedwater flow caused low pump suction pressure.
75-06	7-29-75	Hot Standby	Feedwater pump trip, low suction pressure.
76-02	5-10-76	25%	Feedwater pump speed control ramped pump to minimum rpm thus insufficient discharge head.
77-03	1-17-77*	100%	Feedwater pump trip, low suction pressure, dump valve on moisture separator drain tank failed open.
77-04	1-18-77	35%	Feedwater pump trip, cause unknown. (See Event 77-08.)
77-07	3-24-77	90%	Feedwater pump trip, cause unknown. (See Event 77-08.)

* Beginning 1-10-77 auxiliary feedwater flow rate restricted to 100 gpm.

TABLE I (Contd)

Trip Number	Date	Power Level	Cause
77-08	3-27-77	82%	Feedwater pump trip, faulty low-pressure switch on condensate pump disch.
77-21	11-27-77	50%	Feedwater reg valve closed, operator error while transferring from manual to auto.
78-02	4-21-78	50%	Feedwater pump trip, defective vibration sensor.
78-04	5-11-79	Hot Standby	Feedwater pump trip, low suction pressure, condensate polisher strainer plugged with powder.
78-09	6-07-78	23%	Feedwater reg valve failed to provide flow. (See Event 78-10.)
78-10	6-08-78	20%	Feedwater stop valve not opened during start-up sequence.
78-12	6-13-78	83%	Feedwater pump trip, severe transient induced by Technician error while maintaining feedwater flow recorder.
78-18	9-19-78	86%	Feedwater pump trip, turbine governor failure.
78-24	10-17-78**	84%	Feedwater pump trip, axial position, operator failed to warm LP STF line prior to cutting it in.
78-27	12-18-78	88%	Feedwater pump trip, cause unknown.
79-03	3-03-79	100%	Feedwater pumps tripped, low suction pressure, moisture separator drain tank dump valve failed open.
79-04	4-07-79	100%	Feedwater pump trip, cause unknown. Pump vibration trip removed from service.
79-09	8-10-79	88%	Feedwater pumps tripped, high axial thrust incorrect main turbine valve test procedure.
79-10	8-24-79	91%	Feedwater pump tripped, low suction pressure, valving error while valving in the condensate demineralizers.

** Beginning 10-04-78, increased recovery flow rate to 150 gpm while sparger is uncovered.

TABLE II

PALISADES PLANT TRIPS DUE TO LOSS OF OFF-SITE POWER

Event Number	Date	Power Level	Cause
72-17	4-15-72	15%	Lightning stroke to tie line.
76-05	7-20-76	93%	Lightning storm, unit ground relay operated.
77-17**	9-24-77*	85%	Lightning stroke caused "R" bus to clear.
77-20**	11-25-77	85%	"R" bus cleared cause unknown.
78-13	6-18-78	84%	Lightning stroke.

* Beginning 1-10-77, auxiliary feedwater flow rate restricted to 100 gpm.

After 10-04-78 recovery flow rate increased to 150 gpm.

** Only events 77-17 and 77-20 actually resulted in a loss of power. The other three events caused a transient severe enough to cause a plant trip.

TABLE III

PALISADES PLANT TRIP HISTORY RESULTING FROM LOW STEAM GENERATOR LEVEL ON LOSS-OF-FEEDWATER (1972)

Trip Number	Cause of Trip	Steam Generator	Reflood Rate Through Sparger, Steam Generator Level, inches/minute (gpm)		Time Below Feed water Sparger (minutes)	Minimum Level During Transient (inches)
72-01	Feedwater pump trip	A	4.5	(677)	< 5	-8
		B	9*	(1354)*	< 5	-8
72-04	Feedwater pump trip	A	-	-	-	N/A
		B	1.39	(209)	21	-24
72-06	Feedwater regulating valve failure	A	9*	(1354)*	< 5	-16
		B	-	-	-	+46
72-10	Feedwater pump trip	A	0.32	(48)	60	> -48
		B	0.49	(74)	113	> -48
72-14	Feedwater regulating valve failure	A	9*	(1354)*	< 5	-28
		B	-	-	-	+38
72-20	Feedwater pump trip	A	3.01	(453)	< 5	-14
		B	-	-	-	+69
72-23	Feedwater regulating valve closure	A	0.76	(114)	69	-44
		B	-	-	< 5	-6

*Note: The maximum detectable.

7590-01

UNITED STATES NUCLEAR REGULATORY COMMISSION

DOCKET NO. 50-255

CONSUMERS POWER COMPANY

NOTICE OF ISSUANCE OF AMENDMENT TO PROVISIONAL OPERATING LICENSE

The U. S. Nuclear Regulatory Commission (the Commission) has issued Amendment No. 56 to Provisional Operating License No. DPR-20, issued to Consumers Power Company (the licensee), which revised the license for operation of the Palisades Plant (the facility) located in Covert Township, Van Buren County, Michigan. The amendment is effective as of its date of issuance.

The amendment incorporates a new License Condition (Paragraph 3.G) into License DPR-20 to allow performance of a feedwater line water hammer test.

The application for the amendment complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations. The Commission has made appropriate findings as required by the Act and the Commission's rules and regulations in 10 CFR Chapter I, which are set forth in the license amendment. Prior public notice of this action was not required since the amendment does not involve a significant hazards consideration.

The Commission has determined that the issuance of this amendment will not result in any significant environmental impact and that pursuant to 10 CFR §51.5(d)(4) an environmental impact statement or negative declaration and environmental impact appraisal need not be prepared in connection with issuance of this amendment.

For further details with respect to this action, see (1) the application for amendment dated April 11, 1980, and a supplement thereto dated April 16, 1980, (2) Amendment No. 56 to License No. DPR-20, and (3) the Commission's related Safety Evaluation. All of these items are available for public inspection at the Commission's Public Document Room, 1717 H Street, N. W., Washington, D. C. and at the Kalamazoo Public Library, 315 South Rose Street, Kalamazoo, Michigan 49006. A copy of items (2) and (3) may be obtained upon request addressed to the U. S. Nuclear Regulatory Commission, Washington, D. C. 20555, Attention: Director, Division of Operating Reactors.

Dated at Bethesda, Maryland, this 30th day of April, 1980.

FOR THE NUCLEAR REGULATORY COMMISSION

Dennis M. Crutchfield

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Division of Operating Reactors