D Heidle
L Lewis

FLORIDA POWER & LIGHT COMPANY

TURKEY POINT UNIT 3

INTERIM REPORT

CONTAINMENT DOME CONCRETE

INVESTIGATION

OCTOBER 2, 1970

50-250, Incident

INDEX

I. Introduction

On June 17, 1970 it was observed that the casing filler had begun to ooze out of the concrete surface of the Unit 3 Containment Dome in a spot at about 216 degrees azimuth and 35 feet radius from the center of the dome. At the close of the previous day, 110 out of 165 dome tendons had been stressed. One tendon was stressed on June 16, 1970 and two on June 17. Basically the tendon stressing activity had been halted on June 16 to pump sheathing filler into the tendons already stressed. Nine tendons had been greased on June 16, 1970 and 5 were greased on June 17. In order to investigate the source of leakage, a small area of concrete was chipped and a layer of separation in concrete was found a few inches below the surface, with evidence of grease flow on the surface.

On June 22, 1970, a small bulge in the dome surface was noticed at approximately azimuth 290 degrees and radius of 25 feet. The concrete was broken through in one small spot with a hammer and separation layer was discovered at about ½" depth. The exploratory chipping was expanded laterally and towards the center of the dome, revealing that the separated layer became thicker towards the center. This stage of chipping was stopped at about 15 feet radius, at which point the separated layer was about 4" thick, same as concrete cover above the upper layer of reinforcing steel in this area.

A detailed investigation is underway to ascertain the extent and the causes of this problem, and to arrive at a suitable method of repairing the damaged concrete. The investigation is being conducted by the Bechtel Corporation with consultant services provided by T. Y. Lin, Kulka, Yang and Associate; Mr. George Nelson, Chairman of Law Engineering; Mr. Lewis H. Tuthill, retired, formerly of California Department of Water Resources, Division of Design and Construction; and Dr. Richard C. Mielenz, Vice President, Master Builders Company.

A verbal presentation on this subject was made to representatives of the Divisions of Reactor Licensing, Compliance, Reactor Standards and staff of ACRS in Bethesda on September 16, 1970. While the investigations are still incomplete, this interim report presents progress to date.

II. Summary

To determine the extent of concrete separation, the primary tools of investigation have been (i) soundings with a steel hammer, and (ii) core borings. The sonic pulse velocity technique does not lend itself to this type of structure. The sonic vibratory resonance technique was tried at site, but was found unworkable. 43 core borings had been completed by September 29, 1970, and the program is still in progress. About 50 core borings are planned. The core holes are examined with a boroscope for existance of concrete separation. The deepest separation noticed so far is about 15 inches below the dome surface. While a meaningful pattern has not yet emerged from the concrete separation detected by hammering and core boring, no separation has been discovered in the north quadrant of the dome.

The investigation into the causes encompasses the construction procedures, the testing of concrete and its constituents, as well as the stresses and strains imposed by the various loads.

Petrographic analysis indicates sound concrete with no signs of aggregate

reactivity, or microcracking and no chlorides, or other chemical impurities.

Since the investigation covering all aspects of the problem is still underway, no conclusions have been drawn as to the causes. Choice of repair method will depend upon a determination of the causes.

III. Construction of Containment Dome

The sequence of concrete placement for the dome is shown in Appendix A. The lower half of the ring girder was placed in Lift (A), in 60 degree segments like a typical wall pour. Lift (B) consisted of 2-180 degree segments and covered the 8" thick structural slab which provides a work platform for installation of the tendon sheathing, and a support for the dead weight of the remaining 31 inches of the dome concrete. The upper part of the ring girder, Lift (C) was placed in 3-120 degree segments, while the Lifts (E) and (F) each consisted of 2-180 degree segments. Known concrete separation exists in Lift (F) only.

Curing of Concrete

For lifts (C), (E), and (F), the concrete was cured using a membrane curing compound. The compound was sprayed on after the finishing operation was complete and the surface moisture had disappeared. The coating was uniformly applied over the entire surface.

The product used was W. R. Grace's #2803-R white pigmented curing compound meeting ASTM specifications C-309. White pigment was selected for maximum reflection of solar heat and to permit visual inspection for thoroughness of application.

For lift (B), the method and compound was same as above except that the compound was sand blasted off just prior to placing concrete above joint.

For list (A) burlap bags were spread over the top of concrete and continually water soaked.

IV. Extent

The initial investigation to determine the extent of the concrete separation below the surface was performed by soundings with a Swiss hammer and a steel sledge hammer. The steel hammer was found to be more effective in finding separations deeper into the concrete, and is reliable up to a depth of about 10 inches. The 'hollow' sounding areas as indicated by hammering technique have been marked in the sketch in Appendix C.

Sonic investigations with a V-scope were considered. The pulse velocity technique does not lend itself to a concrete mass with large numbers of embedded conduits and a liner plate on the underside of the dome. Moreover, the presense of an intentional construction joint 8 inches from the liner plate further deminishes the reliability of the pulse velocity technique. The reflection method of ultrasonic examination used in metals has not been perfected for a hetrogeneous mass such as concrete. A method of sonic induced vibratory resonance of concrete surfaces was tried but proved unsuccessful.

Core borings appear to be the only reliable method for locating separations at greater depths from the concrete surface. The program of core borings is almost complete. 43 core holes have been drilled out of the 50 planned cores. Due to the presence of 5 layers of tendons in the dome as shown in Appendix B, the likelihood of puncturing through tendons increases with the depth of coring. In general, an attempt has been made to drill the holes to a 16 inch depth, this being supplemented by a few 29 inch deep core holes. The coring log and a sketch showing the location of core holes is included as Appendix B. The deepest lamination found is in core hole #23 at a depth of 15 inches.

The holes are examined with a boroscope that permits a magnified view of the interior surface of the hole. Pictures have been taken of representative holes to record the nature of concrete separation. It has been determined that frequently, air gaps in the order of ¼" to ½" exist at the level of separation.

No concrete separation has been found in an approximate 90 degree area, between 316 degrees and 46 degrees. In the southern portion of the dome, core holes revealed lamination even though hammer soundings did not indicate any separation.

V. Investigation of Potential Causes

An investigation is underway to determine the likely causes for the observed concrete distress. This investigation covers the materials used, the stresses and strains generated by the various loads, and the method of construction used for the containment dome.

(1) Materials Investigation:

(a) Petrographic analysis of concrete has been performed by 2 independent laboratories, namely: Erlin Associates of Northbrook, Illinois through Pittsburgh Testing Laboratory and by Dr. Richard C. Mielenz, Vice President of Research & Development, Master Builders Company of Cleveland, Ohio. The reports indicate concrete of good quality and a high cement factor, low water-cement ratio, and an air-void system characteristic of the intentionally entrained air. There is no indication of aggregate reactivity nor of voids introduced by presence of aluminum in the concrete. No microcracking has been observed.

(b) Water and ice used in the concrete have been subjected to a chemical analysis. The results of a few typical test reports are included as Appendix D. All chemical inclusions are within the specified limits.

(c) The cement used for the dome concrete is Type II Portland Cement. Mill Test Reports are regularly received from the supplier and grab samples have been tested by the user through Pittsburgh Testing Laboratory. A few typical user sample test reports are included as Appendix E.

The cement conforms to the requirements of Type II cement with the exception that the combined limit of 58% on Tri-calcium silicate and Tricalcium aluminiate has not been enforced on this project. (The ASTM limit of 58% for Type II cement is optional and applies only when specifically so indicated by the user.) However, this non-enforcement is not considered to be serious in view of the strict control of concrete temperature at 70 degrees F. and the use of Retardwell for slowing down the rate of hydration of cement.

(d) The concrete specified for the dome should have a 28-day compressive strength of 5000 psi. The actual values generally were over 6000 psi. However, no limit has been specified for the tensile strength of concrete. This is not generally done for concrete used in buildings, etc. The tests are now being made to determine the tensile strength as indicated by cylinder splitting tests (ASTM C-496) and by third point load method for flexural tensile strength of concrete (ASTM C-78). These tests are also being run on materials from a few other projects. The results available to date are shown in Appendix F. Values for direct tensile strength are expected from tests arranged through the U. S. Army Corps of Engineers in Vicksburg, Mississippi. The results will be available by about October 10, 1970.

(e) Tensile strain capability of concrete can become an important property for dome concrete in view of the biaxial membrane compression in the dome which could cause radial tensile strain. Tests are now underway at Vicksburg to simulate the actual load condition of the dome and to determine the tensile strain capability of the dome concrete for Turkey Point and a few other projects. The results will be available by about October 10, 1970.

(2) Stresses and Strains

A detailed review and analysis is in progress to determine the stresses and strains expected from the various loads. In particular, the following loads are receiving attention:

(a) Stresses caused by pre-stressing tendons.

(b) Stresses developed during the various stages of prestressing in accordance with the actual stressing sequence followed at Turkey Point.

(c) Grease pressure and temperature are under evaluation. The shut-off head of the two pumps used for injecting grease into the tendon sheathing has been tested at jobsite and has been found to be 200 psi for one pump and about 250 psi for the second. Considering the static head of the vertical riser from the pump to the dome, the pressure in the tendon sheathing cannot exceed 150 psi.

The pumping temperature ranges between 90 degrees F and 125 degrees F.

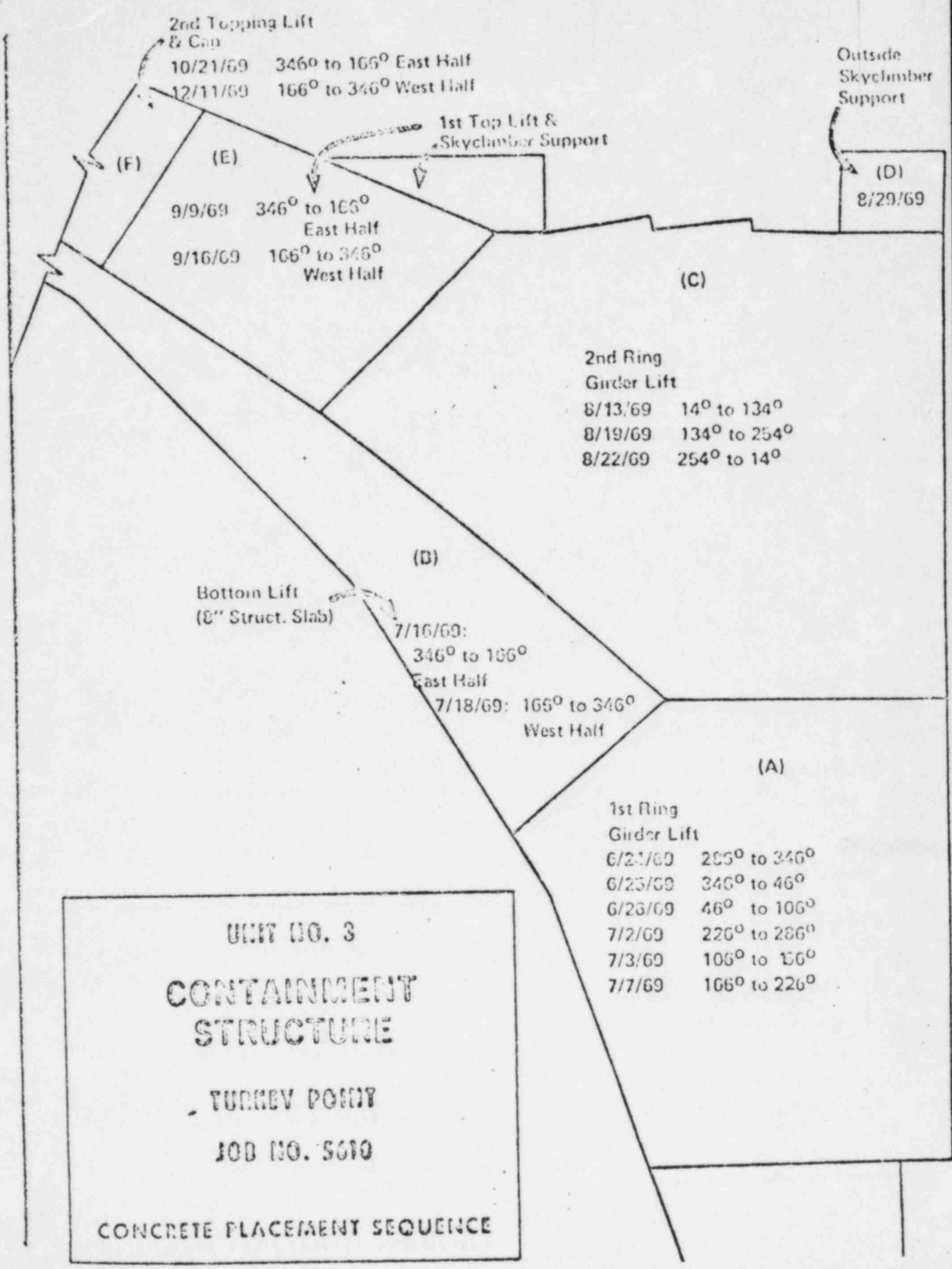
(d) The effect of weathering and curing like rain, solar heat and heat of hydration is being studied.

(c) A truck crane is parked at the center of the dome to make light construction lifts. The maximum load hoisted by this crane is 5000#. The lift load along with the dead weight of the truck crane has been studied for its effect on the structural integrity of the dome. The stresses induced by the crane seem to be minimal.

VI. Miscellaneous Observations

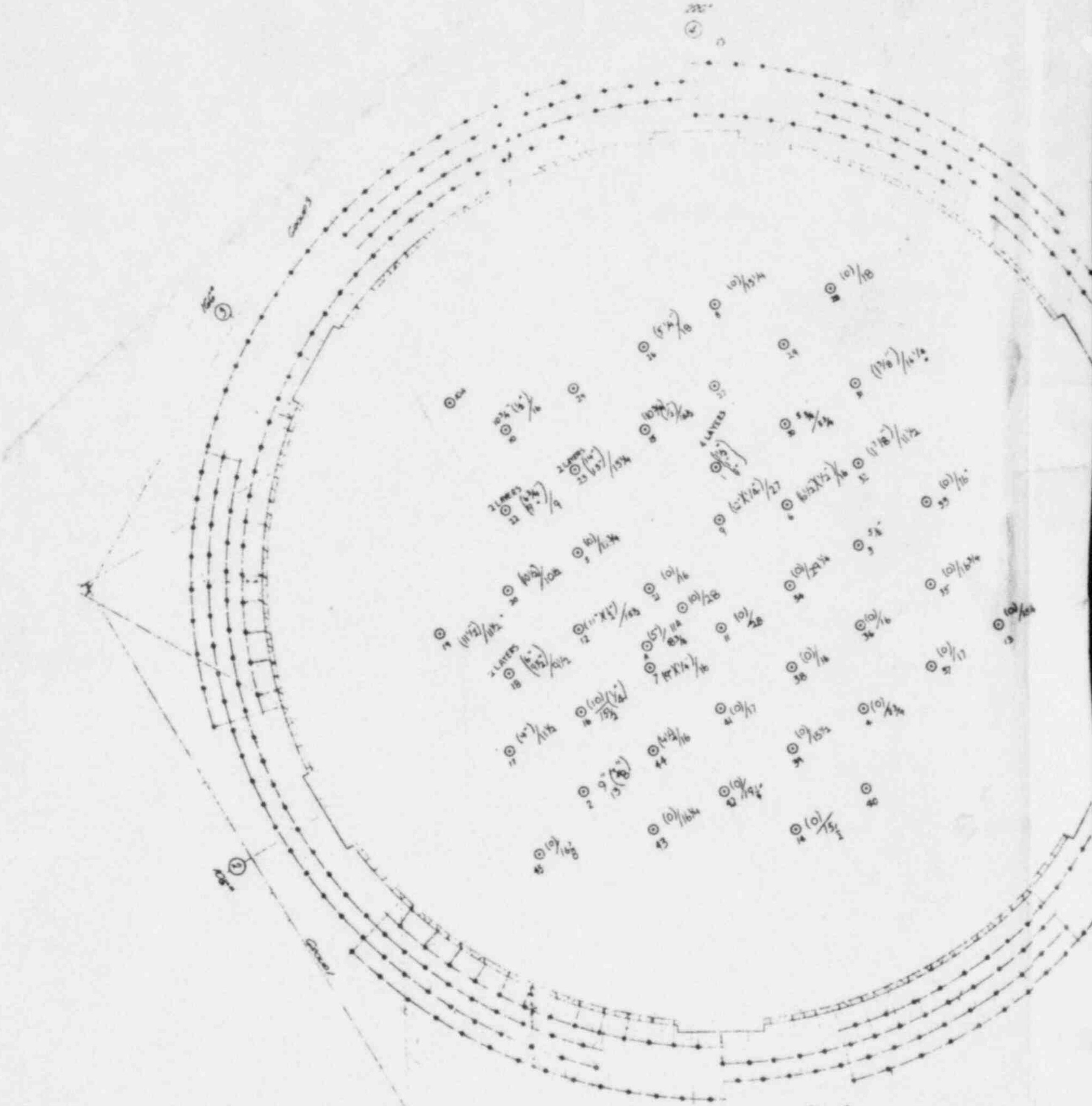
(a) The deflection of the dome has been measured by comparing the elevation of the liner plate at the time the dome liner was installed over the dome trusses, and the present elevation of the liner plate. The observed deflection is 1-5/8". The predicted deflection due to prestress of the dome alone is about 1". Allowing for the dead weight deflection of the dome and the shrinkage of the vertical cylinder, the dome deflection does not indicate any unexpected movement.

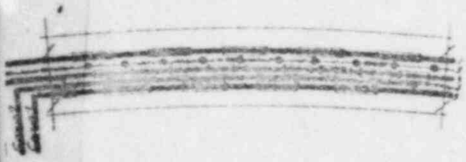
(b) Three dome tendons were relaxed to take the lift off readings. Appendix G compares the initial and the present lift off readings. The actual and predicted losses in stress are also compared. There is no indication of unexpected stress loss in the tendons.



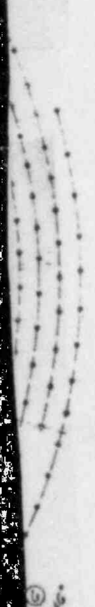
2nd Topping Lift & Cap
10/21/69 346° to 166° East Half
12/11/69 166° to 346° West Half
Outside Skyclimber Support
1st Top Lift & Skyclimber Support
(F)
(E)
9/9/69 346° to 166° East Half
9/16/69 166° to 346° West Half
(D)
8/29/69
(C)
2nd Ring Girder Lift
8/13/69 14° to 134°
8/19/69 134° to 254°
8/22/69 254° to 14°
(B)
Bottom Lift (8" Struct. Slab)
7/16/69: 346° to 166° East Half
7/18/69: 166° to 346° West Half
(A)
1st Ring Girder Lift
6/24/69 286° to 346°
6/25/69 346° to 46°
6/26/69 46° to 106°
7/2/69 226° to 286°
7/3/69 106° to 166°
7/7/69 166° to 226°
UNIT NO. 3
CONTAINMENT STRUCTURE
TURKEY POINT
JOB NO. 5610
CONCRETE PLACEMENT SEQUENCE

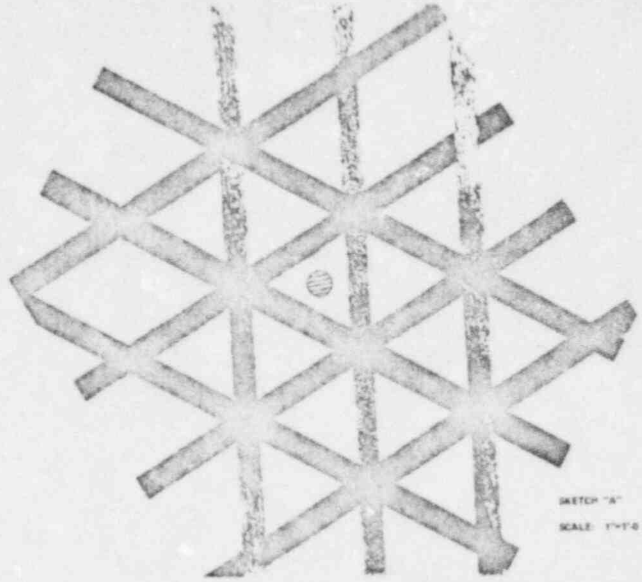
APPENDIX A


GROUP



SECTION C-C
SCALE N.T.S.





SKETCH "A"

SCALE: 1"=1'-0

FLORIDA POWER & LIGHT COMPANY
TURKEY POINT, UNITS NO. 3 & 4

UNIT NO. 3 CONTAINMENT DOME
CORING LOG

HOLE NO.	DISTANCE FROM CENTER OF DOME	AZIMUTH	DEPTH TO LAMINATION FROM DOME SURFACE	GAP	REMARKS	DEPTH OF HOLE
1	10'	238°	8-1/2"	1/8"	4 LAYERS: 1-1/2", 1/2", 1" BELOW FIRST LAYER	18"
2	36'3"	70°	9"	3/8"		13"
3						
4	30'2"	354°-30'	-	-	NO LAMINATION	11-3/4"
5	18'8"	142°			SMALL GAP ABOVE TENDON SHEETING ONE WIRE CUT	12-3/4"
6	16'10"	270°	6-1/2"	1/2"		16"
7	15'4"	83°	9"	1/4"		15"
8	39'10"	228°		-	NO LAMINATION	15-1/4"
9	8'5"	243°	12"	1/4"	GREASE PRESENT	27"
10	38'	174°	10-3/4"			16"
12	18'	109°-30'	11"	1/2"		15-1/2"
13	41'9"	322°-30'	-	-	NO LAMINATION	15-3/4"
14	37'	28°-30'	-	-	NO LAMINATION SMALL VOIDS AT 6-1/2", i.e. UNDER REBAR	15-1/2"
15	24'10"	208°	10-3/4"	1/2"		16-1/2"
16	25'	83°	10"	1/4"		15-1/2"
23	24'6"	177°	14"		TWO LAYERS: 2nd 15"	15-1/4"
10A	43'8"	170°	-		NO LAMINATION	17"
11A	5'2"	38°-15'	-		NO LAMINATION	28"
A	16'5"	294°-40'	5"			18-3/4"
29	26'4"	127°-30'	10-1/2"		GREASE PRESENT	10-1/2"
30	24'11"	254°-40'	5-3/4"		GREASE PRESENT	5-3/4"
34	12'10"	326°	-		NO LAMINATION	25-1/4"
39	23'8"	331°	-		NO LAMINATION	16"
41	21'8"	36°-30			NO LAMINATION	17"
42	31'8"	43°-45'	-		NO LAMINATION	19-1/4"
45	40'8"	77°-45'	-		NO LAMINATION	18-7/8"
39	28'4	18°-00'	-		NO LAMINATION	15-1/2"
11	9'8"	29°-30	-		NO LAMINATION	21"
17	35'10"	92°-09'	4		GREASE PRESENT	11-1/2"
18	30'11"	106°-51'	5" & 9-1/2"		GREASE PRESENT	9-1/2"
19	36'2"	121°-51'	11-1/2"		GREASE PRESENT	11-1/2"
21	8'3"	114°-06'			NO LAMINATION	18"
22	10'6"	147°-11'	8-3/4" & 9"			9"
26	38'6"	210°-38'	5-1/4"		GREASE PRESENT	17-1/2"
28	45'11"	251°-42'	-		NO LAMINATION	18"
31	34'9"	284°-40'	1-3/8"		GREASE PRESENT	14-1/4"
32	25'3"	284°-54'	1-7/8"			11-1/2"
33	33'7"	297°-08'			NO LAMINATION	18"
35	37'1"	317°-35'	-		NO LAMINATION	16-3/4"
37	35'11"	338°-19'	-		NO LAMINATION	17"
38	18'10"	359°-13'	-		NO LAMINATION	16"

NOTE: THE NUMBER SHOWN ON THE PLAN INDICATES THE BORING NO. LOCATE THE HOLES APPROXIMATELY AT THE CENTER OF THE PARALLELOGRAM FORMED BY THE TOP THREE LAYERS OF TENDONS AS SHOWN IN THE ATTACHED SKETCH "A"

KEY
(1/4") SIZE AIR GAP
(2") DEPTH TO LAMINATION
16 TOTAL DEPTH OF HOLE
⊙ HOLE NUMBER

TURKEY POINT UNIT
CONTAINMENT DOME
CORE BORING LOG

PITTSBU[illegible]GH TESTING LABOR[illegible]TORY

FORM 1243

ESTABLISHED 1881

PITTSBURGH, PA.

ORDER NO. MA-2955

LABORATORY NO. 70105

TESTS OF CEMENT

QUALITY ASSURANCE FILE

DATE 12/30/69

FOR Bechtel Corporation

PROJECT Florida Power & Light Co. - Turkey Point Units 3 and 4, Sample No. 5

BRAND FROM Sampled Turkey Point Batch Plant Hopper 11/25/69

BIN NO. CONTAINING BARRELS SPECIFICATION ASTM C-150 TYPE II

RESULTS OBTAINED

PHYSICAL TESTS

SAMPLE NO.	SOUNDNESS AUTOCLAVE EXPANSION-%	Gillmore TIME OF SETTING INITIAL HRS.-MIN.	FINAL HRS.-MIN.	Compressive STRENGTH AVE. 3 SPEC.-P.S.I. 3 Days	7 Days	28 Days	AIR CONTENT % BY VOL.	SPECIFI[C] SURFAC[E] (BLAIN[E]) SQ. CM/[G]
1	.01	2 Hrs. 5 Mins.	5 Hrs. 5 Mins.	3040	4220	6120	6.7	4114
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
SPEC. REQ.	.80Max.	60Mins. Minimum	10 Hrs. Maximum	1000Min.	1800Min.	3500Min.	12.0Max.	2600Mi[n.]

JAN 6 1970 BECHTEL CORP.

CHEMICAL ANALYSIS

SAMPLE NO.	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	Loss on Ign.	Insol. Res.	C_3A / * C_3S	Vicat Set	C[illegible]
1	22.22	4.42	2.82	1.11	2.07	1.00	.24	65.8	1 Hr. 40Mins.	6.9
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
SPEC. REQ.	21.0Min.	6.0Max.	6.0Max.	5.0Max.	2.50Max.	3.0Max.	.75Max.	58.0Max.	45 Mins. Minimum	8. Ma[x.]

APPENDIX E Sheet 2

* This limit applies when moderate heat of hydration is required.

QUALITY ASSURANCE FILE

SAS 1/12/70

JB 1/6/70

REMARKS:-

MATERIAL DOES [X] DOES NOT [ ] COMPLY WITH SPECIFICATIONS

REG/mb/3-Bechtel Corporation
mb 1-Bechtel Corporation
1-Bechtel Corporation

PITTSBURGH TESTING LABORATORY

R. E. Gardner

R. E. Gardner, Manager

PITTSBURGH TESTING LABORATORY

FORM 1243

ESTABLISHED 1881

PITTSBURGH, PA.

ORDER NO. MA-2955

LABORATORY NO. 700009

TESTS OF CEMENT

DATE 10/6/69

FOR Bechtel Corporation

PROJECT Florida Power and Light Co. - Turkey Point Unit No. 3 and #4 Sample No. 4

BRAND Florida FROM Truck - 3065 - 75626 - 10/17/69

BIN NO. CONTAINING BARRELS SPECIFICATION ASTM C-150 TYPE II

RESULTS OBTAINED

PHYSICAL TESTS

SAMPLE NO.	SOUNDNESS AUTOCLAVE EXPANSION-%	Vicat Set TIME OF SETTING XXXXX	XXXXX	Compressive STRENGTH AVE. 3 SPEC.-P.S.I. 3 Days	7 Days	28 Days	AIR CONTENT % BY VOL.	SPECIFIC SURFACE (BLAINE) SQ. CM/GM
1	.00	1 Hr., 25 Mins.		3070	4440	Due 11/25/69	7.8	3599
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
SPEC. REQ.	.80Max.	45 Mins. Minimum		1000Min.	1800Min.	3500Min.	12.0Max.	2600Min

	INITIAL	FINAL
Gillmore Setting Time	2 Hrs.	5 Hrs., 15 Mins.
Specification Requirements	60 Mins. Minimum	10 Hrs. Maximum

CHEMICAL ANALYSIS

SAMPLE NO.	Si O2	AL 2O3	Fe2 O3	Mg O	S O3	Loss on Ign.	Insol. Res.	C3 S (C_3A *)	C2 S	C3 A
1	22.36	4.19	3.01	0.62	2.09	1.19	.26	66.0		6.0
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
SPEC. REQ.	21.0Min.	6.0Max.	6.0Max.	3.00Max.	2.5Max.	3.0Max.	.75Max.	58.0Max.		8.0Max.

APPENDIX E Sheet 1

* This limit applies when moderate heat of hydration is required

QUALITY ASSURANCE SGJ 11/18/69

NOV 10 1969 BECHTEL CORP.

REMARKS:-

MATERIAL DOES [x] DOES NOT [ ] COMPLY WITH SPECIFICATIONS.

PITTSBURGH TESTING LABORATORY

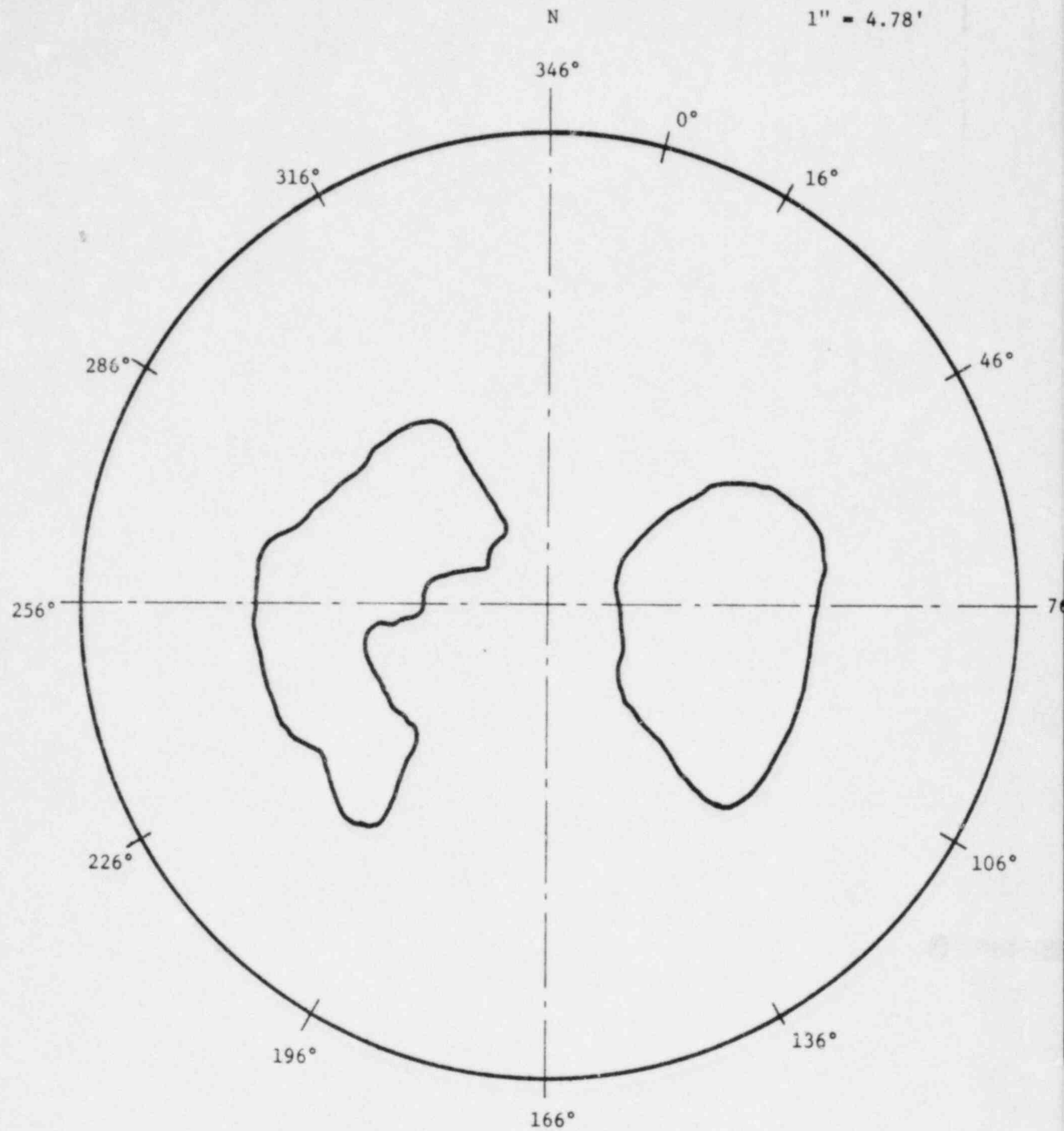
REG/mb 3-Bechtel Corporation
1-Bechtel Corporation
1-Bechtel Corporation 1-PTL, Miami
1-Florida Power & Light 1-PTL, Turkey Point

R. E. Gardner, Manager,
Cement & Concrete Department

TURKEY POINT UNITS 3 & 4

WATER AND ICE ANALYSIS

	DATE	pH	ppm $CaCO_3$ PA	ppm $CaCO_3$ MA	ppm $CaCO_3$ HARDNESS	ppm CHLORIDES	ppm TOTAL SOLIDS	TURBID	COLOR
SPECIFIED				250	250	250	500		
ACTUAL WATER	12/12/67	-	-	-	200	20	-	-	-
	3/9/68	-	0	199	-	22	306	-	-
	3/26/68	-	0	210	-	21	257	-	-
	4/21/68	7.36	0	197	-	21	309	-	-
	6/5/68	7.30	0	203	-	18	306	-	-
	8/21/68	7.43	0	143	-	15	231	-	-
	1/4/69	7.10	0	151	-	15	198	6	-
	2/14/69	7.09	0	160	200	18	243	6	-
	6/18/69	7.19	0	204	250	18	296	3	-
	10/2/69	7.24	0	183	235	19	294	0	-
	6/29/70			207	254	19	339		
ICE	3/25/68	-	0	142	-	21	380	-	-
	4/21/68	7.34	-	9	-	1	12	-	-
	6/6/68	7.20	-	37	-	17	108	-	-
	8/21/68	7.75	0	13	-	5	27	-	-
	1/4/69	7.38	0	8	-	2	13	-	-
	2/14/69	7.90	0	15	-	8	22	1	-
	9/16/70				-	5		6	-



SEPARATION AREA
DEFINED BY HAMMER TEST

APPENDIX C

TURKEY POINT UNITS 3 & 4

COMPARISON OF TENSILE SPLIT TEST RESULTS

	TENSILE		COMPRESSIVE	
	psi	Age	psi	Age
TURKEY POINT				
6" x 12" cylinders	473	73 days	7060	90 days
	390	20 days	5990	28 days
	359	28 days	5820	28 days
2.2" Dia. cores from shipped concrete	651		6810	Dry Cores
	718		6710	Dry Cores
	561		6270	Water Cured
			5570	Water Cured
			5840	Water Cured
OCCONEE				
6" x 12" cylinders	580	29 days	5838	28 days
	563		6013	28 days
			STRAIN	
6" x 12" cylinders (Direct Tensile)	347	(tested 9-21-70)	24.5×10^{-6}	
	345	(tested 9-21-70)	70.5×10^{-6}	
POINT BEACH				
6" x 12" cylinders	585,615	28 days		
	560,620	28 days		
	515,595	28 days		
			COMPRESSIVE	
	800	150 days	9730 psi	28 days
	730	170 days	8420 psi	28 days
	630	170 days	8130 psi	28 days

APPENDIX F

TENDON LIST OFF READINGS

COMPARISON OF ACTUAL V/S PREDICTED

All values are in terms of jack pressure, psi. to obtain tendon force in kips, multiply by 0.1202

TENDON NO.	INITIAL STRESSING				DESTRESSING							AVERAGE STRESS LOSS %	
	DATE	LIFT OFF READING			DATE	LIFT OFF READING							
		END-1	END-2	AVERAGE		END-1		END-2		AVERAGE BOTH ENDS			
						ACTUAL	CALCU-LATED	ACTUAL	CALCU-LATED	ACTUAL	CALCU-LATED	ACTUAL	CALCU-LATED
1D30	6-1-70	6800	6500	6650	10-1-70	5800	5630	5900	5320	5850	5475	12%	17.7%
2D37	6-15-70	6500	6300	6400	10-1-70	5700	5320	5900	5140	5800	5230	9.4%	18.2%
3D21	6-10-70	6450	6350	6400	10-1-70	5800	5260	5700	5420	5750	5340	10.1%	16.6%

NOTES: Assumptions for stress loss are as in FSAR Section 5.1.4.