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FACIL:50-397 WPPSS Nuclear Project, Unit 2, Washington Public Powe 05000397
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SUBJECT: Forwards justification for continued operation re emergency Diesel Generator 2 shorted turns.

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WASHINGTON PUBLIC POWER SUPPLY SYSTEM

P.O. Box 968 • 3000 George Washington Way • Richland, Washington 99352

July 27, 1990
G02-90-130

Docket No. 50-397

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Gentlemen:

Subject: NUCLEAR PLANT NO. 2, OPERATING LICENSE NPF-21
EMERGENCY DIESEL GENERATOR-2 SHORTED TURNS;
JUSTIFICATION FOR CONTINUED OPERATION

Reference: Letter, G02-90-123, JW Baker (SS) to JD Partlow (NRC), "Request for Waiver of Compliance Relative to Technical Specification 3.8.1.2, AC Sources - Shutdown", dated July 11, 1990

The reference requested a waiver of compliance to allow for removal of the Division 2 diesel generator from service for the purpose of performing testing relative to a shorted turn condition that exists on one rotor pole of the unit.

A purpose of the testing was to develop information to support a justification for continued operation (JCO) with the shorted turn condition. The testing was successfully performed on July 17, 1990. Attached for your information is the JCO that is based, in part, on the results obtained from this testing. The JCO concludes that the diesel generator is capable of supporting the present operability requirements of the Technical Specifications and fulfilling its design function with the shorted turn condition.

It is our plan to startup from the R5 refueling outage with the existing generator condition and perform those monitoring and trending activities proposed on page 5 of the JCO for as long as the JCO is in effect.

Very truly yours,

R. Latone

G. C. Sorensen, Manager
Regulatory Programs

AGH/bk
Attachment

cc: JB Martin - NRC RV
NS Reynolds - BCP&R
P Eng - NRC
DL Williams - BPA/399
NRC Site Inspector - 901A

A001
1/1

JUSTIFICATION FOR CONTINUED OPERATION

PER NO. 290-0533

1.0 COMPONENT IDENTIFICATION

This JCO discusses the discovery of indications of shorted turns within a pole on the rotor of the generator for DG2. This JCO follows the original JCO prepared to document the use of the Division 2 diesel generator to fulfill the operability requirements of Technical Specification 3/4.8.2, A.C. Sources - Shutdown. This JCO is being prepared to support the use of the Division 2 diesel generator to fulfill its portion of the requirements of Technical Specification 3/4.8.1, A.C. Sources - Operating.

There are eight poles on the rotor which provide field flux required to generate a voltage in the stator of the generator. A rotor pole field coil AC voltage drop test has been performed and has revealed indications of shorted turns on one pole of the rotor for DG2.

2.0 ACCIDENT CONDITIONS

Diesel generator onsite power capacity is required to assure that fuel design limits are not exceeded for anticipated operational occurrences and core cooling and containment integrety are maintained for postulated accidents assuming the offsite power system is not available.

Sufficient redundancy is to be provided to allow the onsite power system, to perform its safety function assuming a single failure.

3.0 COMPONENT SAFETY FUNCTION

The Operability of the A.C. diesel generator and associated distribution systems during power operation ensures that sufficient power will be available to supply the safety-related equipment required for (1) the safe shutdown of the facility and (2) the mitigation and control of accident conditions within the facility.

The operability of the power sources are consistent with the initial condition assumptions of the safety analysis and are based upon maintaining the onsite A.C. power sources and associated distribution systems Operable during accident conditions coincident with an assumed loss-of-offsite power and the single most limiting failure, in this case the loss of the DG1 onsite A.C. source.

The function of the rotor poles is to provide the required rotor field flux to maintain the proper generator output voltage.

4.0 STATUS OF COMPONENT

IEEE Standard 432-1976 also provides guidance on the significance of this type of degradation;

> "Shorted turns of a minor nature, unlike shorted turns in the stator may not necessarily require immediate reinsulation. Rotors have been known to operate for years with a few random short circuits between successive turns in the rotor winding. However, should subsequent periodic impedance testing show the shorting to be progressive in nature, reinsulation would be necessary to assure reliable operation".

The following is an assessment of the activities taken to determine the progressive nature and establish a condition monitoring techniques to give early waring on when reinsulation would be warranted.

Three electric machinery experts were obtained from various companies, other than the original manufacturer, to provide an independent assessment of the as-found condition of the generator rotor. These outside consultants were obtained to augment the site staff evaluation and to provide specific expertese on generators and large rotating machines.

The onsite activity of the consultants included a review of the data from the examination of DG2 and DG1. One of the shorted pole coils from DG1 was dismantled to seek additional information. These consultants provided broad expertese discussion concerning the nature and effects of the deficiencies. They have prepared a written report which is available for review. They also participated in a Supply System conference call including NRC personnel in Rockville, Maryland and Walnut Creek, California on July 11th, to discuss their findings and answer questions.

The root cause determination of the DG1 rotor pole coil shorts determined that the shorts were most likely caused by fabrication defects. The nature of these defects, where localized inadequate wetting of the varnish occurred, produced less than optimum insulation between turns. In other areas, full incapsulation was observed. There was no indication of significant aging deterioration that would lead to additional shorting within the windings.

This conclusion is supported by the lack of significant vibration or increasing field current trends. The extent of the damage is considered to be neglegible and have no impact on the ability of the generator to carry a load at its design rated condition.

A.C. voltage drop test results are pronounced in exposing variation in impedance from even a small number of shorts within the turns of the rotor poles. An EMF is produced within the shorted

turns creating a bucking or opposing flux to the normal field flux during the applied alternating voltage and thus resulting in a significant change in the inductance of the coil causing a voltage balance difference when wired in series with a coil with no shorts. The voltage divides in proportion with the impedance.

During normal operation, the current through the coil is Direct Current and thus the actual variation in field flux during operation of the unit is considered to be negligible and was not detectable during an observation of the generator output waveform and vibration during unit operation.

The diesel generator is demonstrated to be operable annually by the successful completion of a series of integrated surveillance tests. This testing includes fast starts, rapid loading, load rejects, sequential load application and a 24 hour run test. This testing has been completed during this outage for DG2. Due to a scheduling problem, this years testing resulted in greater than 38 hours of operation at equal to or greater than full load operation of DG2.

The unit has also been subjected to an extended run of 72 hours. This testing was accomplished with the unit operating at full load. This testing was followed by another rotor pole A.C. voltage drop test. The results of this test indicated that the voltage values found during the initial examination have not changed which confirm that the shorted turn damage in pole 6 of DG2 is stable.

This JCO establishes that the unit is operable and capable of successfully fulfilling its design function upon demand.

5.0 JUSTIFICATION FOR CONTINUED OPERATION

Summary: This JCO can be summarized by the following general statements.

1. The present condition of the unit is known.
2. The unit has been verified to be capable of performing it's design function in the present condition.
3. The unit condition is not anticipated to change.
4. The unit condition can be monitored using a variety of parameters during operation and will be periodically taken out of service to perform a rotor pole A.C. voltage drop test to trend this phenomenon.
5. The capability of the unit to perform successfully is known for shorted conditions which exceed that of the present rotor condition.

The present status of the Division 2 diesel generator has been determined by internal examination, electrical testing, and operational testing.

The unit successfully completed a series of annual integrated tests which were briefly addressed in the above section. The unit was taken out of service Friday, June 29th, to measure and confirm adequate bearing oil levels, visually inspect the stator end turns and perform rotor pole A.C. voltage drop tests. The bearing oil levels were centered within the minimum and high oil level marks. The stator was found to be in excellent condition. One rotor pole showed indications of some shorting within the coils of the pole. All poles appear to be in good condition physically.

The condition of the rotor pole is considered by site staff and outside consultants to be acceptable with shorted turns as they pose a neglegible effect on the flux field of that rotor pole. The rotor pole A.C. voltage drop test is a good test to indicate the existance of shorts within the rotor pole but does not provide a quantitative assessment of the number of shorted turns within the rotor pole. Due to the flux bucking/opposition nature of the shorted turns, a small number of shorted turns can significantly affect the A.C. voltage drop test. As indicated by D.C. and resistance measurement testing of the DG1 rotor, very little change in these values are noted when significant change in the A.C. pole voltage drop test occurs.

Consultation with industry experts indicates that measurable flux field intensity change is not expected to occur with D.C. operating voltage. This is confirmed by a review of the field current required for full load operation and the vibration levels over the past five years.

To confirm DG2 operability and monitor if propagation of the shorted turns is occurring, the diesel generator was subjected to extended operation during a 72 hour run beginning on Friday July 13th. This test placed DG2 in parallel with the offsite source with the unit loaded to rated load. This test was followed by a rotor pole A.C. voltage drop test. This examination revealed no change in the rotor condition. As anticipated, the A.C voltage drop test results were unchanged.

The generator A.C. output voltage waveform was monitored during the above testing. The purpose was to confirm that there was no deformation of this waveform. A deformation of the waveform may occur as a result of shorted turns within the rotor poles. Pictures of the waveform were obtained and no deformation was discovered.

A further discussion of rotor pole shorted turns is contained in Attachment 1.

The condition of the shorts is stable and not anticipated to change. This was confirmed during the extended run discussed above. The Root Cause for the shorted turns on the DG1 rotor has indicated that these shorts were not causing accelerated degradation of the insulation system beyond the damage site. The rotor poles for DG1 were subjected

to high amperage and voltage (approximately 6 X normal) to locate the shorts. This additional stress did not result in apparent degradation of the insulation outside of the localized area of the discovered shorts.

The condition of the rotor poles on DG2 can be monitored and trended to detect condition change. This JCO proposes a number of parameters which will be monitored during the periodic surveillance of this diesel generator. Additional periodic rotor pole A.C. voltage drop testing will be performed to directly compare the condition of the rotor poles with the data obtained. This condition monitoring activity can adequately detect degrading conditions to allow corrective action to be taken if it is required prior to loss of the generator due to shorted turns.

The following parameters shall be recorded and trended during routine surveillance activities:

1. Field Current. (At established voltage and unit loading)
2. Generator Vibration Levels.

A rotor pole A.C. voltage drop test will be performed quarterly and this data compared to existing data to assess if any condition change is occurring. This data will be trended to assess the rate of change. Some statistical variation in this data base may occur due to normal monitoring data scatter and not be indicative of degrading conditions. The trending data base will be used to confirm a degrading trend and will result in corrective action prior to loss of DG2's ability to perform its safety function.

Some flexability in the condition of the rotor poles, relative to the A.C. rotor pole voltage drop test exists. It is known that the condition can be significantly worse and the unit still be capable of completing its function. The A.C. pole voltage drop test of the rotor poles of DG1 demonstrated that no significant operational effect will occur at pole voltage drop impedance balance ratios of approximately 36% or 23 volts on the shorted pole. This condition was noted on DG1 with no apparent indication of malfunction.

6.0 CONCLUSION

The above arguments support the conclusion that the unit has the capability to support the present operablity requirements of Technical Specification 3/4.8.1, A.C. Sources - Operating. The unit is considered to be operable and capable of providing emergency AC power to fulfill its design function.

Originator/Date

90-215 7/19/90
PQC Mtg. No.

Manager/Date

PQC Chairman/Date

Attachment 1 - Rotor Pole Shorted Turns

The rotor of the Division 1 and Division 2 diesel generators contains 8 poles which are wound using #5 square copper enclosed in double Dacron glass insulation. Each rotor contains 451 turns of this wire. The poles are approximately 43 inches long and the wire is approximately 3/16 inch square.

Minor shorts between turns of rotor poles may result from several different causes. These causes include manufacturing deficiencies, major electrical transients, insulation degradation, and severe overheating.

Examination of the shorted sections of the rotor poles from DG1 have indicated that these shorts occurred during the fabrication process and may have resulted from the inclusion of foreign material betwen adjacent windings. The fabrication of these large poles is difficult. The rotor pole A.C. voltage drop test is a post-assembly test performed at the factory to assure the winding and assembly activity is accomplished successfully. Field rotor condition testing is not a routine periodic test. It was implemented at WNP-2 due to the nature of the cause of the discovered shorted turns within the rotor of the Division 1 diesel generator following the bearing repair effort as a final check after bearing repair.

The Root Cause of the rotor pole shorts for DGI has been determined to be fabrication related.

The effects of shorted turns within the rotor of the diesel generator may include:

1) Severe field coil shorting can reduce the magnetic flux produced by that pole and hence reduce the output voltage generated in the stator coils. The voltage regulator will increase the field current as necessery to maintain the average generator output voltage. Depending on the quantity of shorted turns, this increased field current can result in an increased load on the

excitation system and increased heating in the affected field coils.

2) Shorted turns can cause increased heating within the rotor pole where the shorts exist. This heating will potentially contribute to the acceleration of the localized degradation. This effect does not usually result in a propagation of the failure beyond the localized damage site.

3) The reduced flux at the pole with the shorted turns can result in unbalanced forces across the air gap causing vibration.

The field current required to support generator full load from the WNP-2 design curves is approximately 142 amps. The excitation system is rated to supply 168 amps. This capability exceeds the required amperage and thus the voltage regulator can provide the additional amperage to compensate for shorted turns and still assure adequate generator output voltage. The unit presently requires approximately 135 amps for full load operation. The actual emergency loads are less than the rated load of the diesel generator (less than 86%), which provides additional margin in excitation system capability.

Local and general area heating is not considered to be significantly greater than normal at this time. This heating effect is directly related to the field current. This current is presently less than expected from the regulator design performance curves. This current is not significantly greater than that anticipated.

Examination of the rotor pole coils from DG1 has not found evidence of overheating.

Unbalanced rotor flux values can result in increased vibration levels. The vibration levels of the diesel generator is monitored during periodic surveillances and has not been found to be abnormal. The vibration levels have been found to be minimal during all previous surveillances. Past vibration levels have been reviewed. This data does not indicate a significantly increasing trend. Future vibration levels will be carefully reviewed to determine if an increasing vibration trend is occurring which can be attributed to accelerated rotor pole coil degradation.

SAFETY RELATED **CONTROLLED COPY**

10CFR50.59 EVALUATON PROCESS FLOW CHART

NOTE: The 10CFR50.59 Evaluation implementing processes will typically address items 1 through 4 only and the USQ Analysis would be processed only if required by an affirmative response to question 2, 3, or 4.

	YES	NO
1. Is a change to the WNP-2 Technical Specification necessary to implement this activity?	☐	☒
2. Does this implementing activity constitute a physical change to WNP-2 as described in the FSAR or not in the FSAR and affects nuclear safety in a way not previously evaluated?	☐	☒
3. Does this implementing activity constitute a change to a procedural commitment as described in the FSAR?	☐	☒
4. Does this implementing activity represent a special test or experiment not previously described in the FSAR?	☐	☒

If question 1 is answered YES, then prior NRC approval is required prior to implementation.

If either question 2, 3 or 4 are answered YES, then an USQ Analysis must be performed.

YES (1)

YES (2,3,4)

5. Does the Unreviewed Safety Question Analysis identify the implementing activity as representing an USQ? Refer to Attachment B.	☐ YES	☐ NO

(1,2,3,4) NO

YES

NO

Activity may not be fully implemented without prior NRC staff approval. → NRC Staff Authorization Received → Implement Activity

NOTE: Upon POC approval, partial implementation may occur without prior NRC staff approval.

Prepared by Terry L. Meade Date 7/17/90

Approved by R. P. Vedney Date 7/19/90

Attachment A.

Pole #	120V	60V	30V
6	35.2 36.9	18.76	9.25
5	60.43	30.18	15.24
4	60.24	30.62	15.03
3	59.3	29.97	14.95
2	84.06	42.56	22.20
1	59.84	30.33	15.42
8	59.47	29.61	15.11
7	60.36	30.66	15.48

Tests performed
1/17/90

MAINTENANCE WORK REQUEST

MWR NO: AS8205 (CONTINUATION SHEET) PAGE 11 of

13. Bar the engine over until the next pole is aligned in the same position as the previous pole. This is the position established in step 8.

D Brown / 6/29/90

14. Repeat steps 10 thru 13 until all the pole voltages have been measured.

	voltage	Crankshaft degrees (West side of South Engr.)
Pole 1	59.9	320°
Pole 2	84.1	5°
Pole 3	58.6	50°
Pole 4	60.1	95°
Pole 5	60.0	140°
Pole 6	36.0	185°
Pole 7	60.8	230°
Pole 8	59.6	275°

VOM ID # 41077
Cal due date 10-5-90
(120 VOLT)

VOM ID # 11755
CAL DUE DATE (10-5-90)
(POLE READINGS)

D Brown / 6/29/90

15. NDE TO perform a Bore scope inspection of the generator stator and record on video tape.

/ 6-29-90

16. Terminate the the field leads within the regulator cabinet I.A.W. PPM 1.3.9 determ/reterm sheet.

D Brown / 6/29/90

16. Replace the lower access cover inspection hole covers.

D Brown N/A / 6/29/90

SPARE PARTS/MATERIAL

NO. USED	MATERIAL CODE	NO. USED	MATERIAL CODE	NO. USED	MATERIAL CODE

AS6205

	voltage	crankshaft degree (west side, south engine pad)
Pole 1	N/A	—
Pole 2	N/A	—
Pole 3	N/A	—
Pole 4	36.0	320°
Pole 5	36.14	200
Pole 6 (top)	36.1	185°
Pole 7	36.17	170
Pole 8	N/A	—

METER NO. 1
11754 Due 11-11-90
(120 VOLT SUPPLY)

METER #2
41077 Due 11-5-90
(POLE READINGS)

D Orow 6/29/90

15. Terminate the field leads within the regulator cabinet IAW PPM 1.3.9 determ/reterm sheet.

D Orow 6/29/90

16 & 17. Delete AW

Note

If the lockwashers being re-installed are flat or deformed replace them with new washers

18. Replace the inner housing access covers. Tighten the bolts until the lock washers are flattened. Do not over tighten the bolt.

_____ /