Central files

May 15, 1981

Docket No. 50-255
LS05-81-05-029

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U.S. NUCLEAR REGULATORY COMMISSION

Mr. David P. Hoffman
Nuclear Licensing Administrator
Consumers Power Company
1945 W Parnall Road
Jackson, Michigan 49201

Dear Mr. Hoffman:

SUBJECT: TOPIC III-10.B, PUMP FLYWHEEL INTEGRITY (PALISADES)

Enclosed is a copy of our draft evaluation of Systematic Evaluation Program Topic III-10.B. You are requested to examine the facts upon which the staff has based its evaluation and respond either by confirming that the facts are correct or by identifying errors and supplying the corrected information. We encourage you to supply any other material that might affect the staff's evaluation of these topics or be significant in the integrated assessment of your facility.

Your response is requested within 30 days of receipt of this letter. If no response is received within that time, we will assume that you have no comments or corrections.

In future correspondence regarding Systematic Evaluation Program Topics, please refer to the topic numbers in your cover letter.

Sincerely,

Dennis M. Crutchfield, Chief
Operating Reactors Branch No. 5
Division of Licensing

Enclosure:
As stated

cc w/enclosure:
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NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555
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As stated

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CONSUMERS POWER COMPANY
PALISADES, DOCKET NO. 50-255
SYSTEMATIC EVALUATION PROGRAM BRANCH
COMPONENT INTEGRITY SECTION
SAFETY EVALUATION REPORT

SEP TOPIC III-10.B - PUMP FLYWHEEL INTEGRITY

I. Introduction

The safety objective of this review is to assure that the integrity of the primary reactor coolant pump flywheel is maintained thus preventing failures at normal operating speeds and speeds that might be reached under accident conditions thereby precluding the generation of missiles.

II. Review Criteria

The basis for the review is outlined in Standard Review Plan (SRP) Section 5.4.1.1 and the Regulatory Guide 1.14, which describes and recommends a method acceptable to the NRC staff of implementing General Design Criterion 4, "Environmental and Missile Design Bases" of Appendix A of 10 CFR 50, with regard to minimizing the potential for failures of the flywheels of the reactor coolant pumps.

III. Related Safety Topics and Interfaces

Internally generated missiles protection is evaluated under SEP Topic III-4.C.

IV. Review Guidelines

There are two parts to the recommendations of Regulatory Guide 1.14. The first part is related to the evaluation of materials of construction, design, fabrication, proof testing and pre-service inspection of the pump flywheels. The second part is concerned with the evaluation of the procedures used for the inservice inspection of pump flywheels.

V. Evaluation

A. Material and Fabrication

The flywheels for each pump are divided into three sections, two above the rotor spider, and one below. The two upper flywheels are bolted together and the upper flywheel (72" diameter) is keyed to the lower (52" diameter) one by means of an offset. At operating speed (900 rpm at Palisades) the bore stress due to rotation is 8300 psi and 4100 psi is due to shrink fit. The operating temperature of the Palisades flywheels, which are enclosed by motor stator coils, will be above 100^{o}F.

The disc material is SAE 1017, type 1020, which is equivalent to ASTM A 108 (1017), low carbon steel with a minium yield strength of 27,000 psi and tensile strength of 50,000 psi. The pump flywheels are machined from cross rolled blanks.

Regulatory Guide requires that the nil-ductility transition temperature (NDT) for the flywheel material be no higher than 10^{o}F, that the Charpy V-notch (CVN) upper shelf energy should be at least 50 ft-lb., and that at normal operating temperature the material should have a dynamic stress intensity factor of at least 100 ksi$\sqrt{in}$. This later requirement can be satisfied by demonstrating that the material has a CVN energy level of 50 ft-lb. at normal operating temperature.

Based on our review we have determined that the NDT of the flywheel material at Palisades is no more than 40^{o}F and an average CVN energy of 100 ft-lb. at 70^{o}F. Based on these data we conclude that the NDT requirement of Regulatory Guide 1.14 has not been met while the CVN and fracture toughness requirement have been met. Based on this information we conclude that the flywheels have adequate fracture toughness. Our conclusion is based on the following: Although the NDT is 40^{o}F rather than 10^{o}F, the operating temperature of 100^{o}F is still 60^{o}F above NDT. This margin above NDT coupled with a CVN energy at 70^{o}F that far exceeds the 50 ft-lbs. required by the Regulatory Guide ensures that brittle fracture is unlikely and that a large tolerance to flaw-induced fracture exists. This flaw tolerance and operation in a temperature region where the potential for brittle fracture is reduced meets the intent of Regulatory Guide 1.14 although one specific requirement of the guide has not been met.

B. Design

We have evaluated the pump flywheels at Palisades to compare the ductile strength levels and the fracture toughness at Palisades with the requirements of Regulatory Guide 1.14, "Reactor Coolant Pump Flywheel Integrity."

Regulatory Guide 1.14 requires that the margin against ductile rupture at normal operating speed and design overspeed be 3 and 1.5, respectively, compared to the minimum specified yield strength. For the flywheels at Palisades the margins against ductile rupture at normal operating speed is 3.07 and 2.0 at a design overspeed of 125%. Therefore the margin at normal operating speed is 2% more than that required by the Regulatory Guide while the margin at design overspeed exceeds the required margin by 30%. Hence, the margins against ductile fracture required by Regulatory Guide 1.14 have been met.

C. Inservice Inspection Program

The Palisades plant has three flywheels that are made of SAE 1017, Type 1020, low carbon steel with a minimum yield strength of 27,000 psi. Other flywheels we have reviewed recently were made of higher quality materials, either A533B or A516, Gr65 with yield strength of 50,000 and 65,000 psi respectively. Two of the flywheels have a diameter of about 52 inches and are located within the stator windings of the motor. The third, and uppermost flywheel has a diameter of 72 inches and is located within the motor housing but above the windings of the motor. Unlike previously reviewed designs, the Palisades flywheels are shrink fitted to the motor shaft.

The staff concluded in the presentation of the safety aspects of the Palisades plant to the ACRS committee on November 18, 1969 that no additional protection against the effects of missiles from the small flywheels need be required because the pump speed being only 900 rpm and the stator windings of the motor and the motor housing have the capacity to absorb the kinetic energy of the missile.

However, in view of the use of material of lower toughness than provided in other designs, the ACRS recommended the following inspection program;

1. 100% UT baseline inspection of the upper 72-inch flywheels, including the disc-shaft interface.

2. 100% UT inservice inspection of the upper 72-inch flywheel including the disc-shaft interface, at each refueling shutdown. (about every 19 months.)

3. A visual inspection, to the extent practical, using optical means to provide interior access where required, of all three flywheels in each motor each time UT inspections of the upper flywheels are performed.

Regulatory Guide 1.14 as well as the ASME Code Section XI requires the following inservice inspection program for each flywheel:

1. An in place ultrasonic volumetric examination of the areas of higher stress concentration at the bore and keyway at approximately three-year intervals.

2. A surface examination of all exposed surfaces and complete ultrasonic volumetric examination at approximately 10 year intervals.

In lieu of the requirements of Regulatory Guide 1.14, UT examination of the areas of higher stress concentration at three-year intervals and complete volumetric examination at ten-year intervals, the staff imposed the requirement of 100% volumetric inspection of the upper flywheel at each refueling which occurs approximately every 18 months.

In accordance with the Palisades Plant Technical Specifications 4.3 and 4.12, inservice inspection no. 6 was conducted during the period September 8, 1979 to May 28, 1980. No deterioration has been found in the upper pump flywheel.

The analysis performed by Combustion Engineering shows that a 3.5" through crack will be required to cause failure at 125% overspeed at lower temperature and not extrapolated to operating temperature.

The experience of motor flywheel combinations similar in design to Palisades units has been very favorable. No flywheel failure, or other associated flywheel problem, has ever been experienced with this type design.

We recommend that the Palisades plant continue performing 100% volumetric inspection of the upper flywheel at each refueling and in addition should include a visual inspection of other two flywheels whenever a pump motor overhauling is required.

VI. Conclusions

We have reviewed the materials, fabrication, design and inspection aspects of the pump flywheels at Palisades for compliance with Regulatory Guide 1.14. Based on our review we conclude that the requirements for fabrication and the margins against flow induced fracture and yielding required by Regulatory Guide 1.14 have been satisfied for the flywheels. The present inservice inspection of the upper flywheel is more stringent than Regulatory Guide 1.14. However, the other two flywheels (52") are not inspected at present, hence a visual inspection during a pump motor overhaul will be reassuring.