March-June, 1987	NRC identified a deficiency in the qualification and use of Rawl self-drilling anchors at SQN during formal review/audit of ECTG-SQN Element Reports CO11301 - Design of Plates, CO11305 - Anchors Cut Off and CO11306 - Testing of Anchors. The NRC also identified inadequacies in the sample program performed to satisfy NCR-SQNCEB-8404 (baseplate flexibility). R2
CAQs 1987:	Qualification and use of Rawl self-drilling anchors at SQN. R2
	CAQ: CAQR-SQF870101 R2
	Attachments to building or miscellaneous steel not considered in the calculation of loads.
	CAQ: PIR-SQNCEB-8658

Corrective action for these CAQs are addressed in Section 7.1.1.

Historical Background

In March 1979, the NRC issued IE Bulletin 79-02. The bulletin focused on four areas where problems associated with pipe support base plate designs and anchor bolts had been identified throughout the nuclear industry.

The bulletin specifically identified design deficiencies for pipe support base plates that use concrete expansion anchor bolts in seismic category I systems as defined by Regulatory Guide 1.29, "Seismic Design Classification", Revision 1, dated August 1973 or as defined in the applicable FSAR. Holders of construction permits and operating licenses for nuclear power plants were required to provide a written response to the NRC for the following:

1. Verification that pipe support base plate flexibility was accounted for in the calculation of anchor bolt loads.

2. Verification that the concrete expansion anchor bolts have the following minimum factor-of-safety between the bolt design load and the bolt ultimate capacity determined from static load tests which simulate the actual conditions of installation:

1. Four - for wedge and sleeve type anchor bolts
2. Five - for shell type anchor bolts

3. Description of the design requirements if applicable for anchor bolts to withstand cyclic loads.

4. Verification from existing QC documentation that design requirements have been met for each anchor bolt in the following areas:

   a. Cyclic loads have been considered
   b. Specified design size and type is correctly installed

   If sufficient documentation does not exist, then initiate a testing program that will assure that minimum design requirements have been met with respect to subitems a. and b. above.

Items 1. and 2. addressed by this bulletin are applicable to the concerns stated in section 1.2.1 and will be addressed in this report. Items 3. and 4. are addressed in Subcategory Report C011300 - Anchorages.

In June and July of 1979, TVA provided their evaluation results to the NRC pertaining to IE Bulletin 79-02. The responses relative to flexible plates and expansion anchor factor-of-safety were as follows:

All anchor plates designed by TVA were assumed rigid in calculating anchor loads for WBN, SQN, BLN, and BFN. A comparison of the effects of rigid plate assumptions stated that rigid plate assumptions will underestimate anchor loads under service (normal operating) load conditions. However, it will not affect system capacity if the factor-of-safety utilized in the design of the anchors is equal to or greater than that used in the design of the pipe position retention attachment by a sufficient margin to compensate for any displacement limitations of the anchors. At most, the effect of this underestimation would be an increase in system deflections by 20 to 25 percent under service load conditions. Plate flexibility was considered by ITT Grinnell in their design of anchors for pipe supports for BLN.

The allowable loads for expansion bolt anchors utilized by TVA were obtained from a table based on manufacturers' data for WBN, SQN, and BLN. The allowable loadings according to the tables required a factor-of-safety of 4 for service load conditions. TVA's Civil Design Standard DS-C6.1, "Concrete Anchorages," issued in September 1975 required factors-of-safety of 4 for wedge bolts and 4.5 for shell type anchors based on minimum qualification test requirements. For WBN and SQN, only self-drilling type expansion anchors were used before 1976.

Major piping systems for WBN were designed by Bergen-Paterson (BP) and Engineering Data Systems (EDS) Nuclear. For the design of anchorages, EDS used a minimum factor-of-safety of 6 before the issuance of DS-C6.1. Afterwards, EDS used DS-C6.1 to design anchorages. Bergen-Paterson used the factors-of-safety of 4 for wedge bolts and 4.5 for shell-type anchors as required in DS-C6.1. The piping systems designed by TVA utilized a minimum factor-of-safety of 4 for service loads. All other safety system anchorages designed by TVA engineers used the factor-of-safety specified in DS-C6.1.

Major piping systems for SQN were designed by Bergen-Paterson, Basic Engineers, and EDS Nuclear. For the design of anchorages, Basic Engineers used a minimum factor-of-safety of 5 and EDS used a minimum of 6 before the issuance of DS-C6.1. After issuance of DS-C6.1, EDS Nuclear and Bergen-Paterson used the requirements of DS-C6.1. The piping systems and other safety system anchorages designed by TVA utilized the same factor-of-safety as those stated above for WBN.

Major piping systems at BLN were designed by ITT Grinnell. ITT Grinnell used manufacturer's allowable loads based on a factor-of-safety of 4 for service load conditions.

For BFN, all major piping systems were designed by Bergen-Paterson. Their designs required a minimum factor-of-safety of 8 for self-drilling anchors and 4 for wedge bolts. A few small piping systems were designed by TVA and required a minimum factor-of-safety of 4.

The major portion of cable tray supports were designed by TVA electrical engineers. Sampling of computations indicates a variation in applied factors-of-safety from 6.75 to 9.7. A small number of cable tray supports were designed by TVA civil engineers and for those designs a minimum factor-of-safety of 4 was applied for maximum load combinations.

Electrical support systems, instrumentation lines, battery racks, etc., were designed by TVA civil engineers with a minimum factor-of-safety of 4 for maximum load conditions.

The above factors-of-safety for BFN are very conservative considering that current practice allows increased stress allowables or decreased factors-of-safety for maximum earthquake loading and for other unusual, improbable, or infrequent loading combinations.

Terms that will be used throughout this report are defined as follows:

a. Field Change Request (FCR): document used by DNC and ONP to request DNE approval for changes to approved documents to facilitate construction, correct minor drawing discrepancies, or provide additional design information.

b. Support Variance Sheet (SVS): used to make alterations to an existing typical drawing and only applies to the specified support at the specified location.

c. Typical Support - a field located support configuration which is shown on DNE issued drawings of the 47A051, 52, 53, 54, 56, and 58 series.

d. Engineered Support - a unique designed configuration for a specific location, issued and controlled by DNE by way of an analysis package consisting of a piping segment analysis drawing (if it is a rigorously analyzed segment) and the unique support configuration drawing detailing location, orientation, and configuration.

e. Condition Adverse to Quality (CAQ): Errors, omissions, test failures, incorrect or inadequate documentation, deviations from prescribed inspection or test procedures, or failure to meet engineering design or procedural requirements.

f. Nonconforming Condition Report (NCR): documents a CAQ as utilized by DNC and ONP.

g. Problem Identification Report (PIR): documents a non-significant CAQ as utilized by DNE.

h. Significant Condition Report (SCR): documents a significant CAQ which meets any of the following:

   1. If left uncorrected, the CAQ could challenge the integrity of the reactor coolant pressure boundary, degrade the capability to shutdown the reactor and maintain it in a safe shutdown configuration, or degrade the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposure comparable to those in 10 CFR 100, or

   2. The CAQ requires extensive repair, rework, or

   3. The CAQ has substantial generic implications to other structures, systems, or components in the identified plant or has substantial generic implications at other TVA nuclear plants, or

4. The CAQ is a falsification of records, or

5. The CAQ is a deliberate failure to follow procedures, or

6. The CAQ has recurred repeatedly such as to reasonably indicate an adverse trend or programmatic failure of a substantial nature, or

7. The CAQ is a failure to comply with the Atomic Energy Act of 1954, as amended or any applicable rule, regulation, order, or license of the NRC relating to a substantial hazard.

The majority of the sampling programs initiated by TVA in response to the CAQs are based on the following:

In an unlimited population, zero defects in a sample of 60 provides a 95 percent confidence level that less than 5 percent of the population is defective. Reference: "Attribute Sampling" by Herman Burstein, TVA library 519.52 B97a.

Generic CAQs (for all sites) previously identified and corrected by TVA will be addressed in this section to avoid repetition.

These CAQs include:

a. Multiple supports have been attached to an embedded plate without a design review of the embedded plate capacity. This could have resulted in the plate anchors being overloaded and could effect any system utilizing the plates. The deficiency is documented for WBN on NCR WBNCEB8203 and NCR GENCEB8208 for SQN, BLN, and BFN.

   The deficiency was caused by inadequate requirements issued by DNE to control the minimum distance between attachments to embedded plates or the minimum distance between attachments and embedded plate edges.

   Sampling programs were conducted for WBN, SQN, and BLN to determine if support failure could occur because of multiple loads and evaluate the inplace factor-of-safety against concrete failure for welded stud anchors.

   The samples indicated that an adequate level of safety exists against concrete failure, therefore, embedded plates were approved use-as-is for SQN and BLN. One embedded plate stud at WBN stressed to .96 Fy which exceeds TVA's maximum design allowable of .9 Fy. Stiffners were added to the plate to reduce the stud stress below .9 Fy.

Construction Specifications WBN N3C-928 (February 10, 1983) and SQN N2C-937 (November 20, 1984), both titled "Locating Attachments on Embedded Plates," were issued by DNE. These specifications detail the requirements for locating attachments to embedded plates. The specification requires design approval of all future attachments on embedded plates that do no meet the specified minimum spacing requirements.

With respect to BFN, a field review of approximately 800 significantly loaded embedded plates with multiple attachments revealed that no problem exists at BFN. Unlike WBN, random strip plates were not installed at BFN during early stages of construction with the intention of utilizing the plates for future unidentified supports. With respect to embedded plate design, this was completed at BFN before the issuance of DS-C1.7.1. Therefore, it was determined that NCR GENCEB8208 did not apply to BFN.

In order to assure designers applied the correct factor-of-safety during future design, DS-C1.7.1 was revised for clarification pertaining to correct usage of factors-of-safety.

b. DS-C1.7.1 states that ductility of anchorages should be assured by limiting the failure mechanism to steel where possible. When ductility is not possible and the failure mechanism is concrete, the factor-of-safety for service loads should be at least four. Stud anchors that would be ductile in single loading will fail concrete as a group at some of the spacings used on the strip plates. Computations for strip plates using closely spaced Nelson studs at WBN indicate that in some cases design loads were compared to the ultimate concrete strength when checking attachments. This could indicate that some safety-related supports have a factor-of-safety as low as one when a minimum of four is required.

   This deficiency is documented on NCR GENCEB8205 for WBN, SQN, BLN and BFN and was caused by failure of designers to apply the factor-of-safety as required by DS-C1.7.1

c. Minimum spacing criteria as provided by G-32 R-5 could have been inadequate in that expansion anchors can be installed at various plants which do not meet minimum spacing requirements when the combined action of multiple attachments are considered. This deficiency is documented on NCR GENQAB8203. Field sampling programs were performed for WBN, SQN, and BLN where expansion anchors were installed at less than the G-32 minimum spacing requirements. No deficiencies were noted in the random sample for the sites. Zero failures results in a

95-percent confidence level that no more than 5-percent of the total population would be defective. Therefore, the possible spacing violation covered by this NCR had no significant effect on the expansion anchor factor-of-safety.

BFN has not evaluated the occurrences where expansion anchors for adjacent attachments are spaced closer than the G-32 requirements.

4.1 The findings as indicated below address the first issue noted in paragraph 1.2.1. This issue is relative to errors, omissions or incorrect assumptions in calculations that were identified during 1984 but not corrected, noncompliance with NRC IE Bulletin 79-02 with respect to baseplate flexibility, and undocumented loads on embeds or attachments to embeds without a design review.

4.1.1 Generic

Discussion - WBN

In May 1982, DNE-CEB established a policy for all future support base plate analysis at WBN. The decision was made to complete the analysis of support base plates using the rigid plate method. This decision was primarily based on a sampling program conducted at SQN which revealed adequate conservatism existed in TVA designs using rigid plate analysis to compensate for the effects of base plate flexibility. The NRC reviewed the sampling results and concurred with TVA's findings.

In January 1984, the NRC conducted an inspection in the areas of pipe support base plate designs using concrete expansion anchor bolts as addressed by TVA's Office of Engineering Design (IE Bulletin 79-02). The inspection findings are summarized below:

a. Unresolved Item 390,391/84-05-01, Factors-of-Safety for Concrete Expansion Anchor Bolts (IE Bulletin 79-02) Civil Design Standard DS-C1.7.1, paragraph 5a. This involves the factor-of-safety for self-drilling expansion shell anchors (SSD) and wedge bolts (WB). The factor-of-safety in DS-C1.7.1 (formerly DS-C6.1) for SSD and WB anchors under normal loading conditions are 4.5 and 4.0, respectively. In accordance with IE Bulletin 79-02 the requirements for the minimum factors-of-safety for SSD and WB anchors should have been 5 and 4 respectively.

b. Unresolved Item 390,391/84-05-02, Pipe Support Base Plate Design Consideration (IE Bulletin 79-02), DS-C1.7.1 paragraph 5.b. This requires that the effect of base plate flexibility be considered in obtaining the anchor's maximum design load. As stated in the historical, WBN's base plate designs have not accounted for plate flexibility when determining the maximum anchor design loads and factors-of-safety as required by the bulletin.

c. Violation 390,391/84-05-03, Failure to Follow Procedure DS-C1.7.1 paragraph 5.c. This noted that TVA DS-C1.7.1 had not been implemented by the pipe support group in the area of base plate designs. The failure of implementing this criteria was a violation of 10 CFR 50, Appendix B, Criterion V.

d. Violation 390,391/84-05-04, Failure to Follow Procedures for Pipe Support and Base Plate Design Calculations, DS-C1.7.1 paragraph 5.b. The inspector reviewed portions of design calculations and computer applications in the area of pipe support analysis and base plate designs.

The calculations were evaluated for thoroughness, clarity, consistency and accuracy. Conformance to analysis criteria, applicable code, NRC requirements and licensee commitments were also reviewed. Discrepancies were noted in calculations for four supports which indicated that portions of these design calculations were not performed in accordance with Engineering Procedure EP 3.03, "Design Calculations", Civil Design Standards, and sound engineering applications. These were violations of 10 CFR 50, Appendix B, Criterion V.

The violations and unresolved items have been closed by the NRC for unit 1. Violations for unit 2 are still pending actions by TVA.

Later in 1984, two supports had base plates and anchor bolts designed using the rigid plate theory. However, the configuration of the anchor bolt locations in relation to the attachment did not meet the criteria necessary for design and classification as a rigid plate. This resulted in unequal distribution in the tensile pullout load which could cause the anchor bolts in the immediate proximity of the attachment to take a greater portion of the induced load.

According to approximate hand calculations, the anchor bolts would not be within the specified limits. NCR WBNWBP8402 was initiated to document the two supports and addressed the potential for other similar conditions to exist.

It was determined that designers were not implementing DS-C1.7.1, section 5.1 which states that the limitations for the use of rigid plate analysis methods must be applied unless documented justification is submitted for the limitations.

WBN designers were interpreting the May 1982 memorandum as justification to apply rigid plate analysis to all embedded plate designs. This memorandum did not delineate any limitations and did not provide the necessary justification as required according to the procedure. This misinterpretation resulted in baseplates being designed using rigid plate assumptions when the plates did not meet the rigid requirements specified by NRC IE Bulletin 79-02. In order to evaluate the effect of baseplate flexibility and construction tolerances, a sampling program for pipe supports was conducted. The results confirmed a 95 percent confidence level that less than 5 percent of the pipe supports did not meet the design criteria. Supports identified in the sample that did not meet the criteria were modified. Remaining supports required no further evaluation or rework.

DNE revised the 1982 memorandum to refer designers to the requirements of DS-C1.7.1, clarified limitations and applicability of rigid plate analysis in DS-C1.7.1 and trained designers to this requirement.

DNE drawing series 47A050 includes several tolerances for the location of concrete anchorages, movement of attachments and modifications of baseplates for supports.

The tolerances given in the 47A050 notes were based on rigid plate assumptions. The effect of field tolerances on loads and stresses would be smaller for rigid plates than flexible plates. No documentation exists to show that the effect of construction tolerances on loads and stresses was considered in the development of the 47A050 notes.

NCR WBNCEB8419 was initiated to document that the cumulative effects of these tolerances may have resulted in significant increases in baseplate stresses and anchor bolt loads.

A sampling program evaluating 496 pipe supports produced a 95 percent confidence level that less than 2.1 percent of the supports had a factor-of-safety of less than the 5 required according to 79-02. These results were included as part of a total evaluation for NRC IE Bulletin 79-02.

DNE performed the following actions to prevent recurrence:

a. Revised the 47A050 notes to limit allowable field applied tolerances.

b. Revised G-43 to change the tolerances for the fabrication dimensions of plates.

c. Revised DS-C1.7.1 to specify the method for calculating amplification factors for anchor bolt loads and base plate stresses to account for field installation tolerances.

d. Trained designers in methods for considering baseplate tolerances in design and evaluation of supports.

A review of TVA's final response to NRC IE Bulletin 79-02 has shown that TVA did not take into account base plate flexibility in the design of baseplates before the issuance of DS-C1.7.1 (formerly DS-C6.1 issued September 1975).

In January, 1985, a meeting was held in the Region II offices between TVA and the NRC at TVA's request to discuss design issues involving WBN unit 1. The two major topics of discussion involved IE Bulletin 79-02 factor-of-safety requirements and missing EDS Nuclear calculations (addressed in Subcategory Reports EN20500 - Control of Design Calculations and EN22100 - Pipe Support Design). TVA presented to the NRC their verification of a sample of the calculations affected by the design issues in question.

The NRC agreed that the design verifications provided reasonable assurance that there are no safety concerns which would preclude the issuance of an operating license for unit 1. However, in order to provide complete assurance that no problems exist, TVA and Region II agreed that a complete review of all affected support calculations would be performed. Reasonable completion dates for these reviews as stipulated by the NRC was the first refueling outage for unit

1 and by initial fuel load for unit 2. This is documented in a letter dated February 15, 1985 from D. M. Verrelli to TVA.

TVA's response to the NRC dated May 17, 1985 committed TVA to a 100-percent review of the design calculations for engineered pipe supports for WBN unit 1 to assure that the expansion anchor factor-of-safety requirements of IE Bulletin 79-02 are met. The review will be performed on engineered pipe supports for unit 1 that were designed prior to the implementation of IE Bulletin 79-02 requirements in TVA Civil Design Standard DS-C1.7.1. The methods used for the review of the supports will be the same as those used for evaluation of the sample of the 496 supports reported in revision 2 of the final report on IE Bulletin 79-02 for WBN unit 1. TVA committed to develop a special procedure for the review and complete the review for unit 1 before the first refueling outage. For unit 2, these issues are being addressed in the ongoing design process. Therefore, compliance with the IE Bulletin 79-02 will be achieved by unit 2 fuel load.

Since the May 17 memorandum, fuel load for WBN unit 1 has slipped. As a result, TVA has committed to review the safety-related piping systems and associated engineered supports for WBN unit 1 before loading fuel.

WBN Engineering Project Procedure WBEP-SEP 86-02 is being prepared to establish the program to be used to evaluate these systems and associated supports. This program will render further evidence that WBN is currently in compliance with NRC IE Bulletin 79-02.

The above analysis for baseplate flexibility and tolerances excluded the cable tray support anchor bolt loads.

In 1985, CEB initiated PIR WBNCEB8543 which stated that baseplate flexibility for the calculation of anchor bolt loads was not considered for cable tray supports and possible miscellaneous steel supports. This may have resulted in some supports having a reduced margin of safety. An independent review of 60 embedded plates with cable tray supports was performed by DNE and the following were identified:

a. Cable tray supports may overstress portions of the embedded plate when baseplate flexibility and installed location of the support on the embedded plate are considered.

b. Cable tray support calculations used the wrong allowable anchor stresses in some cases.

c. Cable tray supports did not take into account all design considerations in some cases.

PIR WBNCEB8543 has been superceded by SCR WBNCEB8623 R1. This SCR and the aforementioned CAQ's document the failure of TVA designer's to consider baseplate flexibility.

The QTC investigation of the concern dealing with errors, omissions, or incorrect assumptions found in design calculations during 1984 that were not corrected resulted in additional issues.

These are as follows:

a. Transfer of work between sections (original employee concern)

b. Calculation errors in load determination for EP-FCR's requiring detailed evaluation.

c. [illegible]ectiveness of the visual inspection program and the [illegible]cts of cumulative loads (visual inspection addressed in section 4.2.3).

In order to determine the validity of the above issues, DNE initiated a sampling program consisting of 60 EP-FCRs where analysis packages were available. The EP-FCRs were randomly selected from the population of embedded plates which had been approved the last time a FCR had been initiated on the embedded plate.

The predetermined acceptance criteria for the sample was based on identifying zero defects from the sample of 60 and on identifying no significant program deficiencies.

For each embedded plate in the sample, the following were performed:

a. Field verification comparing the most recent EP-FCR and the as-constructed configuration of embedded plate attachments.

b. Existing calculations for reactions were independently reviewed. The calculations for each embedded plate was revised to document the independent review. Any discrepancies found during the review were included in the revised calculations.

c. Existing calculations of the embedded plates were reviewed by a group independent from the group which handled the original evaluation of the embedded plate FCRs.

The review of the documentation and detailed evaluation of the embedded plates identified the following discrepancies:

a. Incorrect plate numbers or incorrect drawing revision levels were referenced on five EP-FCRs. The errors were not identified by DNE during the initial evaluations for the five embedded plate FCRs, therefore, detailed calculations were performed on the wrong plates.

b. The review of the field sketch for an embedded plate identified four other plates which had additional attachments that were not shown on the sketch and should have been shown based on the requirements of N3C-928.

c. The review of the load determination calculations performed by DNE onsite identified 7 calculations which contained errors or omissions in the load determinations. None of the errors resulted in load increases that were significant with respect to the capacity of the embedded plate.

d. Embedded plate FCRs were visually approved by field inspections by a designer using engineering judgment based on the assumption of the acceptability of an existing attachment with a major load (generally a cable tray support).

e. The allowable stress on 5 of the embedded plates in the sample exceeded the allowable using the cable tray reactions given in the existing cable tray support calculation packages. Using more refined seismic analysis resulted in a reduction in stress to within allowable values.

f. For some calculations for evaluation of the embedded plate FCRs, the effects of baseplate flexibility were not considered.

g. A standard "by inspection" evaluation form was used for evaluation of 10 of the embedded plates. Information contained on the form was generally acceptable, however, some unconservative assumptions were identified.

h. Approximately 30 of the calculation packages for evaluation of the embedded plates documented acceptance by engineering judgment. The basis for the engineering judgment was not explicitly documented as required by procedure.

These deficiencies are documented on SCR WBNCEB8623R1 and document errors, ommissions and incorrect assumptions in previously approved calculations. However, it could not be determined that these particular errors had been previously identified but left uncorrected.

DNE will also investigate two other potential deficiencies in the design of plates under SCR WBNCEB8623. They are as follows:

a. Embedded plates identified by an EP-FCR in accordance with N3C-928 may not have considered the effects of loads on adjacent embedded plates (identified by DNC, Employee Involvement Program EIP-CEO-238).

b. The effects of an adjacent concrete edge on the embedded plate capacity may not have been considered in the design of the plate (PIR WBNCEB8635).

In January 1986, PIR WBNCEB8601 and PIR WBNCEB8602 were initiated.

PIR WBNCEB8601 addressed the potential for insulation to be installed on a conduit after the typical conduit support had been finalized. If the conduit support had been varied from the original design and qualified based on the uninsulated condition, the added weight of the insulation could result in support overstress. Also, embedded features could possibly be affected by the additional loading.

When a typical support is varied, the support has frequently been qualified based on the load from the actual number of conduits or piping attached to the typical. DNC or ONP may have added conduit or piping to the existing varied typical without approval from DNE. Therefore, the qualification of the varied typical based on the actual number of conduit or piping may be unconservative. This problem would also affect the qualification of embedded plates. This is documented on PIR WBNCEB8602.

DNC has initiated NCRs 6735 and W-403-P in response to PIR WBNCEB8601 and PIR WBNCEB8602.

In December, 1985, NCR 6498 was initiated to identify unit 2 process pipe supports attached to embedded features which had been installed and documented without initiating an attachment "G" as required by procedure WBN-QCP 1.14, which is the document which tracks attachments to embedded features and notifies DNE of the existence of the feature. Because of this, supports may have been statused as complete according to WBN QCI-1.40-3, "Universal System Program" without a DNE evaluation of the attachment to the embedded feature being performed. This situation was caused by the fact that WBN QCI-1.40.3 designed test number 1 to be for expansion anchors in hardened concrete without including a test or inspection for the control of the attachment to the embedded plate as required by WBN-QCP 1.14.

A generic applicability review conducted by DNC has identified that this condition also affects structural and miscellaneous steel features attached to embedded plates as well as instrumentation sense line supports. These additional deficiencies have been documented on NCRs 6567 and 6564 for unit 2 and NCR W-435-P for unit 1.

Before 1981, several notes in the drawing series 47A050 and 47A058 permitted DNC to make attachments to miscellaneous building steel (except embedded plates), cable tray supports, and baseplates for supports of all types. These notes specified the additional loading allowance that was acceptable without the benefit of an FCR or support variance.

However, the loading criteria either did not consider the effects of cumulative loads, was not well enough defined for construction application, or was misinterpreted by construction and resulted in overstressing of supports in some cases.

DNC initiated NCR 3659 (September 24, 1981) to document this deficiency and is providing DNE with field installed configuration details of structural steel drawings showing attachment locations to potentially overstressed structures.

DNE will evaluate the attachments to the structures and make the necessary changes to design drawings.

In April 1986, CEB initiated SCR WBNCEB8650. This identified a potential problem with the Office of Nuclear Power attaching engineered supports to cable tray supports, building and miscellaneous steel (excluding embedded plates) without an FCR. This is the same problem identified on DNC NCR 3659.

The WBN ONP site procedures do not require the generation of an FCR when attaching to building or miscellaneous steel (except embedded plates) because of DNE's failure to incorporate the FCR requirement into a governing General Construction Specification such as G-43 or on design drawings.

A review of engineered supports installed by WBN ONP was performed by Modifications to identify supports which were attached to building and structural steel without an FCR showing the exact installed location and configuration.

One support was identified as having been attached to building steel by WBN ONP without an FCR as of June 17, 1986.

The subject support was modified by way of Engineering Change Notice (ECN) 5678 and FCR 86-28 was generated to show the exact location and configuration of the attachment to building steel.

Based on conversations with Civil Design Engineers with the DNE section, the conservatism utilized by TVA designers was confirmed in the various sampling programs conducted in respect to baseplate flexibility and loading on supports. Problems with the qualification of cable tray supports was identified and is in the process of being resolved. Safety related piping systems and associated engineered supports for unit 1 will be re-evaluated before fuel load.

Interviews conducted with DNC engineers concerning the inspection documentation reviews performed ensured that any feature attached to an embedded plate has been or will be documented and inspected. Any feature attached to an embedded plate that is discovered to not have a documented inspection or an approved embedded plate FCR will be inspected, documented, and evaluated by DNE.

Conclusion

The sampling programs initiated by TVA identified errors, ommissions, and incorrect assumptions in previously approved design calculations. Undocumented loads and noncompliance with NRC IE Bulletin 79-02 are factual based on the findings.

Discussion - SQN

Pipe supports for WBN and SQN were designed using the same design criteria and procedures. For the majority of the design period, work for both plants was being performed concurrently by the same designers. The 1982 memorandum (CEB820521003) which discussed baseplate design stated that rigid plate analysis should be used for the completion of WBN. The design instructions were also used for SQN.

The memorandum was generally interpreted by SQN designers to allow use of rigid plate analysis without evaluation of plate rigidity. This interpretation resulted in many baseplates being designed using rigid plate assumptions which would not be classified as rigid using the 79-02 criteria.

Upon identification of baseplate flexibility not being addressed for WBN (NCR WBNWBP8402), DNE-SQN initiated NCR SQNCEB8404.

This NCR stated that DS-C1.7.1 requires that the effects of baseplate flexibility and anchor deformations be considered in determining the loads on anchor bolts if the baseplate does not meet the parameters given in the standard for a rigid plate design. Failure to follow these guidelines could cause the anchor bolts to exceed the allowable loads specified in the standard. The applicable requirements in the standard have not been followed in the design of pipe supports since the standard was issued in May 1983.

The designers were interpreting the 1982 memorandum as justification to the limitations on the use of rigid plate analysis. This memorandum did not delinate any limitations and therefore did not provide the justification required by DS-C1.7.1 to use rigid plate analysis.

Configuration tolerances for pipe supports are given in the DNE drawing series 47A050 for both WBN and SQN. NCR WBNCEB8419 noted that the cumulative effects of these tolerances may result in significant increases in baseplate stresses and anchor bolt loads. SQN also addressed this deficiency on NCR SQNCEB8404.

In order to determine the effect of baseplate flexibility and installation tolerances, SQN initiated a random sampling of 60 pipe supports and calculated the expansion anchor factor-of-safety for each support. The calculated factors-of-safety were based on baseplate dimensions and drawing configuration. The calculations for the supports in the sample included consideration of baseplate flexibility.

DS-C1.7.1 states that self-drilling expansion anchors shall require a factor-of-safety of 5 and wedge bolts require 4. A review of the OE calculation summary for the NCR SQNCEB 8404 sample program revealed 59 out of the 60 sampled supports had factors of safety greater than the DS-C1.7.1 requirement of five for SSDs. One support which used SSD type anchors had a factor of safety of 3.5. However, the support with the reduced factor of safety met the requirements for rigid plate analysis and therefore, had a factor of safety greater than that required for the original design.

In addition, the results of the NCR WBNCEB8419 sampling performed at WBN with respect to construction tolerances are applicable to the expansion-anchored pipe supports for SQN. This conclusion is based on:

a. Pipe supports for both plants were designed using the same methods and procedures. For most of the design period, work for both plants was being performed by the same designers. Therefore, the sample performed at WBN was reflective of the support designs at SQN. |R2

b. The 47A050 drawings for SQN contained fewer and more conservative tolerances than the WBN 47A050 drawings. Because of this fact, the probability of error in the application and/or interpretation of the SQN drawings was considerably reduced. |R2

No failure evaluation of installation tolerances or baseplate flexibility was required because:

a. More conservatism was built into the design of supports for SQN than WBN.

   Note: The sampling program performed at WBN did not identify a problem caused by the use of field installation tolerances.

b. Sampling of 60 SQN supports for baseplate flexibility and comparison of field installation tolerance work for SQN and WBN provided a 95 percent confidence level that less than 5 percent of the embedded plates do not meet design requirements.

However, during an NRC audit in March, 1987, inadequacies were discovered in the sampling program performed as a result of NCR-SQNCEB-8404. The NRC indicated that the subject sampling program did not adequately address the baseplate flexibility issue at SQN. Further discussions between NRC and ECTG led to the following conclusions on this subject: R2

- The NRC is requiring SQN to regenerate calculation packages (approximately 5600) for seismic pipe supports on rigorously analyzed systems prior to unit 2 restart. This action has been designated a SQN restart item. R2

- Calculation packages for affected pipe supports on alternately analyzed/small bore piping systems will be regenerated after restart of unit 2.

- The regeneration of the subject calculation packages will effectively evaluate the issue of baseplate flexibility at SQN. This fact was verified by ECTG in conversations with DNE personnel at SQN and CEB in Knoxville. Civil Design Standard DSC-1.7.1 requires that baseplate flexibility be considered during the analysis process unless the baseplate meets criteria for rigid plate analysis (also specified in DSC-1.7.1). It was also stated that qualification of expansion shell anchors would be to a safety factor of five as required by NRC OIE Bulletin 79-02. Interim qualification to a reduced factor-of-safety would not be performed. R2

CEB initiated SCR SQNCEB8502 to address programmatic deficiencies concerning the design and installation of seismically qualified conduit supports as shown on the 47A056 drawing series of typical supports. A potential exists for electrical conduits and their supports to exceed design allowable stresses. However, because of the ductility of the materials and conservative methods of enveloping loads, physical member lengths, and placement of loads, the possibility of actual conduit failures are extremely remote.

One item identified in SCR SQNCEB8502 that directly relates to this subcategory is:

d. As-constructed cable tray spans are longer than specified by design drawings.

e. Some surface mounted baseplates were modified by field changes and the "as-constructed" baseplates were not qualified by design calculations.

SCR SQNCEB8622R1 was initiated to document these deficiencies.

A review was performed by SQN to determine if attachment of engineered supports to cable tray supports, building steel and miscellaneous steel (except embedded plates) are documented on FCR's that show the actual locations and configuration of the supports.

This review was conducted as a result of the initiation of SCR WBNCEB8650 which identified the above deficiency at WBN.

Initial results indicated that the same deficiency existed at SQN and PIR-SQNCEB-8658 was subsequently initiated.

Interviews with the responsible engineers in the SQN Civil Design Analysis Group and DNE revealed the following:

a. The review performed in accordance with SCR WBNCEB8650 would address errors, omissions, and incorrect assumptions in the calculation/analysis. Preliminary results of the review had revealed potential problem areas with respect to all attachments to structural features not being considered and PIR-SQNCEB-8658 was initiated. However, no instance of actual errors, or omissions in the calculation/analysis process had been identified. It was stated that human error was a reality that had to be considered in calculations/analysis but felt that the Nuclear Engineering Procedure 3.1 "Calculations" provides sufficient checks and balances to overcome this problem.

b. Two responsible SQN engineers were not aware of any situations where identified errors had been left uncorrected.

c. Errors in calculations will be adequately addressed in the review required by SCR SQNCEB8622. Previous sampling programs have not identified problems in this area.

An additional deficiency relevant to the issue(s) of section 1.2.1 is the qualification and use of Rawl self-drilling anchors at SQN. The ECTG evaluation of this subject has revealed the following: R2

- The NRC accepted SQN's final 79-02 evaluation program with approved deviations after SQN had answered additional information requests on 79-02 issues. The NRC's acceptance is documented in the SQN Safety Evaluation Report Supplement 2, section 3.9.2, dated August, 1980. R2

  However, a discrepancy has been identified in the TVA response to six additional questions posed by the NRC concerning specific issues related to 79-02. TVA memorandum NEB 800201 250 dated February 1, 1980, documents the six questions and the TVA response to each question. Question three states, "For each type and size of expansion anchor used at SQN, provide a comparable table of the maximum allowable design loads and the manufacturers' average ultimate strength valves considering the actual concrete strength, embedment depth, plug depth and applied preload (as applicable)." The TVA response to this request included the table as well as the manufacturers' information on which the table was based. The response also stated, "Of the four manufacturers, Rawl is the only one who quotes capacities which are consistently less than G-32 requirements. In our opinion, the lower Rawl test values are directly related to specimen size and testing procedures. To the best of our knowledge, no Rawl self-drilling anchors were used at SQN. Rawl has not bid on supplying any TVA project with self-drilling anchors and therefore, we have not tested any of their anchors." It has been determined however, that Rawl anchors were, in fact, used at SQN. R2

  Therefore, DNE-CEB has initiated CAQR-SQF870101, revision 0, to document the use of Rawl self-drilling anchors at SQN. The CAQR description of condition states, "Rawl self-drilling anchors have been used at SQN. The manufacturers' data indicates capacities less than the Phillips anchors used as the standard. In addition, TVA's response to NRC OIE Bulletin 79-02 states, "to the best of our knowledge no Rawl anchors were used at SQN." This discrepancy was identified by an NRC inspector during an audit of the Employee Concerns Task Group report on anchorage." (CATD CO11301-SQN-09) R2

Conclusion

Errors, omissions, or incorrect assumptions in design calculations that were identified and not corrected during 1984 has not been proven to be factual.

Noncompliance with NRC IE Bulletin 79-02 and undocumented loads are factual based on the findings.

Discussion - BLN

TVA's drawing 3GA0059-00-12, Revision 4, Note III.1, provides TVA's Division of Nuclear Construction with several tolerances for fabrication and modification of baseplates and installation of anchor bolts (excluding TVA typical supports which are modified by field variance). These tolerances were primarily given to allow DNC to resolve problems with interferences of expansion anchors with reinforcing steel. The cumulative effects of the use of these tolerances may have resulted in significant increases in baseplate stresses and anchor bolt loads. The potential increases because of cumulative effects were not considered in the design of the various supports. This deficiency is documented on NCR BLNCEB8421.

Failure to consider the potential cumulative effects of modifying supports within the approved tolerance envelopes could result in an "as-built" support configuration that does not meet design requirements.

For supports already installed, a statistical sampling of existing field installations was made to determine actual field use of baseplate tolerances and existing factors-of-safety.

Ninety-eight expansion anchored pipe supports were randomly selected and inspected. Supports which utilized installation tolerances were reanalyzed. Factors-of-safety for all 98 supports were consistent with design requirements (self-drilling expansion anchor factor-of-safety greater than 5; wedge bolt factor-of-safety greater than 4).

This sample provides a 95-percent confidence level that less than 3 percent of the supports have factors-of-safety less than design requirements. Based on the sample results, modification of existing supports was not required.

A study was made to assess the detrimental effects of failing to consider baseplate configuration tolerances in the original design process. The purpose of the study was to determine the following:

a. Which combination of tolerances will give the worst case condition.

b. Amplification factors which should be applied in the original design process if tolerances are not considered.

Based on the results of this study, the following actions were performed:

a. Support designers were trained in the appropriate methods for consideration of baseplate tolerances.

b. DS-C1.7.1 was revised to specify methods for amplification of expansion anchor loads and baseplate stresses.

In June 1985, TVA's Technical and Administrative Staff (TAS - responsible for maintaining the DNE CAQ data base) identified an apparent adverse trend with regard to conduit supports not complying with the free area of attachment requirements shown on the design drawings.

This trend was identified during a review of CAQ Reports on "Conduit Supports." Nine NCRs had been written involving violations of the free area of attachment requirement on the design drawing for BLN during 1984 to 1985.

The detailed review of the NCRs indicated that all nine NCRs were dispositioned to "use-as-is".

Further investigation revealed that more examples of this type problem exist and will be documented as CAQs in the future.

A concern was expressed that the project and site engineers are aware of the recurring problem with the free area of attachment requirement but have not taken any actions to identify and correct the root cause to prevent these recurring problems.

At this time, the problem does not appear to exist at any other TVA plants and therefore was deemed site specific to BLN.

Note: In August 1985, the free edge violation was investigated for WBN and determined that the problem was not limited to free edge violations but also free area violations of drawing specifications at both WBN and BLN. WBN addressed this on SCR WBNCEB8623.

TAS recommended that the BLN Engineering Project investigate the handling of the free area requirement at other sites and/or the possibility of an over-restrictive free area requirement. Corrective action was to be initiated as necessary.

In response to TAS comments, CEB initiated PIR BLNCEB8518 to address the free area attachment requirements. This PIR was upgraded to a significant condition report SCR BLNCEB8518.

CEB initiated PIR WBNCEB8601 to address the effect of the additional loading when insulation is applied to conduit.

The PIR was reviewed by a BLN Electrical Staff Engineer who stated the following:

a. No conduits supported by TVA are insulated. Therefore, the referenced PIR is not applicable to BLN.

b. After Appendix R evaluations are completed some conduits may require insulation. However, these changes will be coordinated with the project civil group and any changes required will be worked under the ECN existing for Appendix R work.

CEB initiated PIR WBNCEB8602 to address typical support qualification. PIR BLNCEB8610 was generated to identify the problem at BLN. This states that DNC has added conduit or other features (permitted by drawings) to civil structural supports after an altered configuration typical support has been checked and approved for current actual loadings. Verification is required to determine that when the altered support was checked, the maximum loading condition permitted by the typical drawings was used and not the actual loading condition at the time to assure the worst case condition was considered.

Reviews of conduit and instrumentation support calculations and pertinent revision documentation are being performed to determine if deficient calculations for supports were approved by using current loading that was less than the maximum allowable design loading. Corrective actions will be taken as required according to the results of the reviews.

The result of the generic evaluation for SCR SQNCEB8607 resulted in PIR BLNCEB8612 being generated. This PIR states that some embedded plates are installed with the plate edge adjacent to a concrete edge. The edge may not have been considered in the capacity evaluation of the plate in some instances. A cursory review indicates that plate design accounted for edge capacity reductions; however, an in-depth verification will be performed to verify structural adequacy where required.

The generic review for SCR WBNCEB8623 resulted in PIR BLNCEB8616 being initiated. This addressed the design of baseplates for cable tray supports, duct supports, miscellaneous steel access platforms, etc., before May 31, 1983 which were performed using approved computer program BAP222 and design standards then in effect. Because of the effect of plate flexibility on the welded stud capacity, these designs may not have the factors-of-safety against pullout required by DS-C1.7.1 (implemented on May 31, 1983).

The previous sampling programs utilized for GEN NCRCEB8208 and the additional information compiled as a result of PIR BLNCEB8518 will be used to qualify the existing design in response to PIR BLNCEB8616.

BLN Engineering Project reviewed SCR WBNCEB8650 which addressed attachments to engineered supports, cable tray supports, building steel, and miscellaneous steel (except embedded plates) without the benefit of an approved FCR and determined that this condition did not exist at BLN.

This was based on the fact that ONP has not made any installations referenced in this SCR. Modifications or deviations from detail drawings are made by controlled procedures, FCRs, or interface reviews; therefore, this condition does not exist at BLN.

Conclusion

Errors, omissions, or incorrect assumptions in design calculations that were identified and not corrected during 1984 has not been proven to be factual.

Noncompliance with NRC IE Bulletin 79-02 and undocumented loads are factual based on the findings.

Discussion - BFN

In 1982, it was discovered that the minimum spacing criteria as provided by G-32 RS could have been inadequate in that expansion anchors can be installed at various plants which do not meet minimum spacing requirements when combined action of multiple attachments are considered. This deficiency is documented on NCR GENQAB8203. BFN has not evaluated the occurrences where expansion anchors for adjacent attachments are spaced closer than the G-32 requirements.

During a criteria review, the qualification of some baseplates and concrete anchors in the typical support details of design criteria BFN-50-712 could not be verified and no weld details were specified. This is documented on SCR BFNCEB8520. Also addressed is the deficiency noted on NCR BFNMEB8406 concerning some supports for field routed schedule 160 piping which could be undersized based on their selection using the table in BFN-50-712 designated for schedule 40 and 80 piping.

This could possibly result in the baseplates, welds, and/or anchorage for supports given in criteria BFN-50-712 to be overstressed for the design loads given in the support tables.

This problem is not considered to be generic because of the fact that BFN is the only TVA nuclear plant where support typicals are given in the small bore piping criteria.

In order to evaluate the extent of this program deficiency, the following recommendations were given in the Engineering Report:

1. Perform a walkdown review of a representative sample of existing 2-inch and smaller seismic class 1 field-routed pipe support installations. Identify any instances of configurations which cannot be defended on the basis of actual earthquake experience data.

2. As required from the walkdown review, perform an engineering evaluation of the support installations and if required, take corrective action.

3. Prepare DNE output documents as needed for new field-routed pipe support installations.

DNE prepared the scope of work document, engineering costs, and timeframe necessary to perform a walkdown inspection and engineering evaluation of a representative sample of existing 2-inch and smaller class 1 field routed piping supports. The scope of work document was BFPSWD 86-10, "Evaluation of Baseplates and Anchorages of Piping Systems Installed to BFN-50-712."

In 1985, the NRC initiated Unresolved Item (URI) Numbers 50-259/85-21, 50-260/85-21, and 50-296/85-21. These URIs identified deficiencies with DNE employees implementing TVA EP, 3.03 "Design Calculations." The deficiencies identified did not result in unacceptable support designs. The calculations were rechecked and revised in accordance with EP-3.03 and training sessions were held to review the requirements for pipe supports.

The NRC also questioned TVA's technical basis that allowed the applied direct shear for the expansion anchor base plates to be distributed in inverse proportion to the tensile loading in the anchors.

TVA performed a random sample to prove that the use of a shear distribution method (which allowed the distribution of shear in inverse proportion to the tensile load in the anchor) had not resulted in a significant number of supports with an inadequate factor-of-safety. The results indicate with a 95 percent confidence level that less than 5 percent of the anchors have an interaction ratio greater than 1.0.

PIR WBNCEB8601 was initiated to identify a potential problem concerning the application of insulation to conduit after the typical conduit supports had been finalized.

BFN Project Engineering examined their activities in this area and found that the condition does not exist at BFN. This is based on the following:

1. All insulation installed after May 1984, in Class I structures is controlled by MAI 27. This requires installing supports according to typical drawings 45A800 which specifically prohibits the use of any kind of wrap or by using specific drawings which would consider the additional loading.

2. Conduits installed before May 1984, are being addressed by Class 1E conduit qualification program (BFNP PI 85-02).

Note: BFN PI 85-02 was issued to detail DNE's methods for inspection and seismic qualification of existing electrical conduit and conduit supports installed in Class I structures at BFN before May 1984. A final report will be prepared by CEB to document the seismic qualification of all electrical conduit and conduit supports. The report will be prepared after all inspections have been performed, discrepancies resolved, and necessary drawings have been issued.

PIR WBNCEB8602 was initiated to address typical support qualification. BFN Project Engineering examined their activities in this area and found that the condition does not exist at BFN. This is based on BFN Plant Procedure MAI 27 which controls the installation of conduit in Class I Structures. This procedure prohibits any attachment to conduit supports that is not specifically allowed by design drawings. Class 1E conduit installed before May 1984, is being walked down and qualified by a Class 1E conduit qualification program. (BFNP PI 85-02).

Construction tolerances for attachment location, anchor location, and baseplate configuration for pipe supports are noted for BFN on drawing Note 22 on 47B435-1 and Note 35 on 47B435-2. During a design review, it was noted that amplification of calculated anchor bolt loads and baseplate stresses will occur if the tolerances are used. This was not accounted for during the initial design. This deficiency is documented on SCR BFNCEB8614. The remarks section of this NCR references NCR SQNCEB8404, NCR BLNCEB8421, and NCR WBNCEB8419. Each of these NCRs document deficiencies with respect to TVAs failure to consider baseplate flexibility during the initial design process. The baseplate flexibility issue is addressed by SCR BFNCEB8614 in that the description block specifically states that amplification of anchor bolt loads and baseplate stresses (both of which are considerations when accounting for baseplate flexibility) was not accounted for during initial design.

NOTE: The issue of baseplate flexibility was also addressed by the Engineering Category, Browns Ferry Element Report 220.3(c), R2, on Support Design General. The report specifically addresses the Civil Design Standard DS-C1.7.1 requirement for consideration of baseplate flexibility and states that this requirement," is referenced in the BFN Design Criteria." It also states that, "rigid plate analysis instead of flexible plate analysis may be used to calculate the bolt tensile load provided the conditions specified in section 5.1 (DS-C1.7.1) are met." The Engineering Category evaluation included a review of 21 sample supports and their calculation packages. Ten of these supports utilized baseplates and anchor bolts and five supports met the DS-C1.7.1 requirement for the flexible plate method of analysis. The report further states that, "the calculation for support RHR R159, unit 3, did not consider baseplate flexibility as required by DS-C1.7.1."

In the findings section of the Engineering Category Element report, it is stated that ". . . the supports were found to be adequate for the specified load. Although the pipe supports were found to be adequate, their associated calculations were found to be incomplete and/or contained minor discrepancies (. . . baseplate flexibility is not considered in the evaluation of anchor bolts). The calculation for support RHR R159, unit 3, . . . did not provide analyses for the critical baseplates."

Therefore, based on the findings of the Engineering Category Element report, a CATD was issued for BFN to specifically require flexible plate analysis on support RHR R159, unit 3, (CATD 10400-BFN-06). Since this Construction Subcategory report also addresses the baseplate flexibility issue from a broader perspective that includes NRC OIE Bulletin 79-02 criteria, the aforementioned CATD is included in this report instead of the Engineering Category Element report.

SCR SQNCEB8607 identified a deficiency addressing embedded plates installed with a plate edge adjacent to a concrete edge.

A random field walkdown was conducted at BFN to determine generic applicability and several deficient areas were identified. A specific location noted is the Diesel Generator Building.

At the time of the initial design and installation of the embedded plates, considering the effects of a concrete edge on the embedded plate capacity was not a requirement. This is documented on SCR BFNCEB8617.

The deficiencies in embedded plate design for cable tray supports and control of field change requests as identified by SCR WBNCEB8623 and SCR SQNCEB8622 were reviewed by BFN Engineering Project.

The conditions outlined in SCR WBNCEB8623 potentially exist at BFN. BFN has been and is presently undergoing evaluation of the following:

1. Piping systems their supports and anchorages under the 79-02 and 79-14 programs.

2. Conduit and their supports under the conduit qualification program.

3. Cable trays and their supports will be reviewed under the long term cable tray system qualification program.

4. Heating and ventilation ducts (HVAC) and their supports will be reviewed under the HVAC qualification program.

The above programs will address any deficient conditions. A program of constructability walkdowns is now in effect at BFN and all new modifications will be walked down and fully coordinated before the start of the design activity.

In response tc SCR SQNCEB8622 (cable trays do not meet design requirements), BFN stated the conditions do exist and are being covered for unit 2 by an Interim Qualification by United Engineers and for the other units by the long term requalification of the cable trays.

In response to SCR WBNCEB8650 (miscellaneous steel and attachments), CAR 85-059 had already been initiated to address this deficiency.

For any future pipe supports the pipe support designer will be required to design the miscellaneous steel support framing in addition to the pipe support or to transmit the loads to the miscellaneous steel support framing designers for analysis.

The existing pipe supports, cable tray supports, and conduit supports will be verified or qualified by ongoing programs.

Conclusion

Errors, deviations, and incorrect assumptions in design calculations that were identified and not corrected during 1984 has not been determined to be factual.

Noncompliance with NRC IE Bulletin 79-02 and undocumented loads are factual based on the findings.

4.2 The findings as indicated below address the second issue (noted in paragraph 1.2.2). This issue states that the design philosophy for concrete anchor bolt (wedge bolts) allowable loads for unit 1 are greater than unit 2.

4.2.1 Generic

Discussion - WBN

NRC IE Bulletin 79-02 specifies that the factor-of-safety for all loading conditions shall be 5 for expansion shell anchors and 4 for wedge bolt anchors unless justification for a lower factor-of-safety is provided. Before 1981, TVA allowable tensile design loads for service conditions were based on a factor-of-safety of 4.5 for self-drilling anchors (Redheads) and 4.0 for wedge bolt anchors. Initially, the factor-of-safety for shell anchors was applied to the average tensile capacities obtained from manufacturer's tests. In 1977, onsite qualification tests were performed and results were added to G-32 (Appendix C). The factors-of-safety for both shell and wedge anchors were based on the minimum qualification load.

In 1981, the allowable tensile loads for self-drilling anchors were reduced to maintain a factor-of-safety of 5 with respect to the minimum ultimate tensile capacities derived from onsite qualification tests. The service load allowables did not change, however, for those designs that were based on normalized loads. The allowables were reduced to maintain a factor-of-safety of four.

Conclusion:

The allowables for unit 1 are greater than unit 2; therefore, this concern is factual.

Discussion - SQN

The increase in the factor-of-safety required by IE Bulletin 79-02 resulted in a corresponding reduction in the allowable bolt loads. This change occurred during a timeframe which resulted in the allowable loads for wedge bolts in WBN unit 2 being lower than those allowed in unit 1. However, these changes did not effect the methodology utilized in determining the wedge bolt allowables for SQN units 1 and 2 and WBN unit 1.

Conclusion:

The same criteria was used to calculate the wedge bolt allowables for SQN units 1 and 2. Therefore, this concern is not factual.

Discussion - BLN

Before the issuance of DS-C1.7.1 (issued May 31, 1983) allowable loads for expansion anchor bolts were obtained from manufacturer's literature. The allowable loadings were based on a factor-of-safety of four for service load conditions. For extreme loading conditions load allowables were increased by 60 percent. The factors-of-safety of 4 for wedge bolts and 4.5 for shell-type anchors were based on minimum qualification test requirements.

Major piping systems were designed by ITT Grinnell and utilized a factor-of-safety of 4 for service load conditions based on manufacturer's allowable loads.

Conclusion:

There were no changes in the methodology used to calculate the wedge bolt allowables for BLN, therefore, the concern is not factual.

Discussion - BFN

All major piping systems were designed by Bergen-Paterson and required a minimum factor-of-safety of 4 for wedge bolts. In addition, TVA designed systems were also designed with a minimum factor-of-safety of 4 for maximum load conditions.

Conclusion:

The minimum factor-of-safety for loading conditions for wedge bolts has always been 4. Therefore, this concern is not factual.

4.3 The findings as indicated below address the third issue (noted in paragraph 1.2.3). This issue questions visual approval for minor loads on embedded plates.

4.3.1 Generic

Discussion - WBN

The NSRS investigation of this issue consisted of procedural reviews, review of FCRs, interviews with DNE engineers and field observations relating to the visual approval of embedded plate FCRs. The following summarizes their findings:

NSRS substantiated the concern based upon a review of DNE EP-4.03, Appendix 4 and associated FCRs.

Construction Specification N3C-928, "Locating Attachments on Embedded Plates," addresses the minimum spacing requirements and the visual program implemented by FCR H-10917 on January 6, 1984. The procedure states in section 2.4.3: "An FCR may be approved by EN DES representatives onsite without a sketch if they determine by visual examination that a detailed evaluation of the plate is not required."

NSRS stated that no clarification or qualification is provided in the specification. Visual inspection of certain attachments is allowed by EN DES EP-4.03 Appendix 4 if the support attachment exhibits minor load characteristics similar to the following:

a. Small attachment members such as unistrut members or standard structural shapes of strength similar to unistrut.

b. Attachments which support single runs of conduit of diameters less than or equal to 3 inches; or multiple runs of conduit exhibiting similar load characteristics.

c. Attachments which support single pipes of diameter less than or equal to 2 inches.

Design calculations (WBP 840515 212) have been performed to provide technical justification for acceptance of the minor loads listed above in an individual application. However, the calculations do not take into account loads applied by previous attachments. If the attachment cannot be visually approved, further evaluation is required.

The following FCRs were approved visually with minor loads added.

a. FCR EP-3733

b. FCR EP-3752

c. FCR EP-3759

d. FCR EP-3784

e. FCR EP-5171

These FCRs were discussed with DNE personnel and were determined to have been approved when they did not meet the intent of the visual program. The attachments were welded to embedded plates which in most cases supported other attachments.

The visual approval program was observed in the field for eight FCRs. The following FCR's had supports as defined by EP-4.03 Appendix 4 (currently CEB-21.46) however, four of the FCRs were for embedded plates with multiple attachments.

a. FCR EP-9911

b. FCR EP-9912

c. FCR EP-9913

d. FCR EP-9917 (multiple attachments)

e. FCR EP-9918

f. FCR EP-9919 (multiple attachments)

g. FCR EP-9920 (multiple attachments)

h. FCR EP-9921 (multiple attachments)

Discussions between NSRS and DNE personnel indicated that the approval of embedded plate FCRs was an engineering evaluation rather than an actual visual inspection. They stated that the approval process was based upon actual loading, allowable loading and previous engineering evaluations. However, in most cases there was no documentation to support this justification.

NSRS recommended the following:

1. Evaluate the adequacy of the visual inspection program by performing calculations on a random sample of embedded plate FCRs which include:

   a. EP FCRs visually approved more than once to address multiple attachments.

   b. Systems critical to safe shutdown.

2. If the sample provides evidence that the visual program is effective then perform the following:

    a. Develop a procedure to describe the actual EP-FCR approval process

    b. Require DNE approval before actual installation of an attachment which deviates from the required minimum spacing

    c. Provide justification that the visual approval program complies with 10 CFR 50 Appendix B, Criteria III

3. If the sample provides evidence that the visual program is not effective then:

    a. Revise N3C-928 to remove paragraph 2.4.3 which refers to visual inspection

    b. Perform design calculations on previously visually approved EP-FCRs and require calculations of all future EP-FCRs

On October 18, 1985, DNE met with representatives from QTC and NSRS and discussed the following issues:

a. Transfer of work between sections

b. Calculation errors in the load determination for EP-FCRs requiring detailed evaluation

c. Effectiveness of the visual inspection program and effects of cumulative loads (NSRS concern)

Items a. and b. are covered in section 4.1.1.

In order to address the effectiveness of the visual approval program, DNE agreed to evaluate 60 visually approved EP-FCRs. Documentation deficiencies found in the evaluation which did not meet the acceptability criteria would be evaluated as conditions adverse to quality.

The sample was randomly selected from the population of embedded plates which had been approved at least 3 times and had never been office approved. The subpopulation meeting these criteria consisted of 219 embedded plates.

The analysis of the sample showed all 60 embedded plates were qualified. The stresses in the plates, anchors, and concrete are within the allowable limits. Therefore, it can be stated with a 95 percent confidence level that no more than 5 percent of the embedded plates which have been visually approved have stresses which exceed allowable loads. This was in accordance with the original acceptance criteria.

The following items were observed during the sampling program:

a. Approximately 20 percent of 270 FCRs written by DNC in the sample reference incorrect plate numbers. The approved FCRs indicate that most of the errors were identified by DNE during the visual examination and corrected. The document reviews identified four FCRs which were approved but referenced the wrong plate number.

b. The allowable stress for the anchorage for one embedded plate exceeded the allowable stress using the cable tray calculations. Reanalysis of the cable tray using more refined seismic analysis resulted in a reduction in stress to well within the allowables.

c. Reactions calculated by DNE are for the typical configuration currently attached to the embedded plate. There is a potential where the field (DNC) could have added pipes or conduits to the support and not reported the modification to DNE (see section 4.1.1).

With respect to the evaluation procedure and compliance with 10 CFR 50 the following was provided:

a. The visual approval provisions for evaluation of embedded plate FCRs was included in WBN Project General Construction Specification N3C-928 because experience with the evaluation of the FCRs on embedded plates showed that less than 5 percent of the FCRs were being rejected. This occurred primarily because most of the attachments causing the violation of the spacing were typical lightly loaded supports.

b. Since the rejection rate was so small and the preparation of a sketch for each of the FCRs was very labor intensive, the specification was revised. The revision allowed DNE engineers/designers to visually examine the embedded plate to determine if a sketch and detailed evaluation was required.

c. This method of evaluation was considered to be acceptable since the engineers performing the visual examination are experienced in the analysis of the embedded plates and since a review of the approval is performed by an equally qualified individual. This evaluation and review is in compliance with the requirements of 10 CFR 50.

d. The visual approval process is commensurate with the original design. The majority of the embedded plates were designed and installed for intended later use by supports that were unidentified at that time. Many embedded plate details were duplicated from SQN drawings.

   1. While specific loadings were not available for most embedded plates, engineers provided plates which would be expected to provide adequate capacity for any future unidentified supports. The selection of the specific embedded plate size and thickness and the welded stud size, length, and spacing was based mainly on historical usage and engineering judgment. However, some calculations are available for SQN which determine embedded plate dimensions and details needed to envelop loads provided by mechanical support designers.

   2. Embedded plates of the size and configuration used at WBN can accommodate supports with a variety of load magnitudes and locations. Therefore, visual approval of minor load additions is within the scope of the original design.

A review of the work done to date indicates approximately 70 percent of the embedded plate FCRs are visually approved. Of the remaining 30 percent that are submitted for detailed evaluation only 3 percent have been rejected. This indicates that the DNE personnel in the field are conservative in their visual evaluation methods.

Conclusion

The sampling program for visually approved embedded plate FCRs indicates that the procedures used have been effective and comply with 10 CFR 50 Appendix B.

The visual approval process is commensurate with the original design of the embedded plates and the experience and sampling have shown that the program has been effective. However, some enhancements to the visual approval program will be made:

a. The engineering and construction procedures will be revised to emphasize the necessity of assuring the correct plate number is on the FCR.

b. The engineering procedure will be revised to list some standard acceptance criteria. Listing of some examples will be made, however, the visual examination will allow other items to be accepted if justification is given on the FCR form.

The evaluation performed by the NSRS provided examples where attachments to embedded plates had been visually approved but did not meet the guidelines in CEB-21.46 and visual approval was performed for an embedded plate that was already supporting other attachments. A specific definition for a minor load is not given in CEB-21.46. Examples to be used as guidelines are shown. EP-FCRs that did not meet this requirement were determined to have been visually approved, therefore, the concern is considered to be factual.

Discussion - SQN

EP-4.03 Appendix 4 is site specific to WBN. In reviewing the SQN-GCTF Report, it was stated that no issued instructions exist for visual approval of FCRs. However, N2C-937 "Locating Attachments on Embedded Plates," Section 2.5.2 states: "An FCR may be approved by OE representatives onsite without a sketch if they determine by visual examination that a detailed evaluation of the plate is not required."

This provides a mechanism for a visual program. The contradiction in the SQN-GCTF and the procedure resulted in additional evaluation.

Responsible engineers were interviewed in the DNE Civil Design Analysis Section and it was determined that the visual approval mechanism allowed by N2C-937 was not utilized at SQN. Further discussions concerning minor loads revealed the following:

1. A process is used by the Civil Structural Design Group which allows for "preliminary approval" of minor loads attached to embeds. This preliminary approval consists of engineering evaluation of the specific embed attachment by the responsible design engineer. FCRs, ECNs, new attachments, alternate analysis and revised loadings resulting from rigorous analysis are sufficient reason to initiate this evaluation. A detailed sketch of the individual feature or attachment is attached to a log sheet used for attachments to embeds. This sketch along with the information included on the log sheet provides sufficient detailed information for the responsible engineer to evaluate the installation. For cases where minor loads are approved without detailed calculations being performed, the responsible engineer makes a note on the log sheet that only a minor load is involved. Subsequently, the assembled information is entered into the group's computer data base which will establish a baseline of information for future reference. Eventually, detailed calculations can be performed on the embed that will include the minor loads which receive only preliminary approval under the current program.

   It should be noted that this program has been in place approximately one year (established in early 1986). Therefore, only the detailed calculations for each identified embed attachment submitted since the program's origination date and future calculations for specific embed attachments will be retrievable from the data base. All other existing embeds including configurations and loads will not be included in the computer data base unless they are submitted to or identified by the group for evaluation. It is reasonable to assume that the final contents of the data base will include only a portion of the total number of embeds, their attachments and loads if the program continues in its present form. In addition, discussions with the responsible civil engineer in the group revealed that there were no commitments in place at present to perform detailed calculations/analysis on embeds which would include the loadings from minor load attachments currently receiving preliminary approval.

The process used by the Civil Support Design Group includes the following:

a. A detailed sketch attached to the FCR which includes features within a 2-foot radius of the subject embedded plate attachment.

b. When applicable, a note is made on the FCR by the responsible engineer indicating minor loads are attached to the embed. While the minor load is shown on the detailed sketch this load addition to the embed is not always included in the detailed calculations performed to qualify the embed. Instead, engineering evaluation by the responsible design engineer determines whether the minor load is significant to the point that it will be included in the detailed calculations.

Both groups stated that there was no written criteria which clearly defined or provided guidelines for identifying minor loads. Further discussion led to the conclusion that some general guidelines for identifying a minor load could further enhance the engineering judgment and expertise which is currently used to make this determination. This evaluation agrees with that conclusion.

Conclusion:

Concern IN-85-003-001 was not answered adequately by the SQN-GCTF report. However, this evaluation determined that the concern was not generic to SQN. In addition, the programs for evaluation of minor loads attached to embeds are adequate with the following comments:

a. DNE-CEB should consider a review to determine whether implementing general guidelines for identifying minor loads attached to embeds would serve to improve the existing program(s). At WBN DNE-CEB issued CEB-EP 21.46 to provide further guidelines for attachments to embeds which were not addressed in N3C-928. Furthermore, the mechanism for visual approval of loads attached to embeds as allowed by N2C-937 is not used by the site Civil DNE organization. Therefore, consideration should be given to deleting section 2.5.2 of N2C-937 unless it can be established that future installations will be evaluated using the visual approval process.

b. In addition, DNE-CEB should consider a review to determine whether:

The existing program(s) should be expanded so that the detailed sketch reflects <u>all</u> features attached to the embedded plate. This comprehensive sketch would only be required the first time a FCR, ECN, new attachment, etc., caused the subject embed to undergo detailed calculations. This exercise would serve to establish a baseline program which would preclude the potential for overloading an embed because all attachments had not been identified and considered during the calculation process. Future FCR, ECN, etc. sketches would only be required to reflect the individual feature or attachment since the data base would contain detailed calculation data on all other attachments to the subject embed.

Any minor loads receiving preliminary approval under the current program should eventually be included in the detailed calculation process.

4.4 The findings as indicated below address the fourth issue (noted in paragraph 1.2.4). This issue questions the minimum spacing criteria change from 18 inches to 24 inches and 8 nominal bolt diameters to 10 nominal bolt diameters in 1982.

4.4.1 Site-Specific

<u>Discussion</u> - WBN

In March 1982, CEB initiated NCR WBNCEB8203 which addressed loading on embedded plates without a design review of the embedded plate capacity. (See section 4.0.)

A random sampling program of 69 embedded plates did not identify any support failures.

The undocumented loads on the embedded plates resulted from a lack of complete requirements in either a construction specification or design drawings to control the minimum distance between the attachments to embedded plates or the minimum distance between attachments to embedded plate edges. To prevent recurrence, DNE initiated N3C-928 (February 10, 1983) which addressed the minimum distance requirements.

All future attachments that violated the minimum spacing requirements would require approval from DNE.

N3C-928 required a 24-inch minimum clear separation in at least one direction parallel to a plate edge. For specific plates, the minimum clear distance could be reduced to two times the spacing of the embedded (welded) stud rows which are perpendicular to the direction of measurement.

G-32, R7, in effect during the same timeframe, allowed the minimum spacings between expansion anchors and embedded plates or strip inserts and the minimum spacing between grouted anchors and embedded plates or strip inserts to be reduced to a minimum of 2 inches for embedded plates or 1 inch for strip inserts, provided at least 18 inches is maintained between the anchor and any attachment welded to the embedded plate or between the anchor and any bolt installed into the strip insert.

Note: G-32 provided a radial clear distance. The change to the parallel measurement allowed the field to use smaller minimum spacings for plates where the welded stud spacing is less than 12 inches.

The contradiction in requirements between N3C-928 and G-32 was resolved in G-32, R8. This revision included section 3.6 for location of anchors specifically for WBN. The 18-inch minimum spacing requirement was revised to 24 inches to agree with N3C-928. The minimum spacing of 18-inches remained unchanged for the other nuclear plant sites.

The above changes provided:

a. Separate minimum spacing requirements for WBN in order to match N3C-928.

b. Revision to the minimum spacing requirement for expansion anchors to a free edge and embedded plate edge.

c. Allowance for DNC to attach to an embed if two rows of embedded (welded) studs separate an existing attachment and the new attachment.

d. Additional conservatism as compared to the original spacing criteria.

G-32, R5 (issued July 21, 1977) section 3.5.2 required the minimum side cover (edge) distance between an expansion or grouted anchor and a concrete edge to be 6 nominal bolt diameters. The requirement has never been 8 bolt diameters as stated in the concern.

Civil Design Standard DS-C1.7.1 addressed edge distance and the effect that an adjacent free edge may have regarding the capability of an anchor to transfer tension and shear loads to the underlying foundation.

The 6 nominal bolt diameter was for expansion anchors in tension to prevent spalling or cracking of the concrete during installation. This is addressed in Section 8.1.2 of DS-C1.7.1 which states that the primary lateral forces developed in concrete by expansion anchors occur during installation. Therefore, the tensile loading is not of primary importance in determining the edge distance for expansion anchors but to prevent spalling or cracking of the concrete during installation. G32, R6 (issued February 17, 1981) went to a 10 nominal bolt diameter separation for expansion anchors and/or free edge which enabled DNE to maintain a conservative position and eliminated DNC's need to determine whether the load on the anchor was tension and/or shear toward the free edge. The responsibility for determining that load requirements are met is covered by DNE in DS-C1.7.1, section 8.0.

No rework or reevaluation was necessary because of the fact that the changes were not made for technical reasons, inadequate requirements, or load bearing capacity for embeds.

Conclusion

Minimum spacing and edge distance requirements did change and no review was performed of the existing installations; therefore, the concern is factual. However, as stated above, the changes were not made for technical reasons and the 18-inch minimum spacing requirement remains in effect at all other TVA nuclear plants.

4.5 The findings as indicated below address the fifth issue (noted in paragraph 1.2.5). This issue concerned engineering disposition for exemptions of minimum spacing requirements.

4.5.1 Site-Specific

Discussion - WBN

WBN Project Specification N3C-928, R2, "Locating Attachments on Embedded Plates" provides requirements for the location of attachments with respect to minimum edge distance, minimum spacing between attachments, and minimum spacing between expansion anchors and attachments that do not require DNE review. If conformance to the requirement for edge distance or for spacing between attachments on the embedded plate is impractical, an embedded plate field change request (EP-FCR) is initiated by DNC.

The EP-FCR is submitted to DNE for approval of the location and loading on each attachment. This assures that anchors spaced less than the normally applied minimum have been evaluated for the effect of the reduced spacing on anchor capacity. An FCR may be approved visually by DNE representatives onsite if they determine that a detailed evaluation of the plate is not required.

The result of the sampling programs as addressed in Section 4.1.1 and 4.3.1 confirms that the design established for embedded plates has been proven to be conservative enough to accommodate unforeseen deviations from the prescribed parameters without compromising the load bearing capacity of the embed.

The sampling programs provide a 95 percent confidence level that less than 5 percent of the population is defective.

Conclusion:

The concern is factual in that minimum spacing requirements can be reduced according to the FCR process. However, the exemptions to minimum spacing requirements are procedurally controlled to avoid overloading of the embedded plate.

4.6 The findings as indicated below address the sixth issue (noted in paragraph 1.2.6). This issue addresses the hollow sound that occurs when embedded plates are tapped.

4.6.1 Site-Specific

Discussion - WBN

Areas of some embedded plates at WBN have a "dead" or "hollow" sound when struck or tapped with a metal object. This sound indicates that a portion of the plate is not in solid contact with the underlying concrete.

The NSRS investigated concerns addressing the "hollow" plate sound. The concerns were substantiated in that some areas on embeds do sound hollow when tapped. However, NSRS found no evidence of large voids existing behind the embedded plates and although substantiated, this situation does not have an adverse effect on nuclear safety.

DNE met with the Employee Concern Senior Review Panel on June 26, 1986. The panel requested DNE provide input to the engineering significance of the hollow sounds for some embedded plates and their effect on the capacity of the plates. The following excerpt was taken from the DNE-CEB response:

The "dead" or "hollow" sound indicates that the concrete is not bonded to the plate and may not be in solid contact with the underlying concrete. The loss of bond or the lack of solid contact could be caused by:

a. Concrete Placing Void

A concrete placing void behind the embedded plate would result in lack of solid contact. The void could be caused by congestion from the reinforcing bars and the anchors or by inadequate consolidation of the concrete.

Visible warpage o.' embedded plates has occasionally occurred as eviden‹ed by WBNNCR6470, however, no generic problems with warpage of embedded plates have occurred at any TVA plant. E cessive gaps because of welding of attachments is nc: likely to be a problem at WBN.

c. Concrete Shrinkage

The hardening o ncrete is an exothermic reaction (hydration of th. portland cement) which results in significantly increased temperature in the concrete mass for some period of time after placing. The volume change during the cooling to ambient temperature is significant for large ncrete members like those in a power plant. Some d... shrinkage also occurs. These volume changes could resu.t in a loss of bond and could potentially result in a small gap between the plate and concrete.

The shrinkage of the concrete would result in both tensile and shear stresses at the interface between the embedded plate and the concrete. These stresses would be expected to be relatively small but would combine with any stresses because of the temperature cycles that the embedded plate and the concrete surface would have been exposed to during the various stages of construction. The temperature of the underlying concrete would significantly lag the temperature of the plate during periods of fluctuating temperature.

The loss of bond between the embedded plate and the underlying concrete and the possibility of a small gap would be expected to result in a noticeable difference in the sound that would result from striking the plate. However, the gap would not be expected to have a width that would affect the design of the embedded plate.

All baseplates, including embedded plates, are designed by assuming that a perfectly elastic plate is in perfect contact with a perfectly elastic underlying material. These assumptions are never totally achieved for actual installations but engineering experience has shown that these assumptions have r.sulted in safe and serviceable designs.

Should a small gap exist under a portion of an embedded plate, the primary effect on the design would be a potential increase in the deflection of the attached structure and a pot ntial increase in the loads on the anchors.

Deflection could increase if the attachment was placing compression stresses between the plates and concrete and the gap was large enough in area to allow the plate to deform into the gap. Small gaps resulting from plate warpage or temperature change would have minimal effect on the deflection of the structure, especially if the structure was braced or had multiple attachment points.

If a gap with a relatively large area existed under a plate, the anchor loads at working load levels could increase for attachments placing bending moment on the plate. The increase would occur because the moment arm between the anchors and the resultant compressive force would be reduced. For example, it is conceivable that the moment arm for an embedded plate could be reduced from 8 to 6 inches under working load conditions. This would result in a increase of about 30 percent in the anchor loads.

The underestimation of the anchor loads at the working load level is not significant for this condition. As the load increases the plate movement would close the gap and the moment arm would return to the predicted value. Since the factor-of-safety for welded studs for working loads is at least 3 and usually 4 the deviation at the working loads level is not significant. The required factor-of-safety for ultimate loading is maintained.

The unimportance of small gaps or voids under the plate is further emphasized by the fact that most embedded plates would support their design loads with a relatively large gap under the entire plate. Unlike other types of anchors (such as anchor bolts), welded stud anchors will carry a compressive load. Therefore, if a large gap occurred, both the tensile and compression loads would be transferred to the anchors. The anchor loads would probably be somewhat less because of an increase in the moment arm and the plate bending stresses will probably be somewhat higher because of the greater distance between the attachment and the resultant compressive force. If any portion of the plate was in contact with the concrete the stresses and loads would approach the calculated values.

Conclusion:

The "hollow" sounds exhibited by some embedded plates when struck with a metal object are not necessarily indicative of the presence of large voids under the plate. Small gaps are expected to occur under the plates and these small gaps could result in the "hollow" sounds that have been observed.

Small gaps under embedded plates do not have a significant effect on the structural performance of the embedded plates. Unidentified voids large enough to effect the design are very unlikely since these voids would probably have extended beyond the plate and would have been identified and repaired.

The concerns are factual in that some plates do sound hollow when tapped. However, no condition adverse to quality exists.

4.7 The findings as indicated below address the seventh issue (as noted in paragraph 1.2.7). This concern addresses plates with 1 or 2 welded studs and cast-in-place anchors supporting loads for which no documentation exists to verify their ability to support the loads.

4.7.1 Site Specific

Discussion - BLN

The configurations for the subject plates are shown on drawings 4RW0425-X2-10, 4RW0507-X2-02, and 4RW0516-X2-02. The original design of this feature was to have a surface mounted plate installed spanning the existing embedded plate supported by cast-in-place anchors (type 49 plate). FCR-0-4866 was initiated on 3/5/86 to allow the surface-mounted plate to be deleted providing the outer nuts on the cast-in-place anchors were torqued to snug tight. By torquing these nuts the loading is placed on the cast-in-place anchors and not on the welded studs.

A visual inspection of four pipe supports attached to the type 49 plates revealed that the outer nuts on the cast-in-place anchors were not torqued and in most cases were not installed. Three of the four type 49 plates had pipe supports installed according to the DNE drawings.

Note: BLN NCR 5007 was initiated by the site to document the deficiency of improperly installed and/or missing anchor bolt nuts.

In reviewing drawings and procedural requirements, it was noted that no requirements exist for restraining nuts of embedded bolts from movement or loosening during concrete pours.

Note: BLN NCR 5016 was initiated by the site to document procedural and drawing deficiencies in addressing locking/restraining methods for the embedded nuts.

The DNC BLN Civil Engineering Unit Supervisor was interviewed and the following was stated:

a. The pipe support drawings do not reflect the type 49 plate configuration as being part of the support drawing; therefore, Hanger Quality Control (HQC) was not required to inspect the nuts during the hanger inspection.

b. The embedded feature configuration and material requirements are noted on the civil drawings. No provision is provided for a locking/restraining method for the embedded nuts.

A discussion with a BLN DNE unit supervisor revealed the following:

a. The plate integrity where a single nelson (welded) stud is suspected of accepting the entire load of the installation should be questioned.

b. He was not sure what the design basis was for the original analysis of the plate nor could he verify what specific purpose the nelson stud served (alignment versus loading).

Both issues will be addressed in the NCR response.

In regards to restraining the nuts on the embedded bolts during concrete pours a DNE-CEB engineer stated that any problems would have been identified in the proof load failure rates. He estimated that during a concrete pour, if a nut moved it would probably be 1/4 of a turn. He estimated that it would take approximately 8 turns for the nut to back off the stud.

<u>Conclusion:</u>

The concern relative to this issue is factual. The disposition of the nonconformances initiated as a result of this concern will verify stud anchor and/or plate integrity.

5.0 COLLECTIVE SIGNIFICANCE

5.1 Collective Significance of Issues

The following is a summary of collective significance findings for the seven issues comprising this subcategory.

5.1.1 Management effectiveness was exemplary in the development of programs which proved to be economical and time efficient. Anchor spacing tolerances were relaxed where possible and engineering expertise was utilized to visually approve minor loads on embeds. Management also displayed consistency in their willingness to initiate sample programs for field installations to prove the adequacy of design and construction methods for NRC OIE Bulletin 79-02.

However, management was ineffective in their willingness and ability to communicate with the NRC on 79-02 issues. The initial TVA response to the NRC on this subject was based on design methods and criteria which they were confident met or exceeded the intent of the bulletin. Furthermore, correspondence between TVA and the NRC was limited and additional information requests by the NRC should have indicated to management that the NRC was not totally satisfied with the TVA response. Instead of establishing a definitive policy of communication with the NRC on bulletin issues, management's philosophy was to further justify TVA's existing methodology instead of incorporating 79-02 requirements. Failure to establish definitive communication with the NRC and an attitude of "justify" instead of "incorporate and comply" has resulted in the bulletin remaining open for BFN, WBN, and BLN eight years after initial issuance. In addition, the regeneration of calculation packages and the documented deficiency of Rawl anchors has caused additional work at SQN on 79-02 related issues. R2

Management was also deficient in the area of employee training and failed to ensure that adequate procedures were in place to effectively control the required work, or stress the need for high quality and accurate work by employees. A large number of CAQ's have been identified in this area where effective management could have, as a minimum, curtailed these occurrences. Management was also ineffective in communicating with employees on specific technical issues as evidenced by the large number of employee concerns expressed on similar subjects.

Employee effectiveness was impacted by inadequate procedural requirements and a lack of adequate training. However, a lower quality of work than required was identified, as both errors and inaccurate information were found to have occurred more often than was acceptable.

From another perspective employee effectiveness could be regarded as positive when consideration is given to the lack of effective management, inadequate procedures, and training.

Technical adequacy has shown a marked improvement during the mid-1980's. Program changes and enhancements have increased the overall adequacy of design criteria and site procedures. The resolution of generic technical issues identified during the late 1970s and very early 1980s has revealed TVA was effective in identifying and implementing corrective action for significant program inadequacies. However, the number of changes and program enhancements implemented is indicative of the lack of technical adequacy during that time period.

5.2 Collective Significance of the Subcategory

5.2.1 Generic

a. Management Effectiveness

Collectively, TVA responded to NRC Bulletin 79-02 within the 120-day timeframe as required. The generic and individual site responses specified the design criteria utilized by TVA designers which were felt by TVA to meet and/or exceed the intent of Bulletin 79-02.

Additional information requests from the NRC resulted in acceptance and closure of the Bulletin for SQN unit 1 which was under operation and SQN unit 2 which was still under construction.

The WBN unit 1 response (originally submitted in July 1979) has not been accepted nor rejected to date by the NRC. As a result, TVA requested a meeting with the NRC in January 1985, to present the 79-02 factor-of-safety concern and the lack of EDS calculations (addressed in subcategory reports EN 20500 - Control of Design Calculations and EN 22100 - Pipe Support Designs).

The NRC agreed in this meeting that TVA's design verification work provided reasonable assurance that there were no safety concerns which would preclude issuance of an operating license for WBN. The NRC also asserted that a 100% review of all affected design support calculations would provide complete assurance that the requirements of 79-02 were met. TVA subsequently agreed to the review which was to be completed prior to the first refueling outage. This meant that WBN could have loaded fuel and operated prior to the review being completed.

The audit of TVA's design procedures by the NRC five years after the issuance of 79-02 and TVA's negligence in establishing technical communications with the NRC that were necessary in order to resolve TVA's position do not appear to have been performed in a timely manner. However, TVA's assumption that their response to 79-02 was adequate and their failure to incorporate Bulletin requirements into their procedures in 1979 can not be justified. Had TVA incorporated procedurally the bulletin requirements after issuance, questions concerning compliance and closure of this Bulletin for WBN and BFN may have been eliminated.

With respect to loading, the design of embedded plates did not address all the potential factors that could affect the integrity of the embedded plates. This has resulted in various CAQs being initiated to evaluate the potential for overloading embedded plates.

The visual approval EP-FCR program and preapproval program (enhancements suggested) utilized by WBN and SQN respectively, provide an economical and sound engineering method for approving the addition of minor loads. Management utilized past trends of low rejection rates for embedded plate FCRs to establish a program that would minimize construction delays with no impact on quality or performance capabilities.

b. Employee Effectiveness

Employees have not demonstrated the quality in their work that is necessary to ensure all procedural and drawing requirements are implemented.