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July 9, 1979
GQL 0882

Mr. B. H. Grier, Director
Office of Inspection & Enforcement
Region I
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, Pennsylvania 19406

Dear Sir:

Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
I&E Bulletin 79-02/79-02 Rev.1

Enclosed please find Met-Ed's response to the subject bulletin.

Sincerely,

J. G. Herbein
Vice President
Generation

JGH:RJS:mrm
Enclosure

cc: U.S. Nuclear Regulatory Commission
Office of Inspection and Enforcement
Division of Reactor Operations Inspection
Washington, D.C. 20555

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July 9, 1979

THREE MILE ISLAND NUCLEAR STATION
UNIT 1
RESPONSE TO NRC IE BULLETIN 79-02/79-02 REV. 1

1.0 INTRODUCTION

A design review was performed in response to IE Bulletin No. 79-02/79-02 Rev. 1 "Pipe Support Base Plate Design using Concrete Expansion Anchor Bolts," dated March 8, 1979/June 21, 1979 for Three Mile Island Nuclear Station, Unit 1. The review was performed on a representative sample of safety-related supports (Seismic Category I). Possible effects of base plate flexibility on base plate anchors were considered. This report presents the methods and results of the design review. Also a program was developed to inspect the in-place anchor bolts.

2.0 SUMMARY

2.1 Summary of Design Review

1. Most plates were determined to be flexible as defined by the NRC 2:1 ratio criteria. Therefore, plates were reanalyzed using a method in which the effects of plate flexibility and shear-tension interaction were considered. The results of the reanalysis confirmed the adequacy of the original design.

2. A representative sample totaling 40 support base plates for pipe of a diameter 2-1/2" and larger, all anchored with Red Head self-drilling expansion anchors, were reanalyzed. With one exception, the minimum factor of safety against failure was found to be greater than the factor of safety of five (5) required by the Bulletin for shell type anchors.

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3. All Seismic Category I supports are potentially subject to a relatively low number of seismic loading cycles which can be accommodated by the design. Operational loads which could, during the lifetime of the plant, undergo a high number of load cycles, were identified during startup testing, and modifications to the pipe support system were made as required to assure that such loads are minimized.

2.2 Summary of In-Place Inspection

On March 14, 1979, a preliminary inspection of 46 anchor bolts on 35 hangers within the Reactor Building was conducted, and no deficiencies were found. This inspection established bolt size and bolt length.

As of this date, the testing of anchors has not been completed, and it is expected that the additional inspection results will be available by October 15, 1979.

3.0 REVIEW RESULTS

In consideration of the requested action, a representative sampling of base plates for large bore (2-1/2" and larger) Safety Category I pipes were reanalyzed. There are approximately 1,475 base plates in the plant which fit this category and 40 have been investigated.

Small bore (2" and smaller diameter) pipe was designed using a seismic support spacing criteria. The criteria was developed based on a conservative pipe stress and a multi-span model for each pipe size and schedule. The analysis provides pipe stresses and support loads for a given span. This approach has been verified by sample computer analyses to be conservative relative to applicable code requirements.

A series of typical support designs were generated and load rated by analytical techniques. The supports were analyzed for structural adequacy for all members, welds and the expansion anchor bolts. In generating the load rating, the most conservative geometry combination of the maximum distance from the pipe to the structure was used. This resulted in the worst load case.

As a result of this conservative approach, detailed analyses and inspection of these expansion anchor bolts is considered unnecessary.

4.0 MET-ED RESPONSES

4.1 Response to Item 1

Base plates were considered rigid in the original design. For reexamination of the base plates considering plate flexibility, procedures were developed for the analysis of the plates and anchorages for moment and axial load applied to the plate surfaces (Figure 1 and 2). The expansion bolt stiffness (i.e. K_s in Figure 1 and 2) was derived from force-displacement curves provided by the manufacturer.

For both loadings, equations were derived from statics and deflection compatibility which allows calculation of the prying force on the plate and, subsequently, determination of forces in the anchors and stresses in the plates. For both cases, criteria have been formulated to determine whether or not prying exists based upon the geometry of the detail and material properties of the plate and anchor. Prying was found to be negligible.

In all base plates, shear and tension effects were combined directly to evaluate the anchors with the resultant shear force being distributed equally to all anchors in the connection. The method for combining these effects is described below in Section 4.2.

4.2 Response to Item 2

The concrete expansion anchor bolts used at TMI-1 are the Red Head self-drilling expansion anchors as manufactured by ITT Phillips Drill Division. This is a shell type anchor, and therefore requires a minimum factor of safety of five. The results of the reanalysis are summarized in attached Table 1. The minimum factor of safety is 6.8, except for one anchor on one support which has a factor of safety of 4.2. This one case is being evaluated further using a more refined analysis. Approximately 83% have a factor of safety greater than 10.

The factor of safety against failure (F.S.) is determined using the following shear-tension interaction equation:

$$\frac{(F.S.)\ (T_o)}{(T_a)} + \frac{(F.S.)\ (S_o)}{(S_a)} = 1$$

where: F.S. = factor of safety against failure

T_o = Tension Force induced into an anchor (considering plate flexibility)

T_a = ultimate tension capacity of an anchor *

S_o = Shear Force induced into an anchor

S_a = ultimate shear capacity of an anchor *

* From manufaccurers static load tests

The minimum edge distance between the bolt centerline and the edge of a concrete member is equal to 5d or 4 inches, whichever is greater.

In accordance with the manufacturer's instructions, bolt spacings greater than 7 shell diameters develop 100% of the published ultimate strength, and spacings of 3-1/2 shell diameters develop 80%. Therefore, in those cases where the spacing is less than 7 and greater than 3-1/2 shell diameters, the anchor capacity has been reduced 20%. The minimum spacing is 4.7 shell diameters.

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4.3 Response to Item 3

Pipe support reactions are generated as an output of a dynamic analysis and are utilized for the design of the individual pipe supports. Therefore, theoretically, a dynamic amplification factor was not required.

The governing load combination is:

Deadweight + Thermal + OBE Seismic + Occasional Mechanical Loads
$\leq$ Allowable Anchor Bolt Load

A correctly installed shell type anchor develops its tensile capacity by radial expansion of the bottom portion as expanded by a conical plug when the shell is driven into the concrete. In effect, this gives an internally threaded insert rigidly anchored in the concrete. The base plate is bolted to the shell and the shell may or may not be in contact with the back of the base plate.

4.4 Response to Item 4

Sufficient QC documentation does not exist to satisfactorily respond to this item. Therefore a test program has been developed to inspect a random sample, by system, of the expansion anchor bolts. The test procedure is given in the attached Appendix 1. It is expected that the test results will be available by October 15, 1979.

TABLE 1
RESULTS OF BASE PLATE ANCHOR REANALYSIS

Mark	Anchor Size Ø	Min. Spacing Shell Dia.	Factor of Safety	Remarks
DCH-15	5/8"	8.3	13.6	
DCH-27	3/4"	6.0*	10.3*	Rigid Plate Analysis
DCH-52	3/4"	9.5	∞	Compressive Load Only
DCH-53	3/4"	9.5	7.0	
DCH-62	3/4"	7.5	61.3	
MS-228	5/8"	11.5	17.0	
MS-241	3/4"	8.0	92.7	
MS-271	5/8"	9.5	38.7	
MS-277A	1/2"	8.7	33.6	
FW-121	3/4"	9.5	13.6	
FW-122	3/4"	9.5	12.8	
EF-11	5/8"	5.9*	102.8*	
EF-22	3/4"	7.5	70.9	Rigid Plate Analysis
EF-110	1/2"	9.0	7.5	
MUH-5	1/2"	9.0	15.6	
MUH-11	1/2"	8.7	97.7	
MUH-21	5/8"	7.1	123.2	
MUH-42	1/2"	8.7	6.8	
MUH-75	1/2"	9.0	9.2	
MUH-118	1/2"	5.0*	21.0*	
MUH-221	1/2"	7.2	86.2	Rigid Plate Analysis
DHH-187	1/2"	11.6	40.6	
RC-5	1/2"	5.8*	9.1*	
NSE-2	3/4"	7.5	176.1	
NSE-31	5/8"	8.0	58.5	Rigid Plate Analysis
SFH-20	5/8"	8.0	35.1	
SFH-165	5/8"	9.1	107.5	
SFE-28	5/8"	4.7*	47.8*	Rigid Plate Analysis
PR-3A	7/8"	8.0	22.3	
PR-6	3/4"	6.0*	281.8*	
NSH-11	7/8"	11.4	12.0	
NSH-55	5/8"	19.8	15.8	
NSH-90	5/8"	8.0	8.0	
NSH-91	3/4"	7.5	33.8	
NSE-26	7/8"	8.0	26.6	
NSE-93	5/8"	11.5	18.8	
SPSE-2	5/8"	8.1	212.8	
SPSE-3	3/4"	11.5	4.2	
SPSE-4	1/2"	8.7	373.3	
DCH-68	3/4"	4.7*	24.6*	

* Derated 20% due to spacing less than 7 shell diameters but more than 3½ shell diameters.

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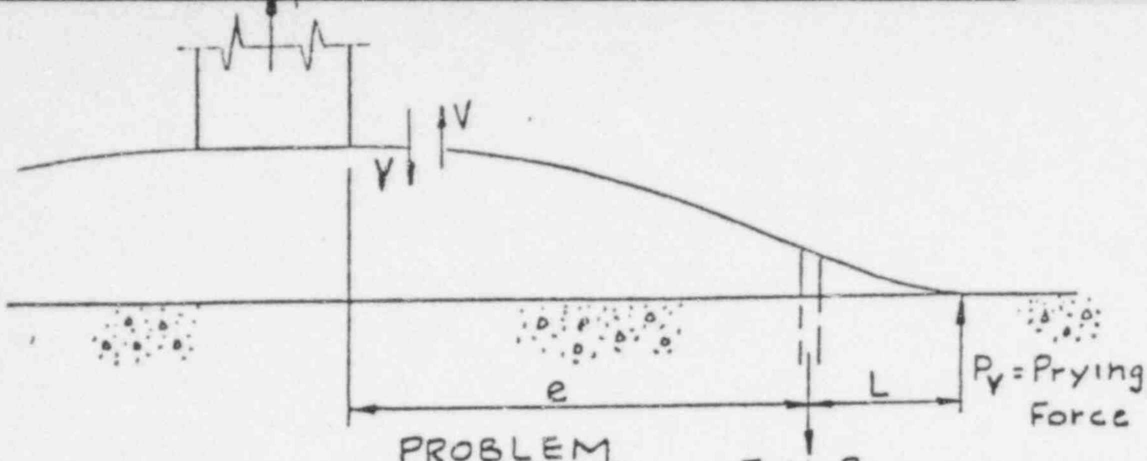
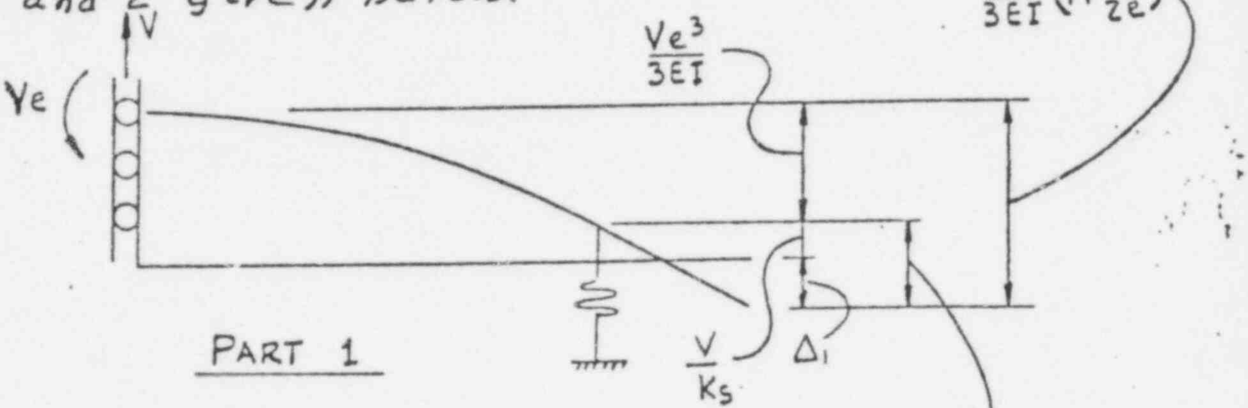


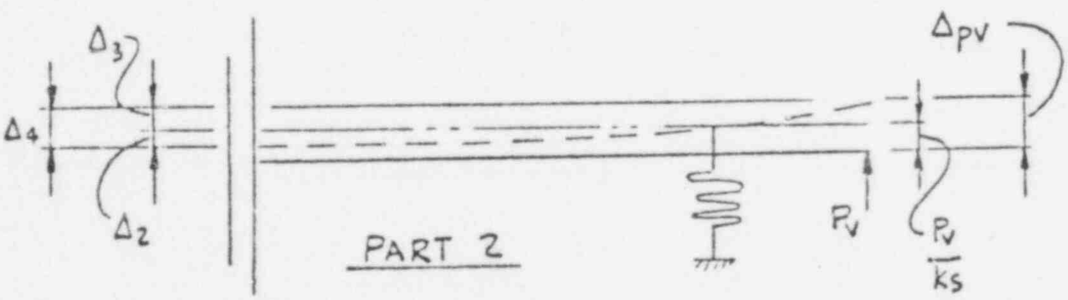
PROBLEM

The problem is solved by superposition, using Parts 1 and 2 given below.



PART 1

$$\Delta_1 = \frac{Ve^2L}{2EI} - \frac{V}{K_s}$$



PART 2

$$\Delta_3 = (\Delta_4 - \Delta_2) = \frac{P_V L^2 e}{EI} + \frac{P_V L^3}{3EI} + \frac{6}{5}\frac{P_V L}{AG}$$

$$\Delta_{PV} = \frac{P_V}{K_s} + \frac{P_V L^2 e}{EI} + \frac{P_V L^3}{3EI} + \frac{6}{5}\frac{P_V L}{AG}$$

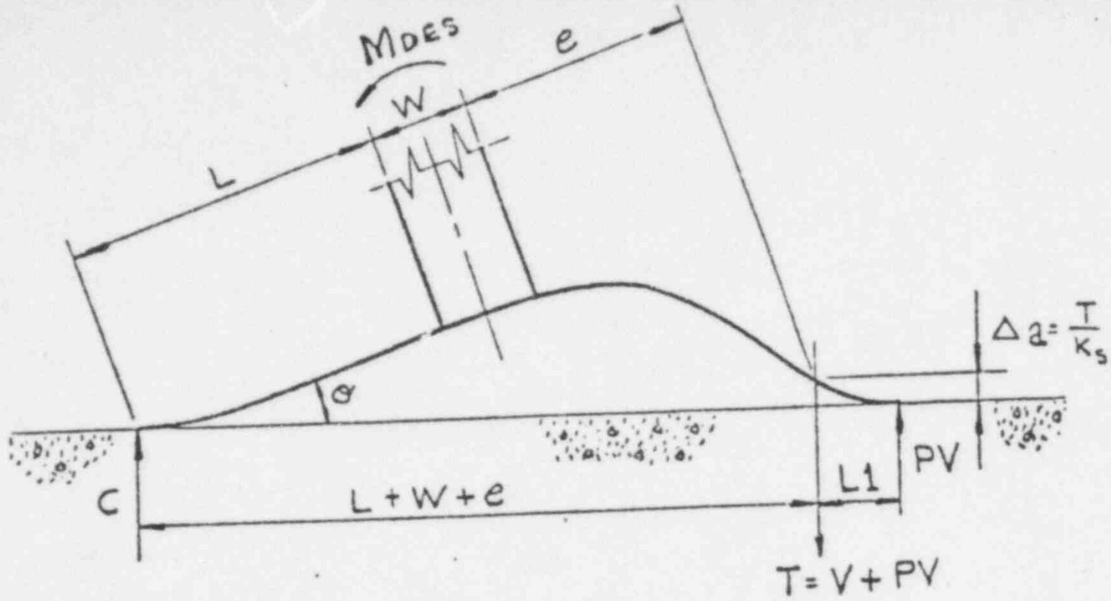
Equating $\Delta_1 = \Delta_{PV}$; $\frac{P_V}{V} = \left[\frac{e^2L}{2EI} - \frac{1}{K_s}\right] \div \left[\frac{1}{K_s} + \frac{L^2e}{EI} + \frac{L^3}{3EI} + \frac{6L}{5AG}\right]$ Eq. 1

If $\frac{1}{K_s} \geq \frac{e^2L}{2EI}$ no prying exists and $T = V$

If $\frac{1}{K_s} < \frac{e^2L}{2EI}$ solution of Eq. 1 will yield the prying force 'P_V'.

FLEXIBLE PLATE ANALYSIS
FOR TENSILE LOAD

Figure 1



$$T = V + P_v$$

$$\Delta a = \frac{T}{K_s}$$

$$\theta = \frac{V L^2}{2 E I_p}$$

$$L = \frac{3}{\theta} \left\{ \left[\Delta a - \frac{P_v L_1 e^2}{2EI} + \frac{V e^3}{3EI} \right] - \theta W - \theta e \right\}$$

$$V = \frac{M_{DES} + P_v L_1}{e + W + L}$$

$$P_v = \frac{V \left[\frac{e^2 L_1}{2EI} - \frac{1}{K_s} \right] - \theta L_1}{\frac{1}{K_s} + \frac{L_1^2 e}{EI} + \frac{L_1^3}{3EI} + \frac{6}{5} \frac{L_1}{AG}}$$

if $\frac{V}{K_s} + \theta L_1 \geq \frac{V e^2 L_1}{2EI}$ no prying exists and $T = V$

if $\frac{V}{K_s} + \theta L_1 < \frac{V e^2 L_1}{2EI}$, simultaneous solution of the six equations given above will yield the location of the compressive force 'C' and the magnitude of the prying force 'PV'.

FLEXIBLE PLATE ANALYSIS
FOR APPLIED MOMENT

Figure 2

POOR ORIGINAL

APPENDIX 1
PROCEDURE FOR INSPECTION OF
CONCRETE EXPANSION BOLTS

1.0 PURPOSE

To set forth requirements for inspecting pipe support plates and concrete anchors. Inspection is required by Nuclear Regulatory Commission (NRC) IE Bulletin 79-02 Rev. 1 dated 21 June 1979.

2.0 ACCEPTANCE CRITERIA

Ensure Item 4 of IE Bulletin 79-02 (verification of anchor bolt design requirements) has been met. Maintain documentation of anchor bolt inspection.

3.0 REFERENCES

NRC Bulletin 79-02 Rev. 1 dated 21 June 1979.

4.0 EQUIPMENT REQUIRED

1. Ultrasonic test equipment to measure bolt/stud embedment depth (wedge type only).
2. Hand tools.
3. Machinist scale or depth gauge.
4. Hanger inspection package - data sheets.
5. Test fixture if required.

5.0 INSPECTION REQUIREMENTS

5.1 Inspect all the concrete anchors used in the base plate of a selected support for the items found on data sheets.

5.2 Record all findings on the data sheets.

5.3 Determine anchor bolt type as defined in section 6.0.

5.4 Inspect bolt for compliance with size specified on support drawing.

5.5 Visually inspect the plate for loose anchors and any gap between the plate and the concrete.

5.5.1 If gap between plate and concrete exists, estimate the percentage of contact area.

5.5.2 Measure gap in the area of the bolts and record.

5.6 Check grouted base plates using the following:

5.6.1 Remove nuts and washers.

5.6.2 Inspect to ensure there are no leveling nuts behind the plate.

5.6.3 If leveling nuts exist, refer to A/E for direction.

5.7 Inspect each type anchor as specified in section 7.0; if anchor inspected does not meet requirements specified, then inspect remaining anchors of support.

5.8 Measure and record the distance from the edges of the plate to the edge of the bolt hole. Measure bolt hole diameter.

5.9 If anchor bolt spins, remove bolt. Check hole diameter, if in tolerance, replace with a like kind and reattempt torquing.

6.0 DETERMINATION OF ANCHOR TYPE

6.1 If threaded portion of anchor bolt protrudes through the plate and nut, the anchor is one of the following:

6.1.1 Hilti Kwik Bolt:

Check embedment depth to distinguish from Phillips Redhead.

6.1.2 Wej-it:

6.1.2.1 Wej-it is further identified by two square grooves cut 180° apart on bolt.

6.1.2.2 Washer will have two corresponding tabs which may not be visible.

6.1.3 Shell-type anchor such as Phillips Redhead self-drilling anchor:

6.1.3.1 A stud or 'all-thread' may be inserted into this type.

6.1.3.2 If a conventional machine bolt or cap screw is used, a shell-type anchor is the likely candidate for the connection in the concrete. Record all findings on the data sheet.

7.0 INSPECTION AND TESTING OF ANCHOR

7.1 Inspect bolt for compliance with size specified on support drawing.

7.1.1 Wedge-type anchor:

Measure diameter of bolt.

7.1.2 Shell-type using standard hexagonal or square head machine bolt. Check bolt head and compare with the following:

TABLE 7.1.2.1

Bolt Diameter	Regular Hexagonal & Square Head	Heavy Hexagonal
3/8	9/16	-
7/16	5/8	11/16
1/2	3/4	7/8
9/16	7/8	15/16
5/8	15/16	1-1/16
3/4	1-1/8	1-1/4
7/8	1-5/16	1-7/16
1	1-1/2	1-5/8

7.2 Inspection of shell-type anchor.

7.2.1 Remove one bolt and inspect and record the following:

7.2.1.1 Expansion device installed (e.g. Redhead plug for Phillips, none for cinch-type). For Redhead with expansion plug measure depth of plug from edge of shell to top of plug. Record dimension and compare with sample for proper expansion.

7.2.1.2 Shell installed in concrete is flush or slightly recessed into concrete. Record value.

7.2.1.3 Measure clearance between shell insert and plate surface (concrete side).

7.2.1.4 Minimum thread engagement (bolt length minus plate thickness minus washer minus gap minus recess).

7.2.1.5 Shell length (hole depth minus plate thickness minus washer minus gap minus recess; measured through plate).

7.2.1.6 Measure clearance between plate and shell of anchor. If clearance less than 1/16" loosen remaining bolts on plate and install 1/8 in. minimum shim but not to interfer with shell and plate.

7.2.1.7 Tighten test bolt to load in Table 7.2.1.7. Remove bolt. Inspect to assure shell has not slipped. If less than 1/16 in. slippage occurs, install plate to its original configuration.

TABLE 7.2.1.7

TORQUE VALUE TABLE

Bolt Size	Torque, in.-lbs*	F lbs
1/4	60	240
5/16	128	410
3/8	228	610
1/2	565	1130
5/8	737	1810
3/4	2032	2710
7/8	3300	3770

* Correlation between torque value and tension load must be verified through actual tests for each size bolt used in the plant. Repeated three times for each size. Tests should simulate conditions as found in the field with regard to plate, bolt head, and bolt threads conditions. Results from this testing may require modification to the values in Table 7.2.1.7.

7.2.1.8 Repeat 7.2.1 for each bolt to be inspected.

7.2.1.9 If more than 1/16 in. slippage occurs, repair will be made in accordance with replacement anchor manufacturer's installation procedure and verified by QC in accordance with QC procedures.

7.2.2 Install all tested bolts to tight condition but not to exceed values in Table 7.2.1.7 for shell type anchor.

7.3 Inspection of wedge-type anchor.

7.3.1 Determine following:

7.3.1.1 Bolt length using ultrasonic test equipment calibrated to type, brand, and diameter of bolt being tested.

7.3.1.2 Nut and washer thickness.

7.3.1.3 Plate thickness.

7.3.1.4 Stud protrusion.

7.3.1.5 Assure nut is not bottomed on threads.

7.3.1.6 Thickness of grout, if used.

7.3.1.7 Apply torque to value in the Acceptable As-Found column in Table 7.3.1.7.

7.3.1.8 If nut rotates before the value is achieved; record value at which rotation begins to occur.

7.3.1.9 Continue to torque nut until table values are achieved.

7.3.1.10 If torque value cannot be achieved record value achieved.

TABLE 7.3.1.7

HILTI

Bolt Dia., in.	Embedment	Design Torque ft-lbs*	F lbs	Acceptable As-Found Torque Ft lbs
1/4	1-1/8	10 max	1225	7
	1-1/2		2050	
	1-3/4		2487	
	2		2825	
	2-1/4		2895	
	2-1/2		3075	
3/8	1-5/8	20-30	2300	15
	2		2875	
	2-1/2		3487	
	3		3800	
	3-1/2		4012	
	4		4135	
	4-1/2		4190	
1/2	2-1/4	35-50	5027	28
	2-3/4		6500	
	3-1/2		8225	
	4-1/2		9250	
	5-1/2		10150	
	6		10650	
5/8	2-3/4	80-100	6005	60
	3-1/2		7675	
	4-1/2		9500	
	5-1/2		10925	
	6-1/2		12012	
	7-1/2		13000.	
3/4	3-1/4	150-175	9152	110
	4		11550	
	5		14100	
	6		15900	
	7		18400	
	8		19500	
	9		19750	

Table 7.3.1.7 (Cont'd)

HILTI (Cont'd)

Bolt Dia., in.	Embedment	Design Torque ft-lbs*	F lbs	Acceptable As-Found Torque Ft lbs
1	4-1/2	225-275	15000	160
	5		17200	
	6		21125	
	7		22850	
	8		22850	
	9		22850	
	10		22850	
1-1/4	5-1/2	375-425	21000	300
	6-1/2		24350	
	7-1/2		27350	
	8-1/2		29850	
	9-1/2		32000	
	10-1/2		33850	

- -

WEJ-IT

Bolt Dia., in.	Embedment	Design Torque ft-lbs*	F lbs	Acceptable As-Found Torque Ft lbs
1/4	1	4-5	1305	3
	1-1/8		1584	
	1-1/4		2097	
	1-1/2		2225	
3/8	1-1/8	15-20	2878	12
	1-1/4		3222	
	1-1/2		3450	
	2		3619	
	3-1/2		3959	
	4		4185	
1/2	1-1/2	30-35	5080	22
	2		5145	
	2-1/4		5210	
	3-1/2		5769	
	4		6491	
	5		7213	
5/8	2	50-75	7455	38
	3		10066	
	3-1/2		11372	
	3-3/4		12503	
	4		12934	
	4-3/4		13769	

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Table 7.3.1.7 (Cont'd)

WEJ-IT (Cont'd)

Bolt Dia., in.	Embedment	Design Torque ft-lbs*	F lbs	Acceptable As-Found Torque Ft lbs
3/4	3	75-100	17369	56
	3-1/2		18373	
	4		19377	
	5		20324	
	7		23166	
1	5-1/2	150-260	24526	112
	6		25641	
	7		26755	
1-1/4	5-1/2	260-330	36392	195
	6		37239	
	7		38085	
1-1/2	5-1/2	330-650	48555	248
	6-1/2		50128	
	8		51699	

PHILLIPS - Wedge type

Bolt Dia., in.	Minimum Embedment	Torque ft-lbs*	F lbs	Acceptable As-Found Torque Ft lbs
1/4	1-1/8	10 max	2400	8
3/8	1-1/2	25-35	4000	19
1/2	2-1/4	45-65	5400	34
5/8	2-3/4	80-90	7680	60
3/4	3-1/4	125-175	10,000	94
7/8	4	200-250	13,700	150
1	4-1/2	250-300	15,000	187
1-1/4	5-1/2	400-500	19,200	300

DATA SHEET

INSPECTION OF PIPE SUPPORT PLATES AND ANCHOR BOLTS

Plante Identification & Tag No. ______________________________

Plate Size: _____ in. x _____ in.

Type Anchor System: Wedge Type _____ Shell Type _____

Bolt Size: Specified ________________ Measured ________________

Bolt Length: Specified ________________ Measured ________________

Nut & Washer Thickness ________________

Plate Thickness ________________

Grout Thickness ________________

Calculated Embedment (Wedge Type) ______________________

or Engagement (Shell Type) ______________________

Plate to Concrete Gap: Yes _____ No _____

Percentage Contact Area ______________

Record Gaps:

______________ ______________ ______________ ______________

Check Torque: (Wedge Type) As Found ______________ As Left ______________

Shell type:

Expansion Device Installed ______________

Shell Flush or Recessed 1/8" max ______________

Measured clearance between shell & back of plate ______________

If clearance exists, reinstall bolt, torque ____________________________

If no clearance exists, complete steps 7.2.1.6 and 7.2.1.7:

Step 7.2.1.7 Complete ____
Step 7.2.1.8 Complete ____
Step 7.2.1.8 Not required ____
Step 7.2.2 Complete ____

SAMPLE

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DATA SHEET

INSPECTION OF PIPE SUPPORT PLATES AND ANCHOR BOLTS (Cont'd)

Measure Edge Distances:

________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________

Repair Performed

_______________________ / ____________

Signed / Date

Engineering Evaluation

_______________________ / ____________

Signed / Date