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MURRAY R. EDELMAN
VICE PRESIDENT
NUCLEAR

September 19, 1984
PY-CEI/NRR-0138 L

Mr. B. J. Youngblood, Chief
Licensing Branch No. 1
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington D.C. 20555

Perry Nuclear Power Plant
Docket Nos. 50-440; 50-441
Response to NRC Question
Nos. 220.32 through 220.36 (480.54)-
Containment Drywell Wall Structural
and Bypass Leakage Integrity

Dear Mr. Youngblood:

This letter and its attachments are provided in response to your request for additional information (dated May 30, 1984), regarding containment drywell Structural and Bypass Leakage Integrity for the Perry Nuclear Power Plant (Units 1 and 2).

The information provided in the attachments will be incorporated into a future FSAR Amendment. If you have any questions, please feel free to contact me.

Very truly yours,

Murray R. Edelman

Murray R. Edelman
Vice President
Nuclear Group

MRE:njc

Attachments

cc: Jay Silberg, Esq.
John Stefano
Jack Grobe

B001
1/1

Response to NRC Item Q220.32

Q220.32: "Provide detail information on the installation of Hilti expansion concrete bolts in the drywell wall such as installing sequences, means for minimizing concrete cracks around the bolts, maximum size of bolt, procedures for achieving air tightness around the bolt, bolt patterns, maximum and minimum spacings of bolts, maximum bolt loads and capacity of the bolt."

Response:

1. Installation Sequence

The installation sequence of Hilti Kwik Bolts through the drywell liner plate are specifically delineated in item 1:13 of Attachment Specification SP-208-4549-00. Attachment 1 is an excerpt of the pertinent section from SP-208; Sub-items 1:13.1 and 1:13.2 define bolt installation requirements. Sub-item 1:13.3 defines concrete and/or liner plate repair requirements for all unused holes.

2. Crack Control Around the Bolts

There have been no detectable cracks around Hilti Bolt installations in the drywell wall or any other plant structures. Industry experience with Hilti bolts in comparable installations and loading conditions prove the above installation specifications; special construction methods for drywell installation are not required. See the response to item Q220.35 for additional discussion on the subject of Hilti Bolts potential for initiating or propagating localized cracks.

3. Maximum Bolt Size

The vast majority of Hilti Kwik Bolts fall in two size categories:

- 5/8" Ø or 3/4" Ø with embedded depth of approximately 4"
- 3/4" Ø with embedded depth of approximately 7"

4. Leak Tightness Around Each Bolt

Each bolt has sealer tape installed in the annular space between the bolt shank and the oversized hole in the 1/4" liner plate, and is individually inspected. Refer to item 1:13.2d of Attachment 1.

5. Bolt Patterns and Spacing

Typical base plate details and patterns of installations through the drywell liner are shown on Attachment No. 2. Pages 1 through 3 of Attachment # 2 show a typical pipe support which uses one of several standard Hilti base plates.

These standard base plates are used by all disciplines. Page 4 of Attachment #2 shows the typical Hilti support detail used for conduit.

Spacings between individual attachments are governed by the following:

A. Maximum spacing - no limit

B. Minimum spacing -

Spacing controlled by Attachment Specification SP-208.
Specifically, the requirements are as follows:

(1) 5/8" Ø or 3/4" Ø with embedded depth of approximately 4":

No defined minimum spacing values. Bolts may be as close as individual adjacent attachment hardware permits. This equates to a minimum bolt-to-bolt spacing between adjacent attachments of approximately 3 inches.

(2) 3/4" Ø with embedded depth of approximately 7" adjacent to the same type bolt or to a bolt from (1) above:

Minimum spacing equals 4 inches.

The spacing from both (1) and (2) above are substantiated by pull-out tests as reported in GAI Report No. 2486, "Perry Nuclear Power Plant Report on Evaluation of Spacing and Edge Distance Violations of Hilti Kwik Bolts and Other Steel Embedments" dated September 19, 1983.

6. Maximum Bolt Loads Versus Rated Capacities

A. 5/8" Ø or 3/4" Ø bolts with embedded depth of approximately 4".

Maximum allowable loads for drywell vacuum load combination:

Tension = 250 lbs.
Shear = 250 lbs.

Maximum allowable loads for jet impingement load combination:

Tension = 900 lbs.
Shear = 1400 lbs.

Notes: 1. The above allowable shear and tension loads may be applied currently.

2. The allowable loads are not governed by Hilti Bo!t hardware capacity but rather by the reserve capacity of the embedded stiffener angles which serve as drywell liner anchors.

The full rated bolt capacitites for the above based on a safety factor of 4 and 5000 psi design strength concrete from the Hilti design catalog (Abott A. Hanks, Inc. File No. H2189-S1, Report No. 8783R) are:

- 5/8" Ø bolt with 4" emb T = 11290/4 =2833>> 900 lbs.
  V = 12531/4 =3133>>1400 lbs.

- 3/4" Ø bolt with 4" emb T = 13550/4 =3380>>900 lbs.
  V = 17618/4= 4404>>1400 lbs.

B. 3/4" Ø bolt with embedded depth of approximately 7"
The maximum allowable design loads are normally limited to approximately 30 percent of the full rated bolt capacities. These allowable values were conservatively based on 4000 psi concrete at the time of bolt design and are as follows:

- For vacuum pressurization load combination:

  Tension = 1000 lbs.
  Shear = 1980 lbs.

- For jet impingement load combination:

  Tension = 1490 lbs.
  Shear = 1980 lbs.

Notes: 1. Linear shear-tension interaction used with above load allowables.

2. The above allowable bolt tension loads are derated as compared to full rated bolt capacity due to pull-out cone overlap with embedded drywell liner stiffener/anchor angles.

The full rated bolt capacity (S.F. of 4 and actual 5000 psi design strength concrete) from the Hilti catalog is:

Tension = 22300/4 = 5575>>1490 lbs.
Shear = 19738/4 = 4934>> 1980 lbs.

In approximately 10% or less of the cases the maximum allowable design loads of the 3/4" Ø bolts with 7" embedment have been increased via case-by-case evaluation. In these few cases, design loads have generally increased by 50 to 60 percent with the full rated bolt capacities (above) being the upper bound.

Add Item 3:02.9.13 to SP-44 as follows in order to modify the provisions of attachment Specification SP-208-4549-00: |D

13. Add Item 1:13 as follows: |D

1:13 <u>Installation Through Drywell Liner Plate</u> C

Hilti Kwik Bolts shall be installed through the Reactor Building drywell liner plate (wall or ceiling) only where specified by the ENGINEER. Unless approved otherwise by the ENGINEER, installation of Hilti Bolts through the liner shall conform to the following requirements:

1. Hilti Kwik Bolts shall be 5/8" ϕ x 6" lg. Minimum embedded depth shall be as specified on the drawings.

2. The sequence of bolt installation shall be as follows:

   a. A 1" diameter oversize hole shall be drilled completely through the liner plate using a suitable bit for steel drilling. Embedded stiffener angle legs attached to the liner shall <u>not</u> be through drilled. If steel is encountered after drilling to a maximum oversized hole depth of 1/2", drilling shall stop immediately and the bolt location shifted within tolerances as permitted by the ENGINEER. The unused hole shall be repaired per Subitem 3 below.

   b. After drilling through the liner, a 5/8" nominal diameter masonry carbide drill bit per Item 1:07.1 shall then be used to complete the hole drilling. The 5/8" diameter hole shall be drilled in the center of the oversized hole (± 1/16" tolerance). If steel is encountered during drilling at approximately a 3" hole depth, an embedded stiffener angle leg parallel to the liner is being hit. This leg of the stiffener shall be through drilled with a 5/8" diameter bit suitable for steel drilling. After drilling the 1/4" thick stiffener angle, a masonry carbide bit (per Item 1:07.1) shall again be used to complete the bolt hole drilling. Drilling shall stop if steel is encountered deeper than 3-1/2". In this case, the bolt location shall be shifted within specified tolerances to clear the interference or, if this is not feasible, the ENGINEER shall be contacted for direction. Any unused holes shall be repaired per Subitem 3 below.

   c. Without the attachment fixture in place, the Hilti Bolt shall be inserted into the hole by hammering or an approved alternate method.

d. Sealer tape shall be applied in the oversized hole in the liner around each Hilti Bolt. Sealer tape shall be 3/16" thick x 1/2" wide HVAC METAL AIR DUCT SEALER TAPE (Type 440) as manufactured by Tremco, Incorporated. The material is classified as Nuclear Safety-Related but need only be supplied from the manufacturer with Certificates of Compliance (COCs) to published physical properties and performance characteristics. The CONTRACTOR is not required to perform a Quality Assurance audit of the manufacturer for the supply of this product.

The sealer tape shall be manually worked into the oversized hole to completely fill the hole around the bolt. Excess sealer tape (1/4" maximum thickness) shall be left projecting above the surface of the liner plate. This will be compressed during Hilti Bolt torquing to ensure complete sealing of the liner plate around each Hilti Bolt.

The CONTRACTOR'S QC shall verify and document that the sealer tape is adequately installed around each Hilti Bolt prior to attachment fixture installation.

e. If welding to the attachment fixture is specified by the ENGINEER, it shall be performed prior to attachment fixture installation onto the Hilti Bolts.

f. The attachment fixture and Hilti Bolt nut and washer shall then be installed on the Hilti Bolt and the Hilti Bolt torqued to specification requirements.

3. Unused holes in the concrete and/or drywell liner plate shall be repaired per the following:

a. Holes in the concrete greater than 1/2" depth shall be dry-pack grouted with Masterflow 713 grout per Item 1:08 of this specification with the exception that the hole shall not be dampened with water prior to placing the grout. The grout shall be allowed to dry for approximately one day prior to weld repairing of the liner plate per Item "b" below.

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b. Holes in the liner plate shall be repaired by:

1) A 1/8" thick x 15/16" diameter round steel slug shall be inserted in the bottom of the oversized hole. Steel slug material shall be per Section 8.2 of AWS D1.1 or a "P" Number material from ASME Section IX and shall be supplied with the appropriate Certificates of Compliance. Unique material traceability to the installed condition is not required. The surface of the slug shall be a minimum of 1/8" below the liner plate surface.

2) The hole shall then be weld repaired to completely seal the opening. The weld repair shall be ground flush with the surrounding liner plate surface. Welders and welding procedures shall conform to either AWS D1.1 or ASME Section IX requirements. Each weld repair shall have final visual inspection and documentation by the CONTRACTOR'S QC.

3) Weld repairs of the liner plate which will be covered by the attachment fixture do not require touch-up of the nuclear coating. If the weld repair will not be covered by the attachment fixture, touch-up of the nuclear coating will be performed by OTHERS.

4. Hilti Bolt spacing requirements for adjacent attachments to the drywell liner plate shall be as follows:

a. 5/8" or 3/4" diameter bolt with 4-1/4" minimum specified embedment depth (or less) adjacent to the same type bolt(s) -

There are no minimum bolt spacing requirements. The attachments may be as close as the physical hardware and specified locational tolerances for the attachments permit.

b. 3/4" diameter bolt with specified embedment depth greater than 4-1/4" adjacent to a bolt from 4.a above -

Minimum spacing (center line to center line) = 4" | C

c. 3/4" diameter bolt with specified embedment depth greater than 4-1/4" adjacent to the same type bolt -

Minimum spacing (center line to center line) = 4" | C

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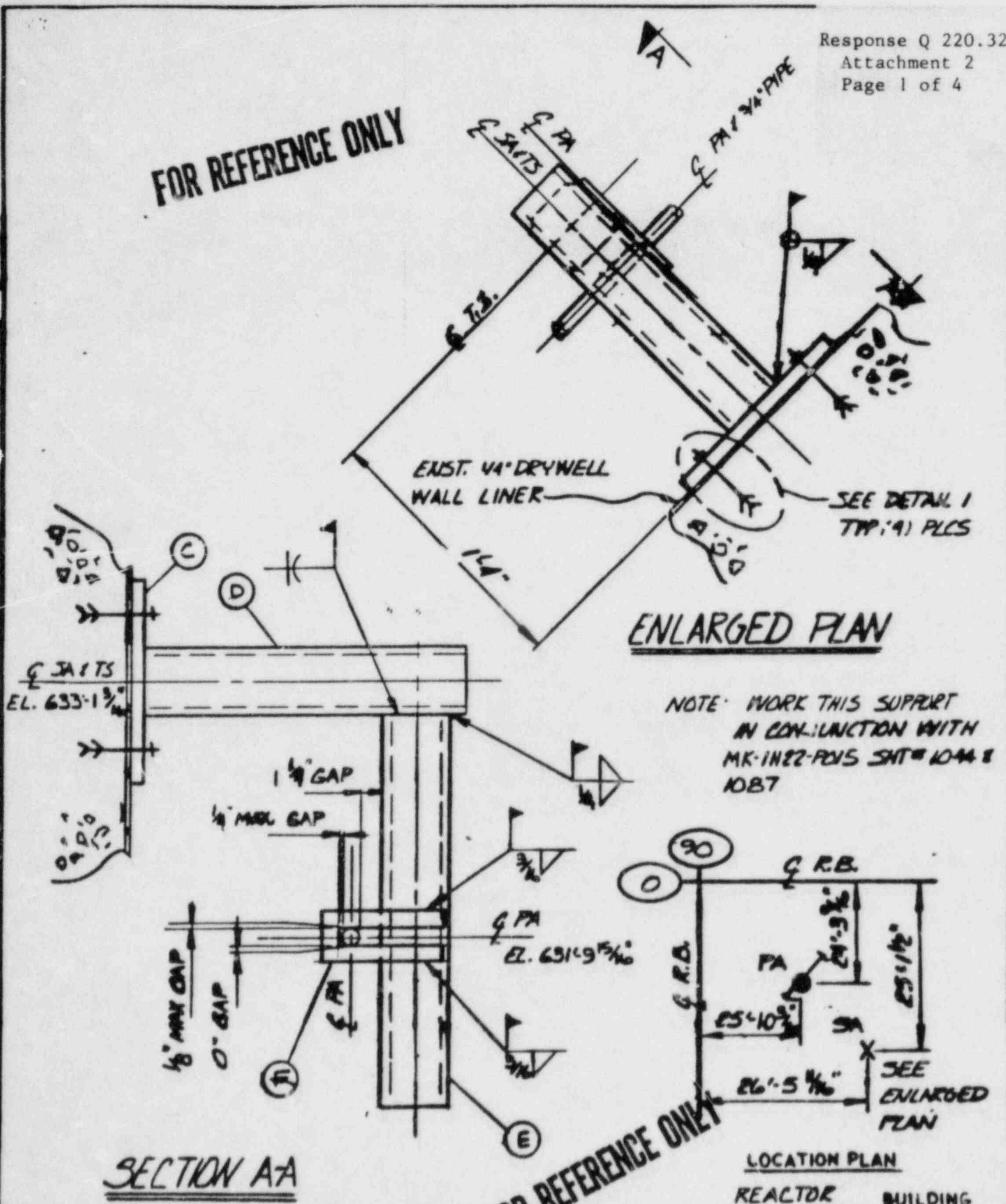

FOR SIGNATURES AND REVISIONS, SEE GA! SHEET 1

THE CLEVELAND ELECTRIC ILLUMINATING CO.

PERRY NUCLEAR POWER PLANT UNIT 1

GILBERT ASSOCIATES, INC.
ENGINEERS & CONSULTANTS
READING, PA.

TITLE	DRAWING NUMBER	SHEET	PAGE	REV.
PIPE SUPPORT MK-1H22-P015	04 4549 S-818-015	1001.2	2 of 4	0

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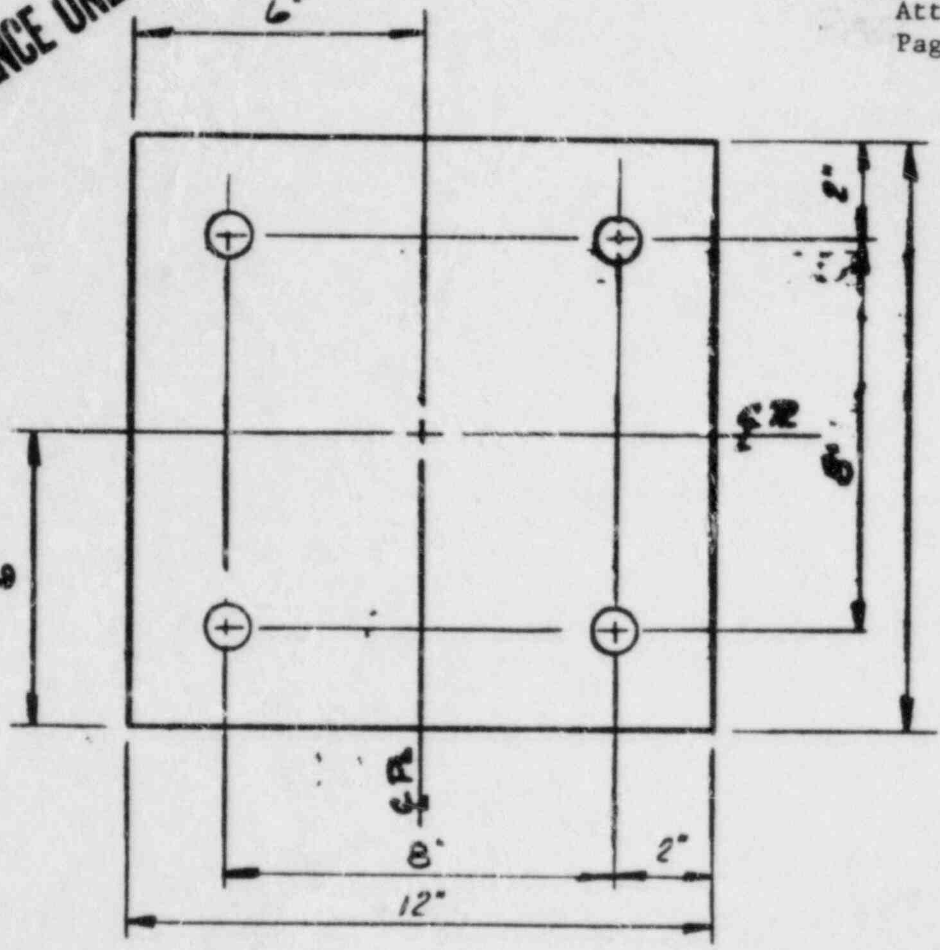
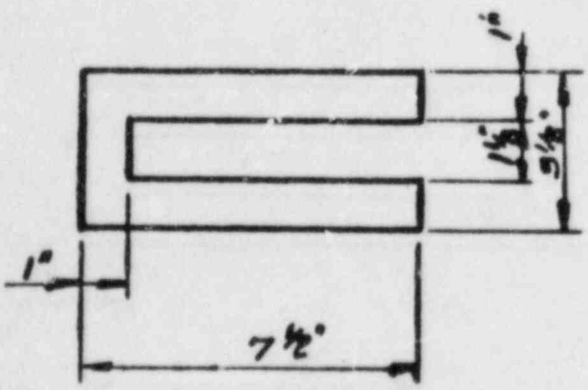


DETAIL ITEM C



DETAIL ITEM F

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NUCLEAR SAFETY RELATED

FOR SIGNATURES AND REVISIONS, SEE GAI SHEET 1

THE CLEVELAND ELECTRIC ILLUMINATING CO.

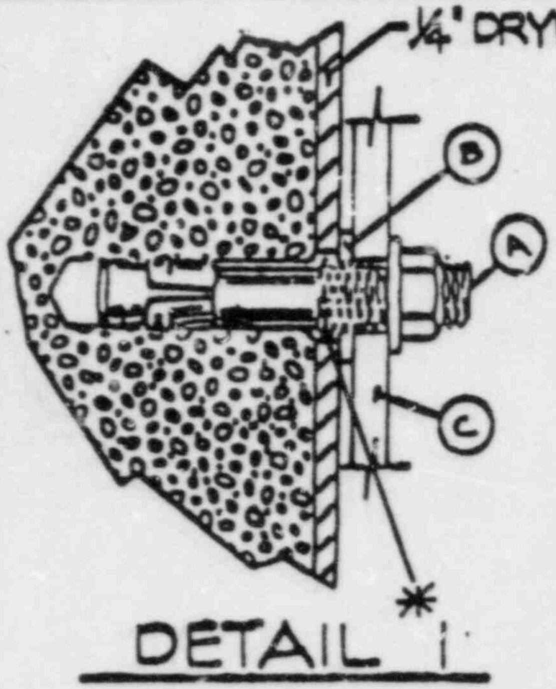
PERRY NUCLEAR POWER PLANT UNIT 1

GILBERT ASSOCIATES, INC.
ENGINEERS & CONSULTANTS
READING, PA.

TITLE	DRAWING NUMBER	SHEET	PAGE	REV.
PIPE SUPPORT MK-1H22-P015	04 4549 S-818-015	1001.3	3 of 4	0

ITEM	NO. REQD.	PART NO.	DESCRIPTION	MATERIAL	MRS	LCR	HEAT NO. / MATL IDENT	MATERIAL VERIFICATION
A	4		3/4"φ x 10" LG HILTI KWIK BOLTS	—				
			W/ MIN. EMB = 7"					
B	4		3/4" φ PLAIN HARDEN WASHER	SA-325				
C	1		PLATE 3/4" x 12" x 1'-0" LG W/(4)	SA-36				
			15/16" φ HOLES SEE DETAIL ITEM C					
D	1		T.S. 4x4x1/4 x 1'-8" LG	A500-GR.B				
E	1		T.S. 4x4x1/4 x 2'-1" LG	A500-GR.B				
F	1		PLATE 1/2 x 3 1/8 x 0'-7 1/2" LG	SA-36				
			SPECIAL CUT PER DETAIL ITEM F					

FOR REFERENCE ONLY



DETAIL 1

FOR HILTI KWIK BOLT INSTALLATION REQUIREMENTS THROUGH 1/4" LINER PL, SEE ITEM 1:13 OF ATTACH. SPEC. SP-208 WITH THE FOLLOWING EXCEPTIONS:

(1) USE 3/4"φ x 10" LG. KWIK BOLT (WITH APPROPRIATE DRILL BITS) IN PLACE OF 5/8"φ x 6" LG. BOLT.

(2) USE 1 1/8"φ OVERSIZED HOLE IN LINER PL IN PLACE OF 1"φ HOLE.

(3) USE A 1/8" THICK x 1 1/16"φ STEEL SLUG IN PLACE OF 1/8" x 15/16"φ SLUG WHEN LINER PL REPAIR IS REQUIRED.

* HVAC SEALER TAPE (TREMCO TYPE 440) TO BE APPLIED IN OVERSIZED HOLE IN LINER PL PER ITEM 1:13.2.d OF SP-208

Response Q 220.32
Attachment 2
Pg. 3 of 4

FOR SIGNATURES AND REVISIONS, SEE GAI SHEET 1

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PERRY NUCLEAR POWER PLANT UNIT 1

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NUCLEAR SAFETY RELATED

PIPE SUPPORT
MK-1H22-P015
TITLE

04	4549	S-818-015	1001.4	4 of 4	0
DRAWING NUMBER				SHEET / PAGE	REV.

DIR ATT SPRT CRIT-IDW LNR BS SPRT

THE CLEVELAND ELECTRIC ILLUMINATING CO.
PERRY NUCLEAR POWER PLANT UNITS 1 & 2
ELECTRICAL
DIRECT ATTACHMENT SUPPORT CRITERIA
CONDUIT ATTACHMENT TO INSIDE DRYWELL
LINER-DETAIL OF BOLTED STRAP SUPPORT

04 N540 SS-216-005 53A

GILBERT ASSOCIATES ENGINEERS AND CONSULTANTS READING, PA.

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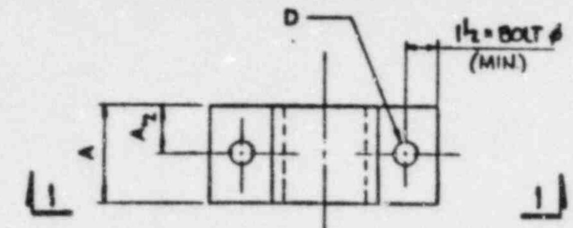
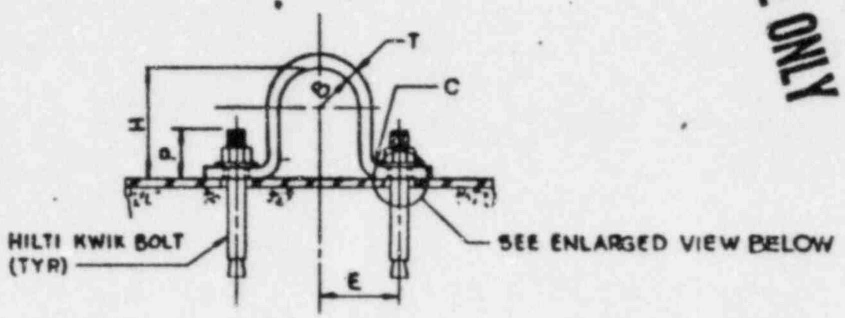
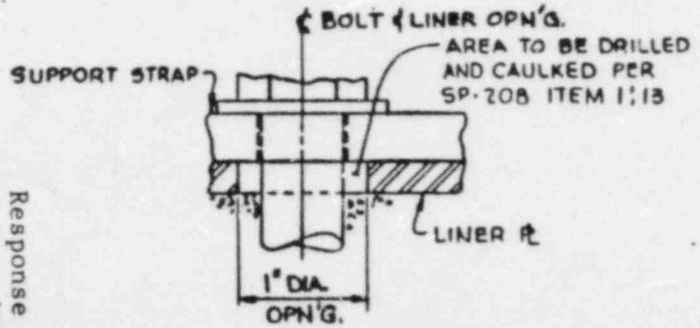
CONSTRUCTION
BIDDING PURPOSES
RELEASED FOR
ENGR.
DATE



DETAIL "GGG"



SECTION 1-1



ENLARGED VIEW

REV "–" PER ECN 14909-33-2580 & AS INDICATED

CND. SIZE	STRAP NO.	HILTI DIA.	A	B	C	D SEE NOTE 6	E	H	P (MAX)	T
3/4"	CS-1 / CS-1A	5/8	2	5/8"	1/4	3/4	1 3/16 / 1 7/16	1 15/16"	1 3/4	1/8
1"	CS-2 / CS-2A	5/8	2	3/4"	1/4	3/4	1 13/16 / 2 1/16	2 3/16"	1 3/4	1/4
1 1/4"	CS-3 / CS-3A	5/8	3	1"	3/8	3/4	2 1/16 / 2 5/16	2 5/8"	1 3/4	3/8
1 1/2"	CS-4 / CS-4A	5/8	3	1 1/16"	3/8	3/4	2 5/16 / 2 5/8	2 13/16"	1 3/4	3/8
2"	CS-5 / CS-5A	5/8	3	1 5/16"	3/8	3/4	2 5/16 / 2 7/8	3 1/2"	1 3/4	3/8
2 1/2"	CS-6	5/8	3	1 1/2	1/2	3/4	3 1/4	3 13/16	1 3/4	1/2
3"	CS-7	5/8	4	1 13/16	1/2	3/4	3 5/8	4 5/16	1 3/4	1/2
4"	CS-8	5/8	4	2 5/16	5/8	3/4	4 5/8	5 9/16	1 3/4	5/8

NOTES:

1. STRAP MATERIAL TO BE ASTM A36 (MIN.)
2. TOLERANCE (+1/16, -1/16 (FOR 3/4⌀-2"⌀ CND) ±1/8 (FOR 2½⌀-4"⌀ CND) ±1/32 (FOR D (HOLE DIAMETER)
3. ALL SHARP EDGES SHALL BE REMOVED.
4. STRAP NUMBER TO BE MARKED ON ALL STRAPS.
5. ALL DIMENSIONS ARE IN INCHES.
6. HILTI BOLTS TO BE 5/8"⌀ × 6" AND SHALL BE INSTALLED PER SP-208 EXCEPT AS NOTED OTHERWISE.
7. T = BAR STOCK THICKNESS PRIOR TO BENDING.
8. STRAPS FABRICATED WITH 11/16" ⌀ HOLES NEED NOT BE REWORKED. THE CONTRACTOR MAY, AT HIS OPTION, ALSO ENLARGE THE HOLES IN ANY EXISTING TYPE "GGG" STRAPS TO 3/4" ⌀.

Response Q 220.32
Attachment 2
Pg. 4 of 4

REFERENCE ONLY

Response to NRC Item Q220.33

Q220.33: Perry FSAR committed that drywell liner and the anchorage system were designed in accordance with the ASME Section III, Division 2 CC-3000 to utilize the liner's inherent leak tightness and achieve leak tight details at penetrations. In view of the 6000-8000 concrete expansion anchor bolts installed through the drywell liner into the concrete wall, provide a discussion to demonstrate that the applicable provisions of the code covering liner integrity and leak tightness are fully met. If the provisions are not fully met, list the deviations and the bases thereof.

Response: The drywell liner was designed in accordance with ASME Section III Division 2, however it was not fabricated and constructed to all the requirements of CC-4000, "Fabrication and Construction" nor all the requirements of CC-5000, "Construction Testing and Examination." The drywell liner was provided as a form for the concrete. The design itself meets the stress and strain allowable of CC-3000 "Design" and materials, fabrication, and construction were all in accordance with the nuclear safety related quality procedures and program.

The ability of the liner and its anchor system to meet the stress, strain and displacement limits of Article CC-3000 is essentially unaffected by the use of concrete expansion anchors, because the anchor or bolt loads are transferred directly to the concrete. To provide structural integrity under vacuum and seismic loads, and to meet the anchor displacement limits of Article CC-3000 the allowable loads on the bolts are limited as described in our response to Q220.32. The allowables are based on the worst possible bolt location - which is directly over the liner anchorage.

In conclusion, although the drywell liner may enhance the leakage integrity of the drywell structure, it is not required to meet the bypass leakage requirements of the FSAR. The use of Hiltis is consistent with the drywell liner's function as a form for the drywell concrete.

Response to NRC Item Q220.34

Q220.34: With respect to the as-built drywell concrete wall, are there through wall concrete cracks? If yes, what are the extent of those cracks and their estimated crack dimensions? What is the potential for those cracks to form an interconnected crack network to the extent of affecting the functioning of the drywell as a pressure barrier under LOCA and SSE conditions?

If your assessment indicates that there should be no through cracks in the drywell wall, please provide the technical basis for the assessment.

Response: There are no through wall concrete cracks in the as-built drywell concrete wall. The as-built wall, even after the SIT at the design pressure of 30 psi, is not expected to have through wall cracks based on calculations performed. These calculations were performed using conservative assumptions and are discussed in response to Q220.35. In addition NEDO-10977 "Drywell Integrity Study: Investigation of Potential Cracking for BWR/6 Mark III Containment [Drywell] " demonstrated that during normal operation only minor surface cracking exists due to drying shrinkage of the concrete. A LOCA (DBA or SBA) plus SSE does not result in significant propagation of normal operational cracking nor does it result in through wall cracks.

Additional factors supporting the conservative nature of these conclusions and the applicablility of the GE study to the Perry Nuclear Power Plant are as follows:

1. Comparison of physical parameters:

   a. Reinforcement ratios, Perry to that used in NEDO-10977

CYLINLER	PNPP/NEDO-10977
VERTICAL REINFORCEMENT	
Below EL 606'-6"	1.72
Above EL 606'-6"	1.45
HORIZONTAL	1.75
DIAGONAL	1.07
TOP SLAB	
RADIAL	1.57
CIRCUMFERENTIAL	2.56

b. CONCRETE COMPRESSIVE STRENGTH

NEDO 10977 based on f'_c=4500 psi
PNPP based on f'_c=5000 psi

c. REINFORCEMENT STRENGTH

NEDO 10977 based on f_y=40 Ksi
PNPP based on f_y=60 Ksi

2. PNPP adapted details around all penetrations to minimize local cracking. Around through-wall or structural penetrations where reinforcement is terminated, the reinforcement area is replaced each side and above and below the openings to satisfy the strength requirements. In addition, although not required for strength, additional reinforcement was added diagonally around the penetrations in two directions on each face to control local cracking and strains.

Response to NRC Item Q220.35

Q220.35: Assuming that initially there are no through thickness cracks in the wall, would the presence of 6000 to 8000 expansion anchor bolts enhance the probability of initiating and propagating localized cracks into through wall cracks, thus affecting the drywell pressure barrier function under LOCA plus SSE?

Response: The Hiltis do not contribute to the initiation and propagation of localized cracks any more than the minor surface cracking which may already exist do to drying shrinkage of the concrete. The presence of expansion anchor bolts will therefore not affect the drywell pressure barrier function due to crack initiation or propagation. The majority of the Hiltis will only be installed 4 to 7" inches deep. The clear cover to the inside face vertical reinforcement is 5 1/2 inches. The majority of the drilled anchors will not go beyond the first layer of reinforcement. Given the installation requirements as described in Q220.32, permissible loads in the Hiltis are so small as to be considered negligible, and thus do not contribute to cracking.

Both the normal operating (135^{o}F inside drywell and 90^{o}F outside), as well as the accident (250^{o}F - 350^{o}F inside drywell and 185^{o}F outside) temperature gradients through the drywell tend to keep the inside of the drywell in compression; in compression there is no potential for crack initiation or propagation.

Response to NRC Item Q220.36, Q480.54

Q220.36:
Q480.54: If no credit is claimed with respect to the liner elements and the drywell concrete is to be depended upon to maintain a leak tight barrier, provide a specific concrete crack analysis to demonstrate that the maximum effective allowable leakage area of 1.68 square feet is not exceeded (Perry SER Section 6.2.1.7), and also that the bypass leakage measured during the leak tightness tests will be maintained within the allowable leak rate (SRP Section 6.2.1.1 C-II.4.C). The effects of potential construction defects such as voids, construction joints, rock pockets, and local effects such as, stress concentration must be considered in the above concrete crack analysis.

Response: The drywell liner is not required to maintain a leak tight barrier and the following discussion of plant-specific and generic concrete crack analyses demonstrates that the maximum allowable bypass leakage will be maintained. As discussed in the FSAR Section 6.2.1.1.5, the allowable bypass leakage capacity expressed in terms of $A/\sqrt{K}$ for a small primary system break is 1.68 ft^2. General Electric (GE) in the PNPP Containment and NSSS Interface Document (Doc. No. 22A3759AL) concluded that for a large break (DBA) the allowable bypass leakage flow path would be nearly an $A/\sqrt{K}$ of 5 ft^2 (720 in^2).

As discussed in our response to Question 220.34, the drywell will have no through cracking due to a rupture in a small primary system (SBA plus SSE). This conclusion was reached by NEDO-10977 and has been confirmed by our own calculations (Attachment 1).

NEDO-10977 also concluded that there was no through cracking due to a large break DBA in a main steam or recirculation line plus SSE. Again, our calculations support this conclusion. For a DBA, a bypass leakage flow path $(A/\sqrt{K})$ of 0.35 ft^2 is predicted. This predicted flow path is much less than the 5 ft^2 allowable as defined by GE. Even the 0.35 ft^2 is very conservative because: (1) it is based on peak drywell pressure of 30 psi (maximum calculated is only 21.4 psi which only lasts for a few seconds), (2) it is based on peak SSE earthquake forces estimated to last for only 10 seconds as referenced in FSAR Section 3.7.1.1.c, (3) it is based on a load combination including a safety relief valve actuation (P_{SRV}) with peak pressures (P_a) from a main steam or recirculation line break which is a non-mechanistic event. Other conservations in the Perry analysis are discussed in Attachment 1. Our calculations have shown that as the pressure is reduced from the design pressure of 30 psi to 0 psi, the crack width is reduced by approximately 50%. Without earthquake, crack widths are reduced to one-third of the maximum crack width at 30 psi and further reduced to no crack width at the maximum calculated pressure (21.4 psi).

The conservatisms in the GE crack study (NEDO-10977) as supplemented by our own calculations, our reinforcement ratios and our penetration reinforcement practices provide a conservative bound on estimated crack widths and drywell bypass leakage flow paths. Under an SBA, no bypass leakage flow paths are predicted through the drywell concrete. Under a DBA, even with the extremely conservative assumption of concurrent peak drywell pressures, maximum SSE earthquake forces, concurrent SRV actuations, and precracks at all construction joints, the maximum predicted bypass leakage flow path is only 0.35 ft^2 as compared to an allowable of 5 ft^2.

With respect to potential construction defects, several voids were found and reported to the USNRC under 10CFR50.55 (e). These voids were found as a result of our Hilti installation program. An evalution of these voids was made including cutting windows in the liner for examination where it was felt reinforcement congestion was heaviest. Voids found as a result of these investigati ns were limited to the steam tunnel slab area of the drywell wall. These limited areas are being repaired. Other than these very localized voids, there has been no evidence of rock pockets or other construction defects in the drywell structure.

In addition to analytical predictions based on design conservatisms which predict drywell leakage integrity, a commitment has been made for a structural integrity test (SIT) at drywell design pressure, and periodic low pressure leak rate tests in FSAR Sections 3.8.3.7 and Section 6.2.6.5. The allowable drywell leakage rate for these tests, L_d, is 0.168 ft^2, which is 10 percent of the allowable bypass leakage for the limiting case of a small break accident with containment spray.

SUMMARY OF CALCLATIONS ON BYPASS LEAKAGE FLOW PATHS

ASSUMPTIONS AND CONSERVATISMS:

1. A precrack exists at all drywell wall construction joints even though these joints are very rough and have a key which is 1 1/2 inches deep and 1/3 the wall thickness.

2. The concrete tensile strength at construction joints is zero.

3. Liner induced tensile forces are included in all calculations for crack widths.

4. No credit has been taken for liner tensile strength when the section is under complete tension for the DBA case at construction joints.

5. Diagonal reinforcement which was added to limit concrete strains and cracking was neglected in calculating crack widths. It is estimated that crack widths would be reduced by approximately 30 percent if diagonal reinforcement were included.

6. Five different references (cited below) were used to calculate crack widths.

   a. ACI 318-84, Section 10.6
   b. ACI 424, Section 4
   c. ACI 313, Section 4.5.5.5.2
   d. "Comparison of Maximum Flexural and Tensile Crack Widths" by L. A. Lutz.
   e. "Reinforced Concrete Structures" by Park & Paulay, John Wiley & Sons, 1975, Section 10.4.

   ACI/313 provided the largest crack widths, and these were used to estimate crack areas at the construction joints.

CONCLUSIONS:

1. No through wall cracking and, therefore, no bypass leakage flow paths through the drywell wall for the small break accident case (including assumed construction joint precracks).

2. A bypass leakage flow path $A/\sqrt{K}$ of 0.35 ft^2 for the DBA (based on the assumption of a complete precrack at construction joints).

3. No through cracks and, therefore, no bypass leakage flow paths through the drywell wall at locations other than construction joints for the DBA.