

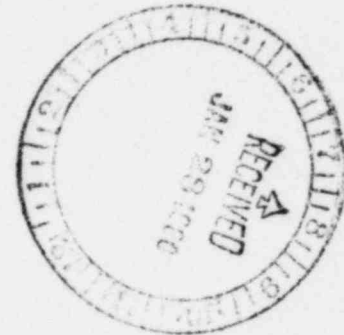
Washington Public Power Supply System
A JOINT OPERATING AGENCY

P. O. Box 988 3000 GEO. WASHINGTON WAY RICHLAND, WASHINGTON 99352 PHONE (509) 375-5000

Docket Nos. 50-460
50-513

January 24, 1980
G01-80-50

Mr. R. H. Engelken, Director
NRC Region V
Suite 202 Walnut Creek Plaza
1900 N. California Boulevard
Walnut Creek, California 94596



Dear Mr. Engelken:

Subject: WPPSS Nuclear Projects Nos. 1 & 4
IE Bulletin No. 79-02, Revision 2,
"Pipe Support Base Plate Designs Using
Concrete Expansion Anchor Bolts", and
Related Reportable Condition 10 CFR 50.55 (e)
Pipe Support Design

References: 1) G01-79-380, Response to IE Bulletin 79-02, Rev. 1,
DL Renberger to RH Engelken, dated July 10, 1979
2) NRC Letter, IE Bulletin 79-02, Rev. 2, RH Engelken to
NO Strand, dated November 8, 1979

Mr. Al Toth, US NRC Region V Resident Inspector, was verbally notified of the reportable 10 CFR 50.55 (e) condition on January 4, 1980 by the Supply System.

As previously notified, the Washington Public Power Supply System has reviewed the related reportable 10 CFR 50.55 (e) condition in conjunction with the response to IE Bulletin 79-02, Revision 2. The attached contains the requested information in response to Bulletin 79-02, Revision 2 as well as the WPPSS final report on the reportable design deficiency.

If you have any questions or desire further information, please advise.

Very truly yours,

D. L. Renberger
Assistant Director of Technology

LCO:jmh

Attachments

8008110323

40-05

cc: CR Bryant, Bonneville Power Administration
V. Stello, Director, NRC Office of Inspection and Enforcement
Engineering Files 1/4
RS Millne, United Engineers & Constructors, Inc.
BD Redd, United Engineers & Constructors, Inc.
AD Toth, Nuclear Regulatory Commission, Region V

Attachment
NRC IE Bulletin 79-02, Revision 2

Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts

The following response to IE Bulletin 79-02, Revision 2 has been updated from the Revision 1 response as indicated in the margin. Included is the final report covering our verbal notification of the related 10 CFR 50.55 (e) reportable design deficiency.

The majority of pipe supports (approximately 80%) do not require concrete expansion anchors and are attached by bolting into embedded inserts or welding to existing structural members, supplementary steel, or embedded structural shapes.

1. VERIFICATION THAT BASE PLATE FLEXIBILITY WAS ACCOUNTED FOR IN CALCULATING ANCHOR BOLT LOADS

The original design calculations for determining anchor bolt loads did account for the effects of base plate flexibility but not to the extent specified in Item 1 of IE Bulletin 79-02 and not to the extent of considering increased anchor loads due to prying action. Calculations for all Seismic Category I pipe supports are therefore being reviewed with the assumption that the base plate is flexible unless the distance from the edge of the support member to the edge of the plate is less than 2 times the thickness of the plate (i.e., the base plate is rigid). When base plates have been determined to be rigid, the compressive force is assumed to act at the centerline of the anchor bolt on the compression side of the plate. (See Attachment 1). When base plates are assumed to be flexible, anchor bolt loads are determined in accordance with the calculation basis described in Attachment 1. This design approach includes consideration of prying action in causing additional anchor bolt loading. The original design calculations utilized the formulas given in Attachment 1 with the exception that there was no factor for prying action and the moment arm "h" was equal to $d + \frac{a+b}{2}$.

For those seismic Category I supports which have already been designed, anchor bolt loads will be recalculated utilizing the approach described in Attachment 1. All future designs will utilize this same approach in determining anchor bolt loads.

Recalculations which indicate maximum allowable anchor bolt loads have been exceeded (See Item 2 of this response) will be rectified by appropriate pipe support redesign, refabrication, and/or field modification as required to meet the maximum allowable design load. The current schedule for recalculating anchor bolt loads on existing designs calls for June, 1980 completion.

2. VERIFICATION OF MINIMUM SAFETY FACTOR FOR BOLT DESIGN LOADS

WNP-1/4 utilizes Hilti-Kwik Bolts exclusively for all Seismic Category I pipe supports with concrete expansion anchors. The original design calculations required that the design tension load be less than or equal to the maximum allowable design load (MADL) where the MADL is defined:

$$\text{MADL} = \frac{F_u}{\text{SF}}$$

Where, F_u = ultimate static capacity of the anchor based on the manufacturer's static test for the applicable strength of concrete

$\text{SF} \geq$ safety factor of 4 for Hilti-Kwik Bolts (shell type anchors are not utilized for Seismic Category I supports on WNP-1/4)

When both shear and tension act on the anchor a straight line shear-tension interaction is assumed as follows:

$$\frac{T}{T_a} + \frac{V}{V_a} \leq 1.0$$

Where: T = Design Tension Load
 V = Design Shear Load
 T_a = MADL in Tension
 V_a = MADL in Shear

Based on test data generated on WNP-2 and WNP-1/4 it became apparent that wedge type concrete expansion anchors (Hilti-Kwik Bolts) slip well below the yield strength of the bolting material and utilizing one-fourth of the ultimate static capacity of the anchor (based on the manufacturer's static test data) does not provide a safety factor of four against slip. The design criteria for the maximum allowable load on Hilti-Kwik Bolts was therefore revised as shown in Attachment 2. All concrete expansion anchors are designed for worst case loadings which include consideration of SSE loadings. Design loads calculated in accordance with Attachment 1 must be less than the maximum allowable load shown in Attachment 2. This approach accounts for shear-tension interaction, minimum edge distance, and proper bolt spacing.

3. DESIGN REQUIREMENTS FOR ANCHOR BOLTS SUBJECT TO CYCLIC LOADS

No specific calculational requirements for seismic loads or high cycle operating loads exist for anchor bolts other than identified in Note 2 of Attachment 2. As a general rule, the use of concrete expansion anchors is discouraged for high cycle operating loads.

All anchors will have an initial preload tension applied which is

greater than 1.5 times the maximum allowable design load identified in Attachment 2. The method of obtaining bolt pre-tension will be torquing.

2

Concrete expansion anchors for Seismic Category I hangers/supports currently being installed are torqued to the following minimum values after nuts have been turned a minimum of three turns past the finger tight position:

| <u>NOMINAL BOLT DIAMETER</u> | <u>MINIMUM INSTALLATION TORQUE</u> |
|------------------------------|------------------------------------|
| 1/2-inch | 30 ft. lbs. |
| 5/8-inch | 60 ft. lbs. |
| 3/4-inch | 130 ft. lbs. |
| 1-inch | 155 ft. lbs. |
| 1 1/4-inch | 230 ft. lbs. |

If torque vs. preload tests to be conducted by UE&C indicate that the minimum torque values identified above do not provide the required preload tension, anchor bolts installed to the above torque requirements will be re-torqued as required to achieve proper preload.

2

4. VERIFICATION THAT DESIGN REQUIREMENTS HAVE BEEN MET FOR EACH ANCHOR BOLT BASED ON EXISTING QC DOCUMENTATION

The installation of concrete expansion anchors is controlled by the installing contractor's (J. A. Jones - Contracts 211 and 257) installation and inspection procedures. The inspection of concrete expansion anchors is included in JAJ-ITI-005, Paragraph 4.3 which includes the inspections and documentation (refer to Attachment #3) necessary to verify that the design requirements have been met for each anchor bolt in the following areas:

4a) Cyclic Loads Have Been Considered (i.e., Anchor Bolt Preload Is Equal To Or Greater Than The Bolt Design Load)

As indicated in the response to Item #3, all concrete expansion anchors are torqued to the minimum values shown. Torque is verified by the installing Contractor's quality control by checking the torque on a minimum of two bolts on each assembly.

Utilizing the formula for determining required wrenching torque values to obtain a given bolt preload, the maximum allowable design load for tension per Attachment 2, and preliminary torque vs. preload data, a comparison between contractor's minimum installation torque and the calculated torque required to obtain an anchor bolt preload of 150% of the MADL is as follows:

| <u>BOLT DIAMETER</u> | <u>CONTRACTOR'S MINIMUM INSTALLATION TORQUE</u> | <u>TORQUE FOR 150% MADL (TENSION-ALL LOADS)</u> |
|----------------------|---|---|
| 1/2-inch | 30 ft. lbs. | 23 - ft. lbs. |
| 5/8-inch | 60 ft. lbs. | 42 - ft. lbs. |
| 3/4-inch | 130 ft. lbs. | 84 - ft. lbs. |

| | | |
|------------|--------------|----------------|
| 1 - inch | 155 ft. lbs. | 149 - ft. lbs. |
| 1 1/4-inch | 230 ft. lbs. | 240 - ft. lbs. |

Subsequent to completion of the WNP-1/4 torque vs. preload testing program, installation torques will be revised as required to assure a minimum preload tension of 150% of the MADL. Anchors which have not been torqued to the minimum values established by torque vs. preload tests will be re-torqued as required.

2

b) Specified Design Size And Type Is Correctly Installed (i.e., Proper Embedment Depth)

Refer to Attachment 3. The installing Contractor's inspection checklist includes an inspection hold point to verify that the proper hole depth and diameter exist prior to installation of the expansion anchor. This approach eliminates any incentive to modify the anchor to accommodate hole depths which are less than the minimum specified. Additionally, expansion anchors are identified with a length code number by the manufacturer so that bolt length can be verified visually after installation. In those cases where anchors do not have the length identifying code number the actual installation of the anchor into the hole is witnessed by the Contractor's quality control inspector. It should be noted that WNP-1/4 uses only Hilti-Kwik Bolts for all Seismic Category I pipe supports which require concrete expansion anchors.

In addition to bolt hole depth and diameter, bolt size, and bolt length, inspection parameters also include verification of the following (refer to Attachment 3) to substantiate that anchor bolts have been properly installed.

| PARAMETER | <u>INSPECTION PROCEDURE-PARAGRAPH</u> |
|-----------------------------------|---------------------------------------|
| Full thread engagement | (JAJ-ITI-005 - 4.3.4) |
| Nut not shouldered out | (JAJ-ITI-005 - 4.3.4) |
| Spacing and edge distance correct | (JAJ-ITI-005 - 4.3.2) |
| Conformance with detail | (JAJ-ITI-005 - 4.4) |

The project will conduct a 100% verification of bolt embedment length for all concrete anchor bolts installed prior to the published requirements shown in Attachment 2. Any deviations will be reviewed and dispositioned on a case-by-case basis.

2

5. EXPANSION ANCHOR BOLTS USED IN CONCRETE BLOCK WALLS

Concrete expansion anchors are not used on concrete block walls to attach piping supports in Seismic Category I systems.

6. PIPE SUPPORTS WITH EXPANSION ANCHOR BOLTS USED WITH STRUCTURAL STEEL SHAPES

Many of the pipe supports with concrete expansion anchors have used structural steel shapes instead of base plates. The design of these supports, however, is consistent with the criteria of IE Bulletin 79-02, Revision 1.

7. COMPLETION OF ITEMS 1, 2 AND 4 FOR OPERATING PLANTS

Not applicable to WNP-1/4

8. COMPLETION OF ITEMS 5, 6, AND 7 FOR OPERATING PLANTS

Not applicable to WNP-1/4

9. COMPLETION OF ITEMS 1-6 FOR INSTALLED PIPE SUPPORTS WITH CONCRETE ANCHOR BOLTS

Seismic Category I pipe supports are supports used in ASME-III, Class 1, Class 2, and Class 3 piping systems. Concrete expansion anchors are being installed and inspected in accordance with the installing contractors procedures JAJ-WI-010.1 and JAJ-ITI-005 respectively. Existing QC documentation verifies that anchor bolts have been properly installed with respect to the following:

- o minimum anchor embedment
- o anchor hole diameter
- o anchor length
- o anchor to anchor spacing
- o anchor diameter
- o anchor to edge distance
- o anchor torqued
- o full thread engagement.

All supports with concrete expansion anchors are being reviewed to assure compliance with items 1 through 6 above. As previously reported, a verification analysis showed that two hangers required design modification namely, CSS-14-RG-22 and NSW-12-RG-3. The modified design has now been completed. Installation of ASME III supports will continue. A verification analysis is being performed concurrent with construction activity.

The scope of the analysis includes the design adequacy with respect to current design guidelines. Among the items addressed are:

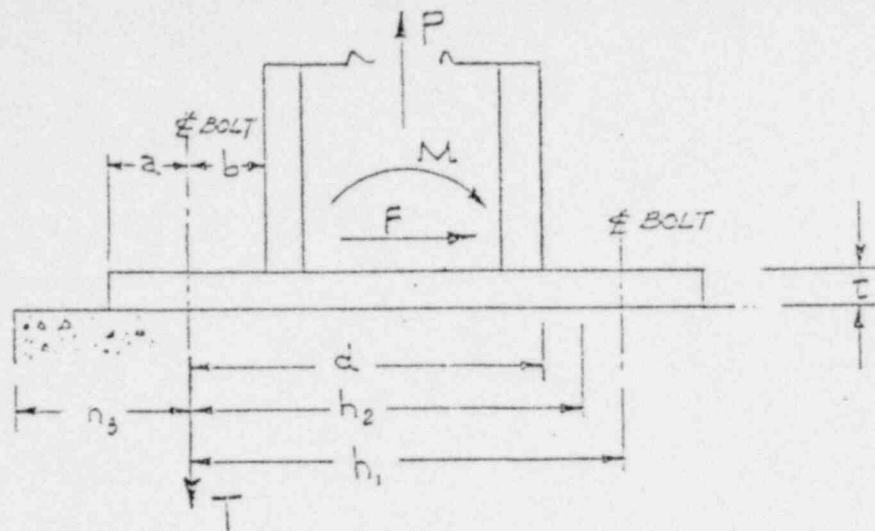
- o concrete expansion anchors
 - prying action
 - shear tension interaction
- o frictional loads
- o weld designs
- o allowable stress limits
- o embedment plates.

While performing this review some supports have been found which will require design modifications. It is because of these design modifications that a 10 CFR 50.55 (e) condition was reported on Jan. 4, 1980. The purpose of reporting was to notify the NRC of the ongoing design review and results of the review to date. See Attachment #4.

If a design modification is required on a hanger, the hanger will be placed on "hold" until the exact modification required has been specified and hardware is available to implement the modification, i.e., the modified design will be installed.

Testing to obtain torque vs. preload data is scheduled to commence during February, 1980, with completion in time to support a June, 1980 resolution to all existing designs as stated in Item 1.

ATTACHMENT #1 - ANCHOR BOLT LOAD CALCULATION BASIS



$$T = \alpha_i \left(\frac{M}{N_1 h_i} + \frac{P}{N_2} \right)$$

$$V = \frac{F}{N_2}$$

- Where: T = Anchor Design Tension Load
 V = Anchor Design Shear Load
 M = Moment Acting on Connection
 F = Shear Acting on Connection
 P = Axial Force Acting on Connection
 N₁ = Number of Tension Anchor Bolts
 N₂ = Total Number of Anchor Bolts
 i = Index to Identify Base Plate Flexibility
 i = 1 for Rigid Base Plates
 i = 2 for Flexible Base Plates
 h_i = Moment Arm
 h₁ = Centerline Distance Between Bolts
 h₂ = d + 2t not to exceed h₁
 α_i = Factor to Account for Prying Action for Base Plate Flexibility
 α₁ = 1.0, α₂ = 1.2

NOTE

Where the connection is subject to biaxial loading the above design approach must be repeated for the other principal plane and the absolute sum of the bolt reactions combined.

ATTACHMENT 2 - MAXIMUM ALLOWABLE DESIGN LOADS

| PART NO. | DIA. (IN.) | EMBEDMENT ¹ (IN.) | DESIGN CRITERIA FOR HILTI KWIK BOLTS | | CENTER TO CENTER SPACING ³ (IN.) | EDGE DISTANCE (IN.) | DIST. FROM PREVIOUSLY DRILLED HOLE (IN.) |
|-----------|---------------|---------------------------------|--|------------------------|--|---------------------------|---|
| | | | ALLOWABLE LOAD ^{2 4} (LBS) | | | | |
| | | | TENSION (WT. & THERM) | SHEAR (WT. & THERM) | | | |
| | | | TENSION (ALL LOADS) | SHEAR (ALL LOADS) | | | |
| 12 - 512 | 1/2 | 2 3/4 | 610 1220 | 740 1480 | 6 | 5 | 1 |
| 5/8 - 812 | 5/8 | 4 1/2 | 890 1780 | 1070 2140 | 7 1/2 | 5 | 1 1/4 |
| 3/4 - 10 | 3/4 | 6 | 1490 2980 | 1580 3160 | 9 | 5 | 1 1/2 |
| 1 - 12 | 1 | 6 | 1980 3960 | 2540 5080 | 12 | 6 | 2 |
| 1/14 - 12 | 1 1/4 | 7 1/2 | 2565 5130 | 3395 6790 | 15 | 7 1/2 | 2 1/2 |

- NOTES: 1. Embedment is defined as the distance from the bottom of the anchor to the top of the concrete after the anchor has been set.
2. Allowable is equal to 9.375% for dead weight and thermal loading or 18.75% for total loading of ultimate strength (interpolated between concrete @ 2000 psi & 4000 psi). REF: Abbot A. Hands Inc., Testing Laboratories Report #8783-R March 24, 1977. For dead weight and thermal loads the allowables are based on a factor of safety of 4 against slip and 10.66 against ultimate failure. For the total loading including all seismic loads the factor of safety against slip is 2 and 5.33 against ultimate failure.
3. For center to center distance less than distance in table the capacity is reduced on a straight line basis down to 50% at 6 diameters center to center anchor spacing.
4. For combined shear and tension use the following interaction formula:

$$\frac{S \text{ (act)}}{S \text{ (all)}} + \frac{T \text{ (act)}}{T \text{ (all)}} \leq 1$$

Where,

- S (act) = Shear Load Applied
- S (all) = Shear Load Allowable
- T (act) = Tension Load Applied
- T (all) = Tension Load Allowable

HANGER INSPECTION CHECKLIST

SUPPORT NO. _____

| ITEM | INSPECTIONS | HOLD POINTS | ACCEPTABLE BY | NOT APPLICABLE |
|--|---|--------------------------|-------------------------------------|--------------------------|
| I | GENERAL: | 1 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1. BLOCKING DEVICES/PINS IN PLACE | 2 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 2. NAMEPLATES/LOADSCALES VISIBLE & ACCESSIBLE | 3 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 3. SUPPORT NOT LOCATED OVER PIPE WELD | 4 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 4. MODIFICATIONS PER RF1/FCV/NCR | 5 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 5. SPRING CANISTERS NOT DAMAGED | 6 | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| II | MATERIAL: | 1 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1. VERIFY CORRECT COMPONENT PIECES USED | 2 | <input type="checkbox"/> | <input type="checkbox"/> |
| III | BOLTING: | 1 | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| | 1. CORRECT HOLE LENGTH & DIAMETER | 2 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 2. MILTI'S IDENTIFIED | 3 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 3. NO REBAR CUT WITHOUT APPROVAL | 4 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 4. LENGTH & DIAMETER PER DETAIL | 5 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 5. UNUSED HOLES GROUTED/CURED | | | |
| | A. DATE GROUTED _____ TIME _____ | | | |
| | B. DATE TIGHTENED _____ TIME _____ | | | |
| | 6. ANCHORS INSTALLED BY _____ | 6 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 7. ANCHOR SPACING/EDGE DISTANCE CORRECT | 7 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 8. ANCHORS TORQUED | 8 | <input type="checkbox"/> | <input type="checkbox"/> |
| A. SER.# _____ EXP. DATE _____ FT/LS _____ | | | | |
| 9. RICHMOND INSERTS TORQUED | 9 | <input type="checkbox"/> | <input type="checkbox"/> | |
| 10. U-BOLTS/OTHER BOLTED CONNECTION TIGHT | 10 | <input type="checkbox"/> | <input type="checkbox"/> | |
| 11. LOCKING DEVICES USED | 11 | <input type="checkbox"/> | <input type="checkbox"/> | |
| IV | WELDING: | 1 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1. WELDING PROCEDURE & FILLER MAT'L CORRECT | 2 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 2. WELDER QUALIFIED | 3 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 3. WELD SIZE, LENGTH & QUALITY | 4 | <input type="checkbox"/> | <input type="checkbox"/> |
| V | ASSEMBLY INSPECTION: | 1 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 1. LOCATION (PLAN, ELEV., ORIENTATION) | 2 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 2. HANGER COMPLETE PER DETAIL | 3 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 3. FULL THREAD ENGAGEMENT | 4 | <input type="checkbox"/> | <input type="checkbox"/> |
| | 4. THREADS STAKED OR DOUBLE NUTS USED | 5 | <input type="checkbox"/> | <input type="checkbox"/> |
| VI | REMARKS: | | | |
| | CV PRELIMINARY INSPECTION BY _____ DATE _____ | | | |
| | | | DRWG REV NO. _____ | |

JAJ-170 (4/12/79)

UNCONTROLLED

T-C-5105C

Attachment 4

Report of 10 CFR 50.55 (e) With Respect to ASME III Pipe Supports

Background

While undertaking a review of ASME III Seismic Category I supports for the NRC IE Bulletin 79-02 Rev 0 it was discovered that there were some inadequate designs of concrete expansion anchors. This led to further investigation of pipe support design calculations which indicated that there were other problems with support designs.

Description of Deficiency

The generic cause of the problem is that earlier design guidelines were not specific enough to assure that the designs adequately addressed frictional loads. The current design guide is much more detailed and is consistent with the IE Bulletin 79-02 response. This current design guide is the basis for the review.

Other problems were discovered in the design review these are isolated errors which do not recur.

As of January 10, 1980 459 supports have been reviewed and 45 require modification. These modifications are relatively minor in nature, typically requiring additional weld length or a knee brace. Of the 45 supports requiring modification the following types of problems have been found:

| | |
|----|----------------------------|
| 25 | Welds |
| 11 | Concrete Expansion Anchors |
| 11 | Stress |
| 47 | Total |

The reason that the total number of deficiencies in the various categories exceeds the number of supports which are unacceptable is that several supports were deficient in more than one category.

Safety Implications

No attempt has been made to determine if this condition would have caused a significant safety hazard since we are modifying the supports as the deficiency is discovered during the review of each support.

Corrective Action Taken

A design review of all ASME III, Seismic Category I pipe supports has been undertaken and will be completed by June, 1980. Necessary design modifications will be ongoing during the review and completed by July, 1980.

LCO:jmh