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

March 6, 1986
ANPP-35459-EEVBJr/LAS/DRL-92.11

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 and Projects
Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, 3
Docket Nos. 50-528, 529, 530

Subject: Final Report - DER 85-39
A 50.55(e) and 10CFR21 Condition Relating to
NSSS Pipe Stop Bolting Material Does Not
Meet Minimum Hardness Requirements for ASTM
File: 86-019-026; D.4.33.2

Reference: (A) ANPP-34232, dated December 12, 1985 (DER 85-39 Interim Report)
(B) ANPP-34396, dated January 3, 1986 (DER 85-39 Time Extension)
(C) ANPP-34664, dated January 16, 1986 (DER 85-39 Time Extension)
(D) ANPP-35127, dated February 14, 1986 (DER 85-39 Time Extension)

Dear Sir:

Attached, is our final written report of the subject deficiency which has been determined to be not reportable under 10CFR50.55(e) and 10CFR21.

Very truly yours,

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

EEVBJr/DRL/ldf

Attachment(s)

cc: See Page 2

IE-27

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

A. C. Gehr (4141)
R. P. Zimmerman (6241)

Records Center
Institute of Nuclear Power Operations
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FINAL REPORT - DER 85-39
DEFICIENCY EVALUATION 50.55(e)
ARIZONA NUCLEAR POWER PROJECT (ANPP)
PVNGS UNITS 1, 2, 3

I. Description of Deficiency

While preloading the saddle studs of the NSSS A and B pipe stops in Unit 2 per EER 85-RC-180, four 2-¼" diameter 8 UN 2A x 14" studs elongated such that the threads deformed and the nuts could no longer be threaded on the studs. The required preload for these studs was 300 kips. The deformation of the threads occurred at approximately 200 kips. These studs were specified as ASTM A540 Grade B23 Class 2 material. As a result of the excessive elongations, tests were performed to determine the stud material and strength.

A. MATERIAL DEFICIENCY

A total of 77 of 123, 2-¼" diameter 8 UN 2A x 14" studs, supplied by Ametek-Straza for use in the Units 2 and 3 NSSS A and B pipe stops, did not meet the hardness requirements of ASTM A540 Grade B23 Class 2 material. These studs were supplied to Ametek-Straza by Southern Bolt and Fastener Corporation. Of the 123 studs, 64 studs had been installed in the Unit 2 NSSS A and B pipe stops. Forty-five of the 64 studs installed in Unit 2 had hardness values less than the required minimum value. A total of 32 studs not yet installed, but intended for the Unit 3 NSSS A and B pipe stops, had hardness values that did not meet the ASTM requirements. Thirty of these 32 studs had hardness values less than that required and two had hardness values exceeding the maximum value allowed for Grade B23 Class 2 material.

Hardness tests were performed on the 2-¼" diameter 8 UN 2A x 14" studs installed in the Unit 1 NSSS A and B pipe stops. These tests identified additional studs that did not meet the specified hardness requirements. The deficient studs in Unit 1 were replaced with studs from the warehouse that had been accepted based on Equotip hardness testing. During installation, four of these replacement studs yielded. The studs yielded in the threaded length, deforming the threads such that the nut could not be threaded. Additional replacement studs were then obtained from Unit 2, which met hardness requirements.

Additional hardness testing performed in the warehouse on material supplied by Southern Bolt for use in other Unit 3 NSSS pipe stops, identified 55 of 100 studs of various diameters that did not meet hardness requirements.

During the retensioning of studs on other pipe stops, additional studs yielded.

B. INSTALLATION DEFICIENCY

During the replacement of the deficient studs in the Unit 1 A and B pipe stops, it was discovered that not all of the studs were preloaded to the specified value. A review of the installation data for all of the NSSS

pipe stops revealed that studs on other pipe stops had also been inadequately preloaded.

A subsequent review of the installation data for the reactor vessels, steam generators, reactor coolant pumps, safety injection tanks and pressurizers for Units 1, 2 and 3 revealed that a majority of the anchor bolts and studs were preloaded to a value less than specified.

C. DOCUMENTATION DEFICIENCY

During the review of Purchase Orders 13-CM-125B with Ametek-Straza and 13-CM-125 with Marathon Steel for A540 bolting material, documentation deficiencies were discovered. NCRs CC-5311 and CC-5312 were initiated to address these deficiencies with Ametek-Straza and Marathon Steel, respectively.

EVALUATION

A. MATERIAL DEFICIENCY

An evaluation of the material strength required for the studs used in the A and B pipe stops determined that the material strength required could be less than that of the ASTM A540 Grade B23 Class 2 material. Based on the reduction in required strength, it was determined, using a Equotip hardness tester, that

a) Thirty-five of the 64, 2-¼" diameter studs installed in the A and B stops in Unit 1 were unacceptable.

b) Thirty of the 64, 2-¼" diameter studs installed in the A and B stops in Unit 2 were unacceptable.

c) Twenty-one of 59, 2-¼" diameter studs, that were stored in the warehouse, but intended for use in the A and B stops in Unit 3, were unacceptable.

The two studs that had hardness values greater than the allowable for Grade B23 Class 2 were acceptable as Grade B23 Class 1 material.

Twenty-nine studs, that were determined to be unacceptable based on Equotip testing, were further tested in a lab to verify compliance with the ASTM A540 Grade B23 Class 2 requirements. Twenty studs were not in compliance. Nine studs were acceptable. The studs that failed did not meet hardness and strength criteria. All studs met chemical requirements.

All 35 deficient studs in the Unit 1 A and B pipe stops were replaced. It was determined in the lab that the replacement studs from the warehouse that yielded during installation had been locally hardened at

the end when the studs were cut to length with a grinder. Note that without proper end preparation, the hardness of the stud would have not been measured correctly regardless of the test method used (Equotip, Rockwell, etc.). The studs that yielded during installation on the A and B stops and on other Unit 1 stops were replaced with studs that were able to resist the preload without yielding.

A further evaluation of the material strength required for the studs used in the pipe stops determined that if the stud did not yield as it was being preloaded, the stud was acceptable. The preload specified for these studs is greater than any load that the stud would be subjected to during the plant life. Therefore, if the stud is able to resist the applied preload, it has in effect been load tested and is acceptable. Note that the sheer load at the connection is resisted by the friction in the connection and that the preload in the studs provides sufficient clamping force to develop the required friction.

A review for ASTM A540 bolting material of Purchase Orders 01-CM-125A with Cal-Pacific Fabricating and 13-CM-125 with Marathon Steel, under which all material for NSSS support anchor bolts was supplied, revealed that only 88 NSSS anchor bolts were supplied by Southern Bolt.

Sixteen of these 88 ASTM A540 bolts were used as anchor bolts for the pressurizers and 72 were used as anchor bolts for the safety injection tanks. It is not known in which unit the bolts were used, however, the review of the installation data for the pressurizers and safety injection tanks of all three units did not reveal any evidence of material problems. All high strength ASTM A540 bolts that are specified on Bechtel Engineering drawings and all ASTM A540 studs in the pipe stops are preloaded. As discussed above, the bolts and studs, if able to resist the preload, have in effect been load tested and are acceptable.

In the review of the installation data for the NSSS supports, one steam generator forging anchor bolt in Unit 1 appreared slightly abnormal. The nut for one ASTM A540 forging A anchor bolt for Steam Generator No. 1 could not be threaded when the bolt was elongated. It was decided to shim the nut such that the bolt had the required elongation and therefore, the required preload. The cause of the threading problem was not determined at the time of installation, however, it was known at the time that some of the anchor bolts had flattened threads. This could have caused the problem. For the purpose of this evaluation, it was assumed that the bolt may have yielded. Due to the reduction in final preload required, this bolt is not needed to resist the forces applied to the forging and would be acceptable without the preload (see Evaluation of Preload Requirements in Section B, Installation Deficiency). In reality, the bolt is supplying the preload at which it was anchored. Other bolts that exhibited threading problems were evaluated as providing the preload at which they were anchored.

A further review of purchase orders revealed that Bechtel placed only one direct order for bolts from Southern Bolt. That was in 1979 for 112 SA193 Grade 7 bolts used for the non-safety related butterfly valve flanges in the Unit 1 Turbine Building. These bolts were preloaded when

installed, and therefore, have been load tested and are acceptable. ANPP has not placed any direct order for bolts from Southern Bolt.

Bechtel audits of Ametek-Straza from 1979 to 1985 confirmed that an effective Quality Assurance program was in-place and adequately implemented. ANPP Vendor Quality reviewed the Bechtel audit reports and evaluated the Ametek-Straza QA Program and found them sufficient for documentation attesting to the establishment and promulgation of an effective Quality Assurance Program satisfying contract requirements.

Ametek-Straza, per their QA Manual, qualified Southern Bolt as a supplier based on the two Quality System Certifications (N-1582 Material Manufacturer and N-1583 Material Supplier) issued to Southern Bolt in 1976. These certifications were renewed in 1979 and expired in 1982. The Certified Material Test Reports (CMTR's) supplied by Southern Bolt and received with the material at the jobsite did certify that the material met specification requirements. There was, therefore, no reason to question the material prior to experiencing installation difficulties. (Because of the installation deficiency addressed in this DER, the material deficiency of the pipe stop studs was not detected during the initial installation.) See Attachment 2 for a QA Summary concerning the Ametek-Straza QA Program.

The root cause of the material problem has been determined to be the inadequate heat treatment of the studs by the supplier. This has been confirmed by laboratory tests.

B. INSTALLATION DEFICIENCIES

The root cause of the installation deficiency was attributed to using the bolt elongation as a measurement of preload combined with the movement of the reference surfaces during the application of the preload. Therefore, the elongations recorded during installation were not necessarily true bolt elongations, but a measurement of the relative movement of the dial indicator and the end of the bolt, i.e., the connection surfaces may not have been tightly clamped together prior to the preloading of the bolts and the dial indicator may have been mounted on a surface subject to movement. The installation procedures also failed to provide a preloading sequence or a preload check.

The inadequate preload of the anchor bolts and studs of the NSSS pipe stops is addressed and resolved in EER 85-RC-203 interim resolutions.

Due to the material and installation deficiencies, the adequacy of the preload was evaluated based on actual lift-off data using a hydraulic tensioner or nut rotation using a calibration wrench. Based on this data, it was determined that either the bolts and studs were adequately preloaded or they were retensioned.

The existing preloads in the anchor bolts and studs of the NSSS equipment were calculated using the data obtained from the Special Construction Inspection Plans (SCIP) used to install the bolts and studs. The installation data for the bolts and studs tensioned with a hydraulic tensioner includes the hydraulic ram pressure, the bolt elongation at pressure and the residual elongation when the hydraulic pressure was relaxed.

With the exception of the reactor vessel column pad studs and the steam generator skirt to sliding base studs, the preloads of the bolts and studs were determined to be the hydraulic pressure recorded times the hydraulic ram area times the ratio of the released elongation divided by the elongation at pressure. This method was used because it was determined that the recorded elongations may not be true bolt elongations. However, it is valid to estimate the preload in the bolt by the ratios of the elongations times the force actually applied to the bolt.

This method of estimating the anchor bolt preloads was shown to be adequate and valid in Calculation 13-CC-ZC-360, preloaded NSSS Studs and Bolts. At the request of the NRC, calculations were performed using the installation data of the Unit 1 NSSS pipe stop SCIP's, to estimate the existing anchor bolt preloads. These estimated values were then compared to the actual lift-off data recorded at the direction of EER 85-RC-203. This comparison proved the method to be satisfactory. See NRC Report No. 85-42, dated January 7, 1986. Also see Attachment 1 of this report for a summary of this comparison.

The Unit 1 SCIP data for the NSSS pipe stop anchor bolts was reviewed to identify those anchor bolts that were preloaded by a 'turn of the nut' method. The lift-off data recorded at the direction of EER 85-RC-203 for these bolts was then reviewed in order to judge the adequacy of this method of preloading anchor bolts. It was determined by this review that the preloads of the anchor bolts tensioned by the 'turn of the nut' method are adequate. Note that the 'turn of the nut' method as discussed herein, is defined as using nut rotation to achieve a required elongation. (Reference Calculation 13-CC-ZSC-360, Preloaded NSSS Studs and Bolts.)

The actual preload of the reactor vessel column pad studs and the steam generator skirt to sliding base studs was determined, based on the residual elongation of the stud and the effective length of the stud. It was determined that the recorded stud elongations for these connections were valid as there would not be any relative motion in the connection as the bolts were preloaded. The dead weight of the reactor vessel or steam generator had tightly clamped the connection before the bolts were preloaded.

The preload requirements for the anchor bolts and studs of the NSSS equipment were reevaluated. The preloads originally specified on the drawings were based on Combustion Engineering's generic seismic analysis. Using seismic loading from the site specific seismic analysis, which had

been subsequently done, it was possible to reduce the preload requirements. Bechtel Engineering, using Revision 4 of IR-90, the NSSS Interface Requirements Document supplied by Combustion Engineering, was able to reduce the preload requirements of the anchor bolts for whose design Bechtel was responsible. The calculated preloads of bolts and studs, for whose design Combustion Engineering was responsible, were transmitted to Combustion Engineering for evaluation. It was determined by each that the existing preloads in the bolts and studs were adequate to meet design criteria.

Bechtel Construction reviewed the procedure utilized during the initial bolt tensioning to determine if any problems reported are transportable to other installations on the project. The review indicates that the problem is limited to those bolt tensioning applications made using the Pilgrim hydraulic stud tensioner for bolt elongation and is not transportable to other installations. The basis for this conclusion is as follows:

1) The reported problem addresses bolt preloads resulting from the use of a Pilgrim hydraulic stud tensioner for bolt elongation. The use of these methods is limited to the NSSS component supports and pipe stops.

2) Bolt tensioning, using a stud tensioner supplied by Combustion Engineering or General Electric, was performed using internal mechanical extensometers to verify bolt elongation rather than external dial indicators as was used on the NSSS component supports and pipe stops.

3) The bolt tensioning methods used in conjunction with the Pilgrim hydraulic stud tensioner and bolt elongation verification utilizing dial indicators are summarized on a discrete set of Special Construction Inspection Plans. These SCIP's were all prepared during the same time frame and consistent areas of concern have been noted throughout the SCIP's. These SCIP's and the methods described are unique on the project.

C. DOCUMENTATION DEFICIENCIES

NCR's CC-5311 and CC-5312 will resolve the documentation deficiencies that are discrepancies between the number of bolts received and the number of bolts reported on the CMTR's.

II. Analysis of Safety Implications

The condition of the NSSS pipe stops, as identified in this DER, is not safety significant based on the NRC exemption of the requirement for the pipe stops as documented in letters from G. W. Knighton, NRC, to E. E. Van Brunt, Jr., ANPP, dated November 22 and 29, 1985. Note that sufficient preload existed in the pipe stops for normal plant operation

and seismic conditions. Also note that, per Bechtel and Combustion Engineering evaluation and concurrence, the NSSS supports and anchor bolts have sufficient preload to meet design requirements.

Based on the above, this condition is evaluated as not reportable under the requirements of 10CFR50.55(e), since if this condition were to remain uncorrected it would not represent a safety significant condition. This project also has evaluated this condition as not reportable under 10CFR21.

Since there is some indication that the material deficiency could be a generic problem throughout the nuclear industry, it may be reportable under 10CFR21 by Southern Bolt and Fastener Corporation. A copy of this report will be sent to Southern Bolt for their use in evaluating reportability.

III. Corrective Action

A. MATERIAL AND DOCUMENTATION DEFICIENCIES

The corrective actions, required to preclude the recurrence of the material and documentation deficiencies, have been addressed in DER 84-41. Note that the Ametek-Straza and Marathon Steel material addressed in this DER and NCR's CC-5311 and CC-5312 were received prior to the issuance of DER 84-41. Had the material been received after the corrective actions of DER 84-41 had been initiated, user's tests conducted during Bechtel receipt inspection would have identified material deficiencies. Note that Specification 13-PM-414 will be modified in Revision 1 (forecast issue date April 15, 1986) to require the preparation of the end of the bolt by removal of 1/4-inch minimum material using a band saw with an approved cutting fluid, prior to the hardness testing. This will preclude incorrect hardness readings.

B. INSTALLATION DEFICIENCIES

It should be noted that all installations of NSSS supports in Units 1, 2 and 3 which have been completed to date are acceptable as-is based on the evaluation of the SCIP data. The corrective action, required to preclude the recurrence of the inaccurate bolt elongation measurements and subsequent inadequate preload on remaining installations, is to mount the dial indicator on a surface that will not move during the preloading operation. Further corrective actions include not using bolt elongation as a final measurement of preload. Bolts will be tensioned in a pattern with multiple passes, if necessary, and a final verification pass will be performed to insure that all bolts in the pattern have been adequately preloaded. Bechtel Construction is currently developing a generic bolt preloading Work Plan Procedure/Quality Control Instruction (WPP/QCI) to insure a consistent and adequate method to preload bolts. This WPP/QCI 157.0, Bolt Tensioning Using a Hydraulic Tensioner, will be complete by February 28, 1986.

IV. References

1. NCR CC-5311
2. NCR CC-5312
3. Calculation 13-CC-ZC-360, Preloaded NSSS Studs and Bolts
4. Bechtel Letter B/ANPP-E-143411, November 18, 1985
5. C-E Letter V-CE-33153, November 22, 1985
6. Bechtel Letter B/CE-E-52426, November 22, 1985
7. C-E Letter V-CE-33170, November 27, 1985
8. C-E Letter V-CE-33199, December 9, 1985
9. Bechtel Letter B/CE-E-52584, December 26, 1985
10. C-E Letter V-CE-33267, January 7, 1986
11. NRC Report No. 85-42, January 7, 1986
12. NRC Letter, G. W. Knighton to E. E. Van Brunt, Jr., November 22, 1985
13. NRC Letter, G. W. Knighton to E. E. Van Brunt, Jr., November 29, 1985

V. Attachments

1. Summary of Results - Predicted vs. Actual Preloads, Unit 1 NSSS Pipe Stops
2. QA Summary of Procurement Activities

ATTACHMENT 1
Summary of Results
Predicted vs. Actual Preloads
Unit 1 NSSS Pipe Stops

Pipe Stop	No. of Bolts Compared	No. of Bolts Actual > Predicted	Remarks
C Stop Vertical Column	12 groups	7 groups	Direct comparison could not be made. In 5 remaining groups, the minimum actual preload was less than the maximum predicted value by 8% or less.
C Stop Main Brace	10	8	For the remaining 2 bolts, the actual was 6% and 16% less than the predicted value.
C Stop Lateral Brace	8	8	
D Stop	48	47	The preload of 1 bolt was approximately 1/2 of the others - installation error
E Stop Base	16	16	
E Stop Lateral Brace	2	2	

ATTACHMENT 2
Ametek-Straza QA Summary

The following is a case history of events surrounding Ametek-Straza.

ASME Section III, NCA-3800, paragraph NCA-3820, Quality Systems Certificate states in part "This Quality System Program shall be surveyed, qualified, and audited by the Material Manufacturer, Material Supplier, or Certificate Holder who directly receives..., except when the party holds a Quality System Certificate which covers those operations."

Section 14 of Ametek-Straza's QA Manual Revision 0, dated March 8, 1983, states in part "Holders of valid ASME Certificates may be placed on the Approved Suppliers List for the Material or items covered in the scope of their certificate without a survey by A/S; however, a copy of their valid QSC or Certificate of Authorization shall be on file in Quality Engineering".

Telephone conversation with Mr. Lance Ferguson, Ametek-Straza Manager of QA indicated that Ametek-Straza (A/S) qualified Southern Bolt as an approved supplier and listed them on the A/S Approved Suppliers List based on Southern Bolt having two Quality System Certifications (N-1582 Material Manufacturer and N-1583 Material Supplier). These certifications were issued to Southern Bolt in December 1976, renewed in 1979 and expired in 1982. Southern Bolt is no longer a supplier of A/S based on a lack of need. Southern Bolt & Fastener was placed on A/S ASL in 1977 and removed in 1982.

Ametek-Straza also conducted receiving inspection on all incoming parts. Section 5.0 of their QA Manual specifies that receiving inspection is limited to physical inspection and review of applicable certifications (CMTR's, C of C, etc.). Therefore,A/S relied on the ASME approved program in place by Southern Bolt to control material manufacturing activities.

Bechtel, through their audits of Ametek-Straza (1979-1985) confirmed that an effective program was in-place and adequately implemented. ANPP Vendor Quality reviewed the Bechtel audit reports, emphasizing on the objective evidence documented for support of receipt inspection activities validation.

Brief summary is as follows:

August 1979 - (N45.2 Audit)
- P.O. N22908-4 - Capital Pipe
- P.O. N22908 - Phoenix Steel
- P.O. N22408-4 - Jorgensen Steel
- P.O. N26246-4 - Jessop Steel

1980 waived until March 1981

March 1981 (N45.2/NCA-3800 Audits)
- P.O. N23631 HT# 79236/SA182 F 304L Material CMTR's reviewed
- P.O. N28575 HT# 802J53640/SA516GR 70 Material CMTR's reviewed
- P.O. N22402 HT# 26477/SA-312F304L
- P.O. N28596 HT# M2955/SA-312F304L
- P.O. N29426 HT# 818533/SA 240TP304

April 1982 (N45.2 Audit)
"Reviewed Receiving Inspection checklists for material used on Bechtel contracts". No deficiencies identified.

1983 Audit waived by Bechtel

August 1984 (N45.2 Audit)
Receiving Inspection Reports for
P.O. N53099, 6/15/83 (Capital Pipe)
P.O. N53456, 8/31/82 (Guyon Alloys)
P.O. N52465, 7/13/84 (Tioga Pipe)
P.O. N53141, 7/12/84 (Jorgensen Steel)

September 1985 (NCA-3800 Audit)
Receiving Inspection Reports for:
P.O. N53455-7, 7/17/84
P.O. N53910, 3/5/85
P.O. N22916, 1/23/85

ANPP Vendor Quality has reviewed the Bechtel audit reports and evaluated the A/S QA Program and found them sufficient for documentation attesting to the establishment, and promulgation of an effective Quality Assurance program satisfying contract requirements.