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PORTLAND GENERAL ELECTRIC COMPANY

121 S. W. SALMON STREET
PORTLAND, OREGON 97204

D. J. BROEHL
ASSISTANT VICE PRESIDENT

July 13, 1979

Trojan Nuclear Plant
Docket 50-344
License NPF-1

Mr. R. H. Engelken, Director
U. S. Nuclear Regulatory Commission
Region V
Suite 202, Walnut Creek Plaza
1990 N. California Boulevard
Walnut Creek, CA 94596

Dear Sir:

Pursuant to IE Bulletin No. 79-02, Revision No. 1 (dated June 21, 1979) concerning Seismic Category I piping system support base plates which use concrete expansion bolts, we have performed extensive analyses, conducted a field inspection and testing program and reviewed relevant documentation. As indicated in our letter dated July 6, 1979, our response to IE Bulletin 79-02 is attached.

Sincerely,

D J Broehl

Attachment

c: Mr. Lynn Frank, Director
State of Oregon
Department of Energy

Director, Office of Inspection and Enforcement,
Division of Reactor Operations Inspection

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TROJAN NUCLEAR PLANT
PIPE SUPPORT BASE PLATES
USING CONCRETE EXPANSION ANCHOR BOLTS

I. INTRODUCTION

NRC IE Bulletin No. 79-02 (Revision No. 1) dated June 21, 1979, requires all licensees of nuclear power plants to review the design and installation of concrete expansion anchor bolts used in pipe support base plates in systems defined as Seismic Category I by the NRC Regulatory Guide 1.29, "Seismic Design Classification", Revision 1, dated August, 1973.

Pursuant to the Bulletin, extensive analytical reevaluations have been performed, and field inspection and testing has been conducted for Seismic Category I pipe support base plates using concrete expansion anchor bolts in order to confirm Seismic Category I piping system operability. This report provides results of the analyses and field testing, and our response to the Bulletin.

II. RESPONSE TO ACTION ITEMS

Item 1

Verify that pipe support base plate flexibility was accounted for in the calculation of anchor bolt loads. In lieu of supporting analysis justifying the assumption of rigidity, the base plates should be considered flexible if the unstiffened distance between the member welded to the plate and the edge of the base plate is greater than twice the thickness of the plate. It is recognized that this criterion is conservative. Less conservative acceptance criteria must be justified and the justification submitted as part of the response to the Bulletin. If the base plate is determined to be flexible, then recalculate the bolt loads using an appropriate analysis. If possible, this is to be done prior to testing of anchor bolts. These calculated bolt loads are referred to hereafter as the bolt design loads. A description of the analytical model used to verify that pipe support base plate flexibility

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is accounted for in the calculation of anchor bolt loads is to be submitted with your response to the Bulletin.

Response to Item 1

Original Design

The original design and installation of Seismic Category 1 pipe supports for the Trojan plant were governed by the following documents:

ANSI B31.1	American National Standard Code for Pressure Piping - Power Piping
ANSI B31.7	American National Standard Code for Pressure Piping - Nuclear Piping
ANSI B31.7b	1970 Addenda to Nuclear Piping B31.7-1969
ASME Section IX	Boiler and Pressure Vessel Code Welder Qualification
ASME Standards	Parts 1, 3, 4 and 31

Bergen-Patterson Pipe Support Corp. Catalog No. 66

Pipe support design loads were determined from piping stress analyses performed in accordance with the requirements outlined in Trojan FSAR Section 3.7.3.3. Design of seismic supports and restraints meets the requirements outlined in Trojan FSAR Section 3.7.3.3.11.

The original design of Seismic Category I pipe support base plates, where concrete expansion anchors were used, was based on a simplified method of analysis using rational assumptions and conservative allowable load criteria.

The distribution of loading on anchor bolts was calculated on the basis of a rigid base plate with pure tension and shear loads distributed equally to the bolts. The effects of bending moment loads were treated as follows:

1. Moments in planes perpendicular to the plate were resolved into tension forces on the bolts by considering the bolt rows to provide the resisting couple.

2. Moments in the plane of the plate were resolved into shear forces on the bolts by considering the bolt pattern to provide the resisting coupl-.

Shear-tension interaction relationships, as presently developed, were not considered in the original design.

Concrete expansion anchors used in the original design were Phillips Redhead self-drilling shell type anchors. Allowable loads used were based on a factor of safety of ten against the manufacturer's ultimate load values determined from tests. The standard used for minimum spacing between the expansion anchors was ten times the nominal bolt diameter. When not otherwise specified, 6" was used as the minimum distance from anchor bolt centerline to edge of concrete.

Reevaluation Analyses

For each safety-related piping system category, a large number of representative pipe anchor and support base plates using concrete expansion bolts were reanalyzed to account for plate flexibility, bolt stiffness, shear-tension interaction, minimum edge distance and proper bolt spacing. Depending on the complexity of the individual base plate configuration, one of the following methods of analysis was used to determine the bolt forces:

1. A quasi-analytical method, developed by Bechtel, was used for base plates with eight bolts or less. A review of typical base plates used in supporting the piping systems indicate that the majority of them were anchored either by 4, 6, or 8 bolts. The base plates typically vary from 3/8" to 1" in thickness and are generally not stiffened. For these types of base plates, an analytical formulation has been developed which treats the plate as a beam on multiple spring supports subjected to moments and forces in three orthogonal directions. Based on analytical considerations as well as the results of a number of representative finite element analyses of base plates (using the "ANSYS" code), certain empirical factors were introduced in the simplified beam model to account for the effect of the concrete foundation and the two-way action of load transfer in a plate. These factors essentially provided a manner for introducing the interaction effect of parametric variables (such as plate dimensions, attachment sizes, bolt spacings and stiffnesses) on the distribution of external loads to the bolts.

   The results of a number of other case studies indicate excellent correlation between the results of the quasi-analytical method and those of the finite element method (using the "ANSYS" Code).

   The effect of plate flexibility has been explicitly considered in the quasi-analytical formulation described above. The effect of prying action on the anchor bolts was determined not to be critical for the following reasons:

   a. Where the anchorage system capacity is governed by the concrete shear cone, the prying action would result in an application of an external compressive load in the cone and would not affect the anchorage capacity.

b. Where the bolt tension determines the anchorage capacity, the additional load carried by the bolt, due to its stiffness, decreases with increasing load. At higher loads the bolt elongation will be such that the corners of the base plate will tend to lift off and the prying action will be relieved. This phenomena has been found to occur when the bolt stiffness in the finite element analysis was varied from a high to a low value, to represent the initial stiffness and that beyond the allowable design load, respectively.

A computer program for the analytical technique described above has been implemented for determining the bolt loads for routine applications. The program requires plate dimensions, number of bolts, bolt size, bolt spacing, bolt stiffness, the applied forces and the allowable bolt shear and tension loads as inputs. Allowable loads for a given bolt are determined based on the concrete edge distance, bolt spacing, ultimate capacity for the bolt based on tests, considering material strengths, and a design safety factor. The program computes the bolt forces and calculates a shear-tension interaction value based on the following interaction formula:

$$\left(\frac{T}{T_A}\right)^2 + \left(\frac{S}{S_A}\right)^2 \leq 1.0$$

Where T and S are the calculated tensile and shear forces and T_A and S_A are the respective allowable values based on a factor of safety of five for shell-type anchors. Typically, no credit is taken for shear resistance by base plate friction due to anchor bolt preload.

The above relationship is an appropriate representation of shear-tension effects demonstrated by test data.

2. For special cases where the design of the support did not lend itself to the foregoing method, the finite element method using the "ANSYS" code and/or other standard engineering analytical techniques with conservative assumptions were employed in the analysis.

Table 1-1 summarizes results of initial reevaluation analyses, as described above, of representative pipe anchor and support base plates for each major safety-related piping system category. (The data presented in the table are for the number of base plates for which analyses were completed before the bulletin reporting date of July 6, 1979. This represents approximately 65% of the total number of base plates in large diameter Seismic Category I piping systems - 3" diameter and larger - which have concrete expansion bolts). In Table 1-1, the numbers of concrete expansion anchors in the various ranges of shear-tension interaction ratios are shown.

TABLE 1-1
SUMMARY OF REEVALUATION ANALYSES OF PIPE SUPPORT
BASE PLATES USING EXPANSION ANCHORS

Seismic Category 1 Piping System	Number of Expansion Anchors per Interaction Ratio Range						
	0<0.25	0.25<0.50	0.50<0.75	0.75<1.0	1.0<1.25	1.25<1.5	1.5<
Reactor Coolant	134	4		2			
Chemical Volume Control	569	67	23	24	3		6
Residual Heat Removal	339	56	8	18			6
Safety Injection	552	62	37	20			
Containment Spray	207	15	18	2			
Main Steam	24	2				14	
Steam Generator Blowdown **							
Condensate and Feedwater	30	16		9			
Component Cooling Water	819	52	16	8	1		
Service Water	794	16	18	8	4	8	6
Diesel Fuel**							
Miscellaneous*	309	22	8		6		
TOTAL	3777	312	128	91	14	22	18

Total No. Anchors Analyzed = 4362

* Miscellaneous systems include:

- Radioactive Gaseous Waste
- Containment Vent Monitoring
- Spent Fuel Pool
- Primary Makeup Water
- Clean Radioactive Waste
- Dirty Radioactive Waste
- Miscellaneous Gas Supply
- Chilled Water
- Solid Radioactive Waste
- Containment Condensate

** Typically small diameter piping (less than 3" diameter)

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Item 2

Verify 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 test (e.g., anchor bolt manufacturer's) which simulate the actual conditions of installation (i.e., type of concrete and its strength properties):

1. Four - for wedge and sleeve-type anchor bolts,

2. Five - for shell-type anchor bolts.

The bolt ultimate capacity should account for the effects of shear-tension interaction, minimum edge distance and proper bolt spacing.

If the minimum factor of safety of four for wedge-type anchor bolts and five for shell-type anchors can not be shown, then justification must be provided.

Response to Item 2

The methods used in the original analysis and design and in the reevaluation analyses of safety-related pipe support base plates which have concrete expansion anchors are described in the response to Item 1.

Table 1-1 shows that the majority of the expansion anchor loadings are in the lower ranges of interaction ratios. The numbers of expansion anchors which have interaction ratios between 0 and 0.25 represent 86.6% of the total, and 98.8% of the anchors have interaction ratios less 1.0. Each of the expansion anchors (Phillips Red Head self-drilling type) which have interaction ratios greater than 1.0, which implies a factor of safety against ultimate capacity less than five, based on a conservative initial reevaluation, will be analyzed in detail to determine the actual factor of safety available. If for any pipe support anchorage it is concluded that a factor of safety less than five exists, the pipe support will be modified unless a reduced factor of safety can be justified.

Item 3

Describe the design requirements, if applicable, for anchor bolts to withstand cyclic loads (e.g., seismic loads and high cycle operating loads).

Response to Item 3

In the original design of the piping sytems, dead weight, thermal loads, and seismic loads were considered in the calculation of the pipe support design loads. To the extent that these loads include cyclic considerations, these effects would be included in the design of the hangers, base plates and anchorages. Dynamic loadings on piping systems (from rapid valve closures, etc) were observed and recorded with instrumentation during plant startup and power ascension, as described if FSAR Section 3.9.1.3.3, to ensure that pipe restraint reactions resulting from thermal and pressure transients did not exceed design allowable values.

The safety factors used for concrete expansion anchors installed in supports for safety-related piping systems were not increased for loads which are cyclic in nature. The use of the same safety factor for cyclic and static loads is based on tests conducted at the Hanford Fast Flux Test Facility (FFTF)*. The test results show:

1. Expansion anchors, which had no apparent material imperfections or installation errors, successfully withstood two million cycles of long term fatigue loading at a sinusoidal load amplitude of above 0.2 of the static ultimate capacity. When the load amplitude was steadily increased above this value and cycled for 2,000 times at each load step, the observed failure load was about the same as the static ultimate capacity. Even those bolts which exhibited premature failure due to material

958052

* Drilled - In-expansion Bolts under Static and Alternating Loads. Report No. BR-5853-C-4 by Bechtel Power Corp., January 1975, P14.

defects or installation error withstood a minimum of 386,000 cycles at an amplitude of 0.2 of the static ultimate capacity. These tests included both the wedge-type and shell-type expansion anchor bolts.

2. The dynamic load capacity of the expansion anchors, under simulated seismic loading, was about the same as their corresponding static ultimate capacities.

Item 4

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

1. Cyclic loads have been considered (e.g., anchor bolt preload is equal to or greater than bolt design load). In the case of the shell type, assure that it is not in contact with the back of the support plate prior to preload testing.

2. Specific design size and type is correctly installed (e.g., proper embedment depth).

If sufficient documentation does not exist, then initiate a testing program that will assure that minimum design requirements have been met with respect to sub-items a and b above. A sampling technique is acceptable. One acceptable technique is to randomly select and test one anchor bolt in each base plate (i.e., some supports may have more than one base plate). The test should provide verification of sub-items a and b above. If the test fails, all other bolts on that base plate should be similarly tested. In any event, the test program should assure that each Seismic Category 1 system will perform its intended function.

The preferred test method to demonstrate that bolt preload has been accomplished is using a direct pull (tensile test) equal to or greater than design load. Recognizing this method may be difficult due to accessibility, in some areas an alternate test method, such as torque testing, may be used. If torque testing is used, it must be shown and substantiated that a correlation between torque and tension exists. If manufacturer's data for the specific bolt used is not available, or is not used, then site specific date must be developed by qualification tests.

Bolt test values of one-fourth (wedge-type) or one-fifth (shell-type) of bolt ultimate capacity may be used in lieu of individually calculated bolt design loads where the test value can be shown to be conservative.

Response to Item 4

Quality Control Documentation

Quality control documentation for Seismic Category 1 pipe supports installed at the Trojan Plant exists for pipe support fabrication details, materials, installation fit-ups, and operational settings. However, where Phillips Red Head self-drilling anchors were used in pipe support installations during the original construction, sufficiently detailed documentation was not developed to fully describe specific pipe support concrete expansion anchor setting requirements. The documentation does show that the expansion anchors were specified to be installed in accordance with the manufacturer's recommendations. Based on the quality control programs in force during construction, subsequent observations, operational experience, and inspection results, we have reasonable assurance that proper concrete expansion anchor installation standards were followed.

For recent pipe support modifications, Phillips Red Head wedge anchors have been used for attachment of Seismic Category I pipe supports. Construction documents prepared for installation of these supports

958054

specified anchor bolt installation and inspection requirements including a requirement to torque test each anchor bolt to a minimum specified torque. Work plans prepared for these pipe support modifications include anchor bolt installation and tensioning specifications. Documentation by inspector signatures on the work plans verifies that the anchor bolts were installed in accordance with requirements and that the anchor bolts were tested to specified torque values.

Cyclic Load Effects

Regarding cyclic load considerations, it is not necessary that the bolt preload be equal to or greater than the bolt design load. Pipe supports and anchors are subjected to static and dynamic loads. The dynamic loads are primarily seismic loads which are short duration cyclic loads. This type of cyclic load is not a high-cycle fatigue load and the amount of preload on the bolts will not greatly affect the performance of the anchorage. As long as the initial installation results in proper setting of the anchor, the ultimate capacity of the anchorage should not be affected by the amount of preload present in the bolt at the time of cyclic loading. Expansion anchors have successfully withstood long-term cyclic load environments, as discussed in the response to Item 3. Further, no credit was taken for anchor bolt preload in the reevaluation analyses.

Field Inspection and Testing

Since quality control documentation was not sufficiently complete to verify installation details for the Phillips Red Head self-drilling anchors (which constitute approximately 95% of the expansion anchors used in the plant), a field inspection and testing program was initiated. The objectives of field inspections and testing were to verify that the size and number of bolts were as specified in the original design, the proper setting of the anchorage, adequate bolt thread engagement, acceptable base plate bolt hole size, and appropriate anchor bolt spacing and edge distance. A description of the field inspection and testing program conducted follows:

1. Sampling. The concrete expansion anchor testing was performed during a scheduled maintenance outage at the plant. An effort was made to obtain a random and representative sampling of pipe support anchors in all Seismic Category I systems. Testing on pipe supports in the residual heat removal system was avoided due to the potential for excessive radiation exposures to the inspection crews. (The RHR system was, however, reviewed in the reevaluation analyses described in Response to Item 1). Since the time-consuming factors of testing were first locating and then obtaining access to the pipe supports, it was decided to test all bolts on each pipe support wherever possible. Supports to be tested were chosen such that the Operational Mode 5 (cold shutdown) operability of the plant was maintained in accordance with the Technical Specifications as the testing program was coordinated with other work in the plant. The test sample included primarily wall-mounted pipe supports, with very few exceptions, because these supports are most likely to experience significant tensile loads on their anchors.

2. Method of Testing. After consideration of various methods of testing, torque testing was chosen as the most viable method of verifying anchor capacity. In an attempt to meet the Bulletin reporting due date, field testing had to be started before analytical data on individual anchor bolt loads were available. Based on preliminary analyses, a test value of 25% of pullout capacity was selected as an appropriate test value. This value is 2.5 times the original anchor design allowable load, 1.25 times the pullout capacity divided by the factor of safety for shell-type anchors (five per Bulletin Item 2), and, as the subsequent analyses have shown, equal or greater than approximately 99% of anchor bolt loads when the effects of base plate flexibility and shear-tension interaction are considered.

During field testing, it was observed that anchor shell defects (failure to resist test load) were not sensitive to the torque value used in testing. The torque-tension correlation was originally calculated from the relationship:

$T = KFd$[1]

T = Torque value (inch-pounds)

K = Coefficient (taken as 0.20)

F = Bolt tensive load (pounds)

d = Nominal bolt diameter (inches)

Information obtained from torque-tension verification tests performed at the Hatch Nuclear Plant demonstrates an average torque-tension coefficient, K, of about 0.16 thereby indicating that the torque values used in the Trojan testing program are reasonable. Calibrated dial-type torque wrenches were used in the test. The torque wrench calibrations were reconfirmed after testing was completed.

3. Test Procedure. Inspection and testing was performed under the supervision of Registered Professional Engineers and Level II Quality Control Inspectors. The pipe support base plates were first inspected and measured to determine compliance with the original design detail sheets. Where design detail sheets were not immediately available, dimensions of the base plates were recorded for later verification. The base plate anchor bolts were then tightened to the test torque value. If preload was found to be less than the test value, the preload torque was recorded. If preload was higher than the test value, the actual preload was recorded while detensioning the bolt.

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(1) Shigley, Mechanical Engineering Design, McGraw-Hill Book Company, Inc., New York, 1963, pp 245 & 246.

The bolts were then removed and inspected. Thread engagement and plug depth were recorded and potential shell-plate contact was inspected both visually and by use of a feeler gage. If the anchor shell was found to contact the base plate, the anchor shell was retested by shimming the plate away from the anchor shell and reapplying the test torque. After testing, all bolts were reinstalled and preloaded to the test torque value.

4. Acceptance Criteria. The pipe support base plate expansion anchors were considered to be defective if they could not provide adequate resistance to the test torque, regardless of their design load requirement. Also, if any obviously improper anchor installation condition existed, the anchor was considered to be defective. Embedment depth was not used as a criterion for the self-drilling anchors since it is not a variable with regard to capacity for this type of anchor (embedment is limited to anchor shell length). Plate dimensions and the proximity of an anchor to the edge of a concrete member were noted on data sheets. Nonconformance reports were written for all defective anchors found, and for supports which did not conform to original design details or which did not have proper edge distance.

Conclusive results could not be obtained regarding plug depth in the anchor shell as a measure of full shell expansion since the measurement varied due to an uneven break surface where the self-drilling anchor shank was snapped off. In some cases, the anchor was embedded with the shank attached. In other cases, the anchor shell was hammered in hard enough to drive the plug up past the end of the shell. In no case, however, was it found that the plug interfered with the threads in the anchor shell.

The engagement of bolt threads into the shell, and enlargement of bolt holes in the base plate were recorded and are presently being evaluated, but appear to be of little concern based on results to date.

5. Test Results. Results of the concrete expansion anchor inspection and testing program are summarized in Table 4-1, Table 4-2, and Figure 4A.

Table 4-1 lists the Seismic Category 1 piping systems, the total number of concrete expansion anchors in each system as identified from records and the number of expansion anchors used in wall-mounted supports. As described above, primarily wall-mounted supports were tested because they are the most likely to have tensile loading on their anchors. The numbers tested and the rate of defects found, R, for each system sample are listed in the table. The column headed R' gives the upper limit of the true defect rate, at a 95% confidence level. The relationship between R and R' is:

$$R' = R + Z \left[\frac{R(1-R)}{n}\right]^{1/2} \left[\frac{N-n}{N-1}\right]^{1/2} \quad (1)$$

Where:

R' = Upper limit of the true defect rate at at specified confidence level, %.

R = Defect rate observed in sample, %.

Z = Confidence coefficient for a normally distributed statistical model of test data. For a 95% confidence level, Z = 1.645.

n = Test sample size.

N = Total population from which test sample was selected.

In Table 4-1, the estimated maximum true defect rate data, R', are conservatively based on the population of anchors in wall-mounted pipe supports because wall mounted pipe supports are most likely to have tension in their anchors.

(1) Cockran, Sampling Techniques, 3rd Edition, John Wiley & Sons, Inc., New York, 1977, Ch. 4.

TABLE 4-1
SUMMARY OF FIELD TESTING OF PIPE SUPPORT
BASE PLATES USING EXPANSION ANCHORS -
RESULTS BY SEISMIC CATEGORY 1 PIPING SYSTEM

Seismic Category 1 Piping System	No. Anchors		No Wall Tested	% Tested	No. Defects	R(a)	R'(b)
	Total	Wall					
Reactor Coolant	366	298	39	13.1	1	2.6	6.5
Chemical Volume Control	2735	2265	204	9.0	17	8.3	11.3
Residual Heat Removal**	786	614	0	0	-	-	-
Safety Injection	1537	1065	187	17.6	5	2.6	4.3
Containment Spray	346	206	44	8.4	0	0	-
Main Steam	188	132	3	2.3	0	0	-
Steam Generator Blowdown	787	605	190	31.4	4	2.1	3.5
Condensate and Feedwater	330	244	20	8.2	1	5.0	12.7
Component Cooling Water	1131	714	168	23.5	11	6.6	9.4
Service Water	1490	758	199	26.3	20	10.1	13.1
Diesel Fuel	513	247	67	27.1	3	4.5	8.1
Miscellaneous(c)	1173	799	487	41.5	31	6.4	7.5
TOTAL	11,382	7947	1608	20.2	93	5.8	6.7

(a) R = Defect rate observed in sample size (%).

(b) R' = Upper limit of the true defect rate at a 95% confidence level (%).

(c) Miscellaneous systems include:

Radioactive Gaseous Waste
Containment Vent Monitoring
Spent Fuel Pool
Primary Makeup Water
Clean Radioactive Waste
Dirty Radioactive Waste*
Miscellaneous Gas Supply
Chilled Water
Solid Radioactive Waste*
Containment Condensate

* Not sampled.

** See description of sampling.

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Only 12 of the 1608 total anchors tested were in other than wall-mounted pipe supports. As stated previously, emphasis was placed on the wall-mounted supports because they are the most likely to have tensile loading on their expansion anchors.

Although there is considerable spread in the data as presented by system, the basic variables in expansion anchor performance appear to be the materials (concrete or concrete masonry) in which the anchors are installed. Table 4-2 shows the numbers of various size anchors tested and the defects found in concrete and in concrete masonry installations. The data show that the sample size defect rate in concrete masonry is about twice that in concrete. For the anchor bolt diameters where a large enough test sample was available, the data show that the defect rate is essentially uniform in terms of anchor bolt diameter.

Figure 4A shows plots of the successively accumulated expansion anchor test data which illustrate trends of overall test results, and those for installations in concrete and in concrete masonry. The theoretical defect rate lines for 95% confidence shown in the figure are based on the population of expansion anchors in wall-mounted supports. As illustrated in Figure 4A, trends of the data for a representative number of wall-mounted Seismic Category 1 pipe support expansion anchors (about 20% of total installed) indicate:

- The 95% confidence level upper limit defect rate for expansion anchors installed in concrete masonry is between eight and ten percent.

- The 95% confidence level upper limit defect rate for expansion anchors installed in concrete is between five and six percent.

- The 95% confidence level upper limit cummulative defect rate for expansion anchors is between six and eight percent.

TABLE 4-2
SUMMARY OF FIELD TESTING OF PIPE SUPPORT
BASE PLATES USING CONCRETE EXPANSION ANCHORS -
RESULTS BY INSTALLATION MATERIAL

Installation Material	Anchor Bolt Diameter (inches)					Totals	R*
	3/8	1/2	5/8	3/4	7/8		
Concrete:							
Number tested	194	246	161	4	17	622	3.54
Number defects	4	9	8	0	1	22	
Concrete Masonry:							
Number tested	605	253	115	3	10	986	7.20
Number defects	44	17	10	0	0	71	
Totals:							
Number tested	799	499	276	7	27	1608	5.78
Number defects	48	26	18	0	1	93	
R*	6.01	5.21	6.52	0	3.70		

* R = Defect rate observed in sample (%).

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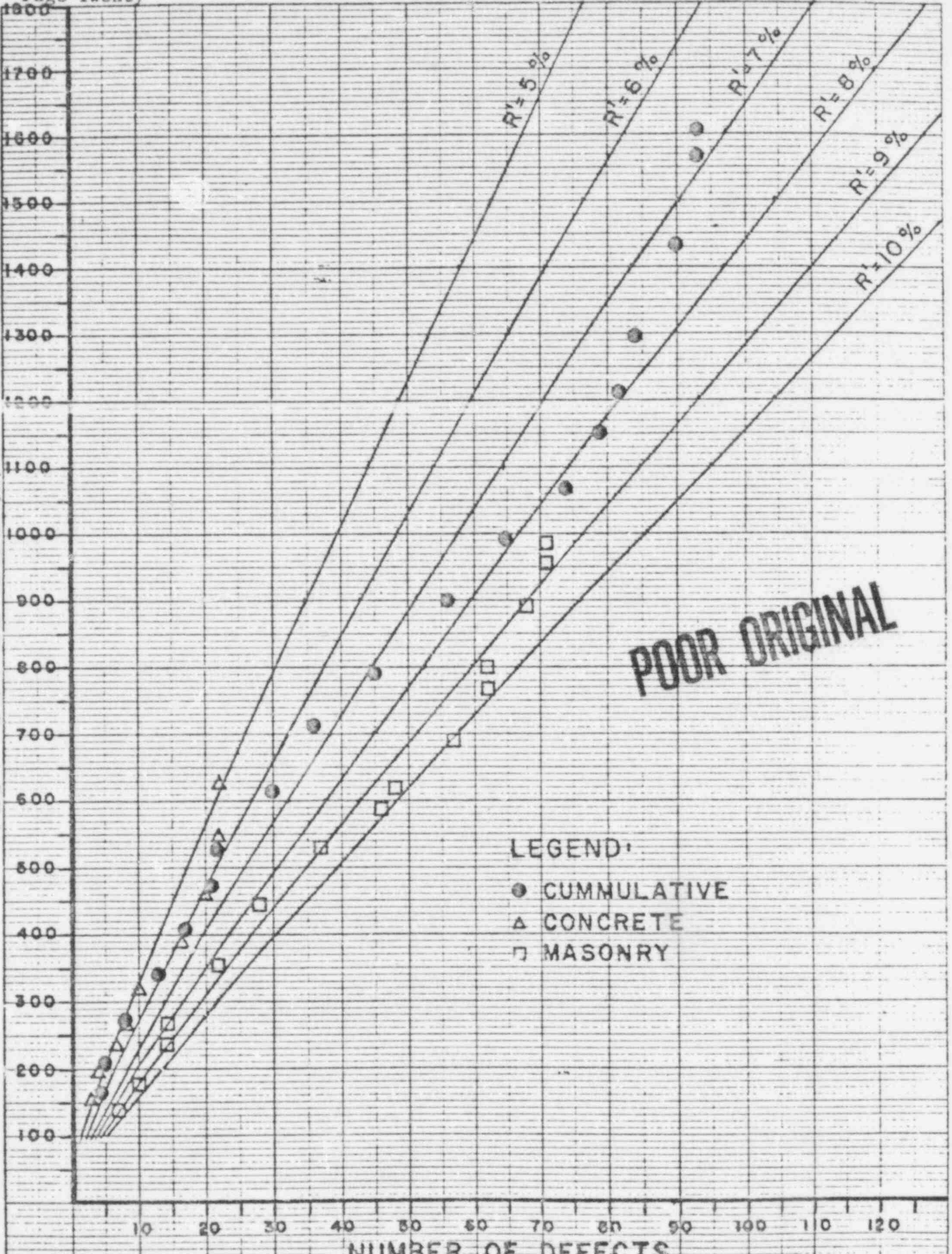
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
TEST SAMPLE SIZE (n)
R' = 5 %
R' = 6 %
R' = 7 %
R' = 8 %
R' = 9 %
R' = 10 %
LEGEND:
CUMMULATIVE
CONCRETE
MASONRY
10
20
30
40
50
60
70
80
90
100
110
120
NUMBER OF DEFECTS

FIGURE 4A

6. Evaluation of Defective Anchors Identified. In accordance with plant procedures, all Seismic Category 1 pipe support base plate expansion anchor deficiencies identified during the field inspection and testing program were documented in nonconformance reports. To date, all nonconforming base plate anchor installations have been dispositioned as acceptable. All but three nonconforming anchor installations have been repaired. Analyses of the three base plate anchor deficiencies that have not been repaired show that the pipe supports still have adequate factors of safety. However, the conditions associated with these three deficiencies are scheduled for repair as soon as practicable.

In summary, no defective anchor condition identified by field inspection and testing of pipe support base plates affected the operability of any Seismic Category 1 piping system.