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Docket No. 50-~~255~~ 302

Applicant: Florida Power Corporation

Facility: Crystal River, Unit 3

SUMMARY OF STATUS REPORT BY FLORIDA POWER CORPORATION ON THE CONCRETE SEPARATION IN THE CRYSTAL RIVER, UNIT 3 REACTOR BUILDING DOME

The Florida Power Corporation (FPC) and their consultants (Gilbert Associates, Incorporated; MPR, Incorporated; and Construction Engineer Consultants, Incorporated) presented a status report to the NRC staff on May 12, 1976, regarding concrete separation in the Crystal River Unit 3 (CR-3) reactor building dome. An attendance list is provided in attachment 1.

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Background

On April 14, 1976, while installing lightning arrestors on the CR-3 reactor building dome, the FPC observed that there appeared to be a void about one inch below the surface of the concrete dome. Investigations on April 16, 1976 involved the cutting and removal of a one by three foot concrete [illegible] the area where the void was first observed. It was found t[illegible] void increased in depth in the direction of the dome apex. Further core drilling on April 17 and 18 determined that the concrete separation continued on across the dome and went as deep as 15 inches with a maximum separation of about 2 inches. Acoustic sounding determined that the outer periphery of the separated area extended all around the dome in Pours G and H (See attachment 2).

Pursuant to 10 CFR 50.55e, the FPC notified the Directorate of Regulatory Operations about these matters by telephone on April 19, 1976 and by letter on April 21, 1976.

FPC Status Report

The FPC stated that the single or mutiple sequence of events causing the concrete separation had not yet been identified. The FPC indicated that the dome would be repaired and the NRC staff would be kept informed on the investigations and yet to be determined "corrective fix" for the reactor building dome.

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Reactor Building Design

The CR-3 reactor building is a concrete structure with a 3 1/2 foot cylindrical wall and a 3 foot thick torispherical dome. Contiguous to the inner surface of the concrete is a 3/8 inch carbon steel liner plate. The dome design is identical to the 1967 Bechtel design. The cylinder wall is prestressed with a post-tensioning system in the vertical and horizontal direction.

The dome is prestressed by means of tendons forming a three layer system (See attachment 3). There are 123 dome tendons arranged in 41 tendons per layer. The conduit sheathing for each tendon is a 5 inch diameter schedule 40 galvanized pipe. Each tendon has an ultimate strength of 2.355 million pounds and was made of 163 seven millimeter low-relaxation wires. The tendons are corrosion protected by bulk filling the conduit with grease.

The dome concrete was poured in concentric rings from February to July, 1974. The lower rings were poured in sections and the upper rings in complete pours. For this facility, the concrete code followed ACI-318-63 and ACI 301-66 with modifications (as specified in the FSAR). Aggregate used in the concrete mix was native to the state of Florida.

The Class I structure was designed for an internal pressure of 55 psig and accident temperature conditions of 281°F. Accident pressure conditions call for 49.6 psig. Design parameters include dead load, live load, and temperature gradients. The structure will be pre-operationally tested at a pressure of 63.3 psig.

Field Investigation Program

The FPC stated that their core sampling program to date indicates the concrete separation is clear of debris and the cleavage zone is smooth. There are no visible signs of surface cracking. Core samples continue to be drilled and FPC stated that extreme care is being observed not to damage rebar or tendons.

The FPC is presently conducting a concrete analysis which includes:

(1) An evaluation of cores available from the earliest pour (797 days) to the latest pour (647 days).

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(2) An evaluation of cores obtained since the concrete separation was first noticed. There are presently 30 core samples and core drilling continues such that samples will be available with 1/2 of the core sample in adjacent pours. The FPC is coring three samples to a set. Plans call for testing one set and the saving of one set for any additional tests. For any set being tested, 2 samples will be tested for compression, and one sample will be tested for tension.

(3) The FPC is presently tabulating data available from their documented micro-fiche QA records.

Core sample #30 has showed three cracks at the depths of 1 3/8 inches, 9 1/2 inches, and 11 1/16 inches. The core drilling program requires the use of water and it has been observed that water must be vacumed out of the core sample holes indicating cracks are not excessive.

Ambient internal and external temperature measurements are being made and strain gage measurements have been completed. The dome is now instrumented to check for the possible recurrence of additional concrete separation. (See attachment 4).

Investigation of Causes for Concrete Separation

The FPC is presently evaluating factors which may have contributed to the concrete separation. They are:

(1) Properties of Concrete

(2) Failure Due to Radial Tension

(3) Compression-Tension Interactions

(4) Thermal Effects

(5) Tendon Alignment

(6) Construction Loads

(7) Coastal Location

(8) Nearby Fossil Plants, and

(9) Construction Methods

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Items 7 and 8 above have been ruled out at this time.

Item 4 above may be a significant contributing factor to the problem. The temperature of the anti-corrosion grease when introduced in the tendon conduit was 130-150°F. A expansion study of 40 schedule pipe indicates a 1° rise in grease temperature produces a pressure of 10 psi on concrete surrounding the pipe conduit.

Load Bearing Analyses

The FPC stated that computer analyses are now being made to determine if the delaminated structure in its currently observed conditions can meet the load combinations as specified in the CR-3 FSAR criteria (i.e., dead load, pre-stress, normal, LOCA, Accident, and OBE).

Analytical studies are being conducted on both 2 and 3 foot domes to determine if the 2 foot dome (the concrete thickness below the concrete separation) can adequately perform the intended functions of the three foot dome.

Corrective Fix

Factors which the FPC are presently evaluating in order to determine the corrective fix are:

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(1) A tendon lift-off-program.

(2) The probability for additional damage to the dome cap if detensioning becomes part of the corrective fix.

(3) Determination of a detensioning and re-tensioning sequence to minimize compression-tension forces in the structure.

(4) Additional survey of concrete cracking below the concrete separation and the possible effect on expoxy grouting of the void.

(5) The assessment of material removal of the dome cap (concrete above separation) and replacement with new material.

(6) The use of anchor bolts as radial reinforcement for the repaired reactor building dome.

(7) Additional analyses to determine compression-tension interactions for required safety load combinations.

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Possible Timing of Crack

The FPC stated that examination of their construction records revealed that on December 4, 1974 at 7:20 A.M. a loud noise or boom occurred on site. The noise-reportedly appeared to come from the Reactor Building and was heard by certain construction workers. One worker was in the Reactor Building personnel lock at the time and felt vibrations and saw dust falling. Subsequent visual inspection inside and outside of containment revealed nothing. It was assumed the disturbance might have been a "sonic boom". The event was not reported to the NRC.

NRC Staff Concerns

The NRC staff expressed their concerns regarding these matters as follows:

(1) The establishment of the causes of the concrete separation is important in order to provide the ultimate "corrective fix".

(2) The use of radial anchors will enhance the capability of the repaired dome to resist radial tension.

(3) Because of the temperature effect of the grease in the tendon conduit. the effect of pressure in the conduit on concrete should be considered in the stress analysis of the dome concrete.

(4) Since the shrinkage of lower portions of the dome concrete is restrained by the steel liner, and the top portion has no such restraint. consideration should be given to the effect of concrete differential shrinkage.

(5) The presence of the 5-inch schedule 40 pipe as tendon sheathing in the dome give rise to:

(a) Reduction of effective concrete area, and

(b) Stress concentration, in the dome.

Therefore, the use of a 24" thick concrete dome section for the 2 foot analytical model does not represent the actual conditions.

(6) The photographs of the cored concrete indicate fracture through the aggregate which may indicate that the concrete has a weak aggregate in the direct tensile strength of concrete. This factor should be investigated.

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(7) Any analysis for dome models using less than the original three foot design thickness of the dome should considr the following effects:

(a) increase in concrete compressive stress

(b) increase in creep as a consequence of (a)

(c) increase in ring girder compressive stress

(d) increase in the Poisson's ratio for concrete

(8) The effects resulting from construction methods should include:

(a) vibration of concrete

(b) adequacy of construction joints between successive ring pours.

(c) the prestressing sequence should be evaluated with the use of a finite element computer program with input parameters for all prestressing components acting on the dome.

(9) The staff advised the FPC of references applicable to compression-tension stress analysis. For the tension-compression interaction, refer to p. 448, item 6 of "Handbook of Experimental Stress Analysis" by M. Hetenyi, John Wiley & Sons, Inc., 1950. The other reference mentioned in the meeting is: "Strength of Plain Concrete Under Biaxial Stress" by Israel Rosenthal and Joseph Glucklich, p. 905, ACI JOURNAL, Nov. 1970.

The staff concluded with the statement to the FPC that "the repaired reactor building dome must meet the applicable safety codes and criteria specified in the CR-3 FSAR, and the repaired structure will be required to meet the requirements of the preoperational containment integrity and leakproof tests."

Original signed by
Leon B. Engle

Leon Engle, Project Manager
Light Water Reactors Branch No. 1
Division of Project Management

Attachments:
1. Attendance List
2. Delaminated Area on CR-3 Reactor Building Dome
3. Reactor Building Dome Tendon Detail
4. Core Sampling Program

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OFFICE ▶			LWR #1	LWR#1		
SURNAME ▶			LEngle/LLM	JFStolz		
DATE ▶			08/05/76	08/05/76		

Form AEC-318 (Rev. 9-53) AECM 0240   ☆ U.S. GOVERNMENT PRINTING OFFICE: 1974-526-166

 AUG 0 9 1976

cc: Florida Power Corporation
ATTN: Mr. J. T. Rodgers
Assistant Vice President and
Nuclear Project Manager
P. O. Box 14042
St. Petersburg, Florida 33733

Mr. S. A. Brandimore
Vice President and General Counsel
P. O. Box 14042
St. Petersburg, Florida 33733

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SURNAME ➤						
DATE ➤						

ATTACHMENT 1

Attendance List

Florida Power Corporation

Crystal River, Unit 3

Florida Power Corporation

L. Alberdi
D. Black
W. Nisula
R. Raymond
J. Rodgers

Gilbert Associates, Incorporated

C. Bitling
D. Croneburger
E. Hottenstein
J. Herr
R. Pages
F. Moreadith
P. Zia

Stiefel Associates

J. Stiefel

NRC Staff

E. Arndt
H. Ashar
L. Beratan
W. Butler
S. Chan
L. Engle
M. Fields
T. Greene
A. Gluckman
C. Hofmayer
W. Laudan
R. Lewis
R. Shewmaker
J. Shapaker
W. Swan

Construction Engineering Consultants, Incorporated

J. Artuso
P. Mast

MPR, Incorporated

N. Cole

Ebasco, Incorporated

H. Kuo
E. O'Connor

ACRS Staff

R. Muller

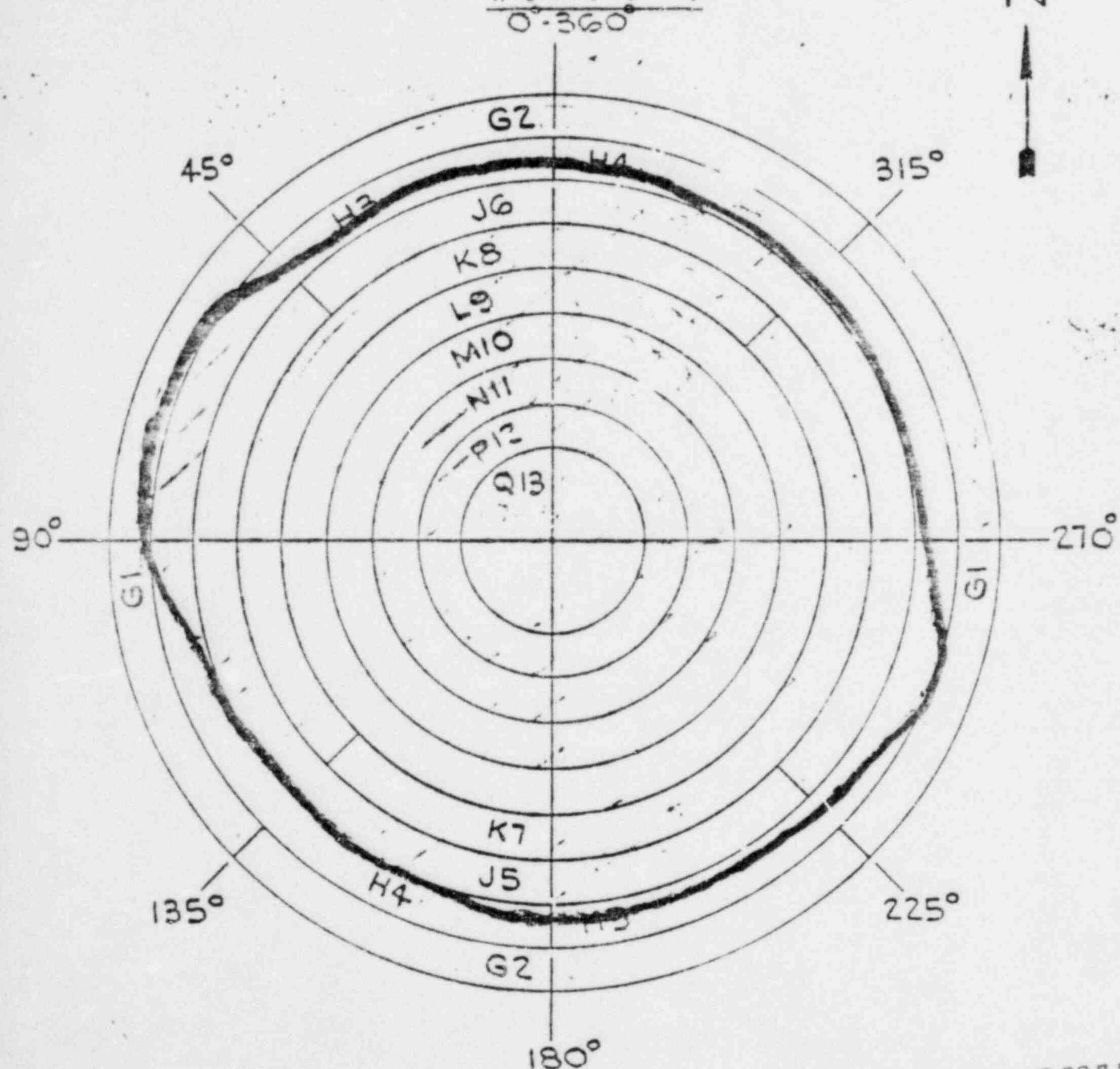
ATTACHMENT 2

Delaminated Dome Area

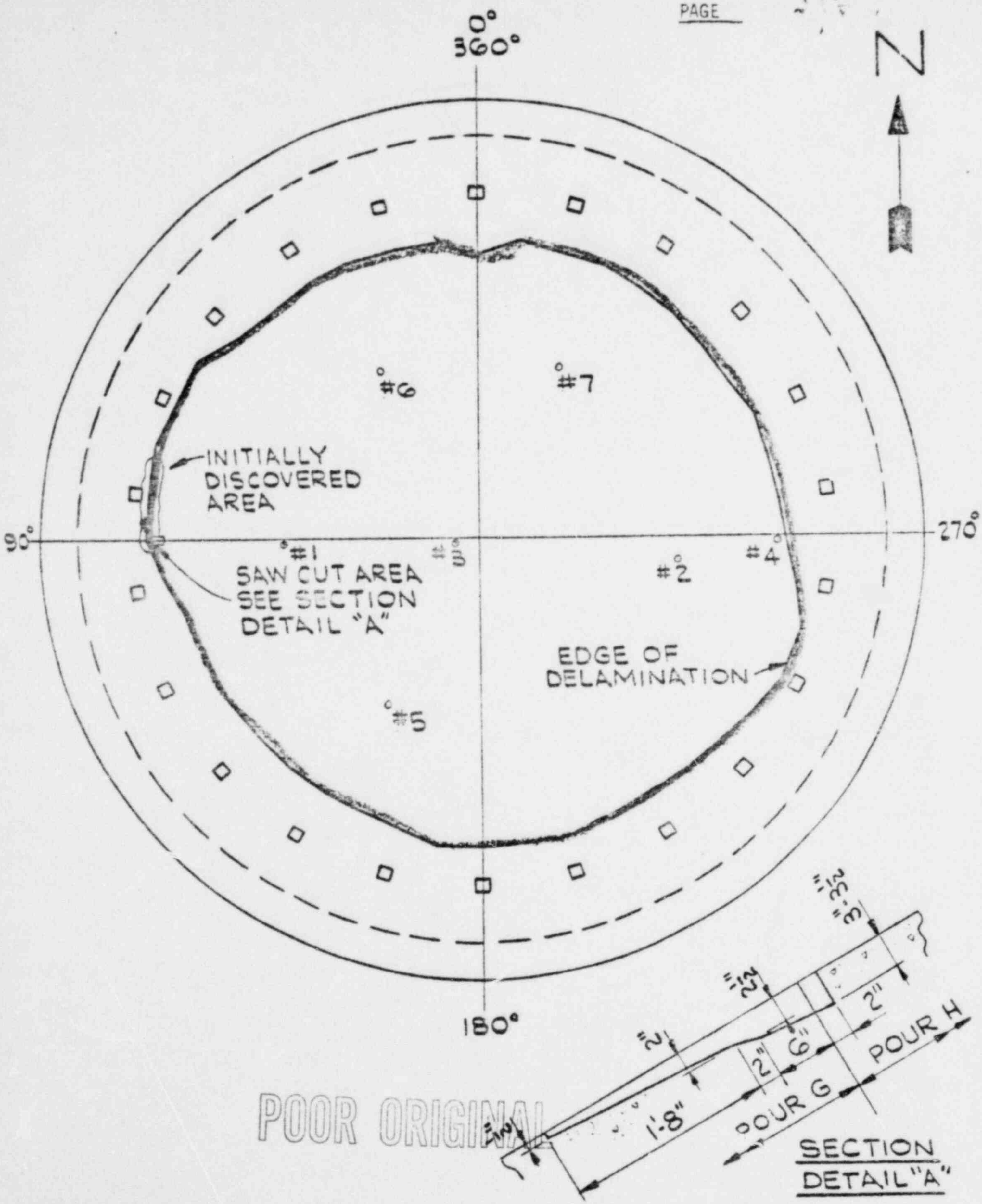
for

Crystal River, Unit 3

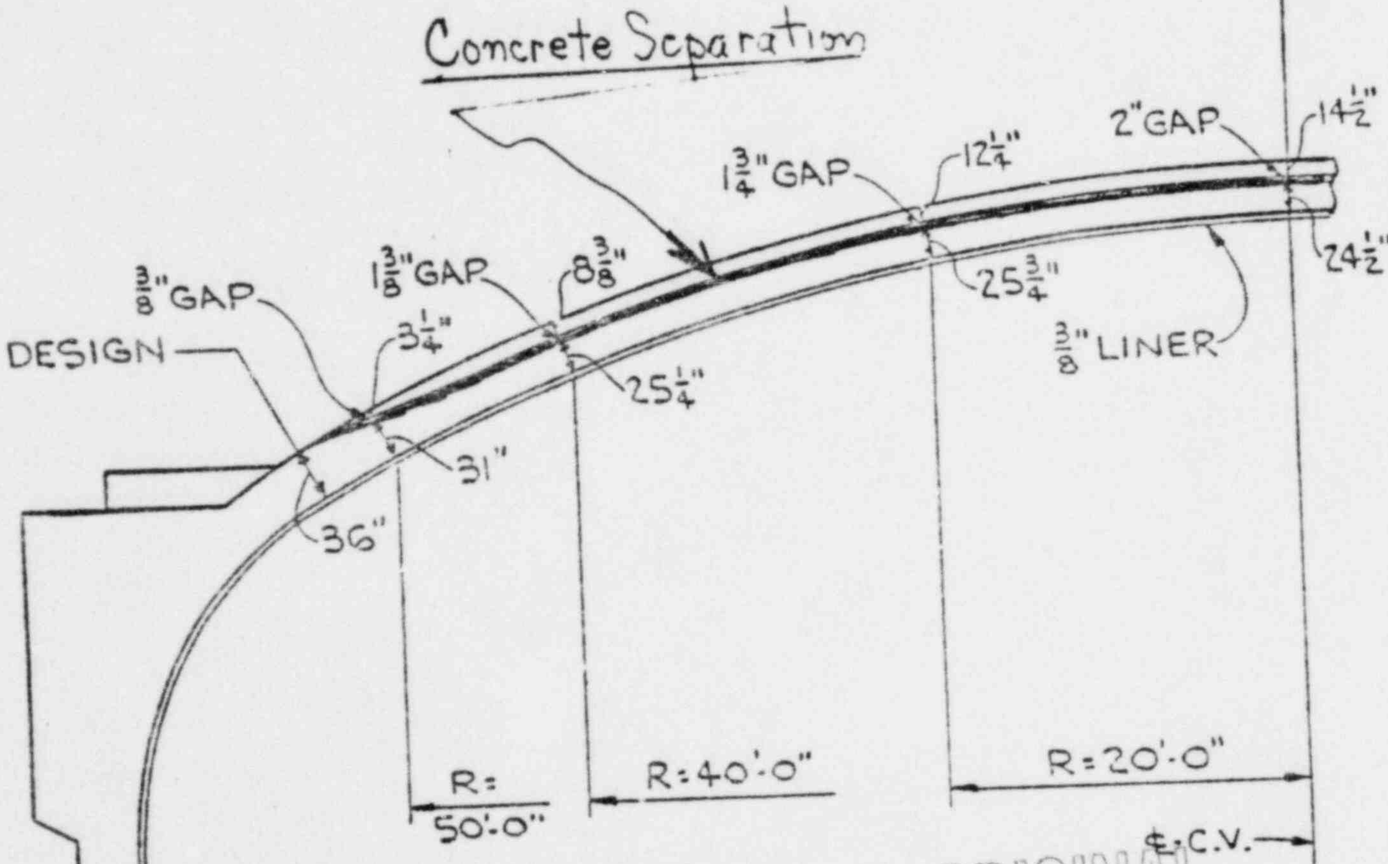
(pages 1, 2, & 3)



DELAMINATED AREA



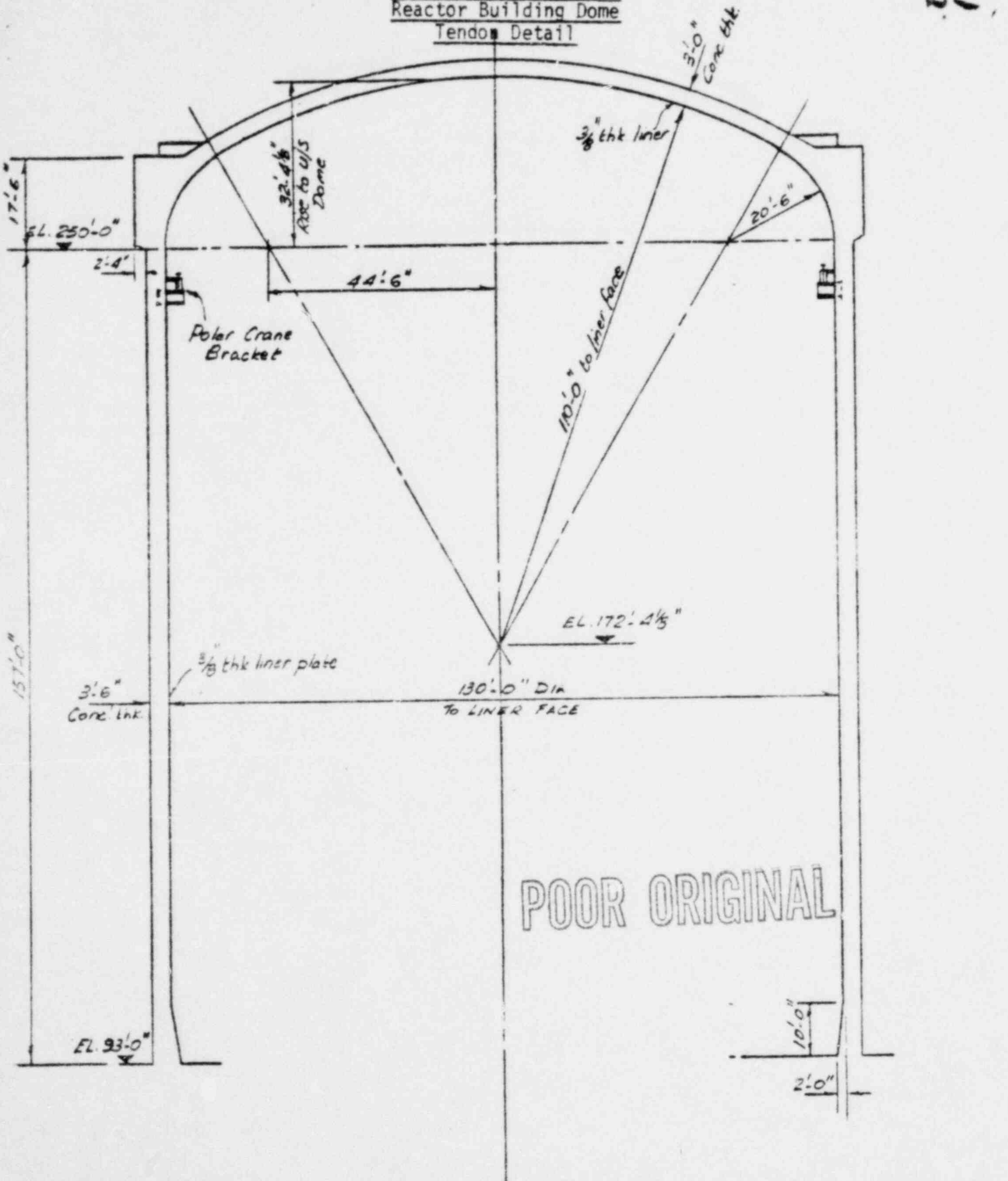
FIELD INVESTIGATIVE PROGRAM



DOME SECTION - 90° AZIMUTH
(GOVERNING AS IS DOME THICKNESS)

DC.

ATTACHMENT 3
Crystal River, Unit 3
Reactor Building Dome
Tendon Detail



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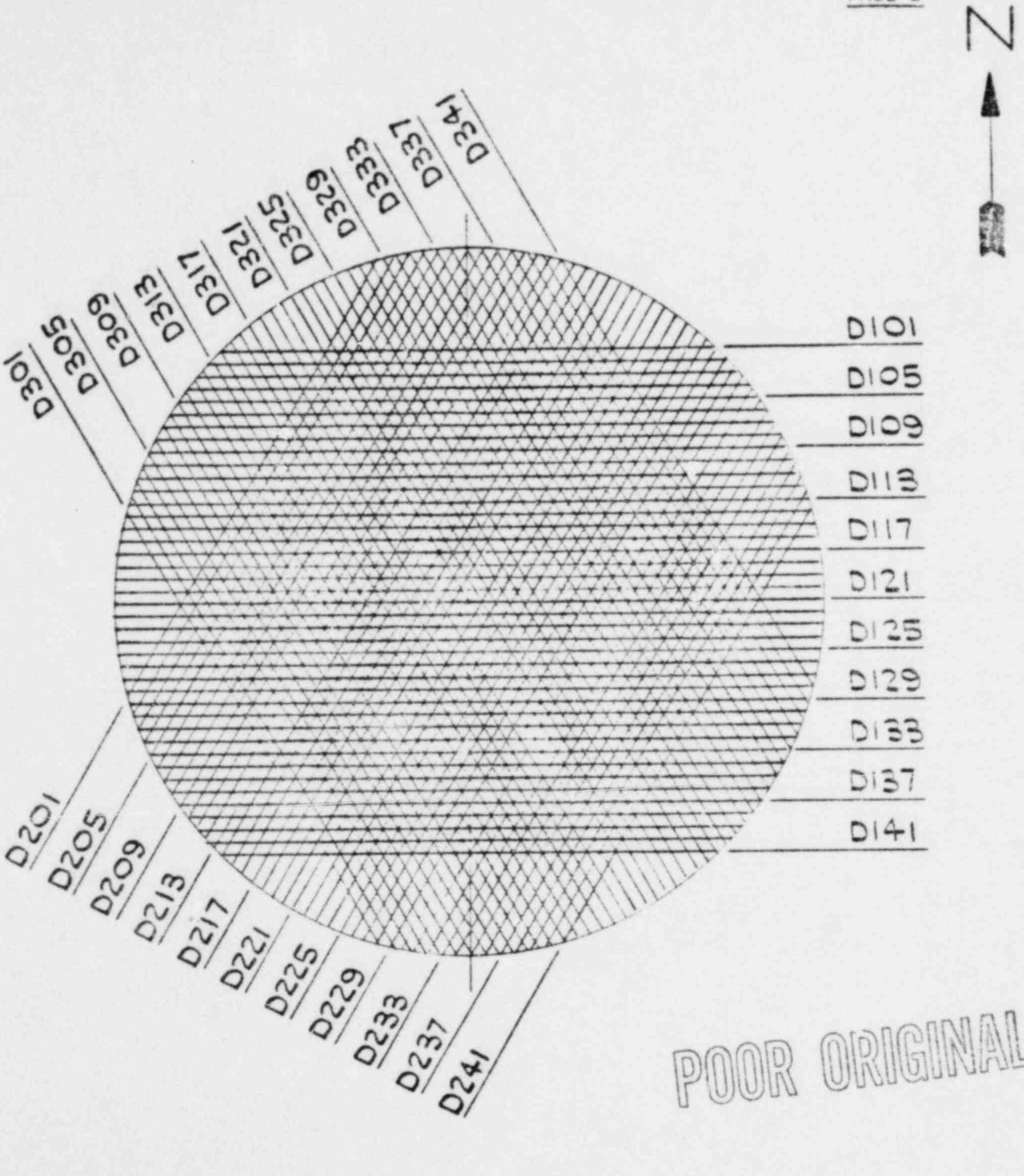
ORIGINAL DESIGN

D. CRONEBERGER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D101
D105
D109
D113
D117
D121
D125
D129
D133
D137
D141
D201
D205
D209
D213
D217
D221
D225
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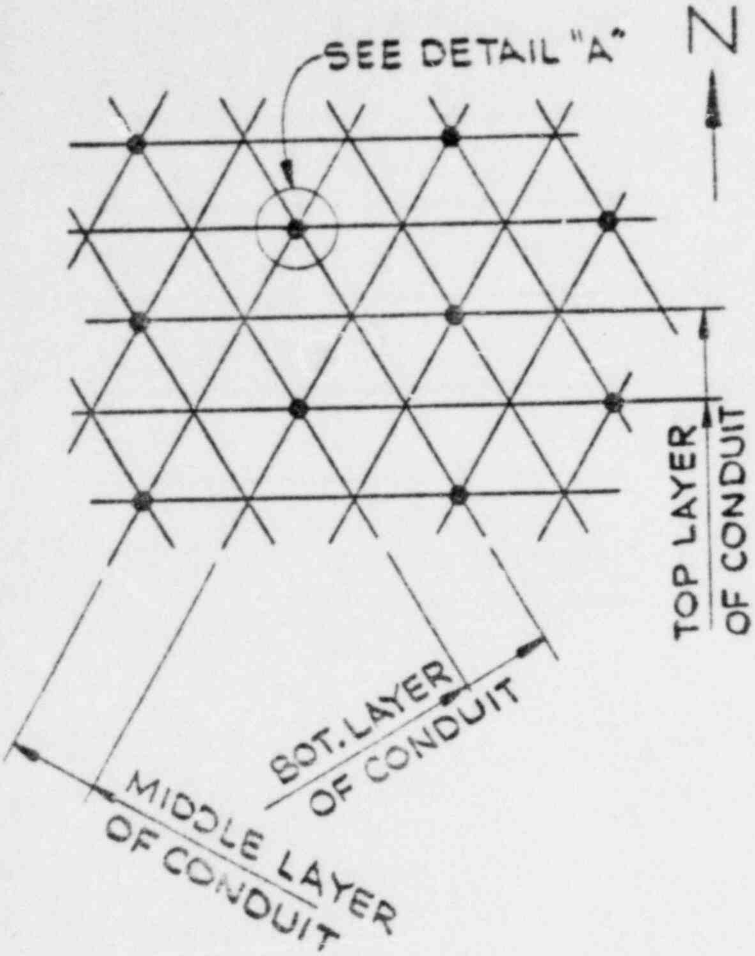
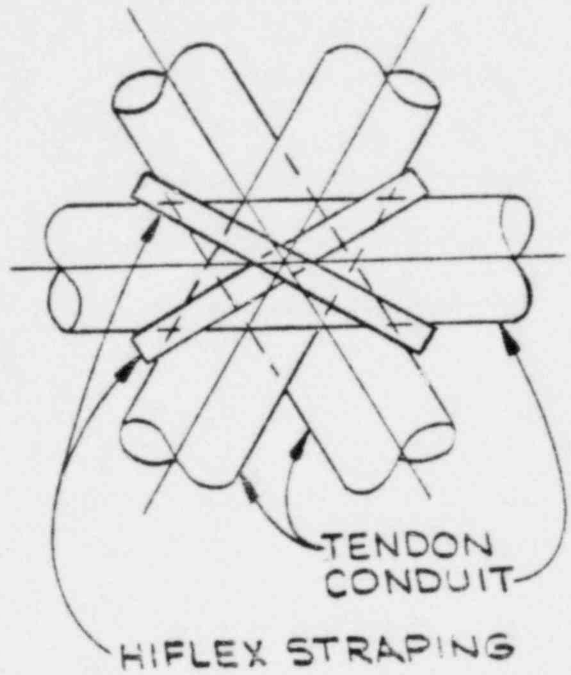
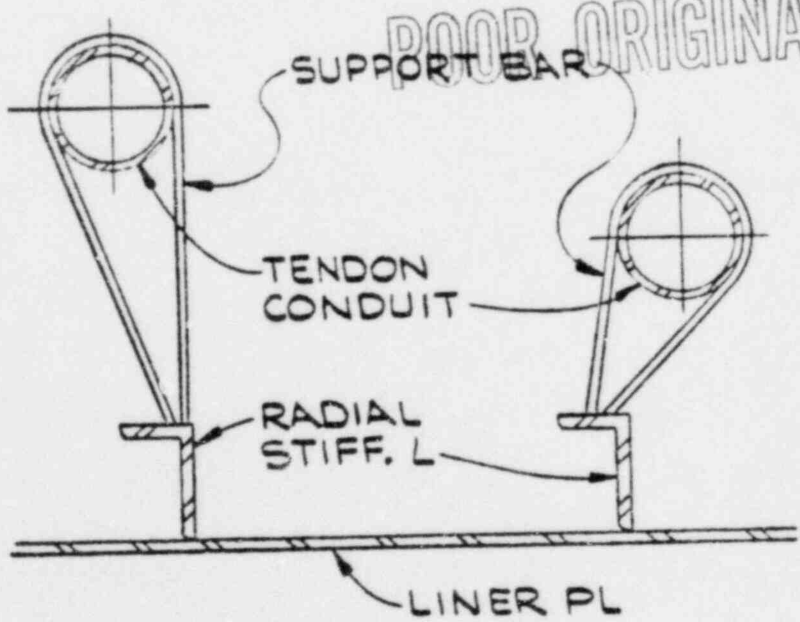
D329
D333
D337
D341



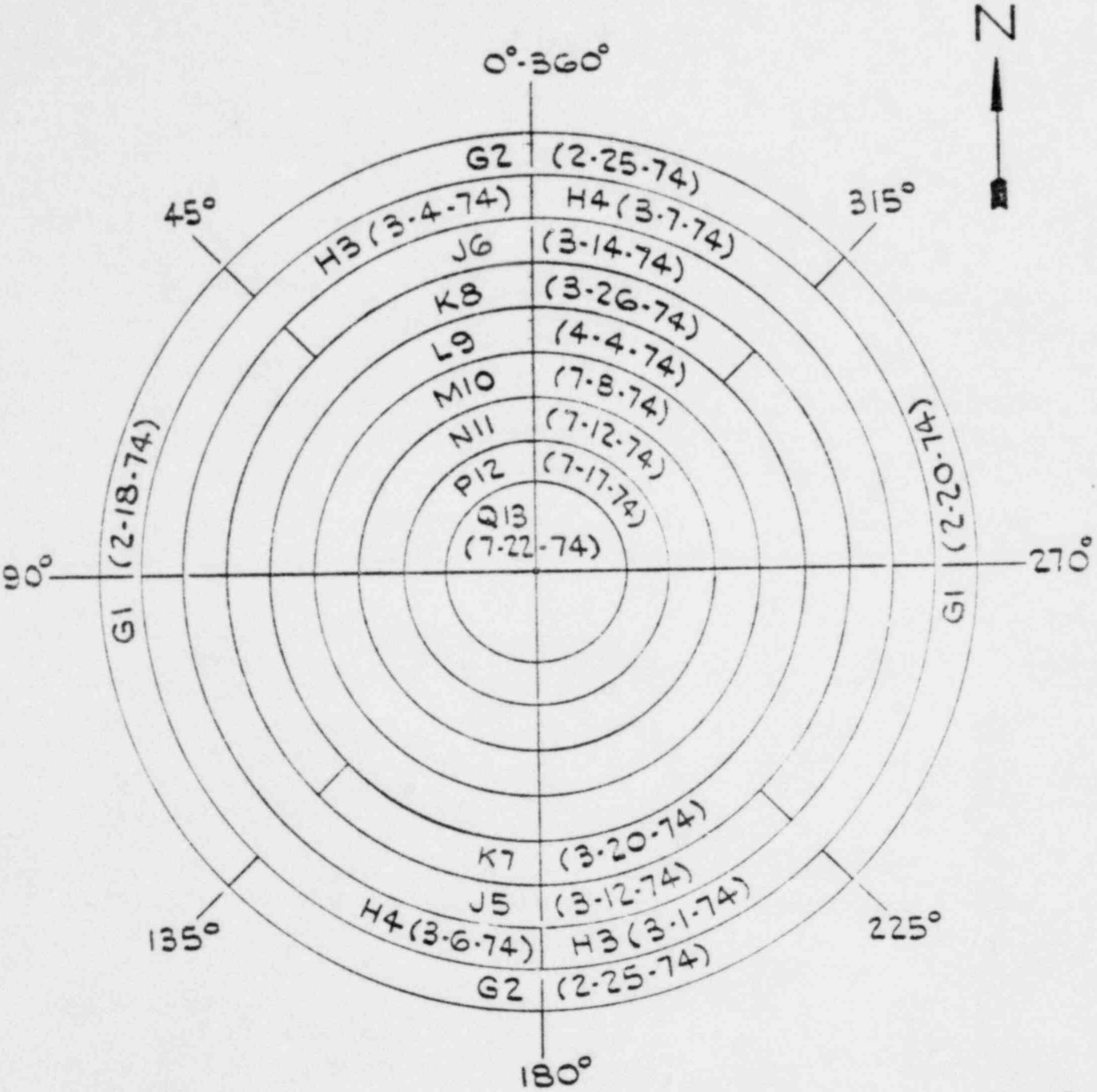
PLAN

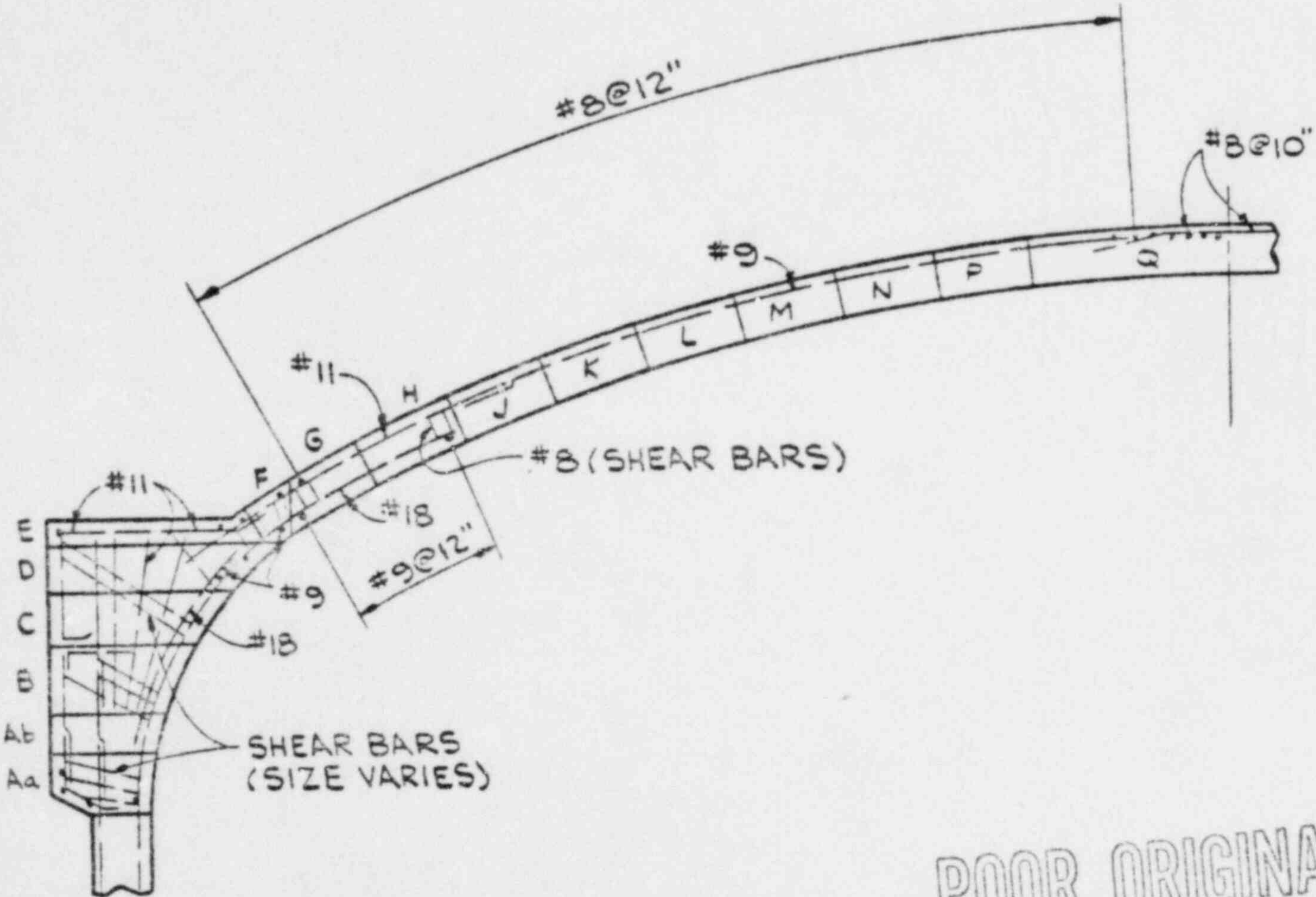


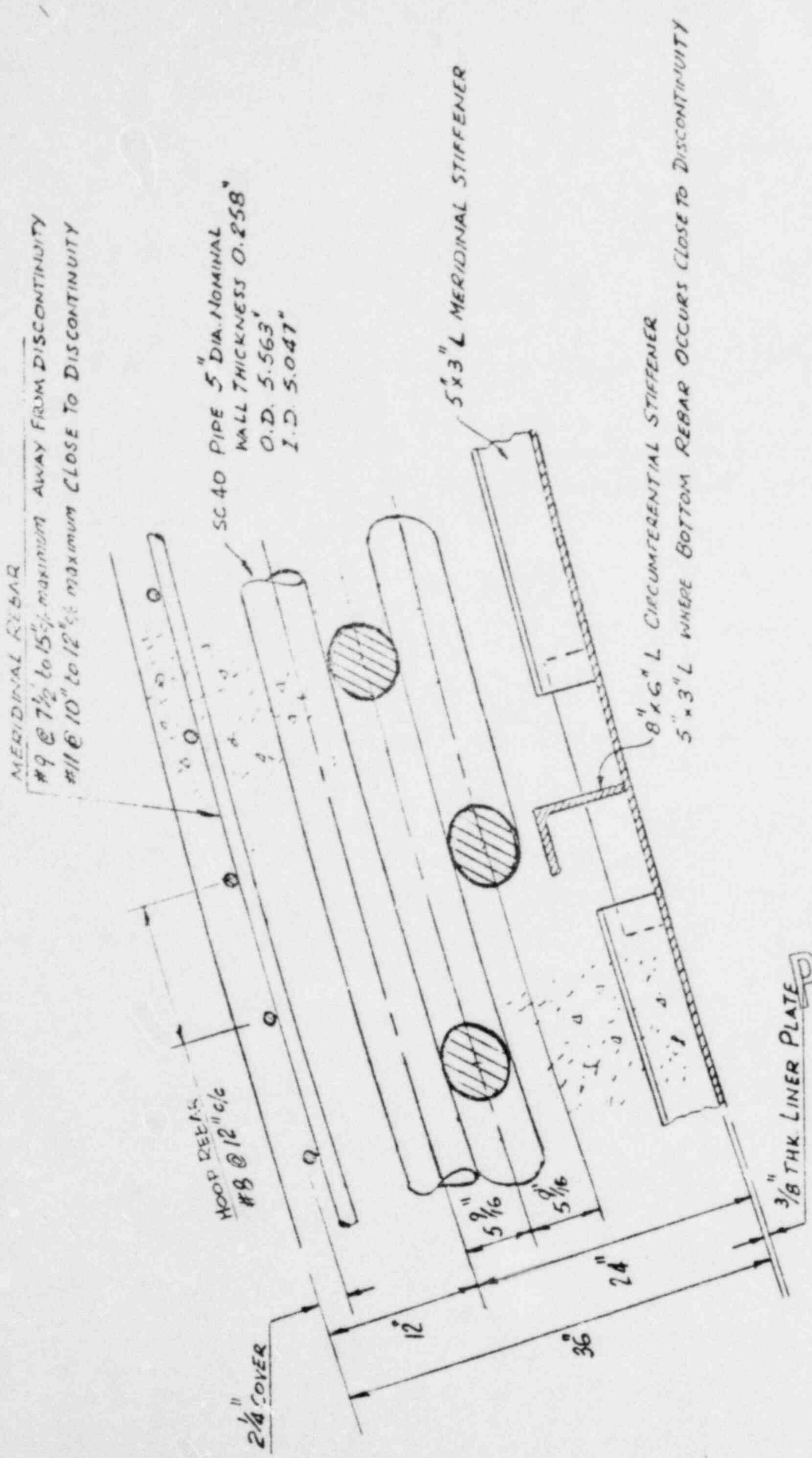
DETAIL "A"



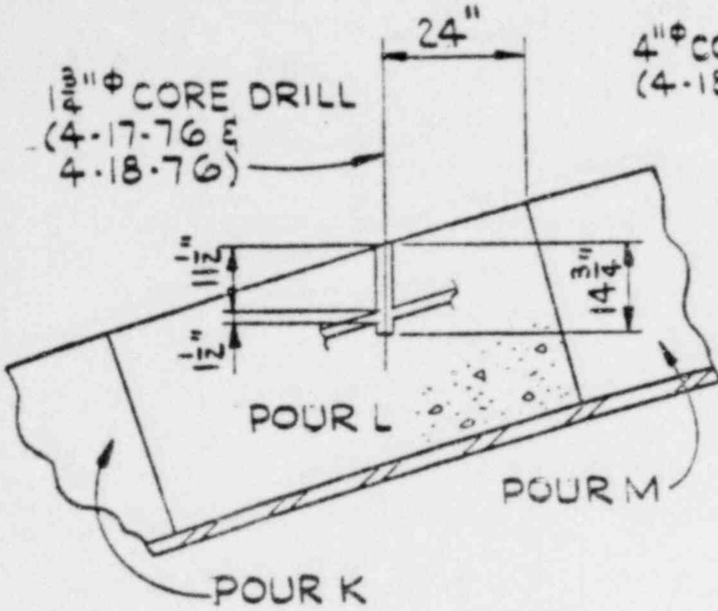
SUPPORT DETAIL

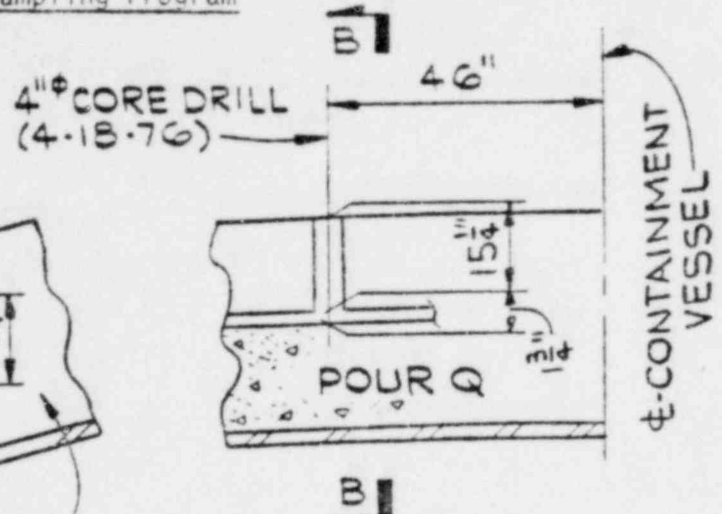

N
0°-360°
45°
315°
90°
270°
135°
225°
180°
G2 (2-25-74)
H3 (3-4-74)
H4 (3-7-74)
J6 (3-14-74)
K8 (3-26-74)
L9 (4-4-74)
M10 (7-8-74)
N11 (7-12-74)
P12 (7-17-74)
Q13 (7-22-74)
G1 (2-18-74)
G1 (2-20-74)
K7 (3-20-74)
J5 (3-12-74)
H4 (3-6-74)
H3 (3-1-74)
G2 (2-25-74)


#8@12"
#8@10"
#9
#11
#11
#8 (SHEAR BARS)
#18
#9@12"
#9
#18
SHEAR BARS
(SIZE VARIES)
E
D
C
B
Ab
Aa
F
G
H
J
K
L
M
N
P
Q


MERIDINAL REBAR
#9 @ 7½" to 15" c/c maximum AWAY FROM DISCONTINUITY
#11 @ 10" to 12" c/c maximum CLOSE TO DISCONTINUITY
SC 40 PIPE 5" DIA. NOMINAL
WALL THICKNESS 0.258"
O.D. 5.563"
I.D. 5.047"
5"x3" L MERIDINAL STIFFENER
8"x6" L CIRCUMFERENTIAL STIFFENER
5"x3" L WHERE BOTTOM REBAR OCCURS CLOSE TO DISCONTINUITY
HOOP REBAR
#8 @ 12" c/c
2¼" COVER
12"
24"
36"
5 9/16"
5 9/16"
3/8" THK. LINER PLATE

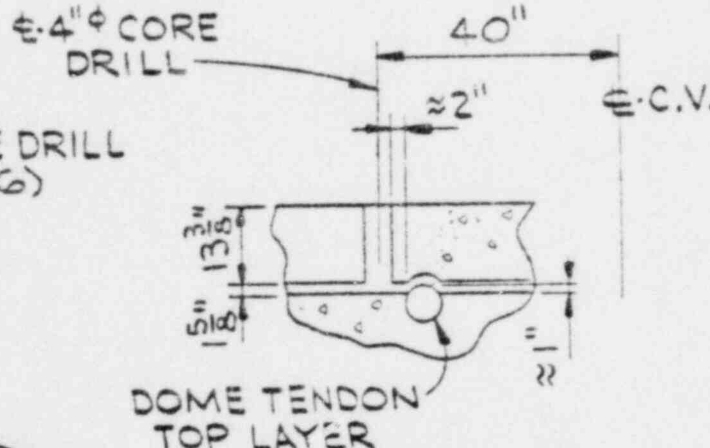
ATTACHMENT 4
Crystal River, Unit 3
Core Sampling Program



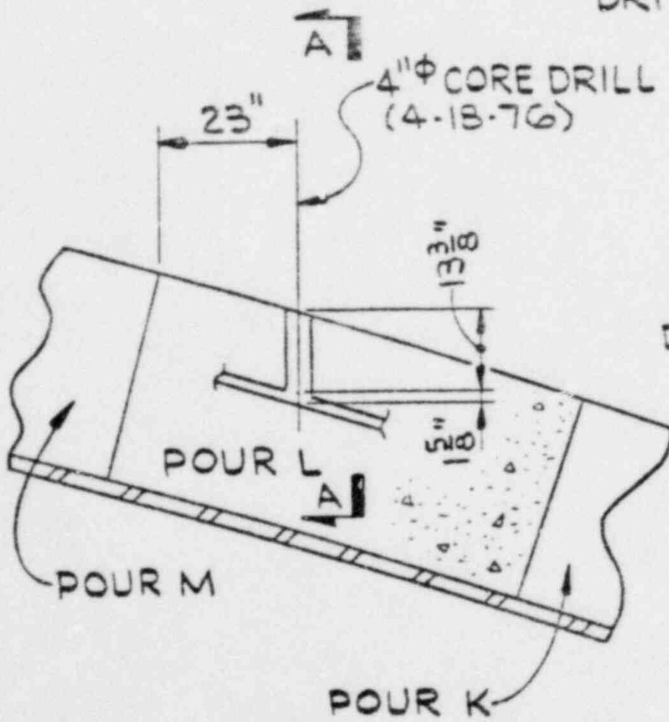


CORE #3

CORE #1



SECTION A-A



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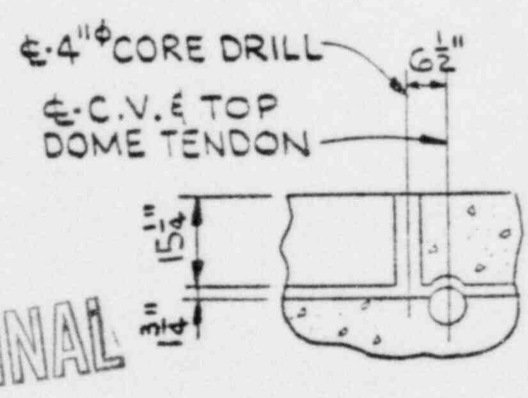

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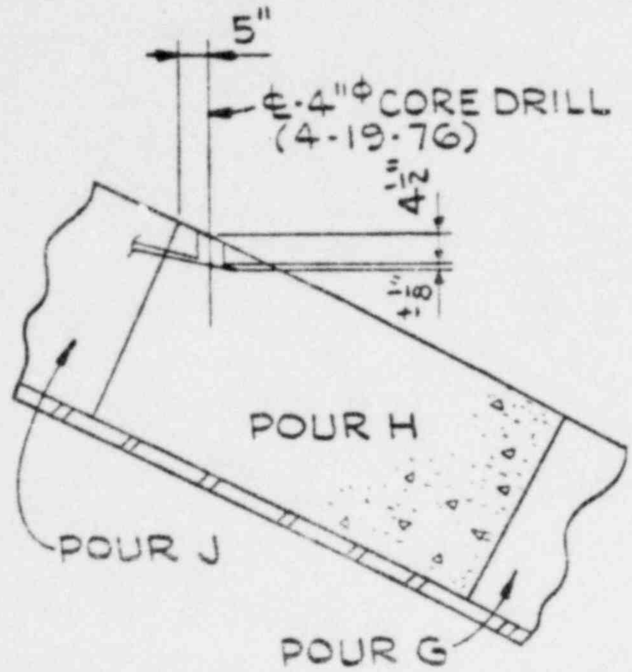

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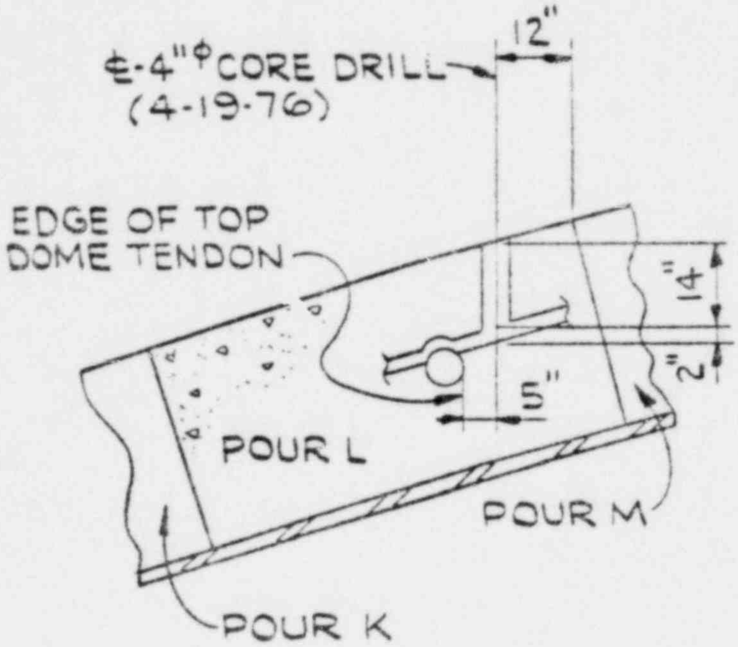

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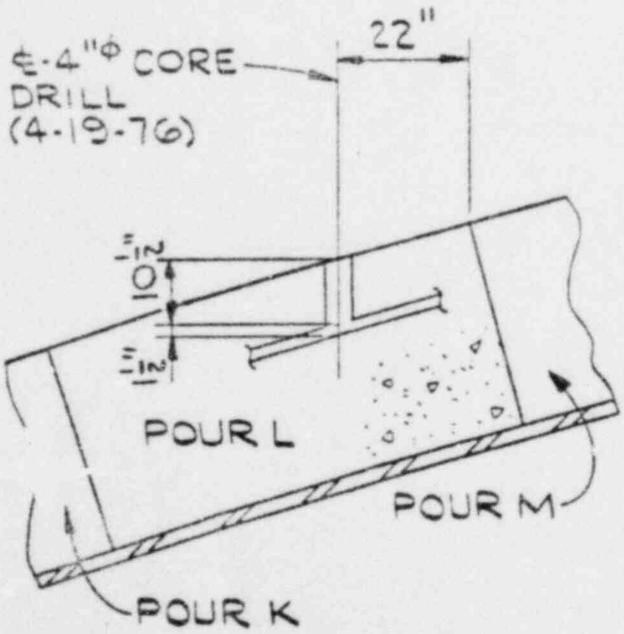

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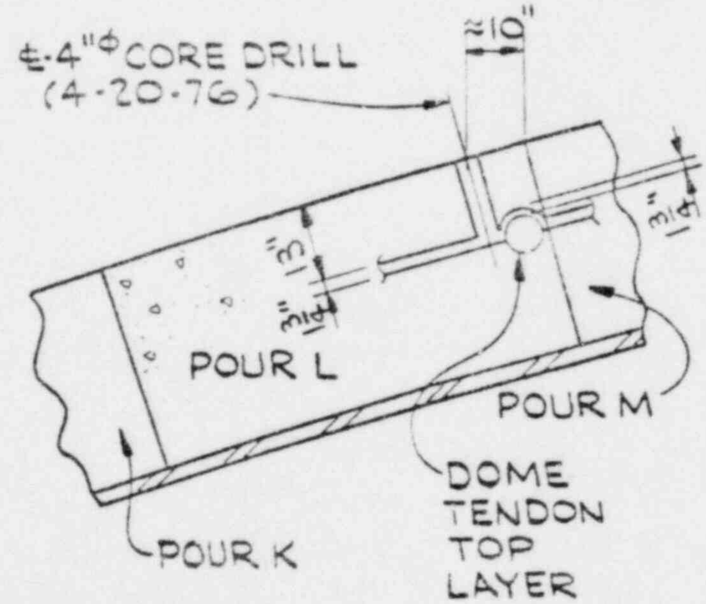

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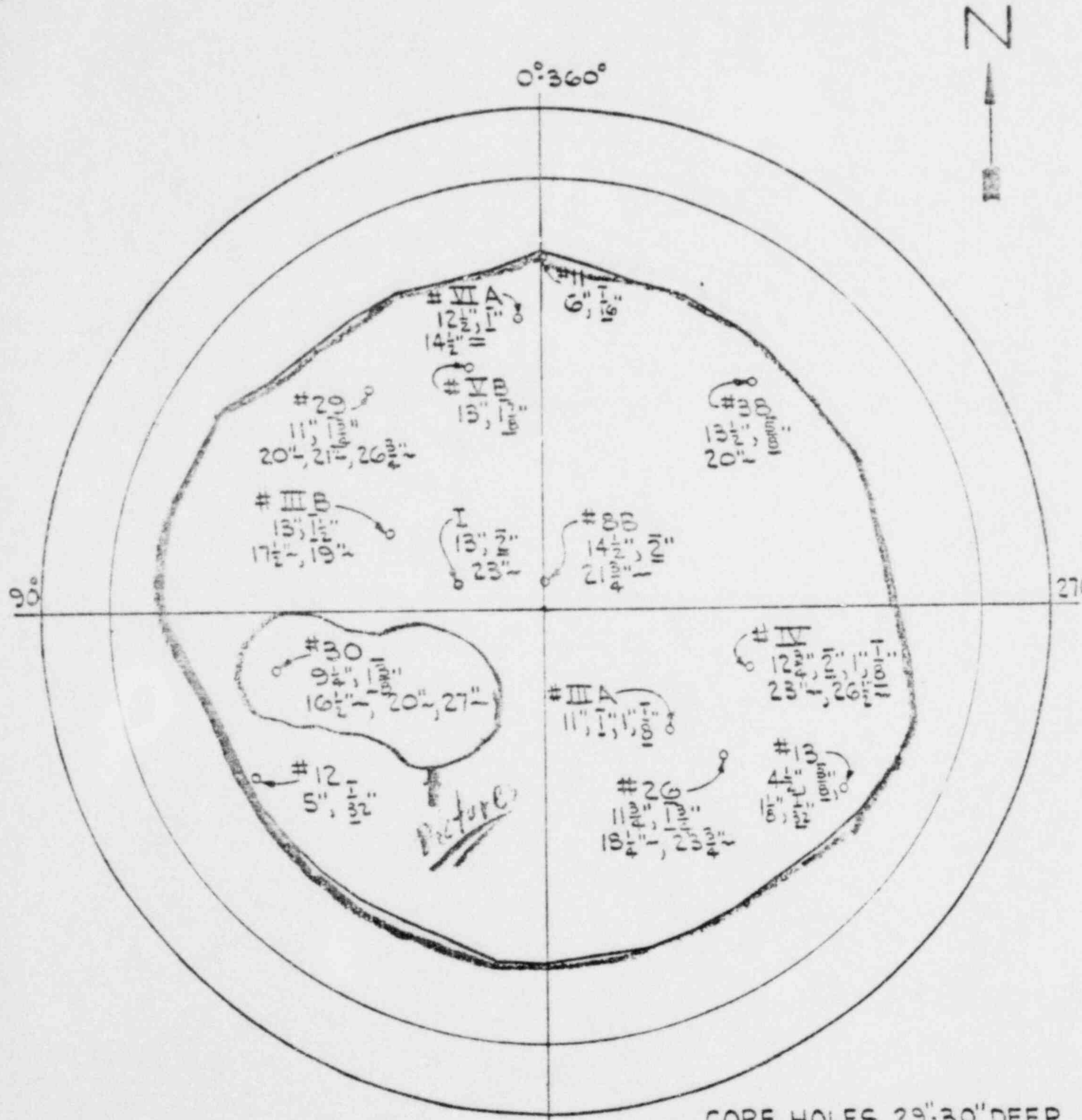
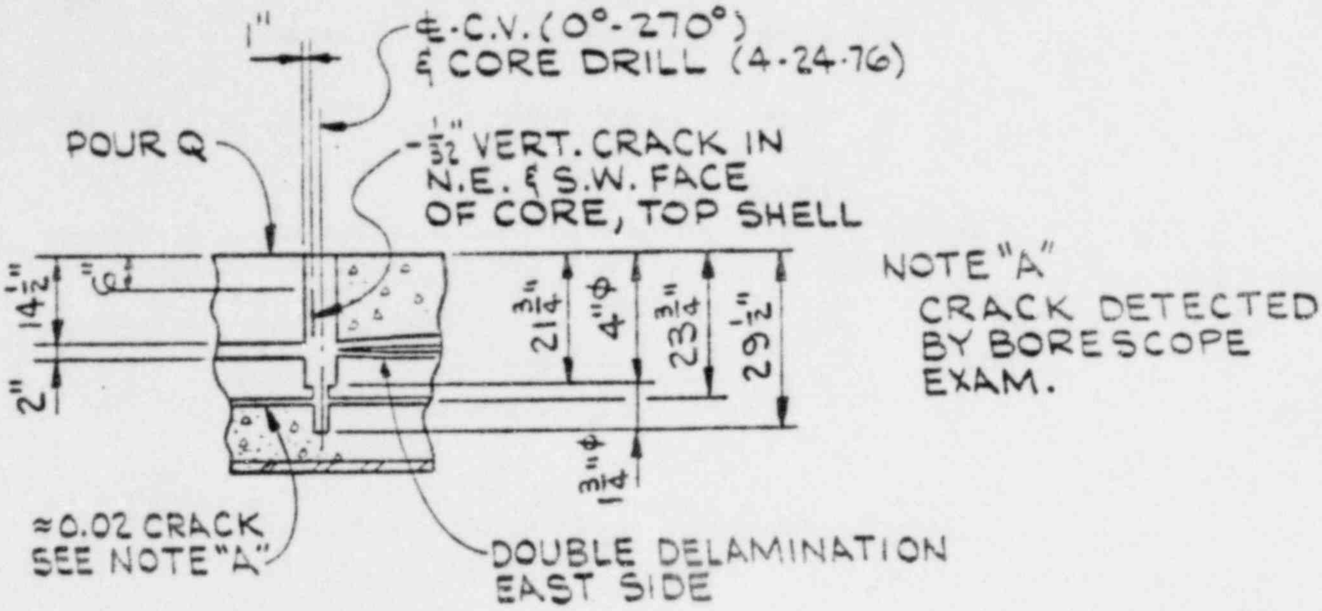
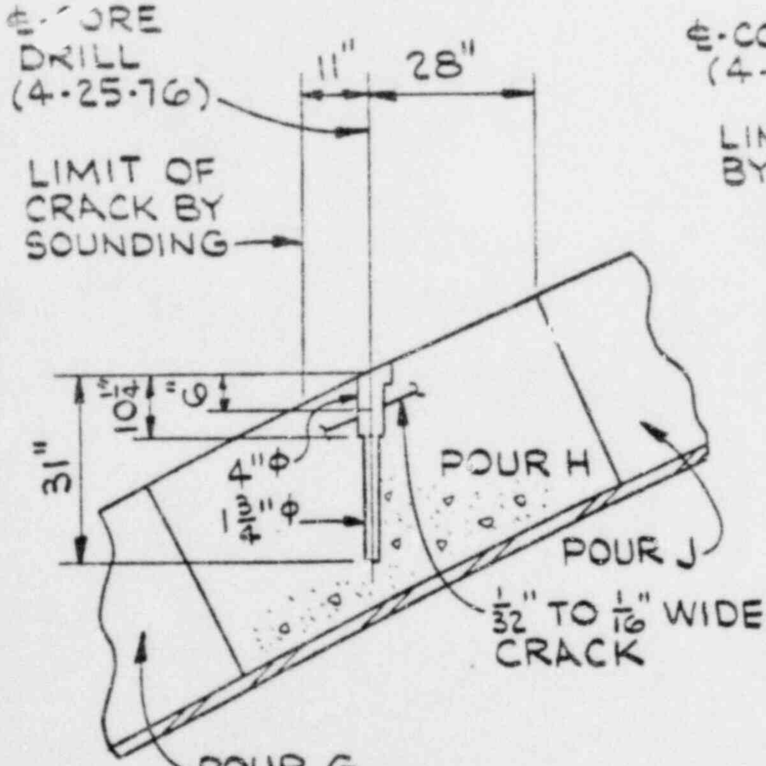


CORE HOLES 29"-30" DEEP
EXCEPT FOR: I-27", III A-19¼",
III B-28", V B & VI A-20"

DEEP EXPLORATORY CORE HOLES



CORE #8B



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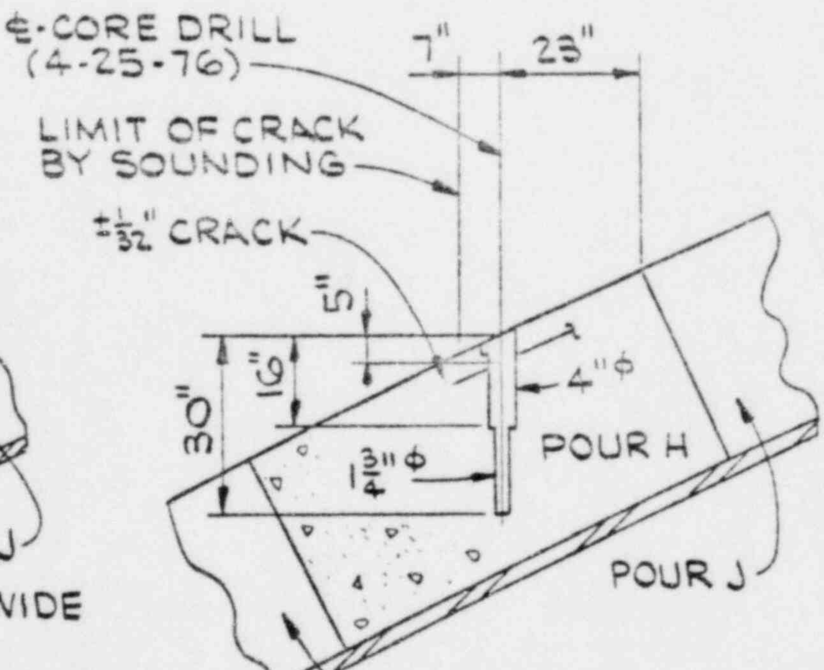
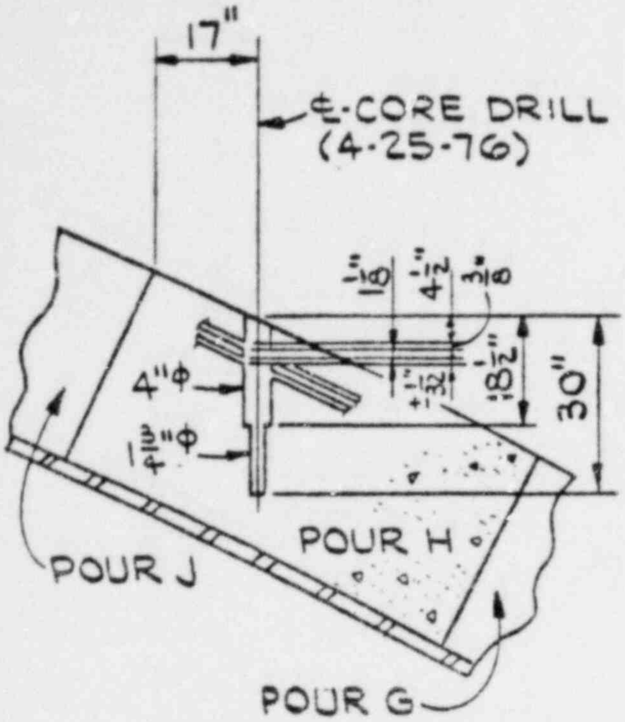


CORE #12

3-4



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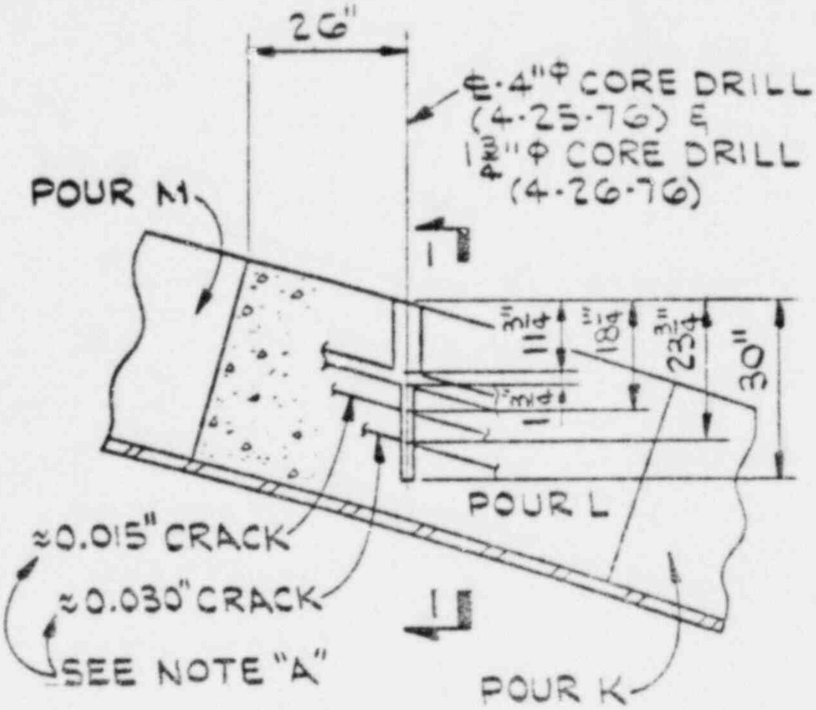

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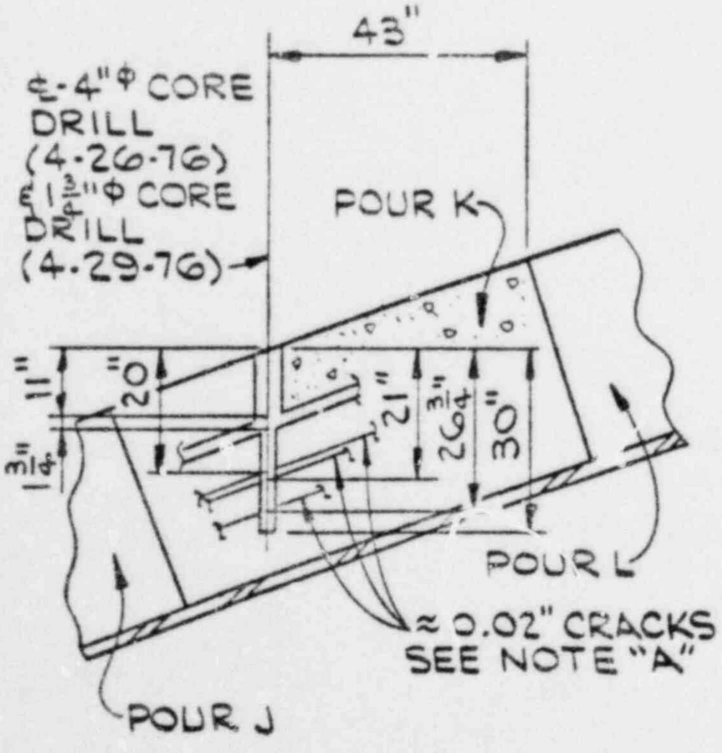

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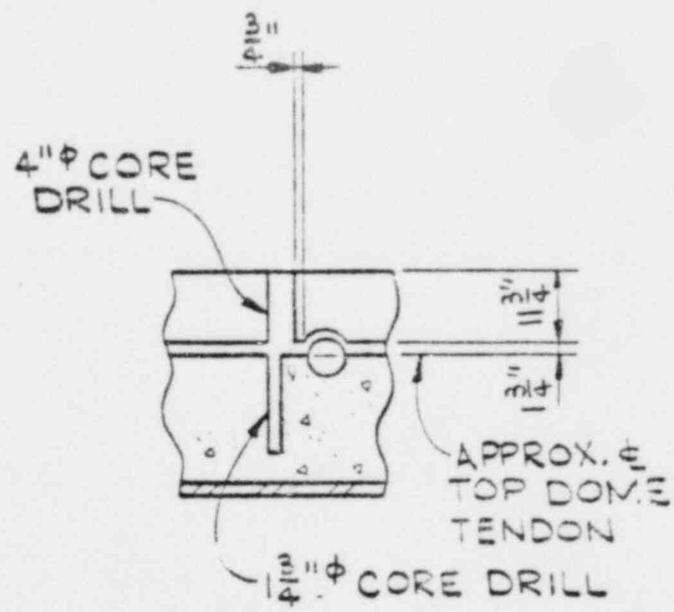
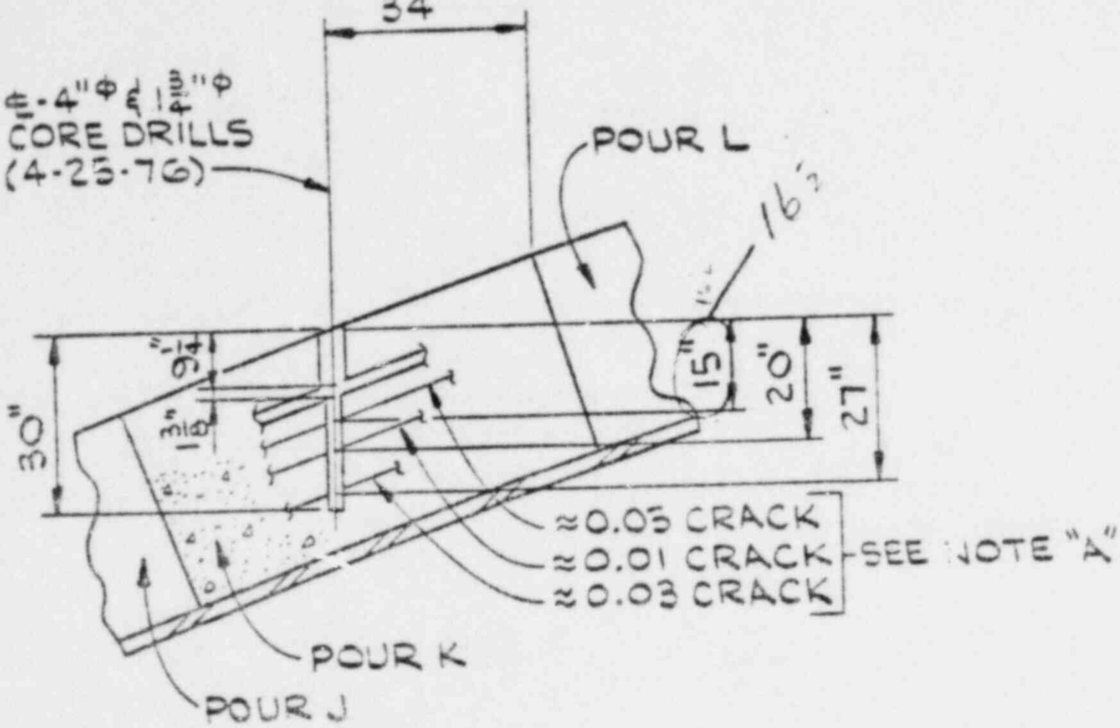


SECTION 1-1



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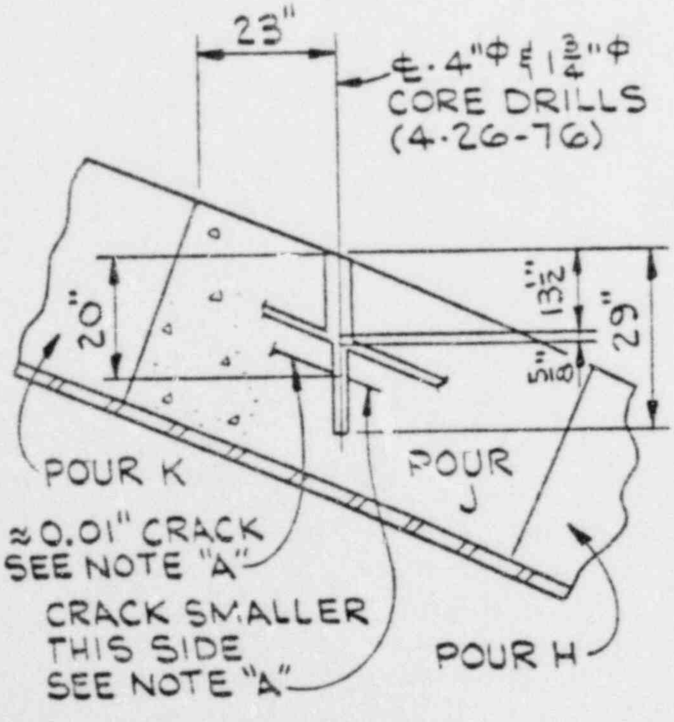

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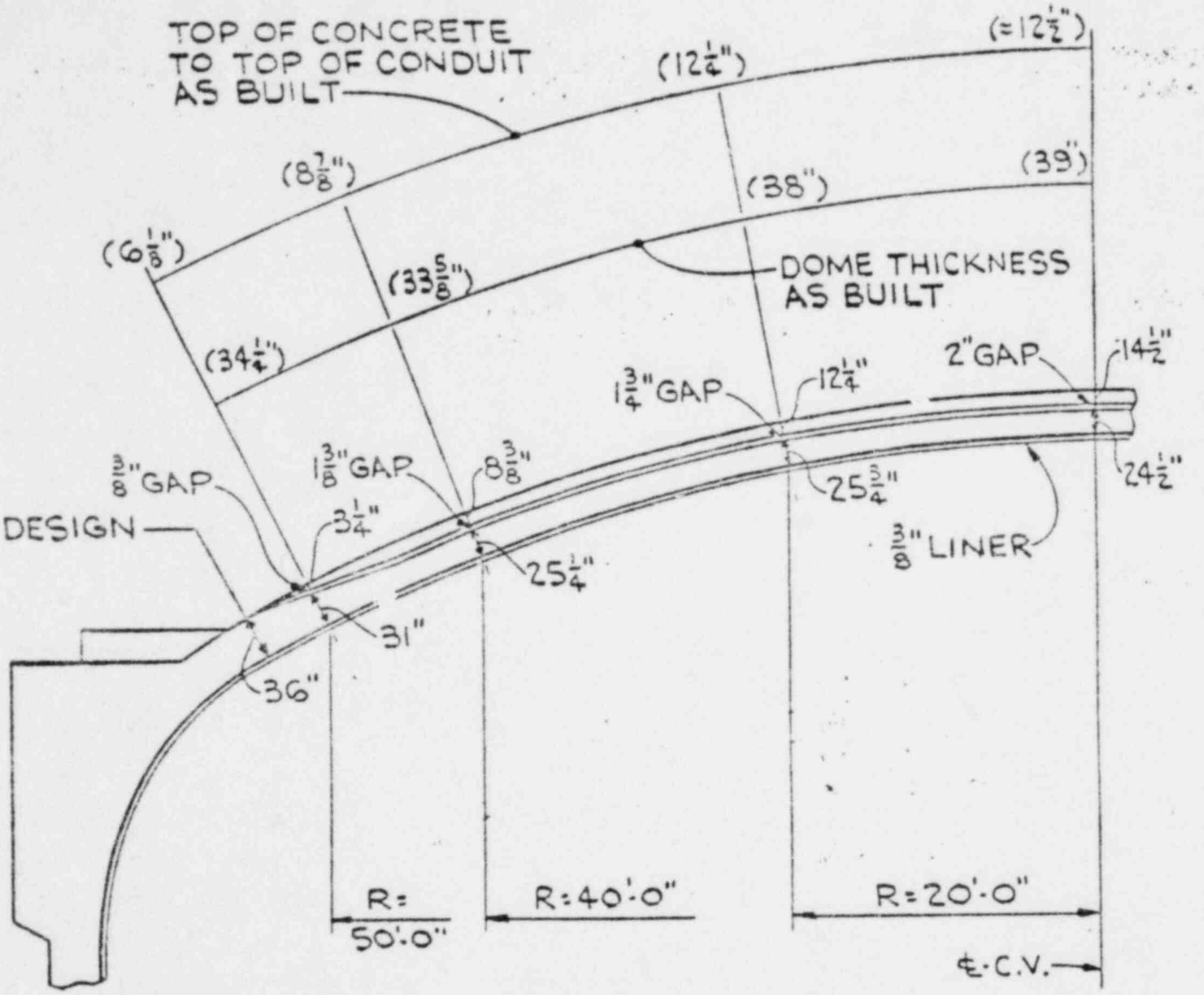

DOME SECTION - 90° AZIMUTH

(GOVERNING AS IS DOME THICKNESS)

NOTES

MEMO ROUTE SLIP Form AEC-93 (Rev. May 14, 1947) AECM 0240		See me about this.		For concurrence.		For action.
		Note and return.		For signature.		For information.

TO (Name and unit)	INITIALS / DATE	REMARKS
J. Collins, Chief ETSB/DSE THRU: F. Congel FJC		50 - 302
cc: J. Boegli, ETSB		
		CRYSTAL RIVER UNIT 3 APPENDIX I RADIOLOGICAL DOSES

FROM (Name and unit)	REMARKS
M. A. Parsont RIS/RAB P-214	Attached please find the appendix I Radiological dose evaluation for Crystal River Unit 3.
PHONE NO. 27955 / DATE 8/17/76	

USE OTHER SIDE FOR ADDITIONAL REMARKS

GPO : 1971 O - 445-469

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Comparison of Calculated Doses from
Crystal River Unit 3
With Sections II.A, II.B and II.C
of Appendix I, 10 CFR 50

Criterion	Appendix I Design Objective	Calculated Doses
Liquid Effluents		
Dose to total body from all pathways	3 mrem/yr	$2.7x10^{-3}$ mrem/yr
Dose to any organ from all pathways	10 mrem/yr	$2.6x10^{-3}$ mrem/yr
Noble Gas Effluents		
Gamma dose in air	10 mrad/yr	0.38 mrad/yr
Beta dose in air	20 mrad/yr	0.84 mrad/yr
Dose to total body of an individual	5 mrem/yr	0.017 mrad/yr
Dose to skin of an individual	15 mrem/yr	0.004 mrem/yr
Radioiodines and Particulates[a]		
Dose to any organ from all pathways	15 mrem/yr	0.069 mrem/yr

[a]Carbon-14 and tritium have been added to this category