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AUTH. NAME AUTHOR AFFILIATION
VANBRUNT, E. E. Arizona Nuclear Power Project (formerly Arizona Public Serv
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SUBJECT: Submits addl info re status of diesel generator testing, per 870626 telcon.

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June 28, 1987
161-00318 EEVB/JRP

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

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 3
Docket No. STN 50-530 (License No. NPF-65)
Status of Diesel Generator Testing
File: 87-G-056-026

Dear Sir:

On June 26, 1987, a telecon was held between ANPP and the NRC Staff. During the telecon, ANPP described the testing that had been conducted on the Unit 3 B emergency diesel generator and discussed the engine trips that have occurred due to high temperature on the #2 main bearing. At the conclusion of the telecon, the NRC Staff requested that ANPP provide a submittal to document the discussion. The attachment to this letter provides the requested information.

If you have any additional questions on this matter, please contact Mr. W. F. Quinn of my staff.

Very truly yours,

E. E. Van Brunt

E. E. Van Brunt, Jr.
Executive Vice President
Arizona Nuclear Power Project

EEVB/JRP/jle
Attachment

cc: O. M. De Michele (all w/a)
G. W. Knighton
M. Davis
J. B. Martin
R. P. Zimmerman
A. C. Gehr

A047

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EMERGENCY DIESEL GENERATOR 3B - TESTING SUMMARY

SUMMARY TABLE

EVENT	RUN TIME	TRIP	EXPLANATION	GENERATOR LOADS
#1	150 HRS	NO	#9 ROD FAILURE	VARIOUS
#2	40 HRS	YES	#2 BEARING TRIP (AFT)	VARIOUS
#3	25 MIN 1 MIN	NO YES	#2 BEARING TRIP (AFT)	0% 100%
#4	16 MIN 5 MIN	NO YES	#2 BEARING TRIP (FORWARD)	0% 25%

DETAILED SEQUENCE OF EVENTS

Event #1

During the start-up testing phase, the engine was operated at various load combinations. The engine was run at 0% load on the mechanical governor and on the electrical govenor for initial engine, governor and generator check outs. The engine/generator was loaded to various loads during the final stages of start-up and adjustments were made prior to performing the pre-operational tests. These adjustments included loading the diesel generator from no load to 100% and 110% load to verify correct operation of the engine/generator controls. The pre-operational tests consist of various loads while in the test mode and emergency mode. In the test mode, the 24 hour run was performed beginning at 0% load. Each plateau was maintained until temperatures (mainly generator stator) stabilized. The loads were increased in 25% increments to 110%. When 110% load is achieved, the 24 hour run "officially" begins. 110% load is maintained for 2 hours and then the load is decreased to 100% for 22 hours. After the 24 hour run, the 35 consecutive starts were performed. For each of the starts, the engine/generator was loaded to 50% for 1 hour, then shut down. When the engine came to rest, the sequence was repeated. During the integrated safeguards test, the engine is started by an emergency actuation signal (i.e., SIAS, AFAS, or LOP) and automatically loaded by the sequencer to a maximum of 3300 KW which is approximately 60% load. Towards the end of the integrated safeguards test another 24 hour run is performed. This was the section of testing in progress when the #9 connecting rod failed at about 9 minutes into the 110% load run.

Event #2

A new #2 bearing was installed during the engine rebuild after the #9 connecting rod failure. During the initial inspections, it was determined this bearing should be replaced, although it had not failed. Upon completion of the engine rebuild, the engine was started and loaded in steps while monitoring operating parameters. The initial start consisted of a 15 minute run controlled by the mechanical governor (i.e., the generator field not flashed). After visual inspections were performed, the engine was again started on the mechanical governor and after engine operation stabilized, the field was manually flashed to check the operation of the electrical governor. After all adjustments to the controls were completed, the engine was started and run for 2 hours at 0% load. The load was increased in 25% increments and each level was held for 2 hours prior to increasing up to 100% load. After the engine shut down, the crankcase was opened and inspections were made to ensure that no leaks or visual signs of distress were evident. While the engine was still hot, crankshaft web deflection measurements were taken and an internal visual inspection was performed to check for any anomalies, none were found. The engine was then reassembled and gradually loaded to 100%, over a two hour period, and then load was increased to 110% for a two hour period. All engine parameters were reviewed for any anomalies, none were found. The engine was then turned over for the completion of the carry-over testing of 73PE-3PE01 (Preoperational Carryover Testing of the Diesel Generator B System). The first phase of the testing was a 24 hour run. Since the engine had recently completed a 110% load run, the 24 hour run was started at 100% load. The engine was started and gradually loaded to 100% over approximately a 2 hour period. At 22 hours into the run, the load was increased to 110% to finish the last 2 hours. Upon completion of the 24 hour run, the engine was stopped. Approximately 2 hours later the initial start for the 35 consecutive starts test was performed. The engine was started and the load brought up to 100% within 1 minute. About 2 minutes after reaching 100% load, the engine tripped on main bearing high temperature. At this time, total engine run time was about 40 hours with approximately 33 hours at 100% load or greater.

Action Taken After 1st Engine Trip on High Bearing Temperature

The journal, bearing and bearing cap were inspected for signs and causes of overheating. None were found. It was noted that the journal surface had been factory repaired via a metal spray process. The eutectic temperature detector had only partially actuated. Specifically, it had cooled before fully actuating which suggests that a temperature transient had melted the eutectic, but that it was rapidly cooled. The eutectic was taken to the lab and heated to verify the 228 degree F set point. The eutectic tripped at 233 degrees F. The second eutectic from the #2 main bearing was heated for purposes of a comparison. It actuated between 233 and 234 degrees F. With no indication of anything more than a transient temperature spike, the #2 main bearing was reassembled with a new upper and lower bearing shell and two new eutectic trip devices. Bearing clearance was verified to be .009". The allowable tolerance is .008-.012".

Event #3

After installation of this bearing, the engine was started and run at 0% load for 15 minutes. The engine was then shut down and the #2 inspection door was removed for a visual inspection on the #2 main bearing area. No abnormal conditions were observed. The inspection door was replaced and the engine was started. Preparations were made to load the generator to 100%. After about 10 minutes of running at 0% load, the engine was quickly (35-40 seconds) loaded to 100%. One minute and 7 seconds later, the engine tripped. Subsequent investigation revealed that the aft eutectic temperature detector on the #2 main bearing had tripped the engine. Total engine run time was about 26 minutes, with 1 minute at 100% load. The Cooper field representative had agreed with the above mentioned loading sequence.

Action Taken After 2nd Engine Trip on High Bearing Temperature

The home office representative was notified and was requested to bring the necessary tools to check the journal. The bearing was removed and was visually inspected. When the vendor arrived, the journal was inspected and blued to test for straightness and any other indications of a problem. A small nick (1/8-3/16") was observed on the journal. Blueing of the journal showed that the nick was not protruding above the surface of the journal. It was also noted that the journal surface was slightly rougher than desired. The bearing cap was inspected for straightness across the mating surfaces of the cap. A few small burrs and scrapes were noted that could be contributors to the problem.

The nick on the journal was "dressed" with an oil stone and dimpled to ensure that it was below the surface of the journal. The entire journal was then polished with 400 grit emery cloth. After the journal was polished with emery cloth, it was cleaned with mineral spirits and a clean cloth. Then the journal was again polished with crocus cloth. The final cleaning of the shaft was done with mineral spirits and a non-metallic stiff bristled brush. The shaft was then air dried with compressed air. The burrs and scrapes on the bearing cap were stoned to ensure that they were flush with the mating surface.

Two magnetic base dial indicators were put in place and the runout was measured on the journal at the position that the bearings made contact. The forward end measured .002" and the aft end measured .003". The engine was reassembled using the same upper bearing shell that was previously installed and a new bearing shell on the lower half. After assembly, the bearing clearance was measured to be .010". After reassembly, the eutectic temperature detector was removed from the #3 main bearing, forward position. It was reinstalled in #2 main bearing, forward position. The modified temperature sensors were used in the #2 main bearing, aft position, to monitor bearing temperature. A temperature sensor was also installed in the #3 main bearing, forward position, to be used as a comparison. Just prior to running the engine, the crackcase door was removed at #2L to observe oil flow from the lube oil header to the bearings, rods and pistons. Oil flow appeared to be satisfactory.

Event #4

With a new lower bearing shell installed, the engine was started and run at 0% load for 16 minutes. The load was increased to 25%. After about 10 minutes at 25% load, the load was being increased to 50% when the engine tripped. The engine trip was due to high bearing temperature from the #2 main bearing, forward eutectic temperature detector.

Action Taken After 3rd Engine Trip on High Bearing Temperature

The post trip inspection revealed that the trip had occurred on #2 main bearing forward detector, even though the chart recorder which was on the aft position did not indicate a high bearing temperature. Dial indicators were positioned to monitor the vertical downward movement of the shaft when the bearing cap was removed. As the cap was lowered, no movement of the shaft was observed. The temperaure sensors were removed and tested for a possible error in the readings. It was discovered that the sensors lagged the true readings by approximately 40 degrees F, during rapid transients, due to the epoxy used to position the thermocouple in the sensor. Both the upper and lower bearing shells were removed for inspection.

A new lower shell bearing has been installed. The #2 main journal area has been polished using the following sequence:

1) Polished entire bearing area in both directions using a 400 grit emery cloth.

2) Polished entire bearing area in the direction opposite of crank rotation using a 500 grit emery cloth.

3) Scrubbed entire bearing surface using a fine scotch brite pad.

4) Polished entire bearing area in the direction opposite of crank rotation using crocus cloth.

5) Scrubbed entire bearing surface using a stiff non-metalic brush, fels naptha soap and water. Wiped away soapy residue using a lint free cloth.

6) Washed surface with a lint free cloth and clean mineral spirits. Blow dried using 50PSI/70PSI filtered air.

7) Checked finish to 16/32 micron finish.

8) Following a check of finish with a 20X power microscope, "Touched-Up" scratched areas with a new piece of crocus cloth and rewash with lint free rag and mineral spirits. Air dried as in Step 6.

Initial Break-in Run of the #2 Bearing

#2 main journal bearing will have both the eutectic bearing sensors removed. Thermocouples will be reinstalled and connected to a chart recorder. One side of the #3 main journal bearing will also have a thermocouple installed. The chart recorder will provide a record of the actual bearing temperatures. The maximum #2 main bearing temperature to be allowed during the break-in run will be 260°F.

The engine will be loaded during the initial break-in run of the #2 bearing as follows:

1) Run engine at approximately 400 rpm unloaded for 2 hours and until bearing temperature stabilized.

2) Increase engine to 608 rpm unloaded for 1 hour and until bearing temperature stablized.

3) Load engine to 25% for 30 minutes and until bearing temperature stabilized.

4) Increase load to 50% for 30 minutes and until bearing temperature stabilized.

5) Increase load to 75% for 30 minutes and until bearing temperature stabilized.

6) Increase load to 100% for 30 minutes and until bearing temperature stabilized.

7) Decrease load to 0%, allow engine to run unloaded for at least 5 minutes.

8) Load engine to 100% within 1 minute. Maintain 100% load until bearing temperature stabilized.

9) Shut down engine.

10) Restart and reload engine to 100% until bearing temperature stabilized.

11) Shut down engine.

The data from the break-in run will be evaluated as to what maximum temperature value will be used for the #2 bearing. If a temperature other than the standard 228°F eutectic is used, a trip mechanism (automatic or manual) will be utilized for the break-in run and all following runs until a eutectic of the new value can be obtained.

BEARING ANALYSIS REPORT

Event #1

Heavy scratching and wiping. Alloy smearing is evident over a large portion of surface. No copper was visible, except at bottom of a few scratches, bearing not failed.

Event #2

Moderate wiping and scratching of babbitt overlay. Some overlay has been smeared toward the notched parting line.

Event #3

Minor wiping and scratching. Some overlay has been smeared toward the notched parting line. A few score lines have reached the bronze layer.

Event #4

Moderate wiping and scratching. A few score lines have reached the bronze layer.

General Comments

The wear pattern on each bearing was uniform indicating good journal geometry and proper bore/shaft alignment. The scratching noted is typically indicative of poor shaft finish problem or contaminated (or dirty) oil. The smearing/wiping of overlay indicates that shaft to bearing contact did occur and denotes oil film degradation due to loading conditions, oil contamination, or poor shaft finish. Analytical studies of this engine show loading conditions to be moderate for this bearing design. Extraneous debris was not found embedded into the soft babbitt overlay and oil analysis did not indicate inordinate particulate counts which therefore precludes the dirty oil theory.

With the above conditions noted, prime emphasis must be placed on the finish of the journal. The journal was "cleaned up" between bearing #3 and #4, however, proper refinishing techniques were not used and may have further distressed the journal surface which was previously distressed during the December 23, 1986 shutdown of this engine.

It is CLEVITE's opinion that those bearings have not failed. Each has seen distress ranging from minor scratching to alloy smearing and scoring, however, due to the babbitt overlay's conformability characteristics, self-healing of this distressed surface could most likely have taken place.

Whenever a bearing is removed for inspection it is this manufacturer's recommendation to replace that bearing with a new one. Each new bearing is installed in its unique "position" relative to the housing bore and its mating crankshaft journal and must conform to its assembly in its own unique way. Reinstalling a used bearing may produce a bearing/shaft assembly different than the initial assembly; this is due to the tolerance stack-up and inherent difficulties experienced in field assembly.

When a new bearing is replaced it is highly recommended that the journal is refurbished to new crankshaft specifications. Proper reconditioning of this journal should include polishing to an acceptable finish and cleaning of the shaft surface making certain all pores are debris free. The manufacturer also recommends that a bearing assembly remain undisturbed after initial installation. This again relates to the conforming of the bearing to the shaft plus the reassembly anomalies inherent in field rebuilds.