QUAD CITIES STATION

SPECIAL REPORT NO. 5

TORUS RING HEADER SUPPORT FAILURE

OCTOBER 26, 1972

COMMONWEALTH EDISON COMPANY

INDEX

1.0 INTRODUCTION

During startup testing of relief valves for Quad-Cities Unit 2 on Sunday, May 28, 1972, it was discovered that four pipe hangers for the 24-inch torus suction header had failed. The reactor was promptly shut down for investigation and repair of the failed hangers.

The 24-inch suction header encircles the torus and provides a manifold for the suction of the various ECCS pumps. The header is connected to the torus by four 20-inch OD pipes spaced 90 degrees apart and is supported by twelve hangers which are connected to the torus shell. Three of the four failed hangers were located within a 90 degree segment between two of the 20-inch connecting pipes resulting in a maximum sag in the header pipe of approximately 5-3/4 inches within that segment. The pipe hangers consist of double strap horizontal and vertical members connected to gussets which are welded to the torus shell and the 24-inch pipe. Failure consisted of shearing the bolts that were used to connect the vertical straps to the gusset. Investigation revealed no other damage or evidence of excessive stress at the torus shell, the 24-inch header pipe, the 20-inch connecting pipes, or the welded connections.

2.0 DESCRIPTION OF RING HEADER AND SUPPORT SYSTEM

2.1 Ring Header

The Quad-Cities Unit 2 containment vessel consists of a light bulb shaped drywell and concentric torus shaped suppression chamber. The suppression chamber is filled with water to approximately mid-depth and a pump suction header (ring header) is attached to the outside of the torus. This header is a 24-inch OD pipe and is connected to the torus by short lengths of 20-inch OD pipe. In addition to the four 20-inch header inlet nozzles, there are six outlet nozzles which are used to withdraw water from the header for the Residual Heat Removal System, Core Spray System, High Pressure Coolant Injection System, and Reactor Core Isolation Cooling System. The header is shown on Chicago Bridge and Iron Company (CBI) drawing No. 216, Rev. 5 and No. 217, Rev. 5.

2.2 Header Support System

The 24-inch ring header (suction header) is supported by the four 20-inch pipe connections and twelve hanger assemblies. The hanger assemblies have horizontal and vertical members attached to gussets on the torus shell and the 24-inch header. Details of the assemblies are shown on CBI drawing No. 218, Rev. 1. The gussets consist of 1/2" thick plate welded to 1" thick pad plate which is then welded to the torus shell and a 1/2" thick collar type plate welded to the 24" pipe.

The torus diameter is very large resulting in a radius to thickness (R/t) ratio that is very large (300). The R/t ratio is a measure of the flexibility of t e shell and its ability to withstand concentrated loads. The pad plate is used at the torus shell attachment in order to spread the applied load over sufficient area to minimize stresses and deformations. The smaller diameter pipe is stiff enough (R/T ratio of 30) to resist the applied load by transfer through the yoke-type collar.

The horizontal and vertical double hanger straps originally installed were 2 1/2" wide by 1/2" thick with a 13/16" diameter hole at each end for attachment to the gussets with 3/4" diameter A307 bolts.

Table 2-1 defines the ring header supports, inlet nozzles and outlet nozzles along with their approximate orientation.

TABLE 2-1

QUAD CITIES UNIT NO. 2

HANGER AND NOZZLE ORIENTATION

Header Support Number	Approx. Orientation	Header Nozzle Number	Nozzle Descrip.	Approx. Orientation
1	67°30'	X-204A	Inlet	4[illegible]
2	90°	X-204B	Inlet	135°
3	112°30'	X-204C	Inlet	225°
4	157°30'	X-204D	Inlet	315°
5	180°	X-223A	RHR	157°30'
6	202°30'	X-223B	RHR	202°30'
7	247°30'	X-224A	Core Spray	22°30'
8	270°	X-224B	Core Spray	337°30'
9	292°30'	X-225	HPCI	337°30'
10	337°30'	X-226	RCIC	292°30'
11	0°			
12	22°30'			

2.3 Method of Fabrication and Assembly

As discussed in part 2.1 and 2.2 the ring header and hanger assemblies are shown on CBI drawing Nos. 216, 217, and 218 for CBI Contract 9-6771. The hanger clip assemblies (218-A and 218-B) were welded to the torus shell prior to the shell being assembled in the basement of the reactor building. With the torus assembled in the basement the shop built header sub-assemblies 216-B were attached to the torus penetration at the

field weld joints (see Dwg. 216, Section E-E for field weld location). With these four subassemblies welded in place, the remaining segments of the header were welded together utilizing temporary supports for positioning. The completion of the entire header welding was followed by the attachment of the collar type gussets (pc. 5 on Dwg. 218) to the 24" pipe header.

Because of the allowable fabrication tolerances on both the major and minor diameters of the torus as well as the ring header and the positioning of the header, the attachment of the horizontal and vertical hanger straps could not be completed with the as-built straps. The alignment of the horizontal and vertical straps required some adjustments and strap modifications. At some locations it was necessary to decrease the length of the vertical straps by 2" to 2 1/2". Some horizontal strap lengths were changed by amounts in excess of 2". The modifications required to complete the alignment and assembly of the pipe hanger straps consisted of some torch cutting of bolt holes in the collar gussets and hanger straps as well as torch cutting the straps length to suit each installation. The original holes were punched.

The hanger straps were connected to the gussets with 3/4", 10UNC cap screws (bolts threaded full length). Due to the torch cutting of some of the holes in the vertical straps, there was some misalignment of the bolts and uneven distribution of the load. This was evident from the installed bolts not being perpendicular to the straps.

2.4 Header Support Design

The hanger support assemblies were originally designed for the static dead load of the 24" header plus horizontal and vertical seismic loads. The operating bases earthquake horizontal ground acceleration is .12g. The containment torus analysis in the FSAR (12.2.2.5) used a resulting horizontal coefficient of .40g

combined with the vertical acceleration of .08g acting simultaneously. The original design was based on a computed maximum hanger load of approximately 8,000 lbs. with the load being approximately equal for all hangers.

3.0 DESCRIPTION OF BOLT FAILURE

3.1 Fabrication and/or Assembly Deficiencies

It can be seen from Section 2.3 that the methods used to correct the misalignment problems encountered during assembly were less than desirab'e. Burning holes for bolts, regardless of the craftsman, results in a nonun..orm bearing surface for the bolts. In addition, the holes that were punched appeared to have some slight coning which is common for punching operations. This slight coning effect causes the bolt to be sι.essed at one edge sooner than at the adjacent edges.

Although the contract drawings did not call for bolts with a clean shank, the original stress analysis was based on an unthreaded shank, 3/4" diameter bolt. The effective cross-sectional area o: an unthreaded 3/4" bolt shank is .4418 square inches versus .302 square inches for the threaded shank. This would have increased the calculated failure load in double shear from 27,180 lbs. to 39,760 lbs. for the bolted connections. The use of 3/4" diameter bolts with an unthreaded shank would therefore have been desirable.

Since the original hanger system did not have provisions for adjustments, the exact distribution of loads on the support system were different from the theoretically calculated loading. To assist in determining the reason for the bolt failure and its location, the loading on each vertical hanger in the original installation was determined. The measurements were made by reconnecting the original straps and then applying a force with a hydraulic jack to each hanger point until the bolt in the connection was loose indicating that the jack was carrying all of the load. The weight in pounds was determined from the pressure of the hydraulic fluid in the jack. The measured loads are shown in Table 3-1.

TABLE 3-1

QUAD CITIES UNIT NO. 2

ORIGINAL SUPPORT SYSTEM HANGER LOADS *

SUPPORT NO.	LOAD	SUPPORT NO.	LOAD
1	5.4^k	7	3.6^k
2	13.2^k	8	7.6^k
3	9.4^k	9	12.0^k
4	13.0^k	10	22.3^k
5	0.7^k	11	0.7^k
7	11.6^k	12	13.2^k

*Loads are as measured after replacement bolts had been installed but before any strap lengths were changed. See Appendices, Section 8.2.

It is obvious that the distribution of load is not uniform in that support No. 10 is carrying a load of 22,300 lbs., whereas support Nos. 5 and 11 were only carrying 700 lb. This inequity in load distribution indicates that some more precise method of hanging the ring header should have been used. It also indicates that a static load of at least 22,300 lb. could be accomodated without failure on a 3/4" 10UNC bolt threaded its full length.

3.2 Design Deficiencies

Computing an average of the loads shown in Table 3-1 results in a value of approximately 9,400 lbs. per hanger. The original maximum computed load to which the hangers were designed is approximately 8,000 lbs. The inequities in the load distribution shown in Table 3-1 and the average load per hanger indicate that

the method used in designing the hanger assemblies was inadequate from a purely static condition approach. The wide range of load distribution indicates that the hanger design perhaps should have called for some method of adjustment to make up for the differences in the dimensions that result from allowances for fabrication of the torus and the 24" pipe header. The average load per hanger of 9,400 lbs. (average of measured loads) vs the 8,000 lb. used for the original design, indicates that not all loads were accounted for in the original analysis.

The measured static load at hanger No. 10 was significantly greater than that measured at any of the other hangers. This would indicate that some dynamic effect from the testing that had been performed, contributed the force necessary to shear the bolts in failed hangers 1, 2, 3, and 12, but did not add enough to shear the bolts in hanger No. 10. This dynamic effect was not identified and thus not included in the loading used for the original hanger design.

3.3 Method of Failure and Location

The testing of relief valves (Startup Test No. 26) was being performed when the first indication of failure was noted. Relief valves A then B had been tested when a 3/4" bolt was found beneath hanger No. 12 which is at the point in the torus where A discharges. A temporary replacement bolt was installed and testing proceeded with relief valves C,D, and E. After the

testing was completed, failed bolts were found beneath hangers No. 1, 2, and 3. In each case, it was a bolt in the vertical hanger straps that was sheared. The relative positions of the hangers, the ring header conn-ctions, and the discharge points of the relief valves in the torus are tabulated in Table 3-2. Also shown on the table is the approximate as-built static loading on each hanger from Table 3-1.

TABLE 3-2

QUAD CITIES UNIT NO.2

HANGER, NOZZLE AND RELIEF DISCHARGE ORIENTATION

Approx. Orientation	Header Connection	Relief Discharge	Header Support	Dead Load on Support (lb)
0			11	700
22°30'	Core Spray	A	12	13,200
45°	Inlet			
67°30'		B	1	5,400
90°			2	13,200
112°30'		C	3	9,400
135°	Inlet			
157°30'	RHR		4	13,000
180°			5	700
202°30'	RHR		6	11,600
225°	Inlet			
247°30'		D	7	3,600
270°			8	7,600
292°30'	RCIC	E	9	12,000
315°	Inlet			
337°30'	Core Spray & HPCI		10	22,300

From Table 3-2 it can be seen that hangers 1, 2, and 3 are located within a 90° segment between two 20" inlet pipes which connect the ring header to the torus. With these hangers failed, the span between the inlet pipes was unsupported and dropped 5-3/4" at the lowest point. Non-destructive tests were performed on four critical welds on the torus shell and the ring header to check for damage. No evidence of irregularities (discontinuities) were shown in these dye penetrant non-destructive tests. See Appendix 8.3 for examination report. A stress analysis of the header and torus shell penetrations was performed based on the deflection of 5-3/4" in the header and no stresses were calculated to be in excess of the minimum yield strength of the materials.

As previously stated, the estimated load required for double shear failure of the original bolts is 27,180 lbs. This is based on failure at 3/4 of the ultimate strength of A307 steel and an effective cross-sectional area of .302 square inches for the bolt. This is not to say that the bolts in the hangers all failed in double shear. As discussed in Section 3.1, there were some hangers in which bolt holes were burned and which had pairs of straps with different effective lengths. As a result of these fabrication deficiencies, the load at which the bolts could have failed can not be determined. It is estimated, however, that at least a load of 18,120 lbs. and up to a maximum of 27,180 lbs. would be required.

The dynamic effect of the relief valve discharging into the torus adjacent to a pipe hanger adds significant loads to the hanger. It is postulated that the effect is due to a pressure wave imposed on the torus shell by the expansion of the free air in the relief discharge line upon initiation of relief valve operation. In order to verify the dynamic effect and to determine the adequacy of proposed repairs/modifications, a test was conducted in which measurements were taken (during relief valve operation), of relative motion of the torus shell and the ring header in the area of a header support. These measurements were used to determine maximum hanger loads. Two approaches were used in analyzing the loading. The first approach (Header Analysis) was subjecting a model of the header system to the observed vibrations at instrumented points on the header.

The second approach (Torus Analysis) uses the measured displacements in the torus shell, and a calculated stiffness term to determine hanger load. The maximum vertical hanger load was calculated to occur during the operation of the single relief that discharges in the area of the hanger, Test E_1. The maximum horizontal hanger load was calculated to occur during the simultaneous operation of all relief valves, Test R. The maximum values for the loads which were calculated from the measured displacements observed during the testing are tabulated in Table 3-3.

TABLE 3-3

QUAD CITIES UNIT NO. 2
MAXIMUM DYNAMIC HANGER LOADS
DUE TO RELIEF LINE DISCHARGE

	Test E_1		Test R	
	Header Analysis	Torus Analysis	Header Analysis	Torus Analysis
Vertical Load	11,600	17,700	12,300	13,900
Horizontal Load	3,600	0	13,600	0

The addition of from 11,600 to 17,700 lb. to the dead weight load of 13,200 lb. on the No. 12 hanger was sufficient to exceed the 18,120 - 27,180 lb. failure load for the bolt. The failure load for a clean shank bolt of the same material is 26,500 - 39,760 lb. It is therefore theoretically possible that hanger failure would have occurred even if a clean shank bolt had been used.

During the testing of relief B or C, there was enough effect on hanger No. 2 that it failed resulting in its load being distributed between hanger Nos. 1 and 3. This additional load resulted in failure of these hangers. The hangers adjacent to the discharge of valves D and E did not fail and the reason for this can be attributed to the possibility that the fabrication technique was better on these hangers and that the dynamic load on the hanger used for analysis is computed conservatively.

4.0 CORRECTIVE ACTION

The following corrective action was taken to correct the header support deficiencies:

1. The bolt holes were drilled out to 1 1/16" diameter for 1" bolts
2. All horizontal and vertical hanger straps were replaced with 1/2" thick by 3" wide, 36,000 psi yield material with 1 1/16" diameter bolt holes. The approximate failure load for these straps (in pairs) is 54,375 lbs.
3. New 1" diameter A325 high strength bolts with 1 1/2" unthreaded length were installed with positive locking techniques included. The approximate double shear failure load for these 1" bolts is 70,686 lbs.
4. The lengths of the replacement straps were adjusted to provide a uniform distribution of loads between the hangers.

5.0 EVALUATION

5.1 Static Loading

As part of the bolt and hanger strap replacement, a hydraulic jack with dial pressure gauge was used to measure the actual loads at each support point. The jack was raised enough to pick up the header load at each point. After the loads were reviewed, some modification in the strap lengths effected a change in the load distribution pattern of the entire system. The modifying of strap lengths resulted in the static dead load distribution shown in Table 5-1.

TABLE 5-1*

QUAD CITIES UNIT NO. 2

FINAL SUPPORT SYSTEM HANGER LOADS

Support No.	Load	Support No.	Load
1	7,800	7	6,700
2	10,300	8	7,600
3	9,400	9	7,800
4	7,400	10	7,200
5	8,300	11	8,500
6	7,200	12	8,900

*See Appendix, Section 8.2.

In order to analyze for the dead load and reaction load system, a beam finite element computer program was utilized. This program calculates the loads at each hanger and each nozzle when subjected to the header dead load plus header outlet reaction loads. These calculated loads for the hangers are shown in Table 5-2.

TABLE 5-2

QUAD CITIES UNIT NO. 2

CALCULATED STATIC LOADS AT EACH HANGER FOR DEAD LOADS PLUS OUTLET NOZZLE REACTION LOADS

SUPPORT NO.	CALCULATED LOAD	SUPPORT NO.	CALCULATED LOAD
1	6,900	7	7,000
2	7,100	8	7,200
3	7,200	9	7,400
4	10,400	10	10,400
5	9,700	11	3,700
6	11,300	12	13,000
X-204A	7,200	X-204C	6,100
X-204B	6,400	X-204D	7,400

This table shows that the calculated loads for a balanced system would not necessarily result in uniformly loaded hanger straps.

5.2 Dynamic Loading

In order to analyze the header support system for the maximum postulated load on the vertical hanger, it is necessary to combine the static dead load with the seismic load as well as the maximum relief line discharge load. Utilizing .08g vertical and .40g horizontal accelerations due to the operating basis earthquake (FSAR Section 12.2.2.5) and average dead load on the hangers, the equivalent maximum vertical load is about 600 lb. and the equivalent maximum horizontal load is about 3000 lb. For the loading due to relief valve discharge, the maximum vertical hanger load is chosen to be that determined using the Torus Analysis method, Test E, and for additional conservatism is rounded up to 18,000 lbs.

(see Table 3-3). The maximum horizontal hanger loading from relief valve discharge is taken from the Header Analysis method with a value of 13,600 lbs.

When the horizontal loads are combined, it can be seen that they are small compared to the vertical hanger loads due to the contribution of the static dead load in the vertical direction. Thus, the analysis at the hanger components to determine adequacy is performed using the largest vertical load as determined from the summation of all loads. See Table 5-3 for a tabulation of the total vertical loads. The maximum horizontal load would be 16,600 lb. and the maximum vertical load is 31,600 lb. The failure load is approximately 54,375 lbs. with the failure point being at the strap bolt holes.

TABLE 5-3

QUAD CITIES UNIT NO. 2

MAXIMUM VERTICAL HANGER LOADS

	OBE SEISMIC + STATIC + RELIEF LINE DISCHARGE	
SUPPORT NO.	Load Based on Calc. Static Loads	Load Based on Measured Static Loads
1	25,500	26,400
2	25,700	28,900
3	25,800	27,000
4	29,000	26,000
5	28,300	26,900
6	29,900	25,900
7	25,600	25,300
8	25,800	26,200
9	26,000	26,400
10	29,000	25,900
11	22,300	27,100
12	31,600	27,500

The maximum calculated load is located at hanger no. 12 and is 31,600 lb. This load is an upper bound load, and it is very unlikely that it could occur.

5.3 Calculated Stresses

The stresses in the bolts and hangers from the maximum vertical and horizontal loads is shown in Table 5-4. Also shown in the table are allowable stress levels adjacent to the applicable tabulated value.

TABLE 5-4

STRESSES IN BOLTS AND HANGERS-FINAL HANGER SYSTEM

	Vertical Support		Horizontal Support		AISC Allow. Stress	Approx. Failure Stress
	DL[1]+OBE+ Test E	DL[2]+OBE+ Test E	Test E + OBE	Test R + OBE		
Load (k)	28.9	31.6	6.6	16.6	--	--
Bolt Stress 1" ϕ A325 A = .7854 (ksi)	18.35	20.0	4.2	10.5	22	90
Strap Stress at pinhole 3 x 1/2 (ksi)	14.9	16.0	3.4	8.6	21.5[4]	58
Strap Stress Bearing 1-1/16 ϕ hole (ksi)	28.9	31.6	6.6	16.6	68.2[3]	--
Gusset Stress Bearing 1-1/16 ϕ hole (ksi)	57.8	62.3	13.2	33.2	68.2[3]	--

[1] Measured dead load (see Table 5-1)

[2] Calculated dead load (see Table 5-2)

[3] Based on AISC allowable bearing stress of 1.35 F_y multiplied by 1.33 as allowed in AISC paragraph 1.5.6, and using minimum allowable yield of 38,000 psi.

[4] Based on AISC allowable stress in tension of .45 F_y multiplied by 1.33 as allowed in AISC paragraph 1.5.6 and using a minimum allowable yield of 36,000 psi.

Although the tests showed that the maximum horizontal and maximum vertical hanger loads did not occur under the same conditions, for conservatism the maximum horizontal and vertical hanger loads were assumed to occur simultaneously and the stresses in the torus shell were computed at the point where the hanger support is attached. Figure 5-1 defines the points in question and Table 5-5 lists the stresses at these points.

TABLE 5-5

QUAD CITIES UNIT NO. 2

STRESSES IN TORUS AT HANGER CONNECTIONS

Point	Stress, psi	Point	Stress, psi
K	8,600	P	5,800
L	8,600	R	5,800
M	7,900	S	8,300
N	9,900	T	5,200

The stress at the midpoint between the hanger pads (point V of Figure 5-1) is 8,600 psi. These stresses are all well below the allowable membrane stress for the torus material (SA-515, Gr. 70) of 17,500 psi. Minimum yield stress is 38,000 psi.

Using the displacement measurements taken at the header to torus nozzle during relief testing, the static dead load, and seismic loads, stresses were computed at points around the nozzle to torus junction. The static dead load could not be measured, therefore the computed loading on the nozzles from Table 5-2 are used. These stresses are tabulated in Table 5-6. Figure 5-1 defines the points at which stresses were calculated.

TABLE 5-6

QUAD CITIES UNIT NO. 2
STRESSES IN TORUS NOZZLE CONNECTION

Point	Stress, psi	Point	Stress, psi
A	6,400	A_1	7,700
B	5,200	B_1	8,700
C	2,300	C_1	4,500
D	2,700	D_1	6,900

Stress was calculated in the nozzle at point F figure 5-1, and the result is 700 psi. These stresses are also less than the 17,500 psi allowable membrane stress for the material (A516 Gr. 70). Minimum yield stress is 38,000 psi.

According the operator's log book, the maximum deflection occurred in the ring header at hanger number 2 (with the hangers failed) and was estimated and recorded as 5-3/4 inches. Using this deflection the stresses in the 20" diameter Torus to Header pipes adjacent to the unsupported section of ring header were computed. Stresses were also computed at locations in the unsupported header. These stresses are tabulated in Table 5-7. All stresses were less than the minimum yield strength of 38,000 psi for the material.

TABLE 5-7

QUAD CITIES UNIT NO. 2

STRESSES IN HEADER, TORUS AND NOZZLES IN THE FAILED CONDITION

Stress Summary - Hangers 1, 2, 3 and 12 disconnected
Maximum observed deflection from operator's log book = 5 3/4"

Location	Point	Membrane Stress psi	Point	Membrane Stress psi
Nozzle X-204B	A	21.200	A1	24,100
Nozzle X-204B	B	32,900	B1	35,200
Nozzle X-204B	C	4,800	C1	3,300
Nozzle X-204B	D	10,300	D1	13,800
Nozzle Neck X-204B	F	23,800		
Header at X-204B	G	29,200		
Header at centerline	H	16,100		

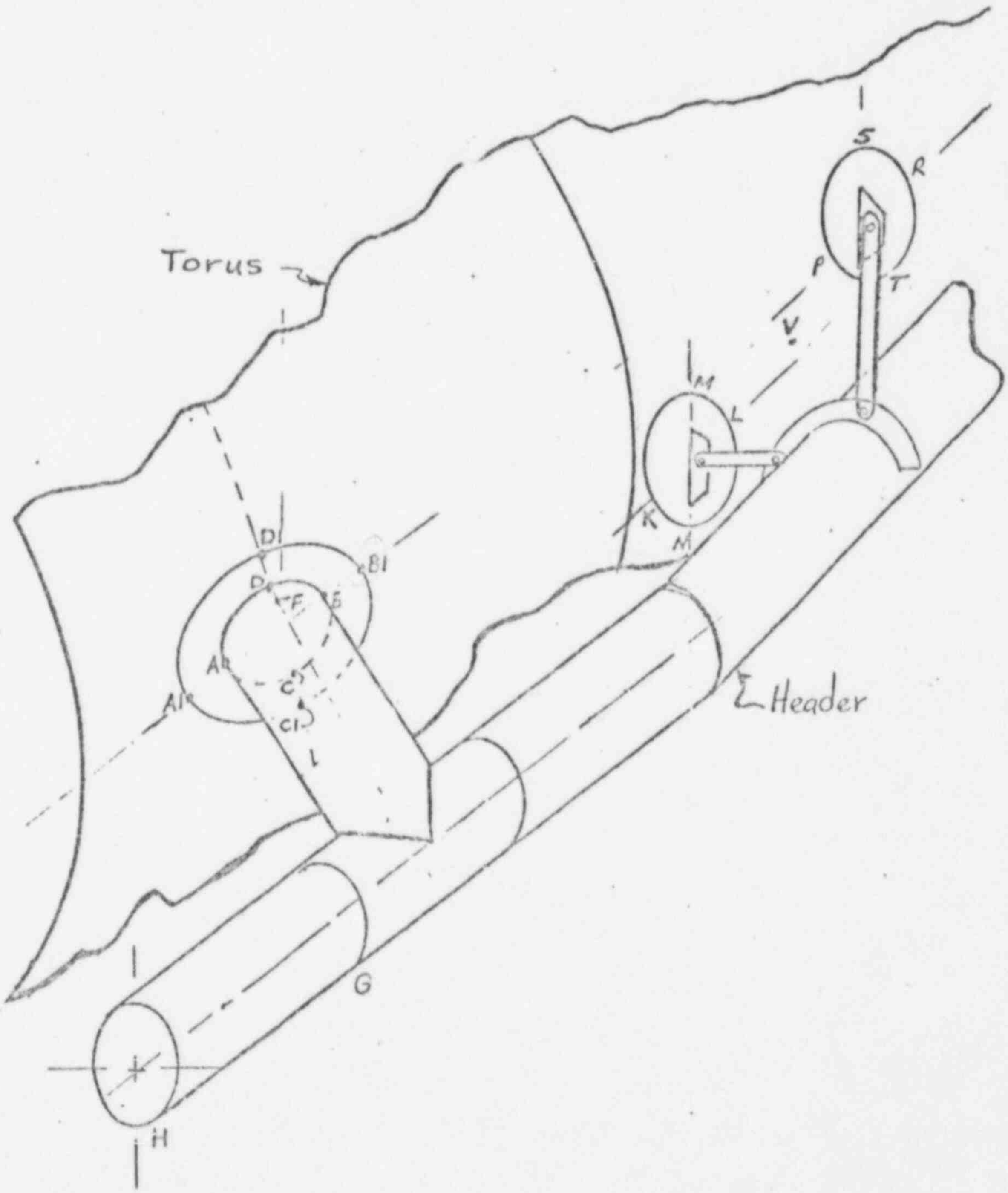


FIGURE 5-1

6.0 CONCLUSIONS

The test program verifies that the relief line discharge sequence introduces substantial loads into the torus and header systems. The combination of the relief line load, the torch cut holes and the poor initial installation load distribution resulted in the failure of hangers 1, 2, 3, and 12. The calculations performed using the results obtained from the test program indicated that stresses were imposed which could have resulted in bolt failure even with drilled holes, although failure probably would not have resulted in all four supports.

It has been shown that there was no evidence of excessive stressing of the torus shell or the ring header as a result of the hanger failures by non-destructive testing. Stresses computed with the system in the failed condition were below allowable limits.

The revised support system has been shown to be adequate for maximum postulated hanger loads of 31,600 lbs. The approximate failure load has been determined to be 54,375 lbs. with the failure point being the pin holes in the hanger straps. These postulated loads are based on maximum relative displacement data taken during relief valve testing as well as design seimsic and static loading. The postulated loads were taken conservatively high for the purpose of evaluating the revised support system. The ring header to torus nozzles were also evaluated using a method similar to that used for the

hangers. Stresses computed for each area all were below allowable limits. All stresses were calculated using methods acceptable to and defined in Section III, Subsection B of the ASME Code, 1965 Edition. This is the applicable edition of the ASME Code defined by the original contract.

7.0 UNIT NO. 1 CORRECTIVE ACTION

When the deficiencies were uncovered due to the hanger failures at Unit No. 2, the hangers were checked at Unit No. 1. Similar conditions that were discovered at Unit No. 2 were also present at Unit 1. The original hanger loadings were checked using the same method described for Unit No. 2 and are tabulated in Table 7-1.

TABLE 7-1

QUAD CITIES UNIT NO. 1

ORIGINAL SUPPORT SYSTEM HANGER LOADS

Support No.	Load	Support No.	Load
1	4,000	7	15,200
2	2,700	8	4,700
3	0,000	9	8,800
4	14,500	10	10,800
5	6,300	11	9,700
6	7,900	12	16,800

Because of the conditions found at Unit Number 1, the same corrective actions were taken as stated in Section 4.0. The hanger loadings were then remeasured and the results are tabulated in Table 7-2.

TABLE 7-2

QUAD CITIES UNIT NO. 1
FINAL SUPPORT SYSTEM HANGER LOADS

Support No.	Load	Support No.	Load
1	2,600	7	8,000
2	7,600	8	5,100
3	7,100	9	7,600
4	7,600	10	7,600
5	5,800	11	6,300
6	6,700	12	7,400

A comparison of the loadings on Unit Number 1 was made with those of Unit Number 2. On the average, the hanger loadings (dead load) are lower for Unit 1, therefore the stresses associated with the support members and attachment points would be lower than those computed for Unit 2. The dead load on the four connecting nozzles is higher on Unit 1; however, the increase in the calculated stresses in the nozzle from this dead load is small and the total is still safely below the allowable limits.

8.0 APPENDICES

8.1 Unit No. 1 Hanger Loads

Sargent & Lundy
140 South Dearborn
Chicago, Illinois

Attention G. Hoveke

Chicago Bridge & Iron Co.
1819 John F. Kennedy Blvd.
Philadelphia, Pa.

Attention T. Ahl

General Electric Company
175 Curtner Avenue
San Jose, California

Attention D. K. Willett

General Electric Company
Quad-City Nuclear Power Station
Cordova, Illinois

Attention R. Leasburg

ON 6/7/72 THE UNIT 1 24" TORUS SUCTION HEADER HANGER LOADINGS WERE MEASURED. THIS WAS ACCOMPLISHED BY USE OF A HYDRAULIC JACK WITH KNOWN EFFECTIVE PLUNGER CROSS SECTIONAL AREA MULTIPLIED BY CALIBRATED PRESSURE GAUGE READINGS. SUFFICIENT JACKING FORCE WAS APPLIED TO PERMIT TURNING THE LOWER HANGER BOLT BY HAND. AT THE TIME OF MEASUREMENTS THE ORIGINAL 3/4" DIAMETER BOLTS WERE STILL IN PLACE EXCEPT AT POINTS 1 AND 2 WHICH HAD BEEN CHANGED TO 1" BOLTS. HANGER NUMBER 10 WAS ASSIGNED PLANT NORTH, WITH NUMBERS DECREASING IN A CLOCKWISE DIRECTION. THE FOLLOWING HANGER LOADS WERE OBSERVED AS COMPARED WITH 8000 POUNDS INDICATED BY CB&I DESIGN.

1.	4,000	7.	15,200
2.	2,700	8.	4,700
3.	0,000	9.	8,800
4.	14,500	10.	10,800
5.	6,300	11.	9,700
6.	7,900	12.	16,800

G. E. Gray
Project Superintendent
United Engineers & Constructors Inc

CHICAGO BRIDGE AND IRON CO.
ATTENTION T. AHL
901 W. 22nd Street
Oakbrook, Illinois 60521

ON 6-12-72 THE UNIT NUMBER ONE SUCTION HEADER HANGER LOADINGS WERE MEASURED AFTER ADJUSTING REVISED HANGER SYSTEM TO IMPROVE LOAD DISTRIBUTION IN ACCORDANCE WITH GENERAL INSTRUCTIONS GIVEN BY T. AHL, CHICAGO BRIDGE AND IRON CO. HANGER NUMBER 10 WAS ASSIGNED PLANT NORTH WITH NUMBERS DECREASING IN A CLOCKWISE DIRECTION. THE FOLLOWING HANGER LOADS WERE OBSERVED.

1.	2,600	7.	8,000
2.	7,600	8.	5,100
3.	7,100	9.	7,600
4.	7,600	10.	7,600
5.	5,800	11.	6,300
6.	6,700	12.	7,400

G. E. Gray
Project Superintendent
United Engineers & Construc

cc: Sargent & Lundy, G. Hoveke

General Electric Co., D. K. Willett
R. Leasburg
L. A. Hartley

UE&C, J. R. Dmytryk

8.2 Unit No. 2 Hanger Loads

CHICAGO BRIDGE AND IRON CO.
ATTENTION T. AHL
901 W. 22nd Street
Oakbrook, Illinois 60521

ON 6-11-72 THE UNIT TWO 24" TORUS SUCTION HEADER HANGER LOADINGS WERE MEASURED. THIS WAS ACCOMPLISHED BY USE OF HYDRAULIC JACK WITH KNOWN EFFECTIVE PLUNGER CROSS SECTION AREA MULTIPLIED BY CALIBRATED PRESSURE GUAGE READINGS. SUFFICIENT JACKING FORCE WAS APPLIED TO PERMIT TURNING THE LOWER HANGER BOLT BY HAND. THE REVISED HANGER SYSTEM CONSISTING OF M-1020 MQ THREE INCH WIDE STRAPS WITH A325 HIGH STRENGTH BOLTS WAS IN PLACE WITH HANGERS INSTALLED TO RE-SUPPORT THE HEADER IN THE ORIGINAL POSITION. THIS IS THE FIRST SET OF LOAD READINGS TAKEN FOR UNIT #2. HANGER NUMBER 2 WAS ASSIGNED PLANT NORTH WITH NUMBERS INCREASING IN A CLOCKWISE DIRECTION. THE FOLLOWING HANGER LOADS WERE OBSERVED.

1.	5,400 ✓	7.	3,600
2.	13,200 ✓	8.	7,600
3.	9,400 ✓	9.	12,000
4.	13,000	10.	22,300
5.	700	11.	700
6.	11,600	12.	13,200 ✓

cc: Sargent & Lundy, G. Hoveke

General Electric Co., D. K. Willett
R. Leasburg
L. A. Hartley

UE&C Inc. J. R. Dmytryk

G. E. Gray
Project Superintendent
United Engineers & Constr

CHICAGO BRIDGE AND IRON CO.
ATTENTION T. AHL
901 W. 22nd Street
Oakbrook, Illinois 60521

ON 6/17/72 THE UNIT NUMBER TWO TORUS SUCTION HEADER HANGER LOADINGS WERE MEASURED AFTER ADJUSTING REVISED HANGER SYSTEM TO IMPROVE LOAD DISTRIBUTION. HANGER ADJUSTMENT WAS ACCOMPLISHED BY REFABRICATION OF HANGER STRAPS IN ACCORDANCE WITH DISCUSSION AND INSTRUCTIONS GIVEN BY T. AHL, CHICAGO BRIDGE AND IRON CO. HANGER NUMBER 2 WAS ASSIGNED PLANT NORTH WITH NUMBERS INCREASING IN A CLOCKWISE DIRECTION. AFTER OBTAINING READINGS, THEY WERE DISCUSSED WITH MR. AHL BY TELEPHONE ON 6/17 AND HE FEELS LOAD DISTRIBUTION IS CURRENTLY ACCEPTABLE. THE FOLLOWING HANGER LOADS WERE OBSERVED.

1.	7,800	7.	6,700
2.	10,300	8.	7,600
3.	9,400	9.	7,800
4.	7,400	10.	7,200
5.	8,300	11.	8,500
6.	7,200	12.	8,900

G.E. Gray
Project Superintendent
United Engineers & Constructors Inc.

cc: Sargent & Lundy, G. Hovcke
General Electric Co.: D. K. Willett
R. A. Leasburg
L. A. Hartley

UE&C INC.: J. R. Dmytryk

8.3 NDT Examination Report

On June 2, 1972 a licuid penetrant examination of Unit #2 suppression chamber to 24" diameter suction header at penetration X204A and B was made. The liquid penetrant examination covered th outside surface of the weld joining the neck (24" pipe nozzle) to insert plate and insert plate to torus shell; with results of examination acceptable.

James H. Eagle

Jim Eagle
Grinnell Company

8.4 Torus Movement Test Procedure

Plant: QUAD CITIES

Test Title: Torus Movement

Test No: 98

Revision No: 1

Date: June 5, 1972

PREPARED BY: Startup Test Design and Analysis Unit
Startup and Training Subsection
Atomic Power Equipment Department
San Jose, California

APPROVED BY: ______________________

ISSUED:

1. PURPOSE

The purpose of this test is to measure the movement of the torus surface relative to the ring header during actuation of relief valves, HPCI, RCIC, RHR & surveillance testing of the core spray system.

2. DESCRIPTION

The position of the torus surface relative to the reactor building will be monitored at preselected locations. The position of the ring header relative to the reactor building also will be monitored at the same or similar locations. These relative positions will be recorded during actuation of one or more relief valves and each of the other systems. The movement of the torus relative to the ring header can be inferred from these measurements. Depending upon the results of the measurements with individual systems, measurements during the actuation of more than one system may be made when the simultaneous operation of these systems is consistent with the design of the Quad Cities station.

3. CRITERIA

3.1 Level 1

3.1.1 Do not exceed the bulk torus air or water temperature limit specified in Figure 26.1 of the Quad Cities Test Instructions.

3.1.2 Stop all testing and return the reactor to a cold shutdown condition if the following displacements are exceeded:

(values to be provided before the test)

3.2 Level 2

3.2.1 Do not exceed a local torus air or water temperature of 200°F.

3.2.2 Do not exceed a torus overpressure of 1.3 psi.

3.2.3 Do not exceed the following displacements:

(values to be provided before the test)

4. INSTALLATION INSTRUCTIONS

4.1 Install instruments and readout equipment as specified in the attached sheets.

ISSUED:

4.2 Set up telephone communications from the control room to the location of the readout equipment.

4.3 It is desired, but not required that the readout be in the same location as was used during the torus temperature measurements test.

5. INITIAL CONDITIONS

NOTE: Before you perform this test be sure to review STI 26 and STI 15 for special instructions or precautions to be taken. Review the operating procedures for the HPCI, RCIC, RHR and core spray systems.

5.1 Station a man at the local panel, in contact with the control room.

5.2 The system of interest is ready to operate.

5.3 Torus water level is no more than 1 foot below the torus center line.

5.4 The torus water temperature should be as uniform as possible, preferably near 70°F.

5.5 The reactor must be operating at a power level sufficient so that reactor depressurization will not occur during the test.

6. PROCEDURE

NOTE: Steps 6.1 thru 6.6 should be done in the sequence listed. The sequence in which the different systems are tested is not important. For example, if desired the HPCI, step 6.8, may be tested before the relief valves, steps 6.1 thru 6.6, or after the RCIC, step 6.9.

6.1 Relief Valve B

6.1.1 Start the recording equipment and record all data for at least 1 minute. Those data which are recorded periodically should have at least 3 sets of data taken.

6.1.2 Make sure that the printer is set to the shortest available cycle time.

6.1.3 Make sure that the linear recorders are set to operate at greater than 5 inches per second and that the timing makers are properly synchronized between the several recorders.

6.1.4 Operate relief valve B.

6.1.5 Record all torus and ring header movements and torus temperature data.

ISSUED:

6.1.6 Record the reactor pressure vessel pressure and the torus pressure.

6.1.7 After the movements of the torus and ring header have damped, close relief valve B. It is expected that this will take one minute or less. Do not leave the relief valve open for more than 5 minutes.

6.1.8 Reopen relief valve within 5 seconds of the time it was closed in step 6.1.7 and allow it to remain open for 10 seconds before reclosing. All recorders should be operating during this step.

6.1.9 Continue data recording until near steady-state conditions are reached.

6.2 Repeat step 6.1 excluding step 6.1.8 for each relief valve in turn. Each valve should be open about 30 seconds.

6.3 Repeat step 6.1 excluding step 6.1.8 for a simultaneous 30 seconds actuation of relief valves A & B.

6.4 Repeat step 6.1 excluding step 6.1.8 for a simultaneous 30 seconds actuation of relief valves A, B, & C.

6.5 Repeat step 6.1 excluding step 6.1.8 for a simultaneous 30 seconds actuation of relief valves A, B, C, & D.

6.6 Repeat step 6.1 excluding step 6.1.8 for a simultaneous 30 seconds actuation of all 5 relief valves.

6.7 RHR

6.7.1 Start the recording equipment and record all data for at least 1 minute. Those data which are recorded periodically should have at least 3 sets of data taken.

6.7.2 Make sure that the printer is set to the shortest available cycle time.

6.7.3 Make sure that the linear recorders are set to operate at greater than 5 inches per second and that the timing makers are properly synchronized between the several recorders.

6.7.4 Start the RHR system in one of the modes of operation which circulates water or steam to or from the torus.

6.7.5 Record all torus and ring header movements and torus temperature data.

6.7.6 Record the reactor pressure vessel pressure and the torus pressure

ISSUED:

6.7.7 When steady conditions are reached relative to torus and ring header movements stop the RHR.

6.7.8 Continue data recording until near steady-state conditions are reached.

6.7.9 Repeat steps 6.7.4 thru 6.7.8 for each of the possible modes of RHR operation with the following restrictions.

6.7.9.1 No water will be injected into the reactor system.

6.7.9.2 Any mode of operation which does not effect the torus will not be tested.

6.8 HPCI

6.8.1 Start the recording equipment and record all data for at least 1 minute. Those data which are recorded periodically should have at least 3 sets of data taken.

6.8.2 Make sure that the printer is set to the shortest available cycle time.

6.8.3 Make sure that the linear recorders are set to operate at greater than 5 inches per second and that the timing makers are properly synchronized between the several recorders.

6.8.4 Initiate a quick start of the HPCI without injecting water into the RPV.

6.8.5 Record all torus and ring header movements and torus temperature data.

6.8.6 Record the reactor pressure vessel pressure and torus pressure.

6.8.7 When steady conditions are reached relative to torus and ring header movements stop the HPCI.

6.8.8 Continue data recording until near steady-state conditions are reached.

6.9 RCIC

6.9.1 Start the recording equipment and record all data for at least 1 minute. Those data which are recorded periodically should have at least 3 sets of data taken.

6.9.2 Make sure that the printer is set to the shortest available cycle time.

ISSUED:

6.9.3 Make sure that the linear recorders are set to operate at greater than 5 inches per second and that the timing makers are properly synchronized between the several recorders.

6.9.4 Initiate a quick start of the RCIC without injecting water into the RPV.

6.9.5 Record all torus and ring header movements and torus temperature data.

6.9.6 Record the reactor pressure vessel pressure and the torus pressure.

6.9.7 When steady conditions are reached relative to torus and ring header movements stop the RCIC.

6.9.8 Continue data recording until near steady-state conditions are reached.

6.10 Core Spray

6.10.1 Start the recording equipment and record all data for at least 1 minute. Those data which are recorded periodically should have at least 3 sets of data taken.

6.10.2 Make sure that the printer is set to the shortest available cycle time.

6.10.3 Make sure that the linear recorders are set to operate at greater than 5 inches per second and that the timing makers are properly synchronized between the several recorders.

6.10.4 Start the core spray system in the mode which draws water from or injects water into the torus.

6.10.5 Record all torus and ring header movements and torus temperature data.

6.10.6 When steady conditions are reached relative to torus and ring header movements stop the core spray system.

6.10.7 Continue data recording until near steady-state conditions are reached.

7. DATA ANALYSIS

7.1 All data will be returned to San Jose for detailed analysis.

ISSUED:

QUAD CITIES UNIT NO. 2

TORUS MOVEMENT TEST

Measurement #	Azimuth	Location
1	67°30'	(at header support) vert. between top of torus and roof of ring room on center line of torus
2	67°30'	hor. at center line of torus [illegible]etween torus inner (Rx) wall of ring room
3	67°30'	vert. at center line of torus between bottom of torus and floor of ring room
4	67°30'	hor. at center line of torus between torus and outer wall of ring room
5	67°30'	vert. at center line of ring header between ring header and floor of ring room
6	67°30'	hor. at center line of ring header between ring header and outer wall of ring room
7	67°30'	on radius of torus through center line of ring header between torus surface and r.h. surface
8	67°30'	vert. between upper connection point of part 6 drawing 218 and upper surface of r.h.
9	67°30'	radially from center line of torus between upper connection point of part 6 drawing 218 and outer wall of ring room
10	45°	(at center line of penetration 216 x 204A on CB&I dwg. 217, rev. 5, vert. between top of torus and roof of ring room on center line of torus
11	45°	hor. at center line of torus between torus and inner wall of ring room
12	45°	vert. at center line of torus between bottom of torus and floor of ring room
13	45°	hor. at center line of torus between torus and outer wall of ring room
14	45°	vert. at center line of ring header and center line of penetration 216 x 204A between r.h. and floor

Measurement #	Azimuth	Location
15	45^0	hor. at center line of r.h. and center line of penetration 216 x 204A between r.h. and outer wall of ring room
16	45^0	vert. at center line of penetration 216 x 204A between the intersection of penetration 216 x 204A and the torus and the floor of the ring room
17	45^0	hor. at center line of penetration 216 x 204A between the intersection of penetration 216 x 204A and the torus and the outer wall of the ring
18	90^0	hor. at center line of torus between torus and outer wall of ring room
19	135^0	hor. at center line of torus between torus and outer wall of ring room
20	180^0	hor. at center line of torus between torus and outer wall of ring room
21	225^0	hor. at center line of torus between torus and outer wall of ring room
22	$67^030'$	Radially from center line of torus between torus and ring room floor as shown on sketch
23	$67^030'$	Radially from center line of torus between torus and outer wall of ring room as shown on sketch

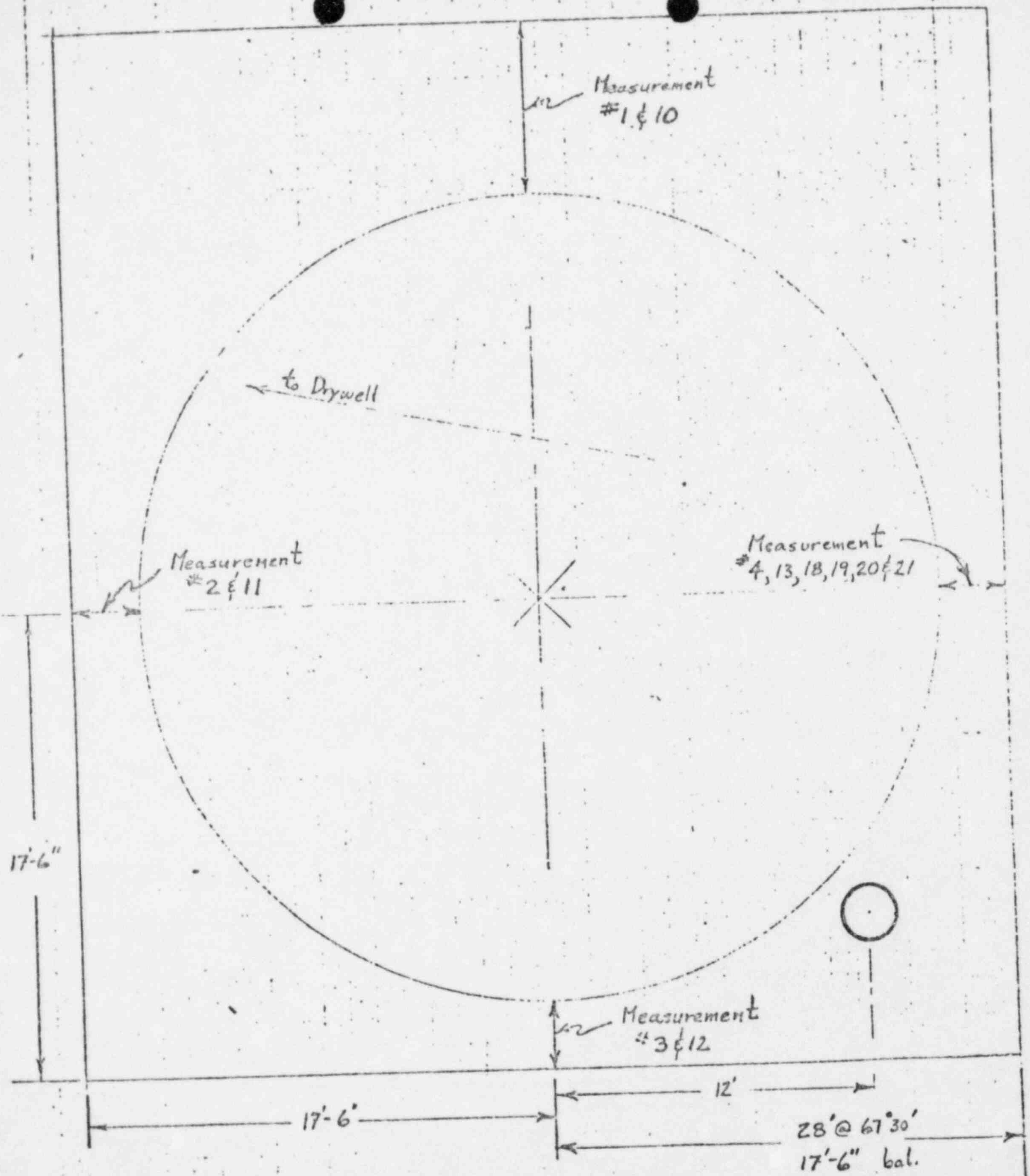
Notes:

A. No clamps, attachments, or other sources of potential interaction are tc be permitted between the measurement devices and their supports and pipes or brackets, etc., which may move during the test. This specifically includes the torus supports.

B. Measurement devices 16 and 17 are to be installed in such a way that there will be no interference with the ring header during the test. Assume the r.h. may move as much as 2" vert. or hor. relative to the torus for the purpose of instrument installation.

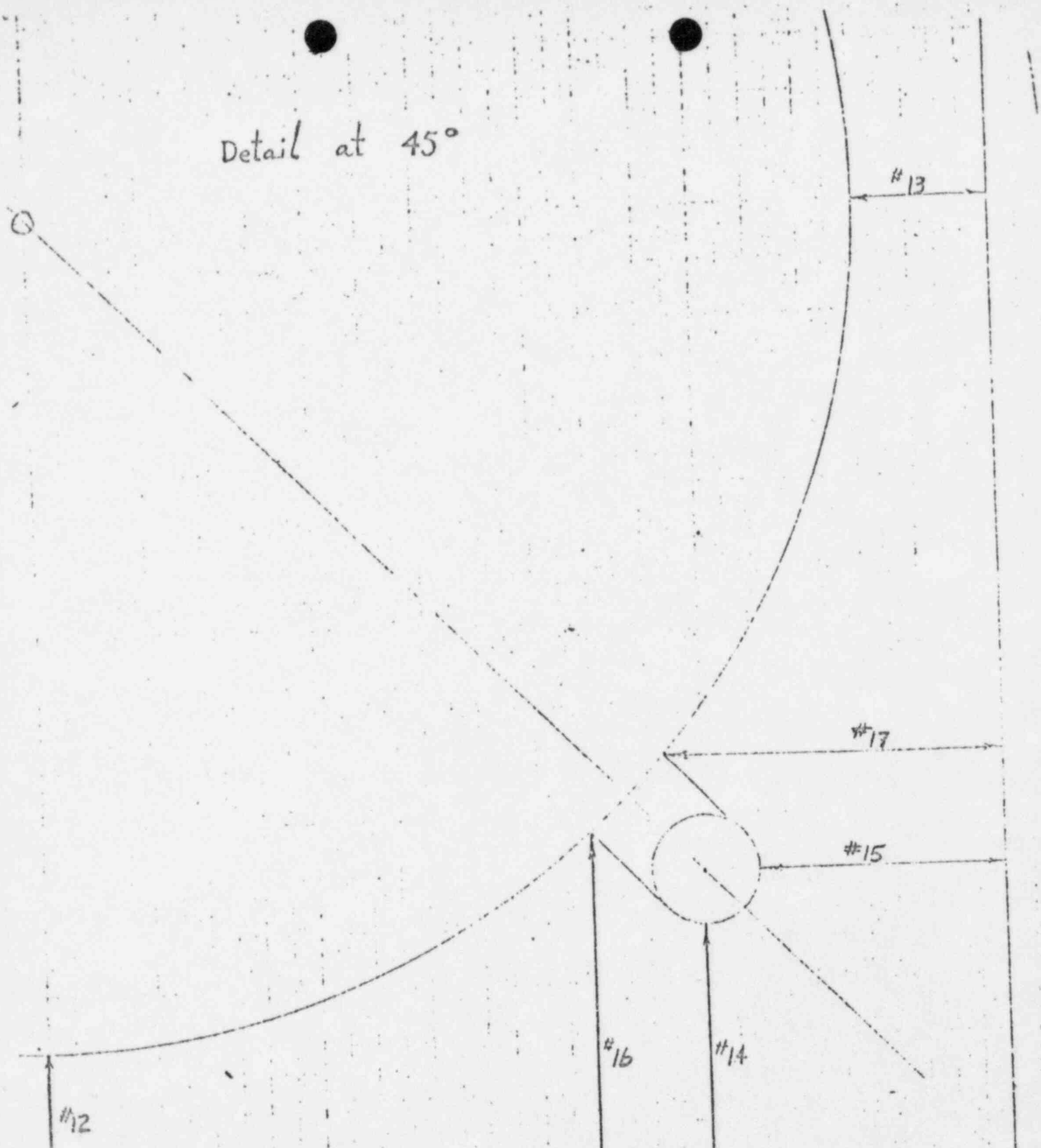
C. All horizontal measurements are to made on a radius from the RPV center line.

D. Azimuth identification is from S&L drawing B-400.

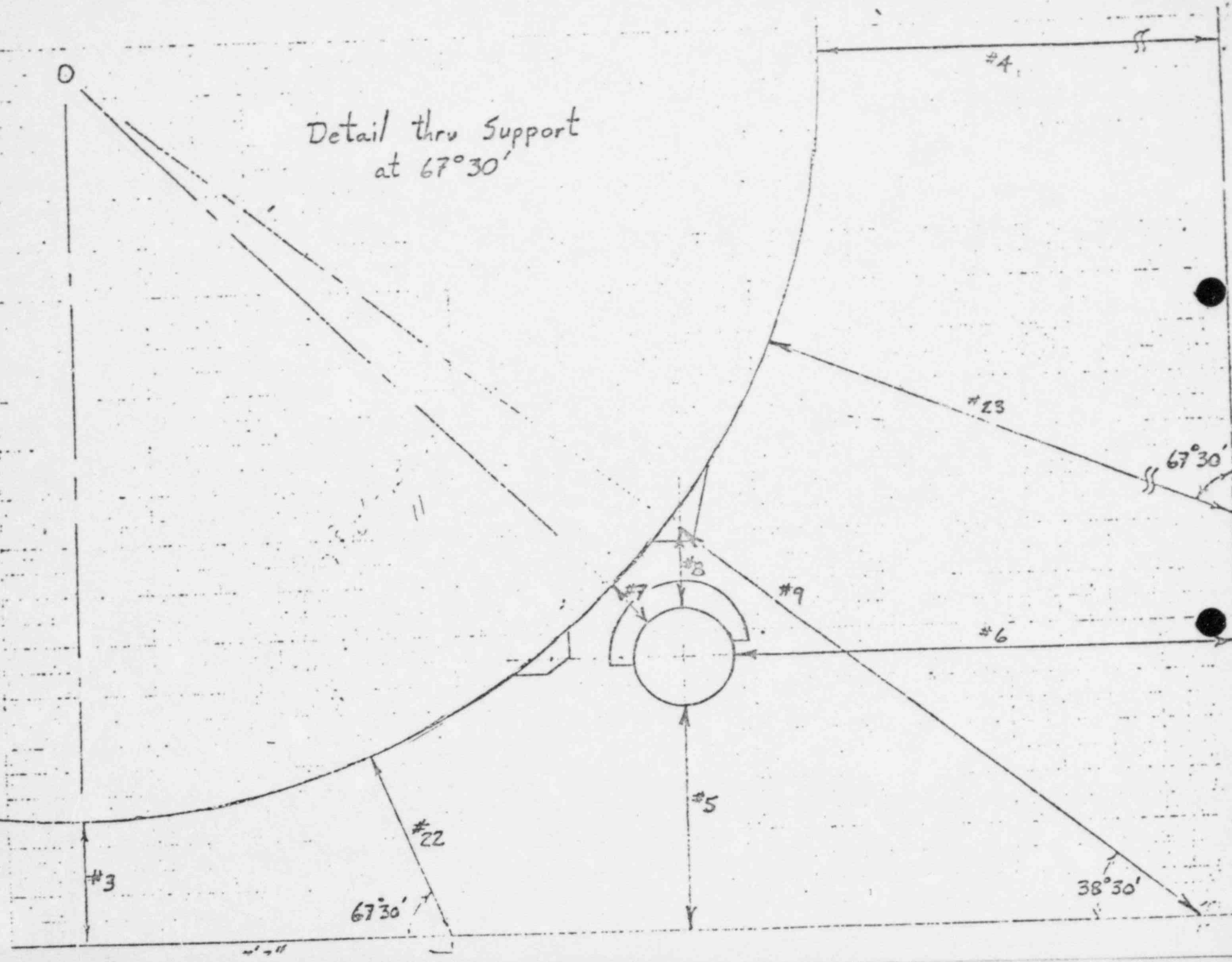

Measurement
#1 ¢ 10
to Drywell
Measurement
#2 ¢ 11
Measurement
#4, 13, 18, 19, 20 ¢ 21
17'-6"
Measurement
#3 ¢ 12
12'
17'-6'
28' @ 67°30'
17'-6" bal.

ELS- 1- 3/6/72

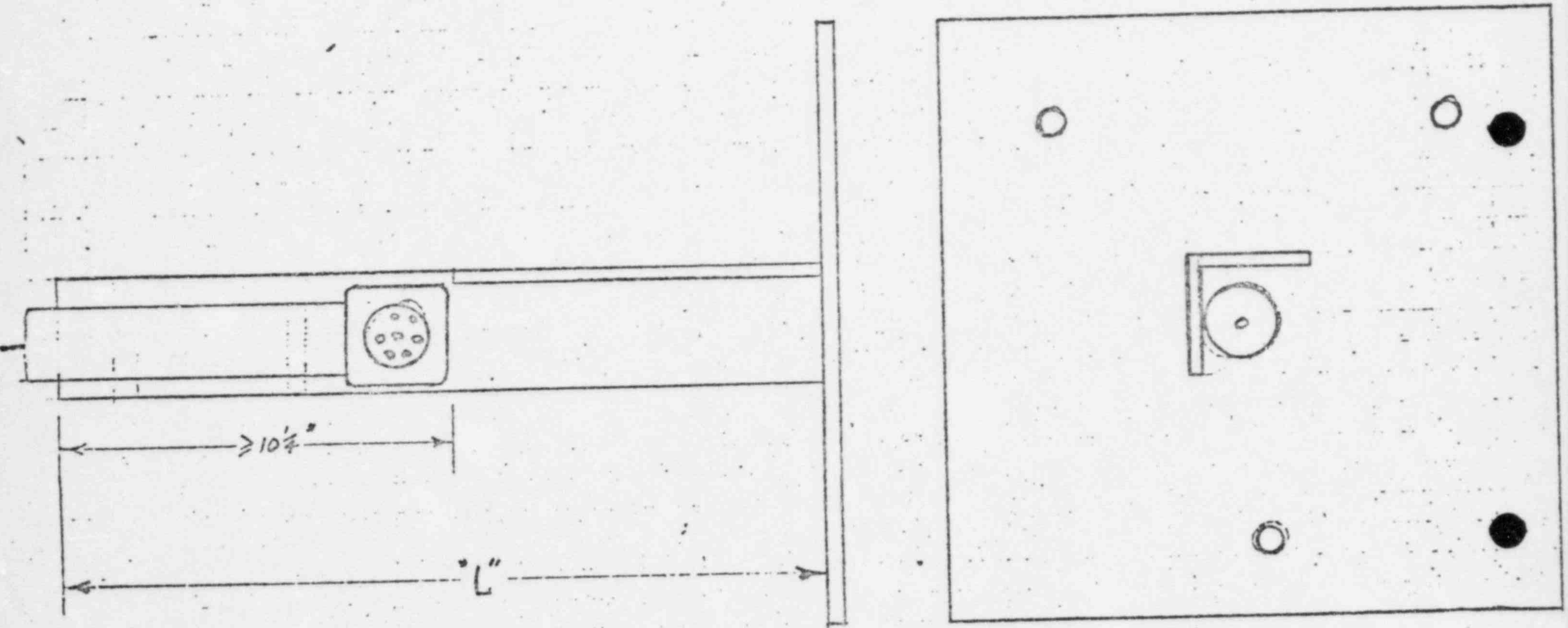
Detail at 45°



ELS-2-3/6/22

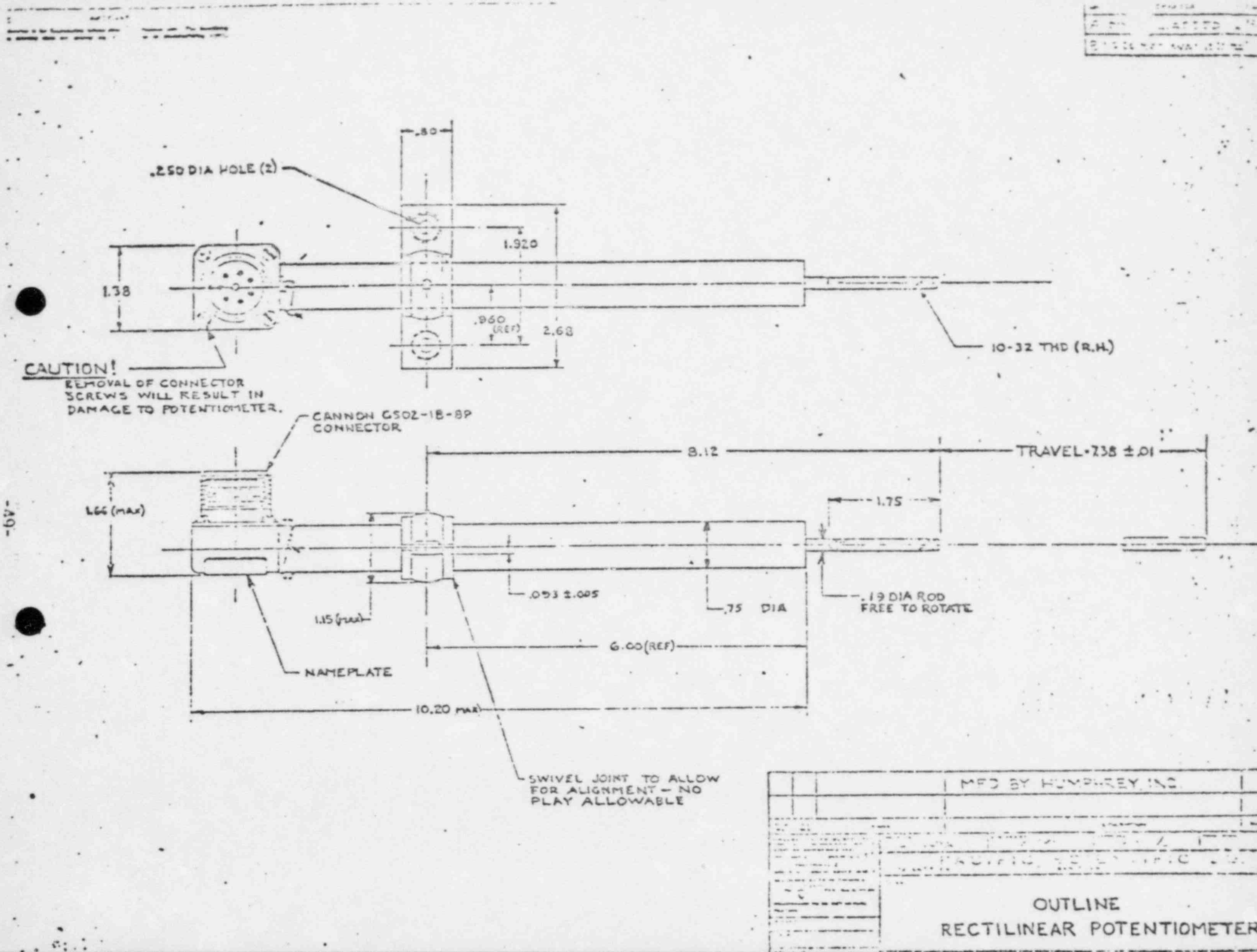


ELS-3-3/6/7..

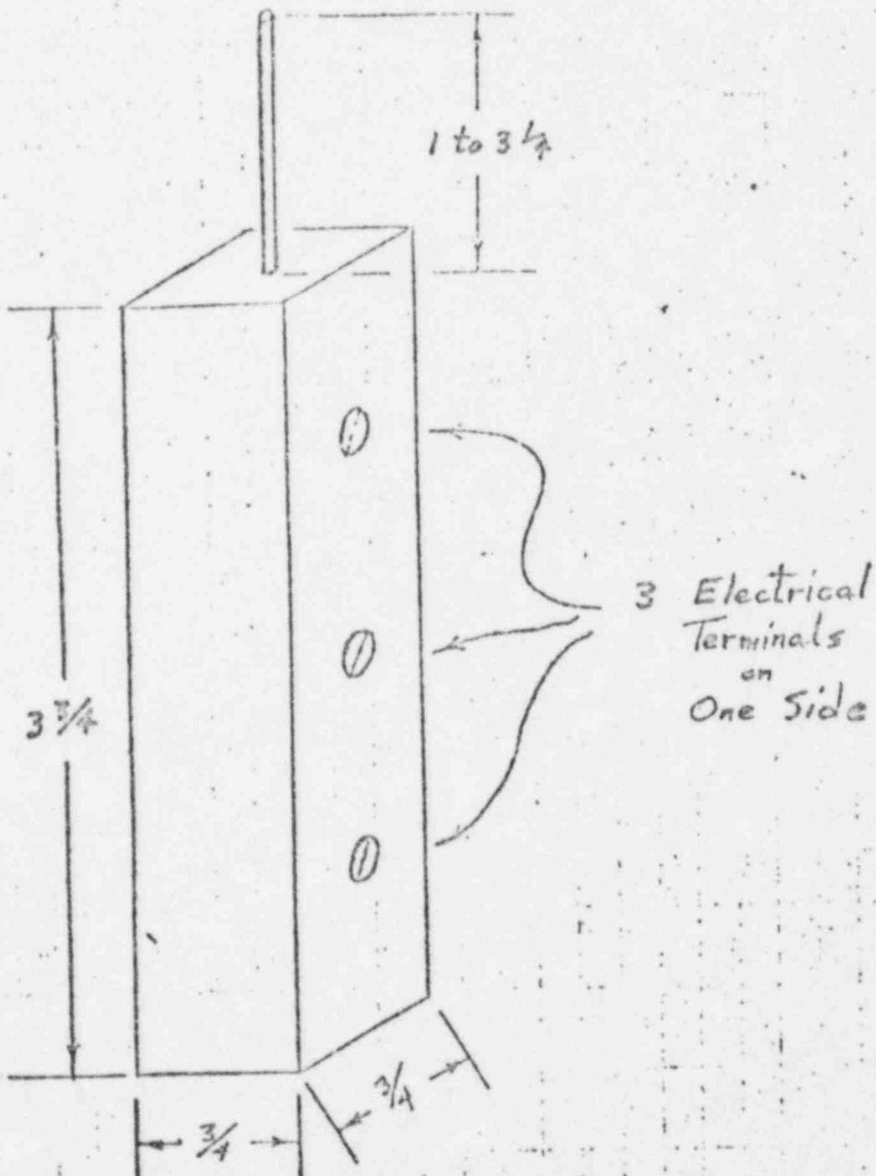


Possible mounting bracket for floor, wall & ceiling measurements

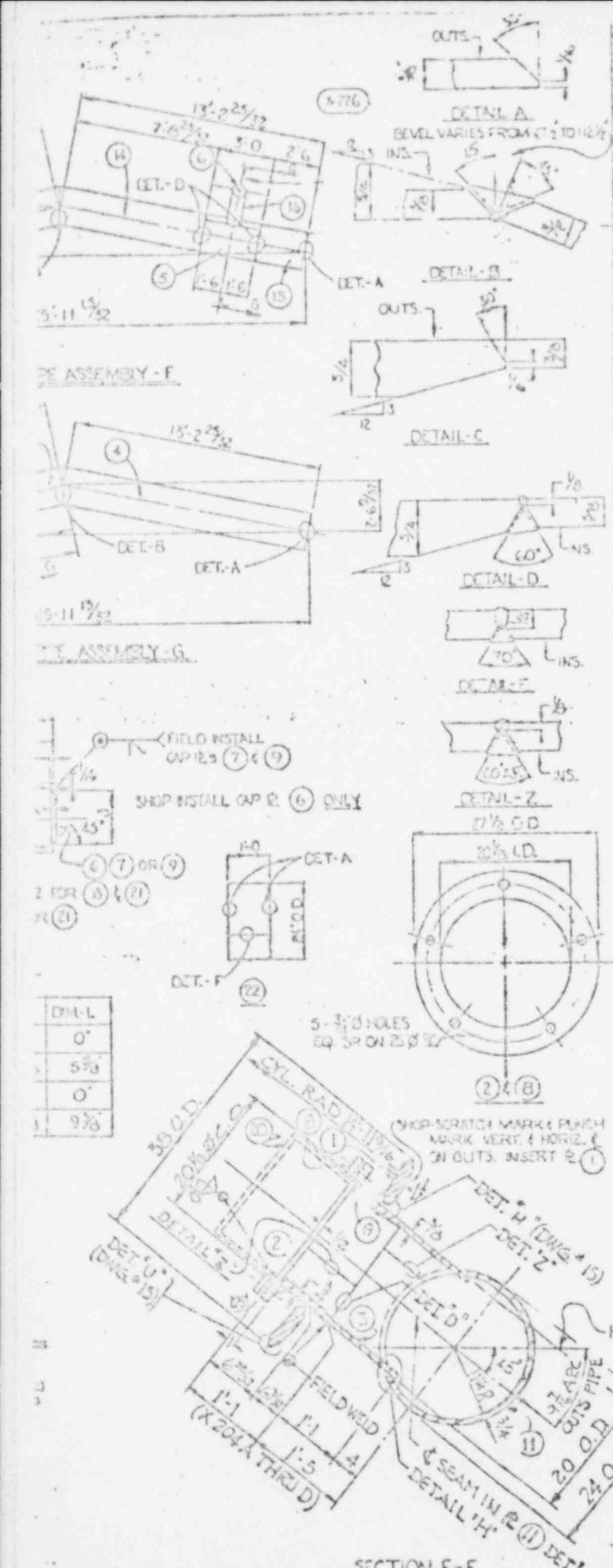
length "L" such that there is ≥ 6" from end of bracket to surface being monitored
linear pot held to bracket by 2 hose clamps
angle iron & plate sized to prevent bending &/or significant vibration
bracket mounted to floor, wall or ceiling by lag bolts in the concrete
4 wire leads pulled from sensor to vibration instrument shack - Beldon 8434 cable is OK


.80
.250 DIA HOLE (2)
1.920
1.38
.960 (REF)
2.68
10-32 THD (R.H.)
CAUTION!
REMOVAL OF CONNECTOR SCREWS WILL RESULT IN DAMAGE TO POTENTIOMETER.
CANNON GS02-18-8P CONNECTOR
8.12
TRAVEL-7.38 ±.01
1.75
1.66 (MAX)
.053 ±.005
.75 DIA
.19 DIA ROD FREE TO ROTATE
6.00 (REF)
NAMEPLATE
10.20 MAX
SWIVEL JOINT TO ALLOW FOR ALIGNMENT – NO PLAY ALLOWABLE
MFD BY HUMPHREY INC.
OUTLINE
RECTILINEAR POTENTIOMETER

Linear Pot
for
Measurement #7



8.5 Twenty-Four Inch Diameter Header Drawings



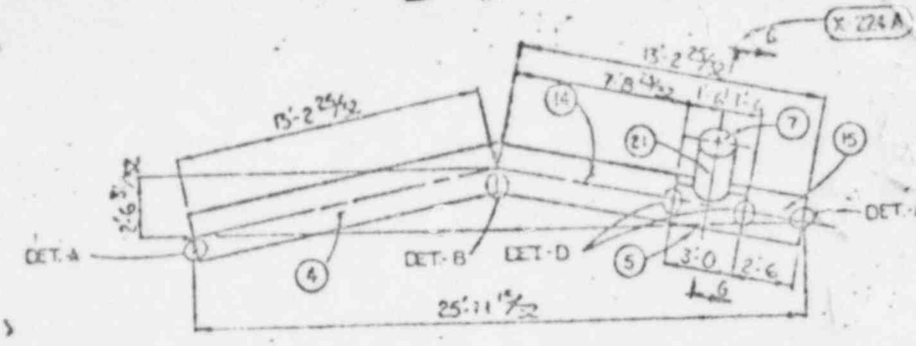
REQ PC	MARK	ASSM PC	DESCRIPTION	FT	IN	SPEC	
1	216-A		24"Ø HEADER SECTION				
	216-4	1	R 161⁵⁄₃₂ × ⅜ × SK (74½ × 13'-5½ ⁹⁄₁₆)	6	2 [illegible]	[illegible]	25/2
	216-4	1	R 95⁵⁄₃₂ × ⅜ × SK (74½ × 7' [illegible])	6	[illegible]	do	[illegible]
	216-5	1	R 36 × ¾ (73⅝ × 3'-0½ ⁹⁄₁₆)	6	[illegible]	do	25/4
	216-21	1	R 54⅜ × ⅝ (55¼ × 4'-6⅝ ⁹⁄₁₆)	4	[illegible]	do	25/2
	216-15	1	R 30 × ⅜ (74½ × 2'-0¼ ⁹⁄₁₆)	6	2 [illegible]	do	25/2
1	216-7		R 17⅞ Ø × 1½			do	25/23
4	216-B		24"Ø HEADER SECTIONS				
	216-4	4	R 161⁵⁄₃₂ × ⅜ × SK (74½ × 13'-5½ ⁹⁄₁₆)	6	2⁷⁄₃₂	[illegible]	25/2
	216-13	4	R 141⁵⁄₃₂ × ⅜ × SK (74½ × 11'-9½ ⁹⁄₁₆)	6	2⁷⁄₃₂	do	25/2
	216-11	4	R 40 × ¾ (73⅝ × 3'-0⅜ ⁹⁄₁₆)	6	[illegible]⁄₃₂	do	25/4
	216-3	4	R 3 × ⅜ × SK (62 × 1'-⅛ ⁹⁄₁₆)	5	1⁵⁄₃₂	do	25/10
4	216 X 204		20"Ø PENETRATIONS				
	216-1	4	INSERT R 38" O.D. × ¾ × SK I.D.			[illegible]	25/5
	216-19	4	R 2½ × ⅜ ([illegible] × [illegible])	5	[illegible]	do	25/17
	216-2	4	FLG. R 27½ O.D. × [illegible] × 20⅜ I.D. (28 × ¼ [illegible])			do	25/20
4	216-8		FLG R 27½ O.D. × ¾ × 20⅜ I.D. (28 × 24 ⁹⁄₁₆)			A 283-C	
4	216-20		STAINLESS STEEL STRAINERS (SEE NOTE 4)			TP 304 SS	25/5
4	216-C		24"Ø HEADER SECTIONS				
	216-4	4	R 161⁵⁄₃₂ × ⅜ × SK (74½ × 13'-5½ ⁹⁄₁₆)	6	2⁷⁄₃₂	[illegible]	25/2
	216-13	4	R 141⁵⁄₃₂ × ⅜ × SK (74½ × 11'-9½ ⁹⁄₁₆)	6	2⁷⁄₃₂	do	25/2
3	216-D		24"Ø HEADER SECTIONS				
	216-4	6	R 161⁵⁄₃₂ × ⅜ × SK (74½ × 13'-5½ ⁹⁄₁₆)	6	2⁷⁄₃₂	[illegible]	25/2
2	216-E R/L		24"Ø HEADER SECTIONS				
	216-4	2	R 161⁵⁄₃₂ × ⅜ × SK (74½ × 13'-5½ ⁹⁄₁₆)	6	2⁷⁄₃₂	[illegible]	25/2
	216-10	2	R 83⁵⁄₃₂ × ¾ × SK (73⅝ × 6'-11½ ⁹⁄₁₆)	6	1 [illegible]	do	25/3
	216-18	2	R 60 × ⅜ (74½ × 5'-0¼ ⁹⁄₁₆)	6	[illegible]	do	25/2
	216-17	2	R 78 × ⅜ (74½ × 6'-6¼)	6	[illegible]	do	25/18
2	216-9		R 23⅛ Ø × 1¼			do	25/21
1	216-F		24"Ø HEADER SECTION				
	216-4	1	R 161⁵⁄₃₂ × ⅜ × SK (74½ × 13'-5½ ⁹⁄₁₆)	6	2⁷⁄₃₂	[illegible]	25/2
	216-14	1	R 95⁵⁄₃₂ × ⅜ × SK (74½ × 7'-11½ ⁹⁄₁₆)	6	2⁷⁄₃₂	do	25/2
	216-5	1	R 36 × ¾ (73⅝ × 3'-0½ ⁹⁄₁₆)	6	1⁵⁄₃₂	do	25/4
	216-16	1	R 8"Ø SCH 80 SML PIPE	4	2⅞	A 333 GR-1	25/19
	216-6	1	R 7½ Ø × ½			[illegible]	
	216-15	1	R 30 × ⅜ (74½ × 2'-0¼ ⁹⁄₁₆)	6	2⁷⁄₃₂	do	25/16
1	216-G		24"Ø HEADER SECTION				
	216-15	1	R 30 × ⅜ (74½ × 2'-6¼)	6	2⁷⁄₃₂	[illegible]	25/2
	216-12	1	R 131⁵⁄₃₂ × ¾ × SK (73⅝ × 10'-11½ ⁹⁄₁₆)	6	1⁵⁄₃₂	do	[illegible]
	216-18	1	R 60 × ⅜ (74½ × 5'-0¼ ⁹⁄₁₆)	6	2⁷⁄₃₂	do	25/2
	216-21	1	R 54⅜ × ⅝ (55¼ × 4'-6⅝ ⁹⁄₁₆)	4	7⅝	do	[illegible]
	216-4	1	R 161⁵⁄₃₂ × ⅜ × SK (74½ × 13'-5½ ⁹⁄₁₆)	6	2⁷⁄₃₂	do	[illegible]
1	216-7		R 17⅞ Ø × 1½			do	[illegible]
	216-9		R 23⅛ Ø × 1¼			do	[illegible]
3	216-22		MAKE-UP R 12 × ⅜ (72¾ × 1'-0¼ ⁹⁄₁₆)	6	2⁷⁄₃₂	do	[illegible]
20			HEX. HEAD BOLTS ⅝ · 1 ¾ / HEX NUTS	0	2³⁄₁₆	TP 304 SS	

QUAD CITIES II

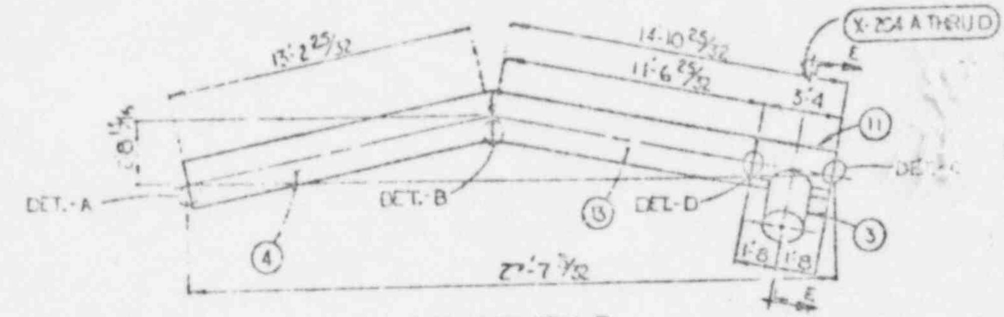
CHICAGO BRIDGE & IRON COMPANY
GREENVILLE, PA

SHOP DETAILS
24"Ø HEADER FOR
SUPPRESSION CHAMBER

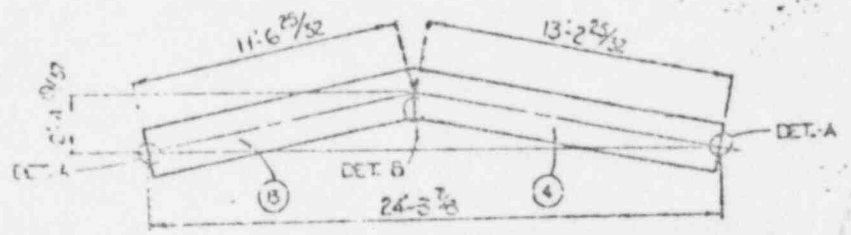
PURCHASER'S NO. GCDC-1429-01 275-1
CONTRACT NO. 9-6771
DRAWN BY [illegible] DATE [illegible]
CHECKED BY [illegible] DATE 11-2-69
BENTLEY
ENGINEERING COORDINATOR
DWG NO. 216 REV 5



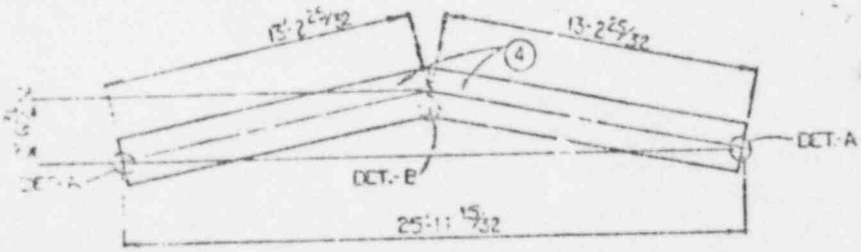
PIPE ASSEMBLY-A



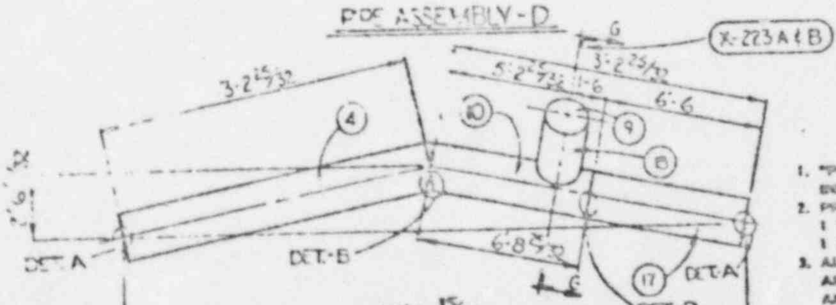
PIPE ASSEMBLY-B



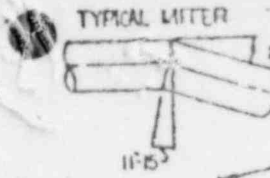
PIPE ASSEMBLY-C

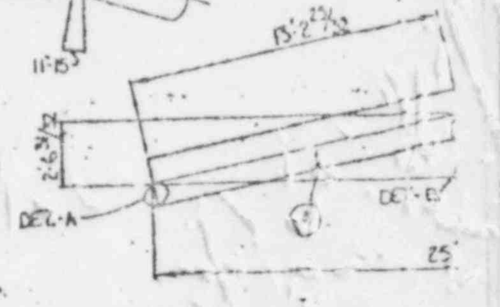


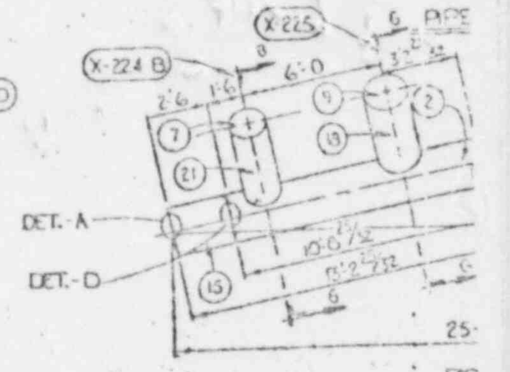
PIPE ASSEMBLY-D

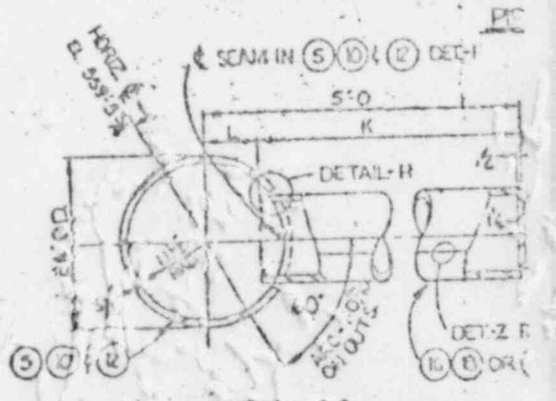


PIPE ASSEMBLY-E R/L
ASSEMBLY-E R SHOWN
ASSEMBLY-E L OPP. HAND



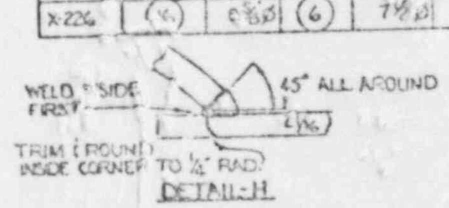






SECTION G-G
X-223 A, X-223 B, X-224 A, X-224 B, X-225, X-226

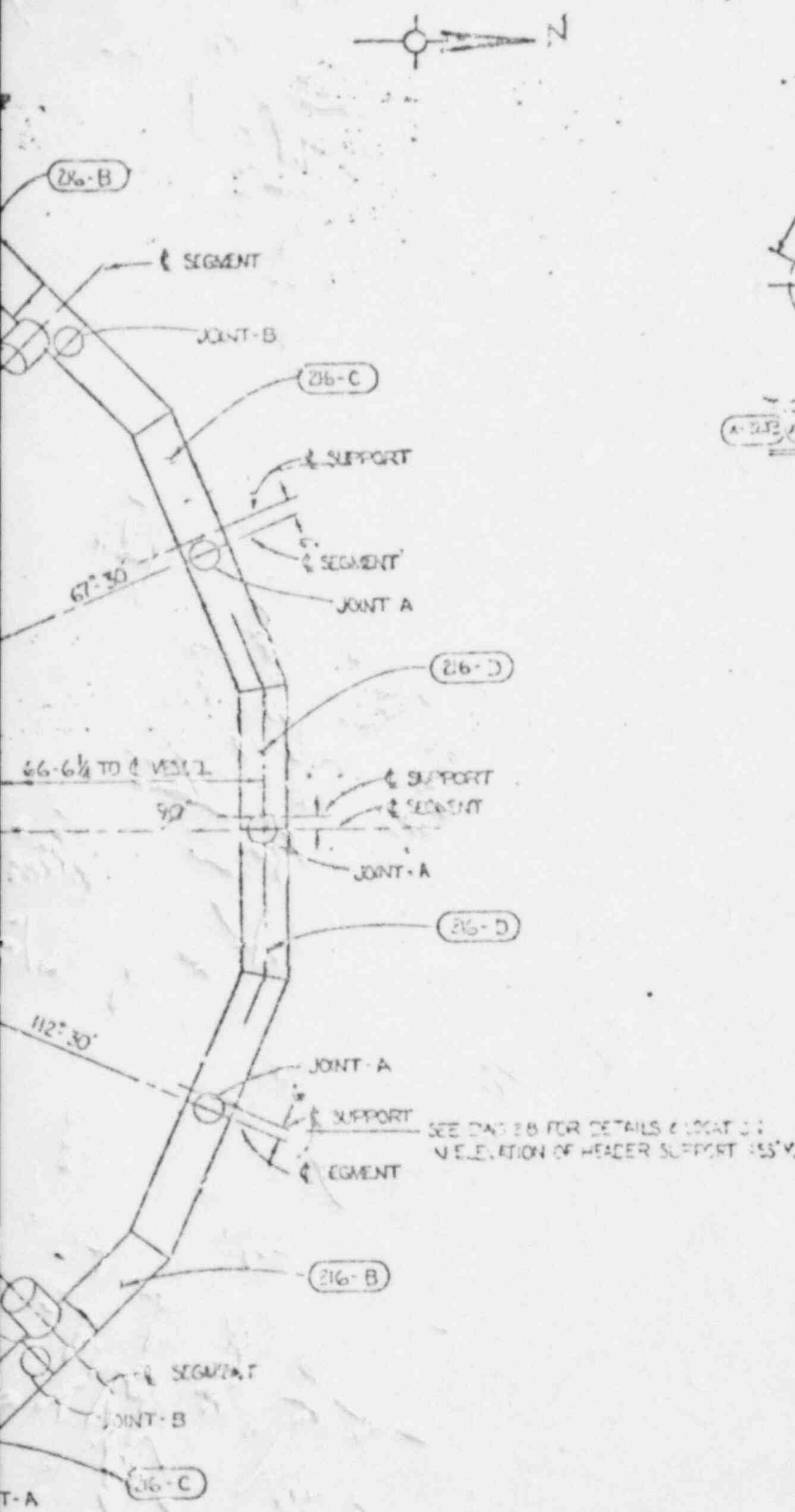
PENT. MARK	PIPE MARK	O.D.	CAP MARK	DIM.-J	DIM.-K
X-223 A&B	(13)	24"Ø	(9)	23 1/8"Ø	5'-0
X-224 A-D	(21)	18"Ø	(7)	17 1/8"Ø	4'-6 5/8
X-225	(10)	24"Ø	(9)	23 1/8"Ø	5'-0
X-226	(16)	8 5/8"Ø	(6)	7 1/2"Ø	4'-2 1/3

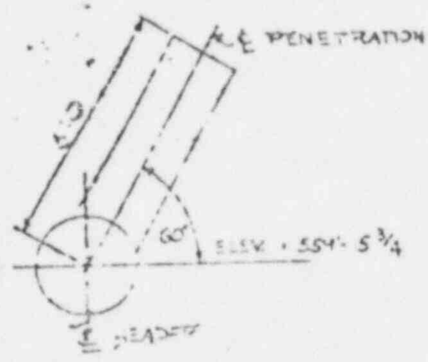


DETAIL-H

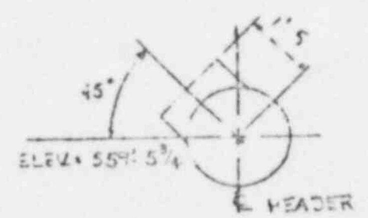
NOTES

1. "POST WELD HEAT TREAT" ALL PIPE "TEE" ASSEMBLIES WITH INSERT PLATE ASSEMBLIES AFTER WELDING IS COMPLETED.
2. PREHEAT TO 200°F (MIN.) ALL SEAMS WHERE THICKNESS EXCEEDS 1 1/4". PREHEAT TO 100°F THOSE SEAMS WHERE THICKNESS ≤ 1 1/4" WHEN AMBIENT TEMPERATURE IS ≤ 40°F.
3. ALL BUTT WELDED MAIN SEAMS (CATEGORIES A & B OF ASME III) ARE TO BE 100% RADIOGRAPHICALLY INSPECTED. CORNER WELDS AND FILLET ATTACHMENT WELDS ARE TO BE INSPECTED BY MAGNETIC PARTICLES PER PARAGRAPH N-625 SECTION III ASME CODE AFTER ASSEMBLY HAS BEEN POST WELD HEAT TREATED.
4. STAINLESS STEEL STRAINER TO BE CONSTRUCTED OF WOVEN WIRE TO ASTM A478-63 TP. 304 AND/OR PLATE MATERIAL TO ASTM A240 TP. 304. EACH STRAINER SHALL PASS 10,000 G.P.M. WITH AN ENTRANCE HEAD LOSS ACROSS THE SCREEN OF ONE FOOT OF WATER MAXIMUM. STRAINER MAY BE OF CYLINDRICAL OR CONICAL SHAPE AND SIZED TO SCREEN OUT PARTICLES GREATER THAN 1/8"Ø.
5. WORK THIS DRAWING WITH DRAWING #217.





SECTION THRU PENETRATION
X-223B X-224A X-220-B X-222 & X-224



SECTION THRU PENETRATIONS
X-204 X-204 X-205-C & X-204

NOTES

1. ALL BUTT WELDED MAIN SEAMS (CATEGORIES A & B OF ASME III) ARE TO BE 100% RADIOGRAPHICALLY INSPECTED. CORNER WELDS AND FILLET ATTACHMENT WELDS ARE TO BE INSPECTED BY MAGNETIC PARTICLES PER PARAGRAPH N-626 SECTION III ASME CODE AFTER ASSEMBLY HAS BEEN POST WELD HEAT TREATED.
2. FOR LOCATING SUPPORT CLIPS IN PLAN, CENTERLINE OF HEADER SEGMENT IS ALSO CENTERLINE OF SUPPRESSION CHAMBER SHELL SEGMENT.

WORK THIS DWG WITH DWG 216
JOINTS SHOWN ON THIS DWG ARE FIELD WELDED

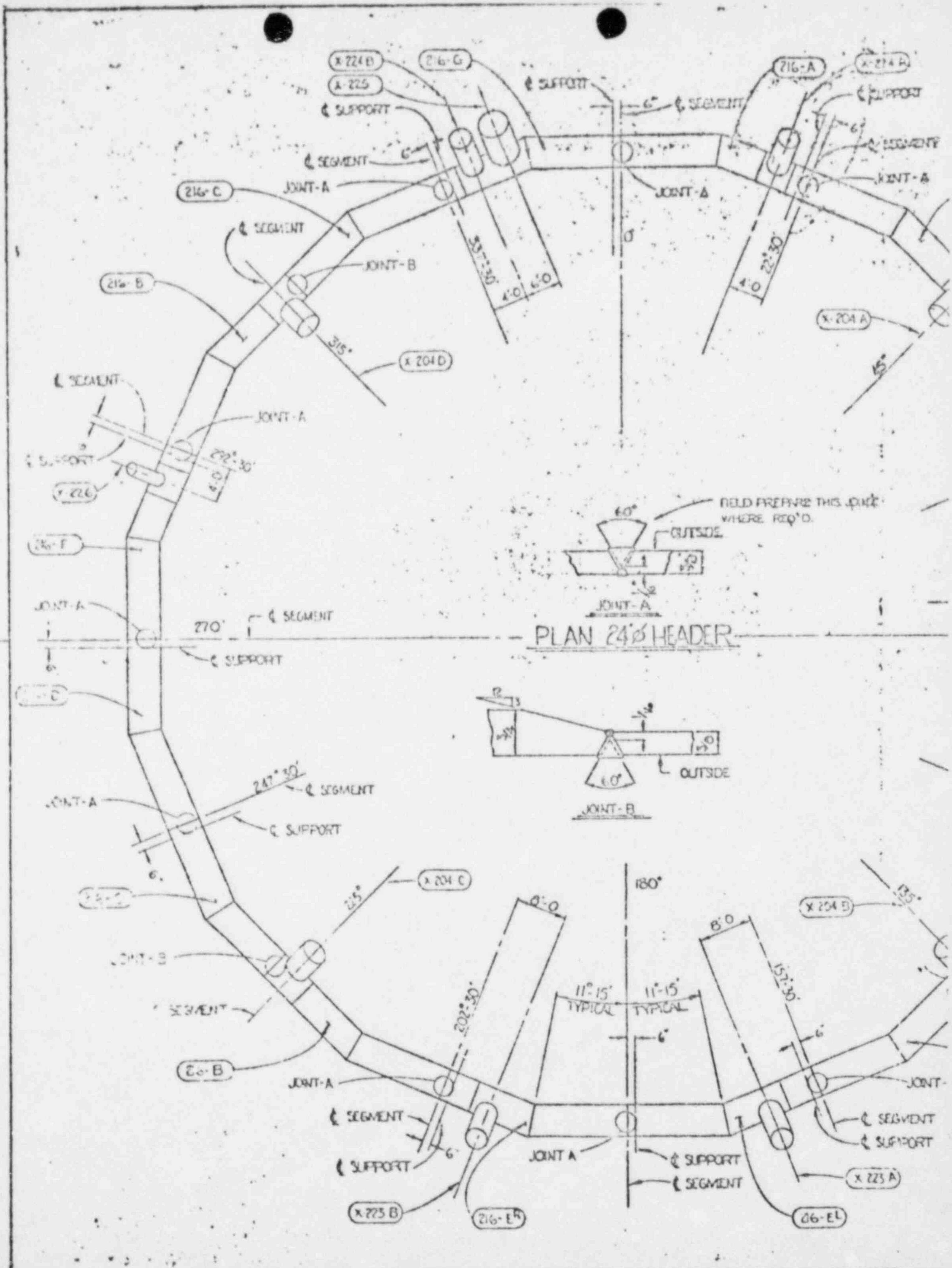
QUAD-CITIES II

DETAILS AND MATERIAL FOR VESSEL — FIELD

CHICAGO BRIDGE & IRON COMPANY

FIELD DETAILS
FOR 24'Ø HEADER
FOR SUPPRESSION CHAMBER

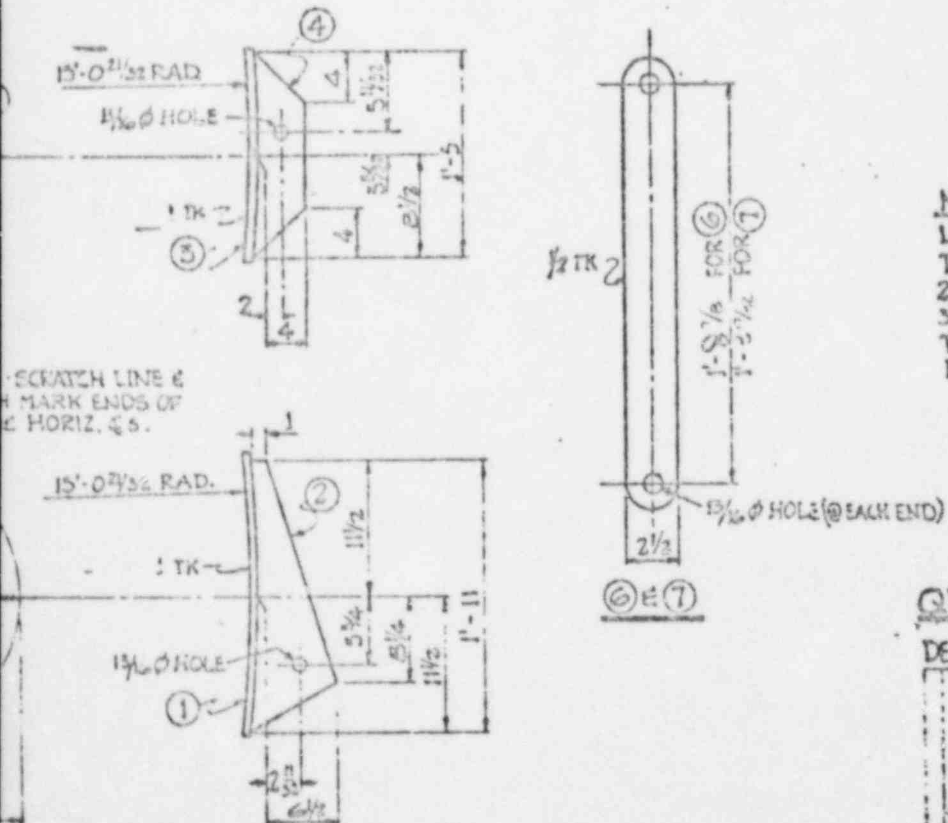
CONTRACT NO. 9-6771
DWG NO 217 REV 5



X-224 B
X-225
216-G
℄ SUPPORT
℄ SEGMENT
216-A
X-224 A
JOINT-A
216-C
216-B
JOINT-B
X-204 D
315°
337°30'
4'-0
6'-0
22°30'
X-204 A
45°
℄ SEGMENT
JOINT-A
℄ SUPPORT
292°30'
X-226
216-F
FIELD PREPARE THIS JOINT WHERE REQ'D.
60°
OUTSIDE
JOINT-A
270°
PLAN 24"Ø HEADER
OUTSIDE
60°
JOINT-B
247°30'
X-204 C
225°
180°
X-204 B
135°
8'-0
202°30'
157°30'
11°-15' TYPICAL
JOINT-B
JOINT A
X-223 B
216-E^R
X-223 A
216-E^L

N CHAMBER

REQ'D PC.	MARK	ASSM. PC.	DESCRIPTION	LENGTH FT.	LENGTH IN.	SPEC.
12	218-A		CLIP ASSEMBLY			
	218-1	12	PLS 24"ϕ • 1 (ROLL) (SEE CS #6)			[illegible]
	218-2	12	PLS SK • 1/2 (7 • 1'-1 1/2 ϕ/1) (SEE CS #6)			do
12	218-B		CLIP ASSEMBLY			
	218-3	12	PLS 15"ϕ • 1 (ROLL) (SEE CS #6)			do
	218-4	12	PLS SK • 1/2 (4 1/2 • 1'-5 1/2 ϕ/1) (SEE CS #6)			do
12	218-5		PL SK • 1/2 (74 • 8'-4 [illegible]) (SEE CS #6)			do
24	218-6		BARS 2 1/2 • 1/2 • SK	1	[illegible]	A-36
24	218-7		do	1	[illegible]	do
48	A.C.		HEX. HD. BOLTS 3/4"-10	0	2 3/4	A-307
48	A.C.		REG HEX LOCK NUTS 3/4"-10			do



NOTE
1. SEE GENERAL PLAN FOR APPROVED TYPES OF WELD ELECTRODE
2. SEE DWG # 217 FOR ORIENTATION
3. FILLET ATTACHMENT WELDS ARE TO BE INSPECTED BY MAGNETIC PARTICLE

CERTIFIED FINAL DRAWINGS
SIGNED [illegible] DATE [illegible]

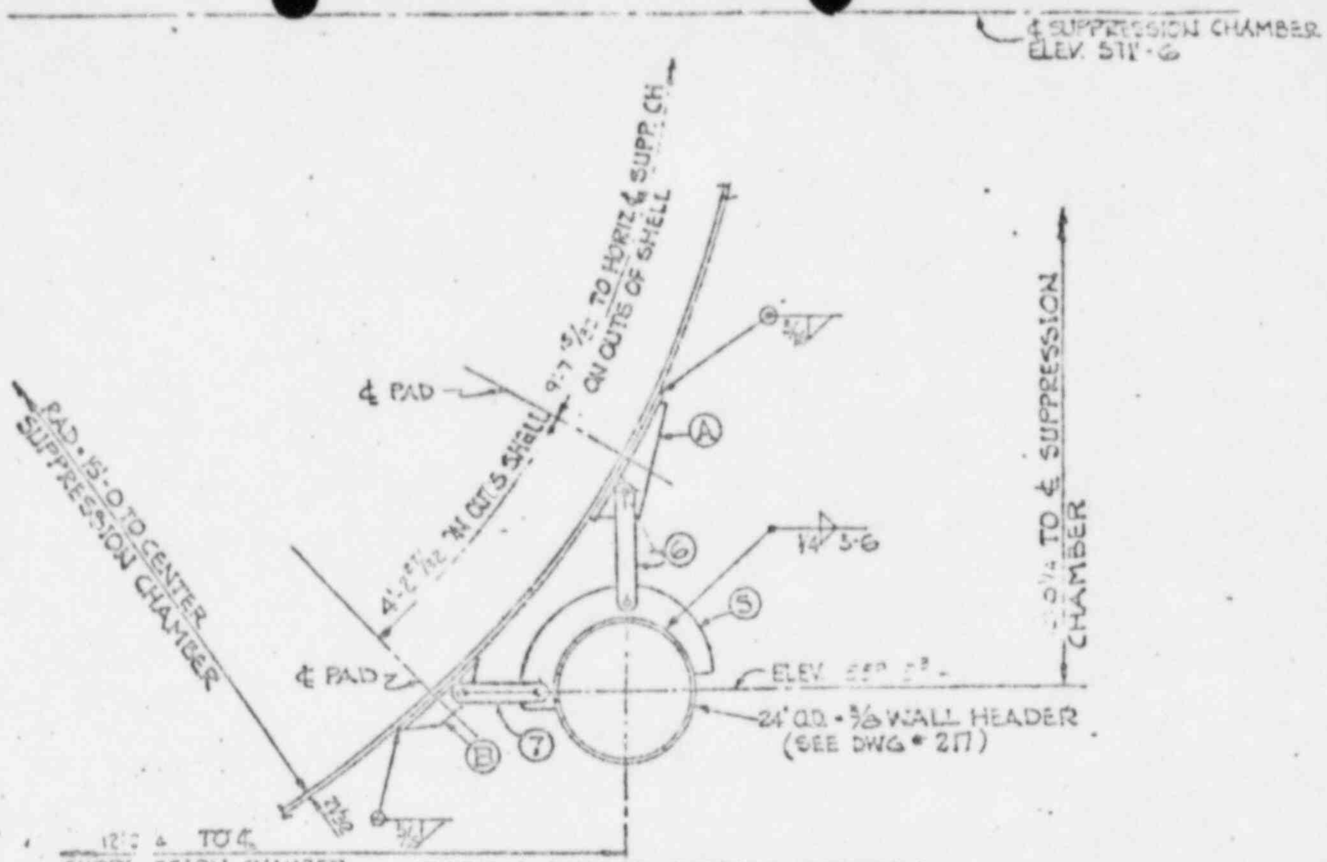
QUAD-CITIES II

DETAILS & MAT'L FOR ONE VESSEL ~ 1 REQD

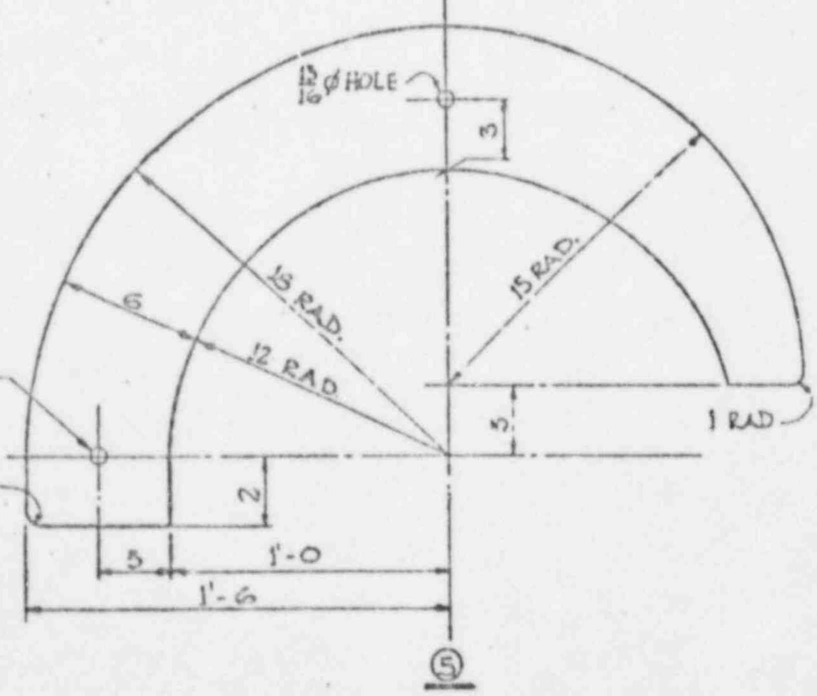
CHICAGO BRIDGE & IRON COMPANY

SUPPORT ASSEMBLY
FOR 24"ϕ HEADER

PURCHASER'S NO. GEX-19829 01-775 CONTRACT NO.
DRAWN BY [illegible] DATE 2-2-67
CHECKED BY [illegible] DATE 2-14-67
BENTLEY
9-67771
DWG NO. 218 REV 1



TYPICAL HEADER SUPPORT ASSEMBLY



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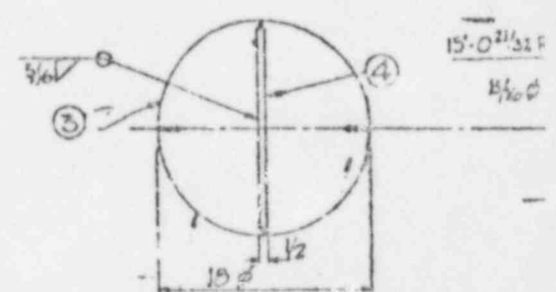

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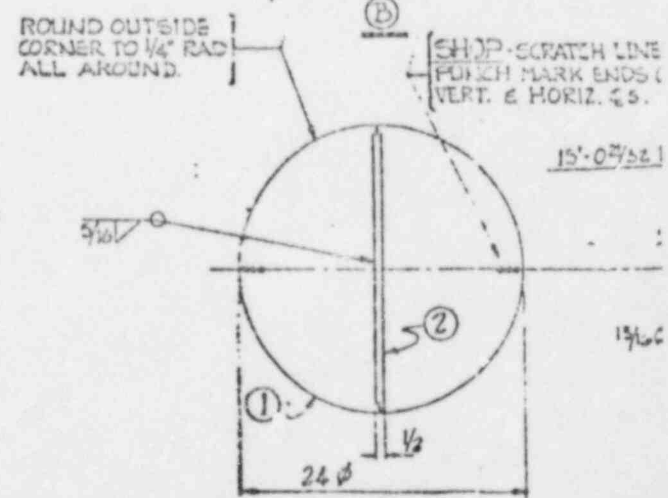

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