Arizona Nuclear Power Project
P.O. BOX 52034 • PHOENIX, ARIZONA 85072-2034

September 13, 1985
ANPP-33461-TDS/TPS

U. S. Nuclear Regulatory Commission
Region V
1450 Maria Lane - Suite 210
Walnut Creek, California 94596-5368

Attention: Mr. D. F. Kirsch, Acting Director
Division of Reactor Safety & Projects

Subject: Final Report - DER 85-24
A 50.55(e) Reportable Condition Relating To Broken Diesel Generator Turbocharger Bolts
File: 85-019-026; D.4.33.2

Reference: A) Telephone conversation between R. C. Sorensen and T. P. Siegfried on June 6, 1985
B) ANPP-32974, dated July 10, 1985 (Interim Report)
C) ANPP-33205, dated August 15, 1985 (Time Extension)

Dear Sir:

Attached is our final written report of the Reportable deficiency under 10CFR50.55(e), referenced above. The 10CFR21 evaluation is also included in this report.

Very truly yours,

E. E. Van Brunt, Jr.
Executive Vice President
Project Director

EEVB/TPS/nj

Attachment

cc: See Page Two

IE-27

cc: Richard DeYoung, Director
Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

J. G. Haynes
D. B. Karner
W. E. Ide
D. B. Fasnacht
A. C. Rogers
L. A. Souza
T. D. Shriver
D. E. Fowler
C. N. Russo
J. R. Bynum
J. M. Allen
D. Canady
A. C. Gehr
G. A. Hierzer
W. G. Bingham
R. L. Patterson
R. W. Welcher
H. D. Foster
D. R. Hawkinson
R. P. Zimmerman
M. L. Clyde
B. T. Parker
T. J. Bloom
J. D. Houchen
D. N. Stover
J. E. Kirby

Records Center
Institute of Nuclear Power Operations
1100 Circle 75 Parkway, Suite 1500
Atlanta, Georgia 30339

FINAL REPORT - DER 85-24
DEFICIENCY EVALUATION 50.55(e)
ARIZONA NUCLEAR POWER PROJECT (ANPP)
PVNGS UNITS 1, 2, 3

I. Description of Deficiency

Workers observed that the head of a turbocharger support bolt had been sheared off on the Unit 2 Train B diesel generator. A check of the Unit 2 Train A diesel revealed that two bolts had vibrated loose and backed out of the holes. Loose bolts were also discovered in both trains in Unit 1 when examined, fractures were found. The bolts in Unit 1 have been replaced with A-193, Grade B7 full thread studs and A-194, Grade 2H nuts under Work Authorizations 87104 and 87109.

Evaluation

The diesel generator (D/G) provides emergency power to equipment required for safe plant shutdown in the event of loss of preferred power. Two D/G sets (Train A, Train B) are provided per plant. The turbocharger is located at the forward end of each diesel engine. Engine exhaust gases drive a turbine which in turn drives an air compressor that draws combustion air in, compresses it, and forces the air into the combustion cylinders.

The turbocharger is mounted on a support bracket which is attached to the engine by eight 5/8" x 11 x 1¼" bolts in the vertical plane and six 5/8" x 11 x 1¼" bolts in the horizontal plane (see attached drawing, item 2). The bolt material is SAE J429, Grade 5. NCR SM-5849 states that bolts in the vertical support member on both trains of the Unit 1 and 2 diesels have either been sheared off or vibrated loose and fallen out.

The vertical bolts in question (eight bolts, three of which have failed on each unit) are installed for seismic reasons only. Cooper Energy Services (CES), the vendor, has reviewed the seismic study conducted on the turbocharger support bracket and determined that six bolts out of the eight bolt pattern could fail before seismic integrity would be compromised (Reference 1).

However, the eight bolts are of the same material and stressed in the same manner, therefore, the eight bolts may all be subject to failure which will compromise diesel generator operability.

The root cause of the bolt failure is attributed to fatigue due to engine vibration as discussed in Reference 2 (attached). The low pre-stress specified for the bolts provided clamping forces which were insufficient to prevent bolt fatigue failure due to vibratory loads.

II. Analysis of Safety Implications

Based on the above evaluation, it is concluded that the condition is Reportable under 10CFR50.55(e) and 10CFR21, since it is a generic design defect, which if left uncorrected would constitute a significant safety hazard. This report addresses the reporting requirements of 10CFR21.21(b)(3) with the exception of subpart (vi), regarding the number and location of such components supplied to other facilities. A copy of this evaluation will be sent to CES for their information.

III. Corrective Action

The existing SAE Grade 5 bolts are to be replaced with longer ASTM A-193, Grade B7 full threaded studs and A-194, Grade 2H nuts. The torque value is to be increased to 110 ft/lbs., which will increase the pre-stress and eliminate vibratory loads. DCPs 20M and 30M-DG-049 have been issued to perform this work on Units 2 and 3. Bechtel calculation 13-CC-ZQ-M01 verifies that 110 ft/lbs. is adequate for this application and has been confirmed by ANPP surveillance procedure 73TI-1DG01. Unit 1 has been corrected under Work Authorizations 87104 and 87109. Work on Units 2 and 3 to be completed prior to fuel load.

CES has been informed of the change in fasteners and material (References 1 and 3). They approved the use of Grade B7 studs as long as they are of equal or greater strength than Grade 5. Grade B7 studs have a yield strength of 105 KSI while Grade 5 has a yield strength of 92 KSI. Studs of Grade B7 are suitable for high temperature use.

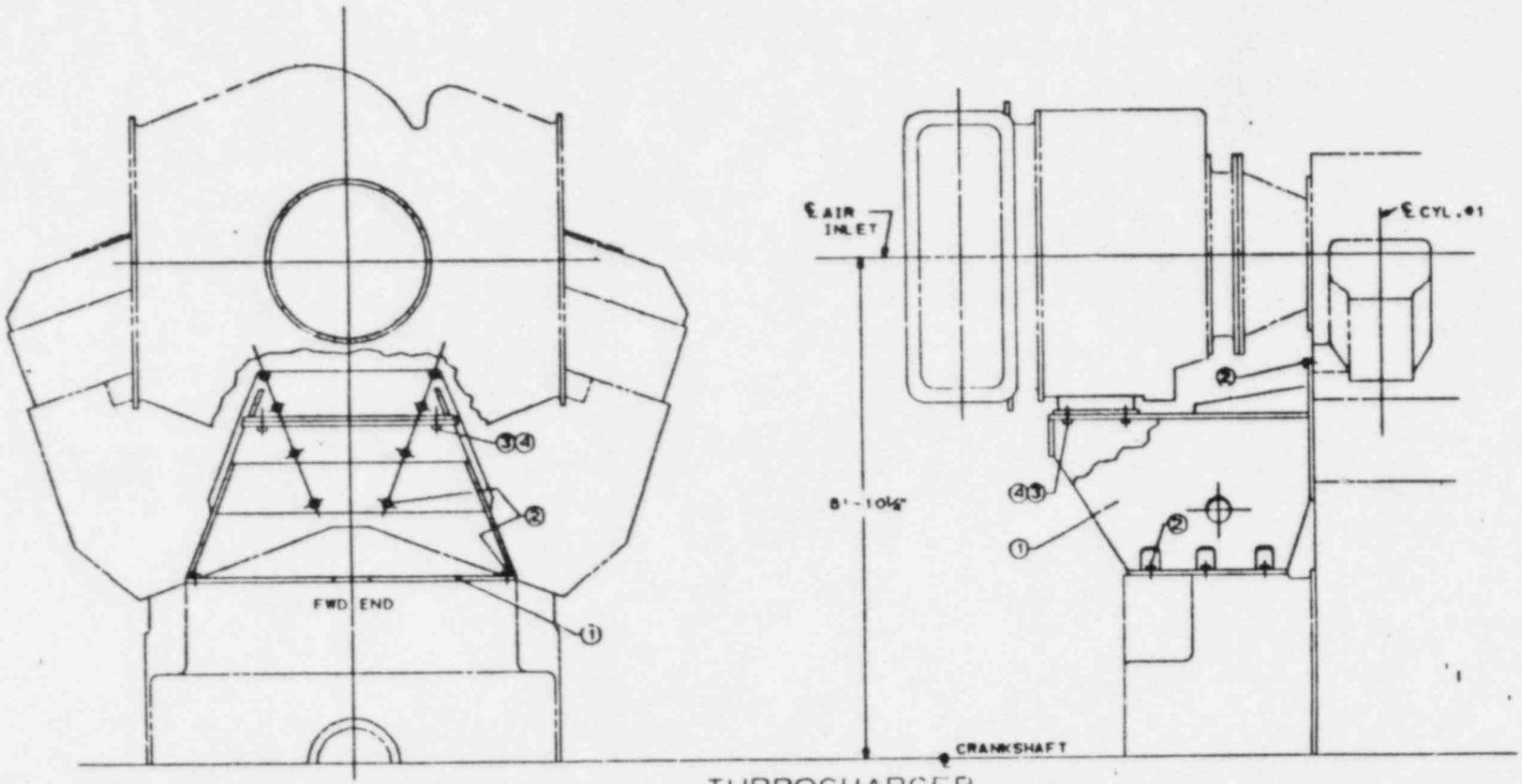
IV. References

1. Cooper Energy Services letter, CES No. 493, June 27, 1985, MIC 245674.

2. APS Memo PVNGS-WMS-M85, May 21, 1985

3. Telex BT/CES-E-6923, August 26, 1985

REQ'D	NAME	PART#	MAT'L	REMARKS	ITEM
1	SUPPORT	KSV-69-6A	STL	CRITICAL	1
14	BOLT $\frac{5}{8}$"-11 X 1½	1-01H-001-040-012	STL		2
4	BOLT 1"-8 X 2½	1-01F-001-100-024	STL		3
4	WASHER	W10A-1#127	STL		4



TURBOCHARGER SUPPORT

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ATTACHMENT

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Arizona Nuclear Power Project
PVNGS-WMS-M85-018

Prepared by: D E Sachs
Signature
Name/Ext./Sta. D. E. Sachs/6557/6077

Reviewed By:
Signature
Name/Ext./Sta. D. E. Hansen/6564/6077

Approved by: William M. Simko
Signature
Name/Ext./Sta. W. M. Simko/6555/6077

DATE: May 21, 1985

TO: L. G. Papworth
Sta # 6075
Ext. 6536

SUBJECT: Failure of Unit 1 Diesel Generator Turbocharger Mounting Bolts (EER-85-DG-028)

File: 85-157-419

On 5/15/85, several of the subject fractured bolts were visually examined and hardness tests were performed. This was done in order to determine why the bolts failed.

The bolts were 5/8" dia., 11 threads per inch (UNC), 1½" long SAE grade 5. Two of the bolts had fractured in the root of the first thread, very close to the underside of the bolt head. Two other bolts had fractured approximately 3/4" from the underside of the heads.

The hardness tests revealed that the bolts met the required values of Rockwell "C" 23-32. Actual hardness was RC 27-28.

None of the fractured surfaces revealed signs of brittle fracture. Rather, they had a very smooth appearance typical of fatigue cracking. Further, evidence of fatigue crack arrest lines (beach marks) were observed on the two bolts that had cracked close to the heads. At least 75% of the fractured area was fatigue cracked, with the remainder typical of a ductile overload. The cracking pattern is typical of a low nominal stress with medium-to-high stress concentration, when compared with drawings of fatigue fracture appearance in the American Society for Metals Handbook. The high stress concentration is caused by the threads.

The recommended fix for this problem is to take the usual steps to reduce or eliminate fatigue cracking conditions, without introducing any new detrimental factors. Two of the recommendations are similar to those used for the successful modification to the RCP diffuser bolt problem of 1983.

Specifically, the following should be done:

1. Upgrade the material from SAE grade 5 to ASTM A-193 grade B7 or SAE grade 8.

2. Use studs instead of bolts to assure full thread engagement of the engine's cast iron threads.

3. Increase the length of the studs or bolts. The present length of 1½" is rather short for a 5/8" dia. bolt. The plate which is clamped by the bolts to the engine is approximately 5/8" thick, which is also

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ATTACHMENT

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rather short for the maintenance of preload when using a 5/8" dia. bolt. This distance should be doubled or tripled.

4. Increase the torque value to at least 110 ft. lb. from the original 50 ft. lb. The original preload was only approximately 26 ksi, or 29% of the SAE grade 5 min. yield strength of 85 ksi. This value is very low, and it allows the stress on the bolt to vary considerably. It is the variance of the stress that results in fatigue fractures, rather than the maintenance of a relatively high uniform stress via high preload. A torque of 110 ft. lbs. will result in a preload stress of approximately 58 ksi if the threads are lubricated. This is 55% of the min. yield strength of B7 material, and 48% if SAE grade 8 is used.

As of now, the actual preload required to prevent any of the bolts from loosening is unknown. The bolts will therefore require periodic checking on a frequent basis (after several hours of running, then after several days) until it can be determined that they remain tight. The tightening torque can be increased considerably (to 200 ft. lb.) if loss of bolt preload is experienced at the 110 ft. lb. level.

The source of the changing stresses on the bolts are believed to be from engine vibrations, rather than from differential thermal expansion.

The use of the above recommendations is expected to prevent future bolt/stud cracking.

WMS/DBH/DES/ds

cc:

J. R. Bynum	6125
O. J. Zeringue	6130
R. K. Nelson	6310
J. E. Kirby	6249
A. C. Rogers	4054
P. L. Brandjes	6234
R. Randals	Bechtel
J. W. Tills	6310
J. V. Crews	6296
C. P. McNemar	6296
R. P. Indap	6296
R. A. Kropp	6077
C. D. Mackaman	6077