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Characterization of Nuclear Reactor Containment Penetrations – Preliminary Report

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CHARACTERIZATION OF NUCLEAR REACTOR CONTAINMENT PENETRATIONS PRELIMINARY REPORT

Sandia Project Officer: C. V. Subramanian

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EXECUTIVE SUMMARY

Argonne National Laboratory (ANL) is currently working on specific tasks in a containment penetration integrity program funded by NRC and managed by the Sandia National Laboratories. The first of these tasks is called "Characterization of Existing Penetration Designs". The objective of this task is to identify those penetrations in nuclear reactor containments which, because of historical data or expected behavior under accident loads, are believed to have a relatively high probability of developing leakage when subjected to temperatures and pressures well beyond the containment design basis values. The ANL program focuses on large, operating-type penetrations -- such as personnel airlocks, equipment hatches, and bellows seals -- and excludes electrical penetration assemblies and valve penetrations. (Sandia is working on electrical penetrations, and EG&G, Inc. at the Idaho Nuclear Engineering Laboratory is studying valve behavior). The penetrations identified under this task are those considered most likely to require both detailed study to determine leakage characteristics, and model and/or large-scale testing to obtain such characteristics.

A comprehensive review of applicable design and shop drawings and other documents for 22 nuclear plants is included in the current survey to characterize the design information and details of construction for the penetrations of interest. (An additional 17 plants are now under review and will be covered in a report to be issued in August 1984). The survey includes all containment types and materials in current use. As expected, based on prior ANL experience, the survey shows that virtually no standardization of penetration design exists. Differences in design make it essential that great care be taken in developing any test program and in selecting specific design characteristics of the test articles, so that the test results can be useful in evaluating the wide spectrum of existing designs.

A penetration may experience increased leakage at loads beyond the design basis by either failure of the seal or gasket, by structural failure of some part of the penetration assembly, or by a combination of both of these. Leakages may occur as the result of relative movements between the mating seal faces, such as opening of the joint gap or by relative rotation of the seal surfaces caused by interaction with the containment shell. An important factor influencing leakage behavior is whether a gasketed joint is pressure-seating or pressure-unseating. The design of the gasket joint geometry and the choice of gasket material are also very important parameters in determining leakage. Some bellows are used to provide for both containment and thermal expansion, such as for a hot pipe penetration. If these bellows are subjected to large axial displacements as could occur by radially outward movement of a steel containment shell under increasing pressure loads, then some concern exists as to possible structural failure of the bellows and possible leakage. Bellows behavior is complex, and testing seems to be necessary to study leakage behavior.

To better evaluate the relative leakage potential for penetrations, a number of figures of merit related to that potential were developed and numerical values of the figures of merit were calculated and compared. The calculations were performed on a microcomputer using a penetration data base generated for that purpose. It is anticipated that eventually the figures of merit can be developed to a point where they will be able to indicate whether

any penetration has higher or lower leakage potential than a penetration that has already been tested, or analyzed in detail, for its leakage characteristics. Descriptions of the figures of merit follow:

Sleeve Wave Lengths. Large containment shell deformation can produce enough load on a penetration sleeve welded to the shell to cause sleeve deformation. When a sealing surface is an integral part of the sleeve (as is the case with many equipment hatches), and within the zone of influence of the shell to sleeve weld (within one "wave length" of the radial load), the sleeve deformation could result in sealing surface separation and seal leakage, even in the case of pressure-seated sealing surfaces. The associated figure of merit is based on the number of wave lengths between shell to sleeve weld and sealing surface (along a sleeve) as compared to the amount of nearby elastic shell strain at design pressure. (Many of the figures of merit have the basis that relative elastic behavior at design pressure is a reasonable indication of relative plastic behavior at fractional overpressure, and practical to use because of its simplicity.)

Cover Strength. Spherical-segment hatch covers pressure-loaded on the convex side are potentially vulnerable to buckling under beyond-design-basis conditions. The associated figure of merit is based on the critical pressure for buckling as compared to the containment design pressure.

Frame Strength. A potential source of leakage results from the inherent greater stiffness of the top and bottom (the short sides) of a rectangular door, as compared to the stiffness of the mating frame members. Under pressure the frame members tend to bend more than the door edges, thus potentially producing seating surface separation and seal leakage, even in the case of pressure-seated sealing surfaces. The maximum elastic deflection of a uniformly loaded beam of uniform cross section at containment design pressure is the basis of the associated figure of merit.

Shear Strength. The amount of steel shear area provided for penetration sleeves anchored in concrete varies widely among penetrations, even when normalized on the basis of sleeve axial load. The associated figure of merit is based on the steel shear area as compared to the sleeve axial load at containment design pressure.

Ring Strength. The height or protrusion extent of anchor rings that are sometimes provided for penetration sleeves anchored in concrete varies widely among penetrations, even when normalized on the basis of potential concrete dilation away from the sleeve. Low ring heights mean that should concrete dilation occur, the shear plane area (in the concrete now unsupported by the sleeve) is smaller than with high ring heights, increasing the concrete shear stresses. The associated figure of merit is based on ring height as compared to nearby elastic radial concrete dilation at design pressure.

Unseating Strength. In the case of pressure-unseating gaskets and seals, the strength of the fasteners is of course important with respect to leakage potential. The associated figure of merit is based on the fastener cross sectional area as compared to unseating load at design pressure. At present it is assumed that the preload stress in all fasteners is the same. The actual preload stress in the field will always be uncertain to some extent, due to variables in such factors as thread lubrication.

Plate Strength. In the case of penetration closures that resemble flat plates, bending of the plates could foster seating surface deformation and consequent seal leakage. The associated figure of merit is based on, and proportional to, the reciprocal of the maximum deflection of a uniformly loaded circular flat plate at design pressure.

Gasket and Seals. Figures of merit in this category were selected by first ranking both geometries (double dog ear, double O-ring, etc.) and gasket materials individually. The figure of merit for a gasket and seal design is taken to be the sum of its geometry and material values. The geometry ranking was based on discussions with vendors and A/Es, and the material ranking was based on a gasket vendor's curves of life vs. temperature.

More, of course, can be done in the area of developing and using broadly acceptable figures of merit for evaluating containment penetration designs; it is believed that the results to date show that the approach is reasonable for ranking leakage potential of penetrations.

A proposed test matrix for seals and gaskets was developed. The matrix is built around the seven key variables: gasket material, material aging, sealing surface geometry, sealing surface roughness, sealing surface deformations, size, and fluid/temperature/pressure loadings. With two values or levels for each variable, except material, the possible number of combinations for testing of each material is 64, but by special treatment the number required can be reduced to 32. The levels recommended for each variable were based primarily on which design features are used most often, as indicated by the results of our characterization to date, on what the exposures encountered in the field are likely to be, and on use of average figure of merit values. The goal was to produce results that will be applicable to as many existing important penetrations as is feasible.

A position regarding which penetrations may be qualified by detailed analysis only was developed. This position is that relatively simple calculations (elastic and, if necessary, inelastic) on an individual containment's penetrations can show that some of its penetrations are highly probable to leak much more than others for any beyond-design-basis situations. In fact, the calculations can show that the former penetrations are acceptably probable to Leak Enough, either to (a) violate environmental limitations or (b) prevent higher containment pressures and temperatures, that the leakage behavior of the latter penetrations is Irrelevant. (In subsequent discussions, these are called Class LE and Class IR penetrations.) The Class IR penetrations are those which can be predicted, by relatively simple analysis alone, to have no potential to leak. (Regarding violation of environmental limitations, specifically on radioactivity releases under beyond-design-basis conditions, the specification of such limitations is, by necessity, expected to proceed at a pace compatible with that of the analyses described here.)

Typical Class IR penetrations are those with no gaskets, seals, bellows, or, in the case of piping penetrations, close-coupled piping restraints. Another example is a BWR Mark I control rod drive removal hatch which is enormously stronger than the suppression chamber access hatch in the same containment.

It is planned to test typical Class LE penetrations, of which equipment hatches are a prime example. Other similar penetrations that have all higher figures of merit would be expected to have lower leakage rates than the test articles, and vice versa. This information should be sufficient to allow releasing some additional Class LE-type penetrations from the need for testing.

Finally, if proposed pre-test analytical ("first principles") predictions of leakage rates, to be measured in future penetration and seal tests, are accurate within an expected error band, which can be "large", then it can be concluded that from that point the determination of a penetration's leakage behavior can be done as accurately by analysis as by test. Certainly, the first-principles analysis approach offers a more economic path to attaching precision indices (e.g. standard deviation) to leakage rates than does testing of complete penetrations.

A proposed test matrix given in this report covers penetrations to be tested, their relative priority in terms of leakage potential, suggested size and type of test articles, and the type and number of tests to be conducted. These tests are necessary to establish, for specified penetration designs, leakage behavior characteristics which may be used to evaluate leakage behavior in other types of penetration designs. This would then permit a rational assessment of the overall leakage behavior of a particular containment subjected to loads beyond the design basis. To help develop the test matrix, the figures of merit analysis developed in this study plus qualitative evaluations were used. The suggested penetrations to be tested, listed in decreasing order of priority, are:

- BWR Drywell Top Head (Bolted-Type)
- Pressure-Unseating Equipment Hatch
- Bellows Seal Joints
- Personnel Airlock with Non-Pressure Seating Seals (Inflatable Seals)
- Pressure-Seating Equipment Hatch
- Personnel Airlock with Pressure-Seating Seals.

I. INTRODUCTION

Argonne National Laboratory (ANL) is currently performing work on leakage and structural behavior of penetrations in nuclear reactor containment structures, when such structures are subjected to pressure and thermal loads beyond the design basis. This work is being managed by the Sandia National Laboratories, under Federal Agency Order, Document No. 47-5594 of August 19, 1983. The overall containment program is funded by the NRC under FIN No. A1375. Not all penetrations are included in this work; specifically excluded are valves and electrical penetration assemblies. This work concentrates on large major penetrations which generally employ some type of seal or gasketed joint, such as airlocks and equipment hatches. Also included are some bellows sealed joints, and some pipe penetrations.

The ANL program consists of three tasks:
Task 1 - Survey of Penetrations in Existing Containment Structures
Task 2 - Structural Analysis of Selected Penetrations (pressure-seating, pressure-unseating, and bellows)
Task 3 - Survey and Evaluation of Existing Test Facilities

This is a report on the work performed in Task 1 - Characterization of Existing Penetration Designs, and includes the evaluation of plant-specific data compiled from a detailed survey of 22 nuclear power plants. The current study reported here includes both PWR and BWR plants, and includes steel, reinforced concrete, and prestressed concrete containment structures. An additional 17 plants will be reviewed, characterized, and included in a subsequent formal report to be issued by August 15, 1984. (Tasks 2 and 3 cited above will be reported separately by May 1984.)

The main objectives of Task 1 of the ANL program include an evaluation of the existing penetration designs to determine what tests are required on seals, gaskets, and penetration assemblies to enable NRC, designers, and plant owners to evaluate leakage characteristics of a specific nuclear power plant. In addition, an evaluation is made to determine which penetrations can be adequately characterized on the basis of analysis alone, rather than by test, in order to obtain leakage and/or structural behavior.

To aid the evaluations, figures of merit related to leakage potential were developed, calculated or estimated, and compared. Many of the figures of merit have the basis that relative elastic behavior at containment design pressure is a reasonable indication of relative plastic behavior at fractional overpressure, and practical to use because of its simplicity. This basis is weak when there is no constant ratio between anticipated beyond-design-basis-accident equivalent* pressures and containment design pressures. A proposed method to compensate for this weakness is described.

II. SUMMARY OF PLANTS INCLUDED IN PRESENT SURVEY

This report includes a survey of 22 nuclear power plants. Table 1 is a summary of the plants surveyed to date, and includes plant type, type of con-

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*Modified by temperature, radiation, etc.

Table 1. Summary of Types of Containments Surveyed

Architect-Engineer	Equipment Supplier	Plant Type (No. of Plants)	Containment Type(1)
Bechtel	Southern Boiler Industries (SBI)	PWR(2)	Prestressed Concrete
	Woolley (W), and Chicago Bridge and Iron (CBI)	BWR Mark I(1)	Steel
Ebasco	CBI	PWR(4)	Steel
Fluor-Pioneer	CBI	PWR(3)	Steel
Gibbs and Hill	CBI	PWR(1)	Reinforced Concrete
Sargent and Lundy	CBI	PWR(5)	Prestressed Concrete
		BWR Mark I(2)	Steel
		BWR Mark II(3)	Prestressed Concrete
		BWR Mark III(1)	Reinforced Concrete

(1)From Ref. [1].

Table 2. Containment Design Conditions

Unit #*	Type Plant	Type Containment	Dia. ft	Wall Thickness Concrete	Wall Thickness Steel	Pressure psig	Temp. °F
1	PWR	Steel	140	--	2"	44	264
2	PWR	Steel	140	--	2"	44	264
3	PWR	Steel	150	--	2-1/16"	[illegible]	257
4	PWR	Steel	140	--	1.9"	44	267
5	PWR	Steel	105	--	1.5"	41.4	268
6	PWR	Steel	105	--	1.5"	41.4	268
7	PWR	Steel	105	--	1.5"	41.4	268
1	PWR	Concrete/Liner	140	3'-6"	1/4" (liner)	47	250
2	PWR	Concrete/Liner	140	3'-6"	1/4"	47	250
3	PWR	Concrete/Liner	140	3'-6"	1/4"	50	--
4	PWR	Concrete/Liner	140	3'-6"	1/4"	50	--
5	PWR	Concrete/Liner	140	3'-6"	1/4"	50	--
6	PWR	Concrete/Liner	140	3'-6"	1/4"	50	--
7	PWR	Concrete/Liner	140	3'-6"	1/4"	50	--
8	PWR	Concrete/Liner	140	3'-6"	1/4"	50	--
9	BWR III	Concrete/Liner	124	3'-0"	1/4"	15	185
10	PWR	Concrete/Liner	135	4'-6"	3/8"	50	280
11	PWR	Concrete/Liner	135	4'-6"	3/8"	50	280
12	PWR	Concrete/Liner	116	3'-6"	1/4"	70	297
13	PWR	Concrete/Liner	116	3'-6"	1/4"	70	297
14	PWR	Concrete/Liner	116	3'-6"	1/4"	55	283
1	BWR I	Steel	63	--	3/4"	56	281
2	BWR I	Steel	66	--	13/16"-1-1/16"	56	281
3	BWR I	Steel	66	--	13/16"-1-1/16"	56	281
1	BWR II	Concrete/Liner	--	--	--	--	--
2	BWR II	Concrete/Liner	--	--	--	--	--

*As can be seen, the first seven numbers refer to PWR steel containments and the next 14 numbers refer to PWR and BWR Mark III concrete containments with steel liners, etc.

tainment, and combinations of architect-engineers (A/Es) and major penetration suppliers involved in the survey. Table 2 contains additional information on containment material (steel, concrete), design pressure, and other data. Summary data sheets and penetration design details for these plants are given in Appendix A of this report. It should be noted that the details are given in a coded numerical system, which is used to eliminate the need to identify specific plants for each detail. This approach was used since we are not interested in a given plant's details, only in the fact that such a plant exists and the details of the penetrations are characterized.

The survey was conducted by a study of the plant FSAR (where readily available) followed by a personal visit to the designer of the facility. Written permission to use the plant specific data (in the format described in the preceding paragraph) was obtained from either the plant owner, designer, or both. Detailed discussions were held with the plant and equipment designers to gain insight into design philosophy and detailed design approaches. Copies of pertinent drawings were then obtained and used to generate the details shown in Appendix A. The ANL sketches were sent back to the appropriate designers for review to assure that these sketches accurately depicted their designs. The cooperation of all parties involved was excellent and contributed to the completeness of the information obtained.

One important, and not unexpected, result of the survey is that there is virtually no standardization of penetration designs. There may even be variations in equipment designed by a single supplier reflecting design improvements which have evolved over time. Also, for concrete containments in particular, the structural load paths between the building liner and penetration sleeves vary considerably. The manner in which the penetration sleeve (or barrel) is anchored in the concrete containment wall also varies from design to design. These differences make it difficult to develop generic designs of test articles. However, it is believed that careful selection of test article features can result in meaningful test results to which any given penetration design can be compared to estimate its leakage behavior.

III. POTENTIAL LEAK BEHAVIOR OF THE PENETRATIONS

A. General Discussion

A given penetration may develop increased leakage (at pressures and temperatures beyond the design basis) by either failure of the seal or gasket to retain their original leak tightness, or actual structural failure of some part of the penetration assembly (e.g., a structural crack or tear of a welded joint or in a bellows), or by a combination of both of these. Leakages may increase in gasketed joints as a result of relative movements between mating seal faces, such as opening of the joint gap or by relative rotation of the seal surfaces caused by interaction with the containment structure displacements. Obviously, leakage behavior will also be a function of whether the gasketed joint tends to be pressure-seating or pressure unseating.

It is interesting to note that even for pressure-seating penetrations (e.g., personnel airlock doors, and equipment hatches) increasing pressure beyond the containment design pressure will probably result in increased leakage. This is because there is almost always a growing mismatch between the mating seal faces as building pressure increases. For example, in the case of a personnel airlock the door itself tends to deflect less than the corresponding part of the door frame located in the penetration bulkhead, thus creating an opening in the joint at the midspan of the door edges. Another example was found during the structural analyses of an equipment hatch penetration. In the latter example, it was observed that significant relative rotation and sliding may occur between mating seal faces. This latter effect depends upon many things and is discussed later in Section IV., Figure of Merit Analyses.

It must be borne in mind when interpreting statements made in this report that what is being discussed is the potential behavior of a penetration, and its seal, under loading conditions which exceed considerably the design basis, and which results in much greater strains and displacements than those that occur at design conditions. From all of this we see that the potential for increased leakage at any penetration will depend on the gasket design and gasket material, the interaction between the various structural parts of the penetration assembly, and the degree to which the containment structure's behavior is reflected at the sealed joint of the penetrations.

Considering all of the preceding discussion it is possible to gain insights into the possible potential leakage behavior of any given penetration assembly. A qualitative discussion of possible leakage-failure modes for the major penetrations is next presented in Section III.B. Later, in Section IV., Figures of Merit Analyses, a quantitative approach is developed to supplement these subjective discussions.

B. Potential Leakage

1. Personnel airlocks

Most of the personnel airlock assemblies observed are attached to the containment structure with considerable distance between this attachment and the actual door-to-bulkhead seal faces. Thus, in general, the major contributor to leakage in a personnel airlock is expected to be caused by mismatches in deflections between the airlock door and the bulkhead caused by increasing containment pressures. Another mode of gasket joint separation may be possible up turning at the corners of the door due to its flatslab bending action.

Another important factor in potential airlock leakage is the type of gasket joint used. Some of the airlocks use inflated double seals, although most of later designs employ a double "dog-ear" seal or a double tongue and groove design. It is believed that the inflatable seals will develop increased leakage at pressures less than that required for the double tongue and groove seal design. Recently postulated severe accident pressures are much greater than those considered in the design or experienced in actual testing of any of these sealed joints. Thus, it is not possible to predict the corresponding leakage rates without performing some full-size (or large scale) tests. Later in this report such tests are recommended to be performed on parts of an actual personnel airlock assembly.

It also must be noted that personnel airlock doors are usually subjected to several "open-close" cycles during the life of any given gasket used. The effects of such "aging" can only be evaluated by appropriate testing using seal material removed from actual in-service use. Some earlier personnel airlocks were constructed with a single tongue and groove seal. This latter seal is considered to be among the least effective of all those in use. The leakage past shaft seals is also a source of concern and should be determined by test.

2. Pressure-unseating penetrations

There are two types of pressure-unseating penetrations of concern: (1) the drywell top head closure for BWRs; and (2) some equipment hatch covers located such that pressure tends to open the gasketed-joint. In either case the internal containment pressure loading tends to unseat the tongue in sealing contact with the gasket. In addition, rotations of the seal surface occur from stress deflection and the eccentric "pull" of the bolts. These two effects combine to produce a potential source of leakage at the sealing surface. The metal-to-metal contact of the mating parts combined with prestress in the bolts is employed to counteract the unseating pressure. Scoping analysis performed on a selected BWR drywell top head design shows that the specified bolt preload effect (on keeping the joint closed) is overcome at roughly the containment design pressure. At that point, very little leakage is expected; however at higher pressures the gasket joint gap will increase with a corresponding increase in potential leakage. Because of the large size of this closure head the length of the potential leakage path is great and represents an area of concern. (Increasing the bolt prestress, of course, is one way to reduce this potential leakage source).

3. Pressure-seating penetrations

Most of the large equipment hatch penetrations are positioned such that increases in the containment pressure tends to seat the hatch cover more tightly on the gasket. There are two possible structural behavior modes, however, which might be a cause for increased potential for leakage at such penetrations. The first is the possibility of relative rotation and radial sliding between the seal mating surfaces. This effect is strongly influenced by how close the penetration sleeve seal surface is positioned relative to the containment shell. If this surface is not placed sufficiently far away from the shell (a characteristic wave-length) then considerable rotation might occur with accompanying increased leakage potential. The second effect is that of buckling of the hatch cover itself. Though it appears that designs provide adequate margin against such buckling for design pressures it is important to check any particular design to assure that sufficient margin exists for beyond design basis loads. (Currently, NRC is funding work at Ames Laboratory and Los Alamos National Laboratory to investigate the potential for such buckling.)

4. Expansion bellows' seals

Although there are many places where bellows are used, not all of these are part of the containment boundary. Furthermore, many bellows cannot be subjected to significant axial compression (or tension) during the overpressurization of containment. There are some cases, however, where the use of bellows may be a source of potential leakage. Such cases include the bellows seal units used on a steel containment main steam line penetration. The pipe is anchored to the concrete shield wall which might be 2 ft or more away from the steel containment shell. The bellows (there may be 2 or more used in series) are used to seal the containment shell to the hot steam pipes. When the containment shell is overpressurized it may grow radially outward several inches. Scoping calculations suggest the possibility of failure of the bellows at a compression of about 6 inches, leading to a potential leakage path through any structural break in the bellows. Prediction of structural failure of bellows is very difficult. Predicting the amount of leakage would be even more difficult. It seems prudent, therefore, to include such elements in the suggested penetration test program. Bellows used in fuel transfer tubes are still under study and will be covered in future reports.

IV. FIGURE OF MERIT ANALYSES

Nomenclature

Symbol	Description	Units
A	Effective area	in.^{2}
A_{sh}	Shear area	in.^{2}
D	Shell ID	ft
d	Sleeve diam.	in.
d'	Reinforcing ring OD	in.
E	Modulus of elasticity	lb_F/in.^{2}
e	Strain	---
F'	Load per unit length	lb_F/in.
f	Fraction of steel in area	---
H	Rectangular door height	in.
h	Anchor ring height	in.
I	Moment of inertia	in.^{4}
ℓ	Beam length	in.
ℓ_i	Sleeve segment length	in.
n	No. of wave lengths	---
P	Containment design pressure	lb_F/in.^{2} gage
P_c	Critical pressure	lb_F/in.^{2} gage
P_{SA}	Severe accident equivalent pressure	lb_F/in.^{2} gage
R	Effective radius, spherical radius	in.
r_i	Sleeve segment radius (d/2)	in.
t'	Reinforcing ring thickness	ft
t_c	Cover thickness	in.
t_i	Sleeve segment thickness	in.
W	Effective width of beam for estimating load	in.

Penetration Identification Symbols

$X_1X_2X_3X_4$ represents the four-character symbol.

X_1

A - Hatch with airlock
C - Drywell access hatch
E - Equipment hatch
H - Drywell head

X_2 (Type of Containment)

B - BWR I
P - Prestressed concrete
R - Reinforced concrete
S - Steel

Nomenclature (Contd.)

X_1 (Contd.)

L - Escape lock
P - Personnel lock
R - Rod removal
S - Suppression chamber access

X_3X_4

Unit No.
(Steel, concrete, or Mk I containment)

To better evaluate the relative leakage potential for penetrations, eight figures of merit related to that potential were developed and numerical values of the figures of merit were calculated or estimated and compared. The first seven figures of merit are based on structural behavior while the eighth relates to gasket and seal geometry and materials. The calculations were performed on a microcomputer using a penetration data base generated for that purpose. It is anticipated that eventually the figures of merit can be developed to a point where they will be able to indicate whether any penetration has higher or lower leakage potential than a penetration that has already been tested, or analyzed in detail, for its leakage characteristics.

Many of the figures of merit have the basis that relative elastic behavior at containment design pressure is a reasonable indication of relative plastic behavior at fractional overpressure, and practical to use because of its simplicity. This basis is weak when there is no constant ratio between anticipated beyond-design-basis-accident equivalent* pressures P_{SA} and containment design pressures P. To compensate for this weakness, as a first approximation it is suggested that the present relevant figures of merit be multiplied by P/P_{SA}, which is essentially the same as using beyond-design-basis-accident equivalent pressures in the figure of merit formulations instead of design pressures.

No calculations of figures of merit have been made to date for containment penetrations in BWR Mk I Units 2 and 3 and BWR Mk II Units 1 and 2. These data will be included in a subsequent report scheduled for completion in August 1984.

Descriptions of the figures of merit follow:

A. Sleeve Wave Lengths

As discussed in Ref. [2], large containment shell deformation can produce enough load on a penetration sleeve welded to the shell to cause sleeve deformation. When a sealing surface is an integral part of the sleeve (as is the case with many equipment hatches), and within the zone of influence of the shell to sleeve weld (within one "wave length" of the radial load), the sleeve

*Modified by temperature, radiation, etc.

deformation could result in sealing surface separation and seal leakage, even in the case of pressure-seated sealing surfaces.

The associated figure of merit is based on the number of wave lengths between shell to sleeve weld and sealing surface (along a sleeve) as compared to the amount of nearby elastic shell strain at design pressure. With regard to shell strain (Ref. [3]), the design load per unit equivalent circumferential length on the reinforcing ring is:

$$F' = 12\ PD/2$$

Nominal hoop strain of the ring is

$$e = F'R/(AE)$$

$$R \sim (d + d')/4$$

$$A \sim 12\ ft'(d' - d)/2$$

where f is 1 for steel containment and currently assum 0.01 for concrete containments. Eventually, actual f values for each concrete containment will be used. Thus

$$e = PD(d + d')/(4\ ft'(d' - d)E)$$

With respect to number of wave lengths, one wave length equals the textbook value 1.83 $(r_i t_i)^{0.5}$; thus

$$n = (\ell_i/(r_i t_i)^{0.5})$$

where the summation accounts for sleeve dimension variations between containment shell and sealing surface. The figure of merit is

$$F_1 \propto n/e$$

$$F_1 = (\Sigma(\ell_i/(r_i t_i)^{0.5}))ft'(d'-d)/(PD(d'+d))$$

Even though the amount of shell strain at design pressure may be trivial, it is considered to be a reasonable normalization factor for indicating the relative effect of fractional overpressure on shell strain. Also, as stated above, relative elastic behavior is considered to be a reasonable indication of relative plastic behavior.

Table 3 gives the F_1 values for penetrations evaluated. The F_1 values for steel containment penetrations in general are not comparable with those for concrete containment penetrations, because the reinforcing ring in steel containment is anchored much more securely to the sleeve than in the case of concrete containment. For the relevant steel containment penetrations the steel Unit 5 equipment hatch has the highest value and the Mk I Unit 1 hatch has the lowest value. This variation is at least partly because the former hatch has more than 2 ft of sleeve length between shell and sealing surface whereas the latter has less than a third of that distance, at least locally. Thus, the latter is judged to have the greatest leakage potential with respect to sleeve rotation, in the steel containment category.

For the concrete containment penetrations, the Unit 9 equipment hatch has

Table 3. Figures of Merit: Sleeve Rotation

Penetration	$F_1 \times 10^6$
Steel Containment	
ES05*	0.179
ES01	0.158
ES02	0.100
ES03	0.089
ES04	0.055
EB01	0.033
Concrete Containment	
ER09	0.078
PR10	0.070
ER10	0.030
EP01	0.028
EP03	0.026
EP12	0.014

*See Nomenclature for penetration identification symbols.

Table 4. Figures of Merit: Cover Buckling

Penetration	$F_2 \times 10^7$
EB01	123.7
ER09	14.3
EP14	7.7
ES05	7.5
PR10	7.1
ER10	6.9
EP12	6.3
ES01	6.2
ES02	6.2
ES03	6.2
ES04	6.2

the highest value and the Unit 12 hatch has the lowest. Again, this is at least partly because the former has 1-1/2 ft of sleeve length between wall and sealing surface while the latter has less than a third of that distance.

B. Cover Strength

The critical pressure for buckling of a spherical-segment cover pressure-loaded on the convex side is discussed in Ref. [2]. Buckling, at a minimum, could cause sealing surface rotation and leakage. The associated figure of merit is based on the critical pressure as compared to the containment design pressure:

$$F_2 \propto P_c/P$$

$$F_2 = (t_c/R)^2/P$$

Again, design pressure is considered to be a reasonable normalization factor for indicating the relative effect of fractional overpressure on leakage potential.

Table 4 gives the F_2 values for penetrations evaluated. For the penetrations with spherical-segment covers, the Mk I Unit 1 equipment hatch has the highest value and the steel Units 1-4 hatches have the lowest value. This variation is primarily because the former's cover is four times thicker than the latters' covers. The latter hatches are judged to have the greatest leakage potential with respect to cover buckling.

C. Frame Strength

A potential source of leakage results from the inherent greater stiffness of the top and bottom (the short sides) of a rectangular door, as compared to the stiffness of the mating frame members. Under pressure the frame members tend to bend more than the door edges, thus potentially producing sealing surface separation and seal leakage, even in the case of pressure-seated sealing surfaces (Ref. [4]).

The maximum elastic deflection of a uniformly loaded beam of uniform cross section is proportional to, regardless of the end conditions,

$$y \propto PW\ell^4/I$$

This term was the basis for the figure of merit for frame strength:

$$F_3 = I/PW\ell^4$$

where P is the containment design pressure, W is the effective width of the area the frame is supporting (taken to be the distance between middle of door top and sleeve), ℓ is frame length $(2(((d/2)^2 - (H/2)^2)^{0.5}))$, and I is the frame's moment of inertia about its neutral axis calculated by assuming the bulkhead has an effective width of W/2 (bulkhead contribution is small in any event). Even though many escape locks have round rather than rectangular doors, a similar approach was used to evaluate their bulkhead stiffeners. For rectangular doors, when the sealing surface extended beyond the bulkhead, the extending steel was assumed to contribute to I over the entire beam length.

Table 5. Figures of Merit: Frame Stiffness

Penetration	$F_3 \times 10^8$	Penetration	$F_3 \times 10^8$
PR09	8.6	LS05	1.6
LR09	8.6	LS02	1.3
PS02	7.9	LS01	1.3
P[illegible]03	7.8	PS05	1.2
PS01	4.6	PS07	1.2
PS04	2.0	LS03	1.1
PP03	1.9	LS04	1.0
LP03	1.8	PP01	0.7

Table 6. Figures of Merit: Sleeve-anchor Shear

Penetration	$F_4 \times 10^4$
EP12	21.0
LR09	15.9
PR09	15.9
ER09	14.6
LR10	13.1
LP12	12.5
ER10	9.6
PR10	8.3
LP01	7.3
PP12	7.1
LP03	5.1
EP03	2.8
EP01	2.4

Table 5 gives the F_3 values for penetrations evaluated. The concrete Unit 9 personnel and escape locks have the highest value and the concrete Unit 1 personnel lock has the lowest value. This variation is primarily because the beam flange(s) are wider, and the web longer, for the former than for the latter, even though the containment design pressure of the former is less than a third that of the latter. The latter, being less stiff and having a greater design pressure, is expected to have the greatest leakage potential with respect to frame stiffness. Some relevant penetrations are not included in Table 3 because some details of bulkhead stiffening still remain to be collected.

D. Shear Strength

The amount of steel shear area provided for penetration sleeves anchored in concrete varies widely among penetrations, even when normalized on the basis of sleeve axial load. The associated figure of merit is based on the steel shear area as compared to the sleeve axial load at containment design pressure:

$$F_4 \propto A_{sh}/(\pi d^2 P/4)$$

$$F_4 = A_{sh}/(d^2 P)$$

No credit is given here for the steel shear area associated with the bevel that is found on many sleeves. The bevel tapers are typically shallow; any concrete dilation or separation from the sleeve would allow failure strains to occur in the sleeve-liner connection before concrete support of the bevel surface could occur.

Table 6 gives the F_4 values for penetrations evaluated. For the relevant concrete containment penetrations the Unit 12 equipment hatch has the highest value and the Unit 1 hatch has the lowest value. This variation is primarily because the former has a "sealing-surface-sleeve-stub", with an OD that is significantly larger than the concrete opening ID, butted against the reinforcing ring, so that the length of the stub contributes to the steel area. On the other hand, the Unit 1 hatch has a larger diameter sleeve, without the stub feature, a thinner reinforcing ring, and its anchor straps are not equivalent to the Unit 12 hatch anchor rings. The latter hatch is believed to have the greatest leakage potential with respect to sleeve-anchor shear.

The Unit 14 penetrations were excluded from this evaluation because they have unique design(s) that appear to have relatively high resistance to sleeve-anchor shear.

E. Ring Strength

The height or protrusion extent of anchor rings that are sometimes provided for penetration sleeves anchored in concrete varies widely among penetrations, even when normalized on the basis of potential concrete dilation away from the sleeve (zero anchor ring height is the extreme value of that dimension). Low ring heights mean that should concrete dilation occur, the shear plane area (in the concrete now unsupported by the sleeve) is smaller than with high ring heights, increasing the concrete shear stresses. The associated figure of merit is based on ring height as compared to radial corcrete dilation at design pressure:

$$\text{Dilation} = de/2$$

where e is the hoop strain described under figure of merit F_1.

$$F_5 \propto h/\text{Dilation}$$

$$F_5 = hft'(d' - d)/(PDd(d' + d))$$

Table 7 gives the F_5 values for penetrations evaluated. For the relevant concrete containment penetrations the Unit 12 emergency lock has the highest value and the Unit 3 equipment hatch has the lowest value. This variation is because the former has rings almost three times as high as the latter, on a sleeve diameter less than one third as great as the latter. The latter hatch probably has the greatest leakage potential with respect to concrete shear failure and resultant liner tear. However, note that both F_4 and F_5 values are related with respect to sleeve "blowout" and their mutual effects must be considered. In this regard, it is of interest that both F_4 and F_5 values are high for the Unit 12 emergency lock and low for the Unit 3 equipment hatch. Also, note that F_5 assumes concrete shear is more likely than ring bending failure.

F. Unseating Strength

In the case of pressure-unseating gaskets and seals, the strength of the fasteners is of course important with respect to leakage potential. The associated figure of merit is based on the fastener cross sectional area as compared to unseating load at design pressure. At present it is assumed that the preload stress in all fasteners is the same. The actual preload stress in the field will always be uncertain to some extent, due to variables in such factors as thread lubrication.

$$F_6 \propto A/(P\pi d^2/4)$$

$$F_6 = A/(Pd^2)$$

Table 8 gives F_6 values for penetrations evaluated. The BWR Mk I Unit 1 rod removal hatch has the highest value and the Mk I Unit 1 drywell head has the lowest value. This variation is because the former has more than 1/4 the fastener cross sectional area of the latter and only about 1/15 the opening diameter of the latter. The latter should have the greatest leakage potential due to seating surface separation, provided the preload stress in the fasteners is of the same order of magnitude.

G. Plate Strength

In the case of penetration closures that resemble flat plates, bending of the plates could foster sealing surface deformation and consequent seal leakage. The associated figure of merit is based on, and proportional to, the reciprocal of the maximum deflection of a uniformly loaded circular flat plate at design pressure, regardless of the edge conditions:

$$F_7 = t^3/Pd^4$$

Table 7. Figures of Merit: Concrete Shear

Penetration	$F_5 \times 10^8$
LP12	24.0
PP12	13.7
EP12	11.8
ER09	7.0
ER10	5.3
LP03	2.6
EP03	1.9

Table 8. Figures of Merit: Unseating Strength

Penetration	$F_6 \times 10^3$
RB01	2.24
PR10	1.16
CB01	0.15
SB01	0.07
HB01	0.04

Table 9 gives F_7 values for relevant penetrations evaluated. The BRW Mk I Unit 1 access hatch has the highest value and the Mk I Unit 1 suppression chamber access hatch has the lowest value. This variation is because the former's closure plate is almost as thick as the latter's while its bolt circle diameter is less than 60 percent of the latter's. The latter should have the greatest leakage potential with respect to plate bending.

H. Gaskets and Seals

Based on discussions with vendors and A/Es, proposed figures of merit F_{8G} for gasket and seal geometries are given in Table 10. These figures are consistent with the evolution of these geometries. Based on the Parker curves for material life vs. temperature (Ref. [5]), proposed figures of merit F_{8M} for gasket and seal materials are also given in Table 10.

For each penetration, it is proposed that the combined figure of merit for gasket and seal design be the sum of the figures of merit for geometry and for material:

$$F_8 = F_{8G} + F_{8M}$$

In the future it is planned to make $F_{8M} = F_{8T} + F_{8R}$, where F_{8T} is the figure of merit for material resistance to temperature and F_{8R} is for resistance to radiation.

Values of F_8 are likewise given in Table 10. The penetrations with question marks, except for PS03 and LS03, were assigned an F_{8M} of 1 because their gaskets were "unspecified rubber". (See the synopsis of Table 11). If that unspecified rubber should be silicone rubber the F_8 values would increase by 5 points. PS03 and LS03 have gaskets specified as neoprene or butyl (Table 11); because the Parker curves do not address butyl, the neoprene value for F_{8M} was used.

The many units in Table 10 having F_8 values of 12 have double tongue and groove geometries and silicone rubber gaskets, whereas the prestressed concrete Unit 12 personnel lock's F_8 value of 2 results from its use of an inflatable seal of unspecified rubber.

Closing Remarks

This section is not expected to constitute the final word on suitable figures of merit for penetration leakage potential evaluation. In the categories considered there are probably other expressions that other analysts would prefer, and of course there are many other categories for which suitable expressions can be developed. Nevertheless, it is believed that the figures of merit given here are adequate to show relative strengths and weaknesses of many important penetration features, and they emphasize the wide variations that exist in the field.

Finally, the wide scatter in figure-of-merit values here deserves some discussion. First, we are taking it for granted that all the penetrations, including those that have low figures of merit, met all code and regulatory requirements at the time of construction. The situation that some penetrations have larger figures of merit can be attributed to regulatory requirements being different at the times the different plants were built, to design evolution, and to other miscellaneous factors.

Table 9. Figures of Merit: Plate Strength

Penetration	$F_7 \times 10^8$
CB01	11.8
LP12	2.0
SB01	2.0

Table 10. Figures of Merit: Gasket and Seal Design

Geometry	Example	F_{8G}	F_{8M}
Double Tongue and Groove	EP01	6	
Double O-ring	EP12	5	
Double Dog Ear	PP03	4	
Double Gum Drop	EP03	3	
Single Tongue and Groove	PB01	2	
Inflatable	PP12	1	
Material			
Silicone Rubber			6
Fluoroelastomer			5
Ethylene Propylene			4
Neoprene			3
Nitrile (High Temp. Type)			2
Nitrile (Low Temp. Type)			1

Penetration	F_8	Penetration	F_8	Penetration	F_8
EP01	12	PP03	10	ES02	9
PP01	12	LP03	10	ES03	9
LP01	12	PR09	10	ES04	9
LS01	12	LR09	10	AB01	9
ES05	12	PR10	10	PP14	7?
PS05	12	LR10	10	LP14	7?
LS05	12	PS01	10	PS03	7?
ES07	12	PS02	10	LS03	7?
PS07	12	LS02	10	PB01	7?
LS07	12	PS04	10	EP12	6?
HB01	12	LS04	10	LP12	6?
EB01	12	EP03	9	EP14	6?
CB01	12	ER09	9	PP12	2?
SB01	12	ER10	9		
RB01	11	ES01	9		

V. PROPOSED TEST MATRIX FOR SEALS AND GASKETS

The purpose of seal and gasket tests, separate from complete penetration tests, is to allow economic experimental determination of the effects of many variables on leakage rates. The major variables are gasket material, aging, sealing surface geometry (including surface finish), sealing surface deformations, fluid/temperature/pressure loading, and size. Doing these tests on a relatively small circumferential scale, as with the Sandia 36 in. ID, 84 in. potential height, 40 ft^3 potential-volume chamber, allows tests of numerous combinations of the variables at realistic cost. The seal and gasket dimensions would be full scale in the radial direction.

Due to the many (six) variables for each material tested, it is proposed that they be treated as in "Experiment E" of Ref. [6]. To do that requires selecting two "levels" for each variable (except material), as follows:

1. Aging (A). New-condition is proposed for one level and the second level is left for Sandia selection on the basis of their studies of severe accident scenarios.

2. Sealing surface geometry (G). Table 11 gives a synopsis of gasket and seal materials and geometries used in the penetrations described herein. The two most popular geometries are double tongue and groove and double dog ear; these are proposed for the two levels of this variable to gain widest possible application of results. The former geometry is used 5 times out of 16 (a majority) in escape locks; therefore, it is proposed that such dimensions, as in LP01 (which uses unspecified silicone rubber gaskets), are used. The latter geometry is used 7 times out of 13 in personnel locks; therefore, it is proposed that such dimensions, as in PR09 (which uses MS577 gaskets), are used. Use of double dog ear is consistent with using average figure of merit values in tests, see Section VI.B.

3. Surface finish (F): It is proposed that values, to cover a realistic wide range, one level be the value specified for the geometry selected (i.e., LP01 or PR09) and the second level be based on some check measurements made in the field on older plants. (Ref. [7] dramatizes the importance of surface finish to leakage rates.)

4. Sealing surface deformations (D): It is proposed that one level be uniform sealing surface separation of 0.05 in., Fig. 1(a), and the second level be an undulation, with 0.08 in. peak separation, of the "smooth" sealing surface, in simulation of door frame bending, Fig. 1(b). These deformations are consistent with reasonable results given in Refs. [2] and [5]. These deformations are maintained constant during a pressure loading history through use of relatively strong fasteners and spacers.

Table 11. Synopsis of Gasket Usage

Material	No. of Penetrations
Silicone Rubber	
Unspecified	15
MS556B (Garlock #8364)*	7
MS572	3
MS577	8
MS579	1
5418-6 (Parker #5170)	1
Subtotal	35
Unspecified Rubber	6
Neoprene or Butyl	2
Total	43
<u>Geometry</u>	
Double Tongue and Groove	16
Gumdrop	8
Double Dog Ear	13
Double O-ring	4
Single Tongue and Groove	1
Inflatable	1
Total	43

*Numbers preceded by "MS" refer to CB&I materials specifications.

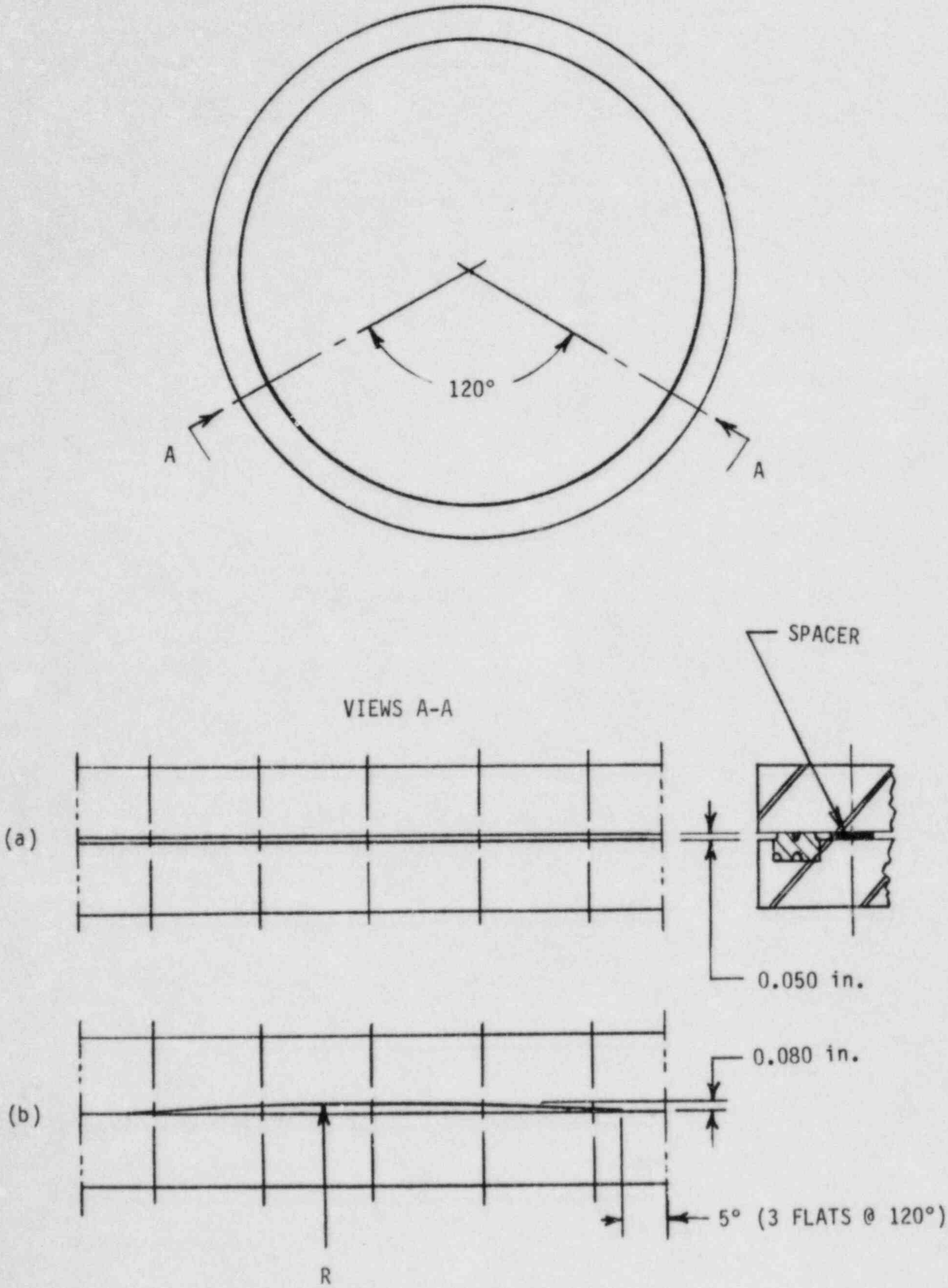

Fig. 1 Proposed Sealing Surface Deformations

5. Fluid/pressure/temperature loading (L). These two levels are left for Sandia selection on the basis of their studies of severe accident scenarios.

6. Size (S): As stated above, all seal and gasket tests are to be full scale in the radial direction. In the circumferential direction, it is proposed that one level of this variable be the largest circumference that can fit with ease in the Sandia test chamber, and the second level be a circumference one half of the first-level value.

The proposed test matrix is given in Table 12. As can be seen, 32 tests are required for each material investigated. As tests are completed, the value of the proposed matrix must be continually evaluated. For example, if a variable is found to have negligible effect on leakage rate, then a smaller matrix that does not include that variable should be developed. On the other hand, if a variable is seen to have a non-linear effect on leakage rate, then it would be advisable to develop a matrix that allows more than two levels of that variable.

The Table 12 matrix does not address inflatable seals, primarily because our penetration data to date disclose only one penetration (PP12) that uses such a seal. Because there actually are quite a few inflatable seals in the field, and because they are widely considered to have relatively poor resistance against severe accident conditions, a separate but similar test matrix could be considered for them. This would involve introducing an additional variable, seal inflation pressure, as well as procuring quite different test hardware than would be used for the Table 12 test matrix. This consideration should take into account the large scale penetration tests, Section VI, that involve inflatable seals.

To be consistent in the use of average figure of merit values in tests, one of the gasket materials tested should be ethylene propylene (Table 10). According to Table 11, this material does not enjoy wide usage. However, we have learned the widely used MS5/7 material, Table 11, is no longer available and that an ethylene propylene compound is being used as a replacement material.

VI. PROPOSED TEST MATRIX FOR MAJOR PENETRATIONS

A. General

This section presents a suggested program for the testing and detailed data analysis of large-scale models or full-size assemblies of major penetrations possibly having a potential for developing significant leakage or structural failure at pressure and temperature levels beyond the design basis. The results of these tests would be used to:

1. Establish a basis of leakage behavior useful in estimating leakage in similar type penetrations in specific plants.

2. Confirm leakage estimates made based on reduced-scale gasket/seal tests and results of model tests, or leakage estimates based on analysis.

Table 12. Proposed Seal and Gasket Test Matrix

(Numbers give the random order in which tests are to be performed.)

			S_1*				S_2			
			A_1		A_2		A_1		A_2	
			G_1	G_2	G_1	G_2	G_1	G_2	G_1	G_2
F_2	D_2	L_2		7	10		20			
		L_1	25			3		5	16	
	D_1	L_2	26			21		1	30	15
		L_1		19	9		6			23
F_1	D_2	L_2	27			14		11	4	
		L_1		32	2		22			8
	D_1	L_2		12	28		24			29
		L_1	17			13		18	31	

*See text for the variable associated with each symbol. The subscripts 1 and 2 indicate the two levels specified for each variable in the text.

3. Increase the confidence level in predicting overall leakage of a given plant for loading conditions beyond the design basis.

It is suggested that the main testing medium be steam to better simulate actual containment atmospheres. Where gaskets are used, tests should be run using both new gaskets and aged gaskets (obtained from existing service in a nuclear containment or by equivalent simulated service). External loadings, such as seismic, tornadoes, etc. are excluded. The test program addresses only those operative-type of penetrations using gaskets and seals, and penetrations in which very large structural deformations might be expected, such as bellows seals.

For some penetrations, and some containments, large relative rotations and slippages may occur between mating seal surfaces. Thus, any testing plan for large scale penetrations should consider the possible simulation of these relative movements, or provide some other means to account for their occurrence. Consideration should be given to provide data needed to evaluate the effect of elevated temperature on the leakage behavior of gasket-sealed joints.

Finally, the upper limits for test pressure should be carefully selected. It appears that either a test pressure of 175-200 psig or a leakage rate of 200% of the containment volume per day at the test pressure be used as the limiting criteria for any tests.

B. Approach Used in Selecting the Test Matrix

In arriving at a rational test program for predicting penetration leakage and structural behavior, several factors must be considered. The following list represents some of these factors believed important in influencing leakage behavior of any given penetration:

1. The size of the potential leakage path.

2. The sensitivity of the gasket-seal leaktightness to containment shell deformations.

3. The sensitivity of the gasket-seal leaktightness to deformations of the penetration assembly itself.

4. The specific gasket/seal joint design used -- e.g., whether single or double seal, inflatable seals versus solid compressible seals, and other features.

5. Whether the penetration is pressure-seating or pressure-unseating.

6. The extent to which the penetration seal is "opened" and "closed" during its design life.

7. The existence of historical problems with actual penetrations during leak rate tests made at design pressure.

Many of these factors have been included in deriving the figures of merit presented in Section IV of this report. An additional factor to be considered in assessing the importance of a given penetration is how many of those penetrations are used in a single containment.

To help develop a test matrix for penetrations, results obtained from the foregoing figure of merit analyses were used. Inspection of the figure of merit tables shows that in half of them equipment hatches have lowest or lower than average figure of merit values, Tables 3 (twice), 4, 6, and 7. For sleeve rotation (F_1) and cover buckling (F_2), steel containment equipment hatches have lower than average values, and for sleeve rotation (F_1 again), sleeve-anchor shear (F_4), and concrete shear (F_5), concrete containment equipment hatches have lower than average or lowest figure of merit values. Thus, selected equipment hatches seem to be logical choices for testing.

Table 5 shows a personnel airlock with the lowest figure of merit (F_3) for frame strength. Table 8 shows a drywell head with the lowest figure of merit (F_6) for unseating strength. (Our latest information is that in BWR Mk I Unit 1 the head fasteners are the only ones, in that containment, with a specified preload stress; that would tend to improve the head's relative position in Table 8. However, that aspect is countered by the much wider potential leakage path of the head as compared to the containment's other pressure-unseating penetrations. Thought is being given to modifying F_6 to include consideration of potential leakage path width.) Tables 8 and 9 show a suppression chamber access hatch with low or lowest figure of merit values for both unseating strength (F_6) and plate strength (F_7). All the situations described in this paragraph were considered while selecting units for test.

The figures of merit may be used to obtain an initial list of penetrations to be tested and the relative priority of the penetrations. In addition, the figures of merit may be used as a basis for specific design features of the test articles.

In selecting figure of merit values to be sought in test articles, several things were kept in mind. On the one hand, if a test article should have low figures of merit, all penetrations having higher figures of merit could be said to have much better leakage behavior than the test article, although it would be difficult to quantify these lower leakages. Conversely, a test article having high figures of merit could exhibit such favorable leakage behavior that it might make it difficult to assess leakage behavior of penetrations having much lower figures of merit.

Accordingly, we have elected to recommend "average" figures of merit to be sought in test articles. A side benefit of this is that it will facilitate making extrapolations of test and analysis results to the extremes of the figure-of-merit range.

The recommended figures of merit to be sought in test articles are given in Table 13. Using average values is done with discretion, to avoid obtaining an impossible combination of design features. In particular, features from more than one vendor's designs should not be blended together. An example of the discretion used was that for drywell head HB01 a lower than average value of F_6 (unseat strength) and a higher than average value of F_8 (gasket and seal design) were selected because otherwise a realistic design for this type of penetration would not have been achieved. Table 13 also shows the initial priorities placed on the penetration tests based on this approach.

Table 13. Recommended Figures of Merit to be Sought in Test Articles

Priority	Penetration	$F_1 \times 10^6$	Example	$F_2 \times 10^7$	Example	$F_3 \times 10^8$	Example	$F_4 \times 10^4$	Example
1	Drywell Head	NA	NA	NA	NA	NA	NA	NA	NA
2	Equipment Hatch (Steel)	10.0	ES02	6.2	ES02	NA	NA	NA	NA
3	Equipment Hatch (Concrete)	3.0	ER10	6.9	ER10	NA	NA	9.6	ER10
4	Personnel Airlock	NA	NA	NA	NA	2.0	PS04	NA	NA

Priority	Penetration	$F_5 \times 10^8$	Example	$F_6 \times 10^3$	Example	$F_7 \times 10^8$	Example	F_8	Example
1	Drywell Head	NA	NA	0.04	HB01	NA	NA	11	HB01
2	Equipment Hatch (Steel)	NA	NA	NA	NA	NA	NA	9	ES02
3	Equipment Hatch (Concrete)	5.3	ER10	NA	NA	NA	NA	9	ER10
4	Personnel Airlock	NA	NA	NA	NA	NA	NA	10	PS04

Additional insight into the need for testing of particular penetrations was obtained from a survey of leakage problems encountered in existing plants, usually during the conduct of integrated leakage rate tests, Ref. [3]. Further information has been gathered during discussions with the suppliers of the large penetration components. These discussions have been quite helpful in arriving at our recommendations. It is quite clear that when specific test articles are designed that detailed advice from specific suppliers will be invaluable.

One type of penetration not covered in the figure of merit section is the bellows seal used for some piping penetrations and fuel transfer tubes (still under study). There are some applications of bellows in which large axial displacements of the bellows could occur. One such case is when bellows are used to provide an expansion seal between a hot pipe and the containment shell and the pipe (and other end of the bellows assembly) is anchored near the containment (usually a concrete shield wall). As the steel containment shell is pressurized and moves radially outward the bellows becomes compressed, and such compression can be several inches. Structural failure, and subsequent leakage, of the bellows must be considered a possibility, and appropriate tests are indicated.

C. Specific Recommendations

In preparing a specific set of recommended tests it was useful to identify which of the factors affecting leakage behavior are dominant. After review of all available information it is believed that the following features are most important in determining which penetrations have the greatest potential for leakage at loads beyond the design basis:

1. The size of the penetration, (i.e., width of the potential leakage path) is large.

2. The penetration seal is pressure-unseating.

3. The penetration seal faces are affected structurally by either interactions with deformation in the containment shell or the penetration assembly itself.

Penetrations having one of these characteristics must be considered as having significant potential for leakage at loads beyond the design basis. Obviously, a penetration which has all three characteristics is considered to have the highest potential for leakage.

The recommended test matrix is summarized in Table 14. This listing indicates the priority of the penetration test, the size of the test articles proposed, suggested model configurations, the numbers and types of tests recommended, and comments on the rationale for selecting that particular penetration for testing. Clearly, large, pressure-unseating penetrations possess the greatest potential for leakage. It is of interest that the recommendations in Table 14 tend to be supported by the preliminary calculated results for penetration seating surface separations reported in Ref. [5], which is being reviewed and is accompanied by "based on engineering judgment only" caveats.

Table 14. Recommended Test Matrix for Major Penetrations

Priority	Penetration Type	Size of Test Article	Suggested Model Configuration[1]	Number of Tests	Special Test Conditions	Comments
1.	BWR Drywell Top Head (Bolted Type)	1/3 Full Size[2]	HB01	2 (1 with New Gasket) (1 with Aged Gasket)	-	Large, Pressure Un-Seating Penetration
2.	Pressure-Unseating Equipment Hatch	1/2 Full Size[2]	EB01	3 (Double Seal - New Gasket) (Double Seal - Aged Gasket) (Single Seal - New Gasket)	-	Large, Pressure Un-Seating Penetration
3.	Bellows Seal Joint	Full Size	Type Similar to Main Steam Pipe Penetration	2	Test must Simulate Axial Compression of Bellows Expected in Some Installations	Bellows Seal Seem Sensitive to Amount of Axial Compression; Pressure Loading is Less Important
4.	Personnel Airlock with Non-Pressure Seating Seals (Inflatable Seals)	Full Size[3]	PP12	2 (1 with New Gasket) (1 with Aged Gasket)	-	Supplier of this Type of Airlock has said Testing is the only Reliable way to Establish Leakage Behavior
5.	Pressure-Seating Equipment Hatch	1/2 Full Size[2]	ES02 (Steel Containment) ER10 (Concrete Containment)	4 (1 with New Gasket) (1 with Aged Gasket) (Do 2 Tests Each for Steel and Concrete)	Test Must Simulate Seal Face Distortions Due to Interaction with Containment Shells	Large Penetration Tests must Establish Leakage Sensitivity to Seal Face Distortions
6.	Personnel Airlock with Pressure-Seated Seals	Full Size[3]	PS04	2 (1 with New Gasket) (1 with Aged Gasket)	-	Important Measurements Include Door Frame Deflection and Separations Between Frame and Door

(1) This corresponds to the geometry of a specific containment penetration as indentifed in Section III.C. of this report.
(2) These scales were selected, in large measure, on the size of available testing facilities.
(3) It is possible to obtain full size airlocks, partially completed for cancelled nuclear plants.

One problem area which is difficult to address -- mainly because of time and cost -- is the testing of penetrations using both new and "aged" gaskets. The approach taken here is that aging of the gasket material is an important factor, and sufficient testing should be done to establish whether aging has a significant effect on leakage behavior. One possible test result is that a penetration will exhibit excessive leakage when tested with a "aged" gasket at pressures much lower than when a new gasket is used. This situation could have significant impact on containment capability. It is recognized that inclusion of these additional tests adds to the cost and schedule of the program, particularly if the first test article suffers permanent deformations, thus necessitating use of a duplicate test assembly. It is further recognized that this recommendation may be revised later to eliminate one of them (new or aged) to reflect the outcome of the seals and gaskets tests. Finally, care must be exercised to assure that duplicate test articles possess nearly identical features (e.g., surface finish, bolt prestress, etc.).

For each test included in Table 14, leakage rate as a function of increasing pressure will be obtained. When structural deformations are important to leakage behavior, these will be measured and recorded.

VII. PENETRATIONS WHICH MAY BE QUALIFIED BY DETAILED ANALYSIS ONLY

At present, if any penetration should commence leaking due to severe accident conditions, the leakage rate probably could not be calculated with defensible precision. Nevertheless, much can be done at once by analysis only to reduce testing requirements, and, by pursuing the right mix of testing and analysis, the capabilities of analyses to reduce further testing can probably be increased greatly.

To start, relatively simple calculations (elastic and, if necessary, inelastic) on an individual containment's penetrations, can show that some of its penetrations are highly probable to leak much more than others for any beyond-design-basis situations. In fact, the calculations can show that the former penetrations are acceptably probable to Leak Enough, either to (a) violate environmental limitations or (b) prevent higher containment pressures and temperatures, that the leakage behavior of the latter penetrations is Irrelevant. (In subsequent discussions, these are called Class LE and Class IR penetrations.) The Class IR penetrations are those which can be predicted, by relatively simple analysis alone, to have no potential to leak. (Regarding violation of environmental limitations, specifically on radioactivity releases under beyond-design-basis conditions, the specification of such limitations is, by necessity, expected to proceed at a pace compatible with that of the analyses described here.)

Typical Class IR penetrations are those that have no gaskets, seals, bellows or, in the case of piping penetrations, close-coupled piping restraints. Another example of a Class IR penetration is a BWR Mark I control rod drive removal hatch, which is enormously stronger than the plant's suppression chamber access hatch (e.g., see Table 8). Typical Class LE penetrations are those that have been recommended for test, Table 13.

Note that enough similarity exists among plants and penetrations that many of the relatively simple calculations would not have to be repeated for other plants. Consideration of the figures of merit approach in comparing penetrations should also be beneficial in reducing the amount of work necessary to separate Class LE and Class IR penetrations in a plant. Also, both experimental and analytical work in the near term on gaskets and seals should make it possible in the simple calculations to be more definite about the influence of gaskets on leakage rate after sealing surface separation is calculated to occur.

In the case of a plant's Class LE penetrations, the proposed plan is to test some typical types of them that have average figures of merit. Those other similar penetrations that have all higher figures of merit should have lower leakage rates than the tested unit, and those having all lower figures of merit should have higher leakage rates. This information should be adequate to qualify (or "disqualify") at least some of the Class LE penetrations, in which case it would be due to analysis only.

To elaborate, if a test should show that a penetration has low resistance to beyond-design-basis conditions, then all similar penetrations having all lower figures of merit would be expected to have even less resistance. All similar penetrations having all similar figures of merit would be expected to have similar resistance. The main difficulty is that, although those similar penetrations having all higher figures of merit would be expected to have higher resistance, it would not be straightforward to prove exactly how much higher. Conversely, if a test should show that a penetration has high resistance to beyond-design-basis conditions, the main difficulty is that although those similar penetrations having all lower figures of merit would be expected to have lower resistance, it would be difficult to prove exactly how much lower. To handle these difficult units analytically, the following procedure is suggested:

For the tests being performed, make pre-test predictions, using "first principles," of the leakage behavior to be measured. First, calculate the width, length, and height of the leakage path, as with finite element methods. Using these leakage path dimensions, calculate the leakage rate, with standard fluid mechanics equations available for that purpose (see below). Compare the calculated (predicted) leakage rate with the measured leakage rate. If the two rates agree within an "expected error band," then confidence is gained that first-principles calculations can be used to qualify a plant's Class LE penetrations that resemble the penetrations tested. The expected error band can be "large": leakage rate is very sensitive to (a) particles in the leaking fluid (Ref. [9]); (b) variations in sealing-surface roughness, gasket compression set, and gasket thermal transient compression set (Ref. [7]); and (c) leakage path minimum transverse dimension (the height, Darcy pressure-drop equation). These sensitivities are of course a problem for experimentally determined leakage rates as well as for analytically predicted rates.

In first principles leakage rate calculations, macro-analyses are used to determine sealing surface deformations and gross-gasket stresses. Then micro-analyses that consider both sealing surface and fluid forces (the latter both static and dynamic) on the gasket, at the surface roughness level, are used to refine the calculation of the leakage path dimensions. The pressures exerted by the gasket on the sealing surfaces are continually compared with the containment pressure. When the latter is higher, the containment pressure determines the gasket shape and leakage path dimension rather than the sealing surfaces. Furthermore, the pressure drop of a leaking fluid can influence local gasket shape and leakage path dimensions.

The standard fluid mechanics equations available for calculating leakage rates are as follows: For single-phase fluid flow with no compressibility effects, the textbook Darcy equation; for single-phase fluid flow with compressibility effects, an average of the textbook equations for compressible flow in insulated paths with friction, and in frictionless paths with heat transfer; for two-phase fluid flow, Ref. [10]; and for flow with solid particles, the above as modified by judicious use of Ref. [9] data on how many particles escape before leakage path plugging occurs.

To summarize, many penetrations can be qualified by detailed, and even not so detailed, analysis only. Relatively simple calculations, bolstered by figure of merit considerations and by forthcoming new gasket and seal data, can separate individual plant's penetrations into Class LE and Class IR categories. The former leak enough that the latter are irrelevant; therefore, the latter are qualified without testing.

Typical Class LE penetrations, proposed to have average figures of merit, will be tested. Other similar penetrations that have all higher figures of merit would be expected to have lower leakage rates than the test units, and vice versa. This information should be sufficient to allow releasing some additional Class LE-type penetrations from the need for testing.

Finally, if proposed pre-test analytical (first principle) predictions, of leakage rates to be measured in future penetration and gasket and seal tests, are accurate within an expected error band which can be "large," then it can be concluded that from that point the determination of a penetration's leakage behavior can be done as accurately by analysis as by test. Certainly, the first principles analysis approach offers a more economic path to attaching precision indices (e.g., standard deviation) to leakage rates than does testing of complete penetrations.

VIII. ADDITIONAL PLANTS TO BE INCLUDED IN SURVEY REPORT OF AUGUST 1984

Work is continuing at Argonne on the characterization of an additional 17 plants. Summary data sheets and penetration detail sketches similar to those in Appendix A of this report will be prepared and reported in an addendum to this report to be completed in August 1984.

ACKNOWLEDGMENTS

The preparation of this report required the collection and analysis of hundreds of drawings and specifications for the plants included in the survey. The authors wish to express their appreciation to the architect-engineering firms and major penetration equipment suppliers for the fine cooperation extended to us in collecting and interpreting all the information. We are also indebted to the following utilities for their excellent cooperation in providing access to relevant information on their nuclear power plants:

Cincinnati Gas and Electric, OH
Commonwealth Edison, IL
Consumers Power, MI
Florida Power and Light, FL
Illinois Power, IL
Iowa Electric Light and Power, IA
Iowa-Illinois Gas and Electric, IL
Louisiana Power and Light, LA
Northern States Power, MN
Public Service, IN
Texas Utilities, TX
Washington Public Power, WA
Wisconsin Public Service, WI

The authors are grateful to Leonard Frost and Paul Basnar of ANL for their tireless efforts in preparing the large number of sketches needed to characterize all the plants. We are also pleased to acknowledge the skillful typing efforts of Joanne E. Harmon, Diane M. Myers, Audrey Salzbrunn, and Kathleen M. Mowrey, all of ANL. Gerald Rosenberg and Stanley Fistedis, ANL, made helpful comments during this study. Finally, the guidance and support provided by the Sandia Project Officer for this work, C. V. Subramanian, Walter von Riesemann, Supervisor, Containment Integrity Division of Sandia, and the NRC Program Manager, Hans Ashar, are sincerely appreciated.

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10. Y. Y. Hsu and R. W. Graham, "Transport Processes in Boiling Two-Phase Systems," McGraw-Hill, New York (1976).

APPENDIX A

Containment Data Sheets and Penetration Details

Appendix A contains summary data sheets and sketches of penetration details for the containment of each of the plants surveyed to date. The Safety Analyses Reports (SARs), A/Es, equipment suppliers, and utility plant owners were used as the main sources of information presented. The data sheets and penetration detail sketches were condensed by careful study of official design and shop drawings for each plant. The information is grouped into the following categories:

1. Concrete containment vessel with steel liner

2. Free standing steel vessel surrounded by concrete shielding building

3. Containment for BWR plants, MARK I and II type.

UNIT 1 & 2 - CONCRETE CONTAINMENT (STEEL LINER)

FSAR DESCRIPTION OF UNITS 1 & 2 CONTAINMENT STRUCTURE

The containment structure is cylindrical with a shallow domed roof and a flat foundation slab. The cylindrical portion is prestressed by a post-tensioning system consisting of horizontal and vertical tendons. The dome has a three-way post-tensioning system. The foundation slab is conventionally reinforced with high-strength reinforcing steel. The entire structure is lined with one-quarter inch welded steel plate. The liner plate is attached to the concrete by means of an angle grid system stitch welded to the liner plate and embedded in the concrete.

The approximate dimensions of the containment structure are:

Inside Diameter	140 ft.
Inside Height	212 ft.
Vertical Wall Thickness	3-1/2 ft.
Dome Thickness	2-3/4 ft.
Foundation Slab Thickness	9 ft.

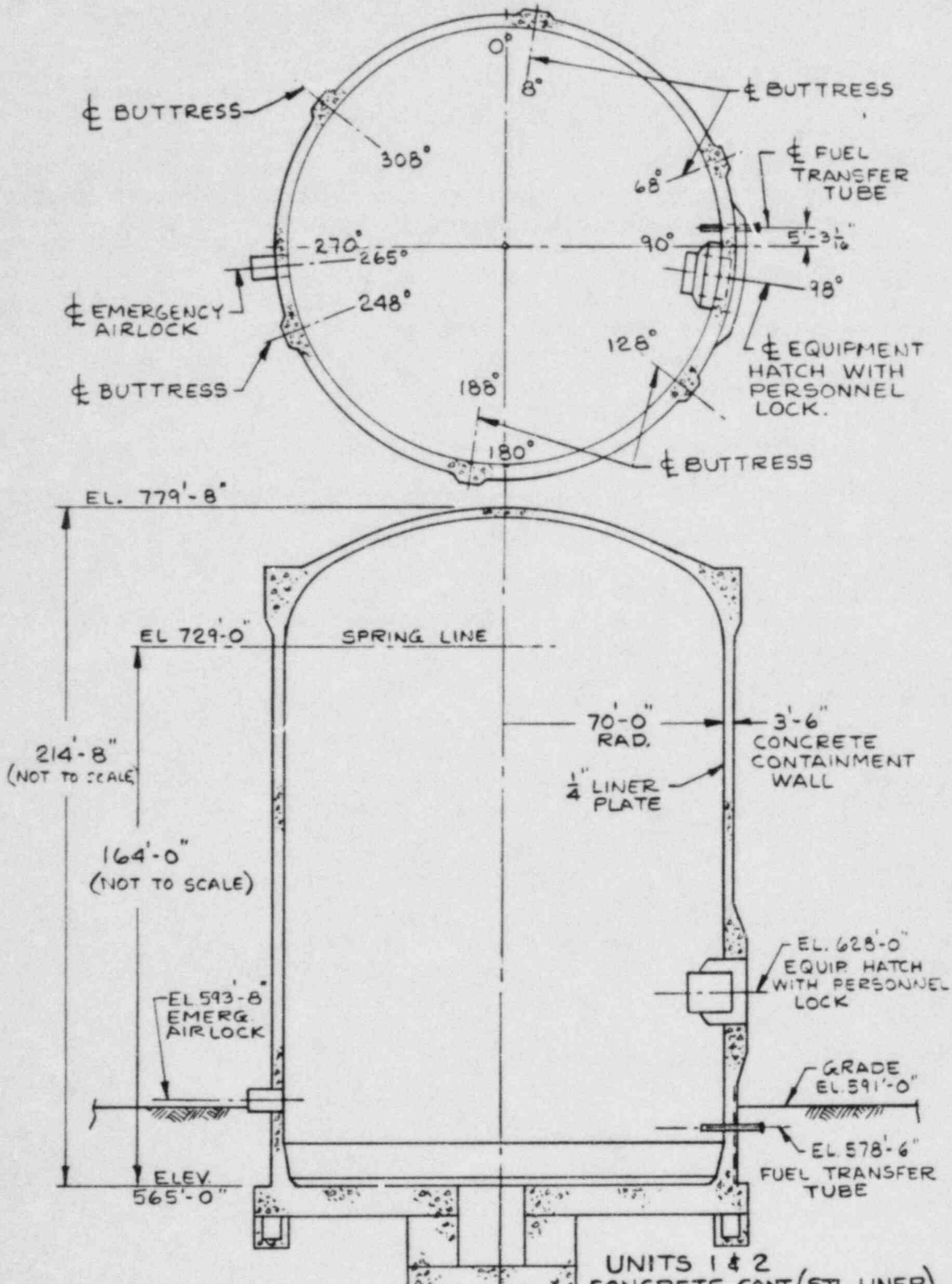
In the concept of post-tensioned containment, the internal pressure load is balanced by the application of an opposing external pressure type load on the structure. Sufficient post-tensioning is used on the cylinder and dome to ensure a margin of external pressure exists beyond that required to resist the internal design pressure. Nominal bonded reinforcing steel is provided to distribute strains due to shrinkage and temperature. Bonded reinforcing steel is used at penetrations and discontinuities to resist local moments and shears.

The internal pressure loads on the base slab are resisted by the soil reaction and the rigidity and strength of the reinforced concrete slab which serves as the foundation mat. Thus, post-tensioning is not required to exert an external pressure for this portion of the structure.

The post-tensioning system consists of:

- Three groups of 63 dome tendons oriented 120° to each other for a total of 189 tendons anchored at the vertical face of the dome ring girder.
- 216 vertical tendons anchored at the top surface of the ring girder and at the bottom of the base slab.
- A total of 555 hoop tendons anchored at the six vertical buttresses.

Each tendon consists of ninety 1/4" diameter wires with button-headed type anchorages.



UNITS 1 & 2
CONCRETE CONT. (STL. LINER)

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

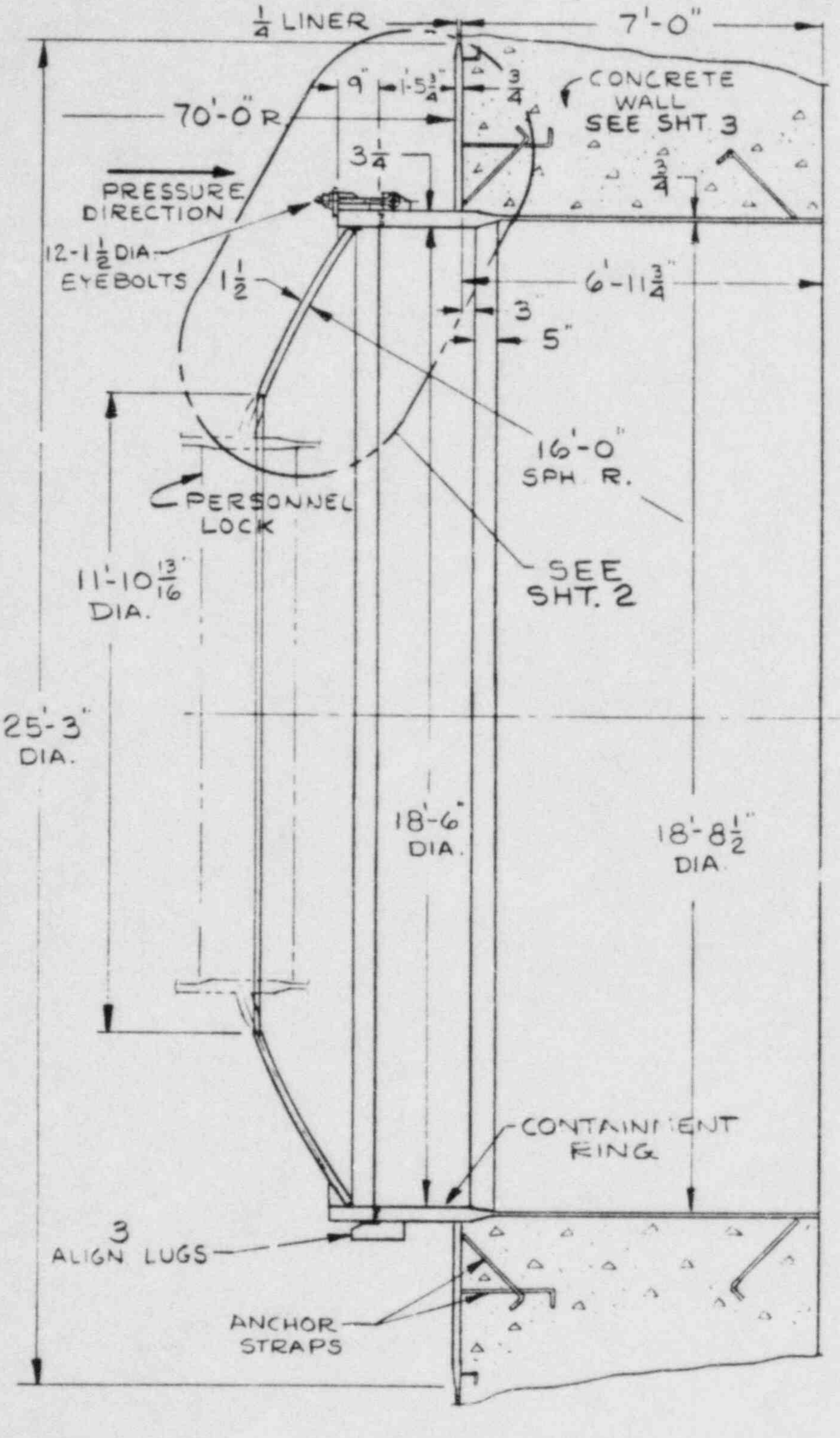
UNITS 1 & 2 - EQUIPMENT HATCH

Equipment Hatch

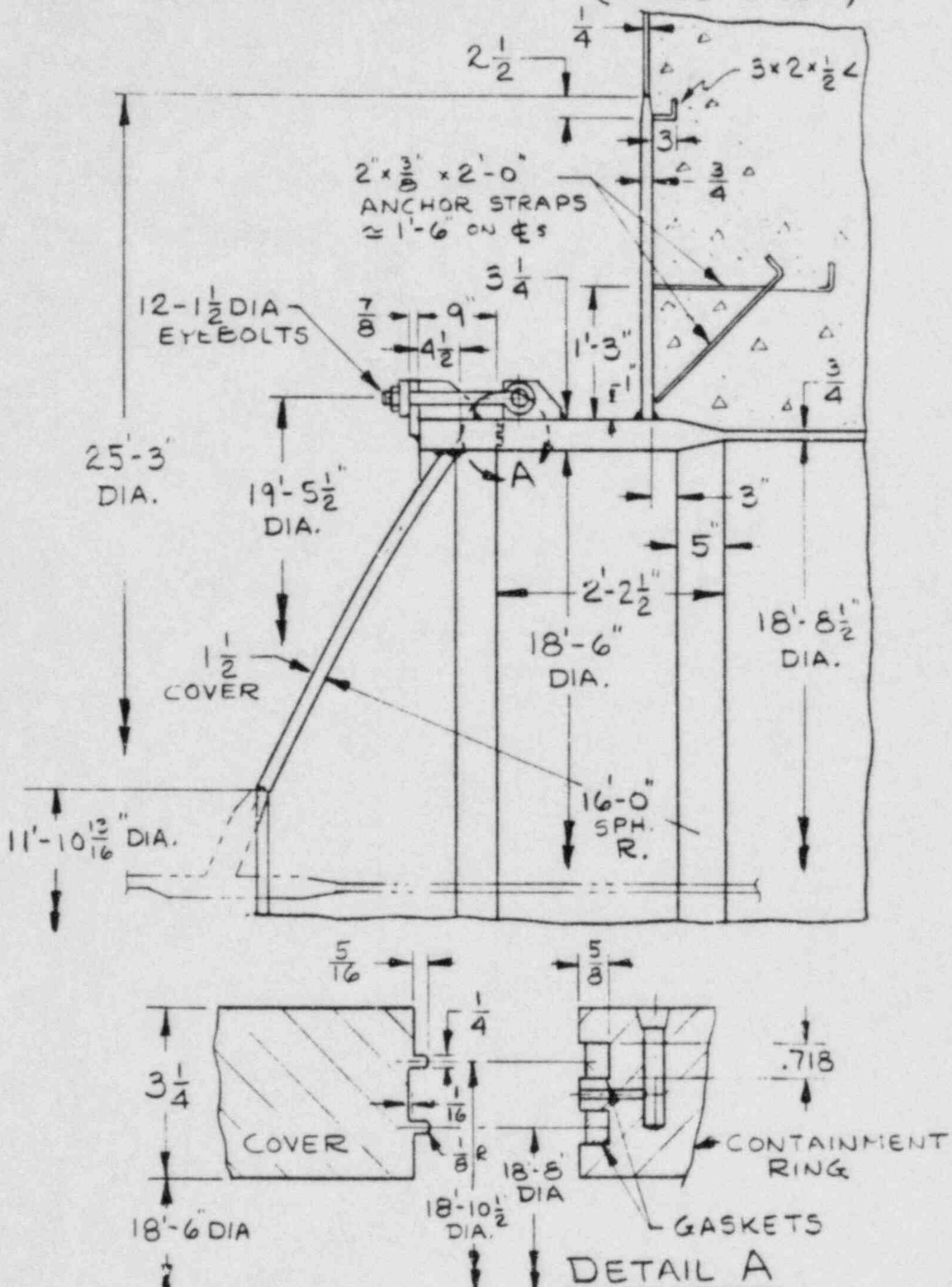
The equipment hatch provides a round clear opening in the concrete containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with double tongue and groove gaskets to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 12 swing bolts mounted on the outer surface of the hatch opening and containment ring. The pressure inside the containment vessel provides the seating force for the equipment latch seal. The personnel lock is mounted in the cover of the equipment hatch. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Units 1 & 2, Figure 1
Clear opening	18 ft. 6 in.
Cover thickness	1-1/2 in.
Cover shape, radius	16 ft. radius
Material	SA-516 Grade 60
Containment Ring	
Thickness	3-1/4 in.
Diameter	18 ft. 6 in. I.D.
Material	SA-516 Grade 60
Gasket	
Gasket type	Double Tongue & Groove
Cross-section	Rectangular 3/4 Wide x 1/2 Thk.
Material	Silicone Rubber
Length, Inner	58 ft. 5 in.
Length, Outer	59 ft. 2 in.
Location of Hatch	
Hatch centerline elev.	628 ft. 0 in.
Hatch centerline azimuth	98^{o}

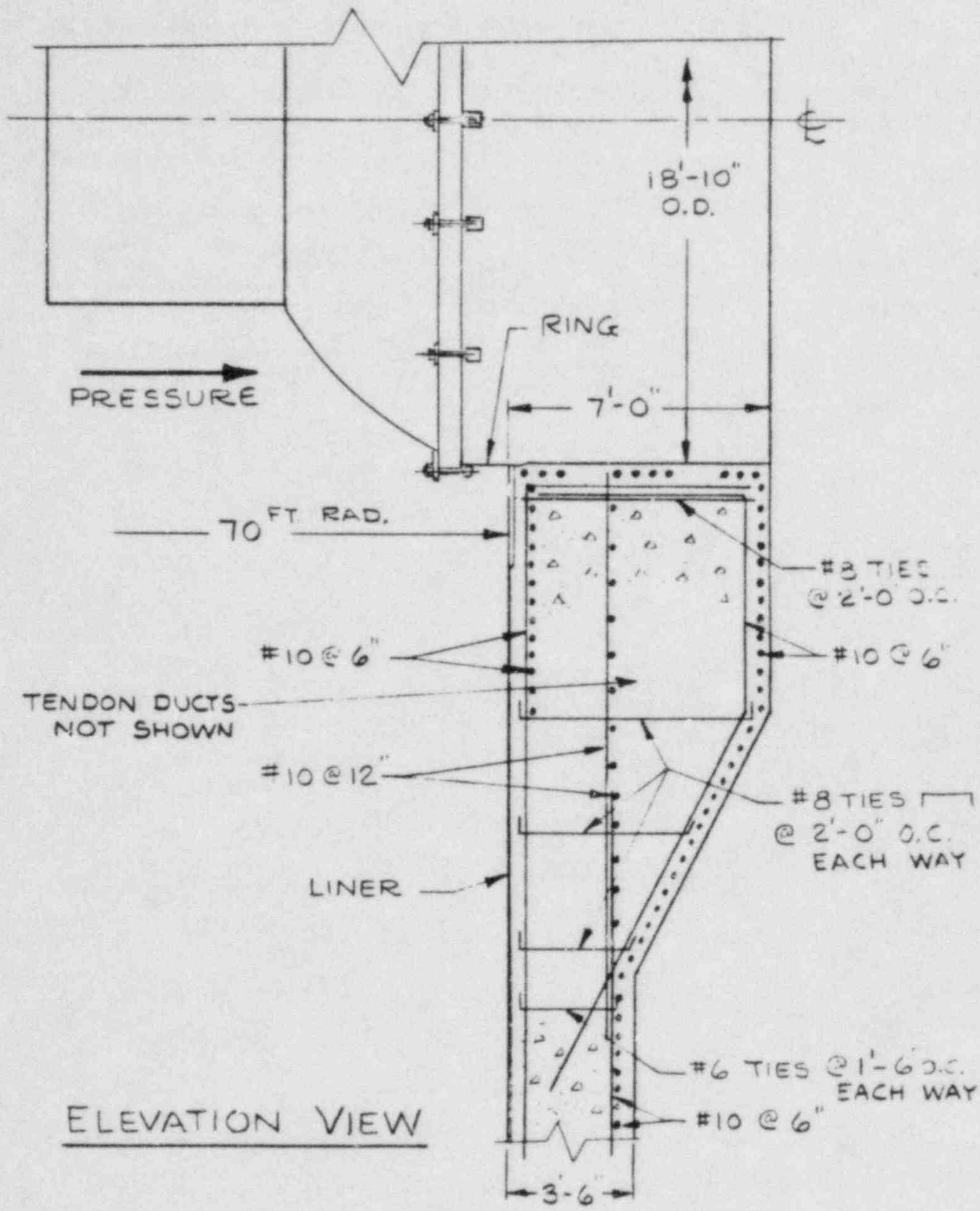
UNITS 1 & 2 FIG. 1 SHT 1 of 3 EQUIPMENT HATCH
CONCRETE CONTAINMENT (STEEL LINER)



UNITS 1 & 2 FIG 1 SHT 2 OF 3 EQUIPMENT HATCH
CONCRETE CONTAINMENT (STEEL LINER)



UNITS 1 & 2 FIG. 1 SHT. 3 OF 3 EQUIPMENT HATCH
CONCRETE CONTAINMENT (STEEL LINER)



ELEVATION VIEW

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 & 2 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the concrete containment wall. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Pressure Lock	Units 1 & 2, Figure 2
Clear opening	4 ft. wide 6 ft. 6 in. height
Door width	4 ft. 5-1/4 in.
Door height	6 ft. 11-1/4 in.
Door-thickness	1 in.
Material	SA-516 Grade 60 FBX

Containment Ring

Thickness	Shell @ 1-1/2 in. and Ring @ 2-1/2 in.
Diameter	10 ft. 5 in. O.D.
Material	SA-516 Grade 60 FBX

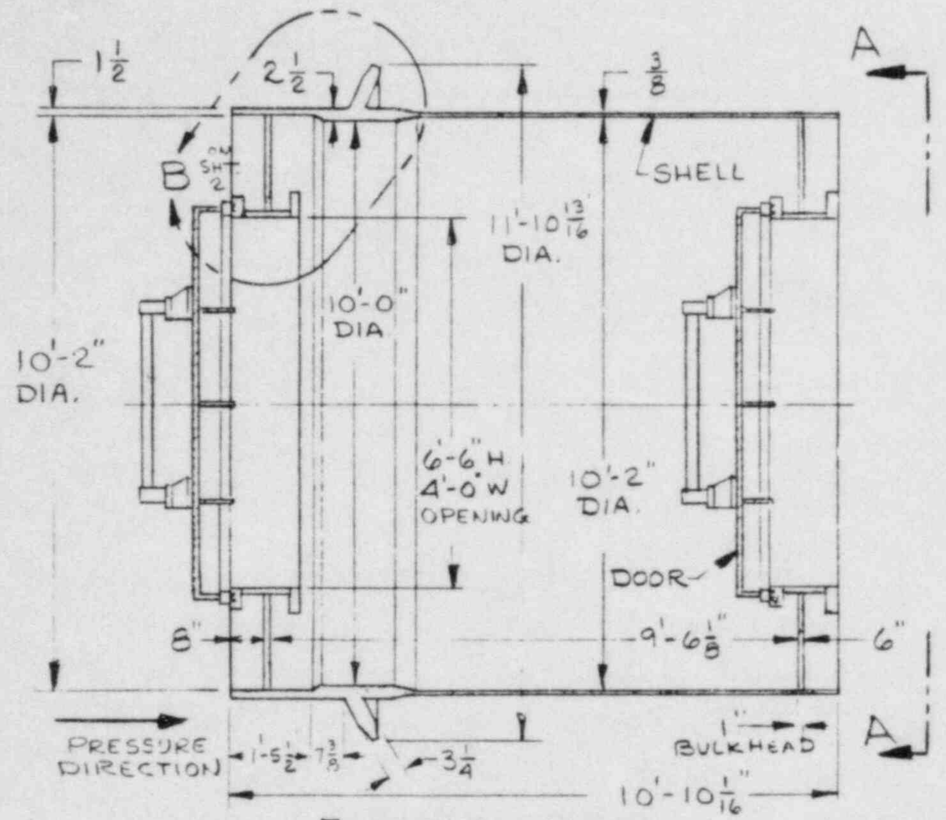
Gasket

Gasket type	Double tongue & groove
Cross-section	Rectangular 1/2 Thk x 3/4 Wide
Material	Silicone Rubber

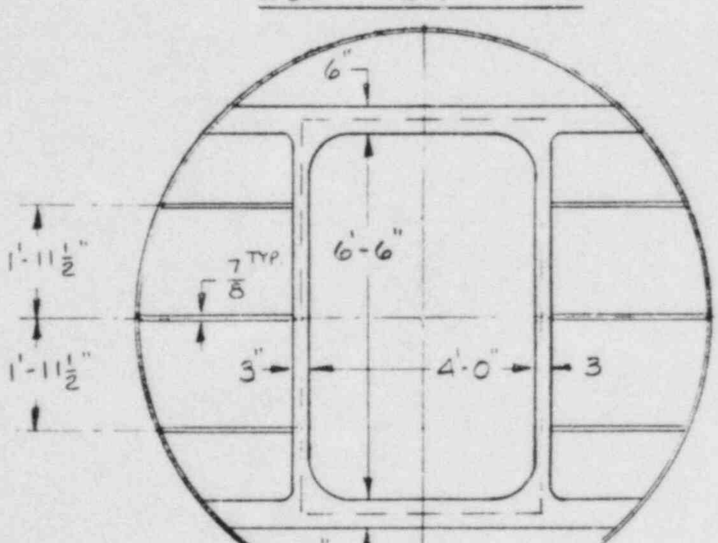
Location of Personnel Lock

Personnel lock centerline elev.	628 ft. 0 in.
Personnel lock centerline azimuth	98°

UNITS 1 & 2 FIG. 2 SHT. 1 OF 2 PERSONNEL LOCK IN EQUIPMENT HATCH COVER -

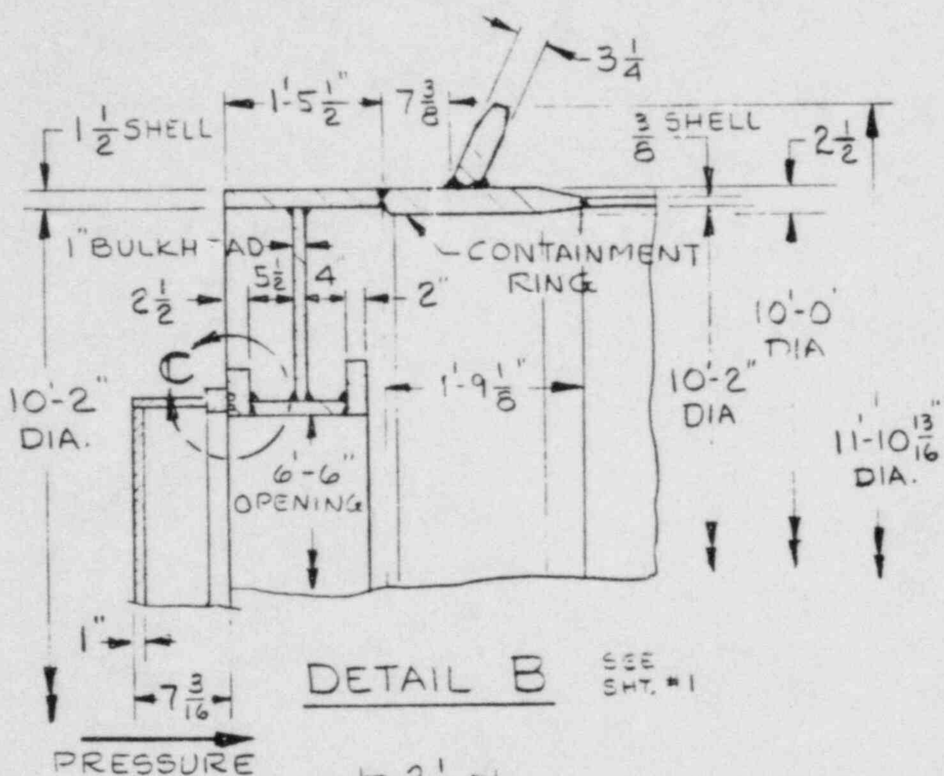


ELEVATION VIEW

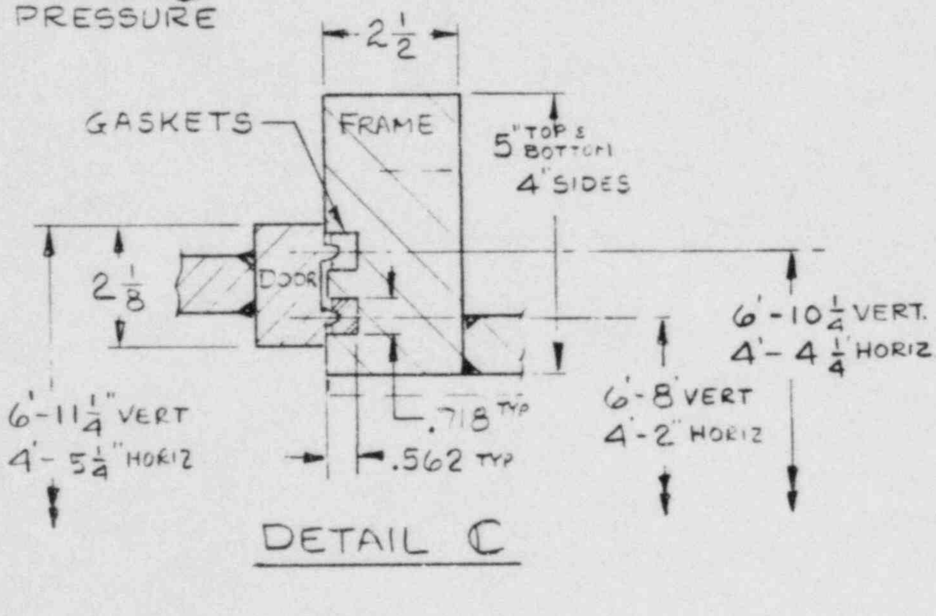


VIEW A-A

UNITS 1 & 2 FIG. 2 SHT. 2 OF 2 PERSONNEL LOCK IN EQUIPMENT HATCH COVER



DETAIL B SEE SHT. #1



DETAIL C

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 & 2 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the concrete containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the escape lock bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Units 1 & 2, Figure 3
Clear opening	30 in. diameter
Door	35-1/4 in. diameter
Door thickness	1-3/4 in.
Material	SA-516 Grade 60 FBX

Containment Ring

Thickness	3/4 in.
Diameter	5 ft. 10-1/2 in. O.D.
Material	SA-516 Grade 60 FBX

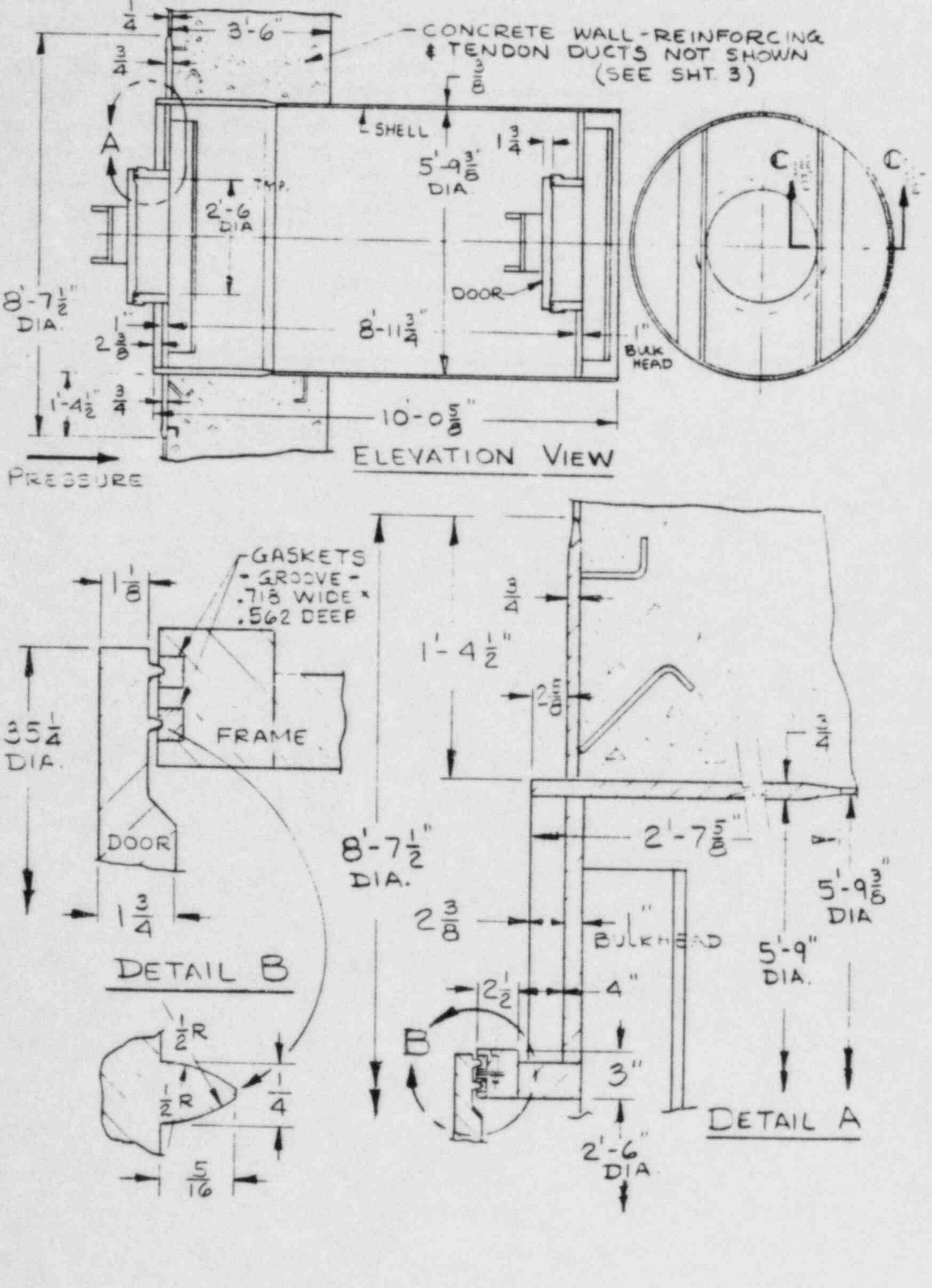
Gasket

Gasket type	Double tongue & groove
Cross-section	Rectangular 1/2 thk. x 3/4 Wide
Material	Silicone Rubber

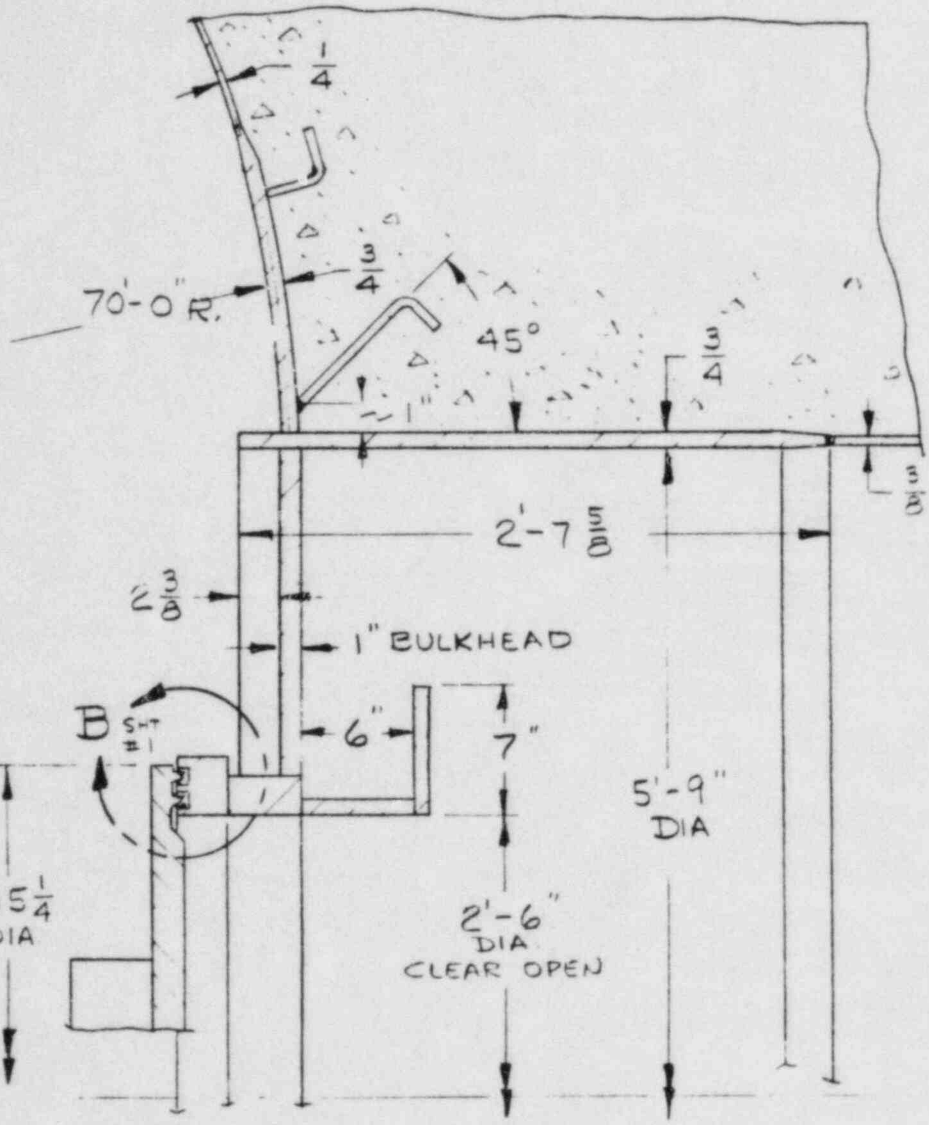
Location of Escape Lock

Escape lock centerline elev.	593 ft. 8 in.
Escape lock centerline azimuth	265°

UNITS 1 & 2 FIG. 3 SHT 1 OF 3 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)

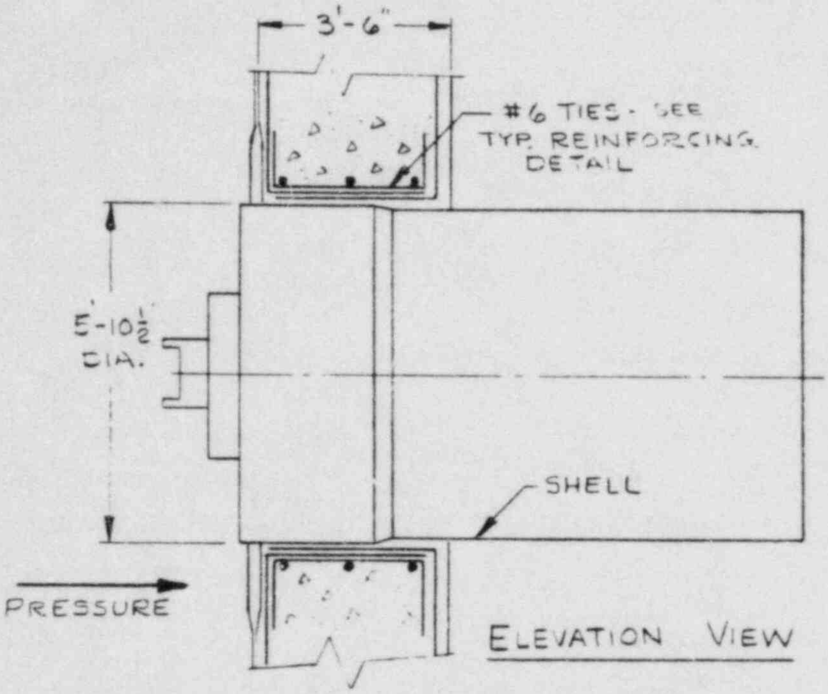


UNITS 1 & 2 FIG. 3 SHT. 2 OF 3 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)

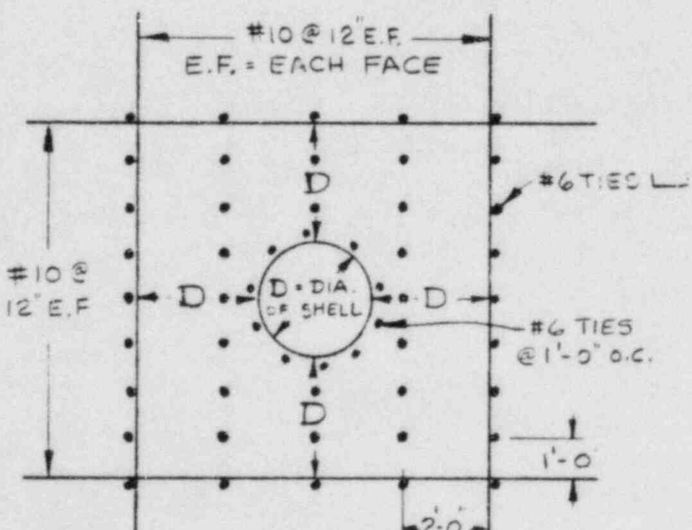


SECT. C - C SEE SHT #1
ROTATED 90° CCW

UNITS 1 & 2 FIG. 3 SHT. 3 OF 3 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)



ELEVATION VIEW



TYPICAL ADDITIONAL REINFORCING AT CONTAINMENT PENETRATION
DETAIL

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 FEEDWATER, MAIN STEAM, AND MISC. PIPE PENETRATIONS (TYPE 1)

Figure 4, Sheet 1 presents the location of Type 1 penetrations in the concrete containment wall. Figure 4, Sheet 2 (Feedwater), Figure 4, Sheet 3 (Main Steam), and Figure 4, Sheet 4 (Misc.), presents the design dimensions for these pipe penetrations. These pipe penetrations designated Type 1 per the plant A/E for these plants. All Type 1 pipe penetrations are mounted non-radially in the concrete containment wall.

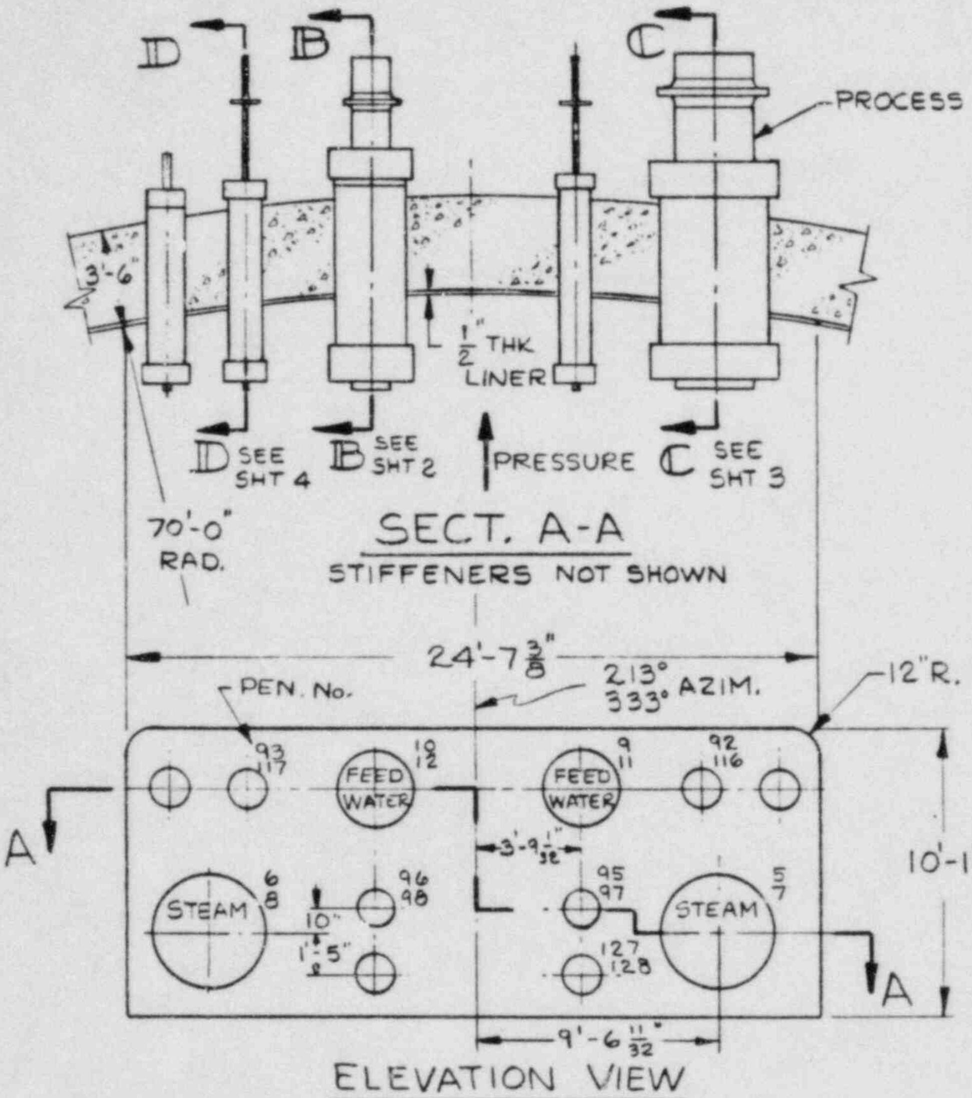
TYPE 1 NON-RADIAL PIPE PENETRATIONS (Total 18)

Type 1 Penet. No.	Name	Process Pipe OD, in*	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth** (Deg.Min)
9	Feedwater	16	32	584-7	213-0
10	Feedwater	16	32	584-7	213-0
11	Feedwater	16	32	584-7	333-0
12	Feedwater	16	32	584-7	333-0
5	Main Steam	34	50	579-6	213-0
6	Main Steam	34	50	579-6	213-0
7	Main Steam	35-1/2	50	579-6	333-0
8	Main Steam	35-1/2	50	579-6	333-0
92	Blowdown	2	16	584-7	213-0
93	Blowdown	2	26	584-7	213-0
95	Blowdown	2	14	580-4	213-0
96	Blowdown	2	14	580-4	213-0
97	Blowdown	2	14	580-4	333-0
98	Blowdown	2	14	580-4	333-0
116	Blowdown	2	16	584-7	333-0
117	Blowdown	2	16	584-7	333-0
127	Steam Aux. Pump	6	16	578-1	213-0
128	Steam Aux. Pump	6	16	578-1	333-0

* Pipe Size, attached figures present actual pipe dimensions.

**See Figure 4, Sheet 1 for exact location relative to azimuth 213-0 and 333-0.

TYPE 1 (MAINSTEAM, FEEDWATER & MISC.)
UNITS 1 & 2 FIG. 4 SHT. 1 OF 4 PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)



ELEVATION VIEW

TYPE 1 PENETRATIONS (TOTAL 18)

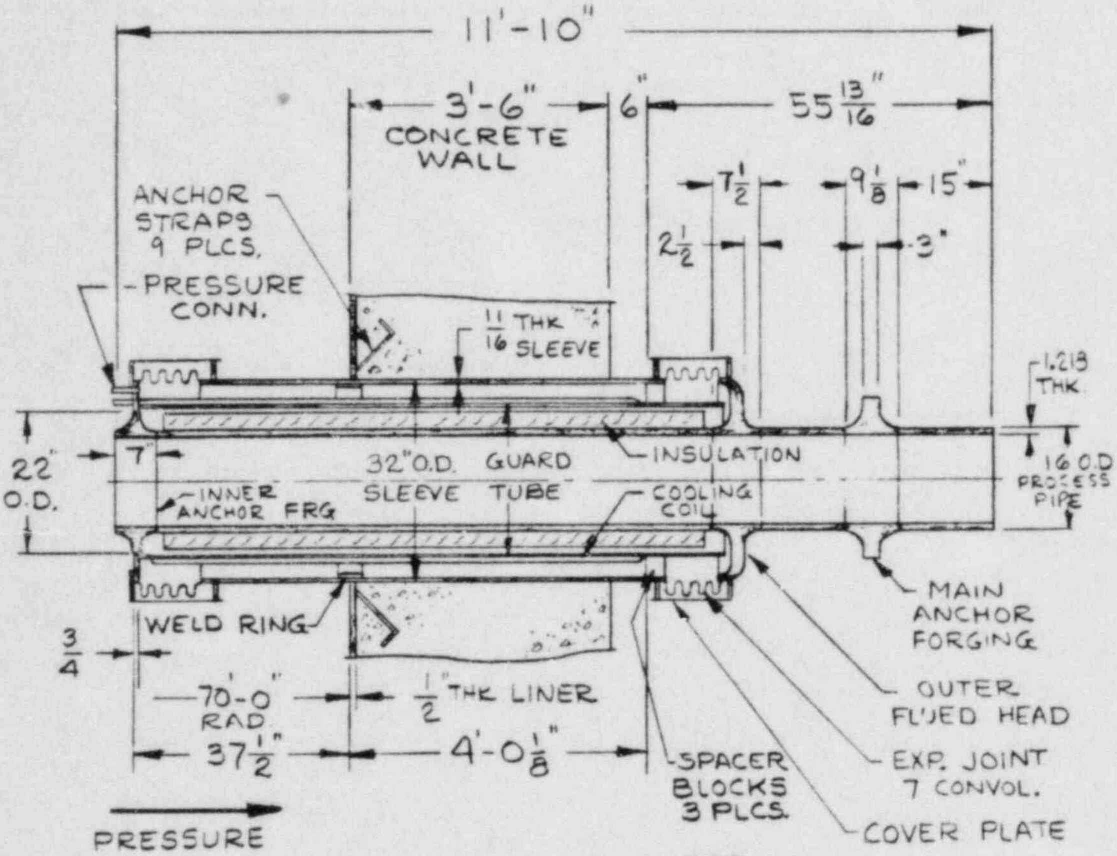
AT AZIMUTH 213°			AT AZIMUTH 333°		
PEN. No.	TYPE	SHOWN ON SHT #	PEN. No.	TYPE	SHOWN ON SHT #
9, 10	FEEDWATER	2	11, 12	FEEDWATER	2
5, 6	MAINSTEAM	3	7, 8	MAINSTEAM	3
92, 93, 95, 96 & 127	MISC.	4	97, 98, 116, 117 & 128	MISC.	4

MISC. = STEAM BLOWDOWN & STEAM TO AUX. PUMPS

TYPE 1 (MAINSTEAM, FEEDWATER, MISC.)

UNITS 1 & 2 FIG. 4 SHT. 2 OF 4 PIPE PENETRATIONS

CONCRETE CONTAINMENT (STEEL LINER)



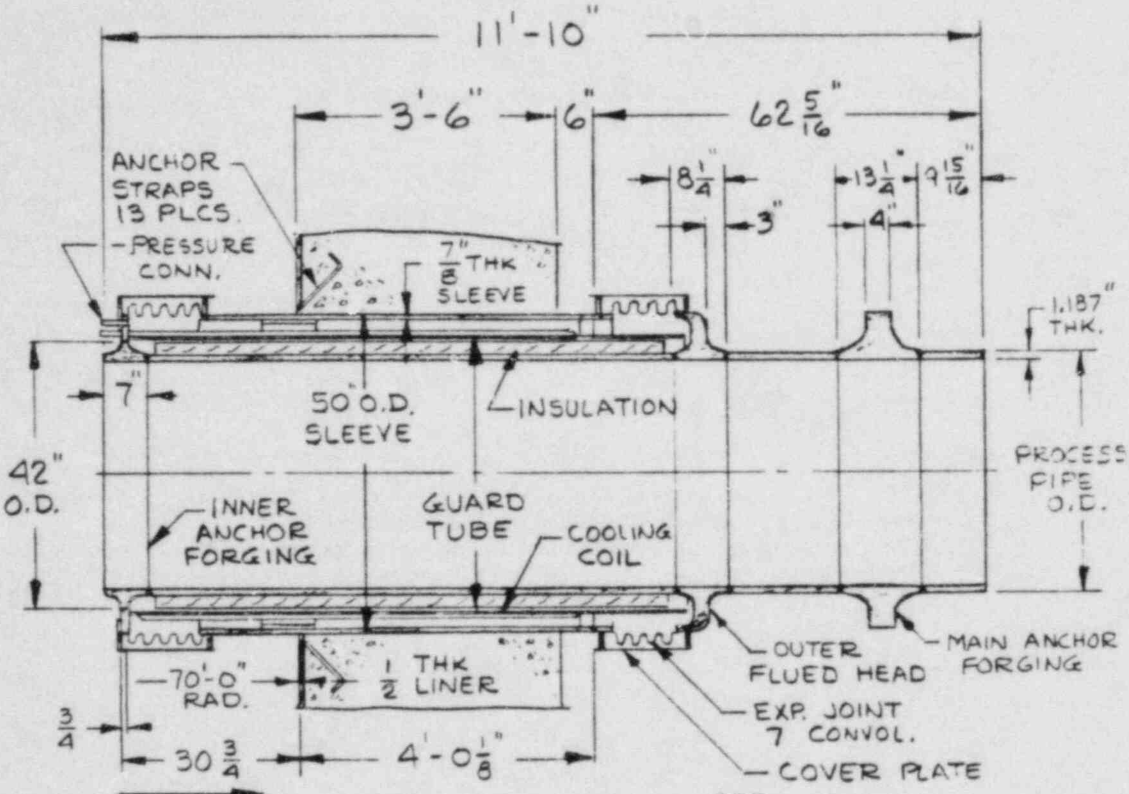
SECTION B-B SEE SHT. #1

PEN. #S 9, 10, 11 & 12 FEEDWATER

TYPE 1 (MAINSTEAM, FEEDWATER, MISC.)

UNITS 1 & 2 FIG. 4 SHT. 3 OF 4 PIPE PENETRATIONS

CONCRETE CONTAINMENT (STEEL LINER)



SECTION ℄-℄ SEE SHT 1

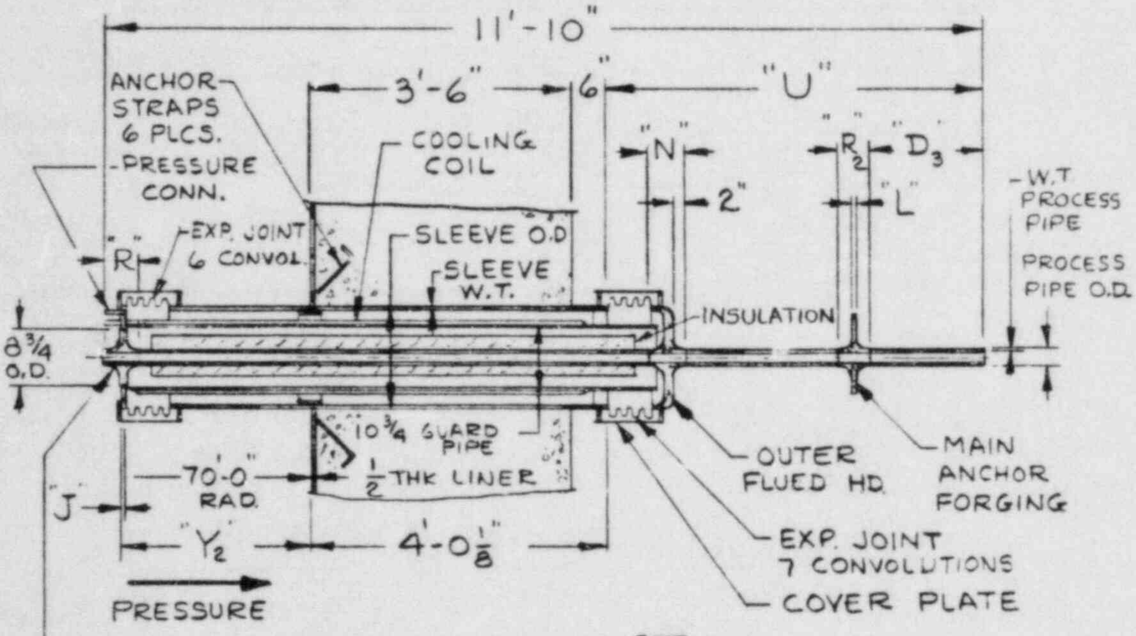
PEN. #S 5, 6, 7 & 8 - MAINSTEAM

PENETRATION NUMBER	PROCESS PIPE O.D.
5, 6	34
7, 8	35 1/2

TYPE 1 (MAINSTEAM, FEEDWATER & MISC.)

UNITS 1 & 2 FIG. 4 SHT. 4 OF 4 PIPE PENETRATIONS

CONCRETE CONTAINMENT (STEEL LINER)



SECTION D-D SEE SHT. #1

DRAWN FOR PEN. #s 92, 93, 116 & 117 - MISC. PENS.

PENET. NUMBER	SLEEVE		PROCESS PIPE		DIMENSIONS								
	O.D.	W.T.	O.D.	W.T.	D_3	J	L	N	R	R_2	U	Y	Y_2
92, 93 116, 117	16"	.500	2.375	.218/.191	17 3/4	5/8	1"	7 1/2	7	5	60 3/16	30 1/16	22 1/16
95, 96 97, 98	14"	.438	2.375	.218/.191	17 3/4	1/2	1"	7 1/4	7	5	55 15/16	34 1/16	26 9/16
127, 128	16"	.500	6.625	.432/.378	16 5/16	1/2	2"	6 1/2	6 3/4	6 1/2	55 15/16	34 9/16	26 11/16

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 PIPE PENETRATIONS (TYPES 2 AND 2A)

Figure 5, Sheet 1 presents the design configuration of Type 2 (Radial) and 2A (Non-Radial) pipe penetrations in the concrete containment wall. Figure 5, Sheet 2 presents the design dimensions for Type 2 (Radial) pipe penetrations. Figure 5, Sheet 3 presents the design dimensions for Type 2 (Non-Radial) pipe penetrations. These pipe penetrations designated Type 2 and 2A per the plant A/E for these plants.

TYPE 2 RADIAL PIPE PENETRATIONS (Total 8)

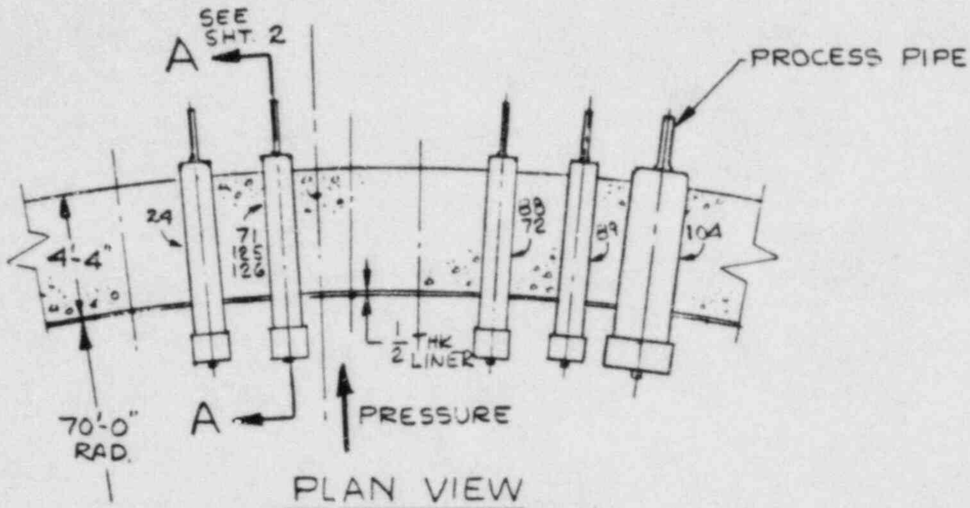
Type 2 Penet. No.	Name	Process Pipe OD, in*	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
24	Safety Injection	4	14	588-10	107-0
71	Blowdown	2-1/2	14	588-10	104-45
72	Letdown Heat Exch.	2	12	592-0	98-30
88	Hot Water	2	12	586-10	98-30
89	Hot Water	2	12	586-10	96-15
104	Aux. Steam Pump	6	24	580-1	94-0
125	ECCS Cold Leg	4	14	594-4	104-45
126	ECCS Hot Leg	4	14	596-5	104-45

TYPE 2A NON-RADIAL PIPE PENETRATIONS (Total 4)

91	Blowdown	2-1/2	16	584-7	213-0**
94	Blowdown	2-1/2	16	584-7	213-0**
115	Blowdown	2-1/2	16	584-7	333-0**
118	Blowdown	2-1/2	16	584-7	333-0**

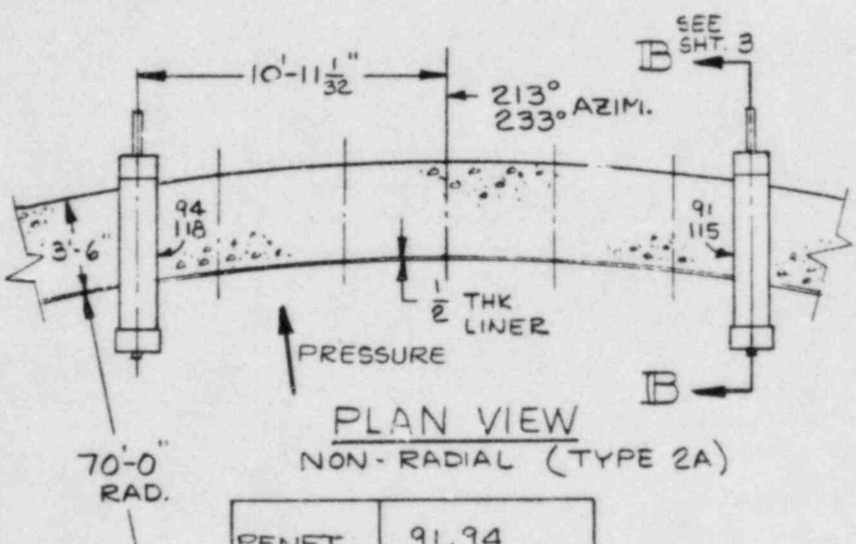
* Pipe Size, attached figures present actual pipe dimensions.
**See Figure 5, Sheet 1 for exact location relative to azimuth 213-0 and 333-0.

UNITS 1 & 2 FIG. 5 SHT. 1 OF 3 PIPE PENETRATIONS (TYPES 2 & 2A)
CONCRETE CONTAINMENT (STEEL LINER)



PLAN VIEW
RADIAL (TYPE 2)

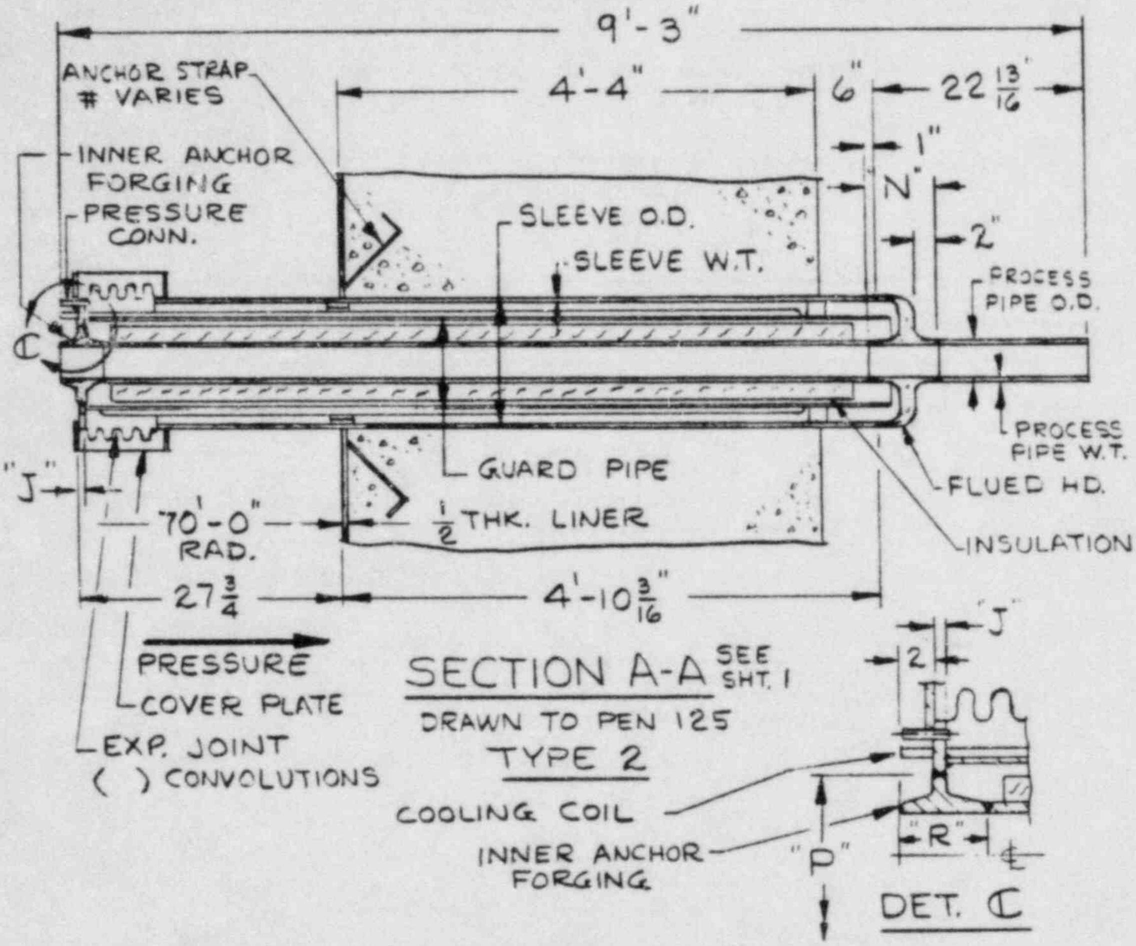
PENET. NUMBER	24, 71, 72 88, 89, 104 125, 126



PLAN VIEW
NON-RADIAL (TYPE 2A)

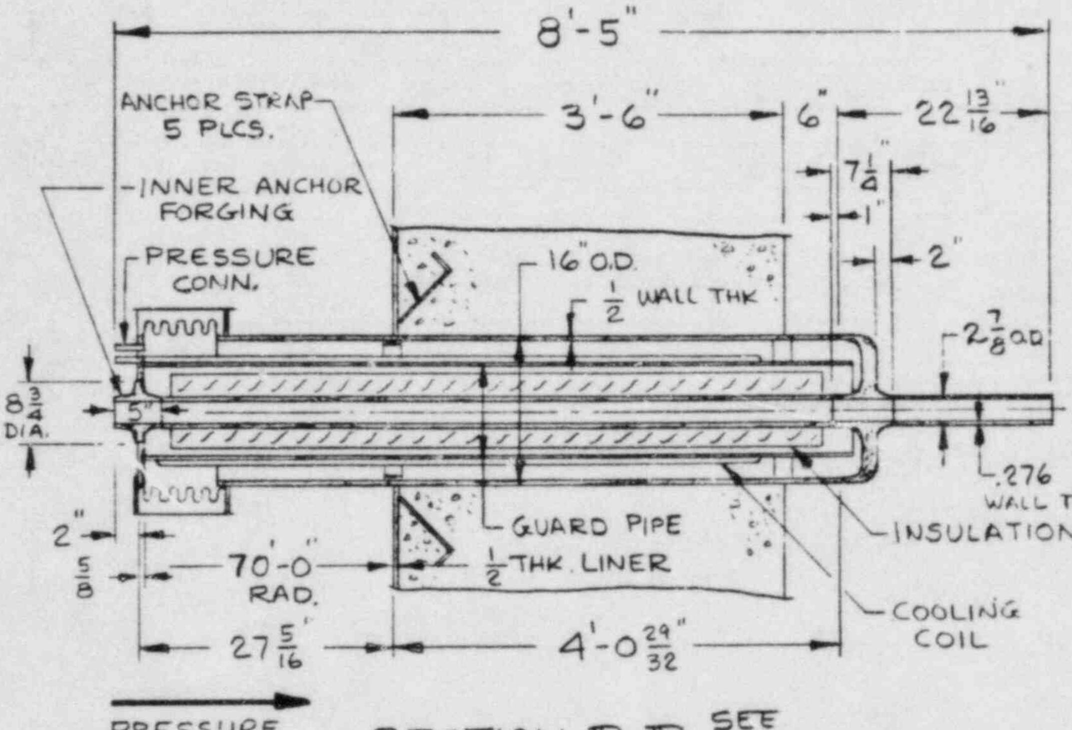
PENET. NUMBER	91, 94 115, 118

UNITS 1 & 2 FIG. 5 SHT. 2 OF 3 PIPE PENETRATIONS (TYPE 2)
CONCRETE CONTAINMENT (STEEL LINER)



PENET. NUMBERS	SLEEVE		PROCESS PIPE		INNER ANCHOR		PLATE	FLUED HEAD	EXP. JOINT
	O.D.	W.T.	O.D.	W.T.	R	P	J	N	No. CONV.
72	12.75	.406	2.375	.154		5	3/4	7	6
88, 89			2.375	.218	4 3/4	6 3/8	1/2	7	6
24,125,126	14	.438	4.5	.438	4 3/4	8 3/4	1/2	7 1/2	7
71			2.875	.276	5	8 3/4	3/4	7	7
104	24	11/16	2.375		8	14	3/4	8 1/4	7

UNITS 1 & 2 FIG. 5 SHT. 3 OF 3 PIPE PENETRATIONS (TYPE 2A)
CONCRETE CONTAINMENT (STEEL LINER)



SECTION B-B SEE SHT 1

PEN. #s 91, 94, 115 & 118 TYPE 2A

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 PIPE PENETRATIONS (TYPE 3)

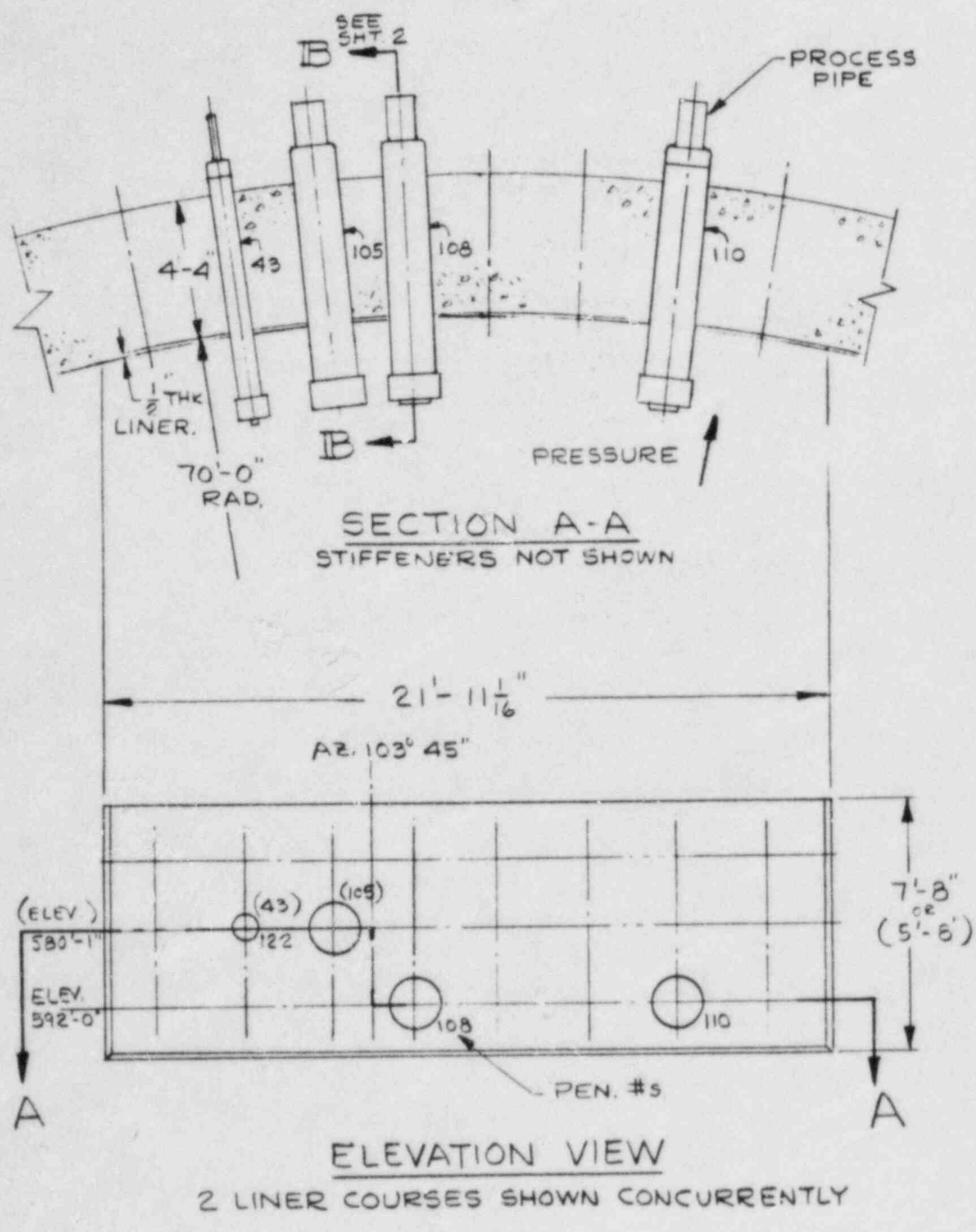
Figure 6, Sheet 1 presents the locations for all Type 3 pipe penetrations. Figure 6, Sheet 2 presents the design dimensions for Type 3 pipe penetrations. These pipe penetrations designated Type 3 per the plant A/E for these plants. There are 4 Type 3 pipe penetrations. All Type 3 pipe penetrations are radially mounted in the the concrete containment wall.

TYPE 3 RADIAL PIPE PENETRATIONS (Total 4)

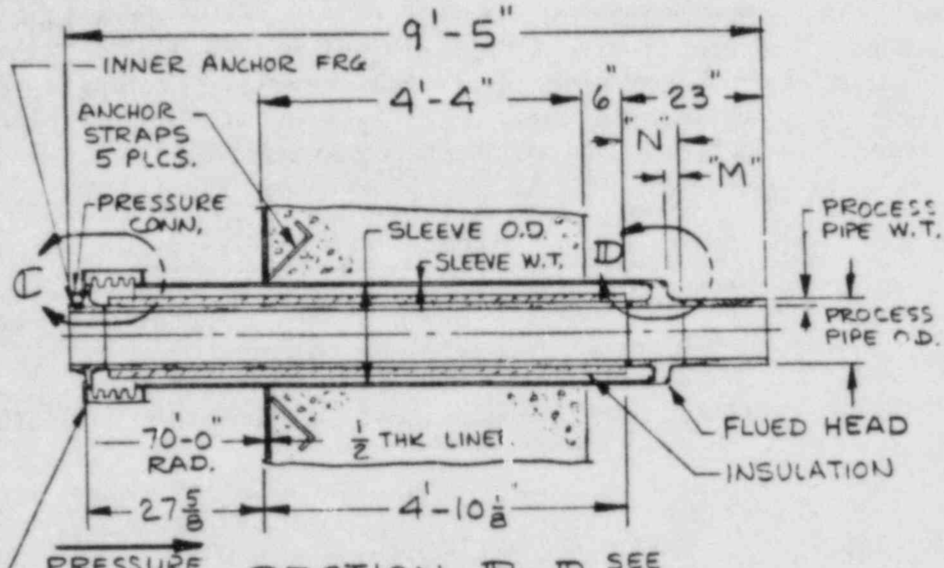
Type 3 Penet. No.	Name	Process Pipe OD, in*	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
43	Drain Discharge	3	8	580-1	107-0
105	Heat Exchanger	10	18	580-1	104-45
108	Heat Exchanger	10	16	592-0	102-45
110	Heat Exchanger	10	16	592-0	96-15

* Pipe Size, attached figures present actual pipe dimensions.

UNITS 1 & 2 FIG. 6 SHT. 1 OF 2 PIPE PENETRATIONS (TYPE 3)
CONCRETE CONTAINMENT (STEEL LINER)

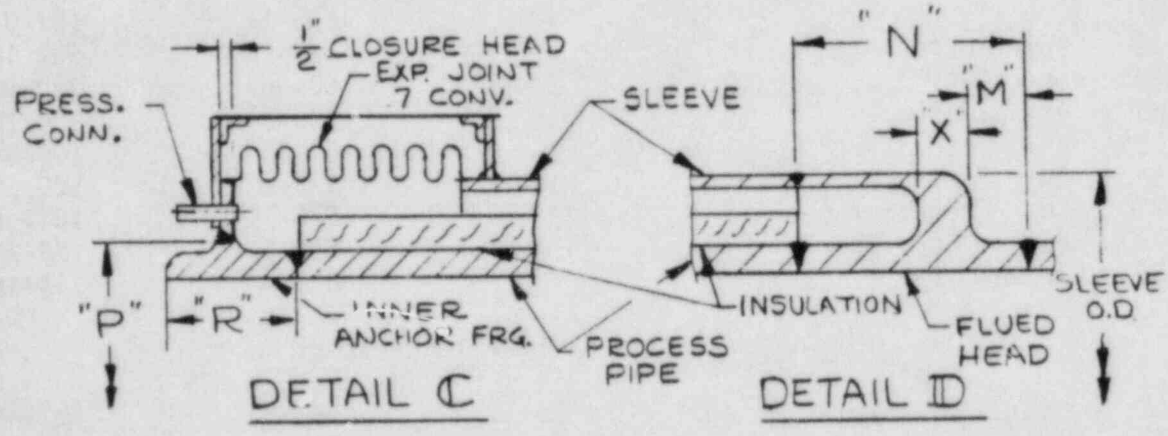


UNITS 1 & 2 FIG. 6 SHT. 2 OF 2 PIPE PENETRATIONS (TYPE 3)
CONCRETE CONTAINMENT (STEEL LINER)



SECTION B-B SEE SHT 1

DRAWN TO PEN 108



DETAIL C　　　DETAIL D

PENETRATION NUMBER	SLEEVE		PROCESS PIPE		FLUED HEAD			INNER ANCHOR FORGING	
	O.D.	W.T.	O.D.	W.T.	"M"	"N"	"X"	"R"	"P" DIA.
43	8.625	.322	3.5	.216	2	6¼		4¾	5
108, 110	16	.5	10.75	1.125	2¼	9¼		5¼	12¼
105	18		10.75						

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 PIPE PENETRATIONS (TYPE 4)

Figure 7, Sheet 1 presents the typical design configurations of Types 4, 4A, and 4B pipe penetrations. There are 15 Type 4, 4 Type 4A, and 1 Type 4B pipe penetrations mounted in the concrete containment wall. Figure 7, Sheet 2 presents the design dimensions for all 15 Type 4 pipe penetrations. Figure 7, Sheet 3 presents the design dimensions for the 4 Type 4A and 1 Type 4B penetrations. These pipe penetrations designated Type 4, 4A, and 4B per the plant A/E for these plants. All Type 4, 4A, and 4B pipe penetrations are radially mounted in the concrete containment wall.

TYPE 4 RADIAL PIPE PENETRATIONS (Total 15)

Type 4 Penet. No.	Name	Process Pipe OD, in*	Sleeve in Wall OD, in.*	Location in Wall Elevation (ft.in.)	Location in Wall Azimuth (Deg.Min)
4	Boron Injection	3	8	577-6	94-0
13	Aux. Feedwater	3	14	599-9	100-45
19	Water Supply	6	12	586-10	107-0
25	Pump Suction	6	12	586-10	100-45
15	Pump Seal Water	4	10	594-4	96-15
28	Cooling Water	3	12	601-11	104-45
29	Cooling Water	3	12	601-11	107-0
33	Pump Suction	3	12	588-10	102-45
38	Spray Discharge	10	20	604-6	102-45
60	Relief Line	10	16	596-5	96-15
68	Aux. Feedwater	3	14	577-6	100-45
69	Aux. Feedwater	3	14	577-6	109-15
74	Aux. Feedwater	3	14	586-10	104-45
75	Regen. Heat Exch.	3	12	596-5	98-30
80	Relief Line	4	10	605-4	104-45

TYPE 4A RADIAL PIPE PENETRATIONS (Total 4)

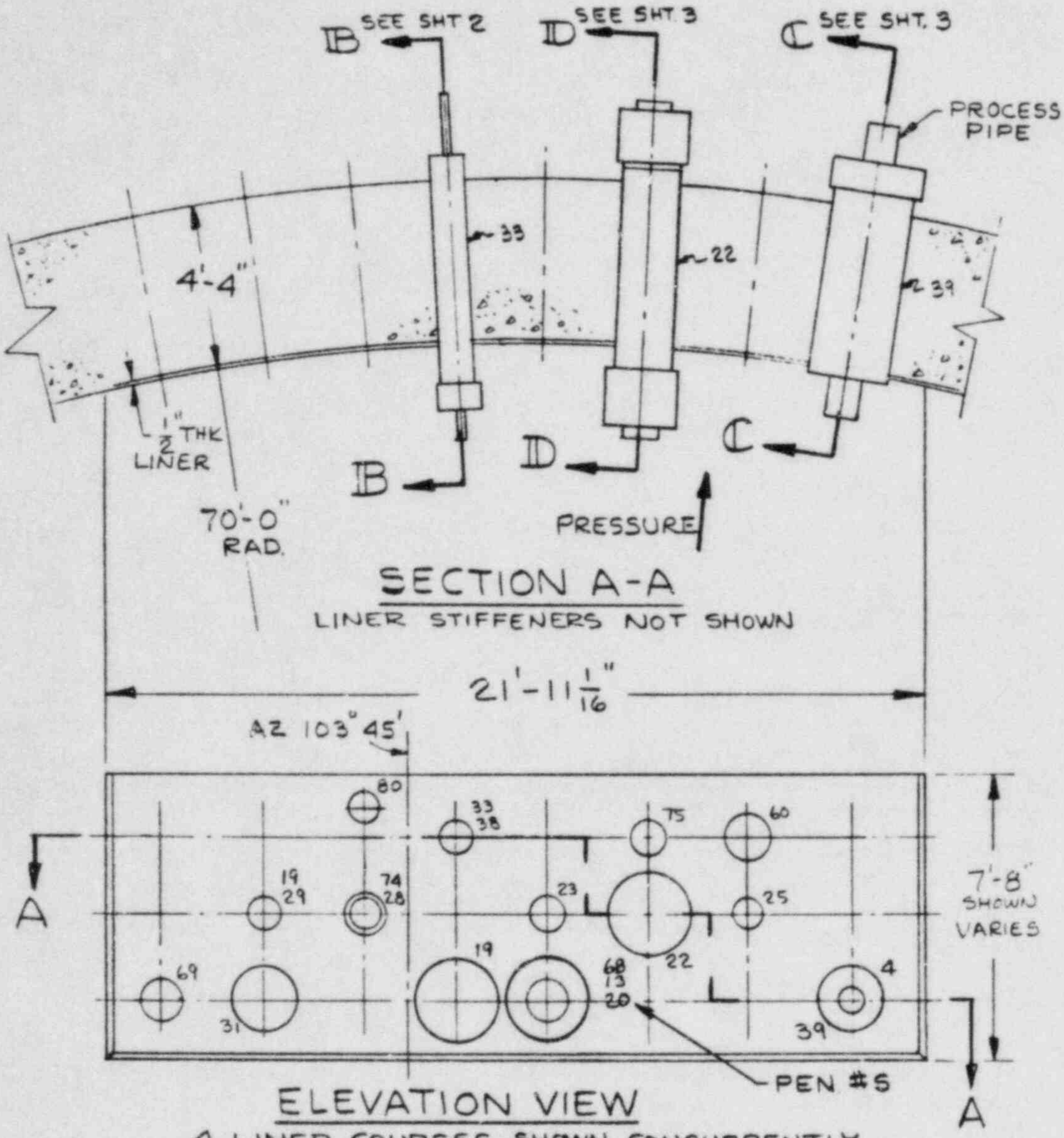
18	Pump Discharge	10	18	584-3	102-45
20	Pump Discharge	10	18	584-3	100-45
31	Cont. Spray	10	20	599-9	107-0
39	Cont. Spray	10	20	599-9	94-0

TYPE 4B RADIAL PIPE PENETRATIONS (Total 1)

22	Resid. Ht. Exch.	12	28	580-1	98-30

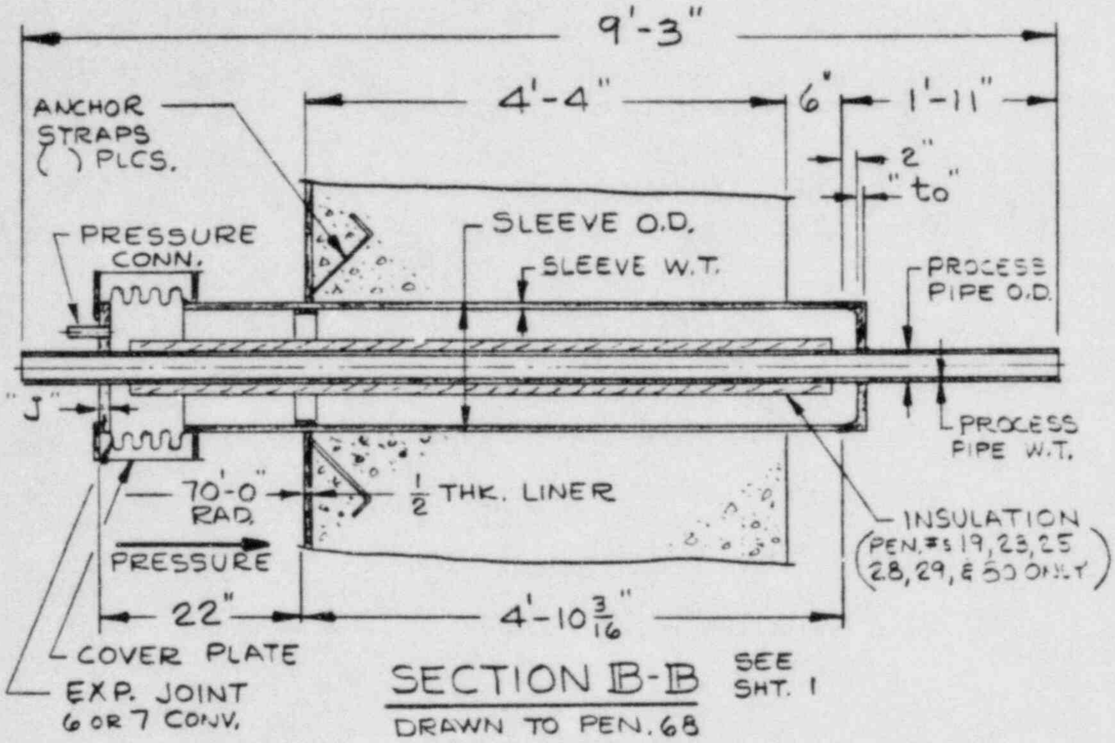
*Pipe Size, attached figures present actual pipe dimensions.

UNITS 1 & 2 FIG. 7 SHT. 1 OF 3 PIPE PENETRATIONS (TYPE 4)
CONCRETE CONTAINMENT (STEEL LINER)



PENETRATION NUMBER		
TYPE 4 ON SHT. 2	TYPE 4A ON SHT. 3	TYPE 4B ON SHT. 3
4, 13, 19, 23, 25 28, 29, 33, 38, 60 68, 69, 74, 75, 80	18, 20 31, 39	22

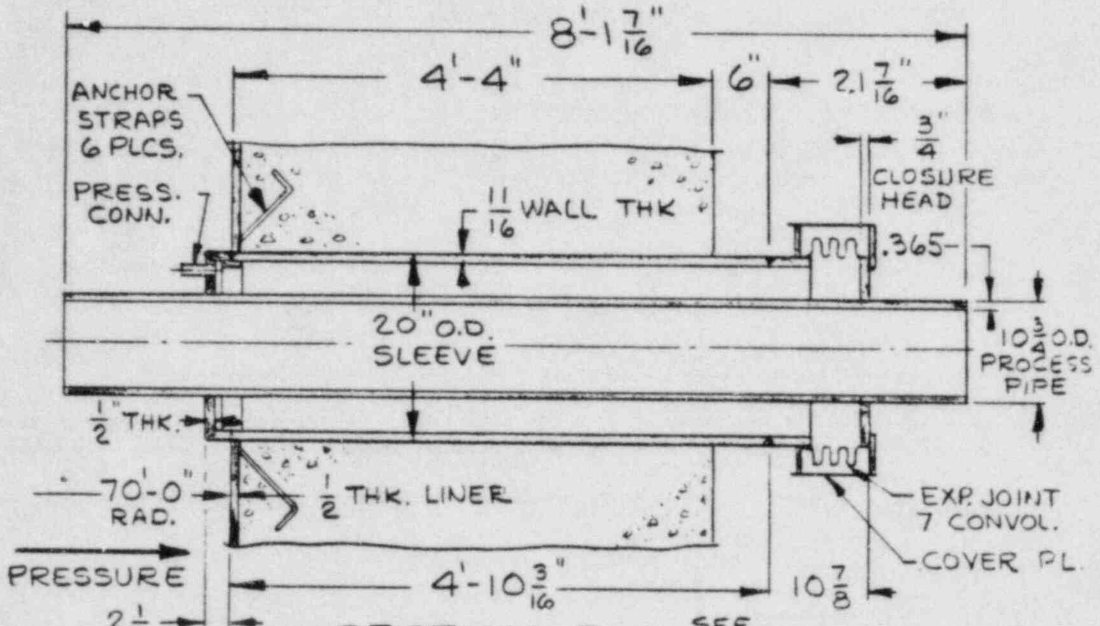
UNITS 1 & 2 FIG. 7 SHT. 2 OF 3 PIPE PENETRATIONS (TYPES 4)
CONCRETE CONTAINMENT (STEEL LINER)



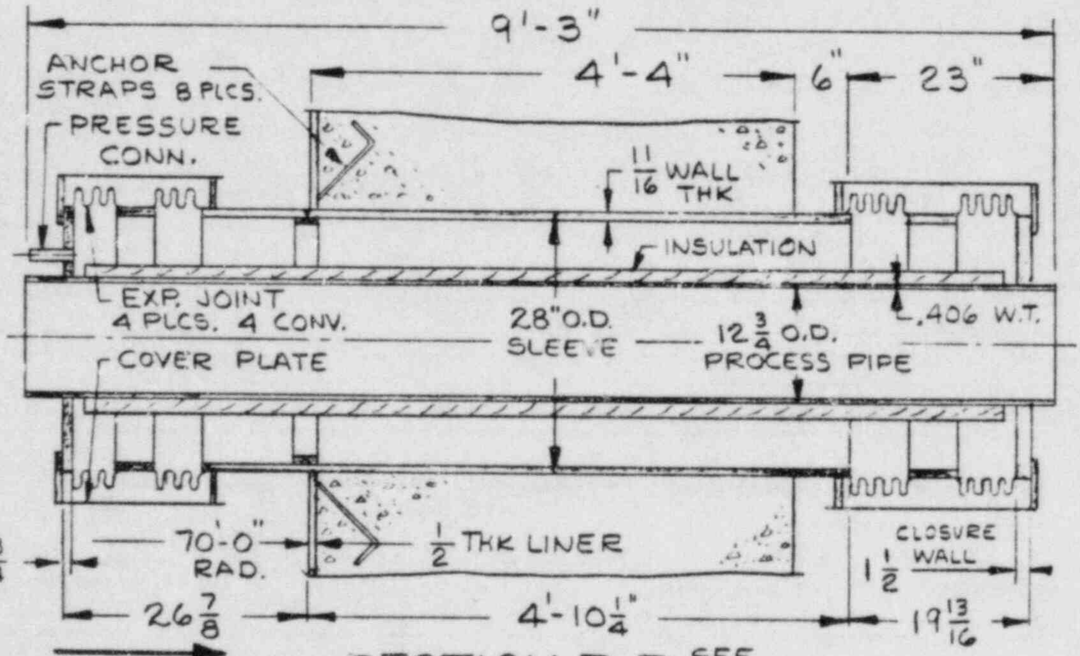
SECTION B-B SEE SHT. 1
DRAWN TO PEN. 68

PENETRATION NUMBER	SLEEVE		PROCESS PIPE		CAP THK		ANCHOR STRAPS	EXP. JOINT
	O.D.	W.T.	O.D.	W.T.	"to"	"J"	No.	NO CONV.
4	8.625	.322	3.50	.438	.750	.5	4	7
25	10.750	.365	4.50	.237	.375	.5	4	7
80	10.750	.365	4.50	.237	.625	.5	4	7
28, 29	12.750	.406	3.50	.216	.375	.5	4	6
33	12.750	.406	3.50	.438	.375	.5	4	6
75	12.750	.406	3.50	.438	.750	.5	4	6
13, 68, 69, 74	14.000	.438	3.50	.438	.875	.75	4	7
60	16.000	.500	10.750	.365	.500	.5	5	7
38	20.000	.593	10.750	.365	.625	.5	6	6
19, 23	12.750	.406	6.625	.280	.375	.5	4	6

UNITS 1 & 2 FIG. 7 SHT 3 OF 3 PIPE PENETRATIONS (TYPES 4)
CONCRETE CONTAINMENT (STEEL LINER)



SECTION C-C SEE SHT. 1
PEN. #s 31 & 39 TYPE 4A



SECTION D-D SEE SHT. 1
PEN #22 TYPE 4B

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 PIPE PENETRATIONS (TYPE 5)

Figure 8, Sheet 1 presents the typical design configuration of Type 5 and 5A pipe penetrations. There are 20 Type 5 and 2 Type 5A pipe penetrations mounted in the concrete containment wall. Figure 8, Sheet 2 presents the design dimensions for the 20 Type 5 and Figure 8, Sheet 3 for the 2 Type 5A pipe penetrations. These pipe penetrations designated Types 5 and 5A per the plant A/E for these plants. All type 5 and 5A penetrations are radially mounted in the concrete containment wall.

TYPE 5 RADIAL PIPE PENETRATIONS (Total 20)

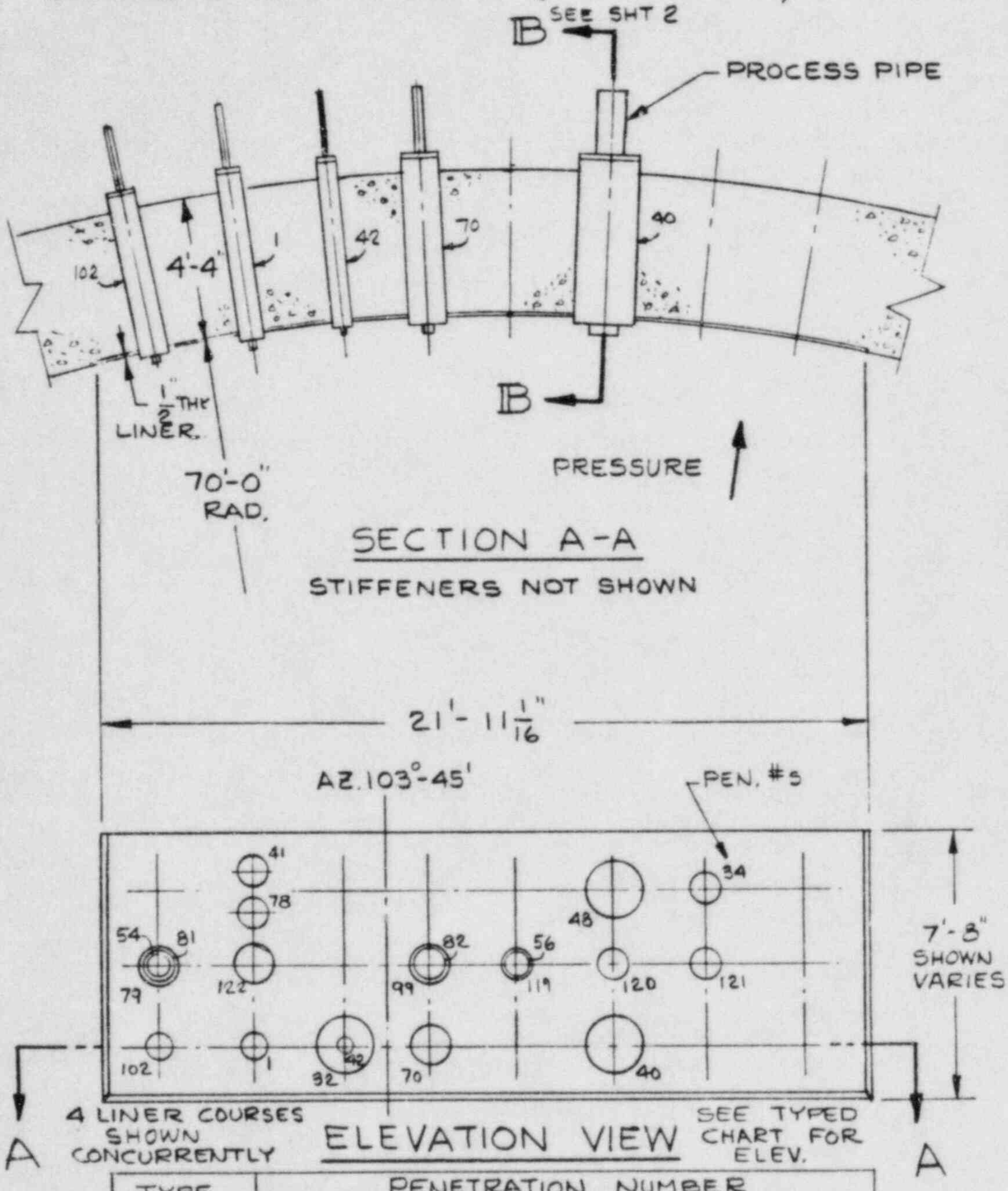
Type 5 Penet. No.	Name	Process Pipe OD, in*	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
1	Fire Protection	4	10	577-6	107-0
32	Serv. Water Pump	14	20	599-9	104-45
34	Demin. Water	12	2	588-10	96-15
40	Vent. Cooler	10	20	599-9	98-30
41	Cont. Press.	2	8	605-4	107-0
42	Sump Discharge	1-1/2	6	577-6	104-45
48	Serv. Water Pump	14	28	604-6	98-30
54	Cont. Press.	2	6	586-10	109-15
56	Filter Vent	2	8	580-1	100-45
70	Cavity Drain	3	14	577-6	102-45
78	Cont. Press.	2	8	603-8	107-0
79	Water Discharge	10	14	594-4	109-15
81	Filter Vent	2	8	580-1	109-15
82	Cont. Press.	2	8	601-11	102-45
99	Pump Discharge	2	14	594-4	102-45
102	Primary Water	3	10	592-0	109-15
119	Water Discharge	10	12	601-11	100-45
120	Water Discharge	10	12	601-11	98-30
121	Serv. Water Pump	10	12	601-11	96-15
122	Cooler Discharge	10	14	594-4	107-0

TYPE 5A RADIAL PIPE PENETRATIONS (Total 2)

51	Purge Air In	42	48	626-0	146-0
52	Purge Air Out	42	48	634-0	146-0

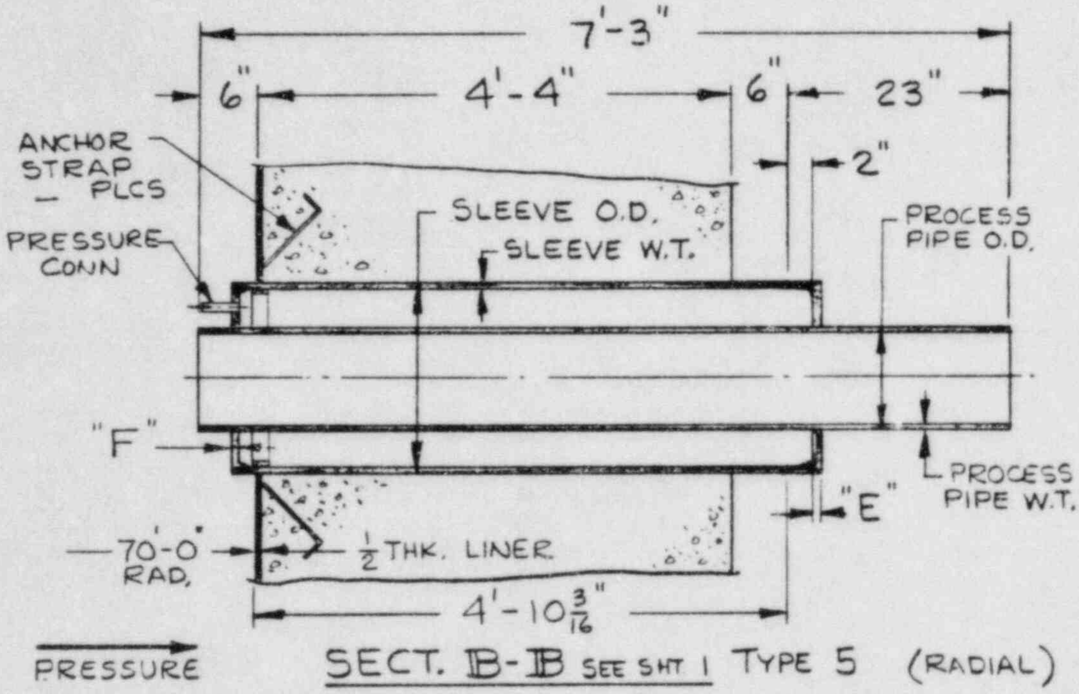
*Pipe Size, attached figures present actual pipe dimensions.

UNITS 1 & 2 FIG. 8 SHT. 1 OF 3 PIPE PENETRATIONS (TYPES 5 & 5A)
CONCRETE CONTAINMENT (STEEL LINER)



TYPE	PENETRATION NUMBER
5	1, 32, 34, 40, 41, 42, 48, 54, 56, 70 78, 79, 81, 82, 99, 102, 119, 120, 121 & 122
5A	51, 52 - SEE SHT. 3 -

UNITS 1 & 2 FIG 8 SHT. 2 OF 3 PIPE PENETRATIONS (TYPES 5 & 5A)
CONCRETE CONTAINMENT (STEEL LINER)

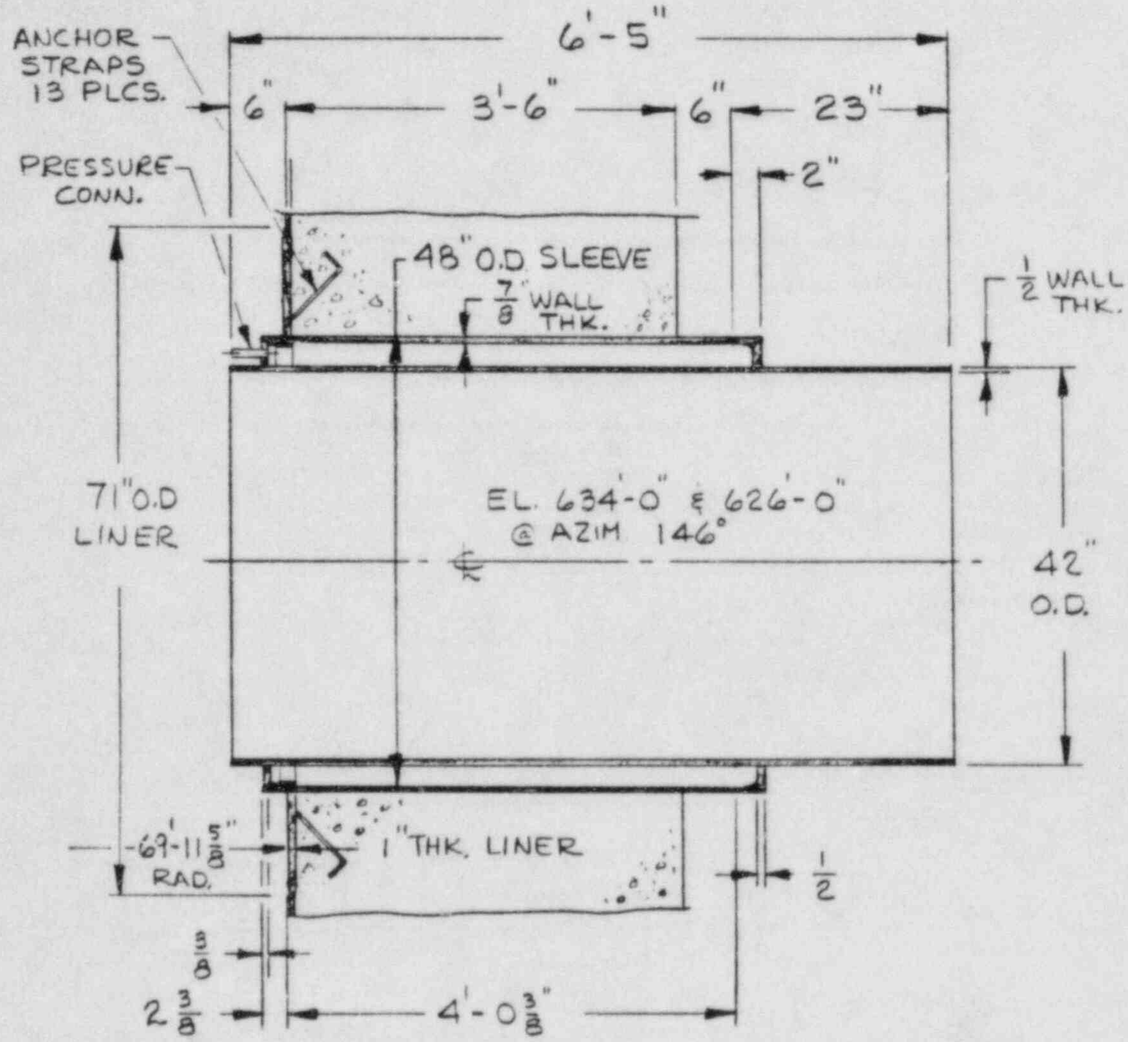


SECT. B-B SEE SHT 1 TYPE 5 (RADIAL)

DRAWN FOR PEN. #40

PENETRATION NUMBER	# ANCHOR STRAPS	SLEEVE		PROCESS PIPE		CLOSURE HEAD	
		O.D.	W.T.	O.D.	W.T.	E	F
42	4	6.625	.280	1.900	.145	.250	.250
54	4			2.375	.218		
41, 78, 82	4	8.625	.322	2.375	.218	.250	.250
56, 81	4				.154		
1	4	10.750	.365	4.500	.237	.500	.250
102	4			3.500	.216	.575	
34	4	12.750	.406	2.375	.154	.500	.250
119, 120, 121	4			10.750	.365		.375
70	4	14"	.438	3.500	.216	.625	.250
79, 122	4			10.750	.365	.500	.375
99	4			2.375	.154	.500	.250
32	6	20"	.593	14	.375	.500	.375
40	6			10.750	.365		
48	8	28"	.688	14	.375	.750	.375

UNITS 1 & 2 FIG. 8 SHT. 3 OF 3 PIPE PENETRATIONS (TYPES 5 & 5A)
CONCRETE CONTAINMENT (STEEL LINER)



VERTICAL SECT. - TYPE 5A

PEN'S. 51 & 52 RADIAL

INDEPENDENT PENS
IE: NOT PART OF A
LINER PANEL AS SHOWN
ON SHT #1

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 MULTI-PROCESS PIPE PENETRATIONS (TYPE 6)

Figure 9, Sheet 1 presents typical Type 6 mult.-process pipe penetrations. Figure 9, Sheet 2 presents the design dimensions of all 6 Type 6 multi-process pipe penetrations. These pipe penetrations designated Type 6 per the plant A/E for these plants. All Type 6 penetrations are mounted radially in the concrete containment wall.

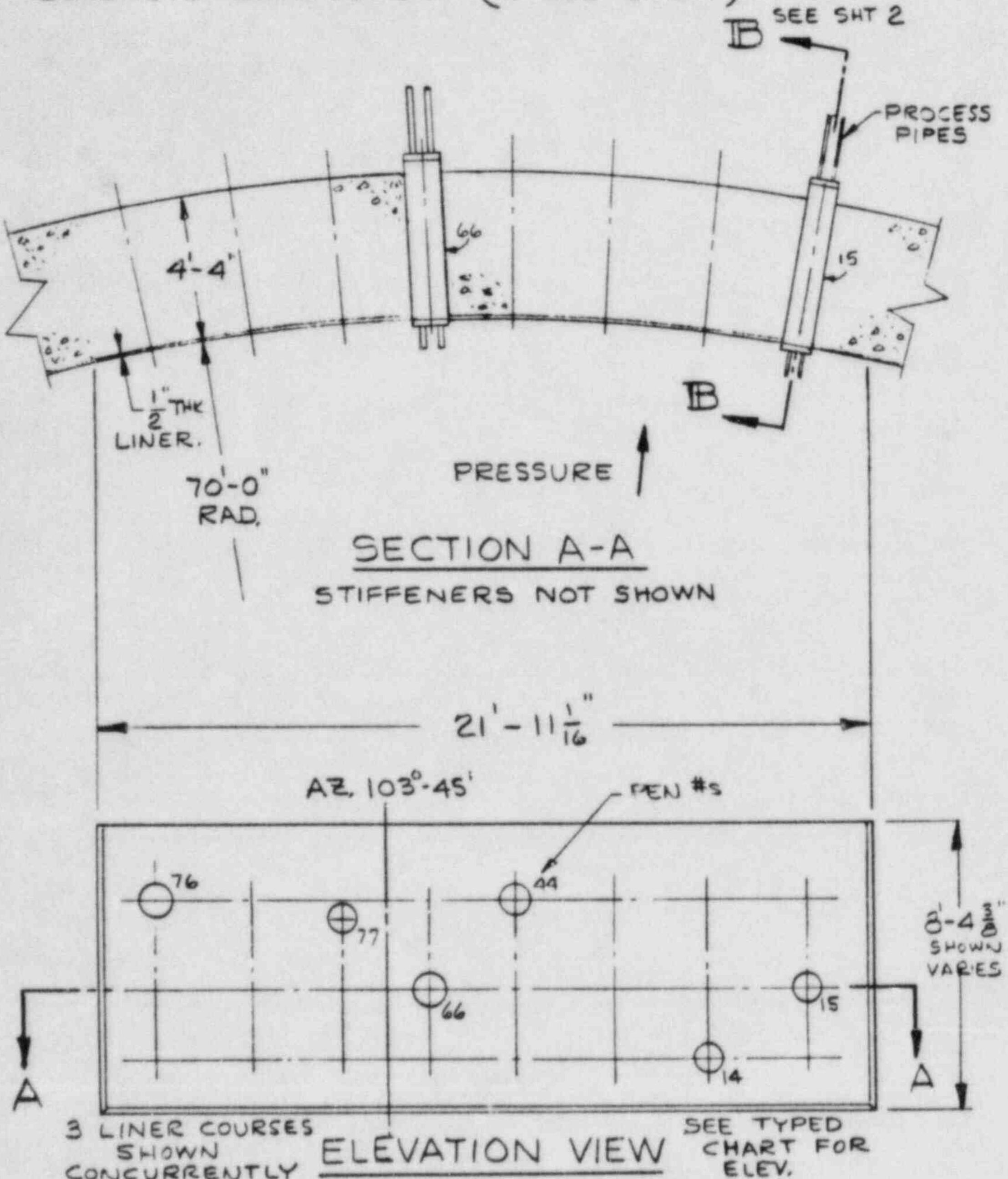
TYPE 6 RADIAL MULTI-PROCESS PIPE PENETRATIONS (Total 6)

Type 6 Penet. No.	Name	Process Pipe No./Size	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
14	Nitrogen Lines	See Sht 2**	10	599-9	96-15
15	Air Samples	See Sht 2**	10	601-11	94-0
44	Air Samples	See Sht 2**	12	604-6	100-45
66	Wtr. Sup. Lines	See Sht 2**	14	580-1	102-45
76	Samples, N_2, Test Line	See Sht 2**	14	588-10	109-15
77	Weld Channel Pressure	See Sht 2**	10	603-8	104-45

* Pipe Size, attached figures present actual pipe dimensions.

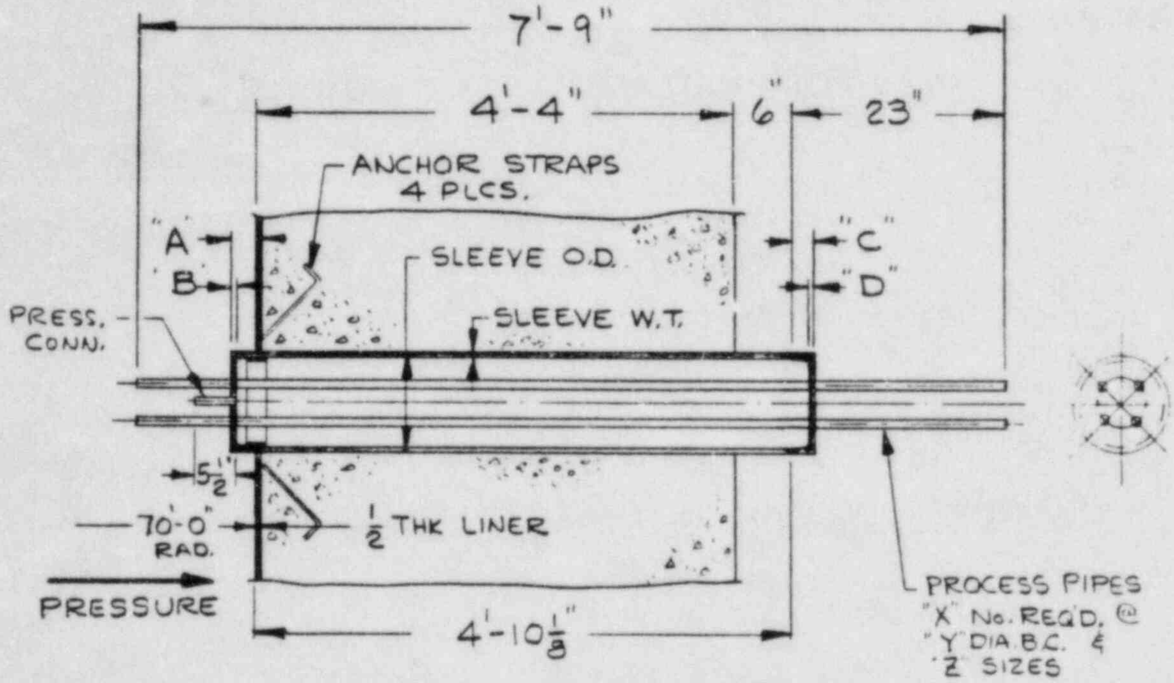
**See Figure 9, Sheet 2 for the number and sizes of process pipes in each penetration in the concrete containment wall.

UNITS 1 & 2 FIG. 9 SHT. 1 OF 2 MULTI PROCESS PIPE (TYPE 6)
CONCRETE CONTAINMENT (STEEL LINER)



TYPE	PENETRATION NUMBER
6	14, 15, 44, 66, 76 & 77

MULTI PROCESS PIPES
UNITS 1 & 2 FIG 9 SHT. 2 OF 2 PIPE PENETRATIONS (TYPE 6)
CONCRETE CONTAINMENT (STEEL LINER)



SECTION B - B SEE SHT 1

DRAWN TO PEN #15

PENET. NUMBER	SLEEVE		DIMENSIONS				PROCESS PIPE		
	O.D.	W.T.	"A"	"B"	"C"	"D"	"X"	"Y"	"Z"
14	10.75	.365	2 1/4	1/4	2 3/8	3/8	3	5	1-3/4 SCHED 40 1-1" SCHED 40 1-1 1/2 SCHED 80
15	10.75	.365	2 1/4	1/4	2 3/8	3/8	4	5	4-1/2" SCHED 40
44	12.75	.406	2 3/8	3/8	2 1/2	1/2	3		2-1" SCHED - 1-1 1/2 SCHED. -
66	14	.438	2 3/8	3/8	2 1/2	1/2	4	7	4-2" SCHED. 160
76	14	.438	2 3/8	3/8	2 1/2	1/2	4	7	(1 EA) 3/8 O.D. x .095 W.T. 3/4 SCH. 80, 1" SCH. 40S 2" SCHED. 80
77	10.75	.365	2 1/4	1/4	2 3/8	3/8	4	5	4-1/2 SCHED. 80

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 MULTI-PROCESS PIPE PENETRATIONS (TYPE 7)

Figure 10, Sheet 1 presents the location of Type 7 (radial and non-radial) multi-process pipe penetrations in the concrete containment wall. Figure 10, Sheet 2 presents the design dimensions of all 5 Type 7 multi-process pipe penetrations. These pipe penetrations designated Type 7 per the plant A/E for these plants. Type 7 penetrations include 3 radial and 2 non-radial penetrations.

TYPE 7 RADIAL MULTI-PROCESS PIPE PENETRATIONS (Total 3)

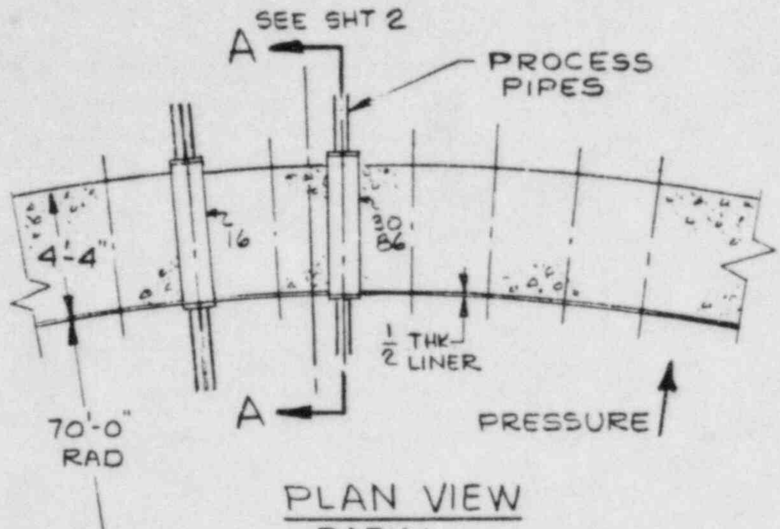
Type 7 Radial Penet. No.	Name	Process Pipe No./Size	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
16	Leak Detection	See Sht 2***	14	596-5	107-0
30	Gas Analyzer	See Sht 2***	14	599-9	102-45
86	Sample, Calibration	See Sht 2***	10	586-10	102-45

TYPE 7 NON-RADIAL MULTI-PROCESS PIPE PENETRATIONS (Total 2)

112	Blowdown Sample	See Sht 2***	16	578-1	213-0**
113	Blowdown Sample	See Sht 2***	16	578-1	333-0**

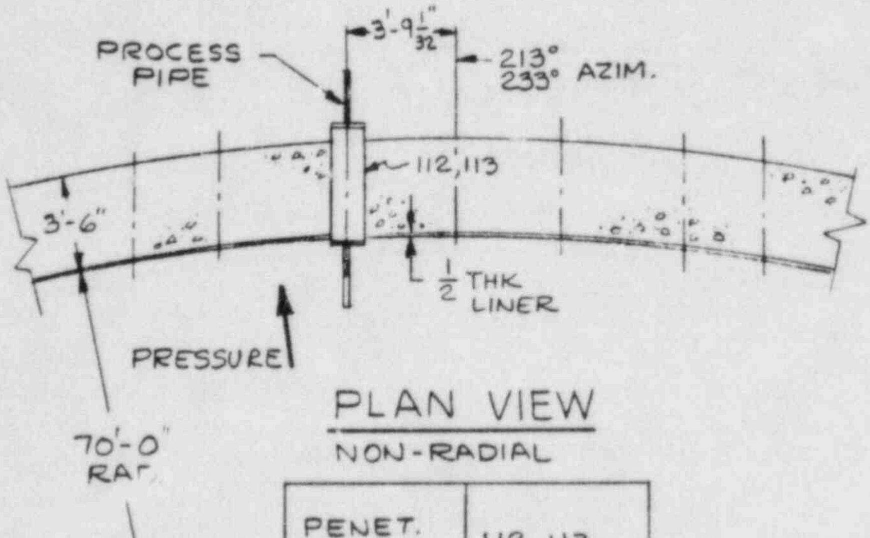
* Pipe Size, attached figures present actual pipe dimensions.
** See Figure 10, Sheet 1 for exact location relative to azimuth 213-0 and 333-0.
***See Figure 10, Sheet 2 for the number and sizes of process pipes in each penetration.

UNITS 1 & 2 FIG. 10 SHT. 1 OF 2 PIPE PENET. (TYPE 7) MULTI-PROC. EXPANSION JOINTED
CONCRETE CONTAINMENT (STEEL LINER)



PLAN VIEW
RADIAL

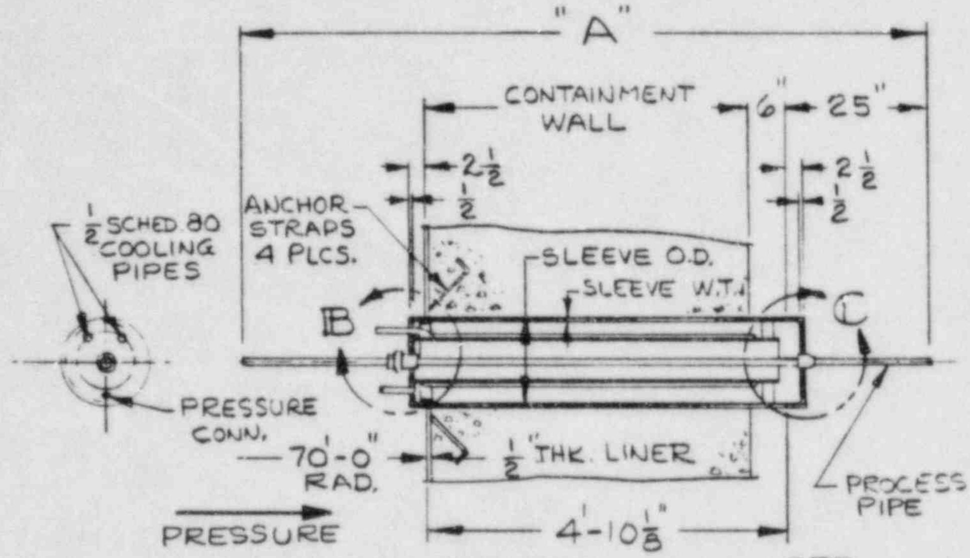
PENET. NUMBER	16,30,86



PLAN VIEW
NON-RADIAL

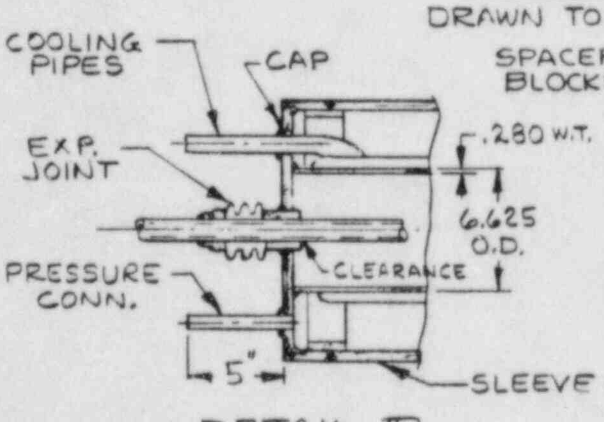
PENET. NUMBER	112, 113

UNITS 1 & 2 FIG. 10 SHT. 2 OF 2 PIPE PENET. (TYPE 7) MULTI-PROC. EXPANSION JOINTED CONCRETE CONTAINMENT (STEEL LINER)

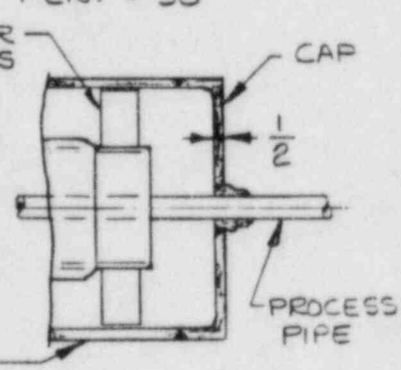


SECTION A-A SEE SHT 1

DRAWN TO PEN. # 30



DETAIL B



DETAIL C

PENET. NUMBER	SLEEVE O.D.	SLEEVE W.T.	CONTAINMENT WALL THK.	OVERALL LGTH. "A"	PROCESS PIPE # REQ'D., SIZE & LOCATION
16	14	.438	4'-4"	99"	5 @ 1/2 O.D. x .095 W.T. ON 4 1/2 DIA. B.C.
30	14	.438	4'-4"	111"	1 @ 3/4 SCH 40 ON CENTER
86	10.75	.365	4'-4"	99"	5-3/8 O.D. x .095 WT ON 4 1/2 D B.C. 1-3/4 SCH. 160 ON CENTER
112, 113 *	16	.500	3'-6"	101"	1-3/8 O.D. x .095 W.T. ON CENTER

* NON-RADIAL TYPE PENET.

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 PIPE PENETRATIONS (SPARE)

Figure 11, Sheet 1 presents the spare pipe penetrations mounted in the concrete containment wall. There are a total of 22 spare pipe penetrations. All 22 spare pipe penetrations are mounted radially in the concrete wall. The dimensions and steel cap on the spare penetrations are presented on Figure 11, Sheet 2.

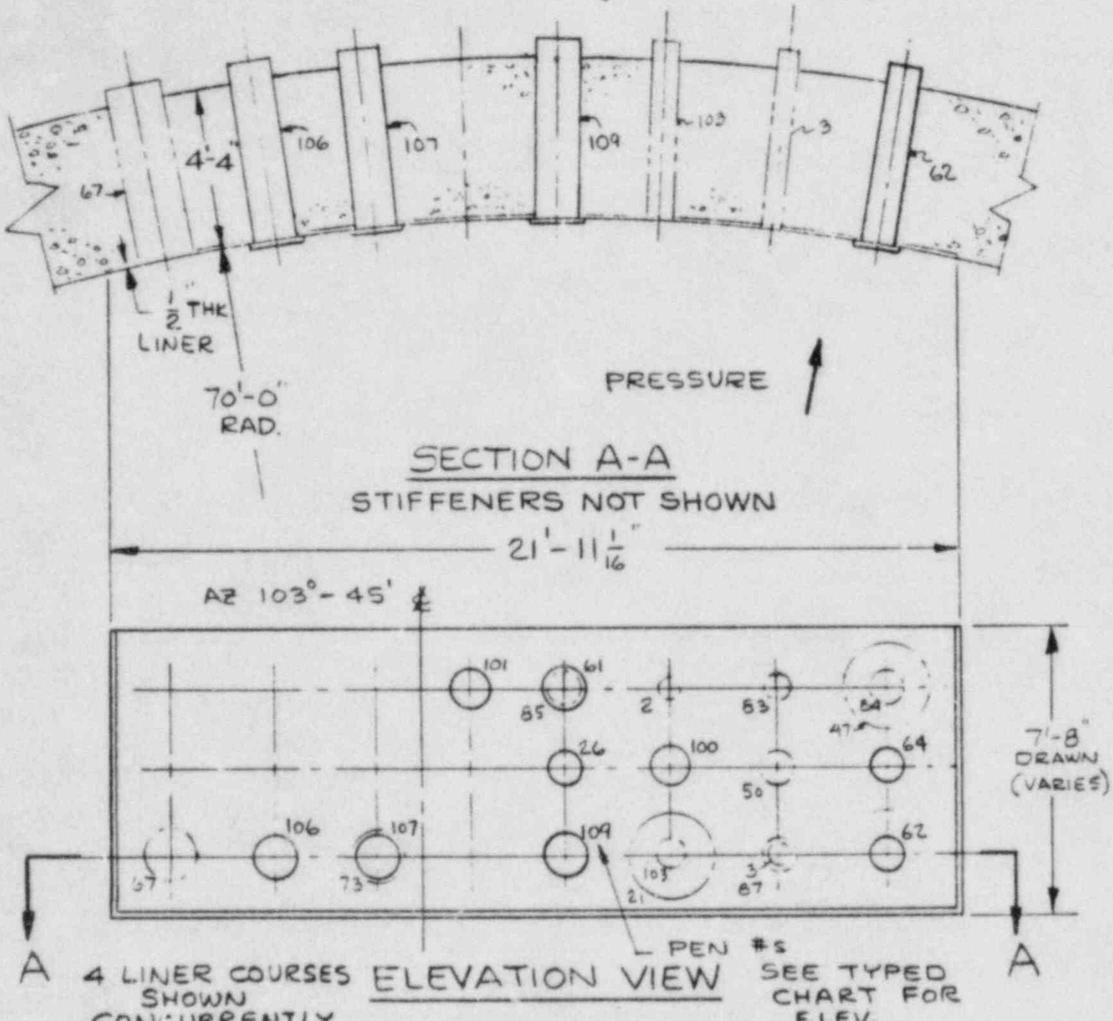
SPARE RADIAL PIPE PENETRATIONS (Total 22)

Spare Penet. No.	Name	Sleeve in Wall OD, in.*	Location in Wall Elevation (ft.in.)	Location in Wall Azimuth (Deg.Min)
2	Spare	6	588-10	98-30
3	Spare	6	577-6	96-15
21	Spare	28	584-3	98-30
26	Spare	10	594-4	100-45
47	Spare	28	604-6	94-0
50	Spare	10	580-1	96-15
61	Spare	16	596-5	100-45
62	Spare	10	592-0	94-0
64	Spare	10	586-10	94-0
67	Spare	18	584-3	108-15
73	Spare	18	584-3	104-45
83	Spare	8	604-6	96-15
84	Spare	10	588-10	94-0
85	Spare	10	588-10	100-45
87	Spare	10	584-3	96-15
90	Spare	10	584-3	94-0
100	Spare	14	594-4	98-30
101	Spare	14	596-5	102-45
103	Spare	8	577-6	98-30
106	Spare	16	592-0	107-0
107	Spare	16	592-0	104-45
109	Spare	16	592-0	100-45

*Pipe Size, the actual dimensions of the sleeve in the concrete wall are presented on the attached figure.

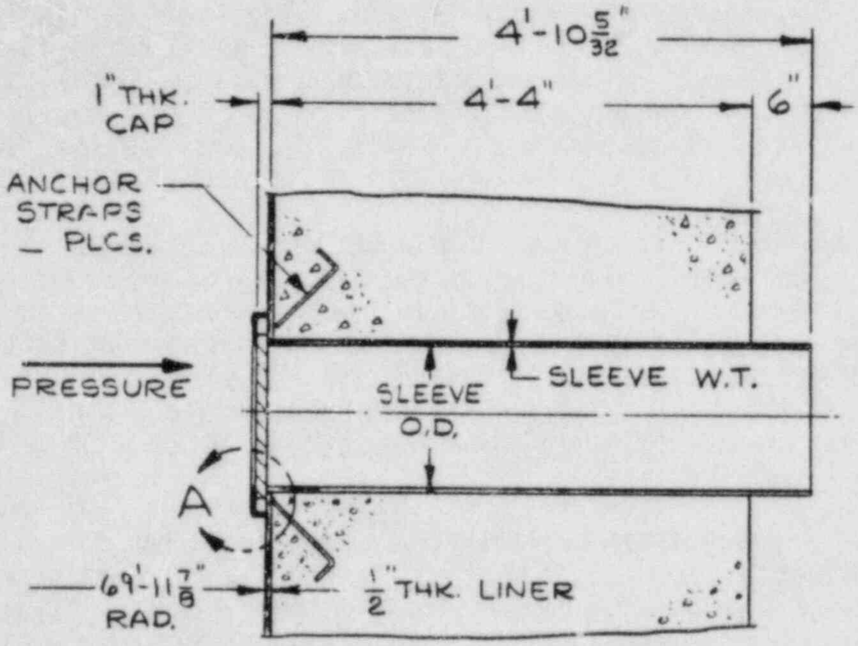
UNITS 1 & 2 FIG. 11 SHT 1 OF 2 PIPE PENETRATIONS · CAPPED & SPARE

CONCRETE CONTAINMENT (STEEL LINER)



NOMINAL SLEEVE SIZE	SPARE PENETRATION NUMBERS	
	CAPPED - SEE SHT 2	
6		2, 3
8		83, 103
10	26, 62, 64	50, 84, 85, 87
14	10C, 101	
16	61, 106, 107, 109	
18		67, 73
28		21, 47, [illegible]

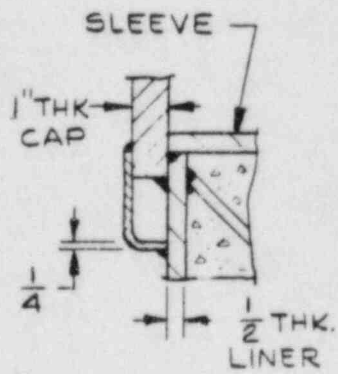
UNITS 1 & 2 FIG. 11 SHT. 2 OF 2 PIPE PENETRATIONS - CAPPED CONCRETE CONTAINMENT (STEEL LINER)



ELEVATION VIEW

DRAWN TO PEN 61

PENETRATION NUMBER	SLEEVE O.D.	SLEEVE W.T.	ANCHOR STRAPS #PLACES
26,62,64	10.750	.365	4
100, 101	14	.438	4
61,106,107,109	16	.500	5



DETAIL A

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 AND 2 FUEL TRANSFER TUBE PENETRATION (No. 49)

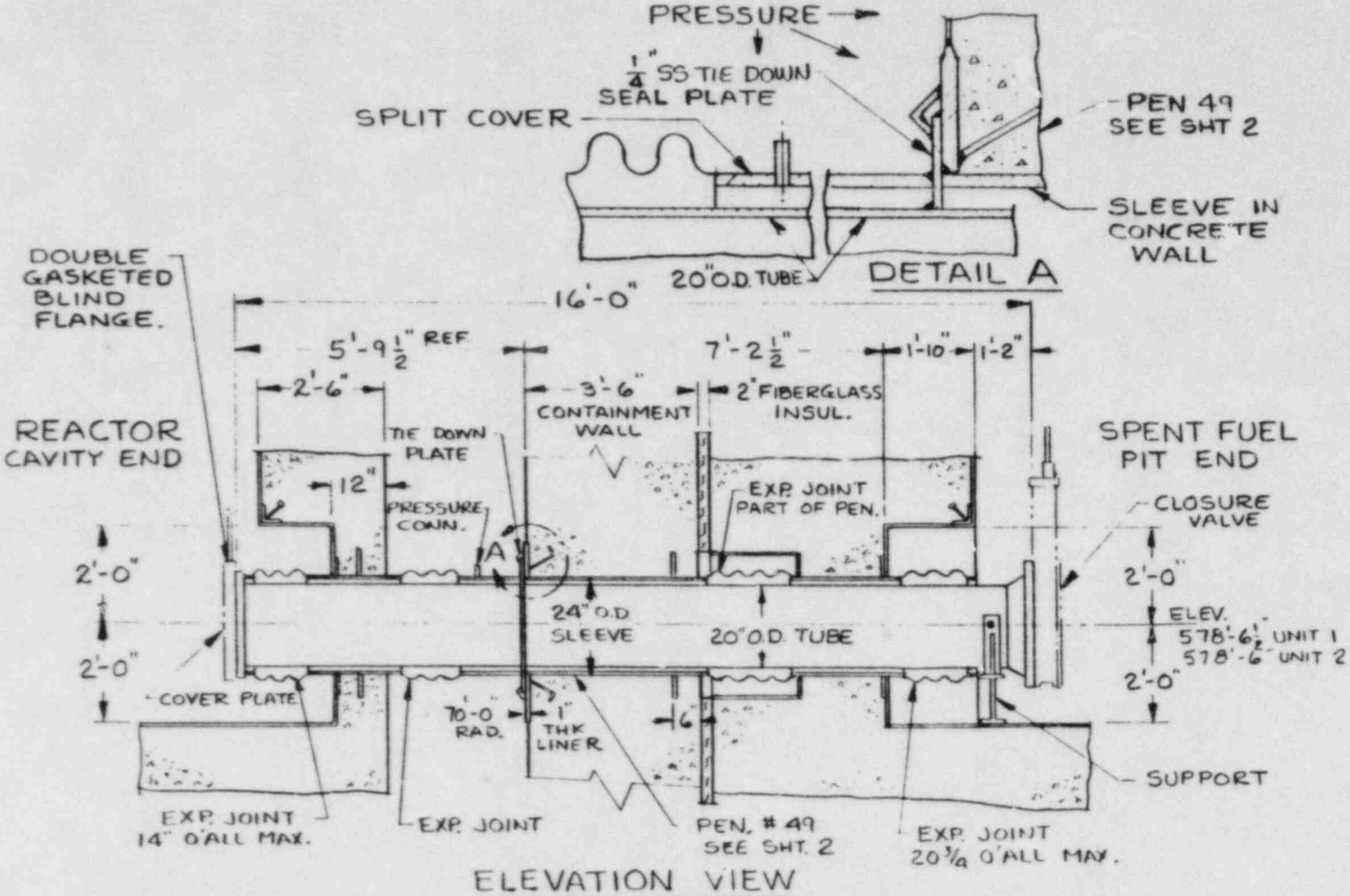
The fuel transfer tube (one penetration) provides for fuel movement between the refueling canal in the reactor containment and the spent fuel pit. The penetration in the concrete containment wall consists of a 20 inch pipe inside a 24 inch sleeve mounted in the concrete wall. The inner (20 in.) pipe acts as the transfer tube and is capped with a double gasketed blind flange in the refueling canal. A seal plate is welded to the containment liner and also to the inside tube at the inner wall surface of the steel lined concrete containment wall. The seal plate and the blind flange provide the containment boundary.

Bellows expansion joints, which are welded to the sleeve in the concrete wall and connected to the tube by welding to the end plates, provide for differential building movement. The sleeve and expansion joints serve to cover most of the welds on the fuel transfer tube inside the containment building. The annulus between the sleeve and fuel transfer tube is pressurized. The (short) length of fuel transfer tube between the containment end plate and the blind flange, which is covered by the sleeve, has its welds covered by a channel. The channel is pressurized inside.

Figure 12, Sheet 1 presents an overall view of the fuel transfer tube assembly. On Figure 12, Sheet 1 the "seal plate" and "blind flange," which provide part of the containment boundary, are identified. Figure 12, Sheet 2 provides the details of the steel sleeve mounted in the concrete containment wall.

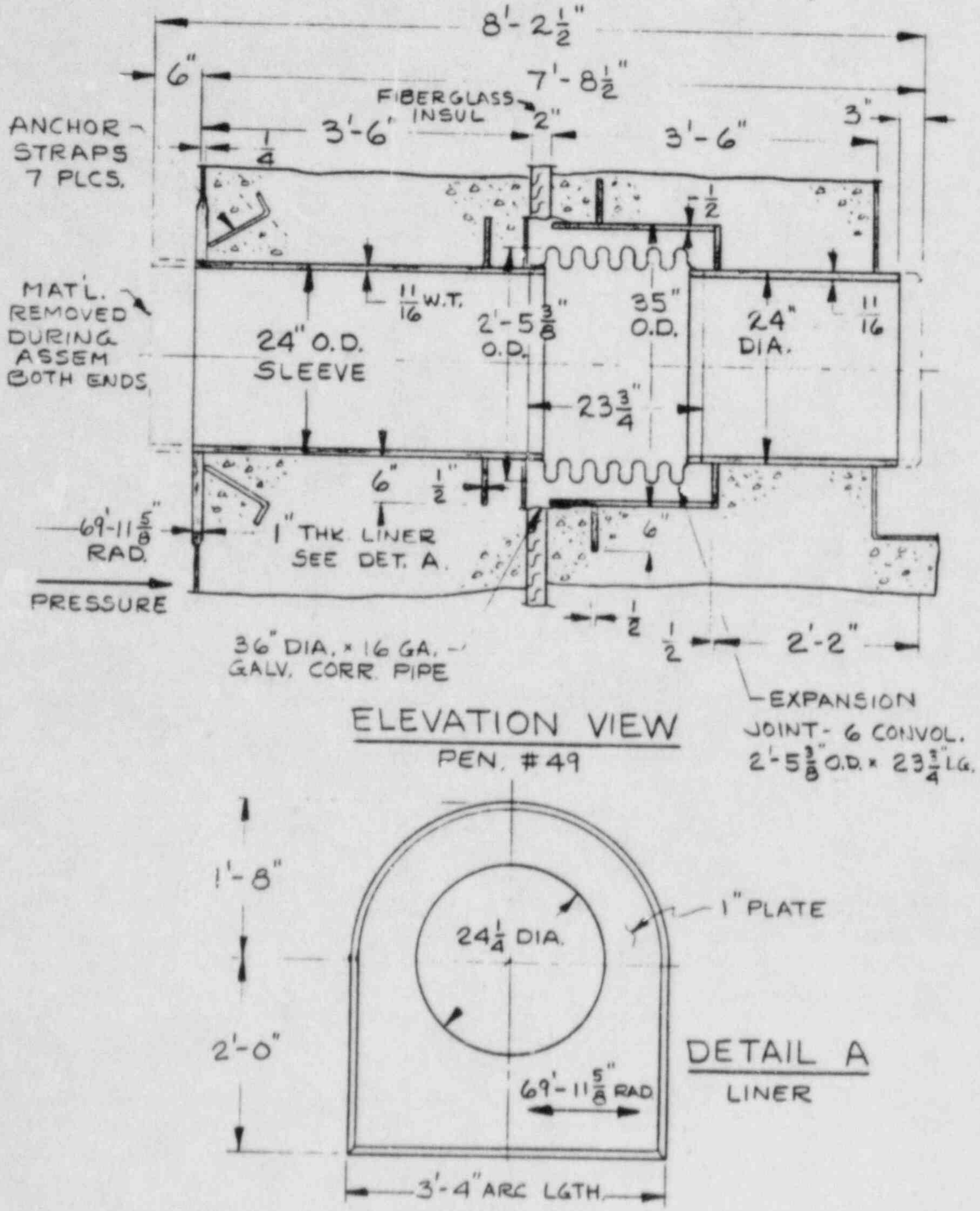
Location of Fuel Transfer Tube - Penetration No. 49

Centerline Elevation	578 ft. 6 in.
Centerline Azimuth	(Non-Radial) parallel to the 90° axis at a distance of 5 ft. 3-1/16 in. between the two centerlines.



UNITS 1 & 2 FIG 12 SHT. 1 of 2 PIPE PENETRATIONS - FUEL TRANSFER TUBE
CONCRETE CONTAINMENT (STEEL LINER)

UNITS 1 & 2 FIG. 12 SHT. 2 OF 2 PIPE PENET. FUEL TRANSFER TUBE
CONCRETE CONTAINMENT (STEEL LINER)



UNITS 3, 4, 5, 6, 7, AND 8 CONCRETE CONTAINMENT (STEEL LINER)

FSAR DESCRIPTION OF UNITS 3, 4, 5, 6, 7, AND 8 CONTAINMENT STRUCTURE

The containment structure is prestressed concrete made up of a cylinder with a shallow dome roof and flat foundation slab. The cylindrical portion is prestressed by a post-tensioning system consisting of horizontal and vertical tendons. There are three buttresses equally spaced around the containment and each horizontal tendon is anchored at buttresses 240° apart, bypassing the intermediate buttress. The dome post-tensioning system is made up of three groups of tendons oriented 120° to each other and anchored at the vertical face of the dome ring. The entire structure is lined on the inside with steel plate. The steel liner plate is 1/4-inch thick and is anchored by structural steel rolled sections embedded in the concrete and welded to the liner plate. The 1/4-inch liner plate is attached to the containment wall by means of 3 by 2 by 1/4-inch vertical angles spaced horizontally every 15 inches.

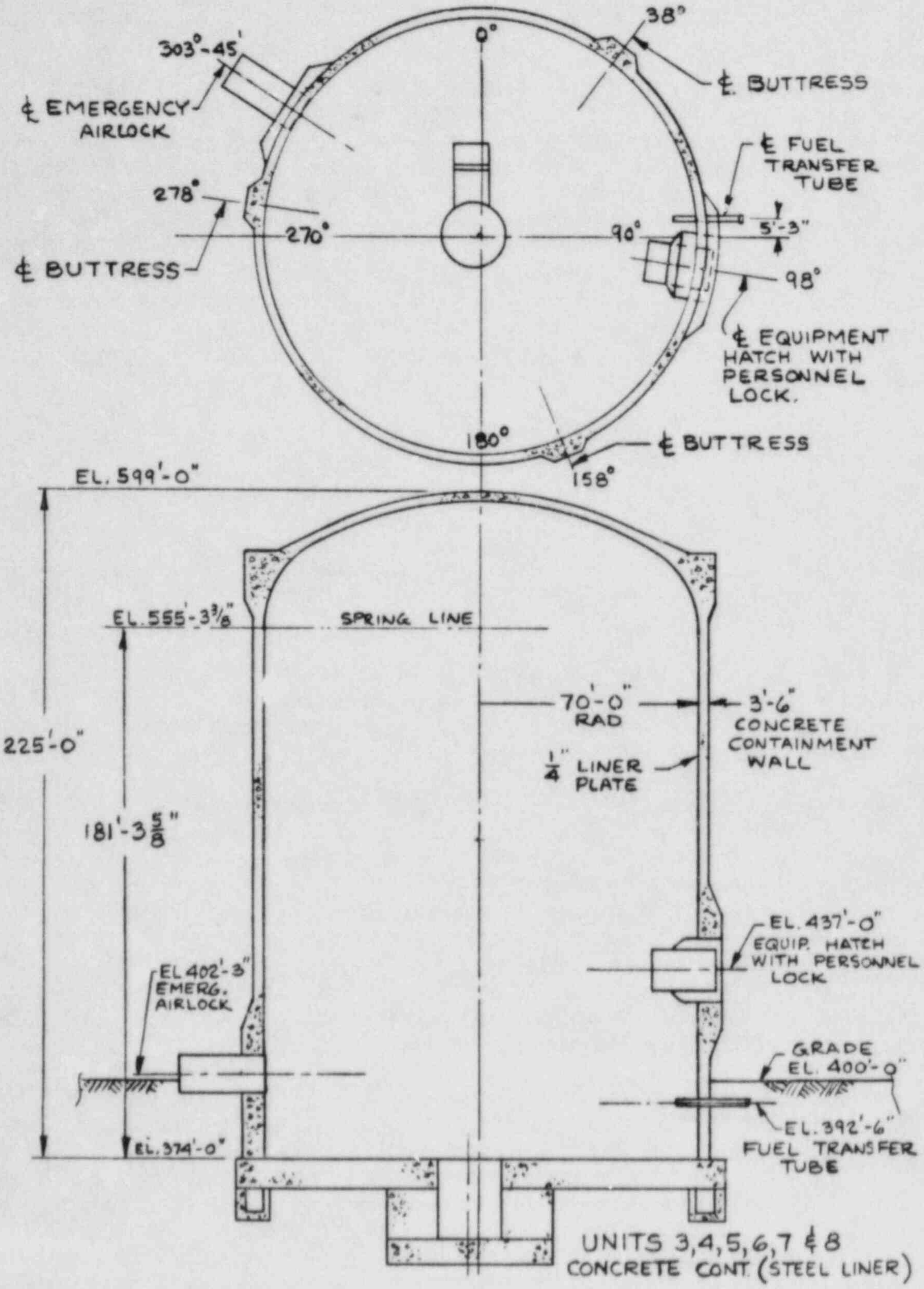
The containment has the following dimensions.

thickness of base slab	12 ft.
diameter of base slab	157 ft.
inside diameter of containment	140 ft.
inside height of containment	222 ft.
thickness of containment wall	3 ft. 6 in.
dome thickness	3 ft.

The base foundation slab is conventionally reinforced with high strength reinforcing steel. A continuous access gallery is beneath the base slab for access to the vertical tendons. The top of the base slab, within the containment, is lined with a steel plate.

The containment cylindrical wall has a constant thickness of 3.5 feet starting from the base slab elevation of 374 feet to the dome springline at elevation 555 feet 3-3/8 inches. The wall has been thickened locally around main steam penetrations, personnel lock, and equipment hatch. Containment reinforcing consists primarily of hoop and meridional steel. Prestressing tendons are arranged in hoop and meridian direction. Continuous hoop and meridian reinforcement is placed at the outside face of the cylindrical wall. Similar reinforcement is placed at the inside face where the cylindrical wall intersects with the base slab or dome ring and in the area where polar crane brackets are embedded in the containment wall.

The containment wall is prestressed using 201 hoop and 162 vertical unbonded tendons. Each hoop tendon is anchored at buttresses 240° apart bypassing the intermediate buttress. The hoop tendons are arranged in the wall between elevation 374 feet 0 inch and 562 feet 0 inch. Vertical tendons are anchored at the underside of the base slab at elevation 362 feet and at the top of the dome ring at elevation 579 feet 0 inch. The anchorage zones for all the tendons have been provided with additional reinforcing to account for transverse tensile stresses resulting from anchorage forces reacting on the concrete.



UNITS 3,4,5,6,7 & 8
CONCRETE CONT. (STEEL LINER)

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3, 4, 5, 6, 7, and 8 - EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the concrete containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two gumdrop gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 20 swing bolts mounted on the outer surface of the hatch opening and containment ring. The pressure inside the containment vessel provides the seating force for the seal. The personnel lock is mounted in the cover of the equipment hatch. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Units 3,4,5,6,7,and 8 - Figure 1
Clear opening	18 ft. 6 in.
Cover thickness	1 inch
Cover shape, radius	10 ft SPH radius
Material	SA-516 Grade 70

Containment Ring

Thickness	3 inch
Diameter	18 ft 6 in. I.D.
Material	A-516 Grade 70

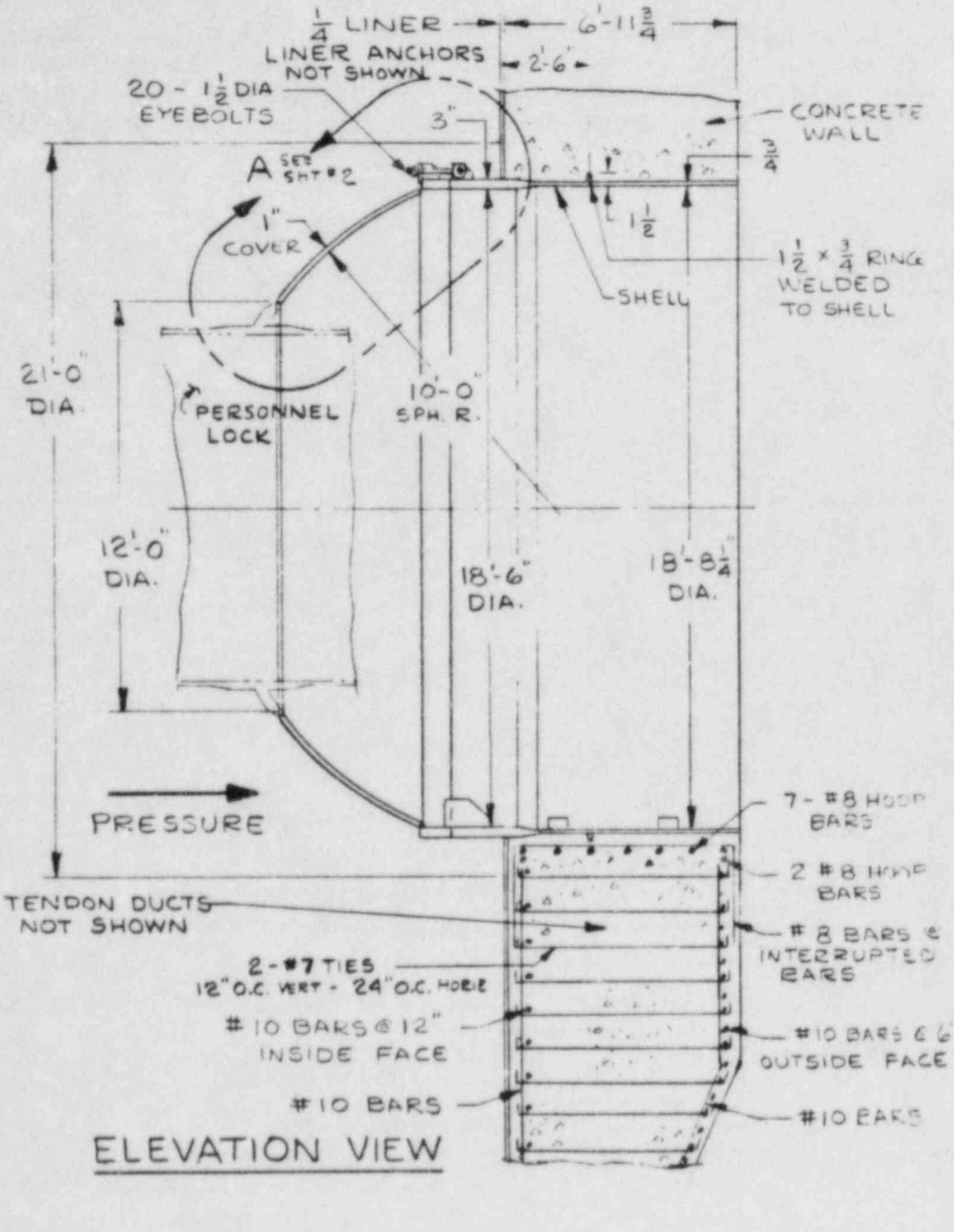
Gasket

Gasket type	Gumdrop
Cross-section	.750 x .812 in.
Material	Silicone Rubber
Length, Inner	58 ft. 5 in.
Length, Outer	59 ft. 1 in.

Location of Hatch Centerline

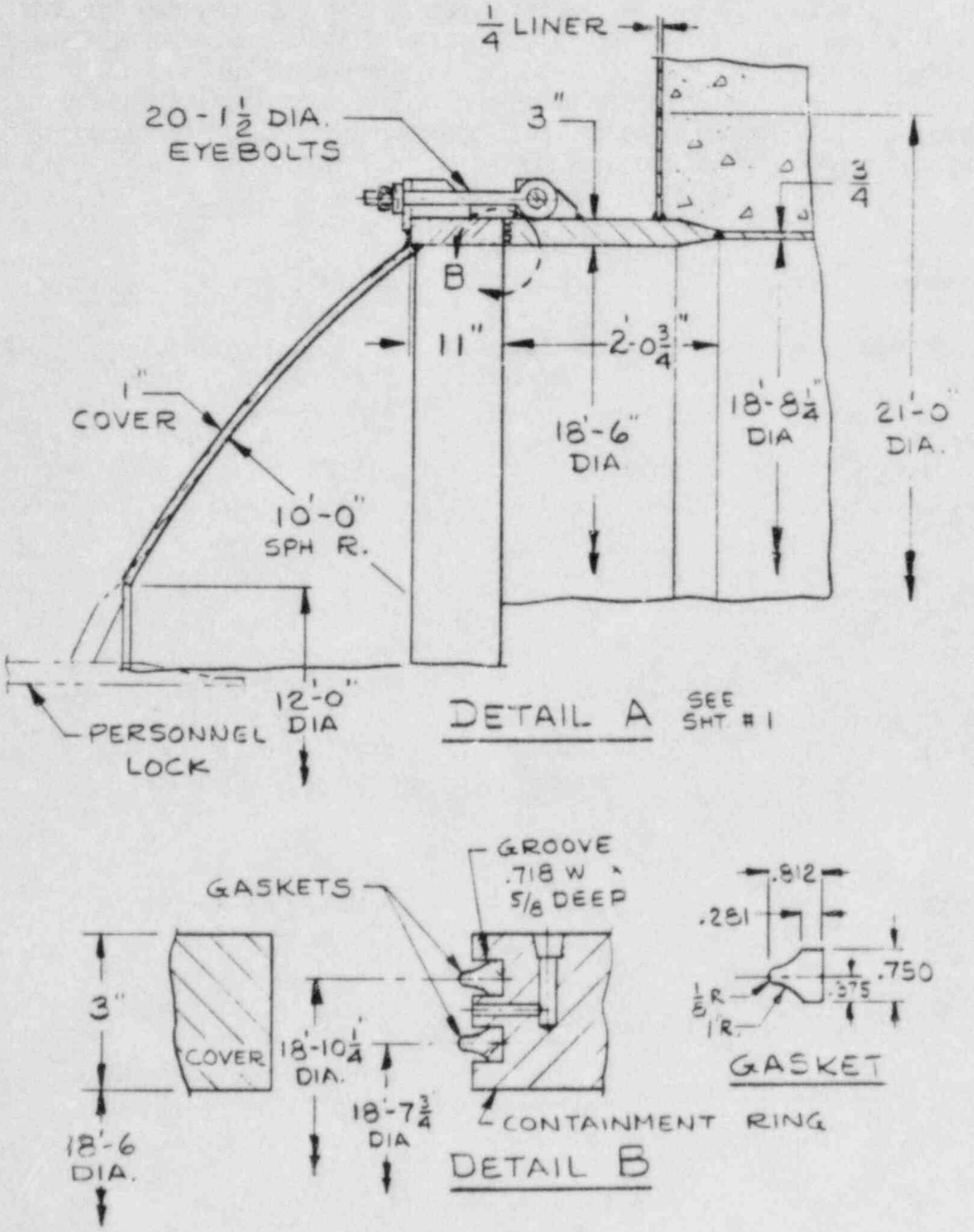
Hatch centerline elev.	437 ft. 0 in.
Hatch centerline azimuth	98°

UNITS 3,4,5,6,7&8 FIG. 1 SHT 1 OF 2 EQUIPMENT HATCH
CONCRETE CONTAINMENT (STEEL LINER)



ELEVATION VIEW

UNITS 3,4,5,6,7 & 8 FIG. 1 SHT. 2 OF 2 EQUIPMENT HATCH
CONCRETE CONTAINMENT (STEEL LINER)



SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3, 4, 5, 6, 7, and 8 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the concrete containment vessel. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by a double dog ear gasket mounted in a groove in the door. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Pressure Lock	Units 3,4,5,6,7, & 8 Figure 2
Clear opening	4 ft. 0 in. wide 6 ft. 8 in. height
Door width	4 ft 4-1/2 in.
Door height	7 ft. 0-1/2 in.
Door-thickness	1-1/2 in.
Material	SA-516 Grade 70

Containment Ring

Thickness	Ring @ 2-1/2 in. Shell @ 1/2 in.
Diameter	10 ft. 2 in. I.D.
Material	SA-516 Grade 70

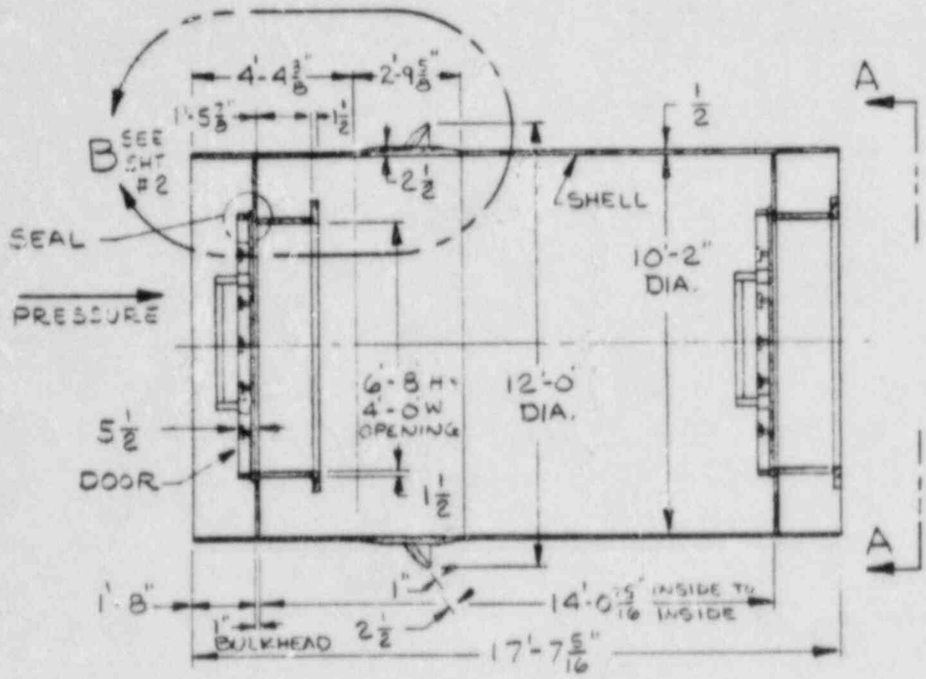
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber

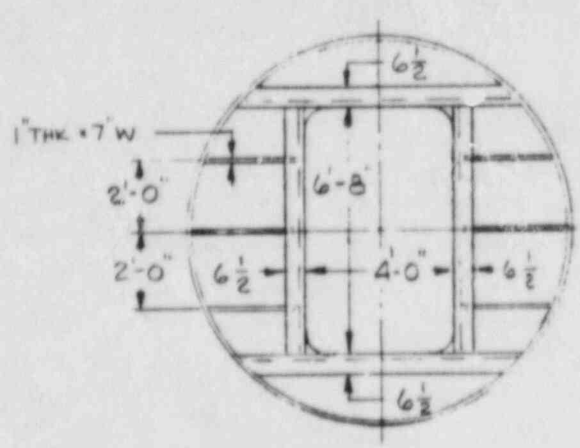
Location of Personnel Lock Centerline

Personnel lock centerline elev.	437 ft. 0 in.
Personnel lock centerline azimuth	98°

UNITS 3,4,5,6,7 & 8 FIG. 2 SHT. 1 OF 2 PERSONNEL LOCK IN EQUIPMENT HATCH

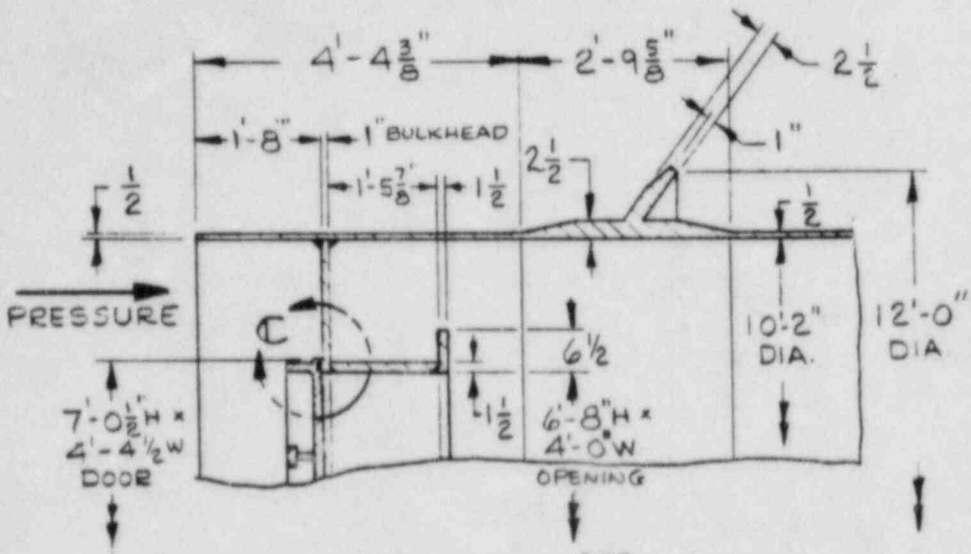


ELEVATION VIEW

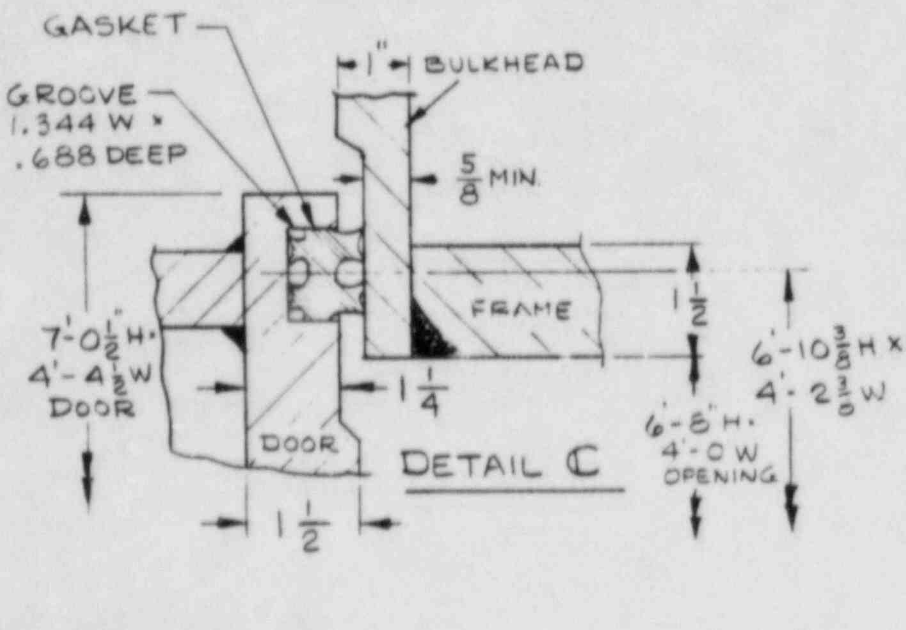


VIEW A-A

UNITS 3,4,5,6,7 & 8 FIG. 2 SHT. 2 OF 2 PERSONNEL LOCK IN EQUIPMENT HATCH



DETAIL B SEE SHT. #1



DETAIL C

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3, 4, 5, 6, 7, and 8 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a rectangular clear opening in the concrete containment wall. The escape lock opening is covered with a rectangular pressure seating door. Leakage is prevented by a Double Dog Ear gasket mounted in a groove in the escape lock door. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Units 3,4,5,6, 7, & 8 Figure 3
Clear opening	4 ft. 0 in. wide 6 ft. 8 in height
Door height	7 ft. 0-1/2 in.
Door Width	4 ft. 4-1/2 in.
Door thickness	1-1/2 in.
Material	SA-516 Grade 70

Containment Ring (Shell of Lock)

Thickness	1/2 in.
Diameter	10 ft. 2 in. I.D.
Material	SA-516 Grade 70

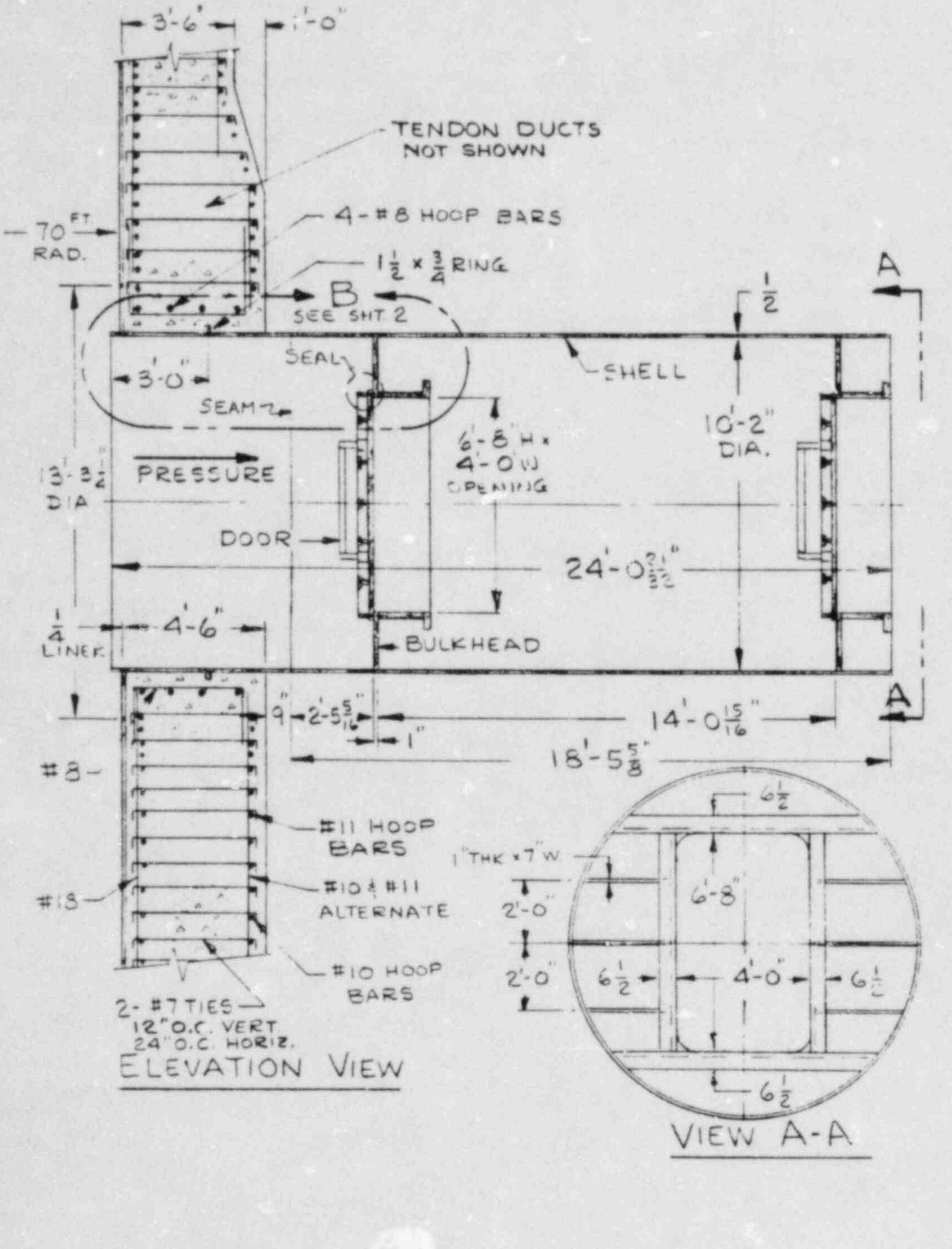
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber

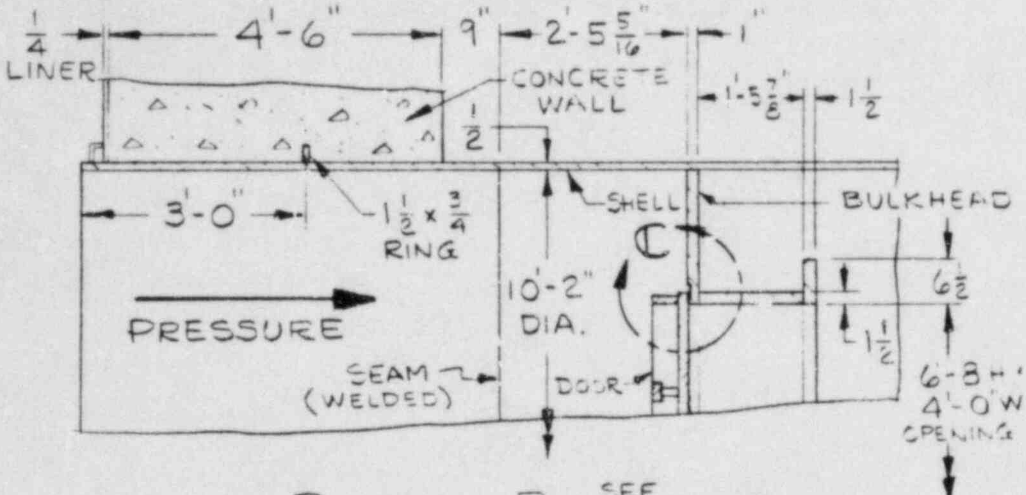
Location of Escape Lock Centerline

Escape lock centerline elev.	402 ft. 3 in.
Escape lock centerline azimuth	303° 45'

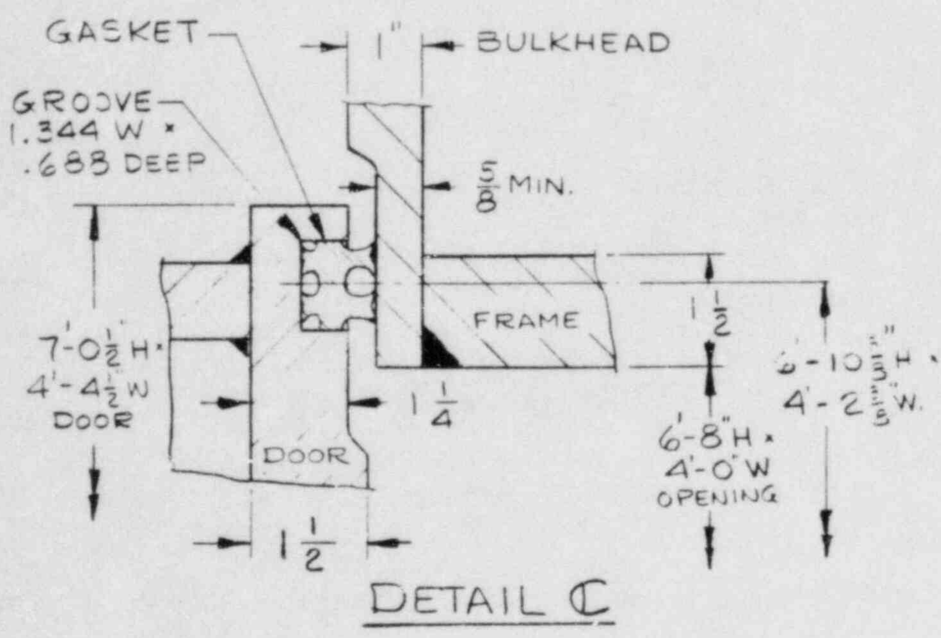
UNITS 3,4,5,6,7 & 8 FIG. 3 SHT. 1 OF 2 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)



UNITS 3,4,5,6,7 & 8 FIG. 3 SHT. 2 OF 2 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)



DETAIL B SEE SHT #1



DETAIL C

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3,4,5,6,7 & 8 FEEDWATER & MAIN STEAM PIPE PENETRATION (Type 1)

Figure 4 Sheet 1 presents the location of the feedwater and main steam pipe penetrations in the concrete containment wall. Figure 4 Sheet 2 presents the feedwater pipe penetration design dimensions. Figure 4 Sheet 3 presents the main steam pipe penetration design dimensions. These pipe penetrations designated Type 1 per the plant A/E for these plants. The feedwater and main steam pipe penetrations are mounted non-radial in the concrete containment wall.

TYPE 1 NON-RADIAL PIPE PENETRATIONS (TOTAL 8)

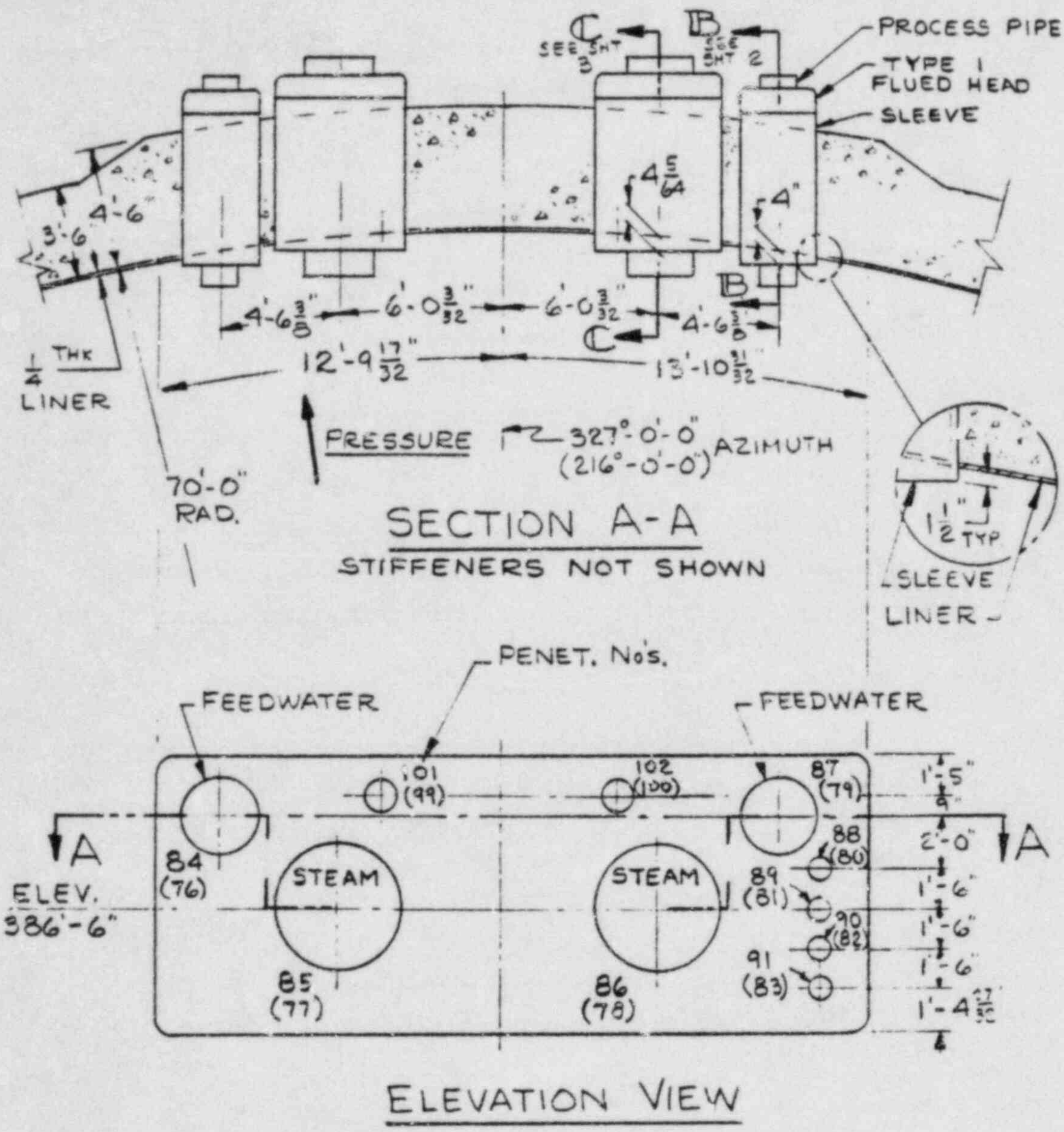
				Location in Wall	
Type 1 Penet. No.	Name	Process Pipe OD, in.*	Sleeve in Wall OD, in.*	Elevation (ft.in.)	Azimuth (Deg.Min)**
76	Feedwater	16	34	390-0	Fig. 4, Sht 1
79	Feedwater	16	34	390-0	Fig. 4, Sht 1
84	Feedwater	16	34	390-0	Fig. 4, Sht 1
87	Feedwater	16	34	390-0	Fig. 4, Sht 1
77	Main Steam	30-1/4	54	386-6	Fig. 4, Sht 1
78	Main Steam	30-1/4	54	386-6	Fig. 4, Sht 1
85	Main Steam	32-3/4	58	386-6	Fig. 4, Sht 1
86	Main Steam	32-3/4	58	386-6	Fig. 4, Sht 1

°Feedwater operating presure 1185 psi and temperature 567°.
°Main Steam operating pressure 1092 psi and temperature 557°.

* Pipe size, attached figures present actual pipe dimensions.
**Figure 4, Sheet 1 for penetration location relative to azimuth 216-0 and 327-0.

Containment building concrete base (floor) at elevation 374-0.

UNITS 3, 4, 5, 6, 7 & 8 FIG. 4 SHT. 1 OF 3 FEEDWATER & MAINSTEAM PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)

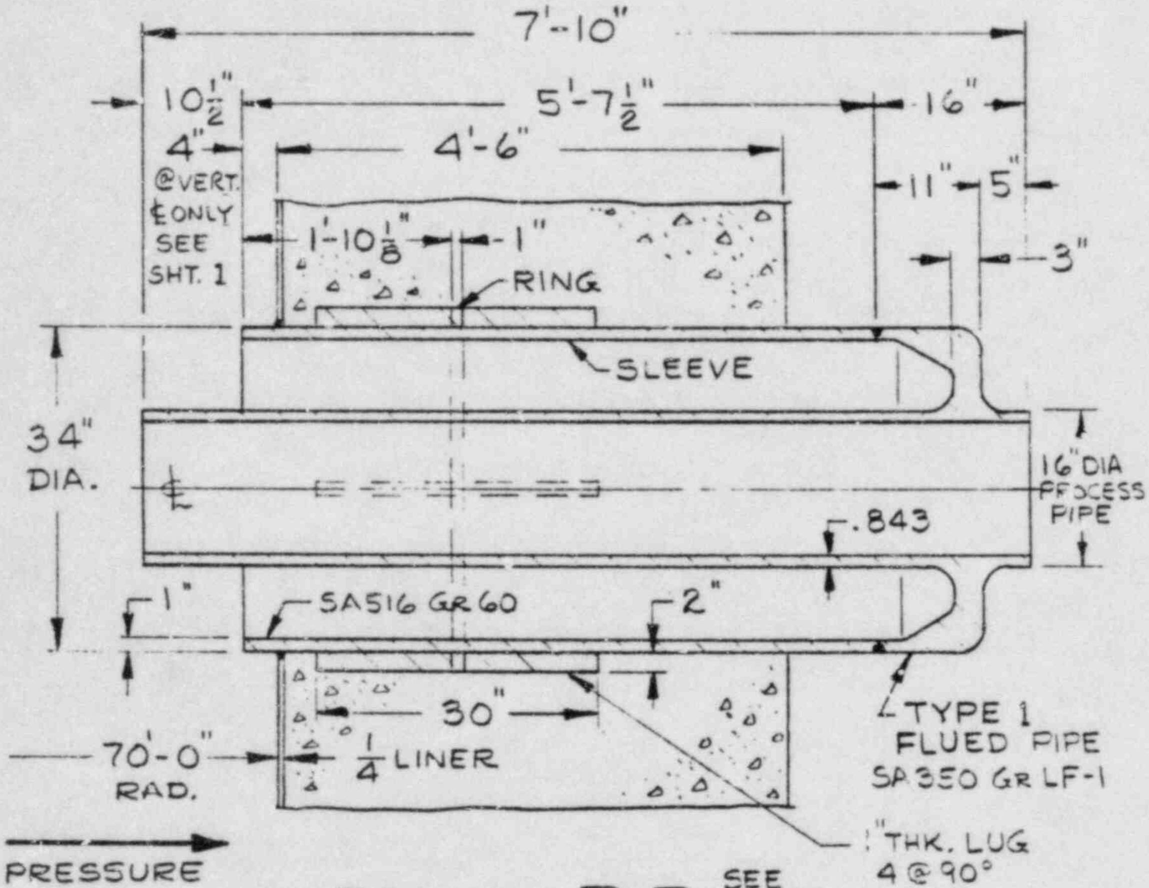


LINER WITH PEN. NOs. 84, 85, 86, & 87 LOCATED @ 327° AZIMUTH

LINER WITH PEN. NOs. (76), (77), (78) & (79) LOCATED @ 216° AZIMUTH

UNITS 3,4,5,6,7 & 8 FIG. 4 SHT. 2 OF 3 FEEDWATER & MAINSTEAM PIPE PENETRATIONS

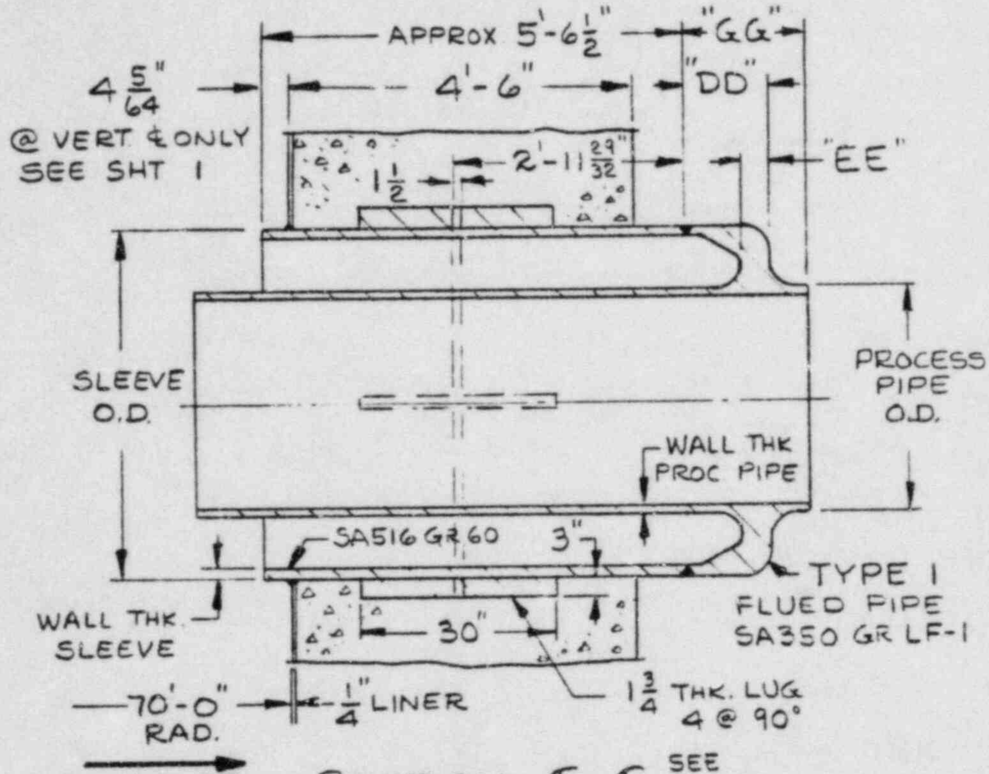
CONCRETE CONTAINMENT (STEEL LINER)



SECTION B-B SEE SHT. 1

TYPICAL FOR PENETRATIONS No. 76, 79, 84 & 87 - FEEDWATER

UNITS 3, 4, 5, 6, 7 & 8 FIG. 4 SHT. 3 OF 3 FEEDWATER & MAINSTEAM PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)



SECTION ℄-℄ SEE SHT #1

FOR PEN'S. 77, 78, 85 & 86 - MAINSTEAM

PENET. NUMBER	SLEEVE		PROCESS PIPE		FLUED PIPE		
	O.D. INCHES	WALL THK IN.	O.D. INCHES	WALL THK. IN.	"DD" INCHES	"EE" INCHES	"GG" INCHES
77 & 78	54	1 3/8	30 1/4	1 1/4	13 1/2	4 1/2	20
85 & 86	58	1 1/2	32 3/4	1.344	15	5	22

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3,4,5,6,7 & 8 PIPE PENETRATIONS (Type 2)

Figure 5 Sheet 1 presents the location of a "Typical" Type 2 pipe penetration (penet. No. 5) in the concrete wall. Figure 5 Sheets 2 and 3 presents the design dimensions for all (Total of 15) Type 2 pipe penetrations in the concrete wall. Figure 5 Sheet 4 presents the materials for the Type 2 pipe penetrations. These pipe penetrations designated Type 2 per the plant A/E for these plants. The 15 Type 2 pipe penetrations are all radially mounted in the concrete containment wall.

TYPE 2 RADIAL PIPE PENETRATIONS (Total 15)

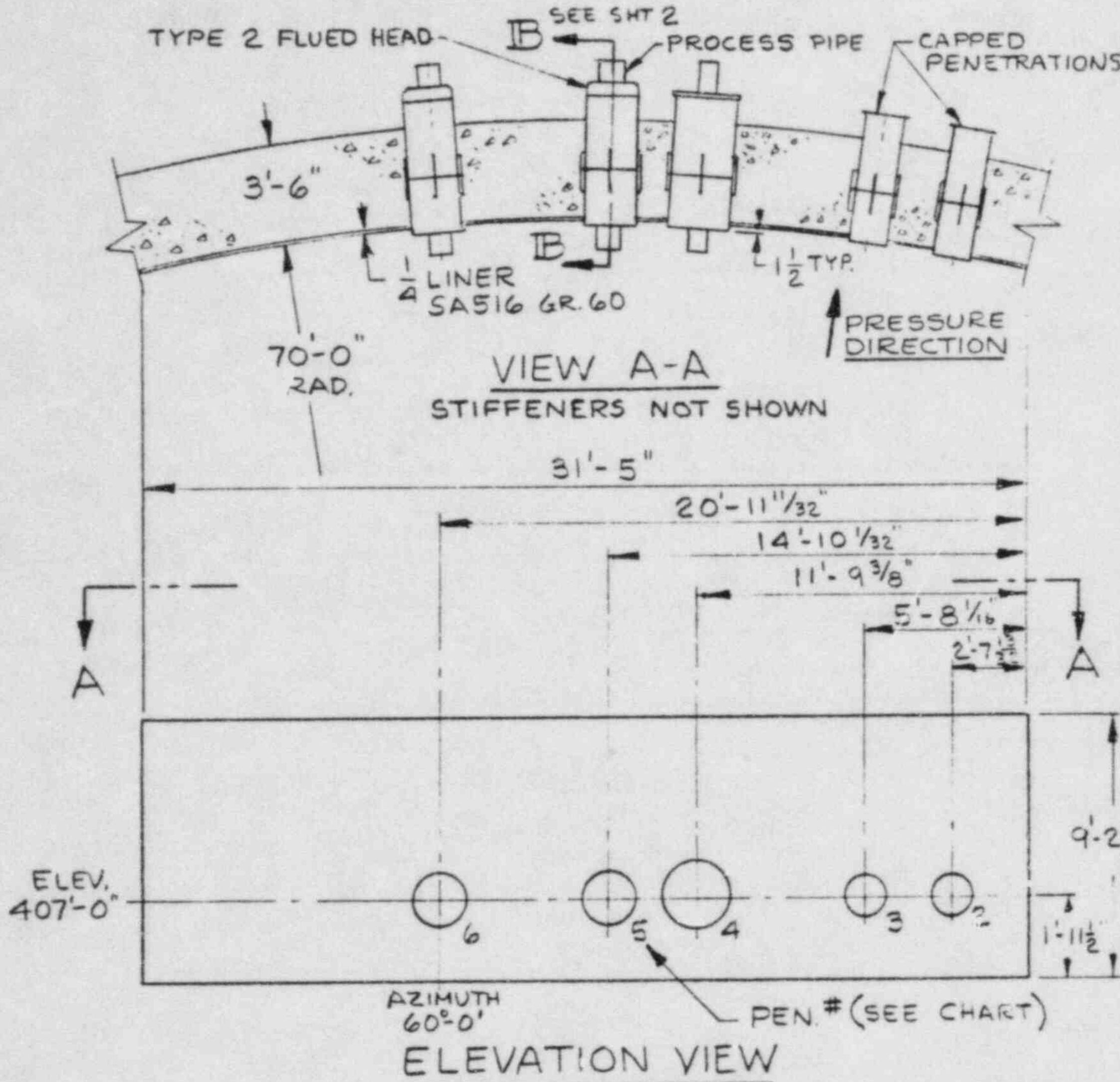
Type 2 Penet. No.	Name	Process Pipe OD, in*	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
1	Containment Spray	10	24	407-0	97-30
5	Chilled Water	10	22	407-0	65-00
6	Chilled Water	10	22	407-0	60-00
7	Service Water	16	30	403-0	105-00
8	Chilled Water	10	22	403-0	102-30
9	Service Water	16	30	403-0	100-00
10	Chilled Water	10	22	403-0	97-30
14	Service Water	16	30	403-0	62-30
15	Service Water	16	30	403-0	57-30
16	Containment Spray	10	24	399-0	75-00
66	Safety Injection	12	24	379-0	122-30
68	Residual Heat	12	24	379-0	112-30
75	Residual Heat	12	24	379-0	57-30
95	Containment Purge	48	60	462-0	123-0
97	Containment Purge	48	60	462-4	139-0

Pipe penetration operating pressure, psi/temperature F: Containment spray 250/165; Chilled water 100/100; Containment purge 50/250; Safety injection and Residual heat 450/350; Service water 75-100/100-189.

*Pipe size, attached figures present actual pipe dimensions.

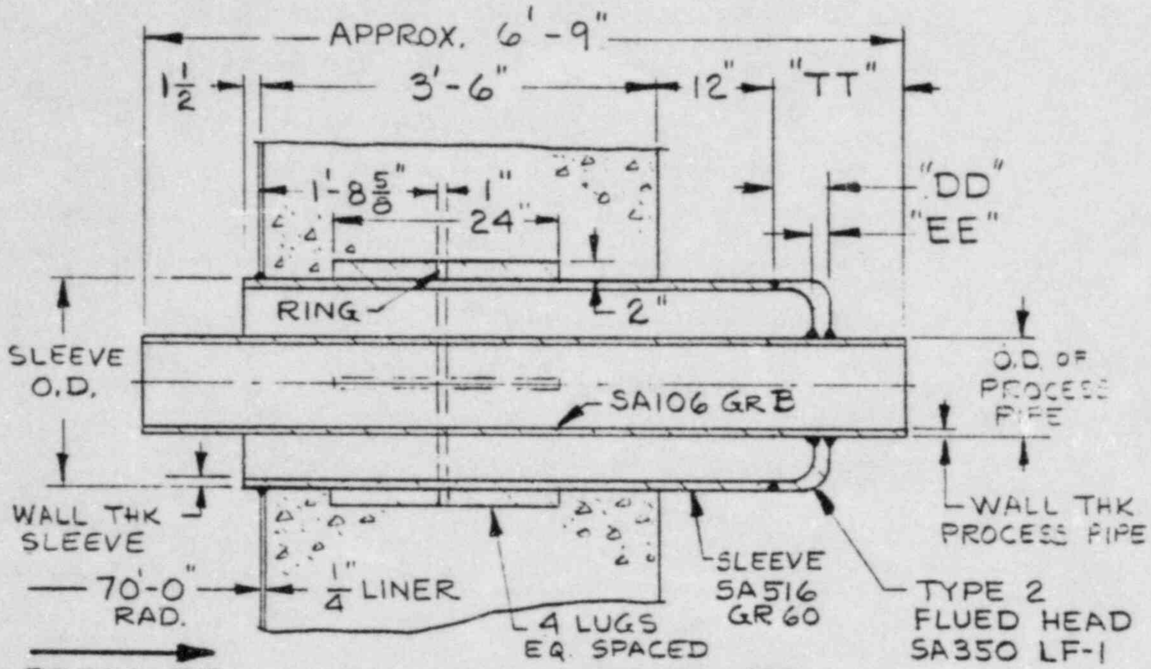
Containment building concrete base (floor) at elevation 374-0.

UNITS 3, 4, 5, 6, 7 & 8 FIG. 5 SHT. 1 OF 3 PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)



PEN. SLEEVE CHART		
PENET. NUMBER	O.D. SIZE INCHES	TYPE
2 & 3	16	CAPPED
5 & 6	22	2
4	28	3

UNITS 3,4,5,6,7 & 8 FIG. 5 SHT 2 OF 3 PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)

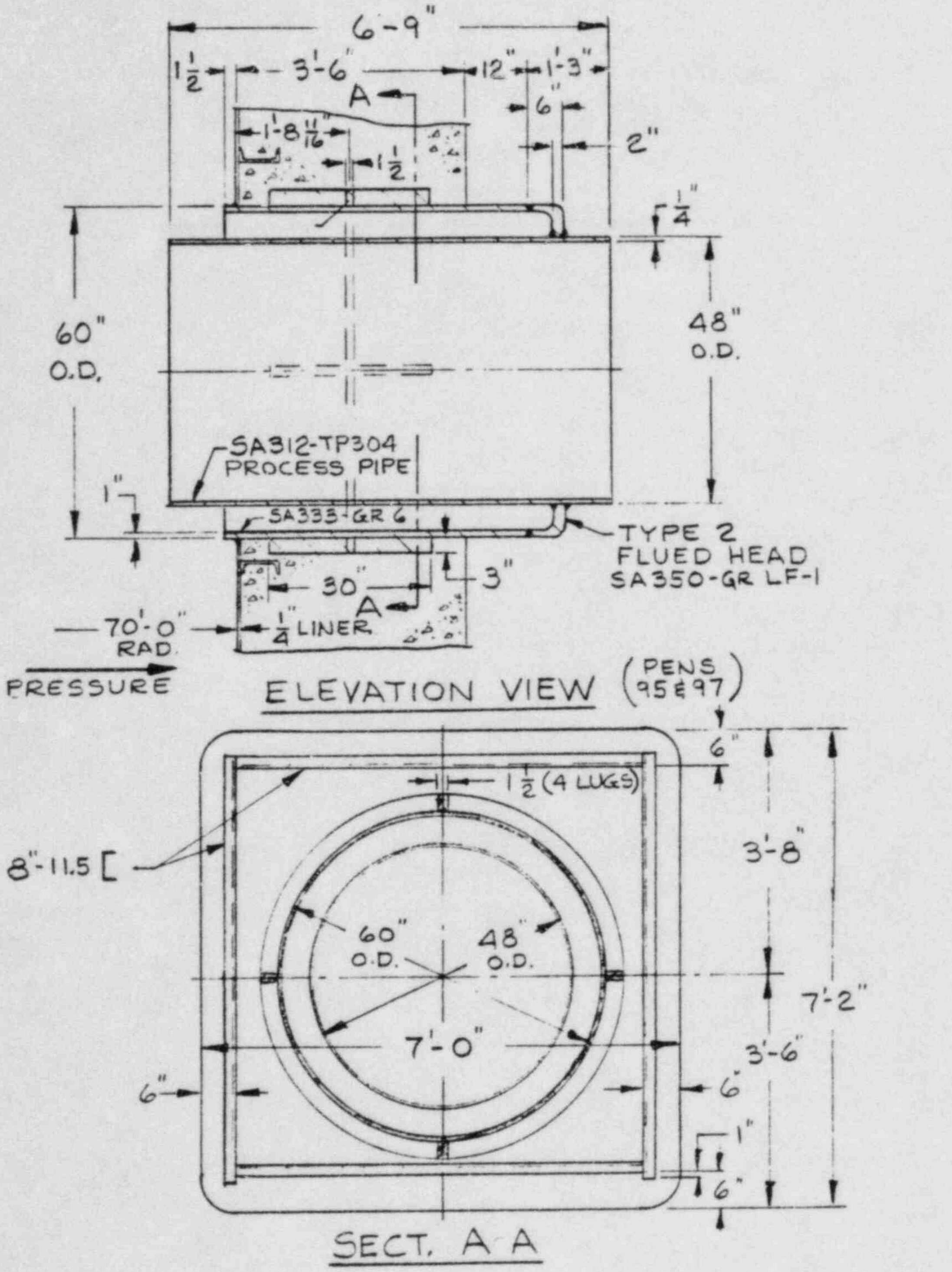


SECTION B-B SEE SHT 1
DRAWN FOR PEN 5

TYPE 2 PENETRATIONS (TOTAL 15)

PENET. NUMBER	SLEEVE		PROC. PIPE		FLUED HEAD		
	O.D. INCHES	WALL THK. IN.	O.D. INCHES	WALL THK. IN.	"DD" INCHES	"EE" INCHES	"TT" INCHES
5,6,8 & 10	22	.875	10.750	.365	5.75	1.75	15
68 & 75	24	.688	12.750	.375	6.5	2	19
7,9,14 & 15	30	1.00	16	.375	7.0	2	15
66	24	.688	12.750	1.125	7.0	2	15
1 & 16	24	.688	10.750	.365	5.75	1.75	15
95 & 97	SEE SHT. 3 OF 3						

UNITS 3,4,5,6,7 & 8 FIG. 5 SHT. 3 OF 3 PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)



UNITS 3,4,5,6,6 & 8 FIGURE 5 SHEET 4 OF 4

PIPE PENETRATIONS - CONCRETE CONTAINMENT (STEEL LINER)

MATERIAL SCHEDULE FOR TYPE 2 PIPE PENETRATIONS

Penet. No.	Steel Sleeve in Concrete Wall		Process Pipe		Flued Head	
	SA	Grade	SA	Grade	SA	Grade
1	333	6	312	Tp 304	350	LF-1
5	516	60	106	B	350	LF-1
6	516	60	106	B	350	LF-2
7	516	60	106	B	350	LF-1
8	516	60	106	B	350	LF-1
9	516	60	106	B	350	LF-1
10	516	60	106	B	350	LF-1
14	516	60	106	B	350	LF-2
15	516	60	106	B	350	LF-1
16	333	6	312	Tp 304	350	LF-1
66	333	6	312	Tp 316L	350	LF-1
68	333	6	312	TP 304	350	LF-1
75	333	6	312	TP 304	350	LF-1
95	516	60	312	TP 304	350	LF-1
97	516	60	312	TP 304	350	LF-1

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3,4,5,6,7 & 8 PIPE PENETRATIONS (Type 3)

Figure 6, Sheet 1 presents the typical configuration for the Type 3 (radial and non-radial) pipe penetrations in the concrete containment wall. Figure 6, Sheets 2, 3, and 4 presents the design dimensions for all (29 radial + 12 non-radial = total 41) Type 3 pipe penetrations in the concrete containment wall. Figure 6, Sheet 5 presents the materials for the Type 3 pipe penetrations. These pipe penetrations designated Type 3 per the A/E for these plants.

TYPE 3 RADIAL PIPE PENETRATIONS (Total 29)

Type 3 Penet. No.	Name	Process Pipe OD, in*	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
4	Containment Purge	6	28	407-0	67-30
11	Equipment Drain	3	10	403-0	95-00
21	Cooling	6	16	395-0	127-30
22	Cooling	3	10	395-0	122-30
23	Off-Gas	3	16	395-0	117-30
24	Cooling	4	16	395-0	112-30
25	Cooling	6	16	395-0	107-30
26	Safety Injection	3	12	395-0	102-30
28	Chemical Control	2	8	395-0	72-30
30	Demineralizer	2	10	395-0	62-30
32	Cooling-Cleanup	3	10	391-0	125-00
34	Fire Protection	4	12	391-0	115-00
37	Chemical Control	2	14	391-0	100-00
39	Instr. Air	3	8	391-0	75-00
41	Chemical Control	3	12	391-0	65-00
44	Reactor Coolant	3	10	387-0	127-30
47	Waste Disposal	3	10	387-0	112-30
48	Component Cooling	3	10	387-0	107-30
50	Safety Injection	8	24	387-0	97-30
51	Safety Injection	8	24	387-0	72-30
56	Service Air	1-1/2	10	383-0	120-00
57	Cooling-Cleanup	4	8	383-0	115-00
59	Safety Injection	4	16	383-0	105-00
60	Safety Injection	4	14	383-0	100-00
69	Off-Gas	3	16	379-0	107-30
71	Chemical Control	3	14	379-0	97-30
73	Safety Injection	4	16	379-0	67-30
94	Purge Exhaust	8	16	474-6	108-00
96	Purge Supply	8	14	462-4	132-45

*Pipe Size, attached figures present actual pipe dimensions.

Containment building concrete base (floor) at elevation 374-0.

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3,4,5,6,7 & 8 PIPE PENETRATIONS (Type 3)

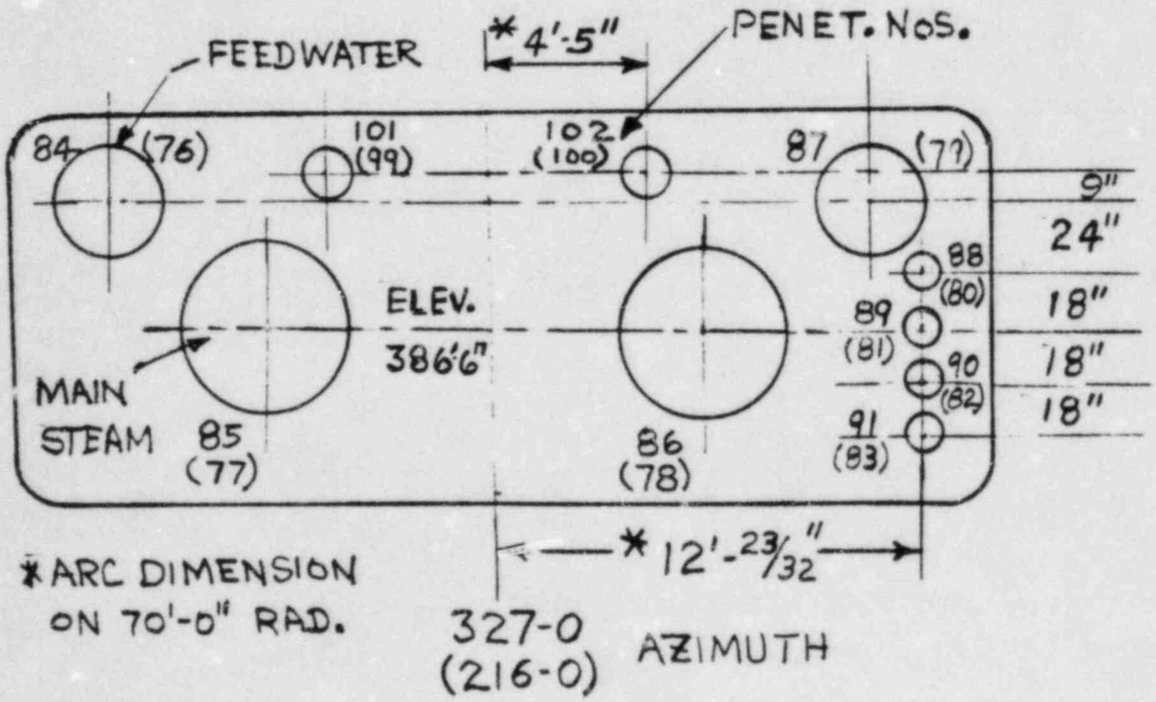
TYPE 3 NON-RADIAL PIPE PENETRATIONS (Total 12)

Type 3 Penet. No.	Name	Process Pipe OD, in*	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
80	Blowdown	2	12	388-0	Note 1
81	Blowdown	2	12	386-6	Note 1
82	Blowdown	2	12	385-0	Note 1
83	Blowdown	2	12	383-6	Note 1
88	Blowdown	2	12	388-0	Note 1
89	Blowdown	2	12	386-6	Note 1
90	Blowdown	2	12	385-0	Note 1
91	Blowdown	2	12	383-6	Note 1
99	Feedwater	6	16	390-9	Note 1
100	Feedwater	6	16	390-9	Note 1
101	Feedwater	6	16	390-9	Note 1
102	Feedwater	6	16	390-9	Note 1

*Pipe size, attached figures present actual pipe dimensions.

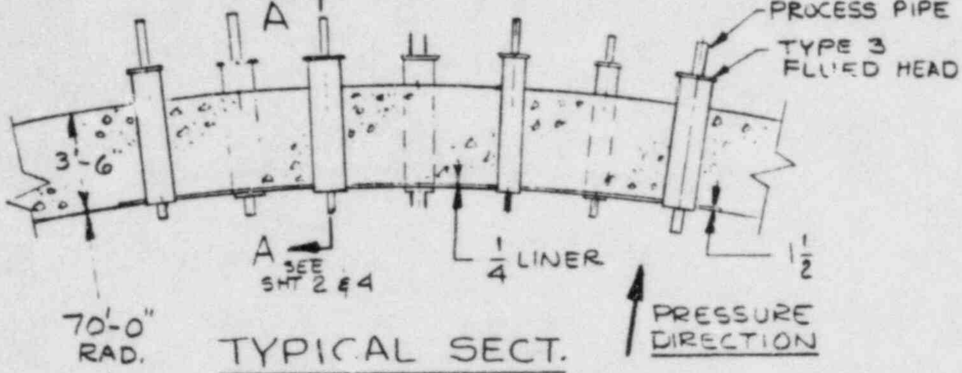
Containment building concrete base (floor) at elevation 374-0.

NOTE 1: Location of non-radial Type 3 penetrations relative to azimuth 216-0 and 327-0 shown below.



UNITS 3, 4, 5, 6, 7 & 8 FIG. 6 SHT. 1 OF 5 PIPE PENETRATIONS

CONCRETE CONTAINMENT (STEEL LINER)

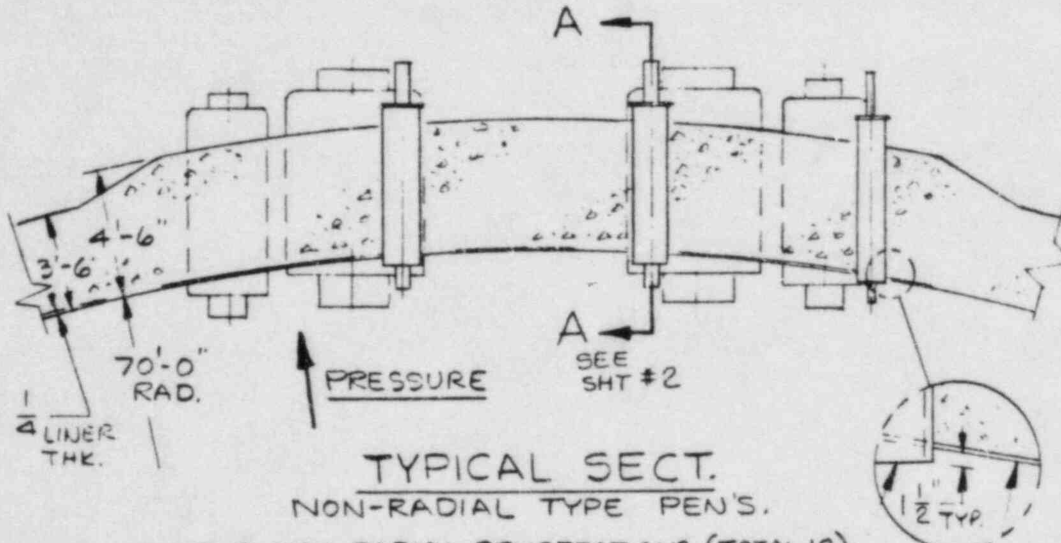


TYPICAL SECT.

RADIAL TYPE PENS.

TYPE 3 RADIAL PENETRATIONS (TOTAL 29)

RADIAL TYPE PEN. NUMBERS	4, 11, 21, 22, 23, 24, 25, 26, 28 30, 32, 34, 37, 39, 41, 44, 47, 48 50, 51, 56, 57, 59, 60, 69, 71, 73, 94 & 96



TYPICAL SECT.

NON-RADIAL TYPE PEN'S.

TYPE 3 NON-RADIAL PENETRATIONS (TOTAL 12)

NON-RADIAL TYPE PEN. NUMBERS	80, 81, 82, 83, 88, 89, 90, 91 99, 100, 101 & 102

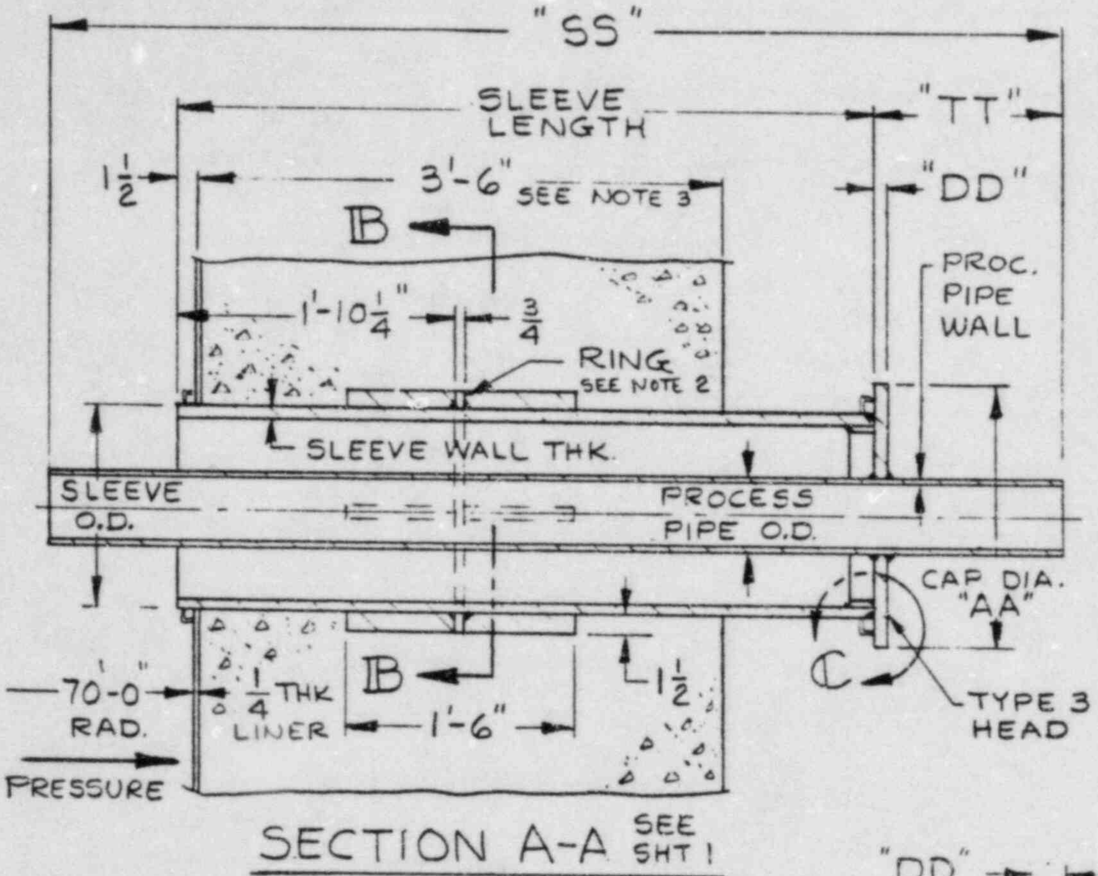
← SLEEVE

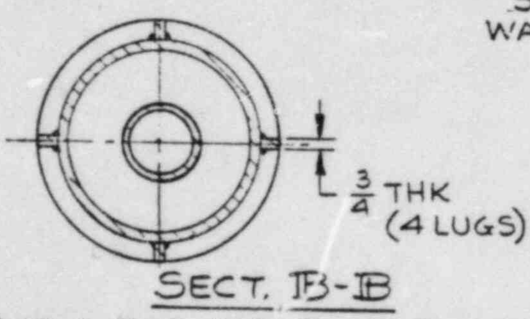
LINER ⌐

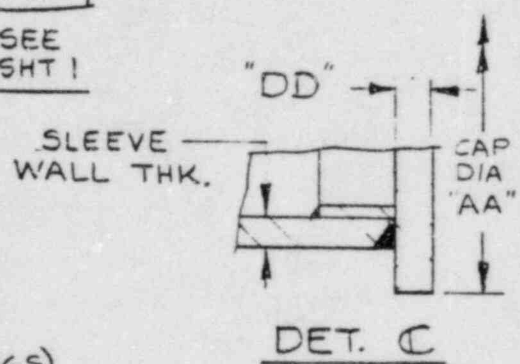
NOTES:

SEE SHEET 5 FOR MATL. CALLOUT

UNITS 3,4,5,6,7 & 8 FIG. 6 SHT. 2 OF 5 PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)







NOTES

1) SEE SHT. 1 FOR IDENT. OF PEN TYPE IE: RADIAL OR NON-RADIAL
2) SEE SHEET 3 FOR DIMENSION CHART.
3) CONC. WALL IS 4'-6" THK FOR PENS 80, 81, 82, 83, 88, 89, 90, 91, 100, 101 & 102.

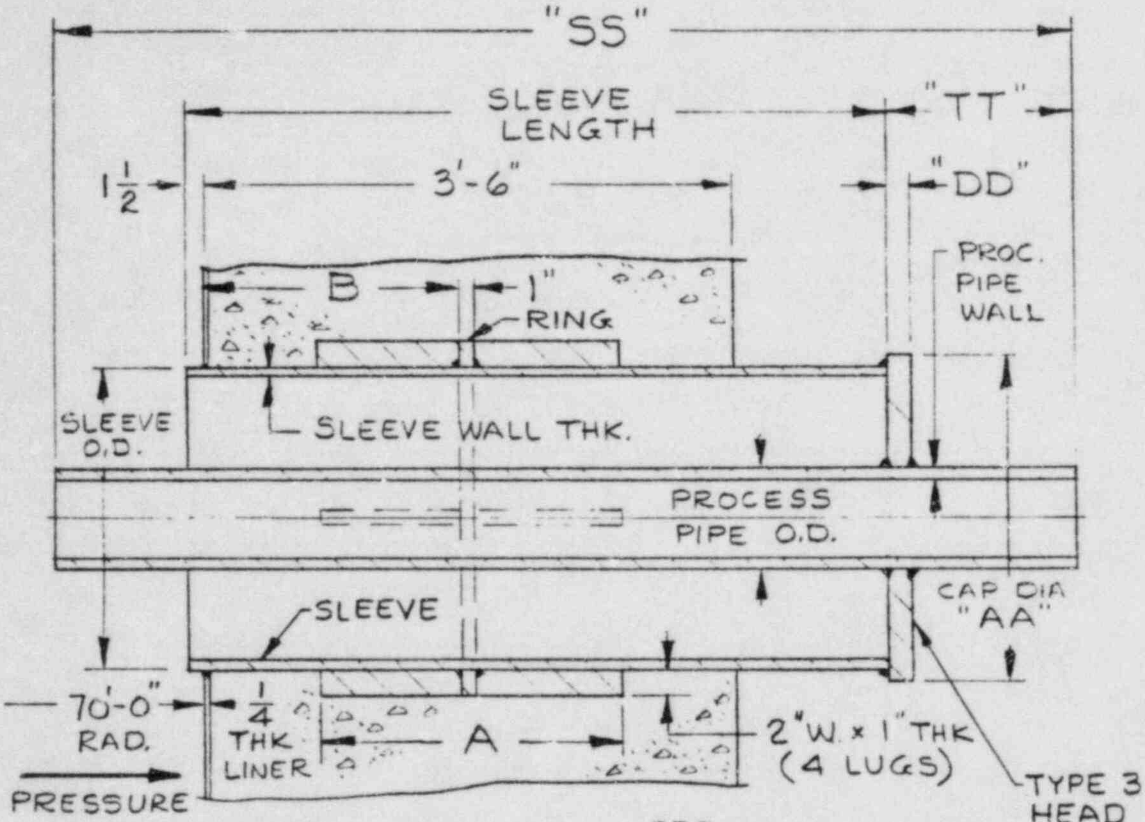
UNITS 3,4,5,6,7 & 8 FIG. 6 SHT. 3 OF 5 PIPE PENETRATIONS

CONCRETE CONTAINMENT (STEEL LINER)

SEE FIG. 6 SHT. 2 FOR DESIGN CONFIGURATION OF THESE PIPE PENETRATIONS EXCEPT AS NOTED. TOTAL 41 TYPE 3 PEN'S.

PENET. NUMBERS	SLEEVE			RING	PROCESS PIPE				CAP	
	PIPE SIZE INCH	THK.	LGTH.	SIZE	PIPE SIZE INCH	WALL	LGTH "SS"	LOCATION "TT"	DIA "AA"	THK "DD"
28	8	.322	4'-7½"	8¾" I.D. × 11⅝ O.D.	2	.154	7'-1"	1'-7"	10⅝	3/4
39					3	.216	6'-6"	12"		3/4
57					4	.237	7'-1"	1'-7"		1 5/8
11	10		4'-7½"	10⅞ I.D. × 13¾ O.D.	3	.216	6'-6"	1'-3"	12¾	1 ½
22		.365			3	.216	6'-11¾ 6'-9"	1'-6"		1 ½
30					2	.154	7'-1"	1'-7"		1
32		.500			3	.216	6'-9"	1'-3"		1 ½
44 & 47					3	.216	6'-9"	1'-3"		1 ½
48		.365			3	.216	6'-10"	1'-4"		1 ½
56					1½	.145	7'-1"	1'-7"		1
26	12	.406	4'-7½"	12⅞ I.D. × 15¾ O.D.	3	.438	6'-3"	0'-9"	14¾	1 5/8
34					4	.237	7'-1"	1'-7"		1 5/8
41					3	.216	6'-9"	1'-3"		1 ½
80, 81, 82, 83, 88, 89, 90, 91		.375	5'-10½"		2	.218	8'-2"	1'-7"		3/4
37	14	.375	4'-7½"	14⅛" I.D. × 17" O.D.	2	.343	7'-1"	1'-7"	16	1
60					4	.531	7'-3"	1'-9"		1 ½
71					3	.438	6'-9"	1'-3"		1 ½
21	16	.500	4'-7½"	16⅛ I.D. × 19" O.D.	6	.280	6'-9"	1'-3"	18	1 3/4
23		.843			3	.216	6'-11¾ 6'-9"	1'-3 1'-5¾		1
24		.500			4	.531	7'-2"	1'-10"		1 ½
25		.500			6	.280	7'-2"	1'-8"		1 3/4
59		.375			4	.531	7'-6"	2'-0"		1 ½
69		.843			3	.216	6'-9"	1'-3"		1
73		.375			4	.531	6'-6"	1'-0"		1 ½
99, 100, 101 & 102		.843	5'-7½"		6	.432	7'-10"	1'-4"		2
50 SEE SHT. 4	24	.687	4'-7½"	24⅛ I.D. × 28" O.D.	8	.906	7'-0"	1'-6"	26	2
51 SEE SHT. 4					8	.906	6'-9"	1'-3"		
4 SEE SHT. 4	28	.365	4'-7½"	28¼ I.D. × 32" O.D.	6	.280	6'-9"	1'-5"	30	1 1/8
94	16	.50	4'-7½"	NONE	8	.322	6'-9"	1'-3"	18	1 3/4
96	14	.375	4'-7½"	14⅛ I.D. × 17 O.D.	8	.322	6'-9"	1'-3"	16	1 3/4

UNITS 3,4,5,6,7 & 8 FIG. 6 SHT. 4 OF 5 PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)



SECTION A-A SEE SHT 1

FOR PEN'S. 4, 50 & 51

PENET. No.	A	B
50 & 51	2'-0"	1'-8 5/8"
4	2'-6"	1'-8 3/8"

NOTES:

1) SEE SHT. 1 FOR IDENT. OF PEN TYPE IE: RADIAL or NON RADIAL
2) SEE SHEET 3 FOR DIMENSION CHART

UNITS 3,4,5,6,7, AND 8 FIG.6, SHT. 5 OF 5 PIPE PENETRATIONS (TYPE 3)

CONCRETE CONTAINMENT (STEEL LINER)

Penetration Number	Mat'l of Process Pipe	Mat'l of Cover Plate	Mat'l of Sleeve
11,26,28,30,32 37,41,44,47,57 59,60,71,73	A	D	G
21,22,23,24,25 34,39,48,56,69	B	E	G
99,100,101,102	A	F	G
80,81,82,83 88,89,90,91	A	E	G
50,51	C	D	G
4	B	E	H

Material Identification

Process Pipe	A = SA312 TP 304 B = SA106 GR B C = SA376 TP 304
Cover Plate	D = SA240 GR 304 E = SA516 GR 60 F = SA350 GR LF-1
Sleeve	G = SA333 GR 6 H = SA516 GR 60

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3,4,5,6,7 & 8 PIPE PENETRATIONS (Type 3 With Multi-Process Pipes)

Figure 7 presents the design and dimensions for Type 3 penetrations with multi-process pipes located in a single penetration sleeve mounted in the concrete containment wall. The 11 penetration sleeves are all mounted radially in the concrete containment wall.

TYPE 3 RADIAL MULTI-PROCESS PIPE PENETRATIONS (Total 11)

Multi-Penet. No.	Name	Process Pipe No. @ Size, OD, in*	Sleeve in Wall OD, in.*	Location in Wall: Elevation (ft.in.)	Location in Wall: Azimuth (Deg.Min)
12	H_2 Monitoring	2 @ 1/2	16	403-0	72-0
13	Off-Gas	2 @ 3	16	403-0	67-30
19	Instrument	2 @ 1/4	16	399-0	60-0
27	Pressurizer	1 @ 3/8 & 1 @ 3/4	10	395-0	97-30
31	H_2 Monitoring	2 @ 1/2	16	395-0	57-30
33	Chem. Control	2 @ 2	14	391-0	120-0
52	Monitoring	2 @ 1	16	387-0	67-30
53	Chem. Control	2 @ 2	14	387-0	62-30
55	Safety Inject.	1 @ 1 & 1 @ 3/4	10	383-0	125-0
65	Equip. Drains	1 @ 1 & 1 @ 3/4	10	379-0	127-30
70	Process Samp.	4 @ 3/8	12	379-0	102-30

*Pipe Size, attached figure and data below present actual pipe dimensions.

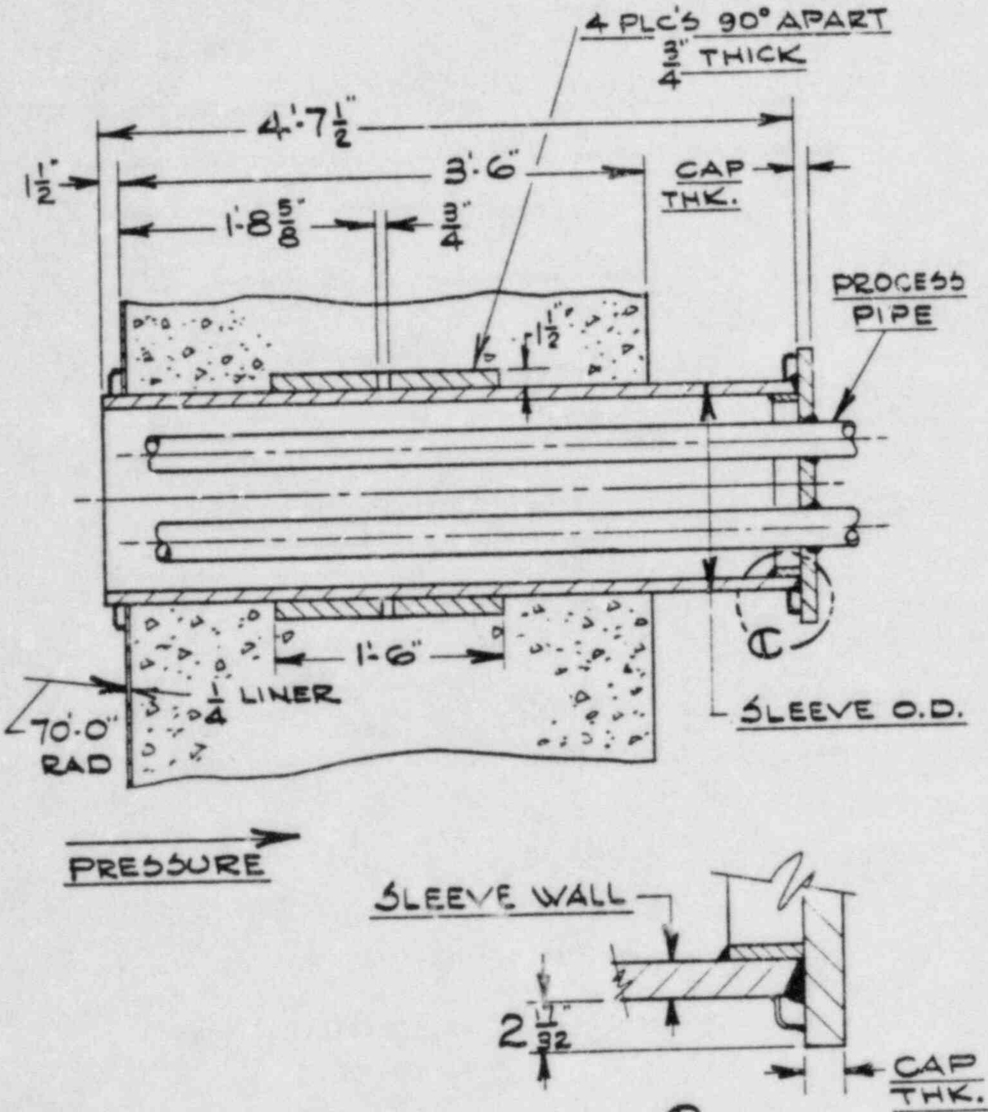
Containment building concrete base (floor) at elevation 374-0.

Type 3 Dimensions

Penet. No.	Sleeve OD. in.	Sleeve Wall Th'k. in.	Cap Th'k. in.
27,55,65	10.750	.365	1/2
70	12.750	.375	1/2
33,53	14.000	.375	1/2
12,13*,19,31,52	16,000	.843	1

*Penet. No. 13 for Units 3 and 4 cap th'k. 3/4 in.

UNITS 3,4,5,6,7 & 8 FIG. 7 TYPE 3
MULTI-PROCESS PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)



•DETAIL C•

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3, 4, 5, 6, 7 & 8 SPARE PIPE PENETRATIONS (CAPPED ENDS)

Figure 8 Sheet 1 presents the location of a "Typical" capped sleeve penetration (Penet. 18) in the concrete wall. Figure 8 Sheet 2 presents the design dimensions for all (total of 15) capped sleeve penetrations in the concrete wall. The 15 spares (Capped Ends) penetrations are all mounted radially in the concrete containment wall.

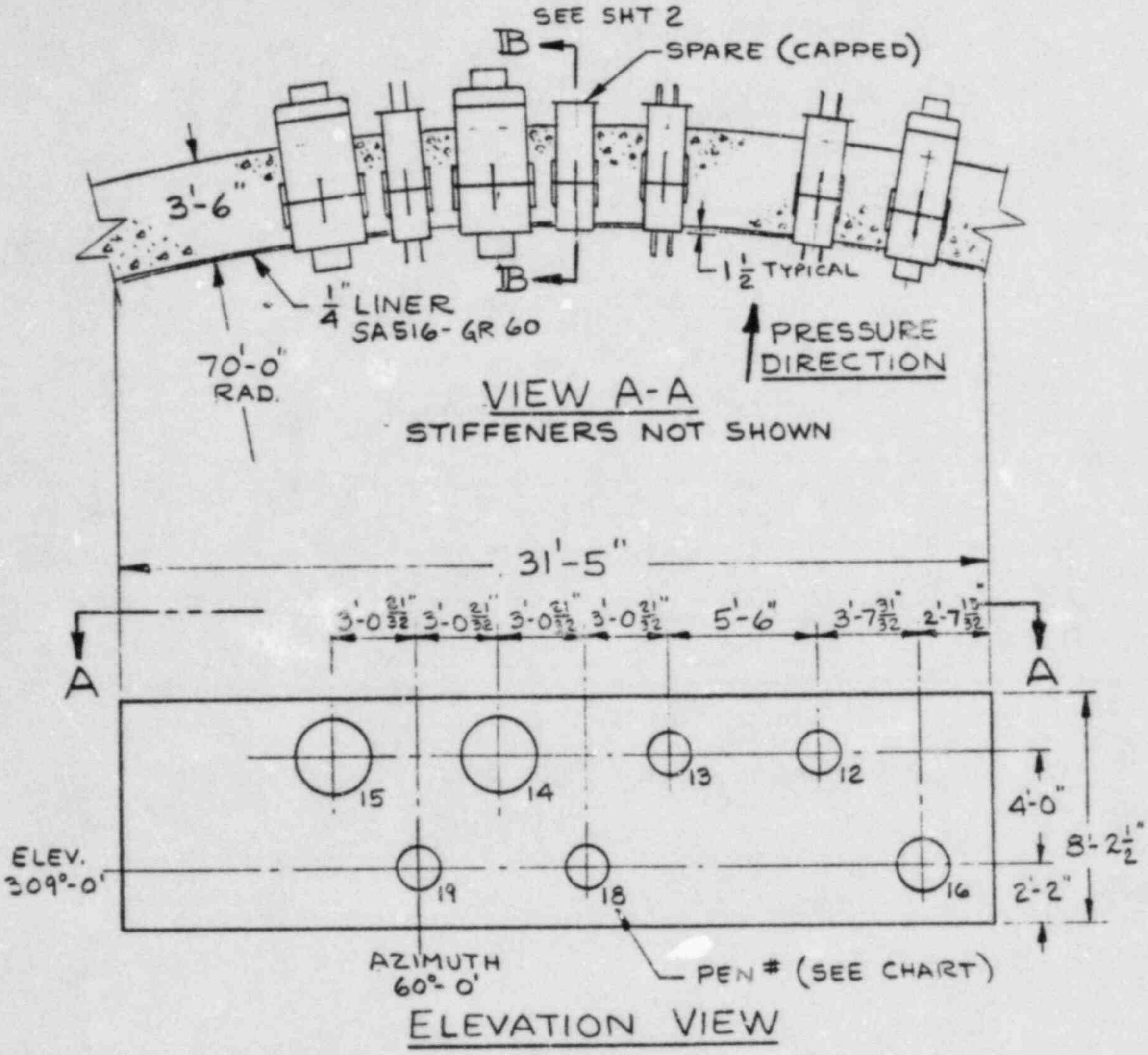
SPARE PIPE PENETRATIONS (Total 15)

Spare Penet. No.	Location in Wall: Elev.(ft.-in.)	Location in Wall: Azimuth (Deg.-Min)	Sleeve in Concrete Wall OD, in.*
2	407-0	75-00	16
3	407-0	72-30	16
18	399-0	65-00	16
29	395-0	57-30	16
36	391-0	105-00	22
42	391-0	60-00	22
43	391-0	57-30	16
45	387-0	122-30	16
49	387-0	102-30	22
54	387-0	57-30	22
61	383-0	75-00	16
63	383-0	65-00	16
64	383-0	60-00	16
72	379-0	72-30	16
74	379-0	62-30	16

*Pipe size, attached figures present actual pipe dimensions.

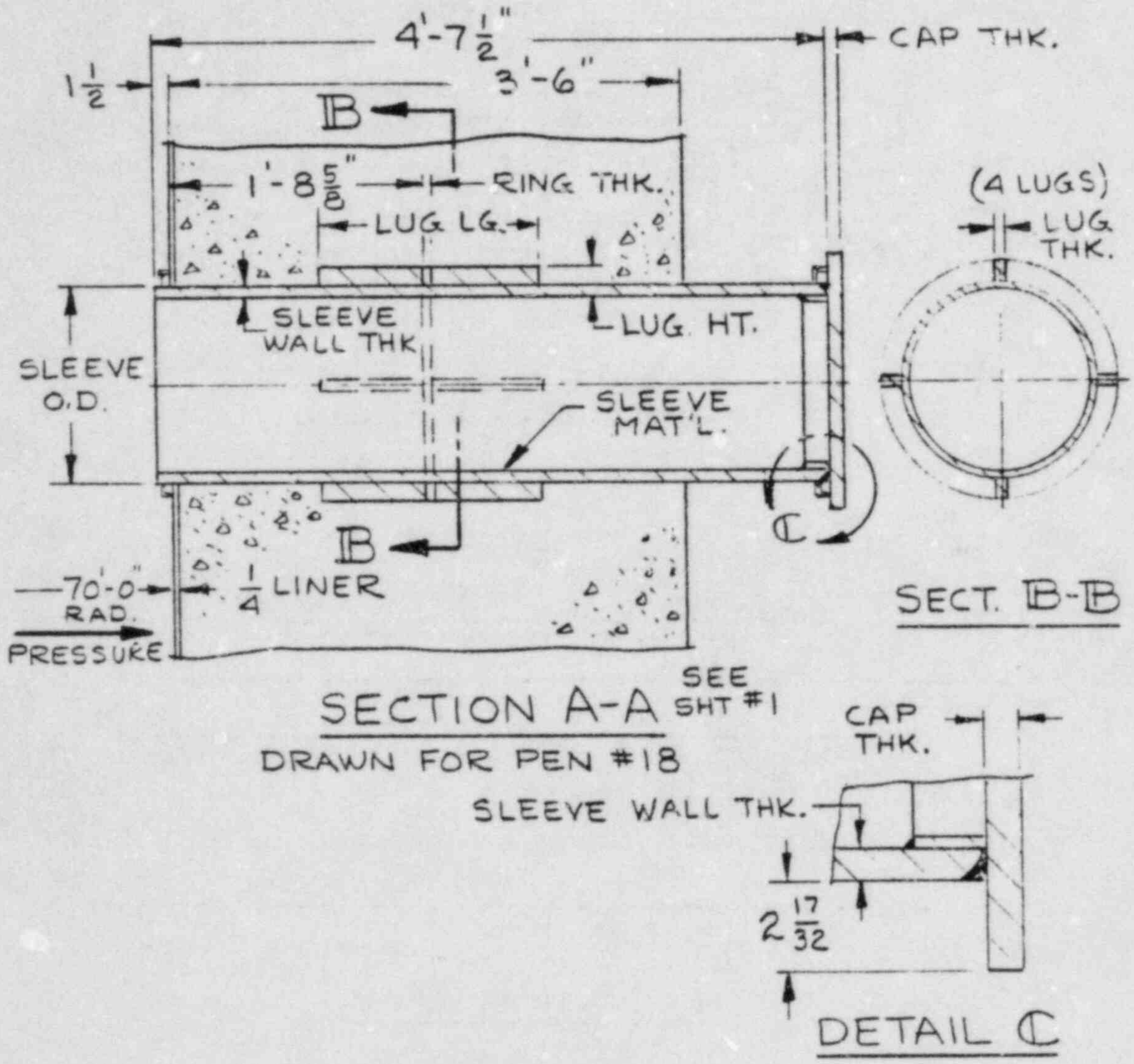
Containment building concrete base (floor) at elevation 374-0.

UNITS 3,4,5,6,7 & 8 FIG. 8 SHT. 1 of 2 SPARE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)



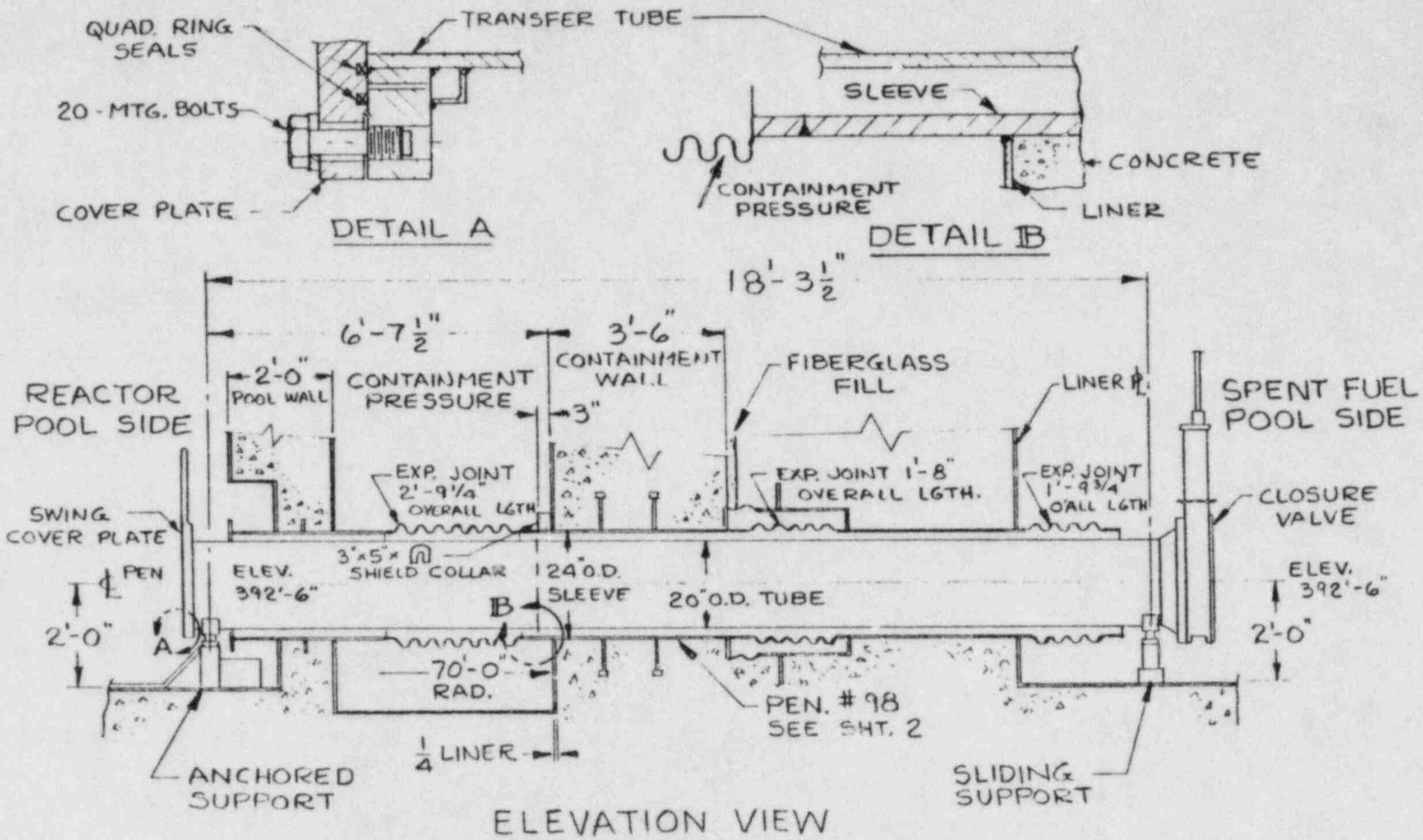
PENETRATION SLEEVE CHART		
PENETRATION NUMBER	O.D. SIZE INCHES	TYPE
18	16	CAPPED
16	24	2
14 & 15	30	2
12, 13 & 19	16	4

UNITS 3,4,5,6,7 & 8 FIG. 8 SHT. 2 OF 2 SPARE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)



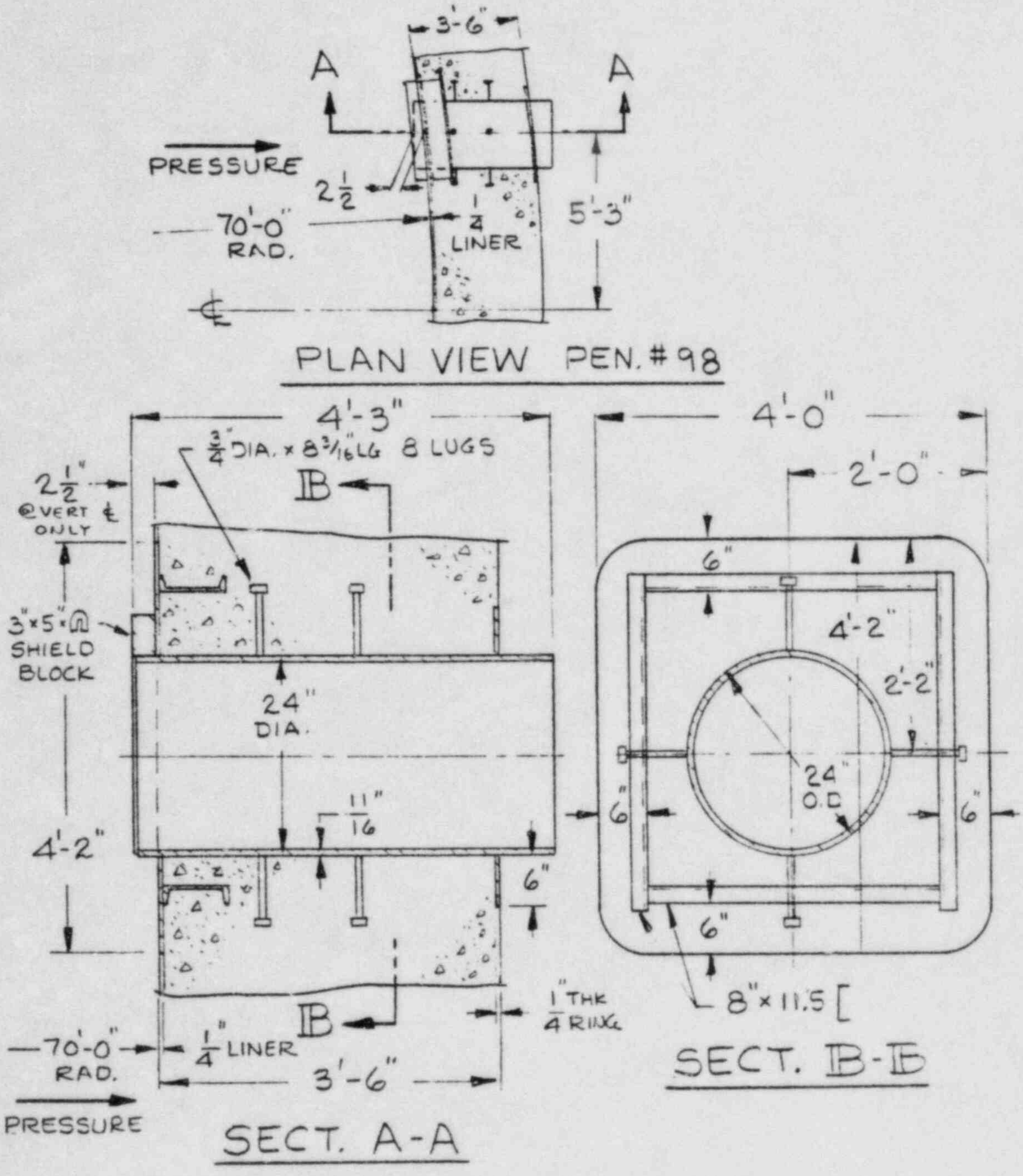
SPARE (CAPPED) PENETRATIONS TOTAL 15 SPARES.

PENET. NUMBERS	SLEEVE			RING	LUG			CAP
	O.D. INCHES	WALL THK IN.	MAT'L.	THK. INCHES	LG. INCHES	HT. INCHES	THK. INCHES	THK. INCHES
2,3,18,29,43,45 61,63,64,72,74	16	.843	SA333 GR 6	3/4	18	1 1/2	3/4	1
36,42,49,54	22	.875	SA516 GR 60	1	24	2	1	1 1/4



UNITS 3,4,5,6,7 & 8 FIG. 9 SHT 1 OF 2 FUEL TRANSFER TUBE PIPE PENETRATIONS
CONCRETE CONTAINMENT (STEEL LINER)

UNITS 3,4,5,6,7 & 8 FIG. 9 SHT. 2 OF 2 FUEL TRANSFER TUBE
CONCRETE CONTAINMENT (STEEL LINER)



Unit 9 - Concrete Containment (Steel Liner)

FSAR Description of Unit 9 Containment Structure

The containment consists of a right circular cylinder with a hemispherical domed roof and a flat base slab. The containment is constructed of reinforced concrete and lined on the inside with 1/4-inch stainless steel plate below elevation 735 feet 0 inch and with carbon steel plate of at least 1/4-inch thickness above elevation 735 feet 0 inch.

The principal dimensions of the containment are:

Height above basemat	215 feet 0 inch
Inside diameter	124 feet 0 inch
Wall thickness	3 feet 0 inch
Dome thickness	2 feet 6 inches
Mat thickness	9 feet 8 inches

The containment structure supports the polar crane, galleries, and the access ramp to the refueling floor. The lower section of the containment acts as the outer boundary of the suppression pool. Two double-door personnel locks, one located at the refueling floor and the other located at the grade floor, permit access to the containment. An equipment hatch is located at the grade floor.

The containment wall is reinforced in the hoop, diagonal and meridional directions. Wall reinforcement is deflected around small penetration sleeves to account for localized stress concentrations. The wall around the equipment hatch and personnel locks is thickened to 6 feet 0 inch. Tangential and transverse shear reinforcement are provided.

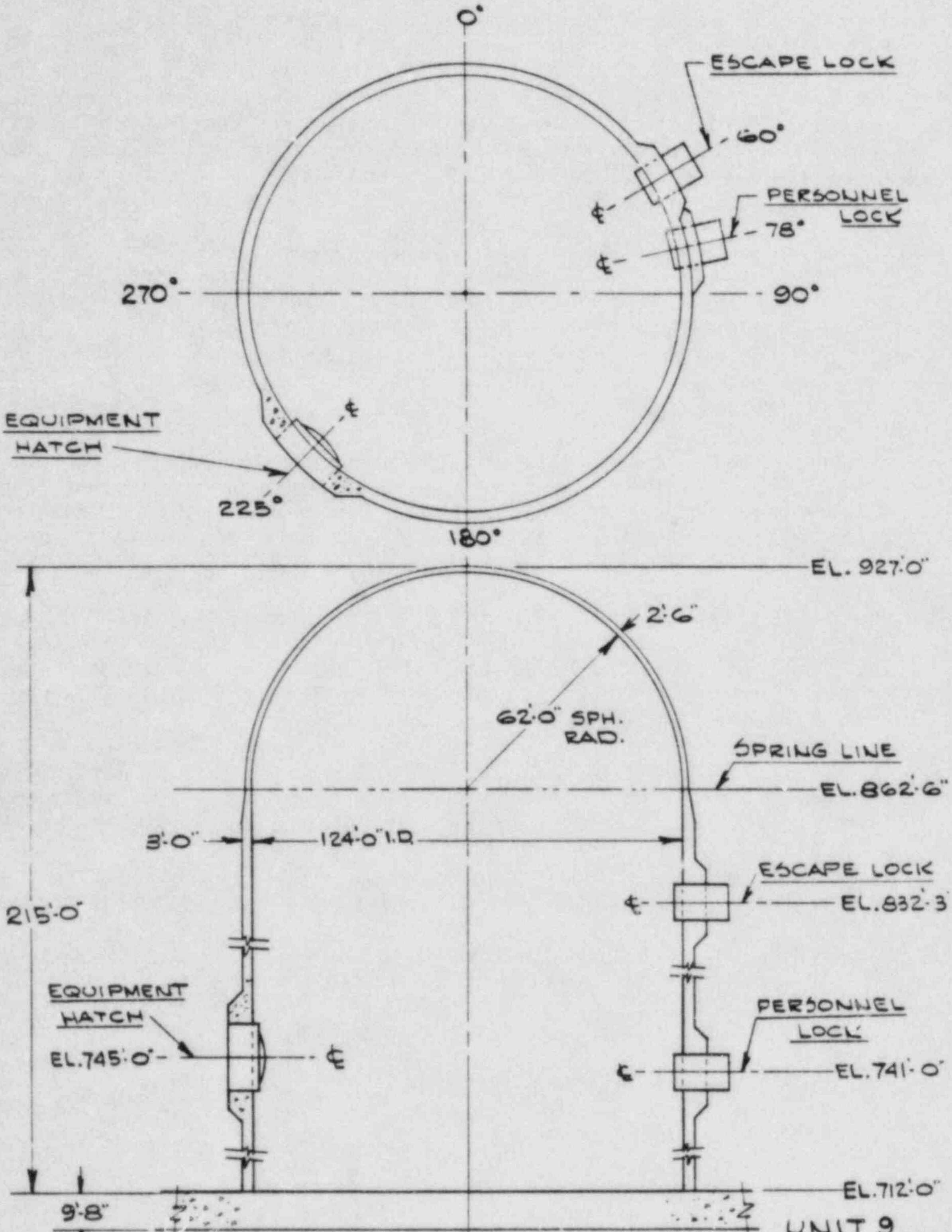
The dome is reinforced in two directions. Orthogonal grid type reinforcement is used within a radius of 45 feet from the apex of the dome. The remaining portion of the dome is reinforced in the hoop and meridional directions.

The containment base slab is continuous with the adjacent auxiliary and fuel building base slabs and is reinforced at top and bottom with reinforcing steel.

The containment wall liner is anchored to the wall with structural T sections. Typical spacing of the liner anchors is 15 inches in the containment wall and the dome. The top of the base slab is lined with 1/2-inch and 1/4-inch stainless steel plate which serves as a leaktight boundary.

The primary parameters used in the containment design are:

internal design pressure	15 psig
external design pressure	3.0 psig
calculated peak pressure	8.74 psig
test pressure	17.25 psig
maximum suppression pool water temperature	185^{o}F



UNIT 9

CONCRETE CONT. (ST'L. LINER)

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNIT 9 - EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the concrete containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two gumdrop gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 20 swing bolts mounted on the outer surface of the hatch opening and containment ring. The pressure inside the containment vessel provides the seating force for the seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Unit 9 Figure 1
Clear opening	18 ft.
Cover thickness	1 inch
Cover shape, radius	18 ft. radius
Material	SA-516 Grade 70

Containment Ring

Thickness	3 inch
Diameter	18 ft. I.D.
Material	SA-516 Grade 70

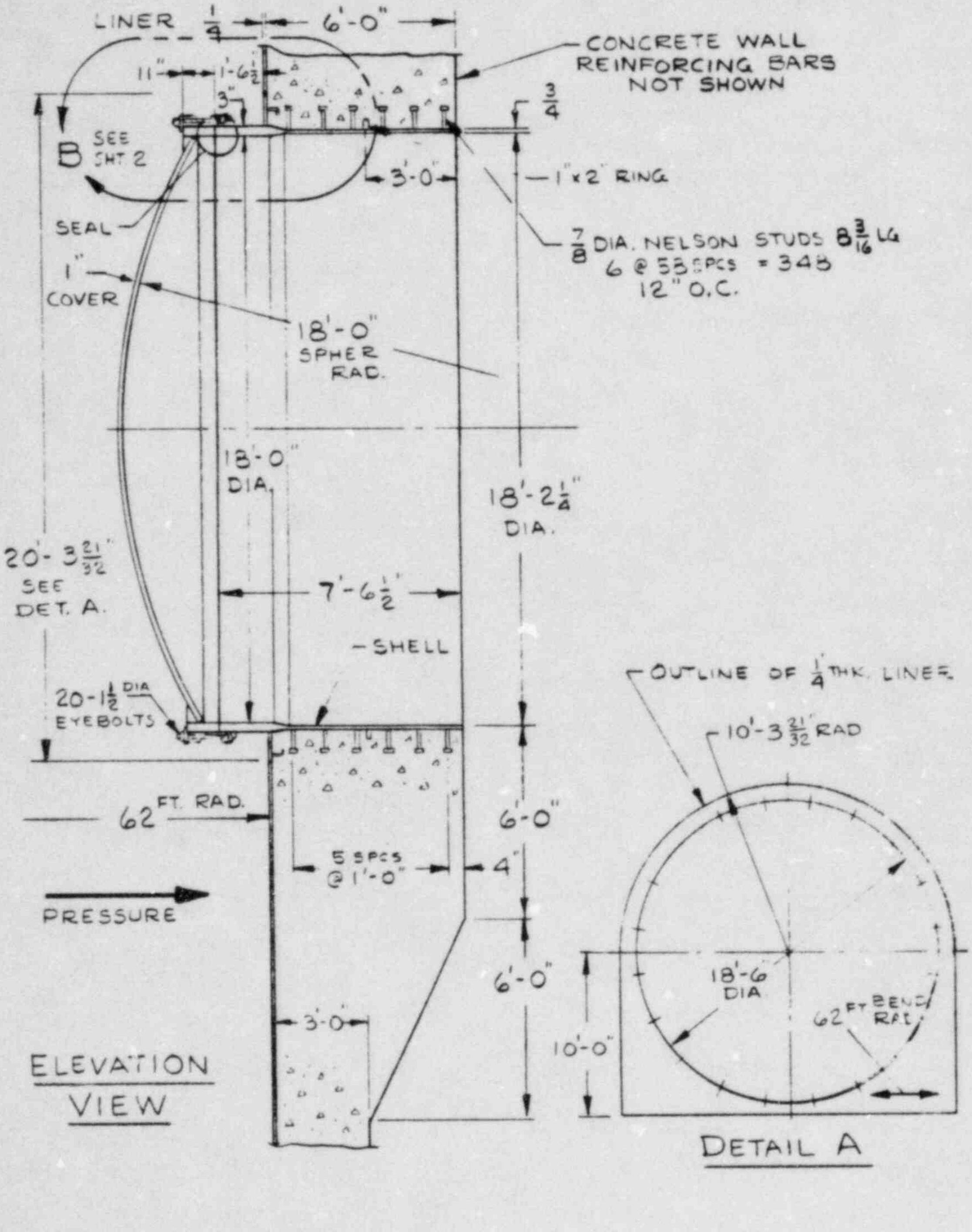
Gasket

Gasket type	Gumdrop
Material	Silicone Rubber MS-577
Length, Inner	57 ft. 0-3/32 in.
Length, Outer	57 ft.7-15/16 in.

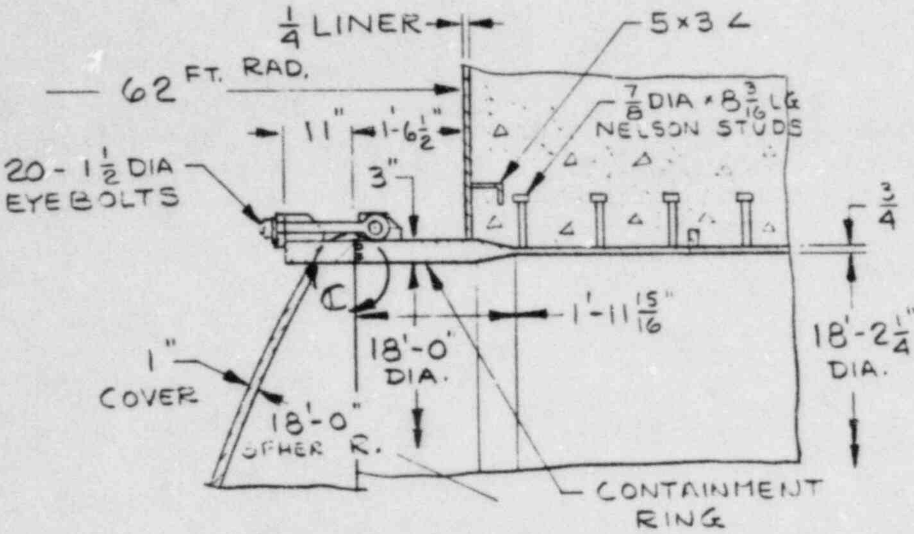
Location of Hatch

Hatch centerline elev.	[illegible]5 ft. 0 in.
Hatch centerline azimuth	[illegible]5°

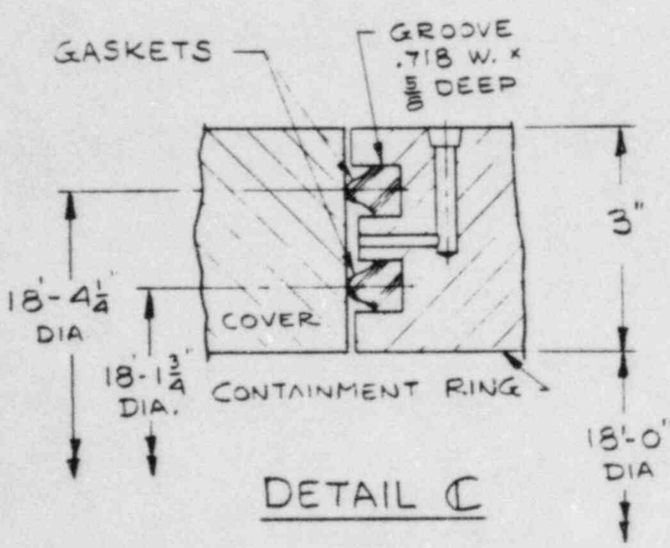
UNIT 9 FIG. 1 SHT. 1 OF 2 EQUIPMENT LOCK
CONCRETE CONTAINMENT (STEEL LINER)



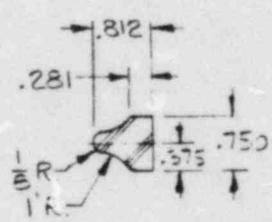
UNIT 9 FIG. 1 SHT. 2 OF 2 EQUIPMENT LOCK
CONCRETE CONTAINMENT (STEEL LINER)



DETAIL B



DETAIL C



GASKET

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNIT 9 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the concrete containment vessel. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by a double dog ear gasket mounted in a groove in the door. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Pressure Lock	Unit 9 Figure 2
Clear opening	3 ft. 6 in. wide 6 ft. 8 in. height
Door width	46-1/2 in.
Door height	7 ft. 0-1/2 in.
Door-thickness	1-1/2 in.
Material	SA-516 Grade 70

Containment Ring (Shell of Lock)

Thickness	5/8 in.
Diameter	9 ft. 11-1/4 in. O.D.
Material	SA-516 Grade 70

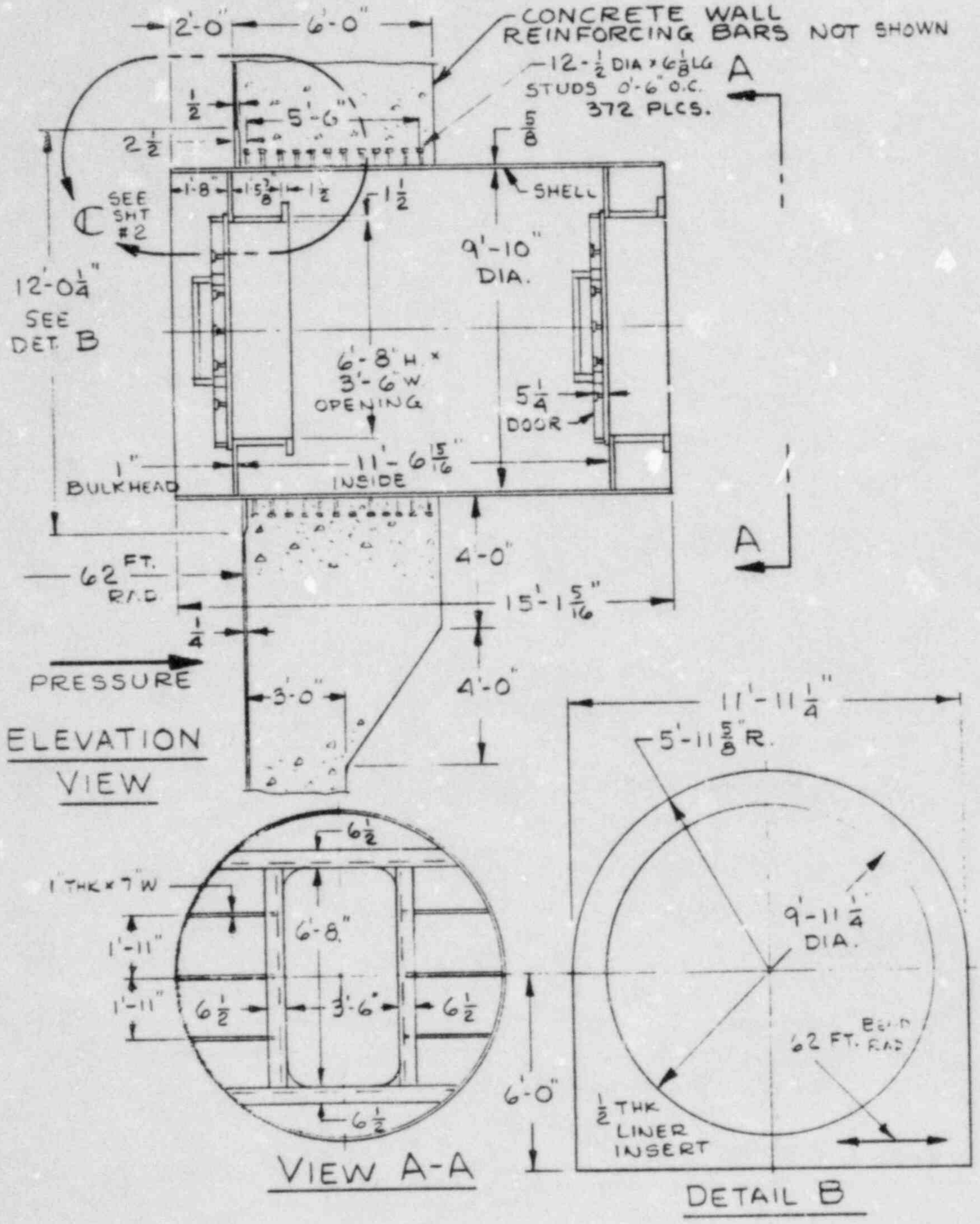
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber MS577
Length	19 ft. 9-7/16 in.

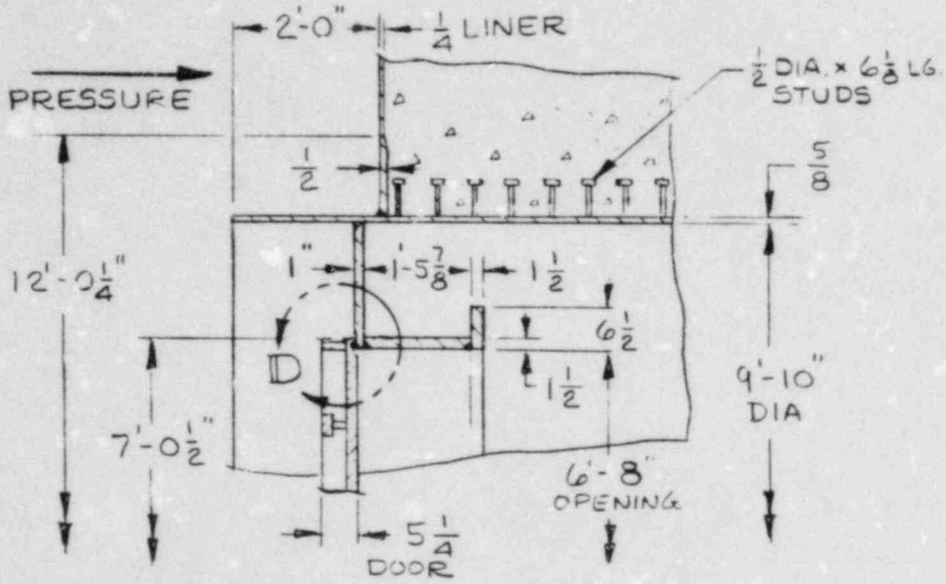
Location of Personnel Lock Centerline

Personnel lock centerline elev.	741 ft. 0 in.
Personnel lock centerline azimuth	78°

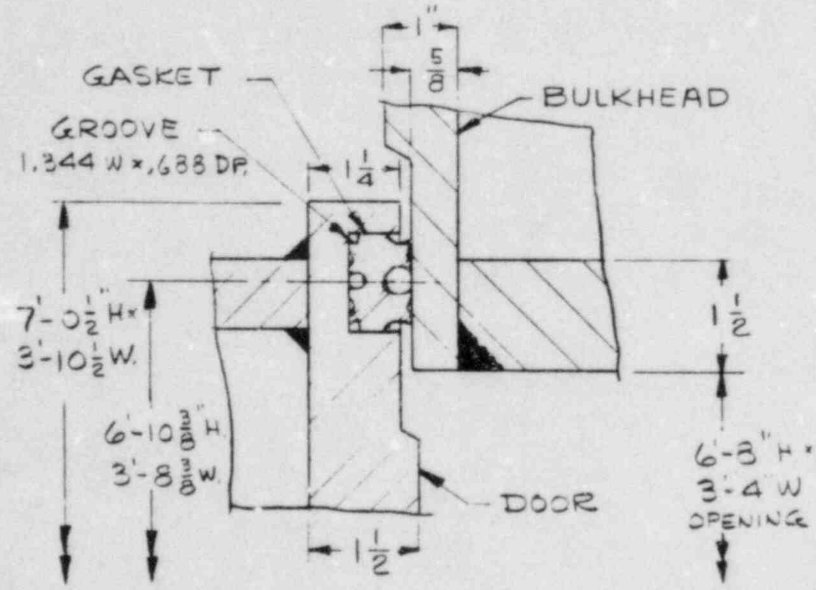
UNIT 9 FIG. 2 SHT. 1 OF 2 PERSONNEL LOCK
CONCRETE CONTAINMENT (STEEL LINER)



UNIT 9 FIG. 2 SHT. 2 OF 2 PERSONNEL LOCK
CONCRETE CONTAINMENT (STEEL LINER)



DETAIL C SEE SHT. #1



DETAIL D

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNIT 9 - ESCAPE LOCK

Escape Lock

The escape lock provides a rectangular clear opening in the concrete containment wall. The escape lock opening is covered with a pressure seating rectangular door. Leakage is prevented by a Double Dog Ear gasket mounted in a groove in the door. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Unit 9 Figure 3
Clear opening	3 ft. 6 in. wide 6 ft. 8 in height
Door height	46-1/2 in.
Door Width	7 ft. 0-1/2 in.
Door thickness	1-1/2 in.
Material	SA-516 Grade 70

Containment Ring (Shell of Lock)

Thickness	5/8 in.
Diameter	9 ft. 11-1/4 in. O.D.
Material	SA-516 Grade 70

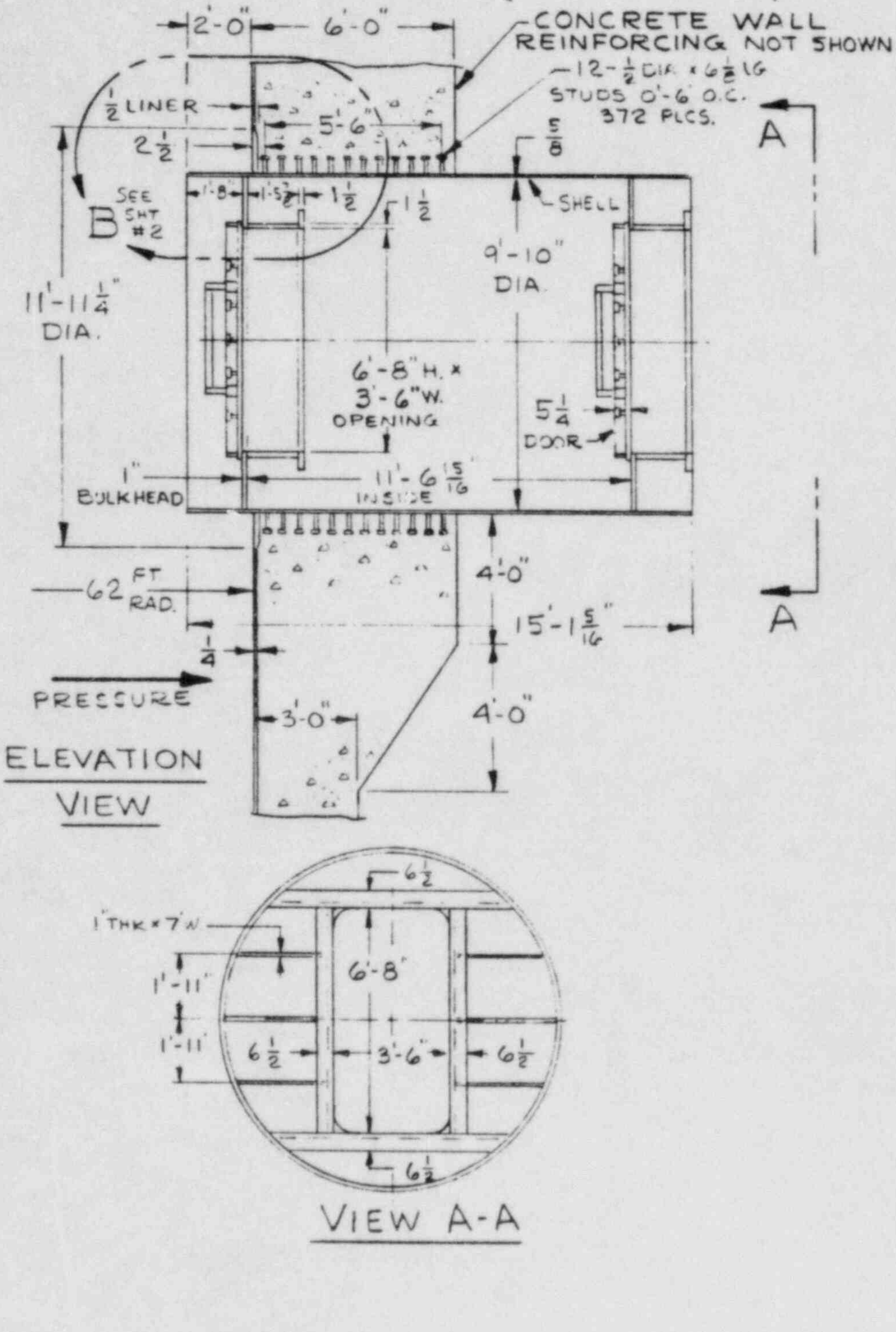
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber MS577
Length	19 ft. 9-7/16 in.

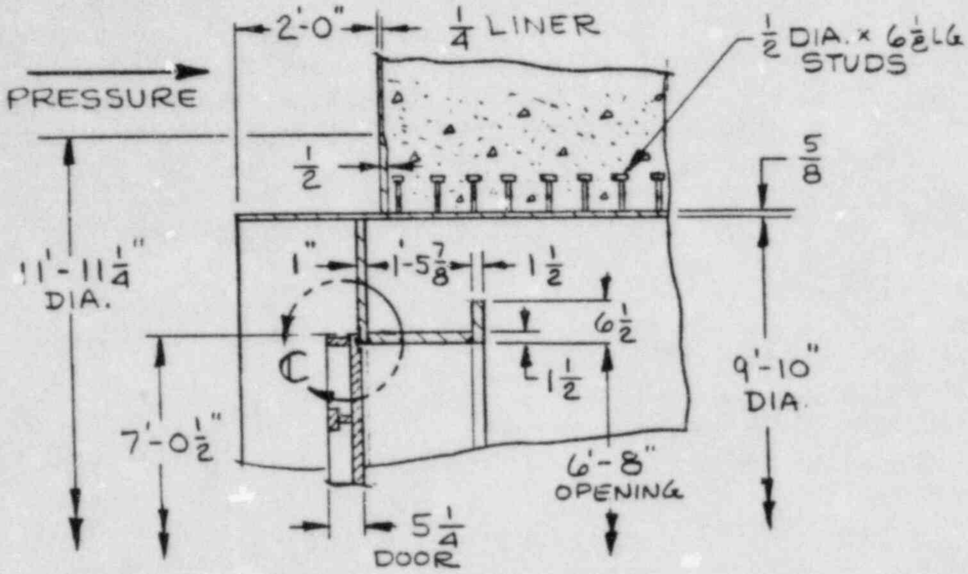
Location of Escape Lock Centerline

Escape lock centerline elev.	832 ft. 3 in.
Escape lock centerline azimuth	60°

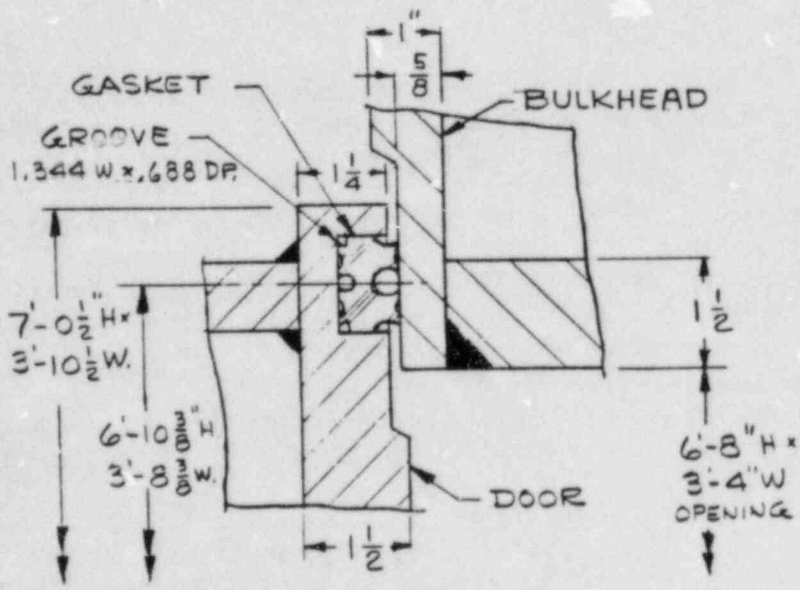
UNIT 9 FIG. 3 SHT. 1 OF 2 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)



UNIT 9 FIG. 3 SHT. 2 OF 2 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)



DETAIL B SEE SHT. #1



DETAIL C

UNITS 10 & 11 - CONCRETE CONTAINMENT (STEEL LINER)

FSAR DESCRIPTION OF UNITS 10 & 11 CONTAINMENT STRUCTURE

The containment structure is a steel-lined reinforced concrete structure. It consists of a vertical cylinder and a hemispherical dome and is supported on an essentially flat foundation mat with a reactor cavity pit projection. The entire inside face of the containment (mat, walls, and dome) is lined with welded steel liner plate, attached with anchors to the reinforced concrete. The thickness of the liner in the wall is 3/8 in. and in the dome is 1/2 in.; a 1/4 in. thick plate is used on top of the foundation mat and covered with a layer of concrete.

The dimensions of the containment structure are as follows:

Inside Diameter	135 ft.
Height of Cylinder (Top of Foundation Mat to Dome Spring Line)	195 ft.
Inside Radius of Hemispherical Dome	67 ft. 6 in.
Thickness of Cylindrical Walls	4 ft. 6 in.
Thickness of Dome	2 ft. 6 in.
Foundation Mat Thickness	12 ft. 0 in.
Top of the Foundation Mat	Approx. 4 ft. 6 in. Below Grade

The principal reinforcement used in the mat, walls, and dome are No. 18 bars, made continuous at splices by the use of Cadweld mechanical connectors.

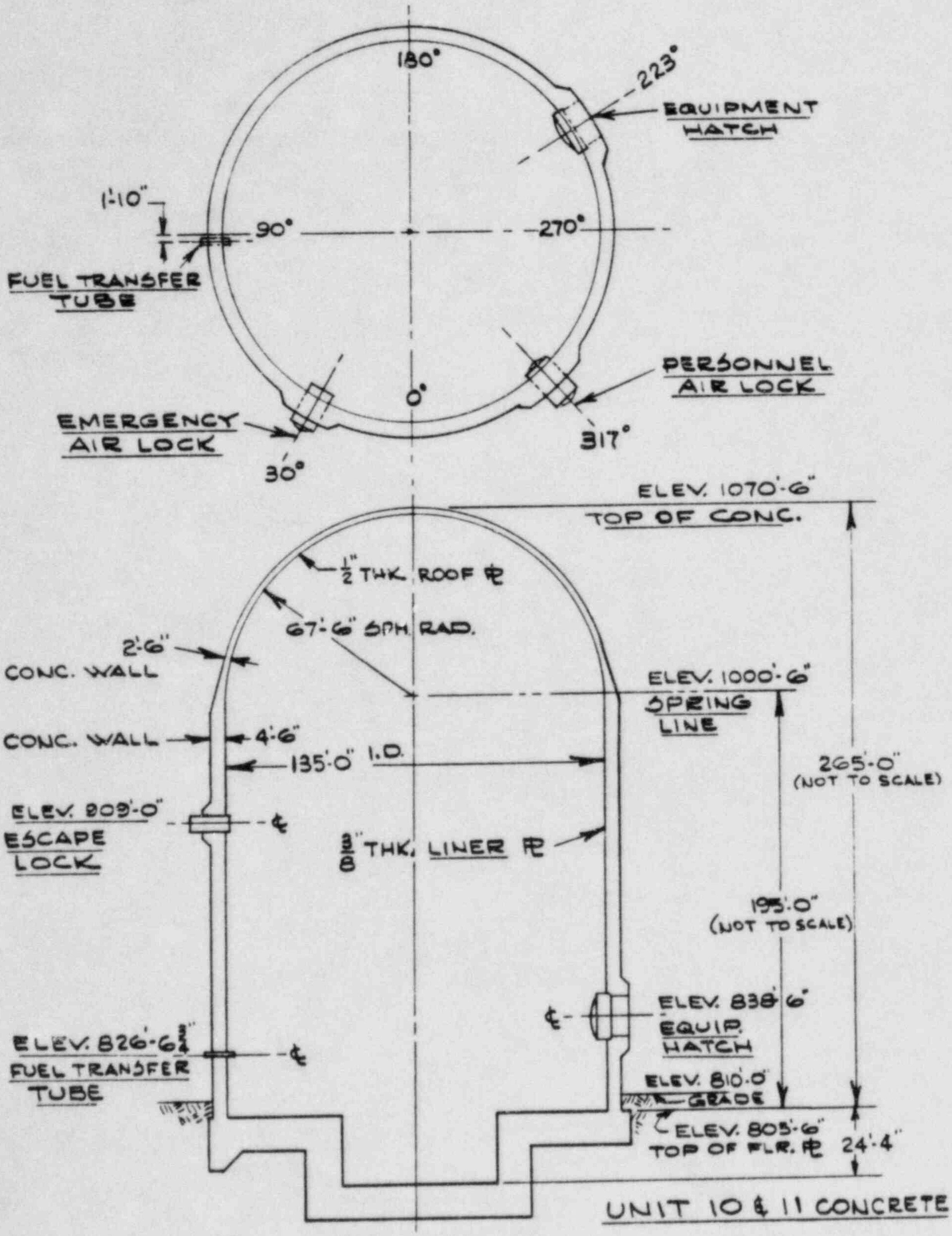
The reinforcing steel pattern in the cylinder wall consists of vertical bars at each face, horizontal hoop bars at each face, and 45-degree diagonal bars, in each direction, near the outside face.

The foundation mat is reinforced with top and bottom layers of bars.

The dome reinforcement consists of top and bottom meridional layers of rebars, extending from the vertical bars of the cylindrical wall and top and bottom layers of circumferential hoop bars.

The meridional reinforcement terminated in the dome is anchored by the use of a positive mechanical anchor, such as a bearing plate cadwelded to the end of the bar.

At penetration openings, reinforcing steel is generally curved around the openings where practical, and supplemental bars are provided around the opening as required. At large major penetrations such as the personnel lock and the equipment hatch some of the wall reinforcement is terminated at the opening by cadwelding steel plates on the end of the bar. Additional reinforcing is provided around these openings to carry stress concentrations and redistributions at these discontinuities.



UNIT 10 & 11 CONCRETE

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

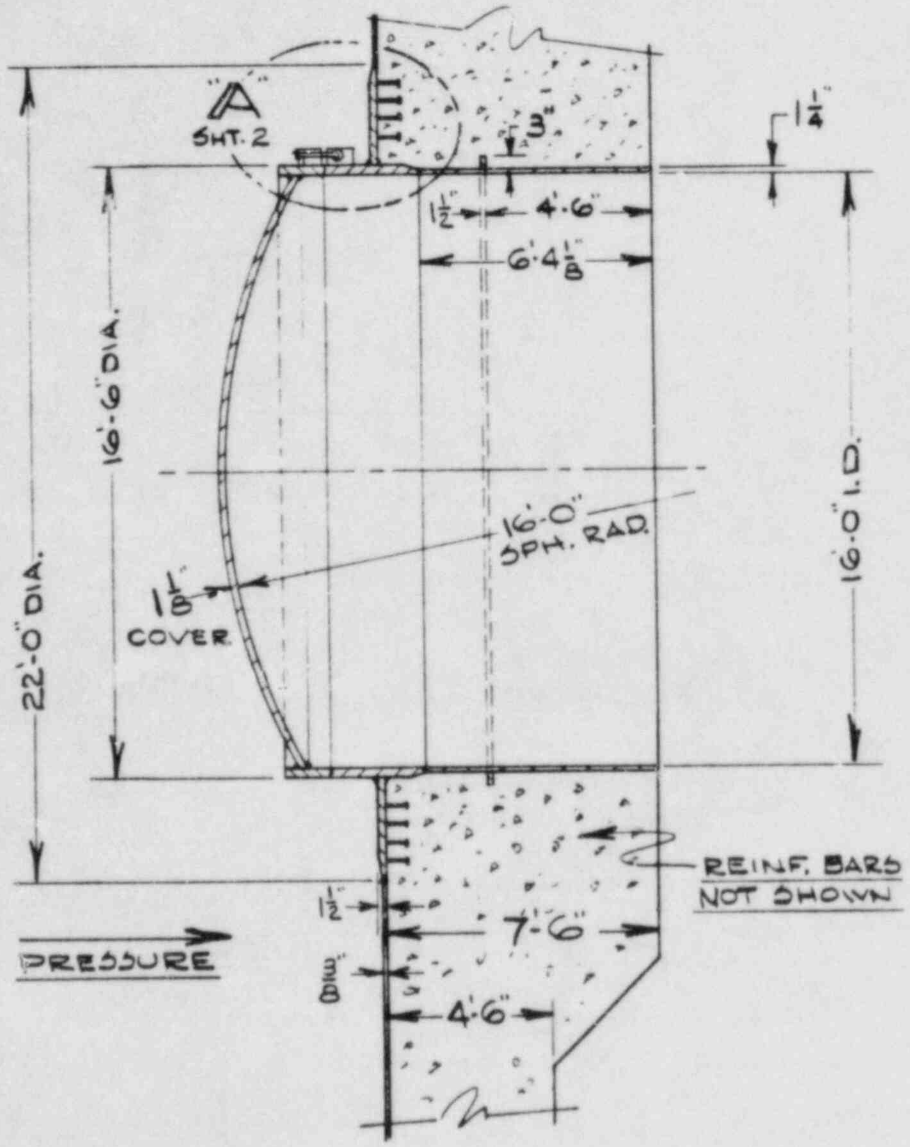
UNITS 10 & 11 - EQUIPMENT HATCH

Equipment Hatch

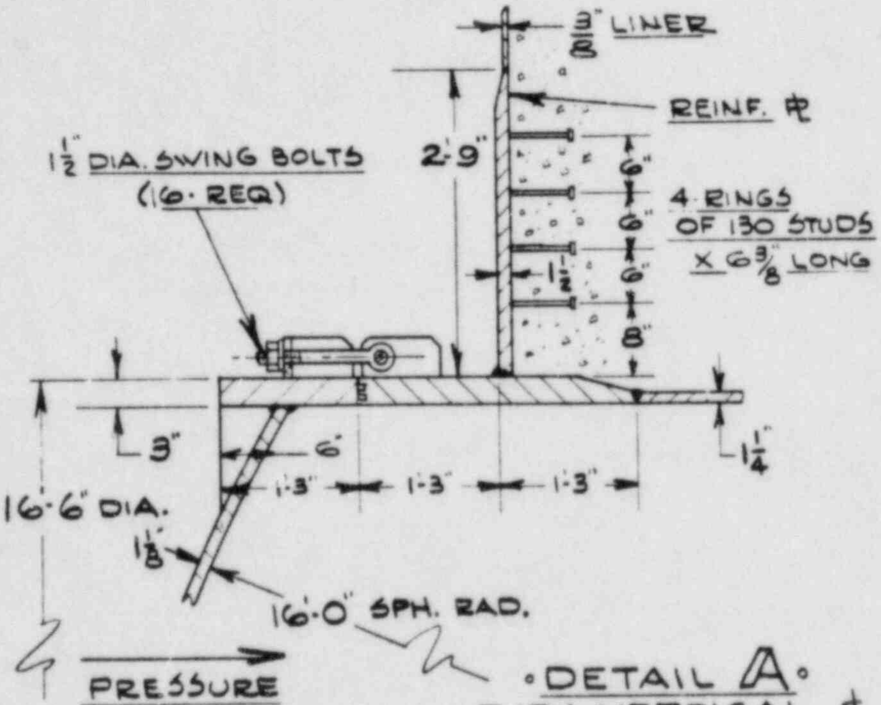
The equipment hatch provides a round clear opening in the concrete containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two gumdrop type gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 16 swing bolts mounted on the outer surface of the hatch opening and containment ring. The pressure inside the containment vessel provides the seating force for the seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Units 10 & 11 Figure 1
Clear opening	16 ft.
Cover thickness	1-1/8 inch
Cover shape, radius	16 ft. radius
Material	A-516 Grade 70
Containment Ring	
Thickness	3 inch
Diameter	16 ft. I.D.
Material	A-516 Grade 70
Gasket	
Gasket type	Gumdrop
Material	Silicone Rubber MS-577
Length, Inner	50 ft. 7-27/32 in.
Length, Outer	51 ft. 5/16 in.
Location of Hatch Centerline	
Hatch centerline elev.	838 ft. 6 in.
Hatch centerline azimuth	223^{o}

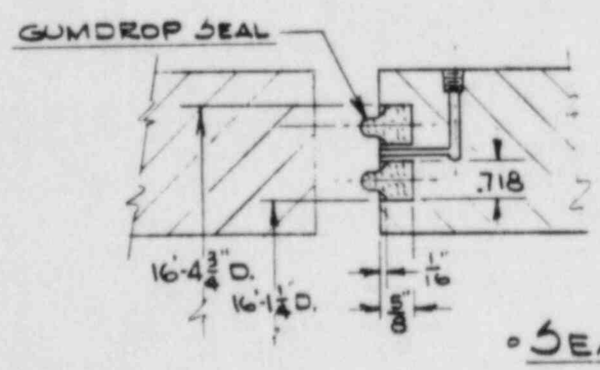
UNITS 10 & 11 FIG. 1 SHT. 1 OF 2 EQUIP. HATCH
CONCRETE CONTAINMENT (STEEL LINER)



UNIT 10 & 11 FIG. 1 SHT. 2 OF 2 EQUIP. HATCH
CONCRETE CONTAINMENT (STEEL LINER)



• DETAIL A •
THRU VERTICAL ℄



• SEAL DETAIL •

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 10 & 11 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a round clear opening in the concrete containment vessel. The personnel lock opening is covered with a pressure seating shaped round plate door. Leakage is prevented by a double dog ear gasket mounted in a groove in the door. Initial locking and seating of the door seal is provided by a mechanical breech lock. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Pressure Lock	Units 10 & 11, Figure 2
Clear opening	9 ft.
Door (including ring)	9 ft. 6 in. O.D.
Door-thickness	3/4 in.
Material	A-516 Grade 70

Containment Ring

Thickness	3 in.
Diameter	9 ft. 6 in. O.D.
Material	A-516 Grade 70

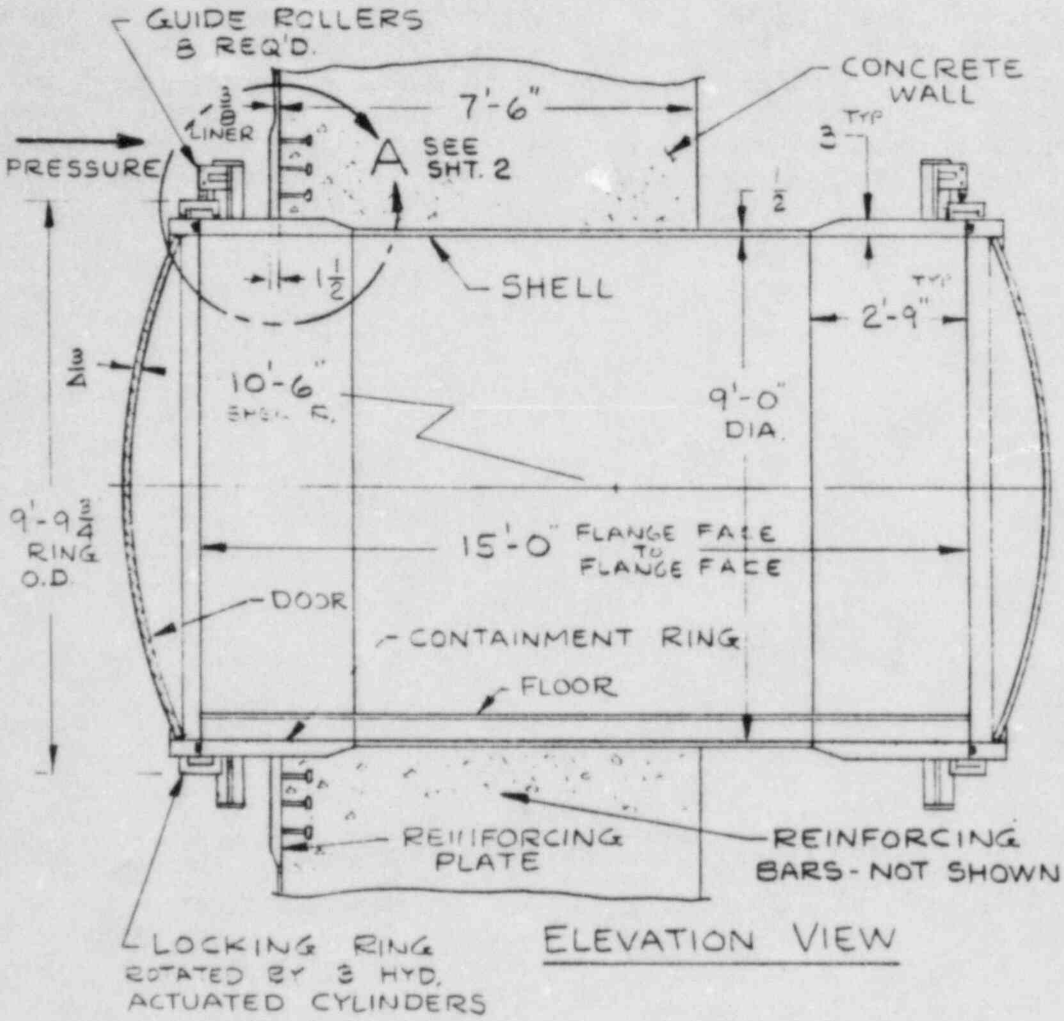
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber MS577
Length	29 ft. 23/32 in.

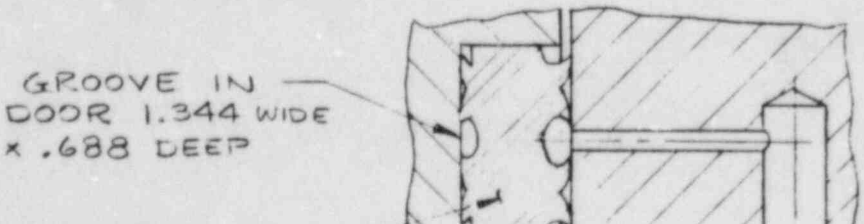
Location of Personnel Lock Centerline

Personnel lock centerline elev.	838 ft. 0 in.
Personnel lock centerline azimuth	317°

UNITS 10 & 11 FIG. 2 SHT. 1 OF 2 PERSONNEL LOCK
CONCRETE CONTAINMENT (STEEL LINER)

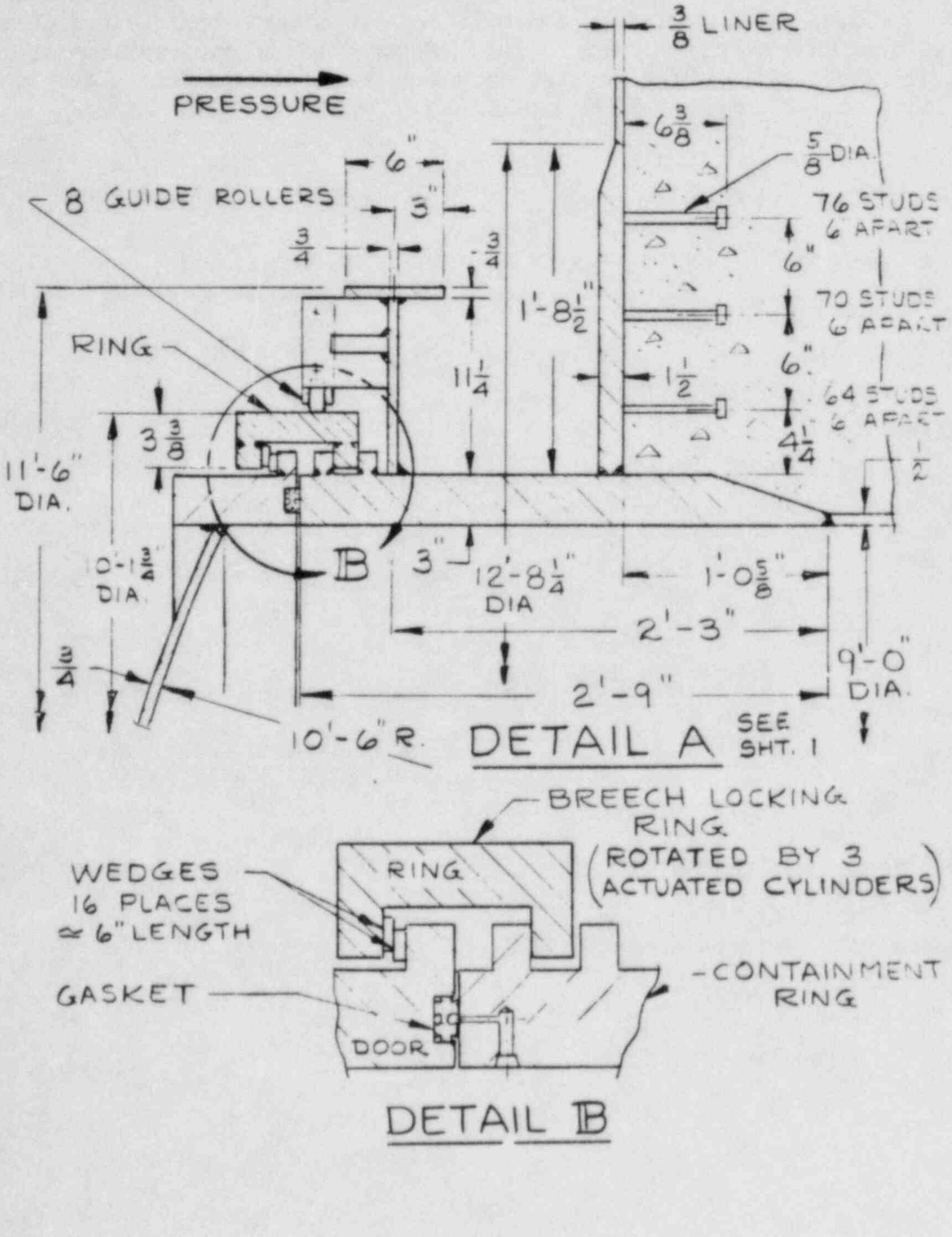


ELEVATION VIEW



SECTION THRU DOOR SEAL

UNITS 10 & 11 FIG. 2 SHT 2 OF 2 PERSONNEL LOCK
CONCRETE CONTAINMENT (STEEL LINER)



SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 10 & 11 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the concrete containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by a double dog ear gasket mounted in a groove in the escape lock bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Units 10 & 11, Figure 3
Clear opening	30 in. diameter
Door	35 in. diameter
Door thickness	1-1/2 in.
Material	A-516 Grade 70

Containment Ring

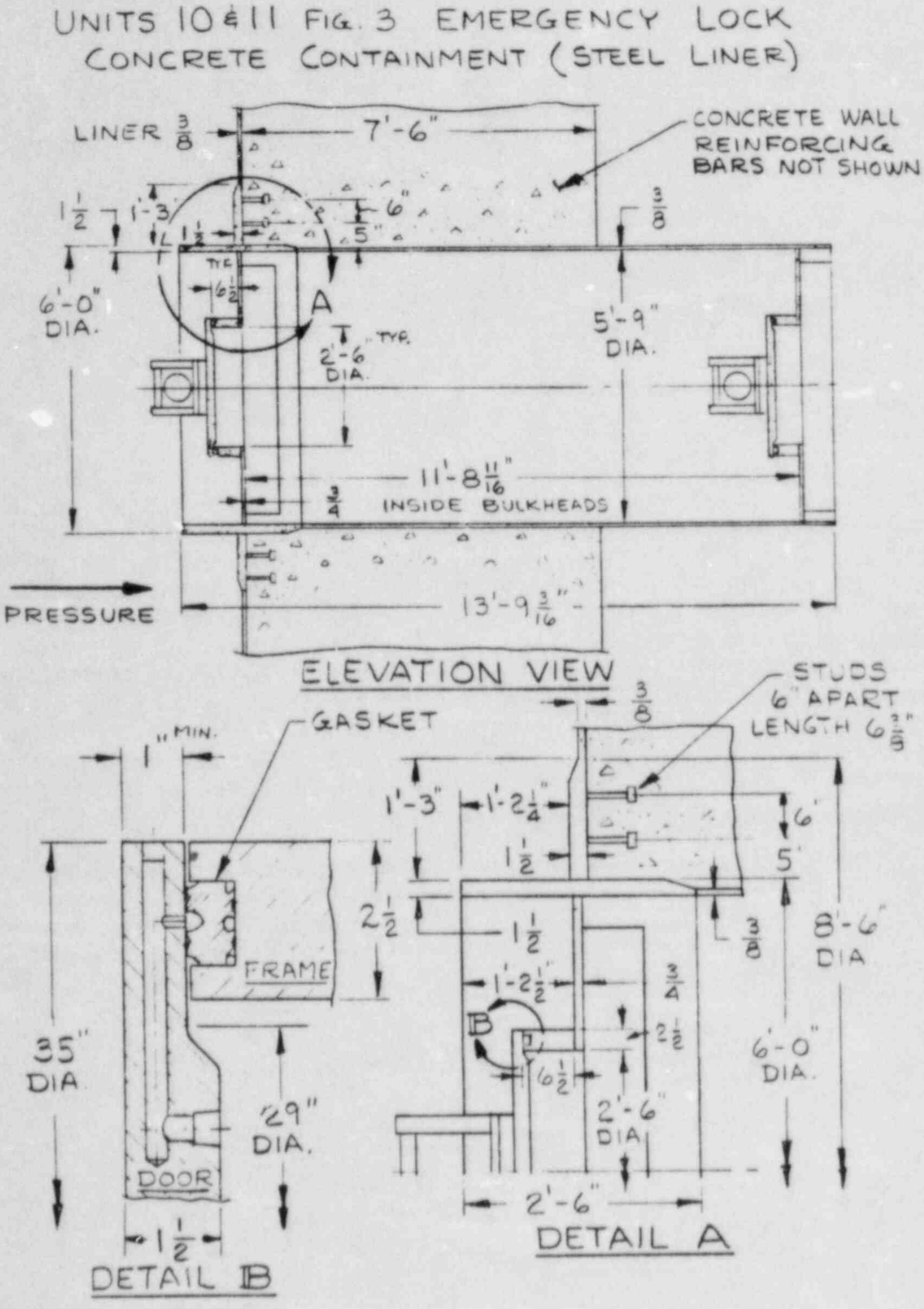
Thickness	1-1/2 in.
Diameter	6 ft. O.D.
Material	A-516 Grade 70

Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber MS577
Length	8 ft. 6-3/32 in.

Location of Escape Lock Centerline

Escape lock centerline elev.	909 ft. 0 in.
Escape lock centerline azimuth	30°


UNITS 10 & 11 FIG. 3 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)
LINER 3/8
7'-6"
CONCRETE WALL
REINFORCING
BARS NOT SHOWN
6'-0"
DIA.
5'-9"
DIA.
2'-6"
DIA.
11'-8 11/16"
INSIDE BULKHEADS
13'-9 3/16"
PRESSURE
ELEVATION VIEW
GASKET
FRAME
DOOR
35"
DIA
29"
DIA.
DETAIL B
STUDS
6" APART
LENGTH 6 3/8"
8'-6"
DIA
6'-0"
DIA.
DETAIL A

UNITS 12 & 13 CONCRETE CONTAINMENT (STEEL LINER)

FSAR DESCRIPTION OF UNITS 12 & 13 CONTAINMENT STRUCTURE

The general arrangement of the concrete containment consists of a right circular cylinder with a shallow dome and a flat base slab. The interior of the containment is lined with welded steel plates. The liner is typically 1/4 inch thick plate, with thicker plate provided locally around penetrations and large structural anchorages.

Approximate dimensions of the containment are as follows:

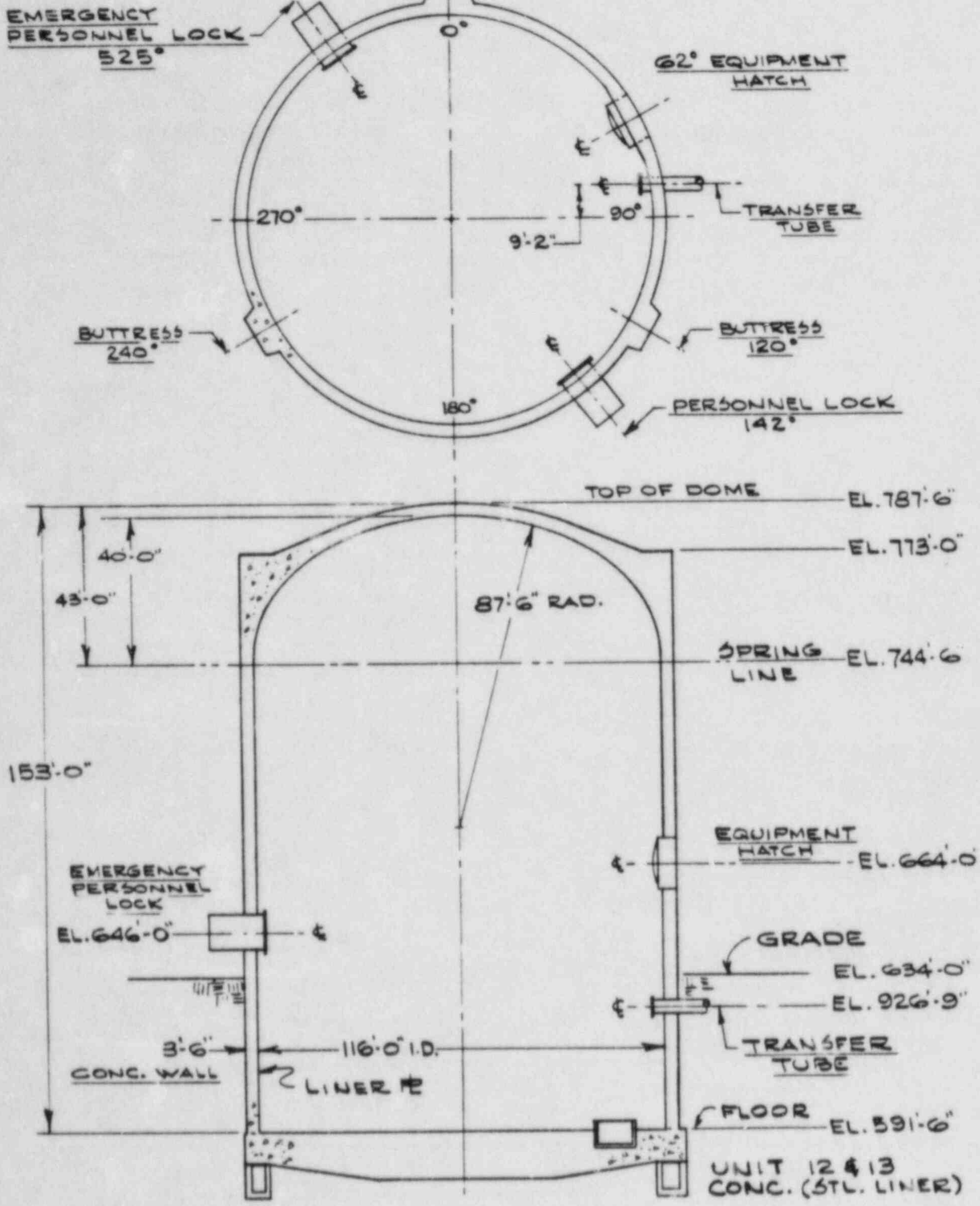
Inside Diameter	116 ft.
Inside Height	193 ft.
Vertical Wall Thickness	3-1/2 ft.
Dome Thickness	3 ft. min.
Foundation Slab Thickness	9 ft to 13 ft.
Internal Free Volume	1,670,000 cu.ft.

The cylindrical wall is prestressed with a system of vertical and circumferential (hoop) tendons. Vertical tendons are anchored at the bottom surface of the base slab and at the top surface of the ring girder. Hoop tendons are anchored at three equally spaced buttresses. Each tendon is anchored at buttresses 240 degrees apart. In general, the tendon center-to-center spacing does not exceed 60 inches, nor is any tendon closer than 6 inches to a penetration. Tendons are installed in sheathing through the concrete between anchorage points. The space between the tendon and the sheathing is filled with a corrosion inhibiting material.

The cylindrical wall is nominally reinforced with bonded reinforcing steel for crack control. Additional bonded reinforcing is provided at discontinuities and around openings in the shell.

The dome is shallow and is prestressed with a three-way pattern of tendons consisting of three groups of tendons oriented at 120 degrees to each other, and which have both ends anchored at the ring girder. The ring girder provides an anchorage surface on the cylindrical face for dome tendons and on the top surface for vertical wall tendons.

The base mat is a reinforced concrete slab. An access gallery is provided below the base slab for access to the post-tensioning system.


EMERGENCY PERSONNEL LOCK
325°
0°
62° EQUIPMENT HATCH
TRANSFER TUBE
270°
90°
9'-2"
BUTTRESS 240°
BUTTRESS 120°
180°
PERSONNEL LOCK 142°
TOP OF DOME
EL. 787'-6"
EL. 773'-0"
40'-0"
43'-0"
87'-6" RAD.
SPRING LINE
EL. 744'-6
153'-0"
EQUIPMENT HATCH
EL. 664'-0"
EMERGENCY PERSONNEL LOCK
EL. 646'-0"
GRADE
EL. 634'-0"
EL. 926'-9"
TRANSFER TUBE
3'-6"
116'-0" I.D.
CONC. WALL
LINER PL
FLOOR
EL. 591'-6"
UNIT 12 & 13
CONC. (STL. LINER)

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 12 & 13 - EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the concrete containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two round gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 8 swing bolts mounted on the outer surface of the hatch opening and containment ring. The pressure inside the containment vessel provides the seating force for the seal. The equipment hatch dimensions and seal information are listed below.

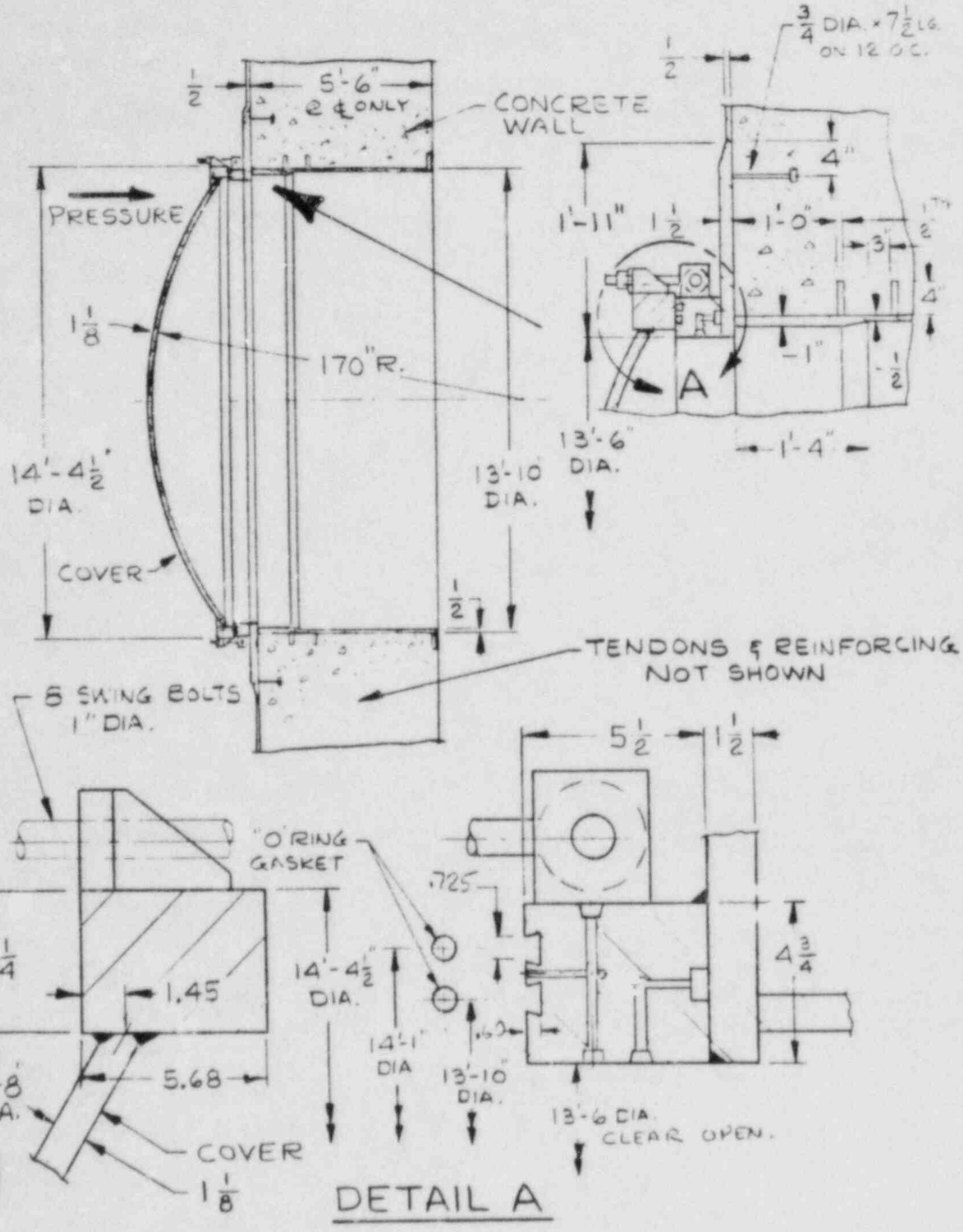
Equipment Hatch	Units 12 & 13, Figure 1
Clear opening	13 ft. 6 in.
Cover thickness	1-1/8 inch
Cover shape, radius	170 in. radius
Material	SA-516 Grade 70

Containment Ring	
Thickness	4 3/4 inch
Diameter	13 ft. 6 in. I.D.
Material	SA-516 Grade 70

Gasket	
Gasket type	"O" Ring
Cross-section	0.750 in. Dia.
Material	Rubber

Location of Hatch Centerline	
Hatch centerline elev.	664 ft. 0 in.
Hatch centerline aximuth	62^{o}

UNITS 12 & 13 FIGURE 1 EQUIPMENT HATCH
CONCRETE CONTAINMENT (STEEL LINER)



SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNIT 12 & 13 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the concrete containment structure. The personnel lock opening is covered with a rectangular door. Leakage is prevented by two inflatable seal gaskets mounted on the door. The personnel lock dimensions and seal information are listed below.

Pressure Lock	Units 12 & 13, Figure 2
Clear opening	3 ft. 6 in. wide 6 ft. 6 in. height
Door width	3 ft. 11 in.
Door height	6 ft. 2-1/2 in.
Door-thickness	7/8 in.
Material	SA-516 Grade 70

Containment Ring

Thickness	1-1/2 in.
Diameter	10 ft. 6 in. O.D.
Material	A-516 Grade 70

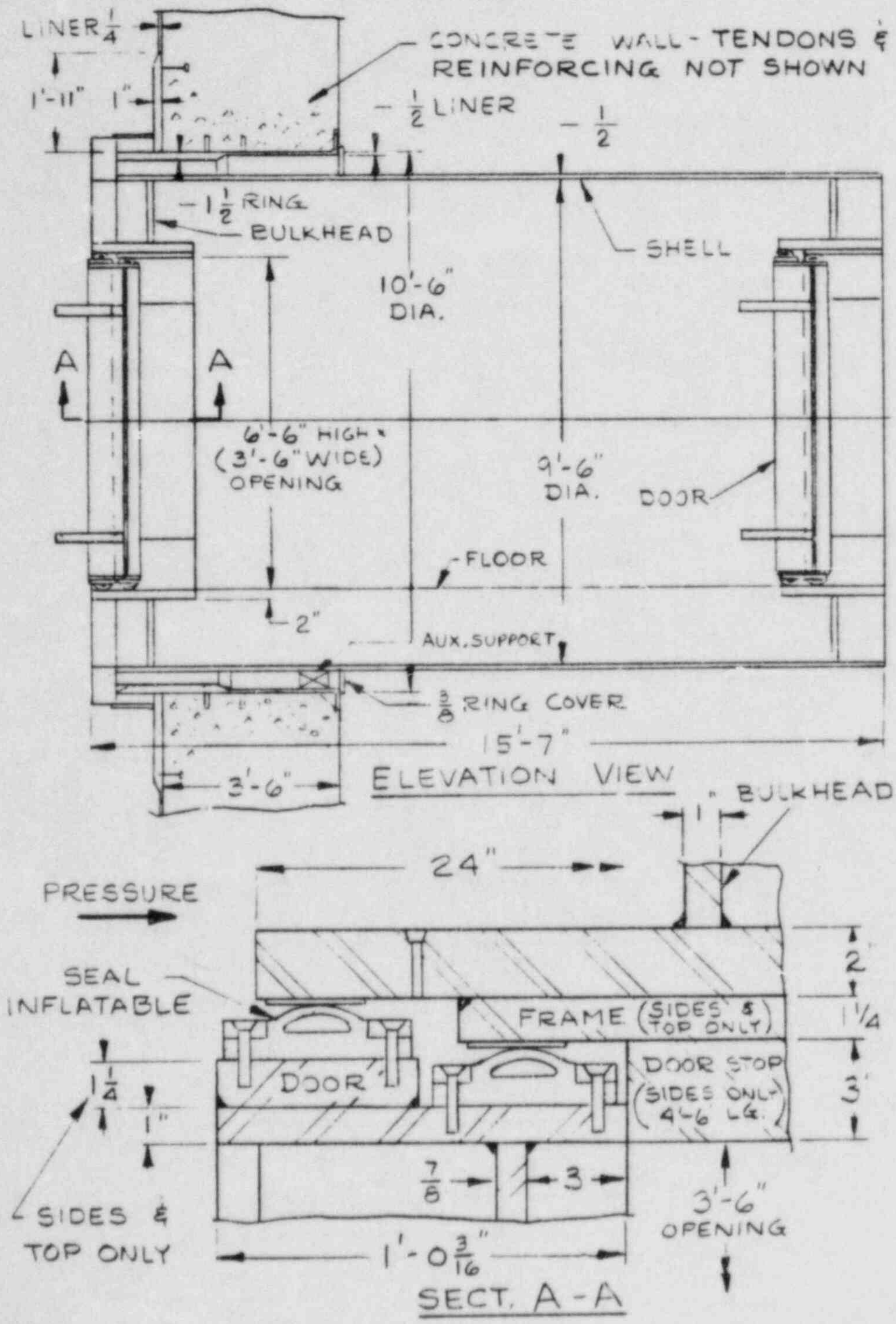
Gasket

Gasket type	Inflatable Seal
Material	Rubber

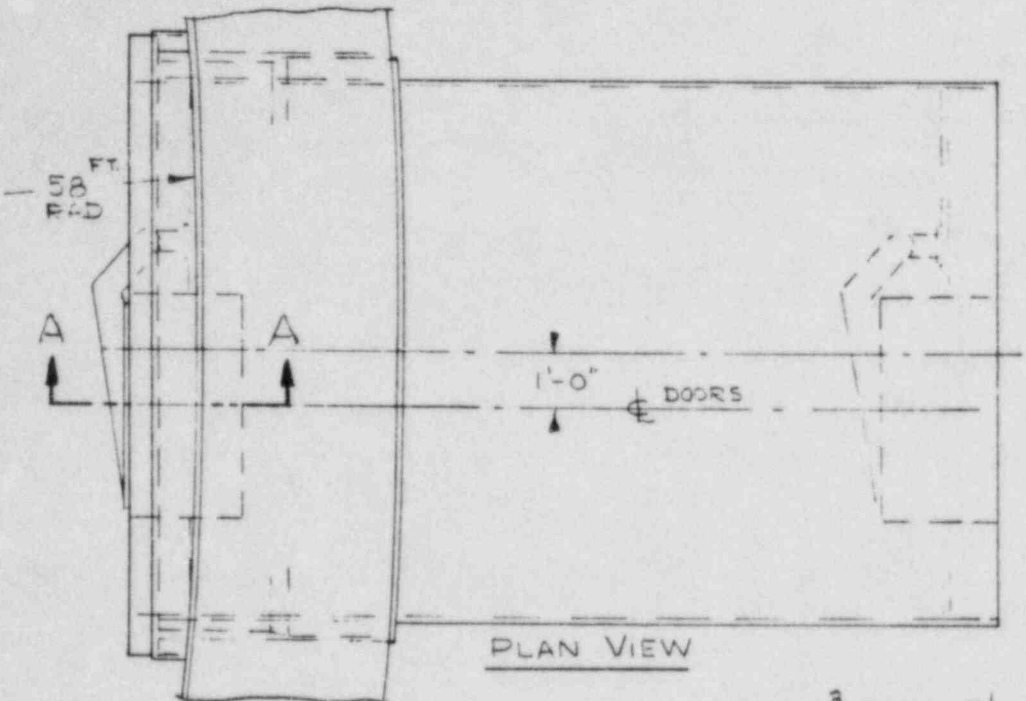
Location of Personnel Lock Centerline

Personnel lock centerline elev.	646 ft. 0 in.
Personnel lock centerline azimuth	142°

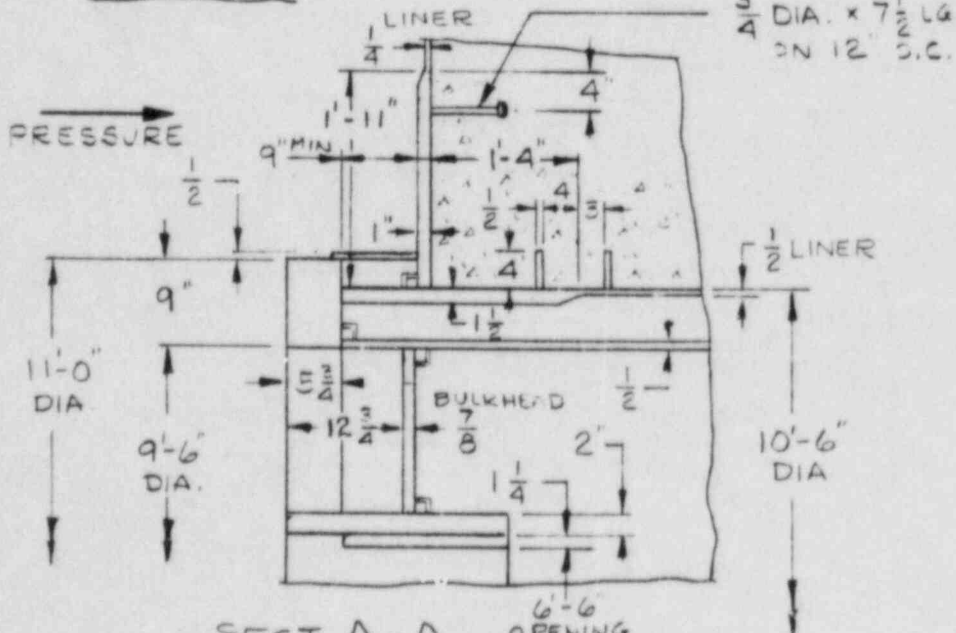
UNITS 12 & 13 FIG. 2 - SHT 1 of 2 PERSONNEL LOCK
CONCRETE CONTAINMENT (STEEL LINER)



UNITS 12 & 13 FIG. 2 - SHT. 2 OF 2 PERSONNEL LOCK
CONCRETE CONTAINMENT (STEEL LINER)



PLAN VIEW



SECT. A-A
AT TOP OF DOOR

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNITS 12 & 13 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the concrete containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by two round gaskets in separate grooves mounted in the escape lock bulkhead. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Units 12 & 13, Figure 3
Clear opening	30 in. diameter
Door	36 in. diameter
Door thickness	1 in.
Material	SA-516 Grade 70

Containment Ring (Shell of Lock)

Thickness	3/8 in.
Diameter	5 ft. 6 in. O.D.
Material	SA-516 Grade 70

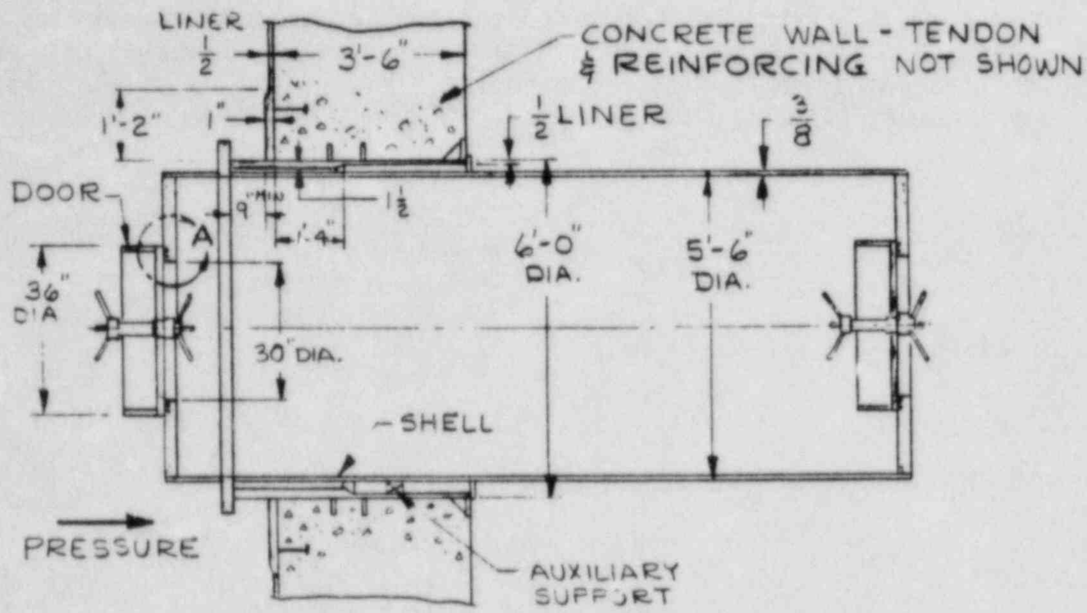
Gasket

Gasket type	"O" Ring
Cross-section	0.750 in. dia.
Material	Rubber

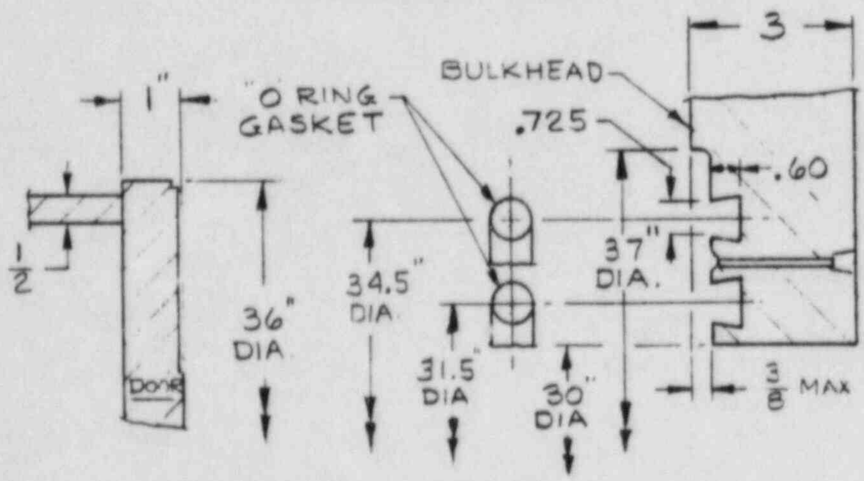
Location of Escape Lock Centerline

Escape lock centerline elev.	644 ft. 0 in.
Escape lock centerline azimuth	325°

UNITS 12 & 13 FIG. 3 SHT. 1 OF 2 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)

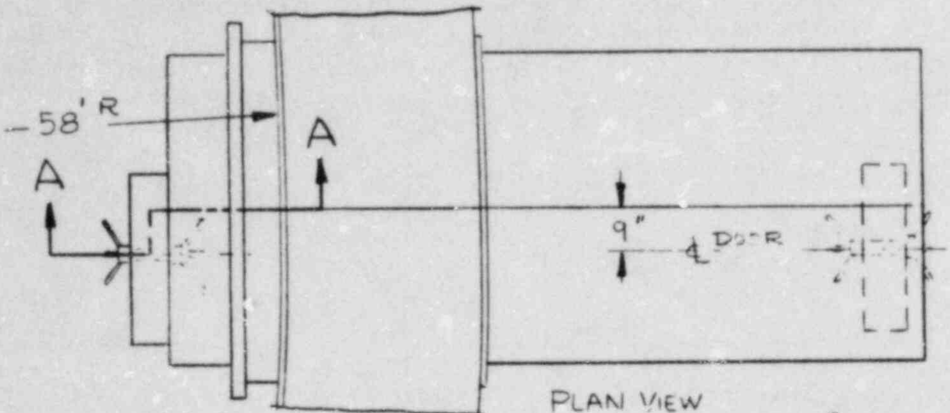


ELEVATION VIEW

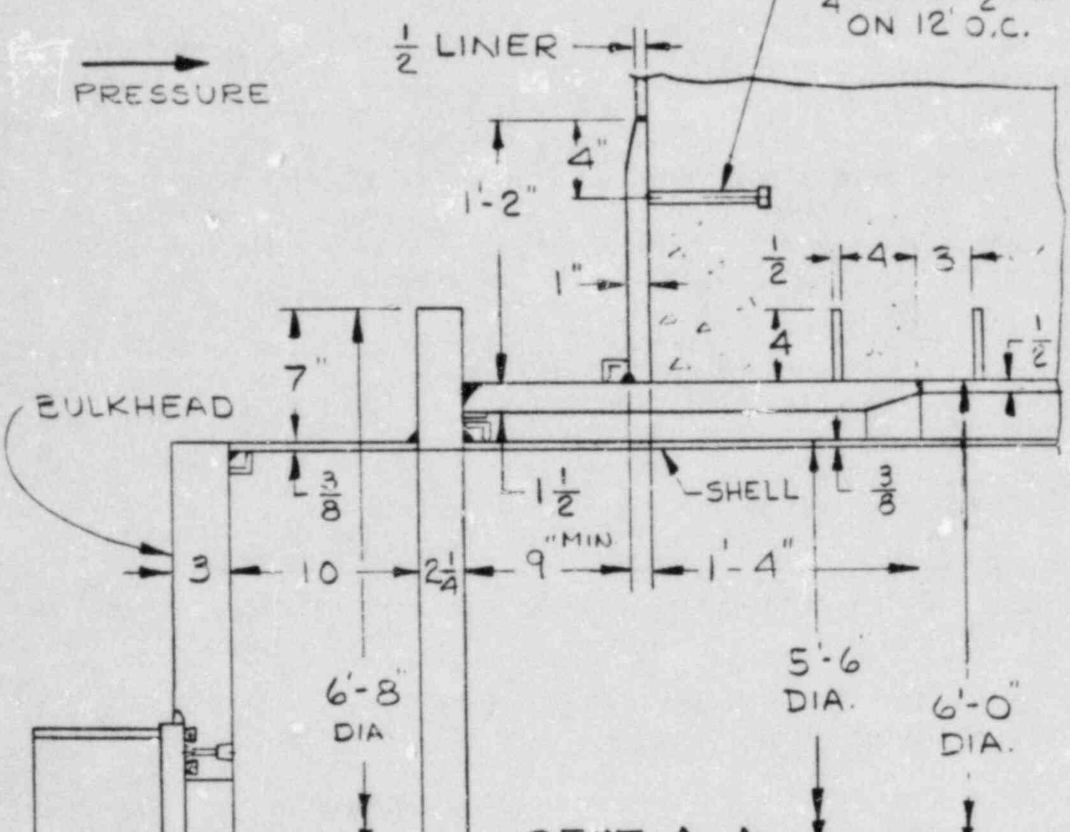


DETAIL A

UNITS 12 & 13 FIG. 3 SHT. 2 OF 2 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)



PLAN VIEW



SECT. A-A

UNIT 14 - CONCRETE CONTAINMENT (STEEL LINER)

FSAR DESCRIPTION OF UNIT 14 CONTAINMENT STRUCTURE

The containment structure consists of a post-tensioned prestressed concrete cylinder and dome connected to and supported by a reinforced concrete foundation slab. The entire interior surface of the structure is lined with a 1/4" thick welded ASTM A-442 steel plate. Mechanical and electrical systems penetrate the containment wall through welded steel penetrations.

Dimensions of the containment structure are as follows:

Inside Diameter	116 ft.
Inside Height (Including Dome)	189 ft.
Vertical Wall Thickness	3-1/2 ft.
Dome Thickness	3 ft.
Foundation Slab Thickness	8-1/2 to 13 ft.
Liner Plate Thickness	1/4 in.
Internal Free Volume	1,640,000 cu.ft.

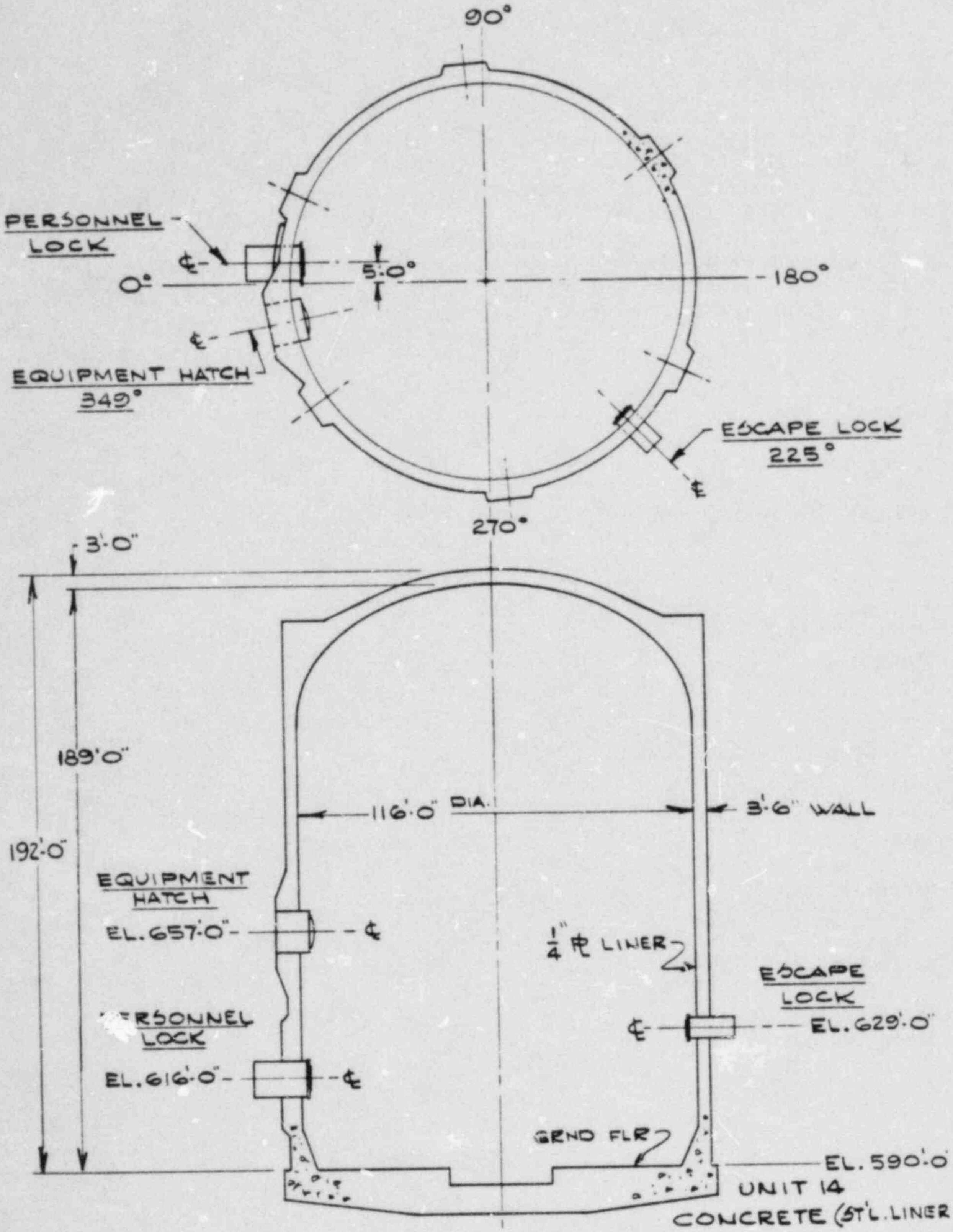
In the concept of post-tensioned containment, the internal pressure load is balanced by the application of an opposing external pressure type load on the structure. Sufficient post-tensioning is used on the cylinder and dome to more than balance the internal pressure so that a margin of external pressure exists beyond that required to resist the design pressure. Bonded reinforcing steel is used to distribute strains due to shrinkage and temperature. Additional bonded reinforcing steel is used at penetrations and discontinuities to resist local moments and shears.

The internal pressure loads on the base slab are resisted by both the external soil pressure due to dead load and the strength of the reinforced concrete slab. Thus, post-tensioning is not required to exert an external pressure for this portion of the structure.

The post-tensioning system consists of:

- Three groups of 55 dome tendons oriented at 120° to each other for a total of 165 tendons anchored at the vertical face of the dome ring girder.
- 180 vertical tendons anchored at the top surface of the ring girder and at the bottom of the base slab.
- Six groups of 87 hoop tendons enclosing 120° of arc for a total of 522 tendons anchored at the six vertical buttresses.

Each tendon consists of ninety 1/4" diameter wires with button-heated type anchorages.


90°
PERSONNEL LOCK
0°
5'-0"
180°
EQUIPMENT HATCH 349°
ESCAPE LOCK 225°
270°
3'-0"
189'-0"
192'-0"
116'-0" DIA.
3'-6" WALL
EQUIPMENT HATCH
EL. 657'-0"
1/4" PL LINER
ESCAPE LOCK
EL. 629'-0"
PERSONNEL LOCK
EL. 616'-0"
GRND FLR
EL. 590'-0"
UNIT 14
CONCRETE (ST'L. LINER

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNIT 14 - EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the concrete containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two round gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 24 swing bolts mounted on the outer surface of the hatch opening and containment ring. The pressure inside the containment vessel provides the seating force for the seal. The equipment hatch dimensions and seal information are listed below.

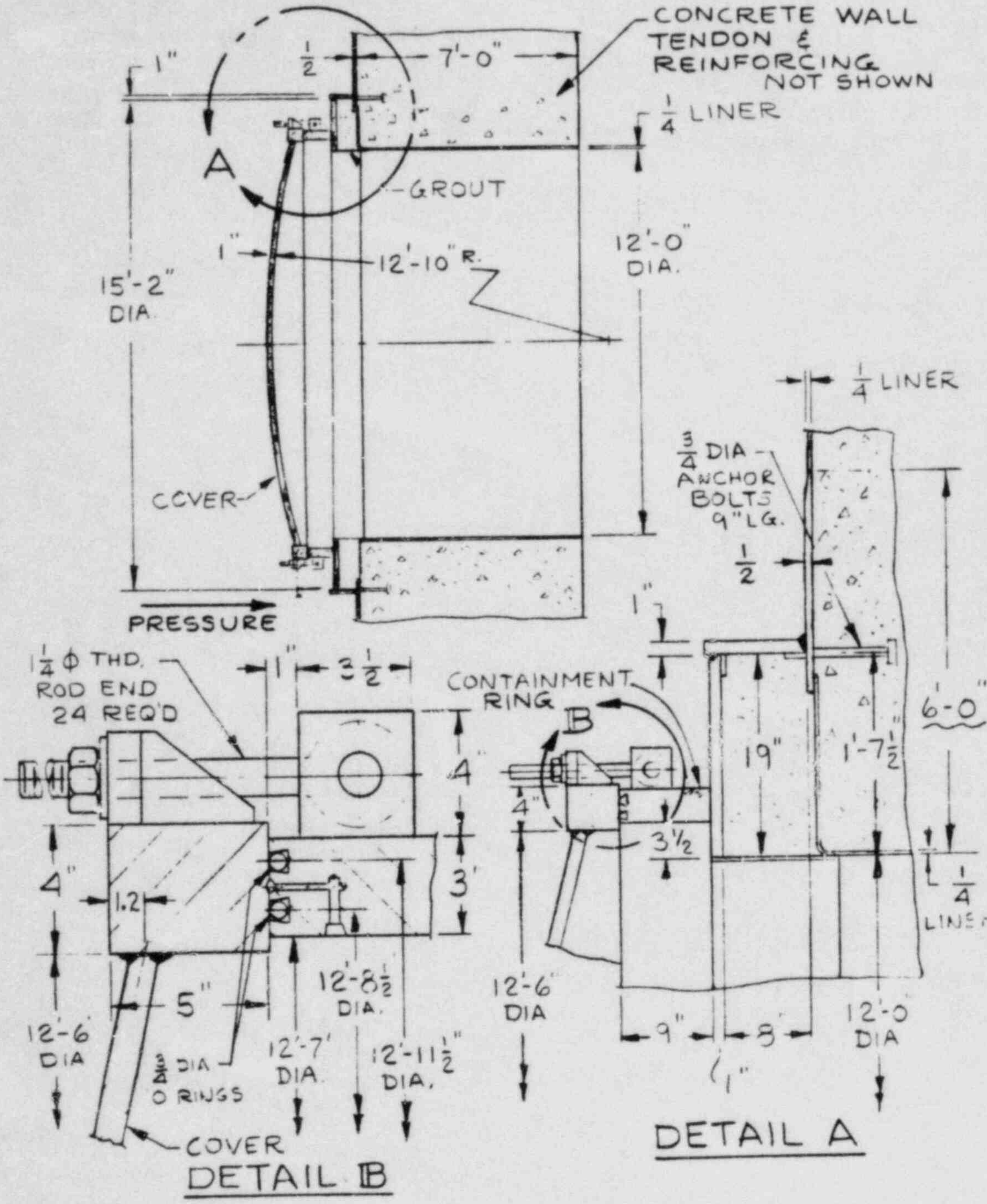
Equipment Hatch	Unit 14 Figure 1
Clear opening	12 feet
Cover thickness	1 inch
Cover shape, radius	12 ft 10 in. radius
Material	A-516 Grade 70

Containment Ring	
Thickness	3 inch
Diameter	12 ft 7 in. I.D.
Material	A-516 Grade 70

Gasket	
Gasket type	"O" Ring
Cross-section	0.750 in. Dia.
Material	Rubber

Location of Hatch Centerline	
Hatch centerline elev.	657 ft. 0 in.
Hatch centerline azimuth	349°

UNIT 14 FIGURE 1 EQUIPMENT HATCH
CONCRETE CONTAINMENT (STEEL LINER)



SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNIT 14 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the concrete containment vessel. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Pressure Lock	Unit 14 Figure 2
Clear opening	3 ft. 6 in. wide 6 ft. 8 in. height
Door width	51-1/4 in.
Door height	7 ft. 5-1/4 in.
Door-thickness	5/8 in.
Material	A-516 Grade 70

Containment Ring (Shell of Lock)

Thickness	1/2 in.
Diameter	9 ft. 2 in. O.D.
Material	A-516 Grade 70

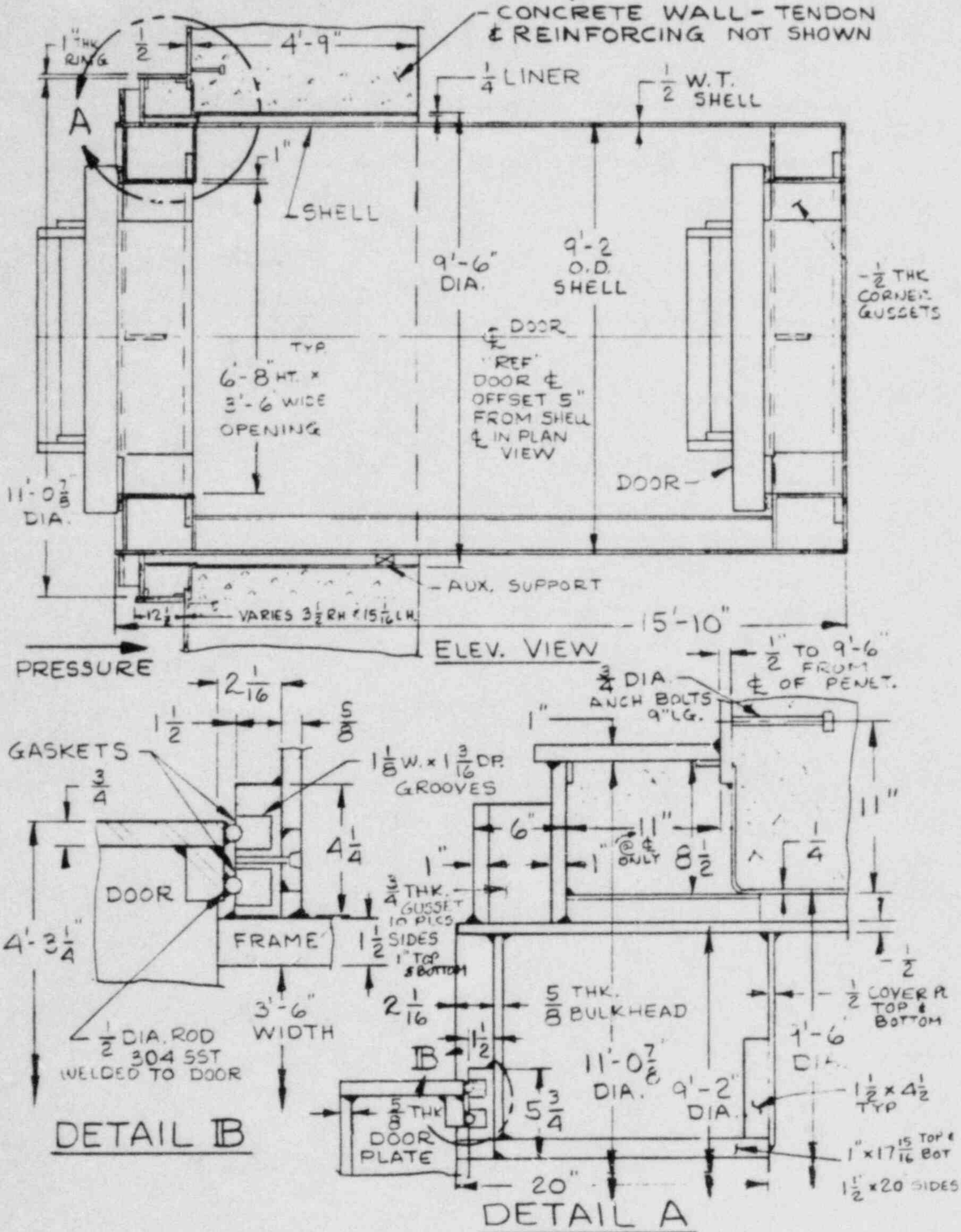
Gasket

Gasket type	Double tongue & groove
Cross-section	Rectangular
Material	Rubber

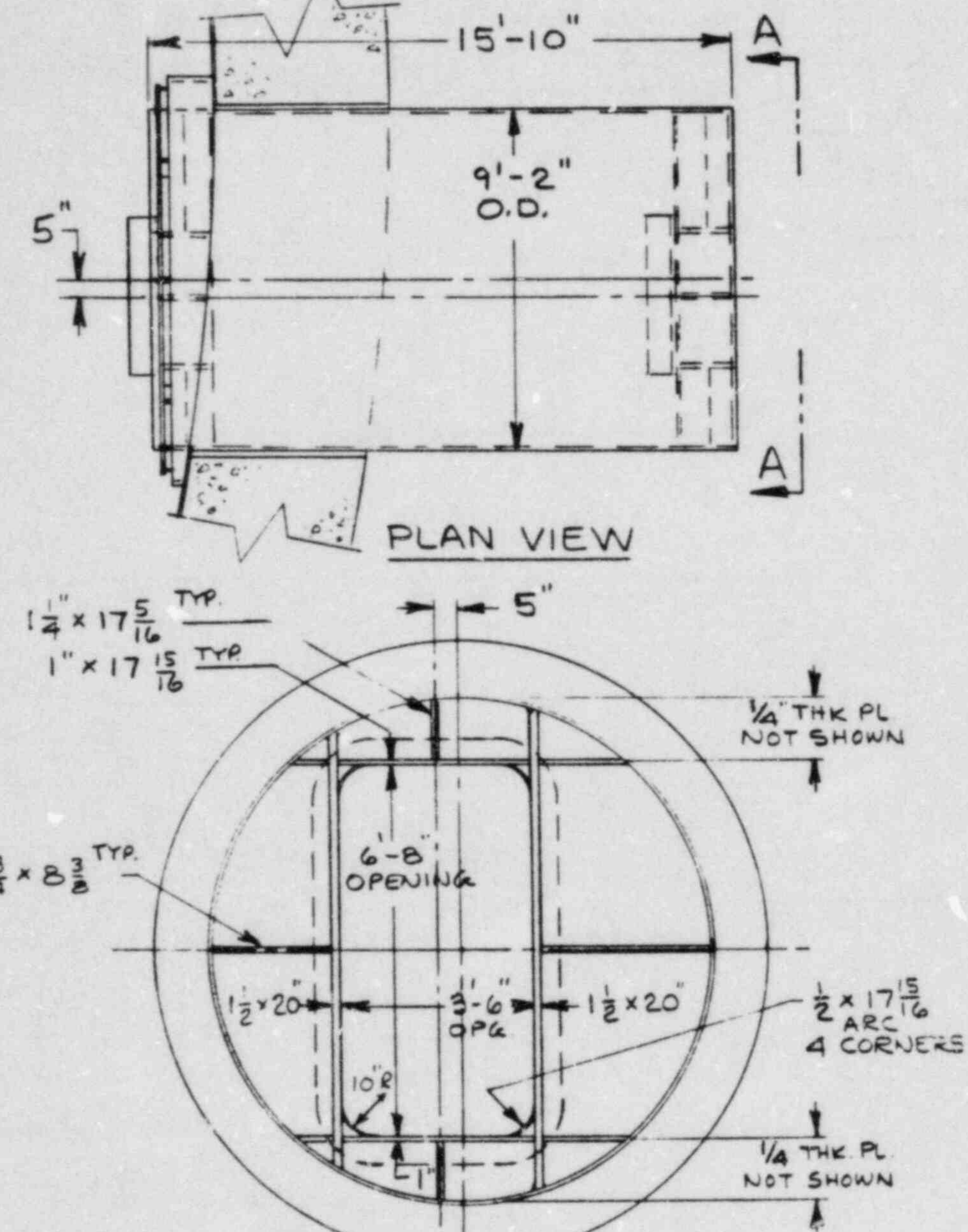
Location of Personnel Lock Centerline

Personnel lock centerline elev.	616 ft. 0 in.
Personnel lock centerline azimuth	Parallel to 0-90° axis Centerline of hatch 5 ft. apart from 0-90° axis

UNIT 14 FIGURE 2 PERSONNEL LOCK (SHT 1 OF 2)
CONCRETE CONTAINMENT (STEEL LINER)



UNIT 14 FIG. 2 SHT. 2 OF 2 PERSONNEL LOCK
CONCRETE CONTAINMENT (STEEL LINER)



VIEW A-A ROTATED 90°

SURVEY DATA - CONCRETE CONTAINMENT (STEEL LINER)

UNIT 14 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the concrete containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the escape lock bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Unit 14 Figure 3
Clear opening	30 in. diameter
Door	37-3/4 in. diameter
Door thickness	1-1/4 in.
Material	A-516 Grade 70

Containment Ring (Shell of Lock)

Thickness	3/8 in.
Diameter	5 ft. O.D.
Material	A-516 Grade 70

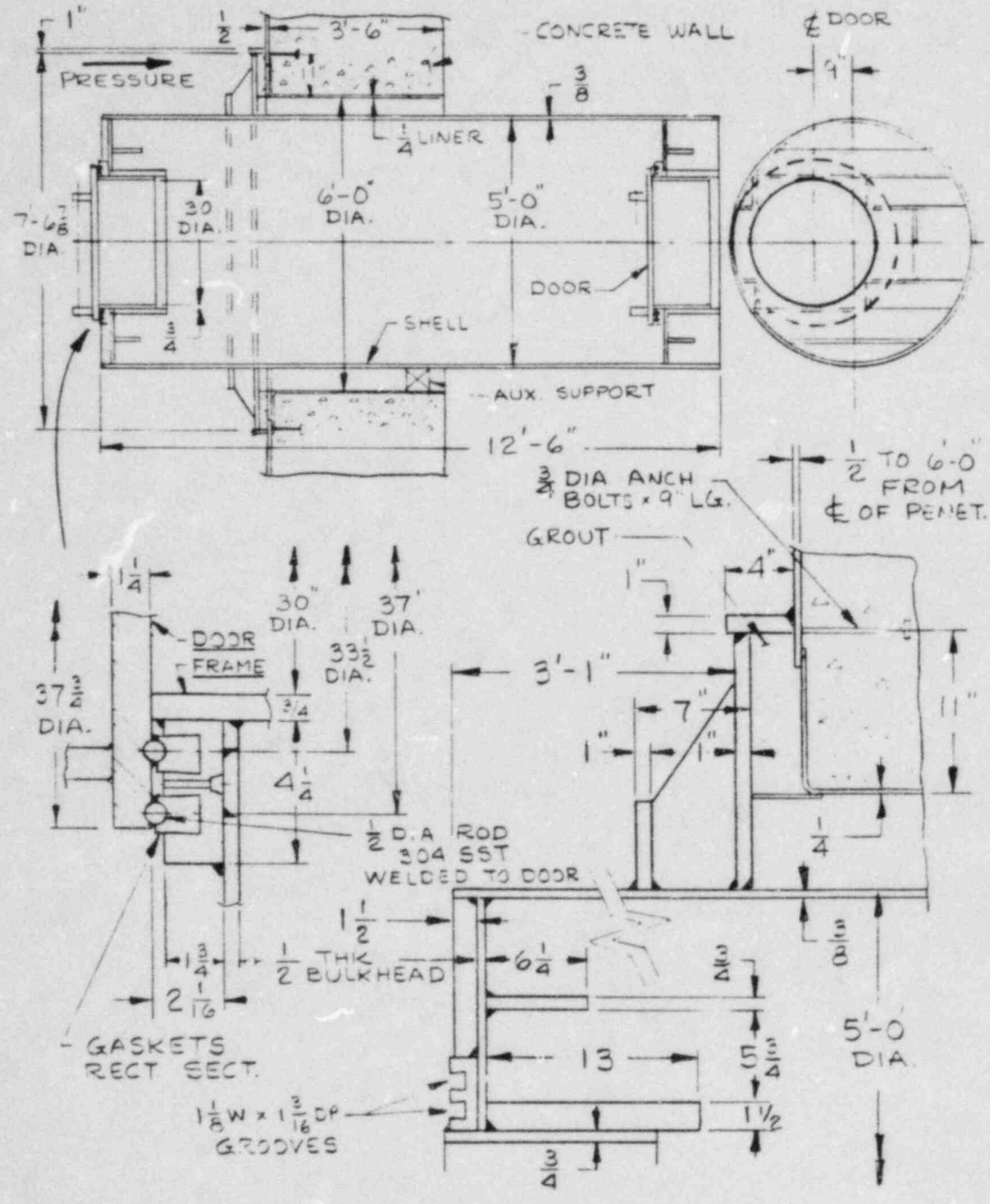
Gasket

Gasket type	Double tongue & groove
Cross-section	Rectangular
Material	Rubber

Location of Escape Lock Centerline

Escape lock centerline elev.	629 ft. 0 in.
Escape lock centerline azimuth	225°

UNIT 14 FIGURE 3 EMERGENCY LOCK
CONCRETE CONTAINMENT (STEEL LINER)



UNIT 1 STEEL CONTAINMENT

FSAR DESCRIPTION OF UNIT 1 STEEL CONTAINMENT

To be included in August 1984 Report.

SURVEY DATA - STEEL CONTAINMENT

UNIT 1 - EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the steel containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two gumdrop type gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 12 swing bolts mounted on the outer surface of the hatch opening and containment penetration ring. The pressure inside the containment vessel provides the seating force for the seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Unit 1 Figure 1
Clear opening	12 ft.
Cover thickness	3/4 inch
Cover shape, radius	12 ft. radius
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	5 1/4 inch
Material	SA-516 Grade 70

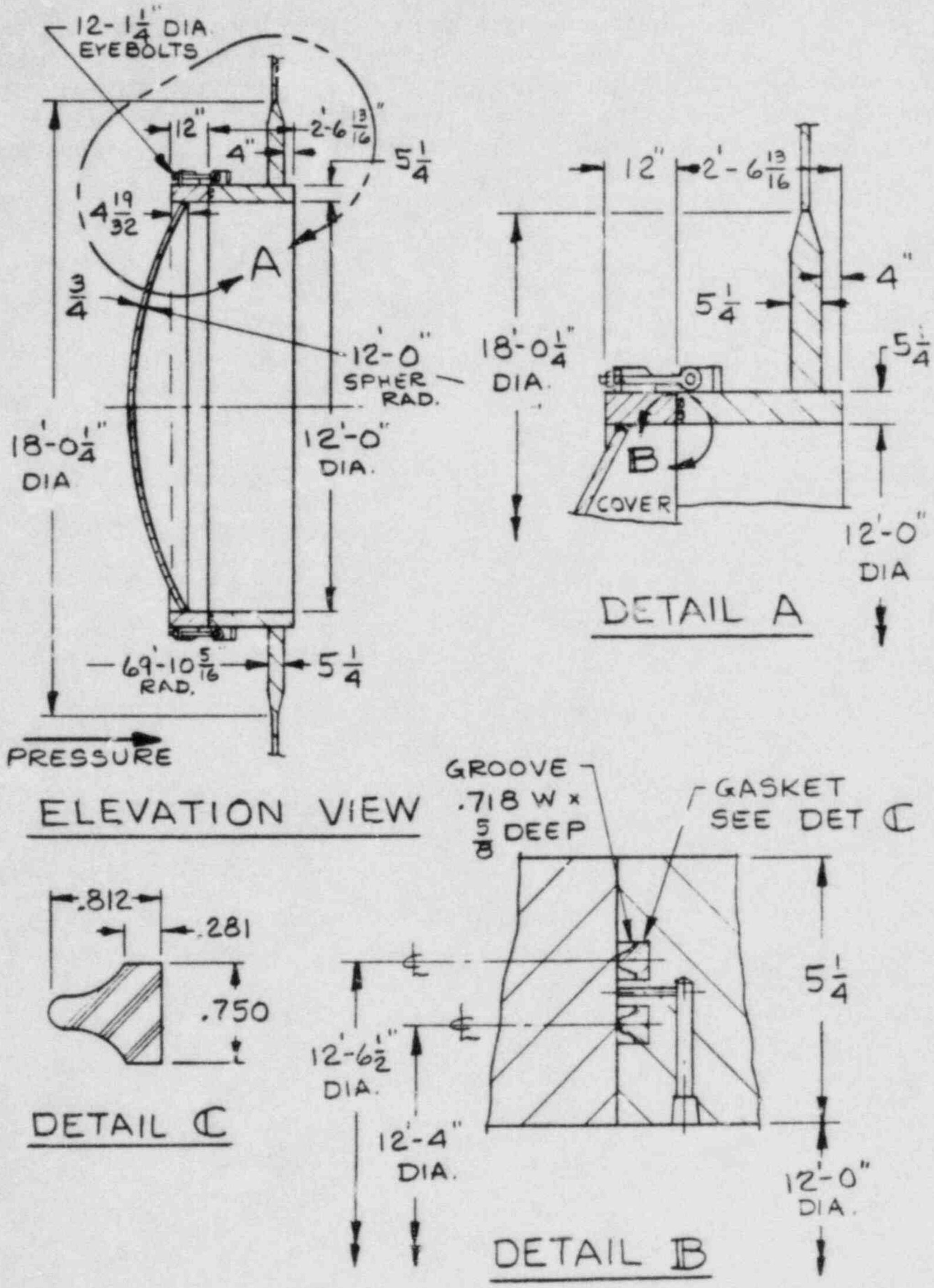
Gasket

Gasket type	Gumdrop
Material	Silicone Rubber
Length, Inner	38 ft. 8 9/16 in.
Length, Outer	39 ft. 2 27/32 in.

Location of Hatch

Hatch centerline elev.	35 ft. 0 in.
Hatch centerline azimuth	30°

UNIT 1 FIG. 1 EQUIPMENT HATCH
STEEL CONTAINMENT



SURVEY DATA - STEEL CONTAINMENT

UNIT 1 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the steel containment vessel. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by a double dog ear gasket mounted in a groove in the door. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Pressure Lock	Unit 1 Figure 2
Clear opening	2 ft. 6 in. wide 6 ft. 6 in. height
Door height	6 ft. 11 1/4 in.
Door width	2 ft. 11 1/4 in.
Door thickness	7/8 in.
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	3 5/8 in.
Material	SA-516 Grade 70

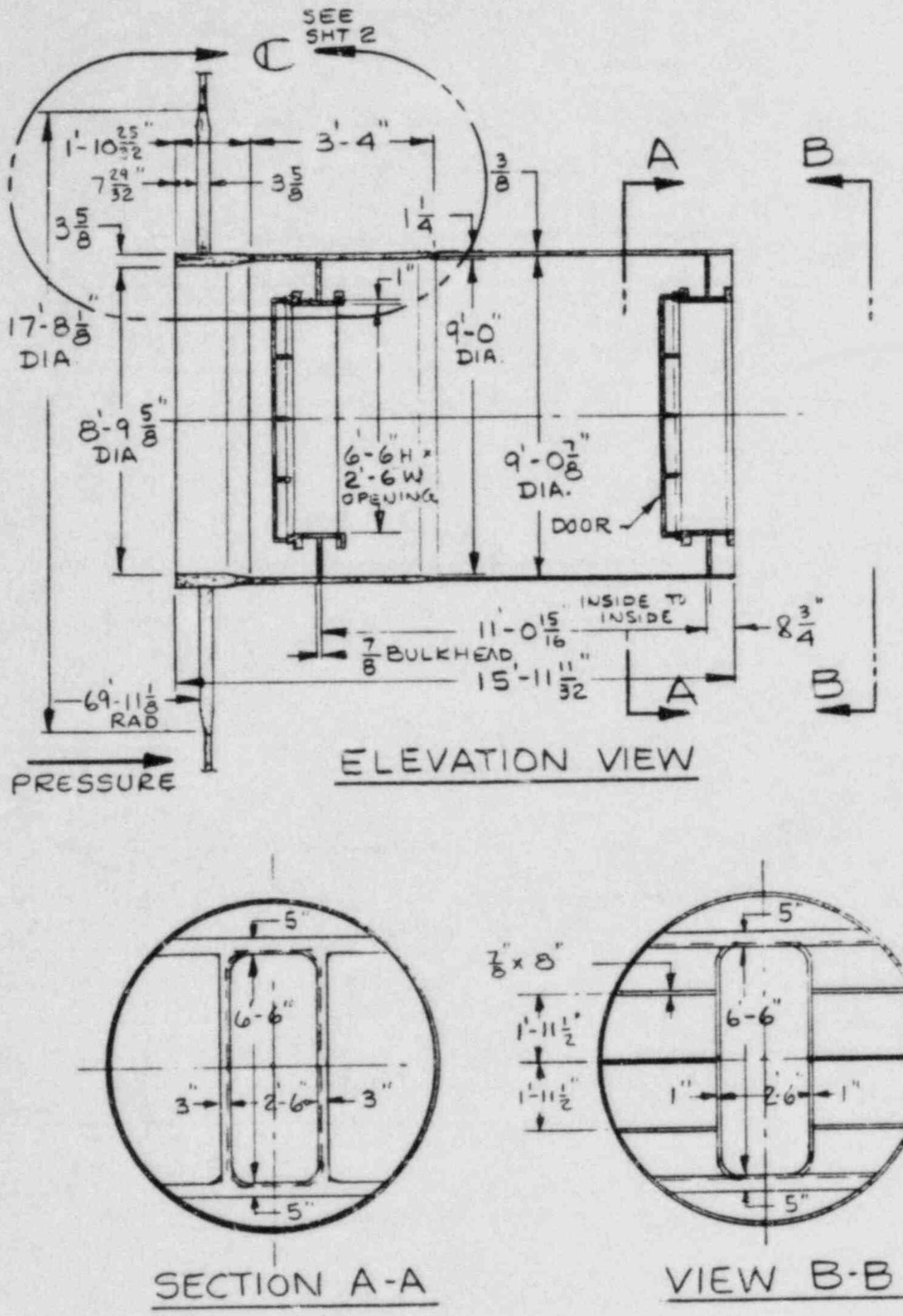
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber MS579
Length	13 ft. 1 11/32 in.

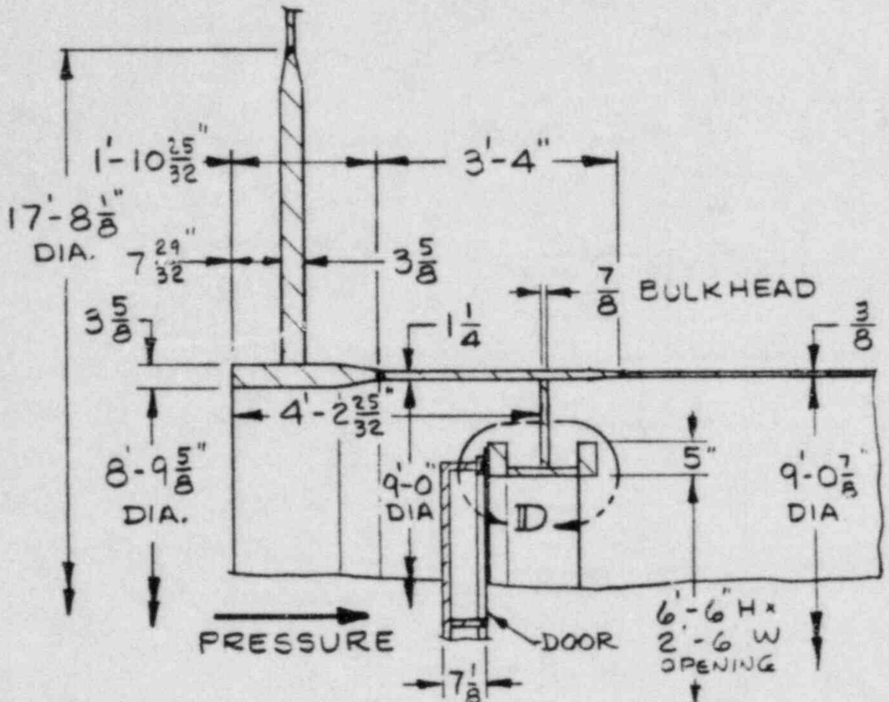
Location of Hatch

Personnel lock centerline elev.	34 ft. 5 in.
Personnel lock centerline azimuth	240°

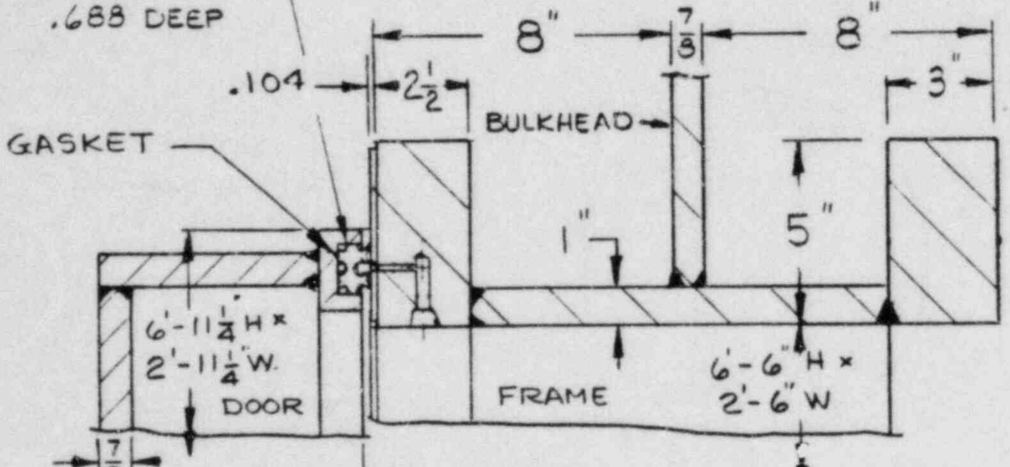
UNIT 1 FIG. 2 SHT. 1 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT



UNIT 1 FIG. 2 SHT. 2 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT



DETAIL C SEE SHT #1



DETAIL D

SURVEY DATA - STEEL CONTAINMENT

UNIT 1 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the steel containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the escape lock bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Unit 1 Figure 3
Clear opening	30 in. diameter
Door	36 in. diameter
Door thickness	1-1/2 in.
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	3-5/8 in.
Material	SA-516 Grade 70

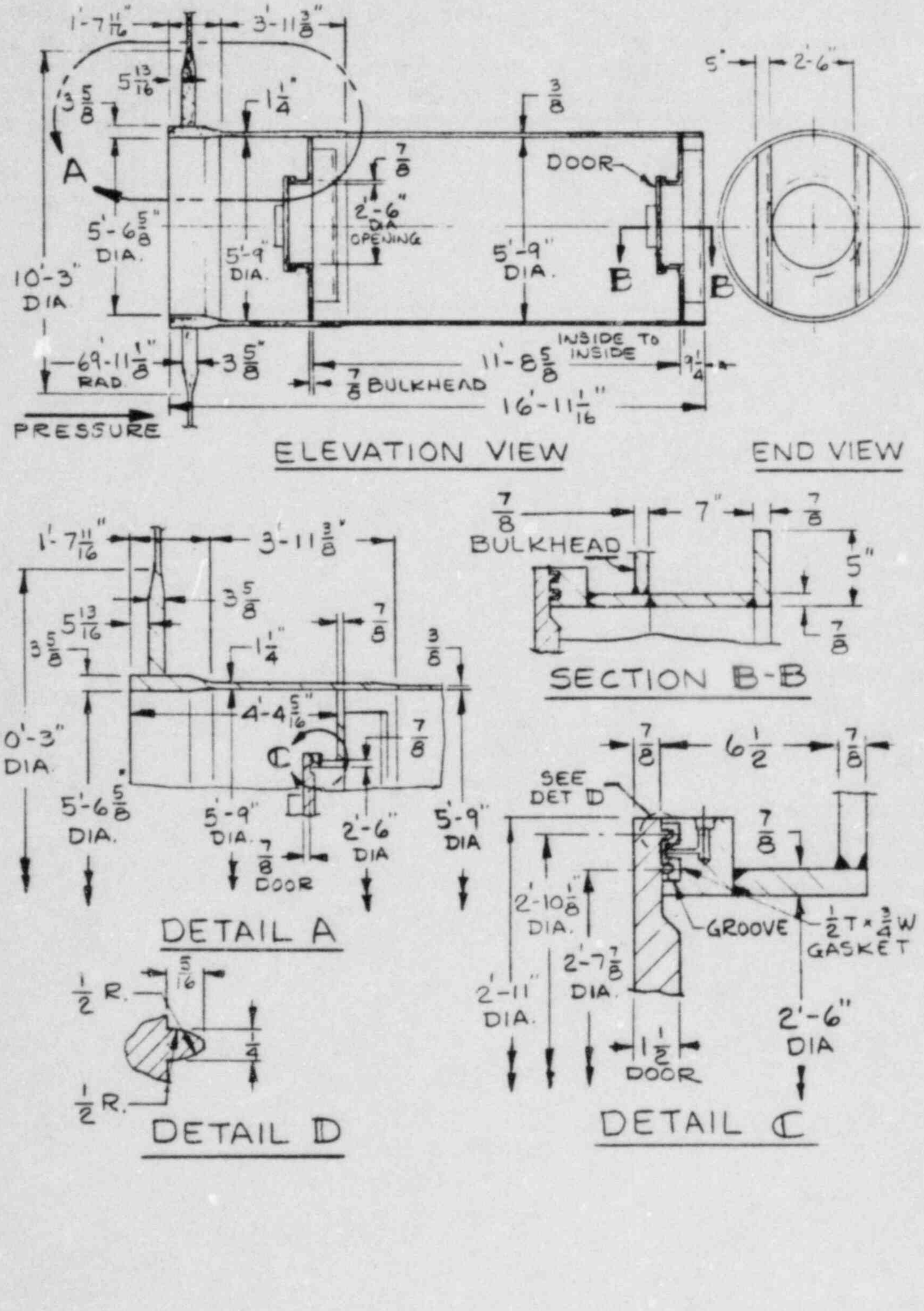
Gasket

Gasket type	Double tongue & groove
Cross-section	Rectangular 1/2 Thk. x 1/4 Wide.
Material	Silicone Rubber

Location of Hatch

Escape lock centerline elev.	65 ft. 3 in.
Escape Lock centerline azimuth	60°

UNIT 1 FIG. 3 ESCAPE HATCH
STEEL CONTAINMENT



UNIT 2 STEEL CONTAINMENT

FSAR DESCRIPTION OF UNIT 2 STEEL CONTAINMENT

The containment vessel is a right circular cylinder (2 in. thick), with hemispherical dome (1 in. thick) and ellipsoidal bottom (2 in. thick) which houses the reactor vessel, the reactor coolant system piping and pumps, the steam generators, the pressurizer and the pressurizer quench tank, and other branch connections of the reactor coolant system including the safety injection tanks. The containment vessel penetrations include a construction hatch, a maintenance hatch, a personnel air lock, and escape lock, and various sized penetration nozzles.

The containment vessel is enclosed by the reinforced concrete Shield Building. An annular space is provided between the walls and domes of the containment vessel and the Shield Building in order to permit construction operations and in-service inspection.

The containment vessel is an independent free standing structure with a net free volume of approximately 2.5×10^6 cubic feet. The containment vessel is rigidly supported at its base near the elevation of its bottom spring line. The concrete base is placed after the cylindrical shell and the ellipsoidal bottom have been constructed and post weld heat treated. Both the Shield Building and the containment vessel are supported on a common foundation mat. With the exception of the concrete placed underneath and near the knuckles at the sides of the vessel, there are no structural ties between the containment vessel and the Shield Building above the foundation slab. There is virtually unlimited freedom for differential movement between the containment vessel and the Shield Building above the top of the concrete base. Concrete floor fill is placed above the ellipsoidal shell bottom, after the vessel has been post weld heat treated, to anchor the vessel.

The cylindrical portion of the steel containment shell has a minimum thickness of 1.92 in. on an inside radius of 70 ft. The 1.92 in. minimum shell plate thickness increases to a minimum of four inches adjacent to penetrations and openings. The inside radius of the hemispherical dome is 70 ft. with a dome plate 0.96 in. thick connected to the cylindrical portion of the shell at the tangent line by means of a full penetration weld.

SURVEY DATA - STEEL CONTAINMENT

UNIT 2 - EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the steel containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two gumdrop type gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 12 swing bolts mounted on the outer surface of the hatch opening and containment penetration ring. The pressure inside the containment vessel provides the seating force for the seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Unit 1 Figure 1
Clear opening	12 ft.
Cover thickness	3/4 inch
Cover shape, radius	12 ft. radius
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	4 1/2 inch
Material	SA-516 Grade 70

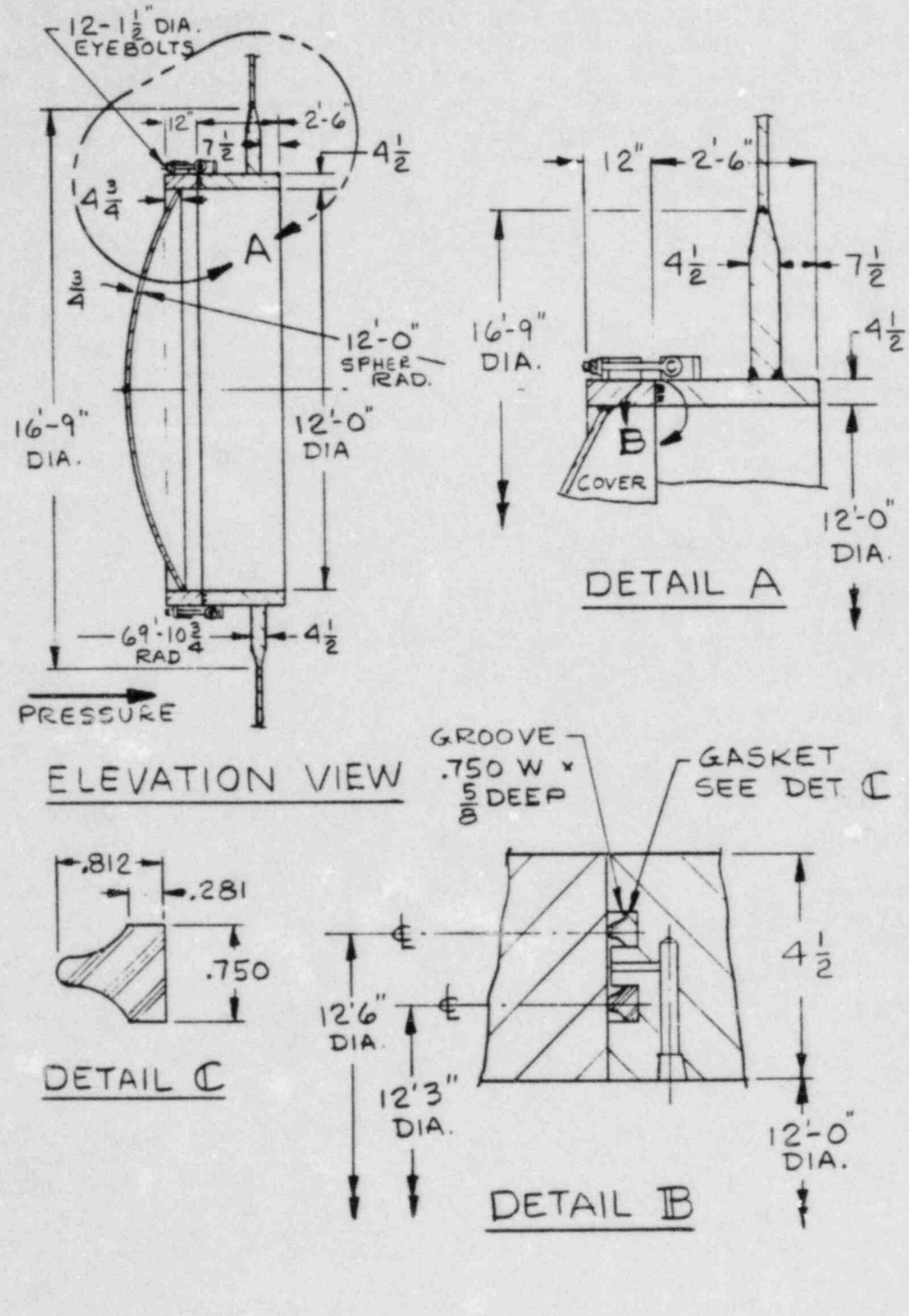
Gasket

Gasket type	Gumdrop
Material	Silicone Rubber
Length, Inner	38 ft. 4 21/32 in.
Length, Outer	39 ft. 2 1/16 in.

Location of Hatch

Hatch centerline elev.	35 ft. 0 in.
Hatch centerline azimuth	30°

UNIT 2 FIG. 1 EQUIPMENT HATCH
STEEL CONTAINMENT



SURVEY DATA - STEEL CONTAINMENT

UNIT 2 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the steel containment vessel. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by a double dog ear gasket mounted in a groove in the door. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Personnel Lock	Unit 2 Figure 2
Clear opening	2 ft. 6 in. wide 6 ft. 8 in. height
Door height	7 ft. 0 1/2 in.
Door width	2 ft. 10 1/2 in.
Door thickness	1 1/2 in.
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	3 5/8 in.
Material	SA-516 Grade 70

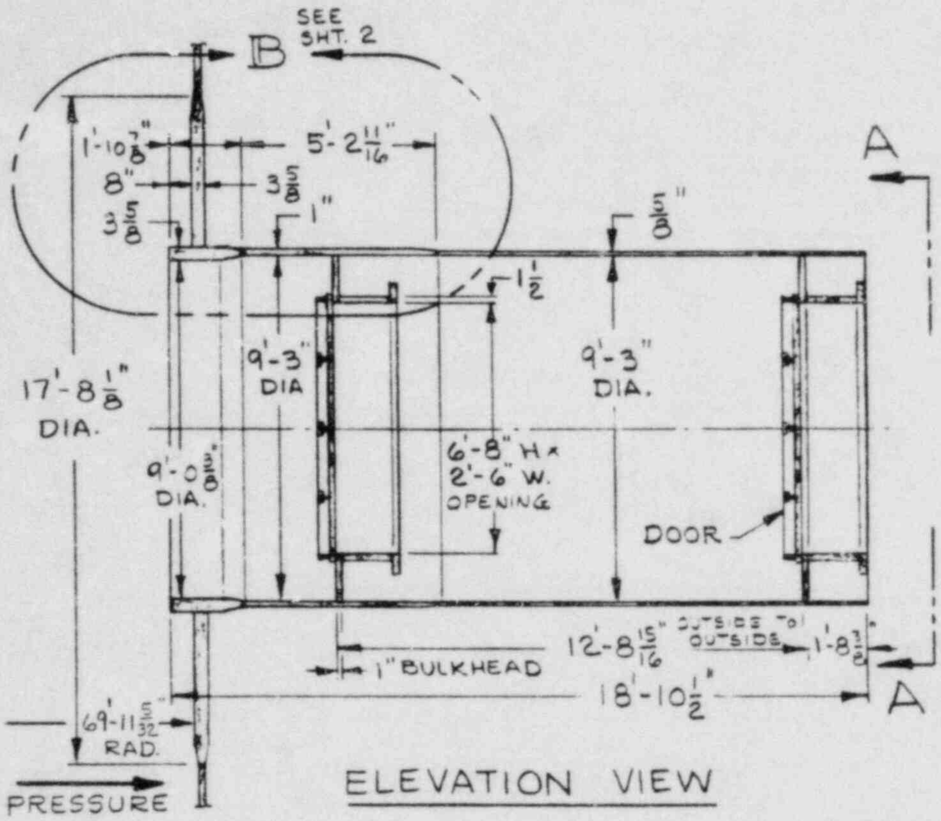
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber MS577
Length	17 ft. 9 15/16 in.

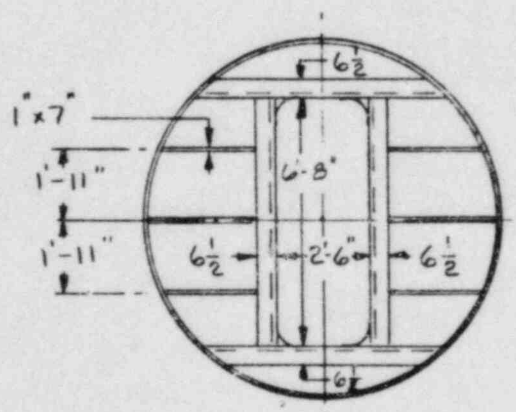
Location of Hatch

Personnel lock centerline elev.	34 ft. 5 in.
Personnel lock centerline azimuth	240°

UNIT 2 FIG. 2 SHT. 1 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT

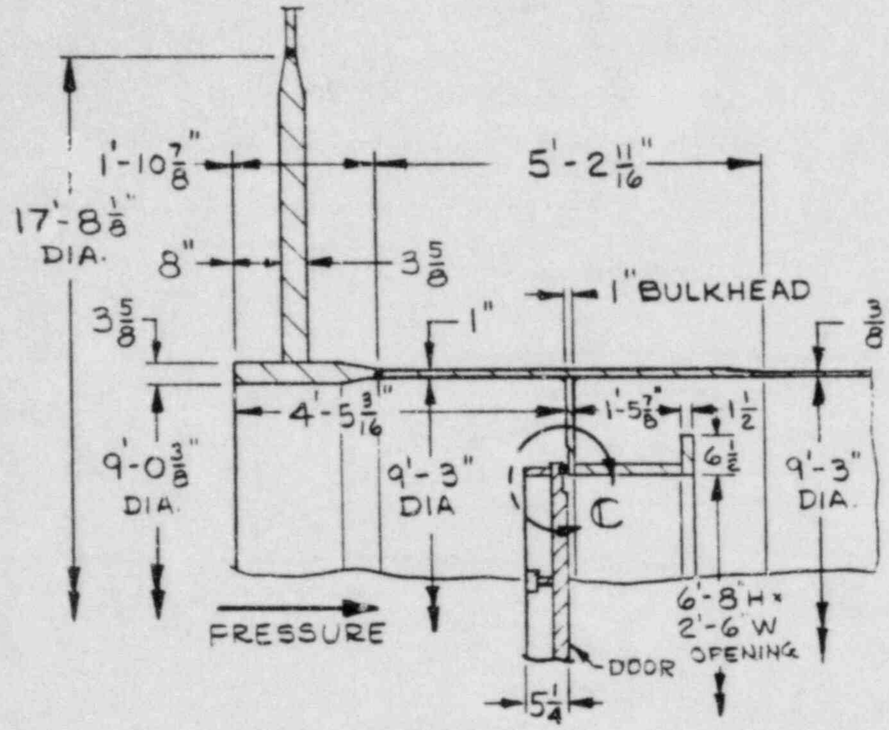


ELEVATION VIEW

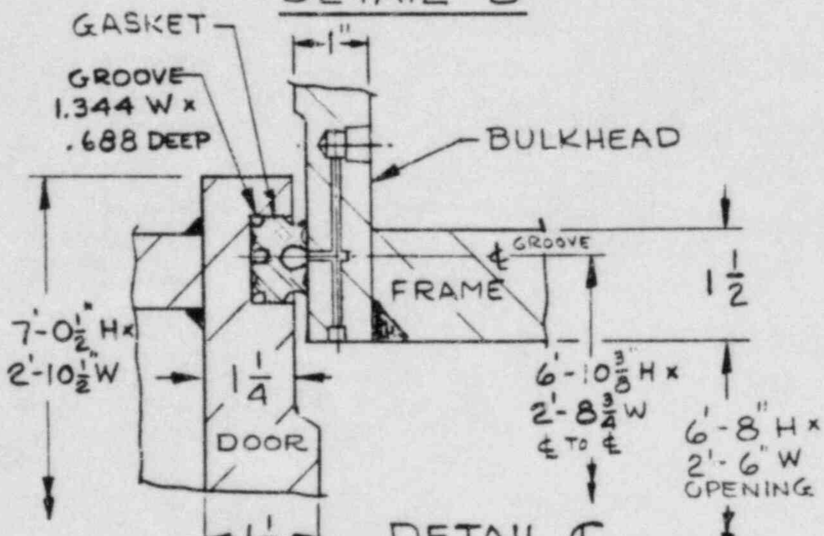


VIEW A-A

UNIT 2 FIG. 2 SHT 2 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT



DETAIL B



DETAIL C

SURVEY DATA - STEEL CONTAINMENT

UNIT 2 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the steel containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by double dog ear gasket mounted in a groove in the escape lock bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Unit 2 Figure 3
Clear opening	30 in. diameter
Door	35 in. diameter
Door thickness	1-1/2 in.
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	3-5/8 in.
Material	SA-516 Grade 70

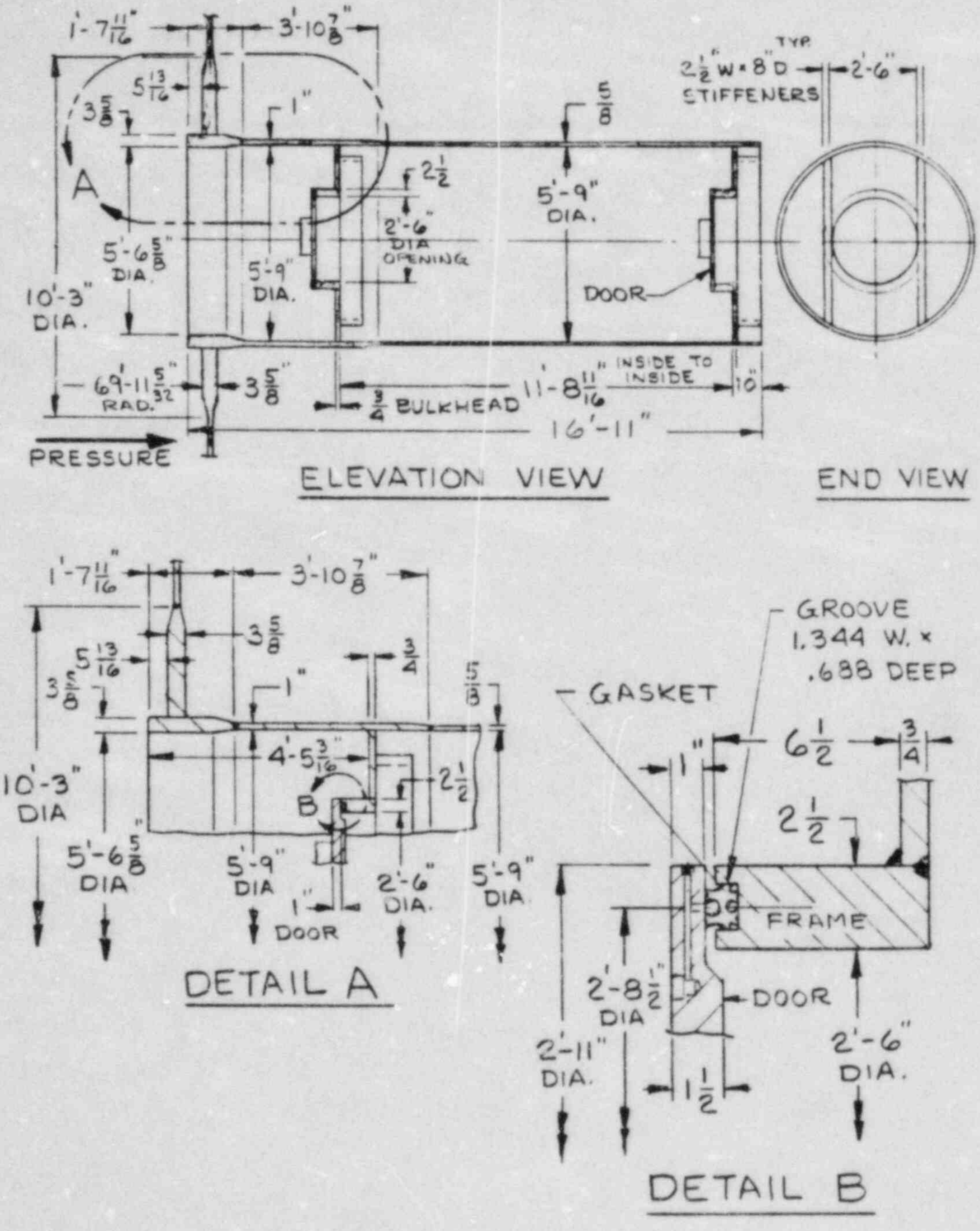
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber

Location of Hatch

Escape lock centerline elev.	65 ft. 3 in.
Escape Lock centerline azimuth	60°

UNIT 2 FIG. 3 ESCAPE HATCH
STEEL CONTAINMENT



UNIT 3 STEEL CONTAINMENT

SAR DESCRIPTION OF UNIT 3 STEEL CONTAINMENT

To be included in August 1984 Report.

SURVEY DATA - STEEL CONTAINMENT

UNIT 3 - EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the steel containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two gumdrop type gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 16 swing bolts mounted on the outer surface of the hatch opening and containment penetration ring. The pressure inside the containment vessel provides the seating force for the seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Unit 3 Figure 1
Clear opening	14 ft.
Cover thickness	7/8 inch
Cover shape, radius	14 ft. SPH. radius
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	4 1/2 inch
Material	SA-516 Grade 70

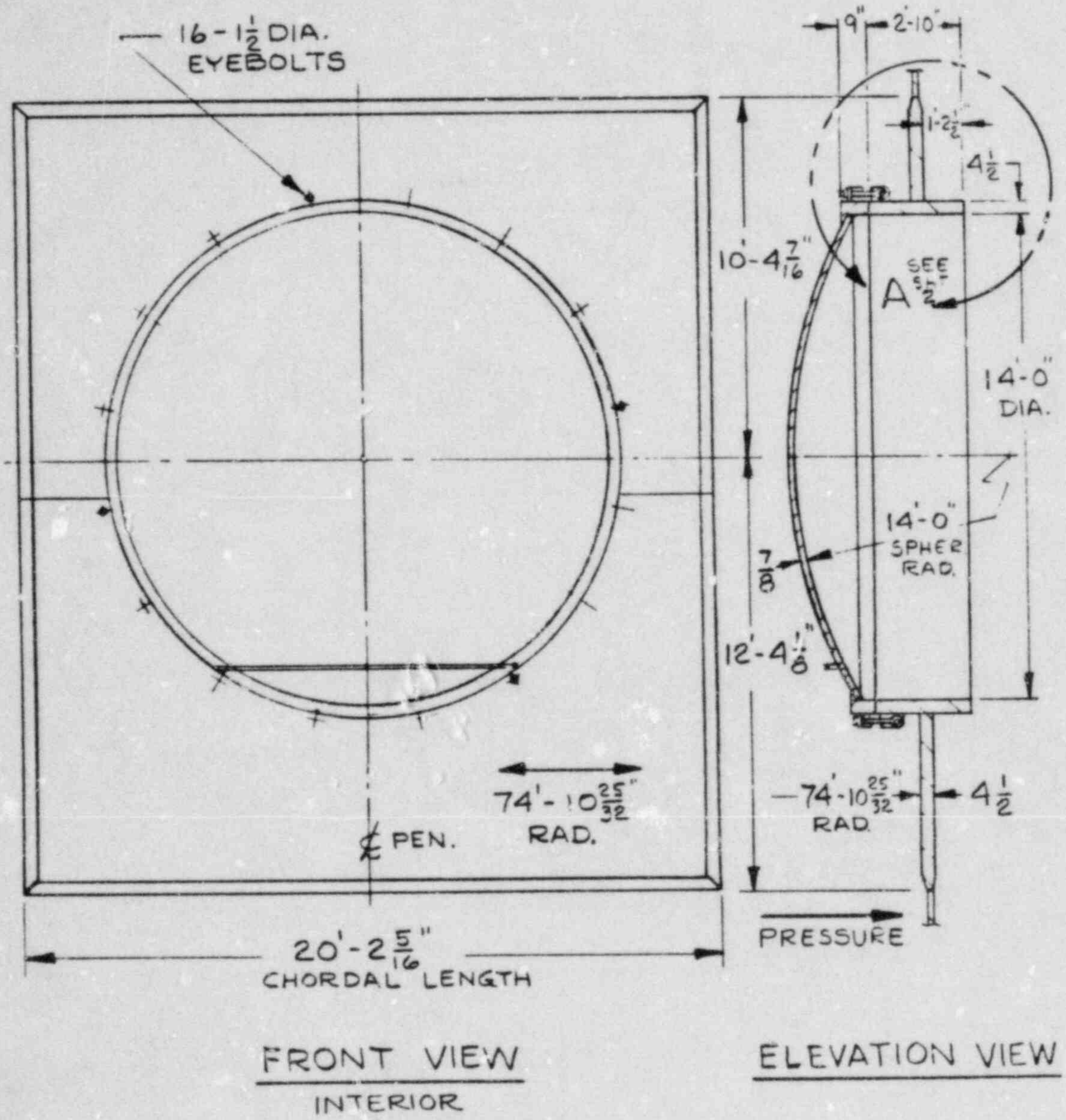
Gasket

Gasket type	Gumdrop
Material	Silicone Rubber MS577
Length, Inner	44 ft. 6 3/8 in.
Length, Outer	45 ft. 6 3/4 in.

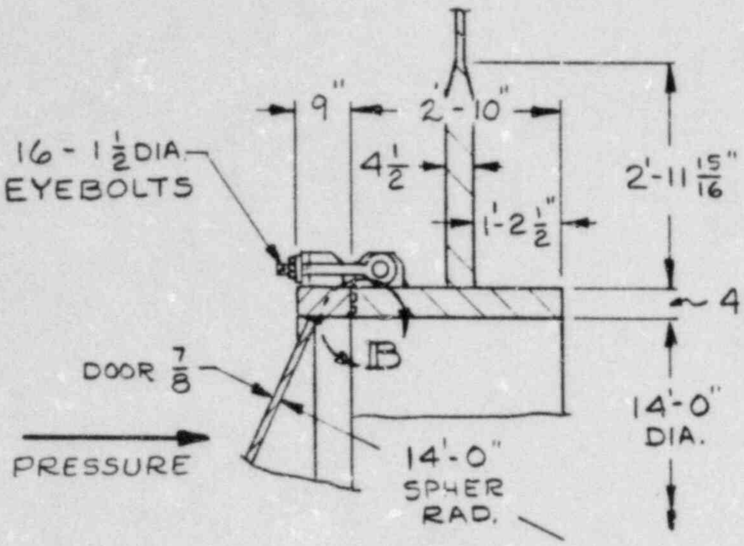
Location of Hatch

Hatch centerline elev.	395 ft. 10 in.
Hatch centerline azimuth	287° 30'

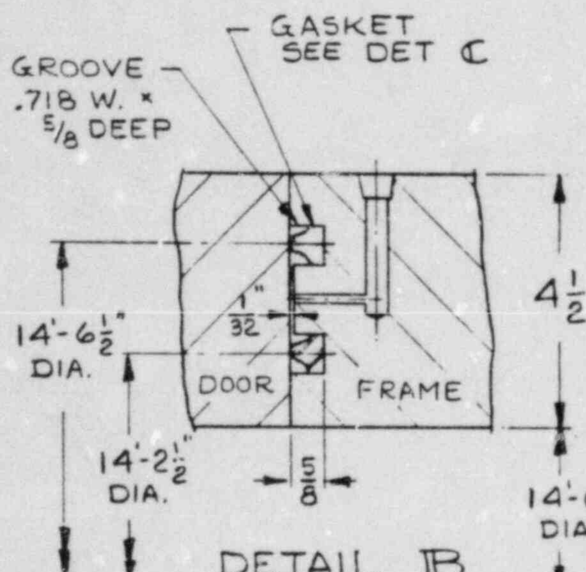
UNIT 3 FIG. 1 SHT. 1 OF 2 EQUIPMENT HATCH
STEEL CONTAINMENT



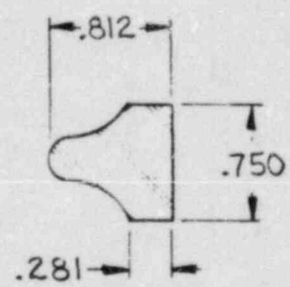
UNIT 3 FIG. 1 SHT. 2 OF 2 EQUIPMENT HATCH
STEEL CONTAINMENT



DETAIL A SEE SHT. 1



DETAIL B



DETAIL C

SURVEY DATA - STEEL CONTAINMENT

UNIT 3 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the steel containment vessel. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by a double dog ear gasket mounted in a groove in the door. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Personnel Lock	Unit 3 Figure 2
Clear opening	2 ft. 6 in. wide 6 ft. 8 in. height
Door height	7 ft. 0 1/2 in.
Door width	2 ft. 10 1/2 in.
Door thickness	1 1/2 in.
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	4 in.
Material	SA-516 Grade 70

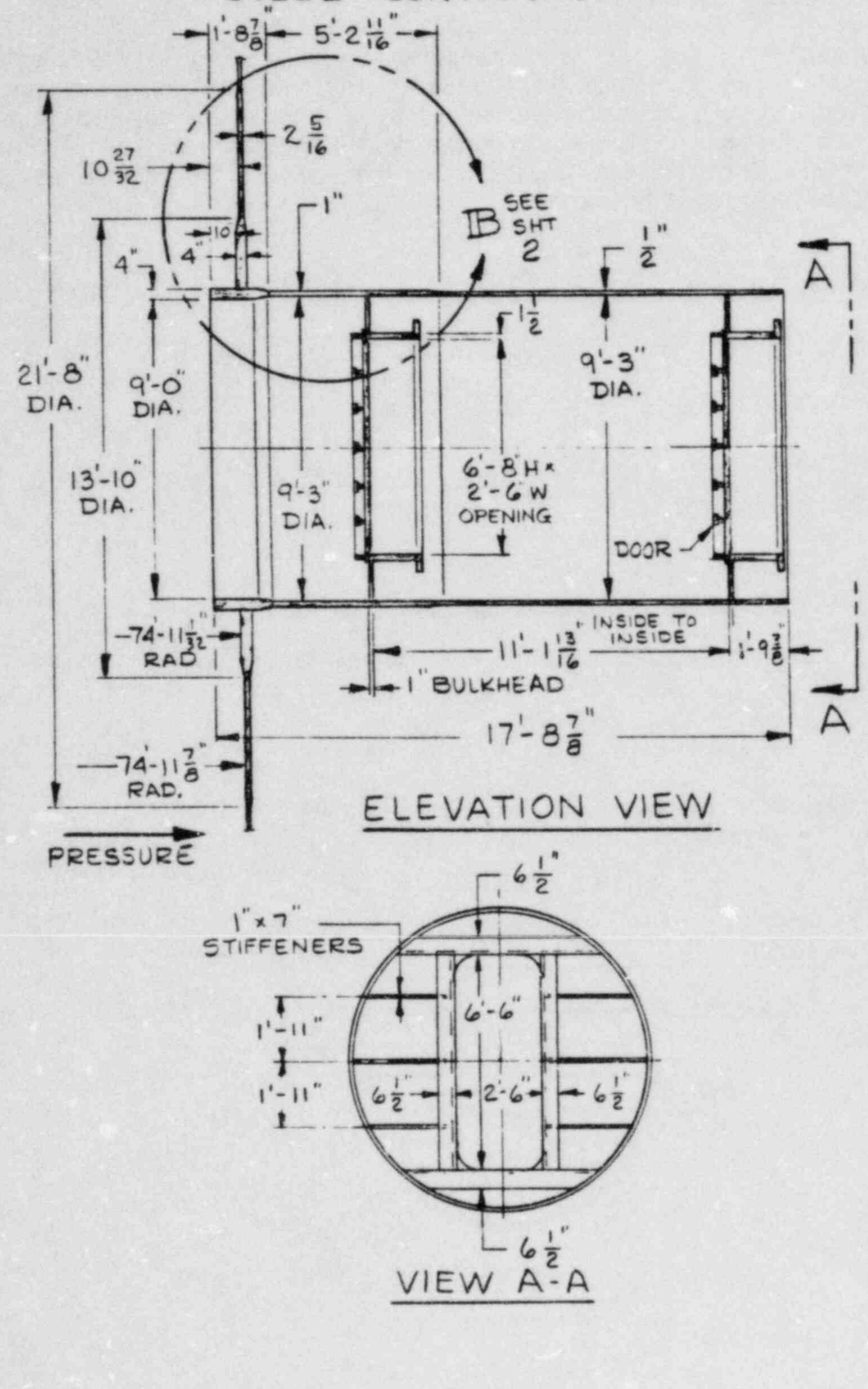
Gasket

Gasket type	Double Dog Ear
Rectangular gasket	1 11/21 in. wide x 13/16 in. thk.
Material	Neoprene (or Butyl)

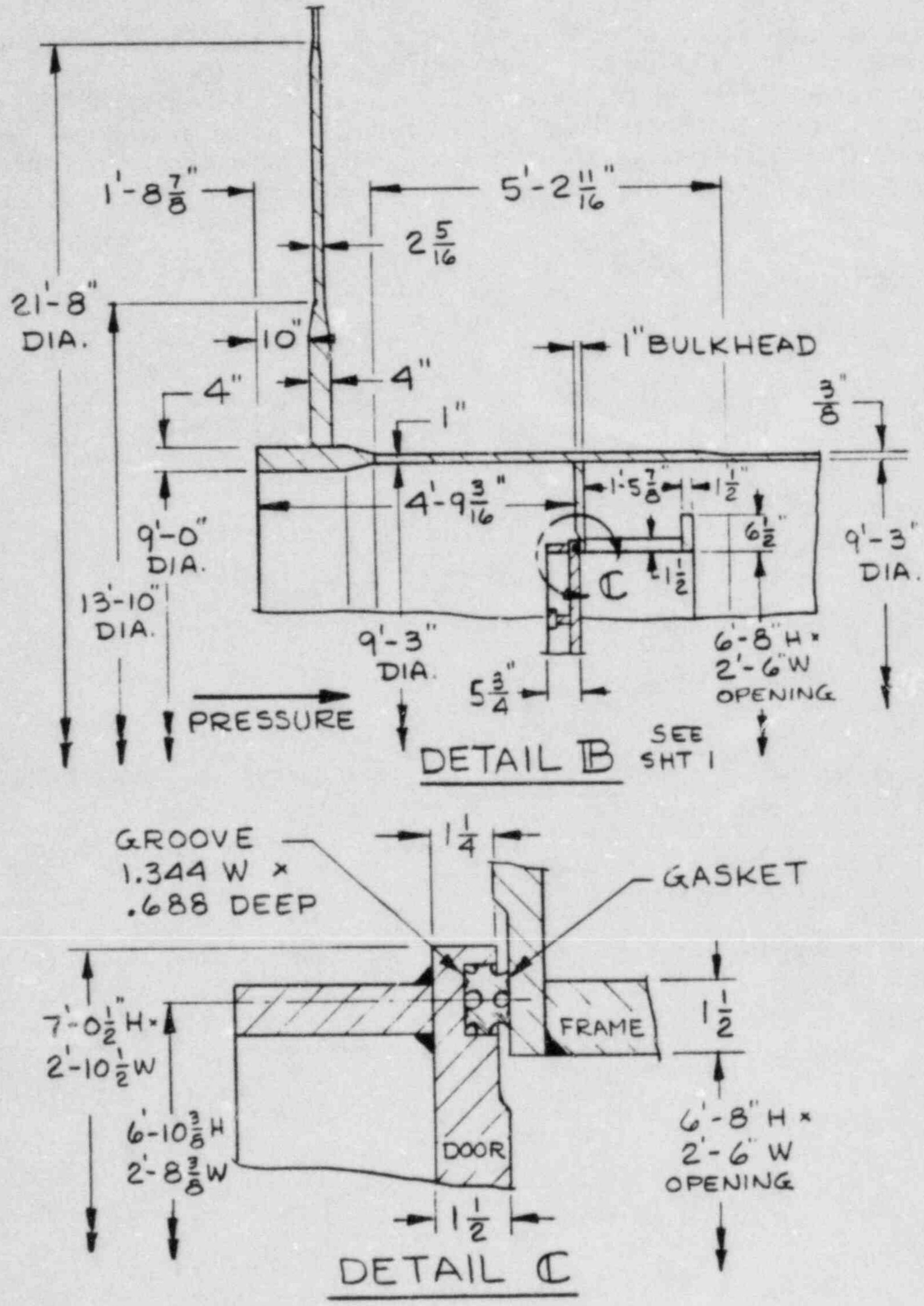
Location of Hatch

Personnel lock centerline elev.	398 ft. 6 19/32 in.
Personnel lock centerline azimuth	215°

UNIT 3 FIG. 2 SHT 1 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT



UNIT 3 FIG. 2 SHT. 2 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT



SURVEY DATA - STEEL CONTAINMENT

UNIT 3 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the steel containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by a double dog ear gasket mounted in a groove in the escape lock bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

Escape Lock	Unit 3, Figure 3
Clear opening	30 in. diameter
Door	35 in. diameter
Door thickness	1-1/2 in.
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	4 in.
Material	SA-516 Grade 70

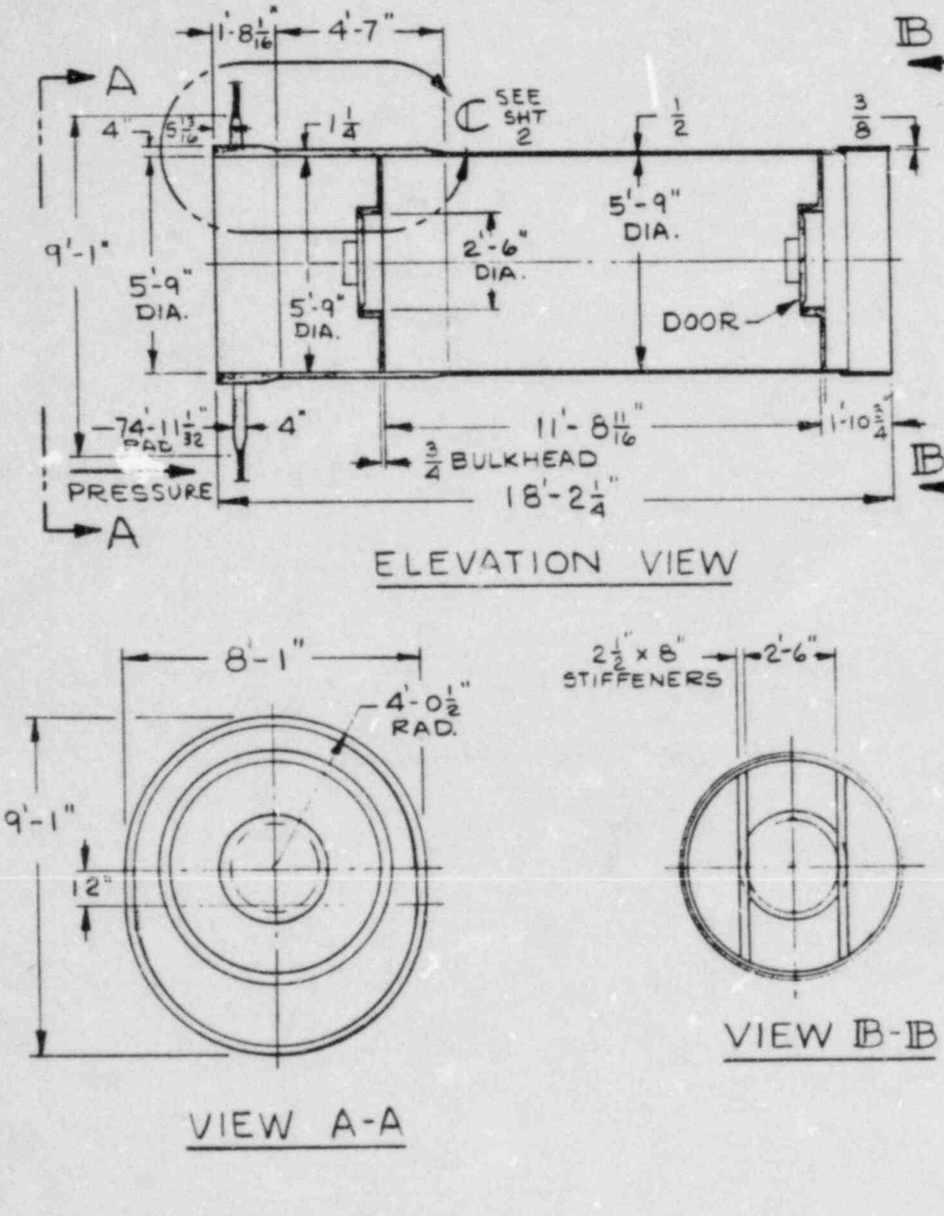
Gasket

Gasket type	Double Dog Ear
Rectangular gasket	1 11/32 in. wide x 3/4 in. thk.
Material	Neoprene (or Butyl)

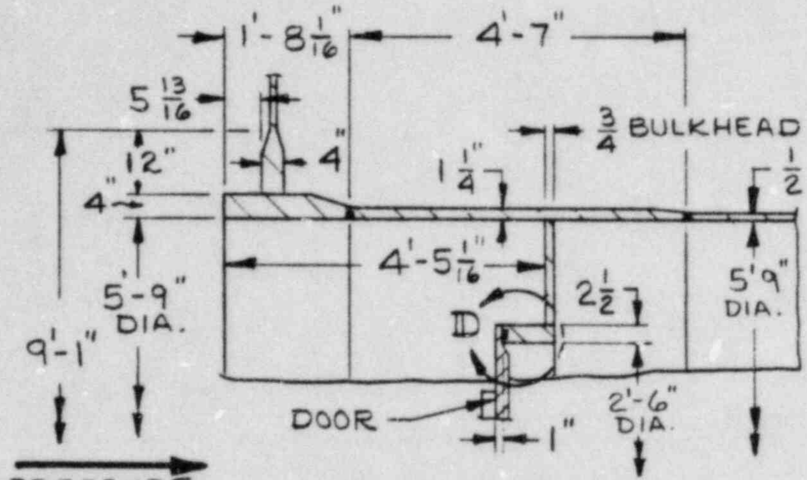
Location of Escape Lock Centerline

Escape lock centerline elev.	399 ft. 0 in.
Escape lock centerline azimuth	322° 30'

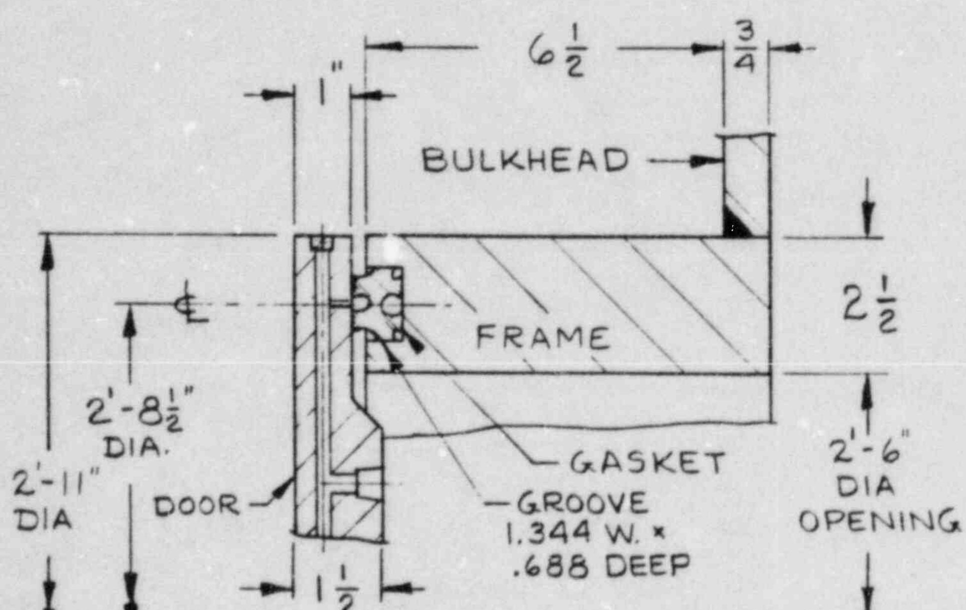
UNIT 3 FIG. 3 SHT. 1 OF 2 ESCAPE HATCH
STEEL CONTAINMENT



UNIT 3 FIG. 3 SHT. 2 OF 2 ESCAPE HATCH
STEEL CONTAINMENT



DETAIL C SEE SHT 1



DETAIL D

UNIT 4 STEEL CONTAINMENT

FSAR DESCRIPTION OF UNIT 4 STEEL CONTAINMENT

The containment vessel is a cylindrical steel pressure vessel with hemispherical dome and ellipsoidal bottom which houses the reactor pressure vessel, the reactor coolant piping, the pressurizer, the quench tank, the reactor coolant pumps, the steam generators, and the safety injection tanks. It is completely enclosed by the reinforced concrete Shield Building. An annular space is provided between the walls and domes of the containment vessel and the concrete Shield Building to permit construction operations and in-service inspection. The containment vessel is an independent free standing structure with a net free volume of approximately 2,680,000 cubic feet, rigidly fixed at its base near the elevation of its bottom spring line. The containment vessel is supported on a concrete base that is placed after the cylindrical shell and the ellipsoidal bottom have been constructed and post weld heat treated. Both the Shield Building and the containment vessel is supported on a common foundation mat. With the exception of the concrete placed underneath and near the knuckles at the sides of the vessel, there is no structural ties between the containment vessel and the Shield Building above the foundation slab. There is virtually unlimited freedom for differential movement between the containment vessel and the Shield Building above the top of the concrete base. Concrete floor fill is placed above the ellipsoidal shell bottom after the vessel has been post weld heat treated, to anchor the vessel.

The cylindrical portion of the steel containment shell has a minimum thickness of 1.903 in. on an inside radius of 70 ft. The 1.903 in. minimum shell plate thickness increases to a minimum of four inches adjacent to all penetrations and openings. The inside radius of the hemispherical dome is 70 ft. 15/32 in. with a dome plate of 0.95 in. thick connected to the cylindrical portion of the shell at the tangent line by means of a full penetration weld.

SURVEY DATA - STEEL CONTAINMENT

UNIT 4 - EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the steel containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edges with two gumdrop type gaskets in separate grooves to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 16 swing bolts mounted on the outer surface of the hatch opening and containment penetration ring. The pressure inside the containment vessel provides the seating force for the equipment hatch seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Unit 4, Figure 1
Clear opening	14 ft.
Cover thickness	7/8 inch
Cover shape, radius	14 ft. SPH. radius
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	4 1/2 inch
Material	SA-516 Grade 70

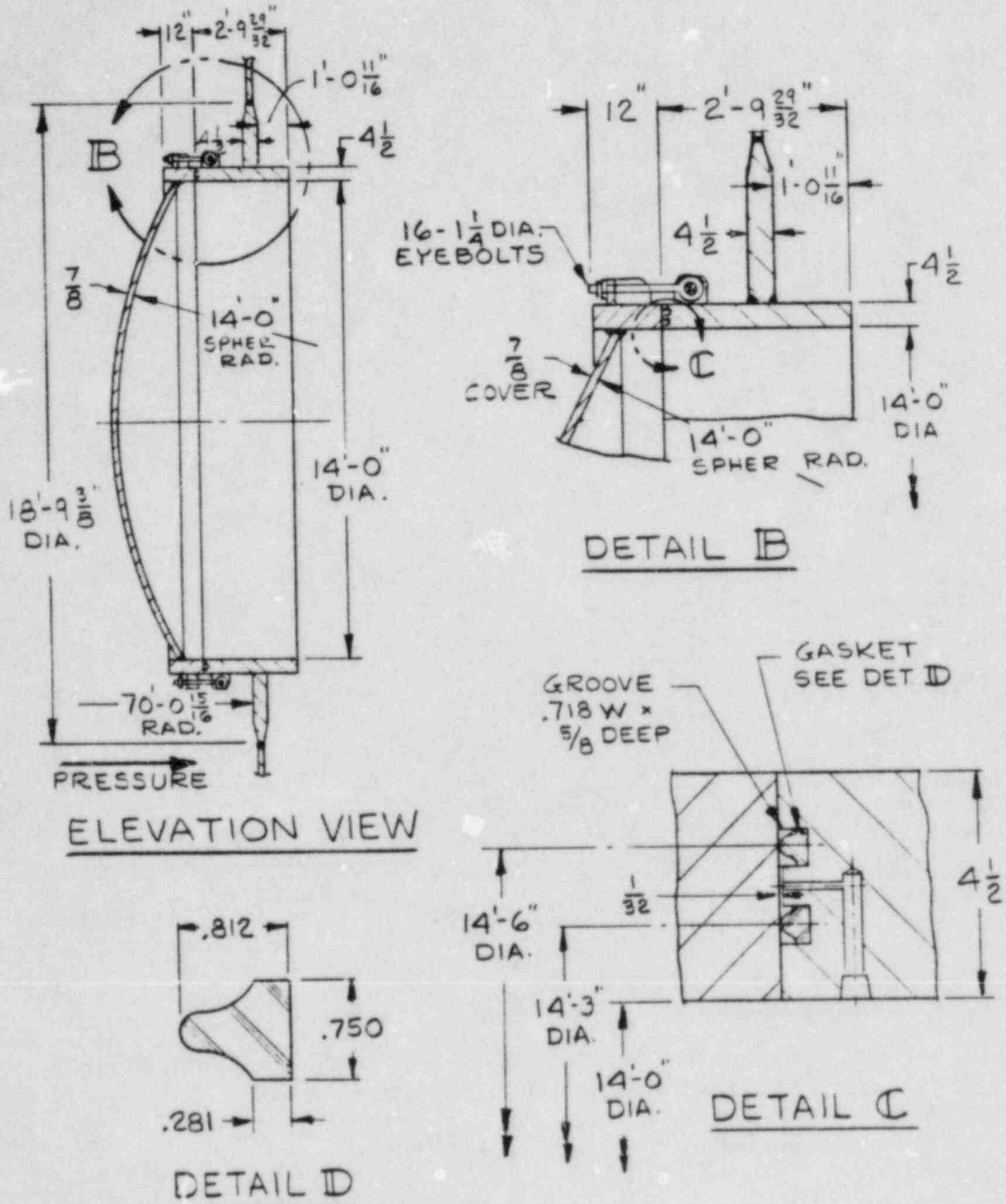
Gasket

Gasket type	Gumdrop
Material	Silicone Rubber MS572
Length, Inner	44 ft. 7 7/8 in.
Length, Outer	45 ft. 5 1/4 in.

Location of Hatch

Hatch centerline elev.	26 ft. 6 in.
Hatch centerline azimuth	277° 30'

UNIT 4 FIG. 1 EQUIPMENT HATCH
STEEL CONTAINMENT



SURVEY DATA - STEEL CONTAINMENT

UNIT 4 - PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the steel containment vessel. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by a double dog ear gasket mounted in a groove in the door. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Personnel Lock	Unit 4, Figure 2
Clear opening	2 ft. 6 in. wide 6 ft. 6 in. height
Door height	6 ft. 11 in.
Door width	2 ft. 11 in.
Door thickness	2 in.
Material	SA-516 Grade 70 FBX

Containment Penetration Ring

Thickness	4 in.
Material	SA-516 Grade 70 FBX

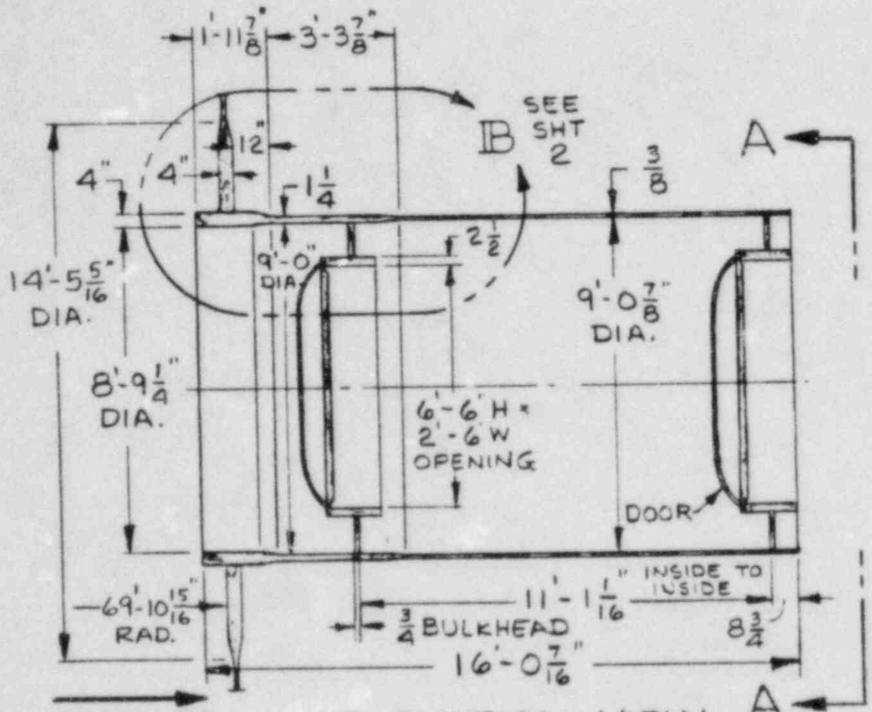
Gasket

Gasket type	Double Dog Ear
Material	Silicone Rubber MS572
Length	17 ft 6 29/32 in.

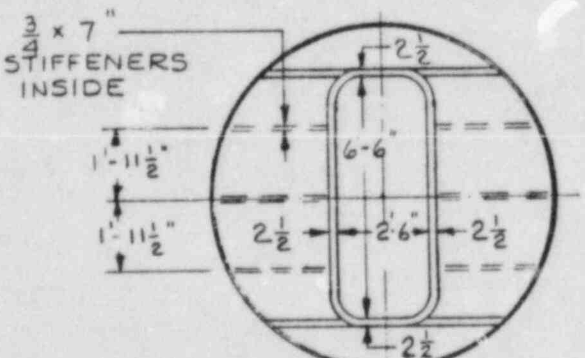
Location of Personnel Lock

Personnel lock centerline elev.	11 ft. 0 in.
Personnel lock centerline azimuth	172°

UNIT 4 FIG. 2 SHT. 1 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT

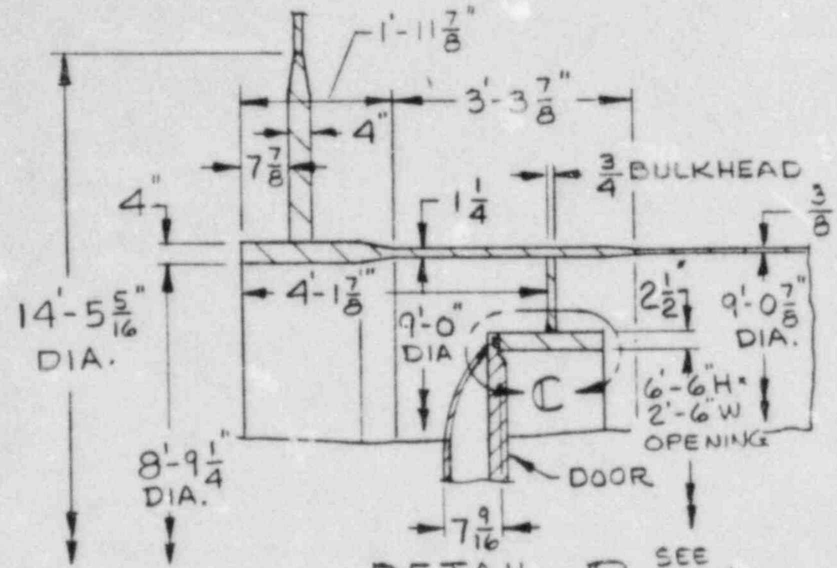


ELEVATION VIEW

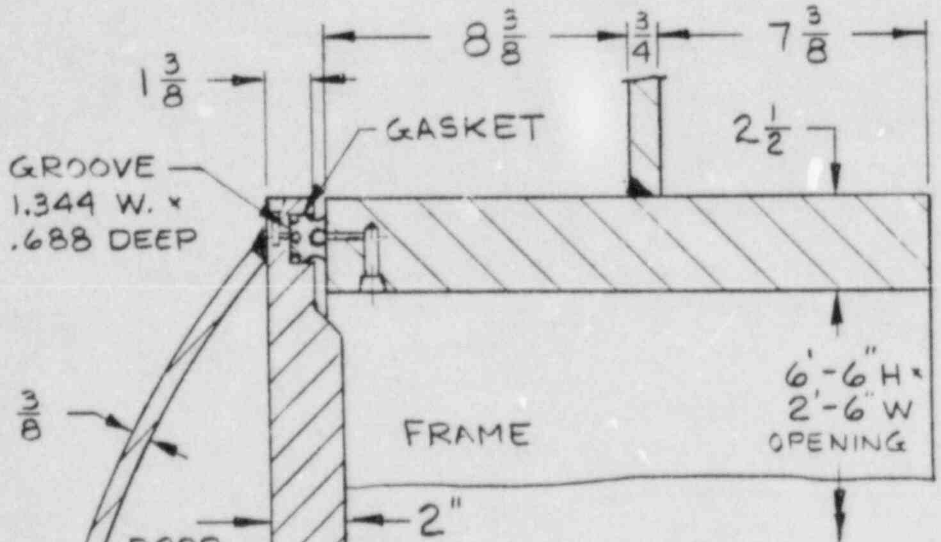


VIEW A-A

UNIT 4 FIG. 2 SHT. 2 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT



DETAIL B SEE SHT 1



DETAIL C

SURVEY DATA - STEEL CONTAINMENT

UNIT 4 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the steel containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by a double dog ear gasket mounted in a groove in the escape lock bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

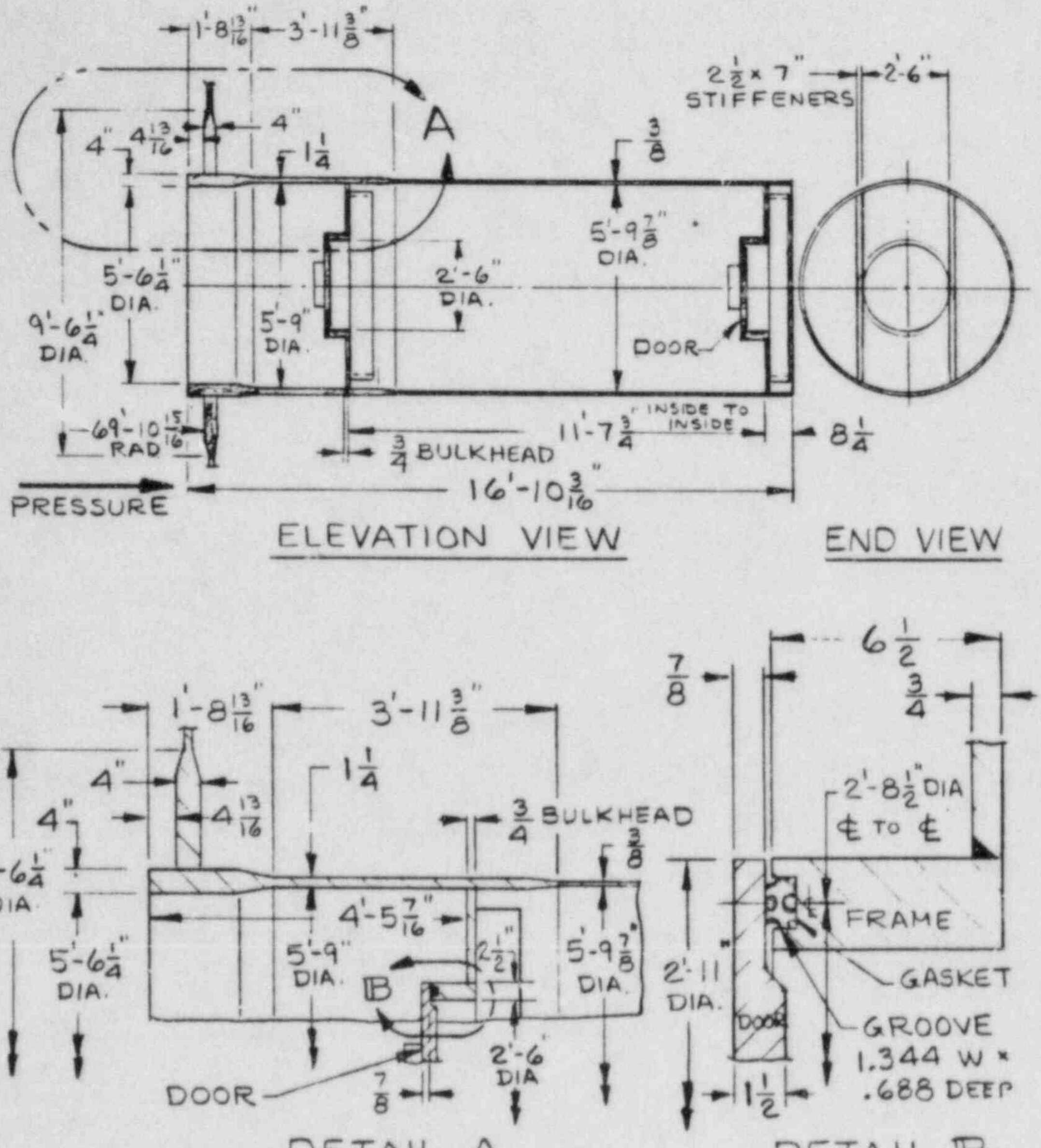
Escape Lock	Unit 4, Figure 3
Clear opening	30 in. diameter
Door	35 in. diameter
Door thickness	1-1/2 in.
Material	SA-516 Grade 70

Containment Penetration Ring	
Thickness	4 in.
Material	SA-516 Grade 70

Gasket	
Gasket type	Double dog ear
Material	Silicone Rubber MS572

Location of Escape Lock	
Escape lock centerline elev.	25 ft.
Escape lock centerline azimuth	322^{o} 30'

UNIT 4 FIG. 3 ESCAPE HATCH
STEEL CONTAINMENT



UNIT 5 STEEL CONTAINMENT

FSAR DESCRIPTION OF UNIT 5 STEEL CONTAINMENT

The containment vessel is a cylindrical steel pressure vessel with hemispherical dome and ellipsoidal bottom which houses the reactor pressure vessel, the steam generators, reactor coolant pumps, the reactor coolant loops, the accumulators of the safety injection system, the reactor coolant pressurizer, the pressurizer relief tank, and other branch connections of the reactor coolant system.

The containment vessel is completely enclosed by the Shield Building. The Shield Building has the shape of a right circular cylinder with a shallow dome roof. A 5 ft. annular space is provided between the containment vessel and the Shield Building. Clearance at the roof of the Shield Building is 7 feet.

The containment vessel is supported on a grout base that was placed after the vessel construction was completed and tested. Both the containment vessel and the Shield Building are supported on a common foundation.

Freedom of movement between the containment vessel and the Shield Building is virtually unlimited. With the exception of the support grout placed underneath and near the knuckle sides of the vessel, there are no structural ties between the containment vessel and the Shield Building above the foundation slab.

The containment vessel is designed for a maximum internal pressure of 46 psig and a temperature of 268°F. The containment vessel design internal pressure as defined by ASME Boiler and Pressure Vessel Code is 41.4 psig.

The vessel is 105 ft. inside diameter, 206 ft. high, and contains an internal net free volume of 1,320,000 $ft.^3$.

The vessel plate nominal thickness does not exceed 1-1/2 in. at the field welded joints so the vessel, as an integral structure, did not require field stress relieving. The hemispherical dome is 3/4 in. thick and the ellipsoidal bottom is 1-1/2 in. thick. Reinforcing plates at penetration openings exceed 1-1/2 in. in thickness; however, these were fabricated as penetration weldment assemblies and were stress-relieved before they were welded to adjacent vessel shell plates.

SURVEY DATA - STEEL CONTAINMENT

UNIT 5 EQUIPMENT HATCH

Equipment Hatch

The equipment hatch provides a round clear opening in the steel containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edge with double tongue and grooved gaskets to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 12 swing bolts mounted on the outer surface of the hatch opening and containment penetration ring. The pressure inside the containment vessel provides the seating force for the equipment hatch seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Unit 5, Figure 1
Clear opening	21 ft.
Cover thickness	1-1/8 in.
Cover shape, radius	16 ft-10 in. SPH. Radius
Material	SA-516 Grade 70

Containment Penetration Ring

Thickness	4 1/2 in.
Material	SA-516 Grade 70

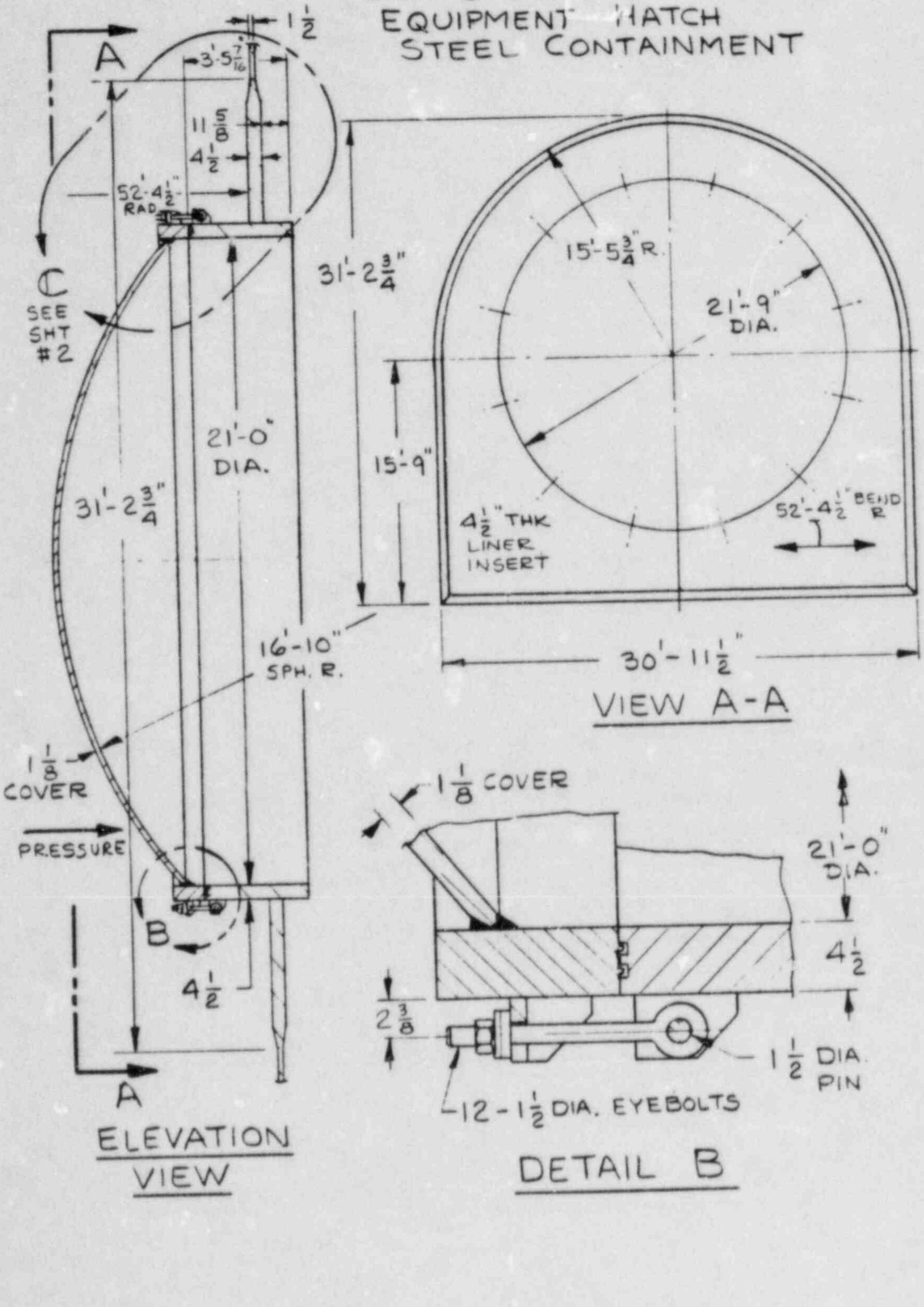
Gasket

Gasket type	Double Tongue & Groove
Cross-section	Rectangular 3/4 Wide x 1/2 Thk.
Material	Silicone Rubber Compound 8364

Location of Hatch

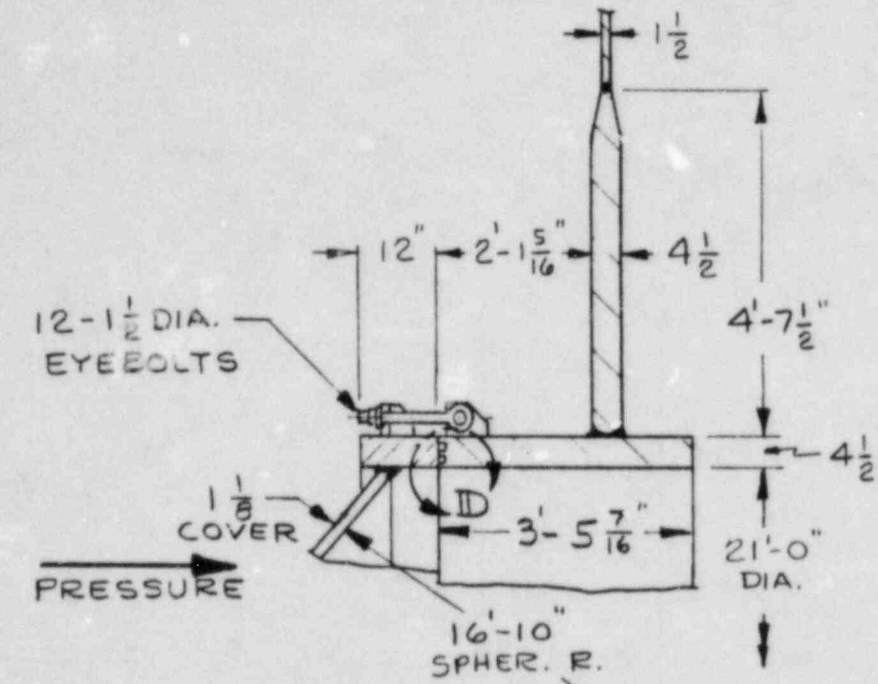
Hatch centerline elev.	619 ft. 6
Hatch centerline AZIMUTH	206°

UNIT 5 FIG. 1 SHT. 1 OF 2
EQUIPMENT HATCH
STEEL CONTAINMENT

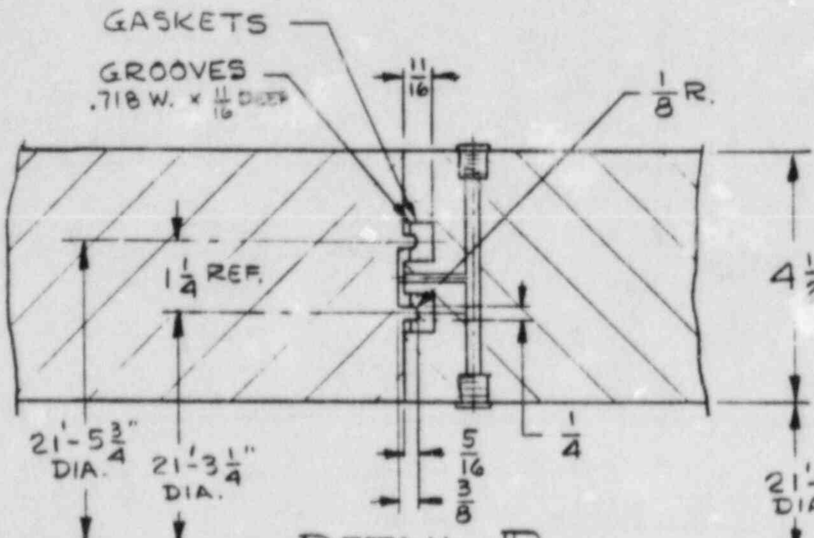


UNIT 5 FIG. 1 SHT. 2 of 2

EQUIPMENT HATCH STEEL CONTAINMENT



DETAIL C SEE SHT. #1



DETAIL D

SURVEY DATA - STEEL CONTAINMENT

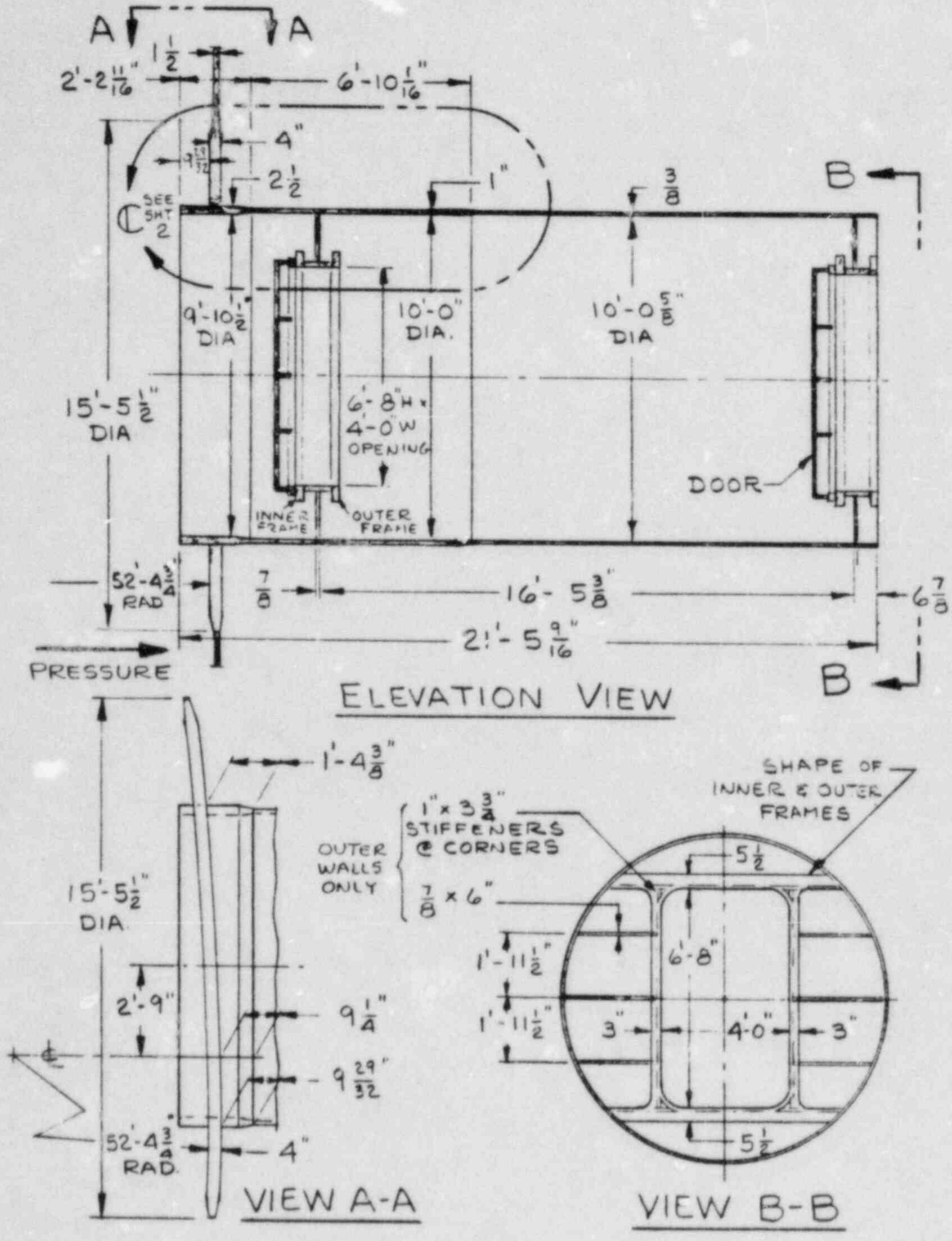
UNIT 5 PERSONNEL LOCK

Personnel Lock

The personnel lock provides a rectangular clear opening in the steel containment wall. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

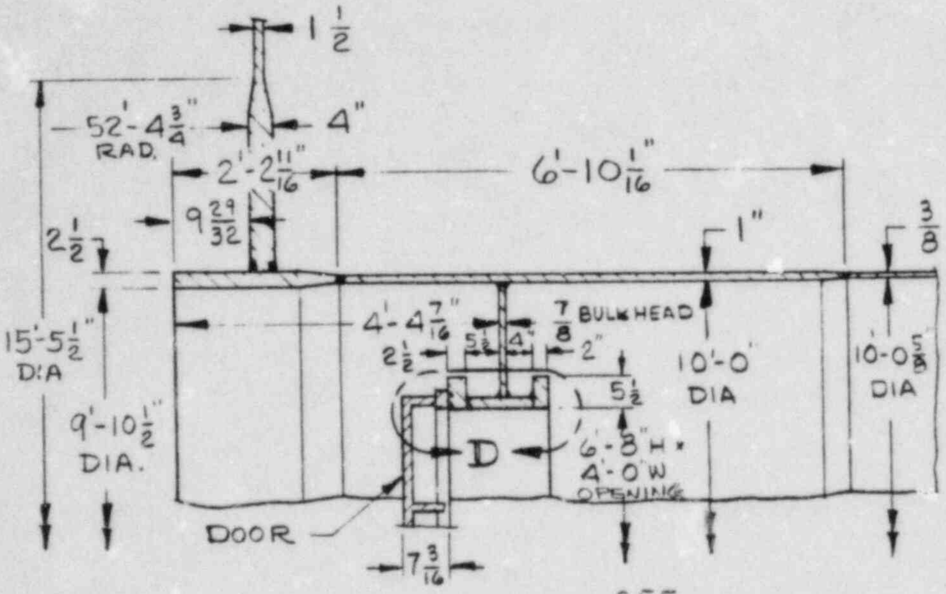
Personnel Lock	Unit 5, Figure 2
Clear opening	4 ft. wide 6 ft. 8 in. height
Door width	4 ft. 5 1/4 in.
Door height	7 ft. 1 1/4 in.
Door thickness	3/4 in.
Material	SA-516 Grade 70 FBX
Containment Penetration Ring	
Thickness	2 1/2 in.
Material	SA-516 Grade 70 FBX
Gasket	
Gasket type	Double Tongue & Groove
Cross-section	Rectangular 1/2 Thk x 3/4 Wide
Material	Silicone Rubber
Location of Personnel Lock	
Personnel lock centerline elev.	625 ft. 10 in.
Personnel lock centerline azimuth	357°

UNIT 5 FIG. 2 SHT. 1 OF 2
PERSONNEL LOCK STEEL CONTAINMENT

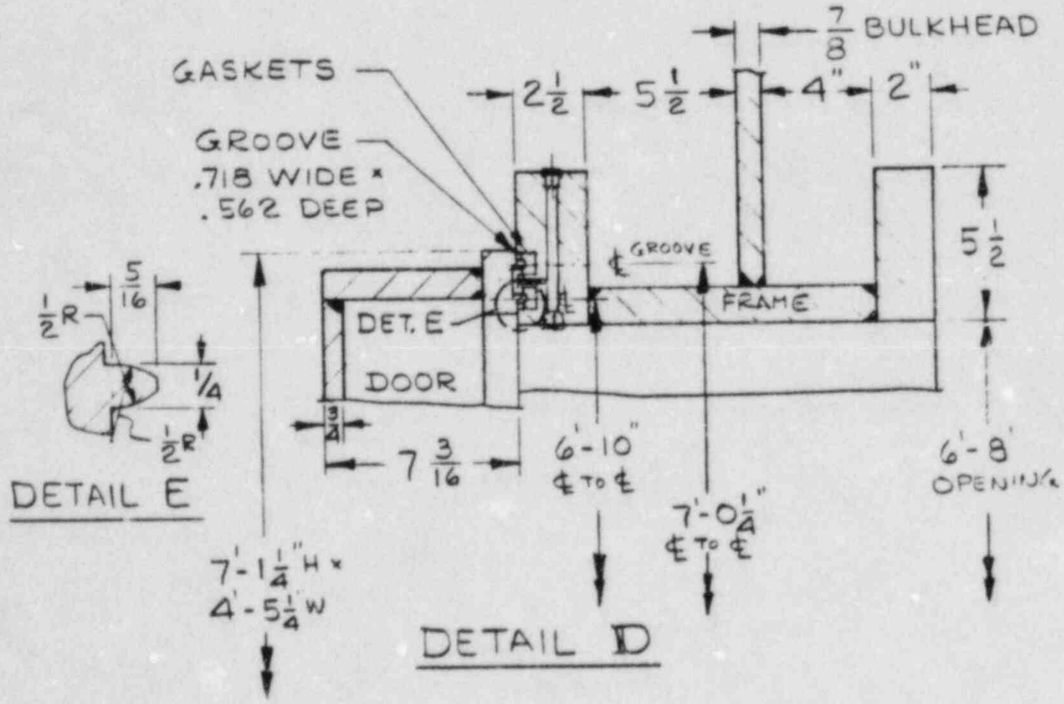


UNIT 5 FIG. 2 SHT. 2 OF 2

PERSONNEL LOCK STEEL CONTAINMENT



DETAIL C SEE SHT #1



DETAIL E

DETAIL D

SURVEY DATA - STEEL CONTAINMENT

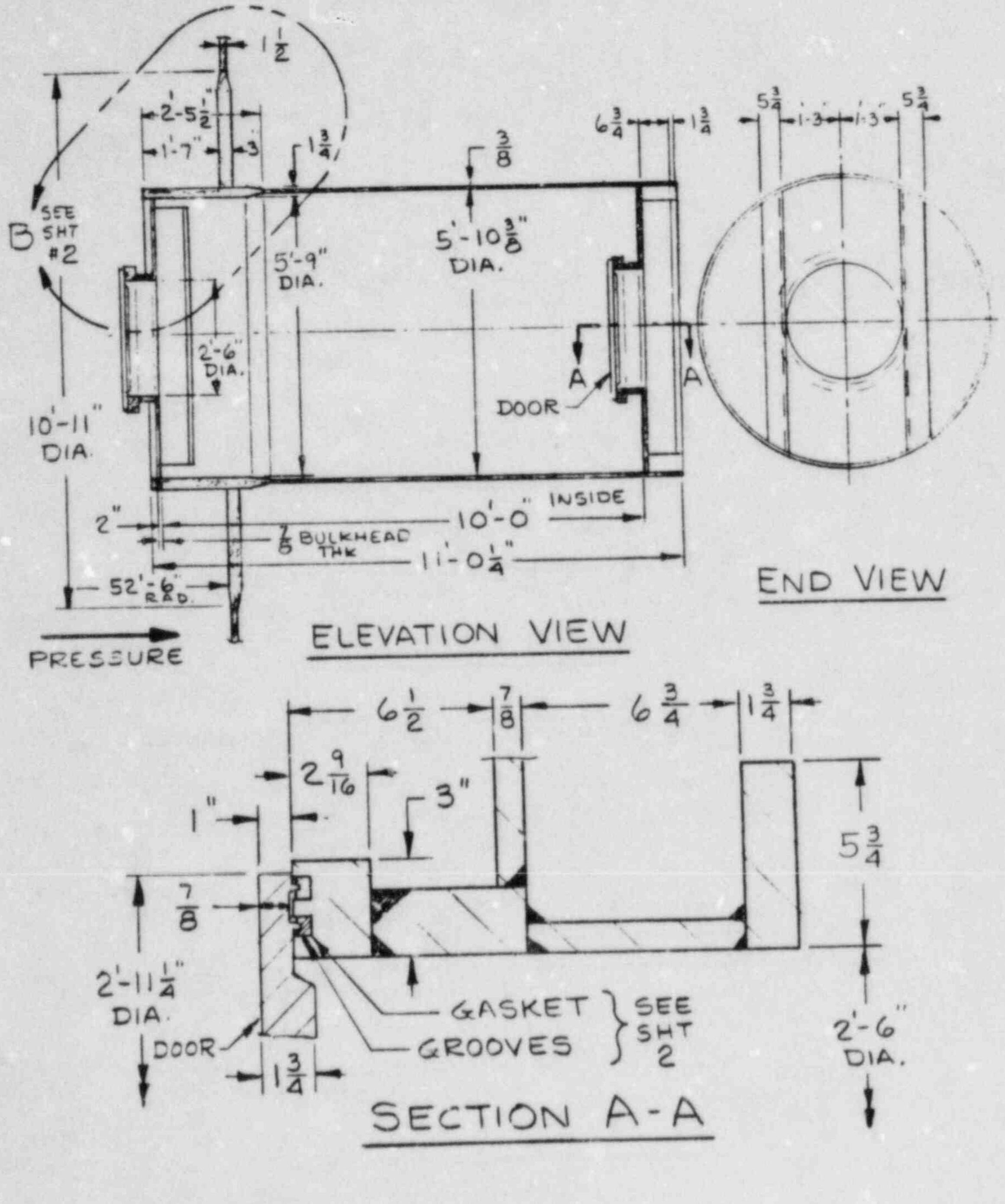
UNIT 5 - ESCAPE LOCK

Escape Lock

The escape (emergency) lock provides a round clear opening in the steel containment wall. The escape lock opening is covered with a pressure seating door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the escape lock bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

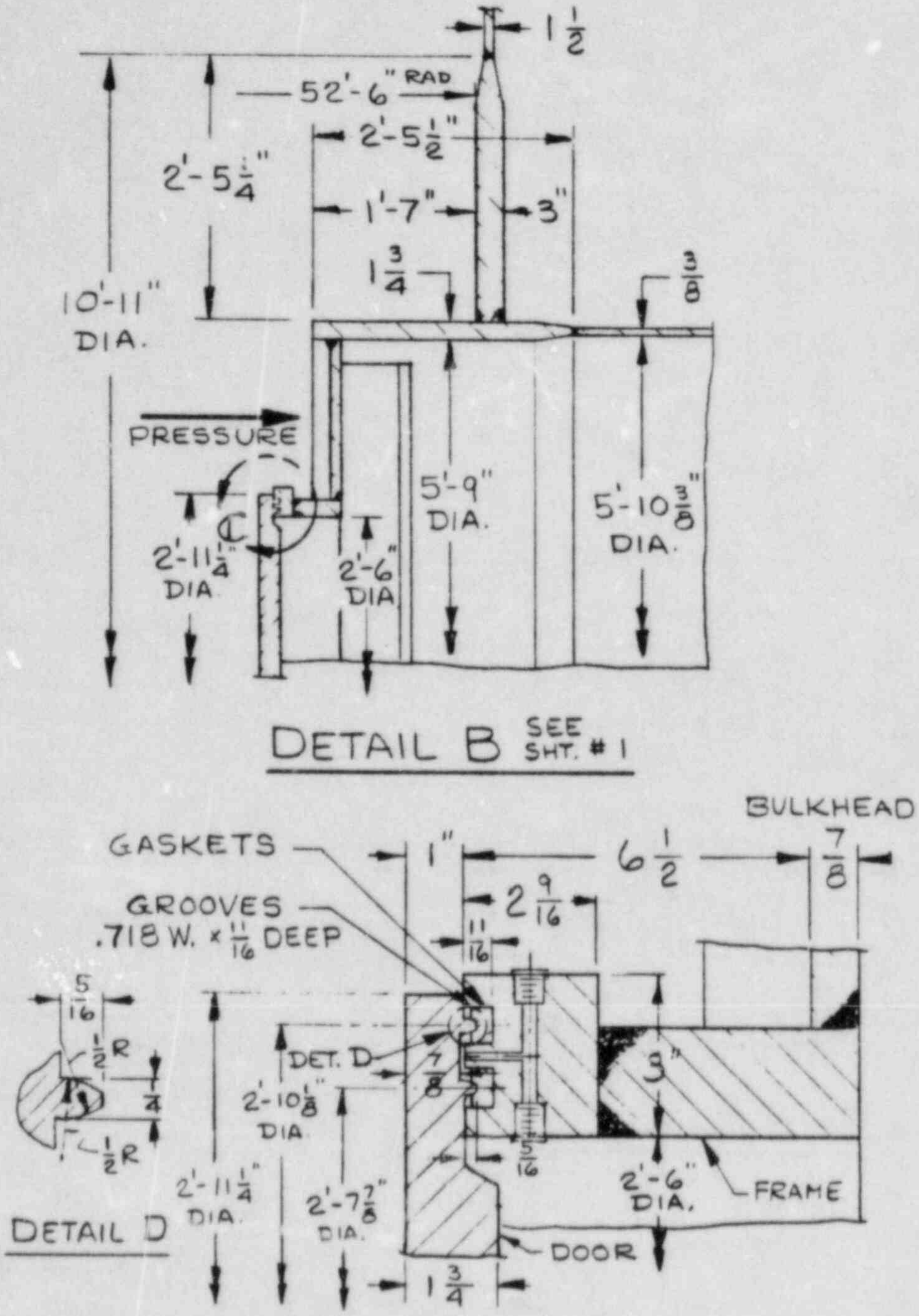
Escape Lock	Unit 5, Figure 3
Clear opening	30 in. diameter
Door	35 1/4 in. diameter
Door thickness	1 3/4 in.
Material	SA-516 Grade 70 FBX
Containment Penetration Ring	
Thickness	1 3/4 in.
Material	SA-516 Grade 70 FBX
Gasket	
Gasket type	Double Tongue & Groove
Cross-section	Rectangular 1/2 Thk x 3/4 Wide
Material	Silicone Rubber
Location of Escape Lock	
Personnel lock centerline elev.	630 ft. 0 in.
Personnel lock centerline azimuth	135°

UNIT 5 FIG. 3 SHT. 1 OF 2
EMERGENCY LOCK STEEL CONTAINMENT



UNIT 5 FIG 3 SHT. 2 OF 2

ESCAPE LOCK STEEL CONTAINMENT



UNIT 6 AND 7 STEEL CONTAINMENT

FSAR DESCRIPTION OF UNIT 6 AND 7 STEEL CONTAINMENT

The containment vessel is a cylindrical steel pressure vessel with hemispherical dome and ellipsoidal bottom which houses the reactor pressure vessel, the steam generators, reactor coolant pumps, the reactor coolant loops, the accumulators of the safety injection system, the primary coolant pressurizer, the pressurizer relief tank, and other branch connections of the reactor coolant system.

The containment vessel is completely enclosed by the Shield Building. The Shield Building has the shape of a right circular cylinder with a shallow dome roof. An annular space of 5 ft. is provided between the wall of the containment vessel and the Shield Building. A 7 ft. clearance is provided between the roofs of the containment vessel and the Shield Building.

The containment vessel is supported on a grout base that was placed after the vessel construction was completed and tested. Both the containment vessel and the Shield Building are supported on a common foundation.

Freedom of movement between the containment vessel and the Shield Building is virtually unlimited. With the exception of the support grout placed underneath and near the knuckle sides of the vessel, there are no structural ties between the containment vessel and the Shield Building above the foundation slab.

The containment vessel is designed for a maximum internal pressure of 46 psig and a temperature of 268°F. The containment vessel design internal pressure as defined by ASME Boiler and Pressure Vessel Code is 41.4 psig.

The vessel is 105 ft. inside diameter, and contains an internal net free volume of 1,320,000 $ft.^3$.

The vessel plate nominal thickness does not exceed 1-1/2 in. at the welded joints so the vessel, as an integral structure, did not require field stress relieving. Reinforcing plates at penetration openings exceed 1-1/2 in. in thickness; however, these were fabricated as penetration weldment assemblies and were stress-relieved before they were welded to adjacent vessel shell plates.

SURVEY DATA - STEEL CONTAINMENT

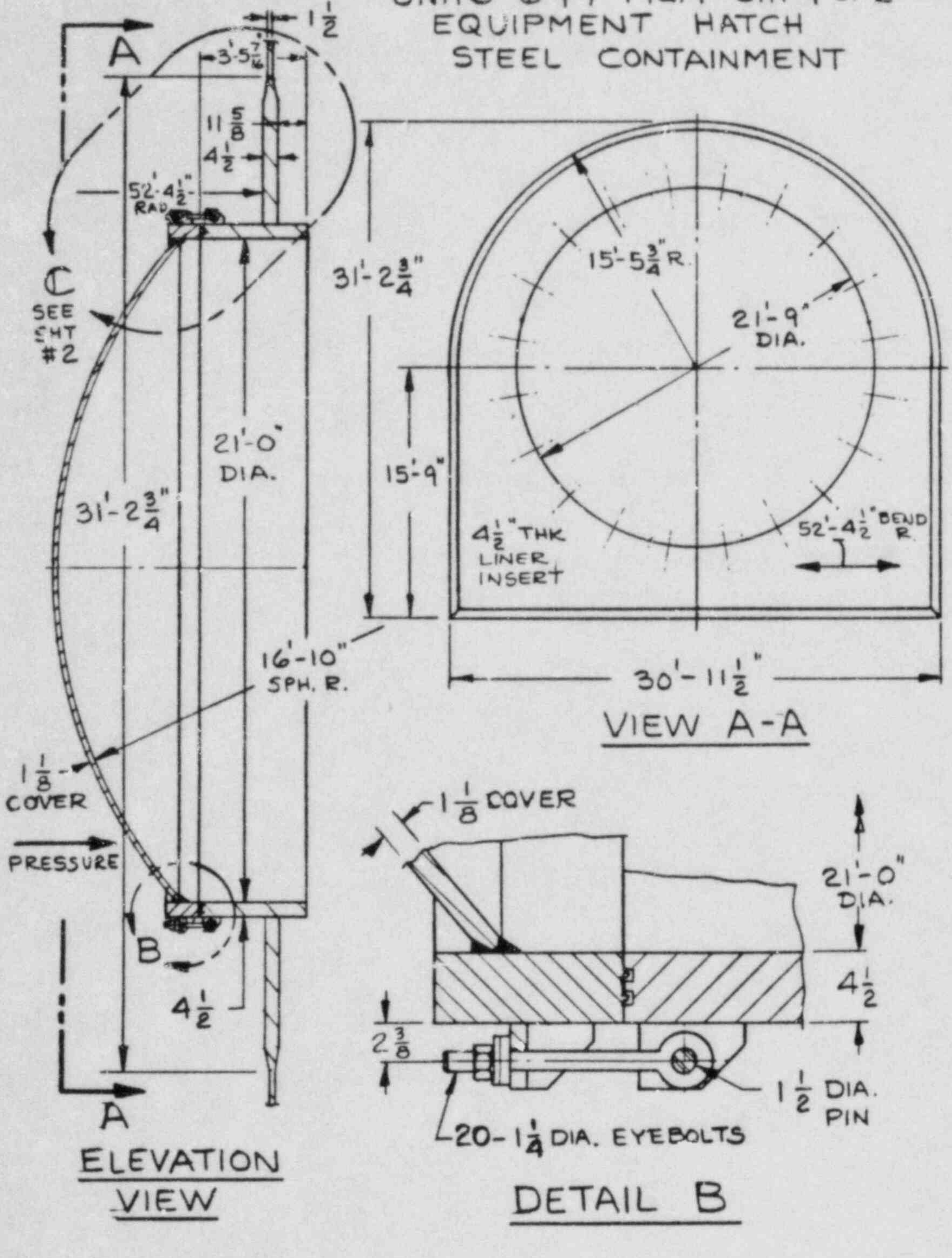
UNITS 6 and 7 EQUIPMENT HATCH

Equipment Hatch

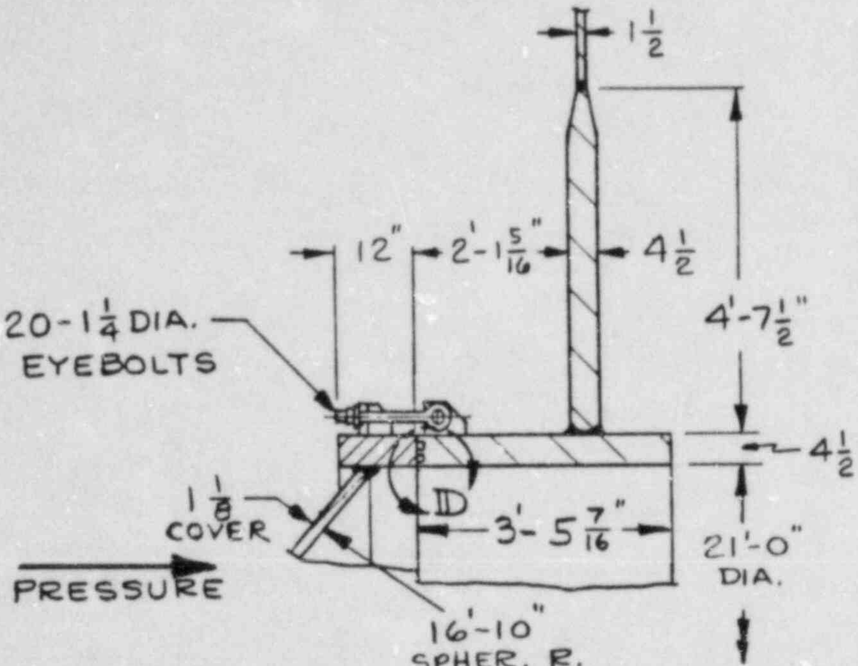
The equipment hatch provides a round clear opening in the steel containment wall. The equipment hatch opening is covered with a shaped plate and pressure sealed at the edge with double tongue and grooved gaskets to prevent leakage from the containment vessel. The equipment hatch cover is held in position by 20 swing bolts mounted on the outer surface of the hatch opening and containment penetration ring. The pressure inside the containment vessel provides the seating force for the equipment hatch seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Units 6 and 7, Figure 1
Clear opening	21 ft.
Cover thickness	1-1/8 in.
Cover shape, radius	16 ft-10 in. SPH. Radius
Material	SA-516 Grade 70
Containment Penetration Ring	
Thickness	4 1/2 in.
Material	SA-516 Grade 70
Gasket	
Gasket type	Double Tongue & Groove
Cross-section	Rectangular 3/4 Wide x 1/2 Thk.
Material	Silicone Rubber Compound 8364
Location of Hatch	
Hatch centerline elev.	725 ft. 0 in.
Hatch centerline AZIMUTH	261°

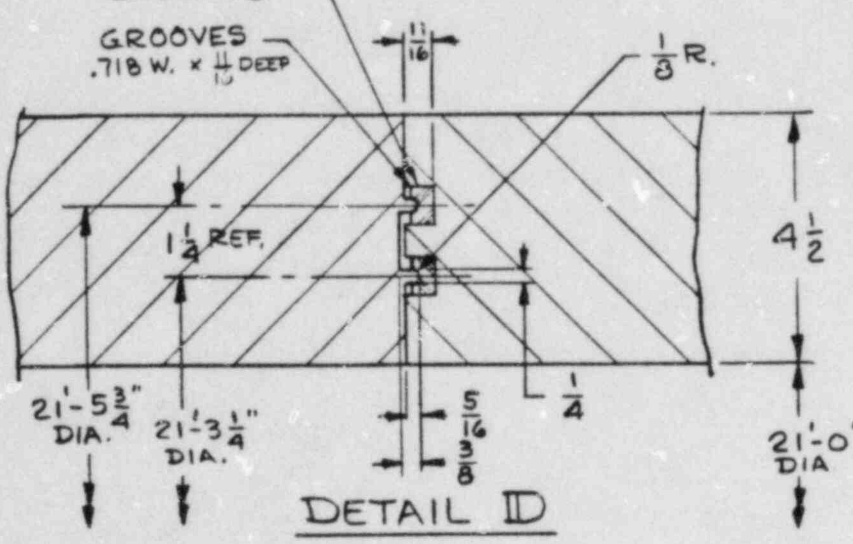
UNITS 6 & 7 FIG. 1 SHT 1 OF 2
EQUIPMENT HATCH
STEEL CONTAINMENT



UNITS 6 & 7 FIG 1 SHT. 2 OF 2 EQUIPMENT HATCH
STEEL CONTAINMENT



DETAIL C SEE SHT. #1



DETAIL D

SURVEY DATA - STEEL CONTAINMENT

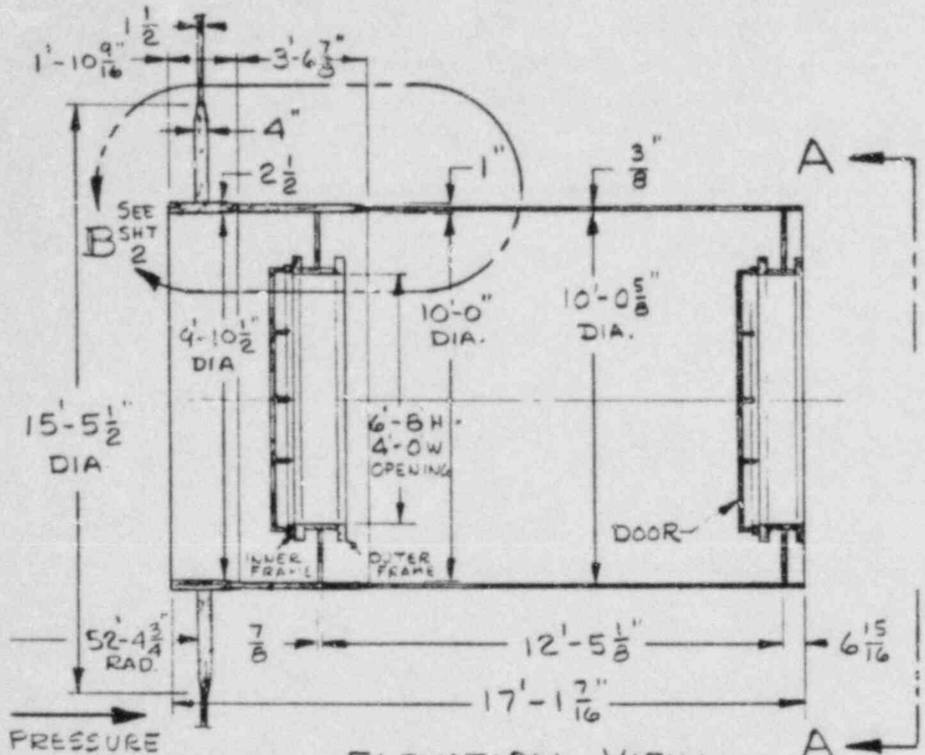
UNITS 6 AND 7 - PERSONNEL LOCK

Personnel Lock

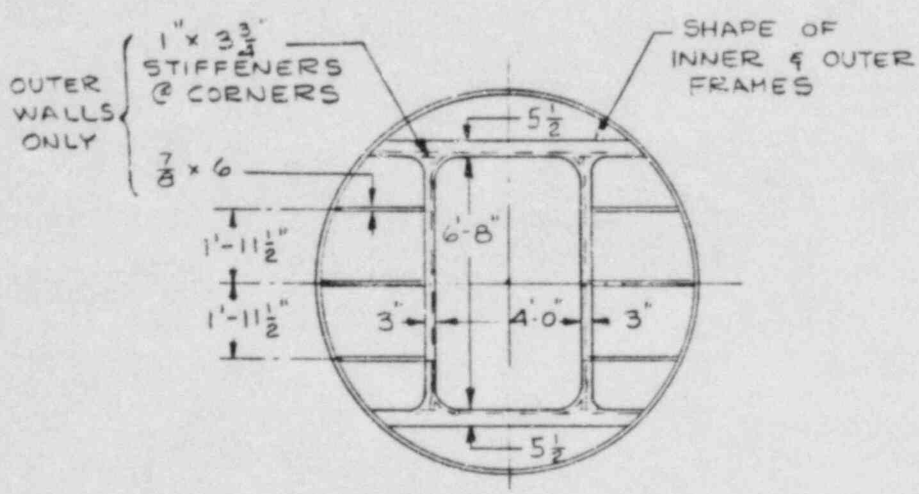
The personnel lock provides a rectangular clear opening in the steel containment wall. The personnel lock opening is covered with a pressure seating rectangular door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The personnel lock dimensions and seal information are listed below.

Personnel Lock	Units 6 and 7, Figure 2
Clear opening	4 ft. wide 6 ft. 8 in. height
Door width	4 ft. 5 1/4 in.
Door height	7 ft. 1 1/4 in.
Door thickness	3/4 in.
Material	SA-516 Grade 70 FBX
Containment Penetration Ring	
Thickness	2 1/2 in.
Material	SA-516 Grade 70 FBX
Gasket	
Gasket type	Double Tongue & Groove
Cross-section	Rectangular 1/2 Thk x 3/4 Wide
Material	Silicone Rubber
Location of Personnel Lock	
Personnel lock centerline elev.	738 ft. 4 in.
Personnel lock centerline azimuth	321°

UNITS 6 & 7 FIG. 2 SHT. 1 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT

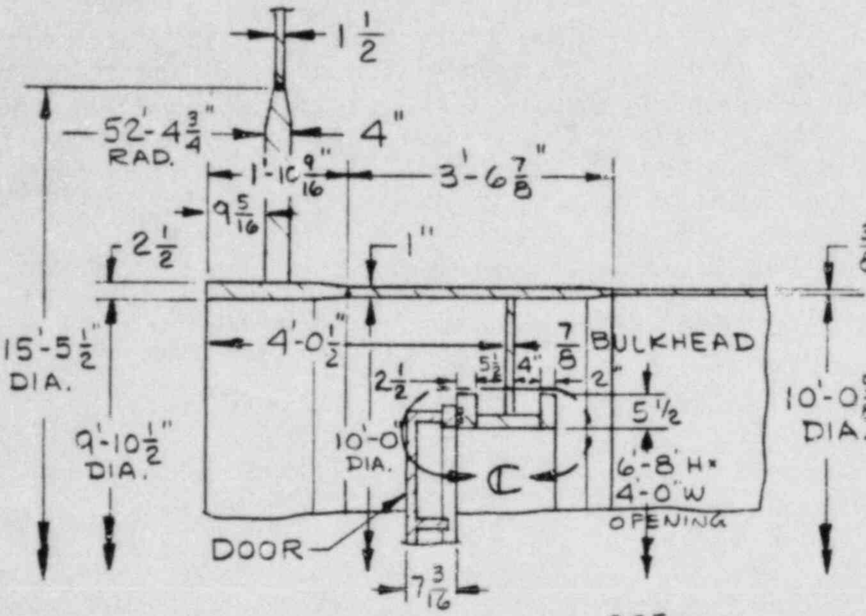


ELEVATION VIEW

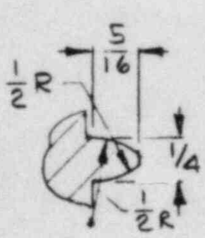


VIEW A-A

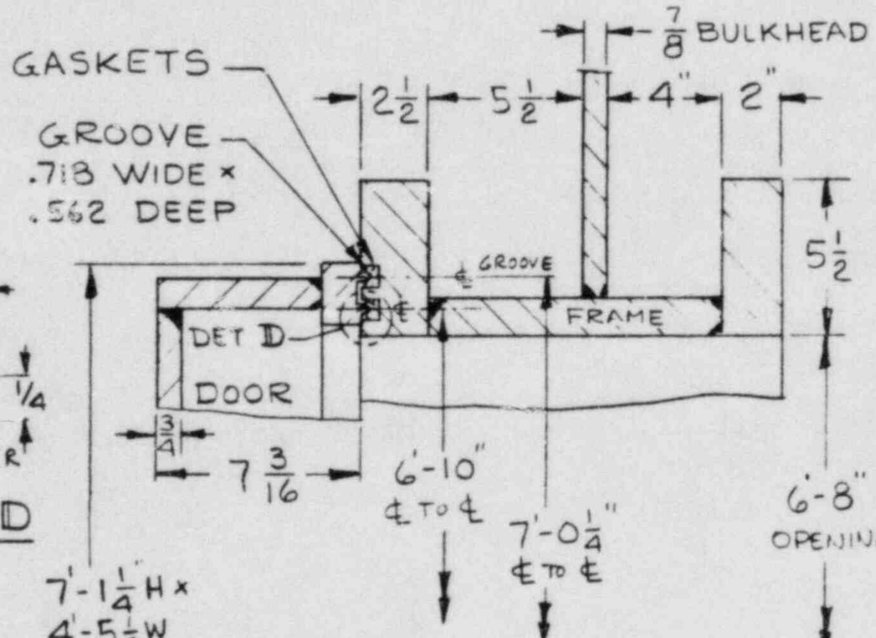
UNITS 6 & 7 FIG. 2 SHT. 2 OF 2 PERSONNEL LOCK
STEEL CONTAINMENT



DETAIL B SEE SHT #1



DETAIL D



DETAIL C

SURVEY DATA - STEEL CONTAINMENT

UNITS 6 AND 7 - ESCAPE LOCK

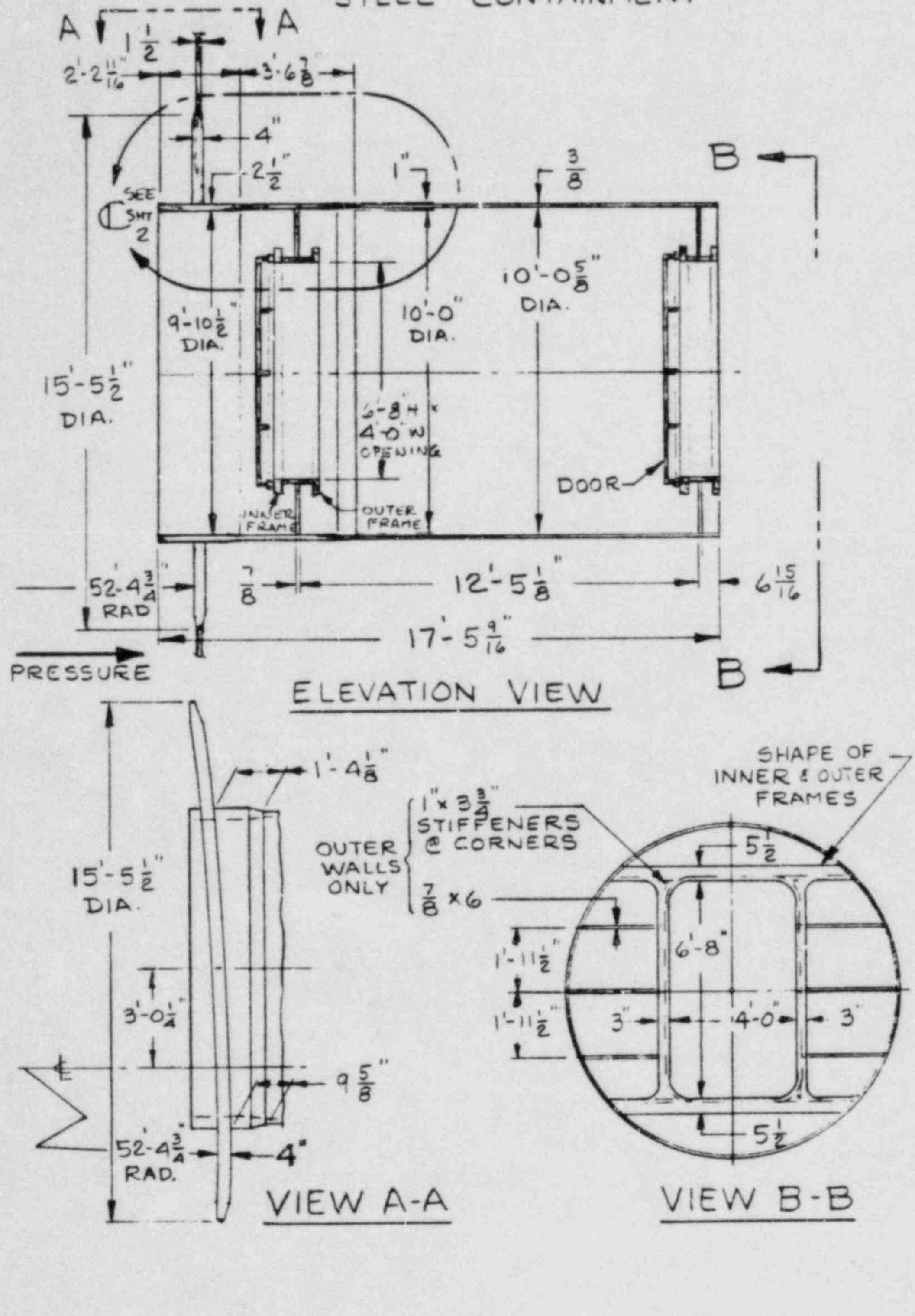
Escape Lock*

The escape lock provides a rectangular clear opening in the steel containment wall. The escape lock opening is covered with a pressure seating rectangular door. Leakage is prevented by double tongue and groove gaskets mounted in grooves in the bulkhead frame. The pressure inside the containment vessel provides the seating force for the door seal. The escape lock dimensions and seal information are listed below.

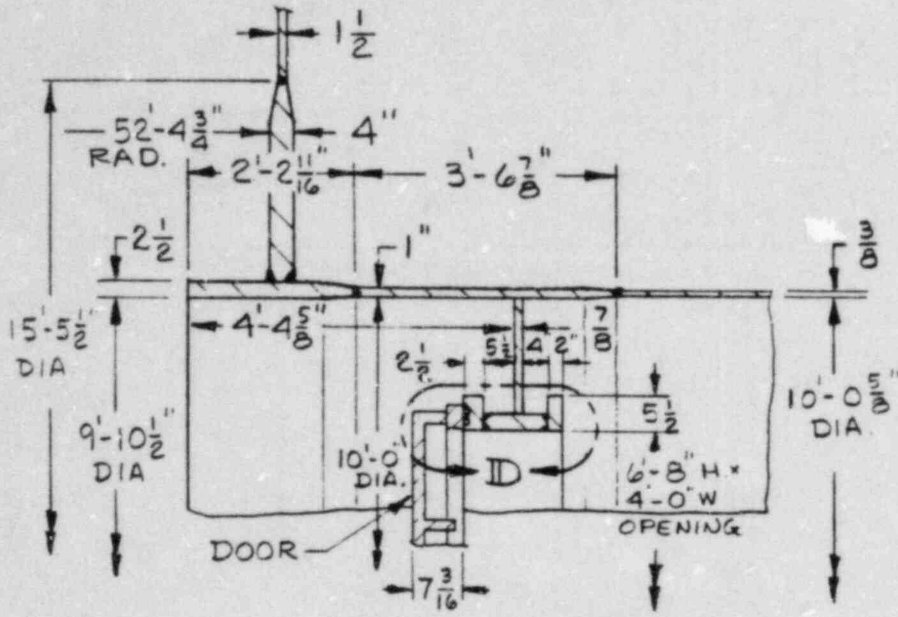
Escape Lock	Units 6 and 7, Figure 3
Clear opening	4 ft. wide 6 ft. 8 in. height
Door width	4 ft. 5 1/4 in.
Door height	7 ft. 1 1/4 in.
Door thickness	3/4 in.
Material	SA-516 Grade 70 FBX
Containment Penetration Ring	
Thickness	2 1/2 in.
Material	SA-516 Grade 70 FBX
Gasket	
Gasket type	Double Tongue & Groove
Cross-section	Rectangular 1/2 Thk x 3/4 Wide
Material	Silicone Rubber
Location of Personnel Lock	
Personnel lock centerline elev.	758 ft. 4 in.
Personnel lock centerline azimuth	93^{o}-17'-27"

*Units 6 and 7 escape lock bulkhead and doors are the same design as the personnel lock.

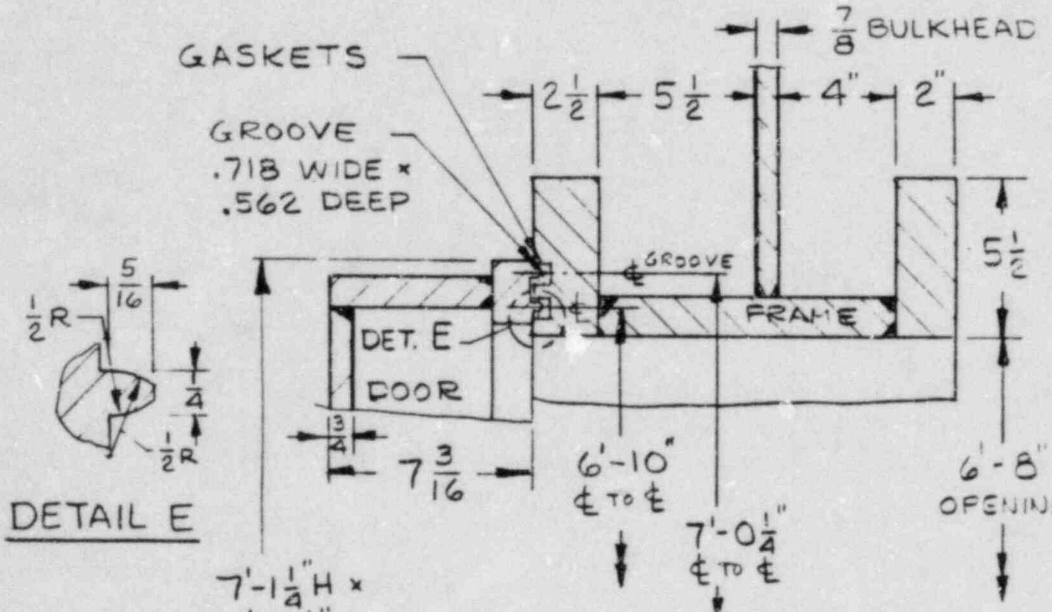
UNITS 6 & 7 FIG. 3 SHT. 1 OF 2 ESCAPE HATCH
STEEL CONTAINMENT



UNITS 6 & 7 FIG. 3 SHT. 2 OF 2 ESCAPE HATCH
STEEL CONTAINMENT



DETAIL C SEE SHT. #1



DETAIL E

DETAIL D

UNIT 1 - STEEL CONTAINMENT BWR MARK I

FSAR DESCRIPTION OF UNIT 1 CONTAINMENT STRUCTURE

The primary containment system houses the reactor pressure vessel, the reactor coolant recirculation system and other branch connections of the reactor coolant system. The primary containment consists of a drywell, pressure suppression chamber (torus) and a connecting vent system between the drywell and the suppression chamber. Figure 1 is a simple configuration of a steel BWR Mark I.

The drywell is a steel pressure vessel in the shape of an inverted light bulb, with a spherical lower portion and a cylindrical upper portion. The top narrow cylindrical portion called the drywell head is made with a double tongue and groove seal which will permit periodic checks for tightness without pressurizing the entire vessel. The drywell head is removed during refueling operations. The head is bolted closed when primary containment integrity is required.

Dimensions of the containment structure are as follows:

Drywell	
Drywell head-diameter	27 ft. 2 in.
Cylindrical section-diameter	32 ft.
Spherical section-diameter	63 ft.
Drywell height (overall)	108 ft. 9 in.
Wall Plate Thickness	
Drywell head	1 7/16 in.
Cylindrical section	1 7/16 in.
Spherical section	3/4 in.
Vent System	
Vent Pipes	
Number	8
Internal diameter	4 ft. 9 in.
Vent Header internal diameter	3 ft. 6 in.
Downcomer pipes	
Number	48
Internal diameter	2 ft. 0 in.
Submergence below suppression pool water level	4 ft. 0 in.
Pressure Suppression Chamber	
Chamber inner diameter	25ft. 8 in.
Torus major diameter	98 ft. 8 in.

The primary containment is primarily fabricated of SA-516 GR70 plates. The drywell and the suppression chamber are both designed for an internal pressure of 56 psig coincident with a temperature of 281°F with applicable dead, live, and seismic loads imposed on the shell.

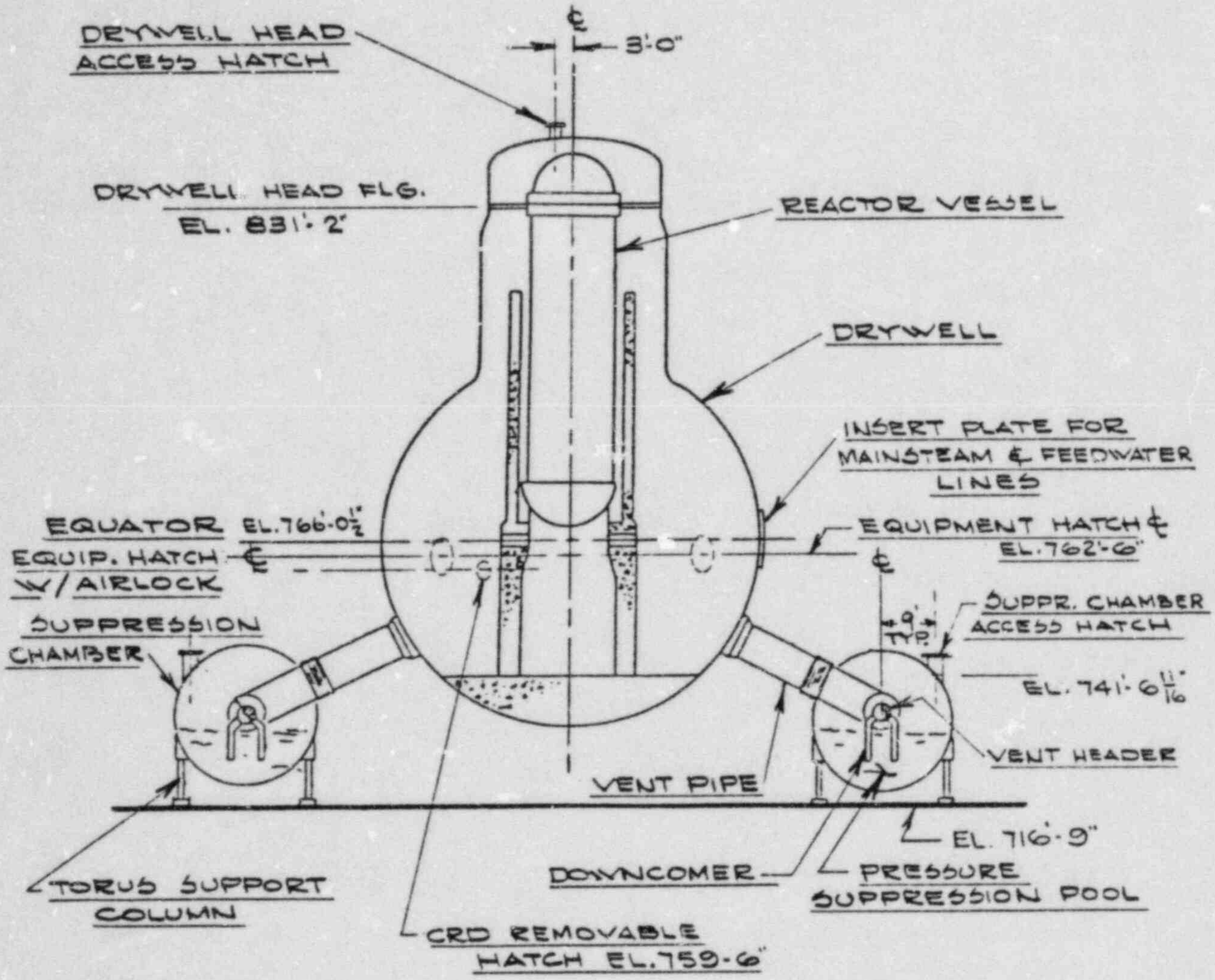


FIGURE I
MARK I CONTAINMENT CONFIGURATION

The drywell is enclosed in a reinforced concrete structure for shielding purposes. In areas where it backs up the drywell shell, this reinforced concrete provides additional resistance to deformation and buckling of the shell. Above the transition zone, and below the flange, the drywell is separated from the reinforced concrete by a gap of approximately 2 inches. Shielding over the top of the drywell is provided by removable, segmented, reinforced concrete shield plugs.

In addition to the drywell head, one combination equipment hatch with double door air lock, one bolted equipment hatch, and one bolted personnel access hatch are provided for access into the drywell.

The pressure suppression chamber is a steel pressure vessel in the shape of a torus located below and encircling the drywell. The pressure suppression chamber contains the suppression pool and the gas space above the pool. The suppression chamber will transmit seismic loading to the reinforced concrete foundation slab of the reactor building.

Large vent pipes connect the drywell and the pressure suppression chamber. A total of 8 circular vent pipes are provided. The vent pipes are designed for the same pressure and temperature conditions as the drywell and the suppression chamber. The vent pipes are also fabricated of SA-516 GR70 steel. The vent pipes are provided with two ply expansion bellows to accommodate differential motion between the drywell and suppression chamber. The vent pipe bellows are designed and fabricated to the same criteria as the containment vessels.

The vent header in the suppression chamber has the same temperature and pressure design requirements as the vent pipes.

SURVEY DATA - STEEL CONTAINMENT BWR MARK I

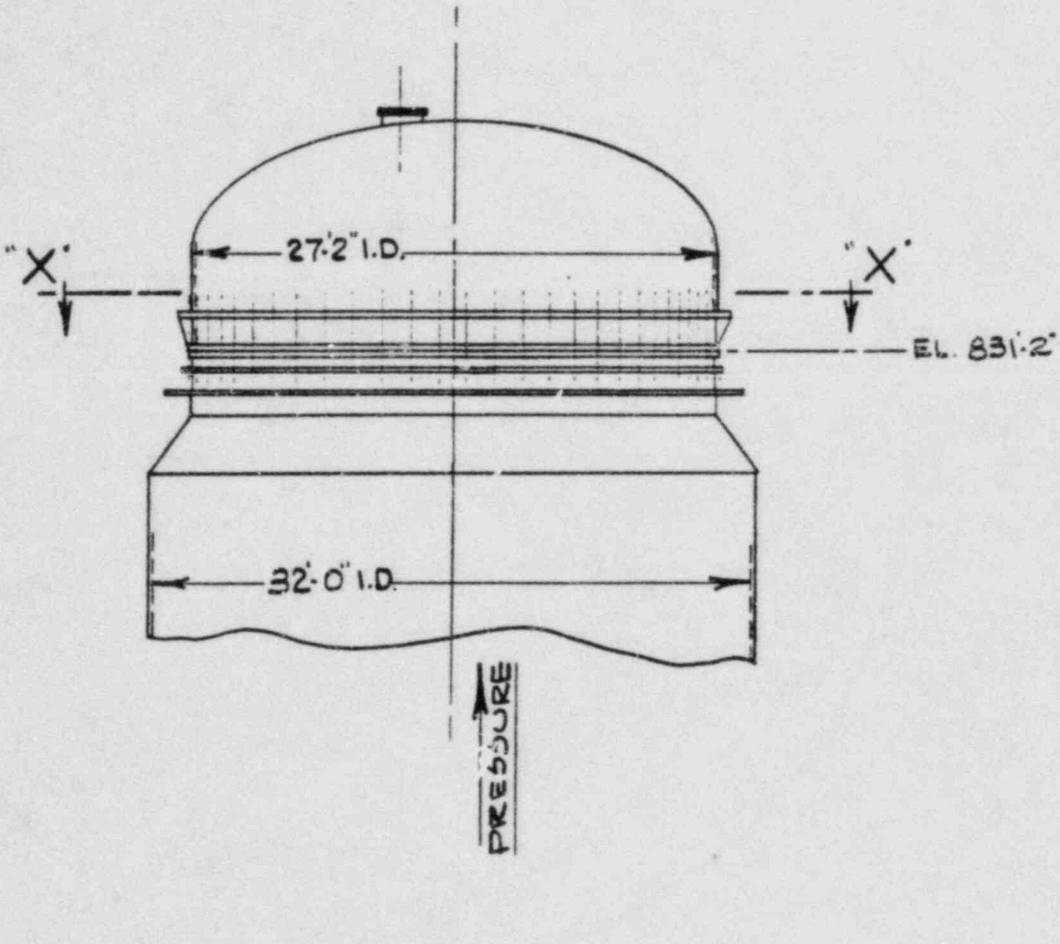
UNIT 1 - DRYWELL HEAD FLANGE

Drywell Head Flange

The top of the cylindrical section of the drywell is capped with a bolted/gasketed head cap which is shown as the narrower section at the top of Figure 1. The drywell head flange and the shell flange are welded to the steel vessel. The shell flange has double grooves in which silicone gaskets are fitted. The head flange has double tongue which fit into the gasketed grooves in the shell flange. These flanges are further tightened by heavy hex headed bolts, 60 in total, placed all around the drywell head flange assembly. Tightening of the bolts provides the pressure for seating of the gaskets to form a seal to prevent leakage from the drywell. Flange assembly dimensions are indicated on sketches. Additional information on sizes and materials is listed below.

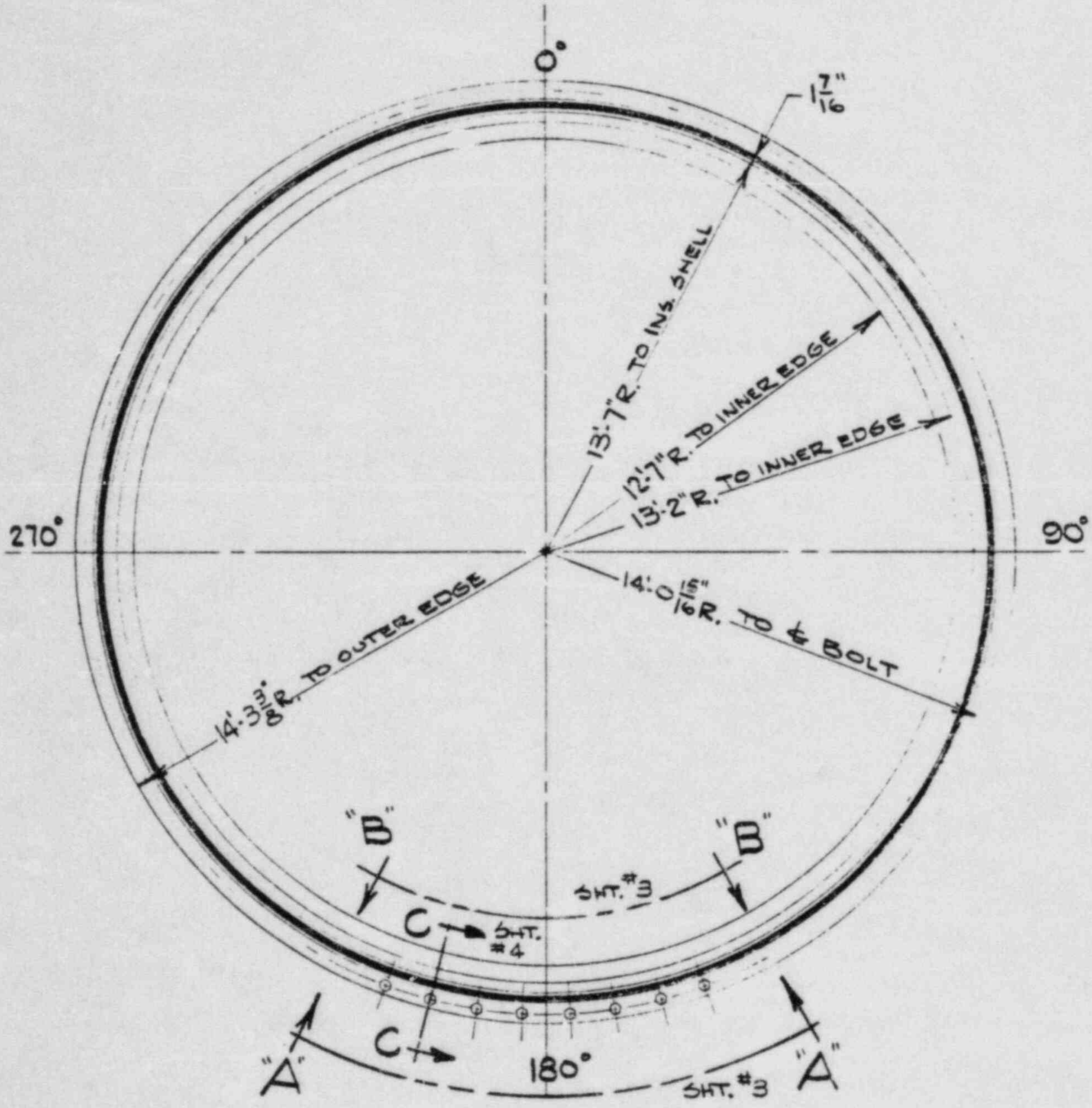
Drywell Head Flange and Shell Flange	Unit 1, Figure 2
Size	Indicated on sketches
Material	SA-516 GR70 to SA300 (MS-504B)
Gaskets	
Gasket type	Double tongue & groove
Cross-section	Rectangular 3/4 in wide x 1/2 in. thick
Length, inner	85 ft. 3 31/32 in.
Length, outer	86 ft. 1 3/8 in.
Material	Silicone Garlock Compound #8364 (MS-556B)
Bolts	
Number	60
Type	Semi-Fin Heavy Hex head bolts with 7 in. threaded 8 UNC-2A
Size, diameter	2 1/4 in.
Length	3 ft. 6 3/16 in.
Material	SA-193 Grade B7 (MS-529B)
Nuts	
Number	60
Type	ASH SF Hex Nuts with 8 UNC-2B Thread
Size, diameter	2 1/4 in.
Material	SA-194 GR 4 or 7 (MS-511B)
Washers	
Number	120 (60 with flat sides)
Type	spherical
Size, outer diameter	4 1/2 in.
Thickness	0.1 in.
Material	AISI 4140 or 4340 (Heat treat to Brinell hardness to 248-352)
Location of Drywell Head Flange	
Elevation	831 ft. 2 in.

UNIT 1 FIG. 2 DRYWELL HEAD FLANGE
STEEL CONTAINMENT BWR MK. I
(SHT. #1 OF 5)



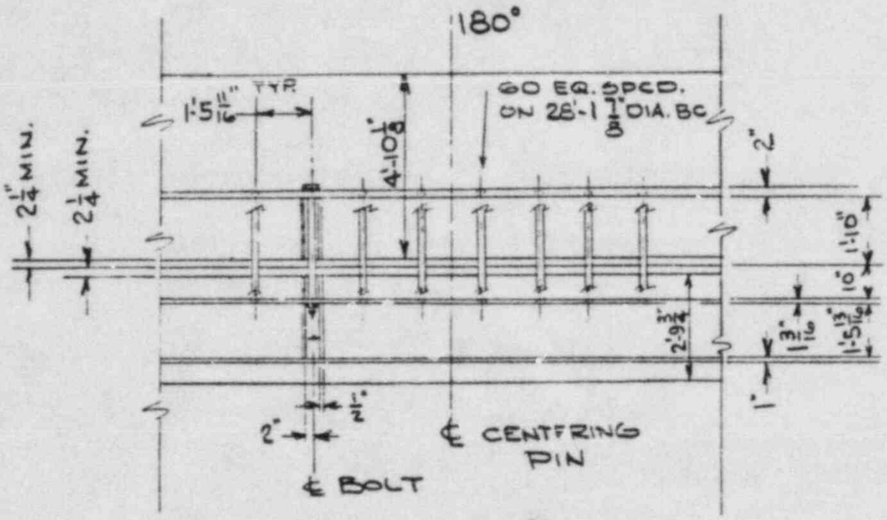
DRYWELL HEAD ELEV.

UNIT 1 FIG. 2 DRYWELL HEAD FLANGE
STEEL CONTAINMENT BWR MARK I
(SHT. #2 OF 5)

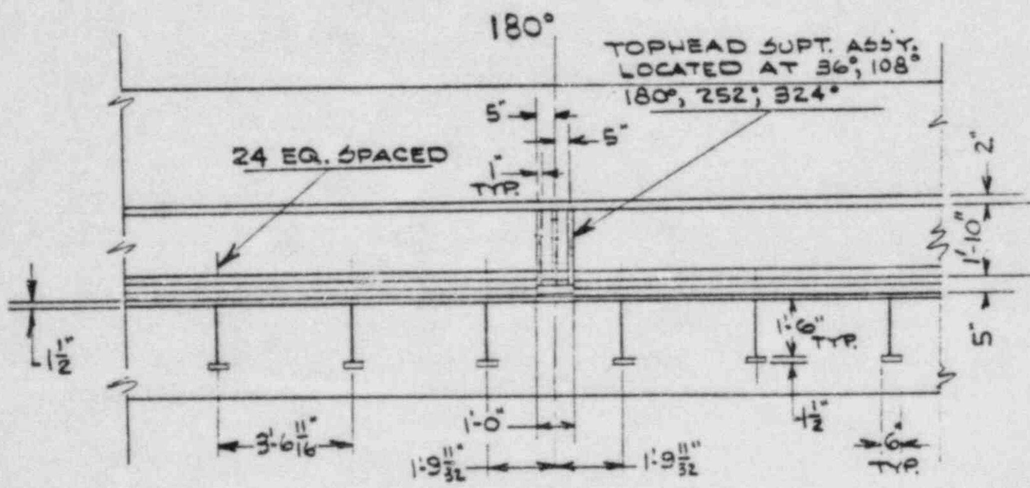


•DRYWELL HEAD FLANGE ASSEMBLY•
•PLAN VIEW X-X•

UNIT I FIG. 2 DRYWELL HEAD FLANGE
STEEL CONTAINMENT BWR MARK I
(SHT. #3 OF 5)

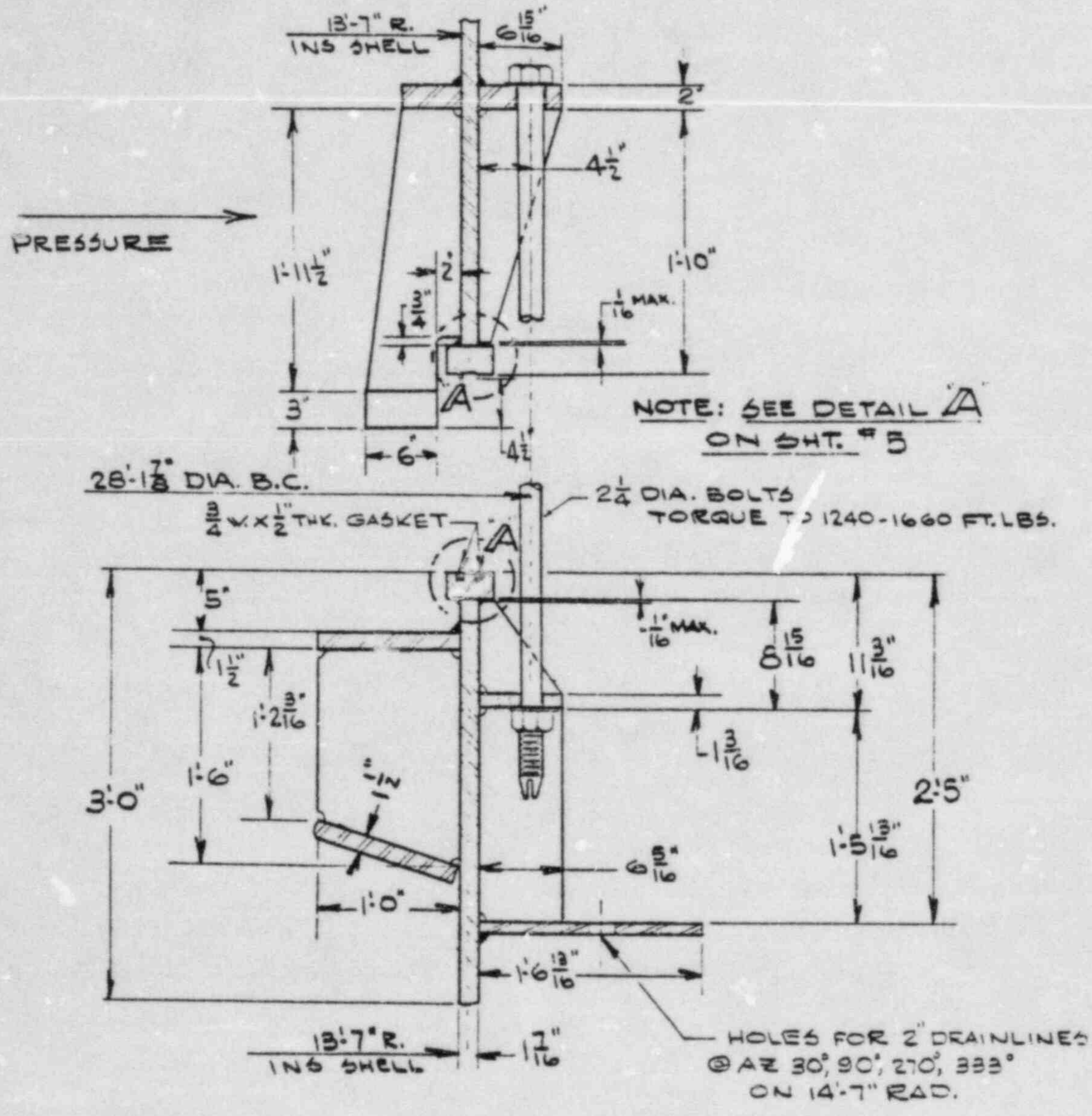


•VIEW A-A•



•VIEW B-B•

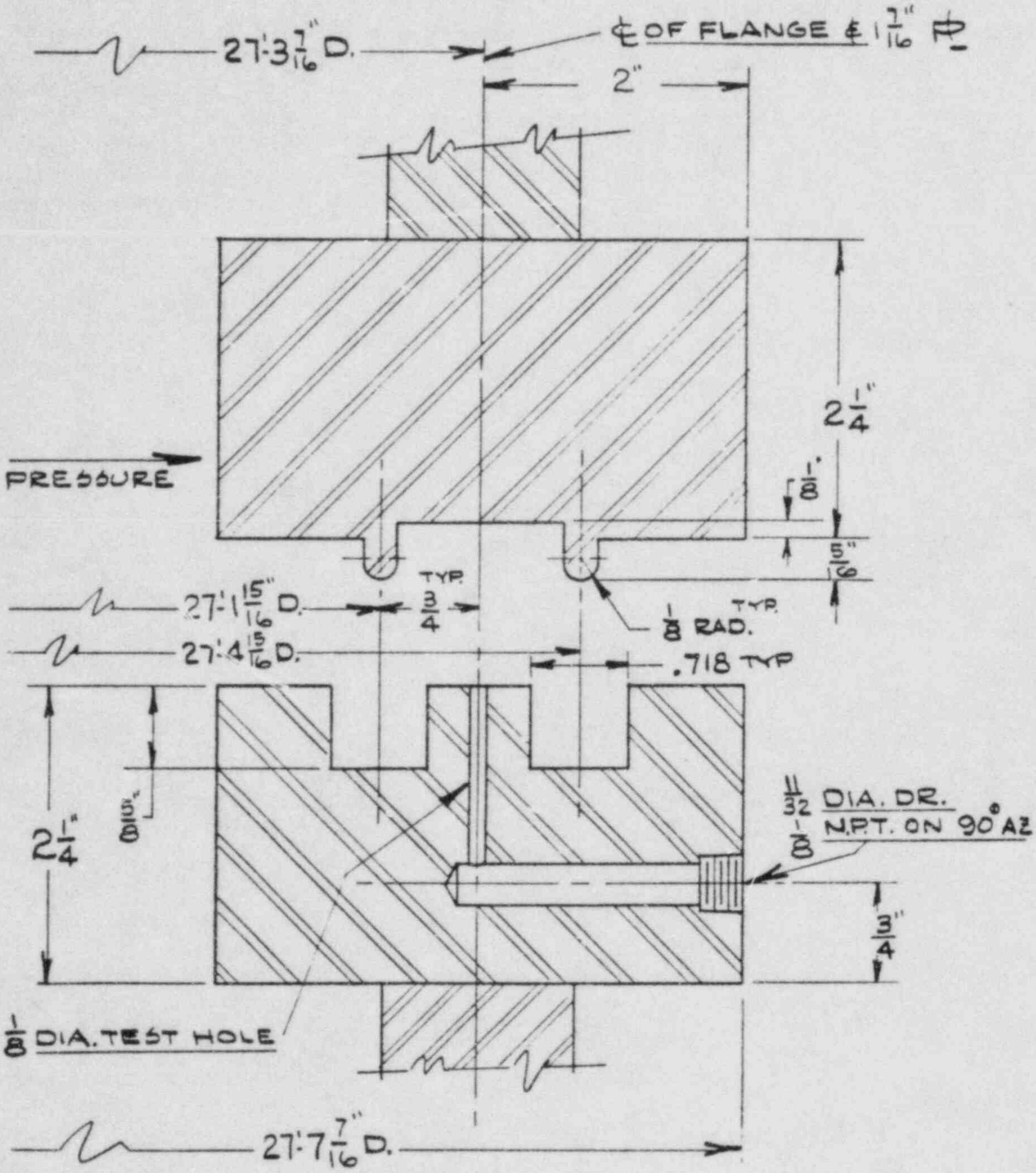
UNIT I FIG. 2 DRYWELL HEAD FLANGE
STEEL CONTAINMENT BWR MARK I
(SHT. #4 OF 5)



• SECTION C-C •

(SEE SHT. #2)

UNIT 1 FIG. 2 DRYWELL HEAD FLANGE
STEEL CONTAINMENT BWR MARK I
(SHT. #5 OF 5)



• DETAIL "A" •
(SEE SHT. #4)

SURVEY DATA - STEEL CONTAINMENT BWR MARK I

UNIT 1 - EQUIPMENT HATCH W/ PERSONNEL AIRLOCK

The equipment hatch provides a round clear opening in an insert plate installed in the spherical portion of the drywell. A segmented sleeve that extends outwards from the drywell sphere, has been installed in this insert plate. The outer end of this sleeve is a ring with double gasket grooves in which "gumdrop gaskets" are fitted to prevent leakage from the drywell. The equipment door for the personnel lock is held in position by swing bolts mounted on the outer surface of this ring. The equipment door is fabricated around an inner personnel airlock section. The outer ring of equipment door/air lock assembly is fitted with plate lugs to receive the swing bolts. The bolts provide the necessary pressure to hold the equipment door and form a seal to prevent leakage from the drywell. The equipment hatch/door assembly dimensions and seal information are listed below.

<u>Equipment Hatch</u>	<u>Unit 1, Figure 3</u>
Clear opening	12 ft. 0 in.
<u>Insert Plate</u>	
Thickness	1 3/4 in.
Spherical radius	31 ft. 6 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
<u>Sleeve</u>	
Internal diameter	Varies 12 ft. 0 in. to 12 ft. 2 5/8 in.
Thickness	Varies 3 in. to 3/8 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
<u>Gasket</u>	
Outer gasket-diameter centerline	12 ft. 4 in.
Inner gasket-diameter centerline	12 ft. 2 in.
Gasket type	gumdrop
Gasket length-outer	38 ft. 7 25/32 in.
Gasket length-inner	38 ft. 1 17/32 in.
Material	Silicone rubber to MS-556B
<u>Swing Bolts</u>	
Number	24
Type	Eyebolt
Diameter	1 3/4 in.
Material	SA-193 B7 (MS-529B)
<u>Equipment Door</u>	
Internal diameter	12 ft. 0 in.
Outer diameter	12 ft. 6 in.
Thickness	3 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
<u>Location of Hatch</u>	
Hatch centerline elev.	762 ft. 6 in.
Hatch centerline azimuth	135°

SURVEY DATA - STEEL CONTAINMENT BWR MARK I

UNIT 1 - PERSONNEL AIRLOCK FOR EQUIPMENT HATCH

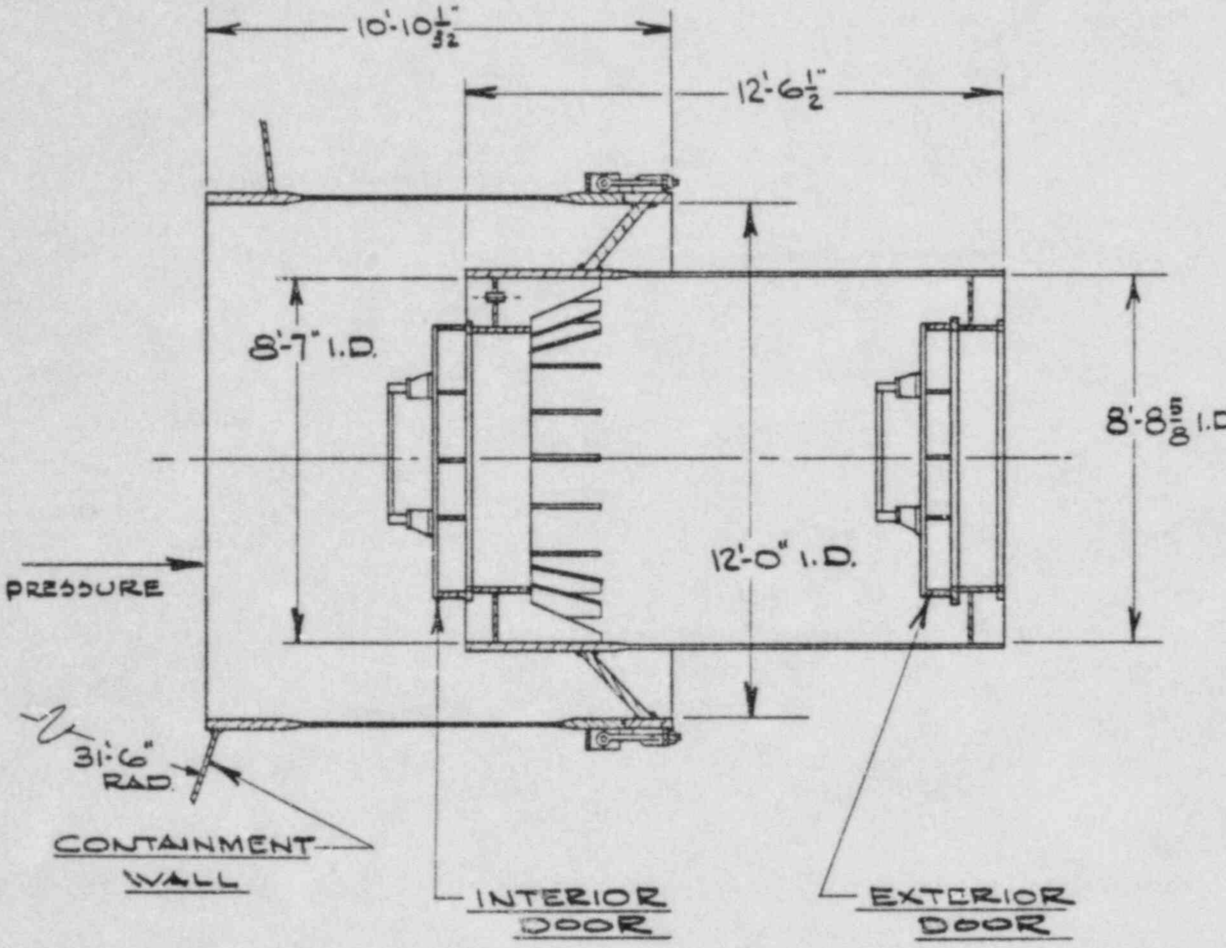
The personnel airlock provides a clear opening in the equipment hatch. The personnel lock opening is covered with two pressure seating rectangular doors, one interior and the other exterior. The locking mechanism is designed to seal the door against a pressure of a 2 psig. Both the doors are interlocked such that one door cannot be opened unless the opposite door is sealed. Leakage is prevented by a gasket installed in the door frame. The personnel air lock dimensions and seal information are listed below.

Personnel Airlock	Unit 1, Figure 3
Clear opening	2 ft. 6 in. wide 6 ft. 0 in. height
Inner diameter (shell)	Varies 8 ft. 7 in. to 8 ft. 8 5/8 in.
Outer diameter (shell)	Varies 8 ft. 11 in. to 8 ft. 9 3/8 in.
Thickness (shell)	Varies 2 in. to 3/8 in.
Thickness (conical section)	3 1/4 in.
Material	SA-516 GR70 to SA-300 (MS-504B)

Gasket	
Gasket type	Rectangular
Cross-section	1/2 in. thick x 1 1/4 in. wide
Material	Silicone rubber

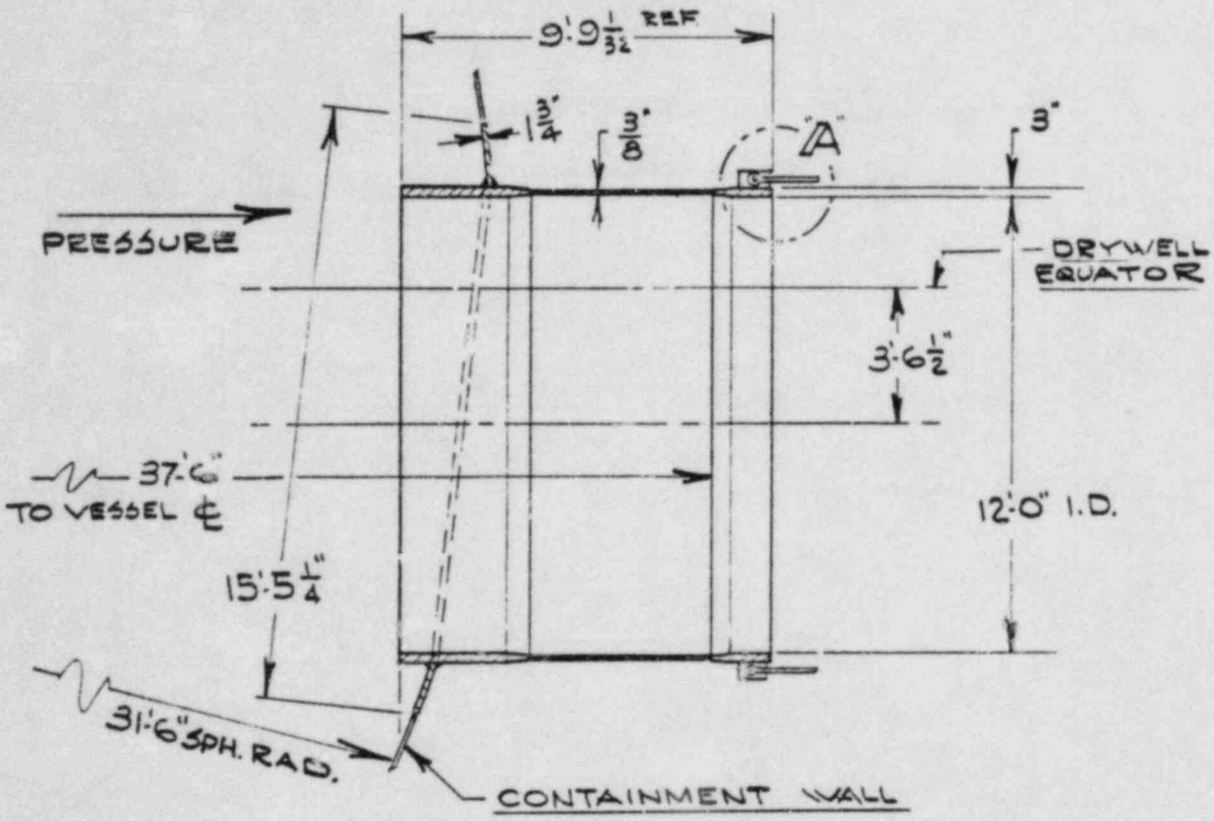
Location of Personnel Lock	
Personnel lock centerline elev.	762 ft. 6 in.
Personnel lock centerline azimuth	135°

UNIT 1 FIG. 3 EQUIPMENT HATCH W/AIRLOCK
STEEL CONTAINMENT BWR MK. I
(SHT. #1 OF 4)

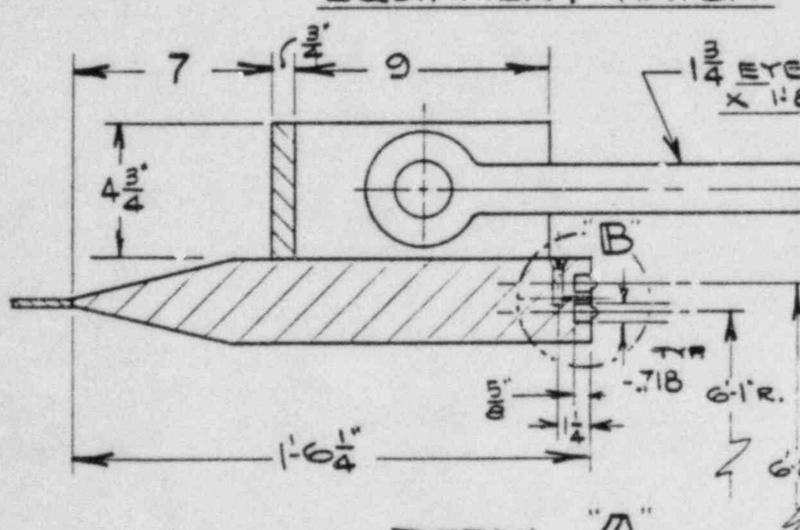


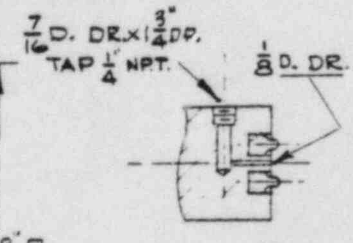
EQUIPMENT HATCH & AIRLOCK ASSEMBLY

UNIT I FIG. 3 EQUIPMENT HATCH W/AIRLOCK
STEEL CONTAINMENT BWR MK. I
(SHT. #2 OF 4)



• EQUIPMENT HATCH •

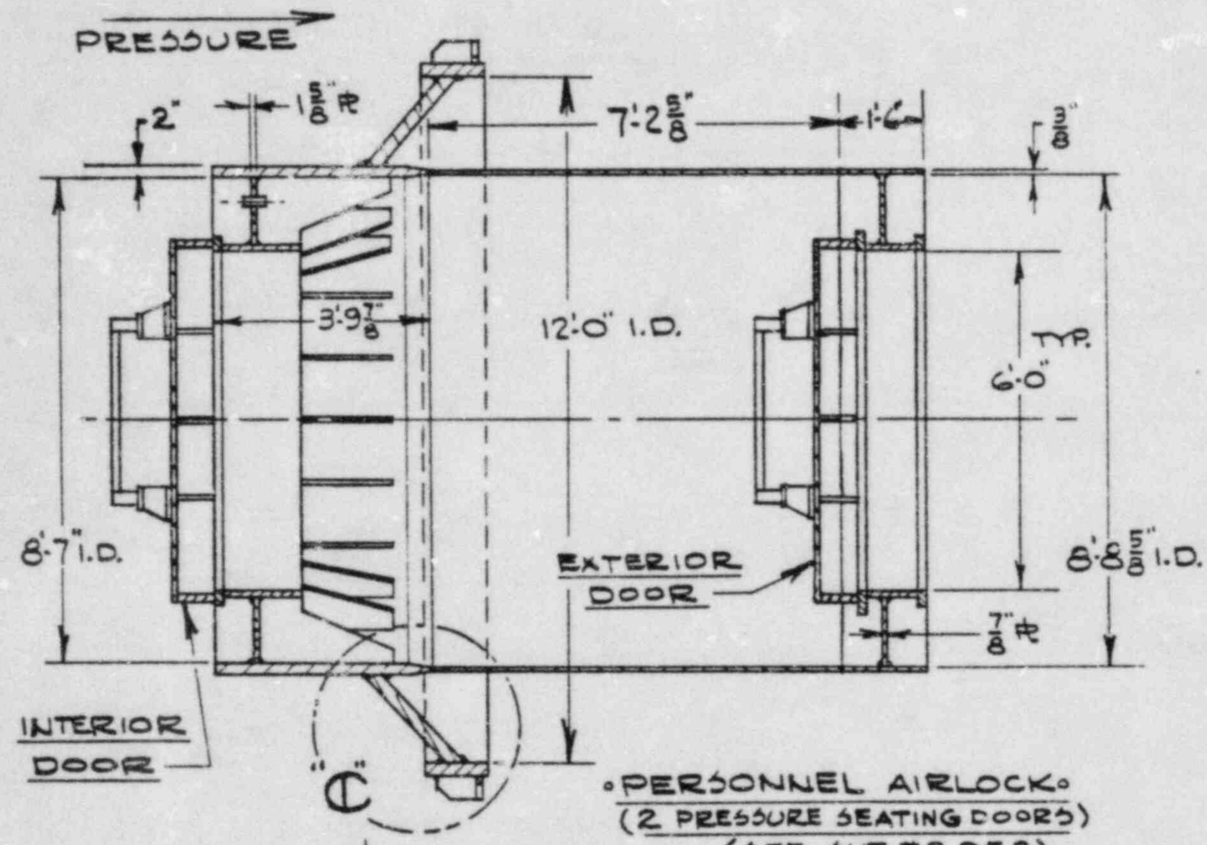


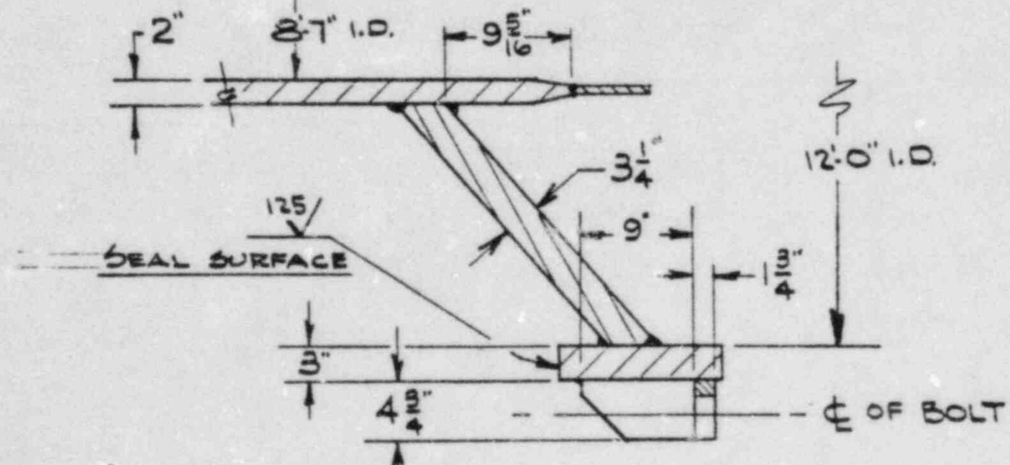


• DETAIL "B" •

• DETAIL "A" •

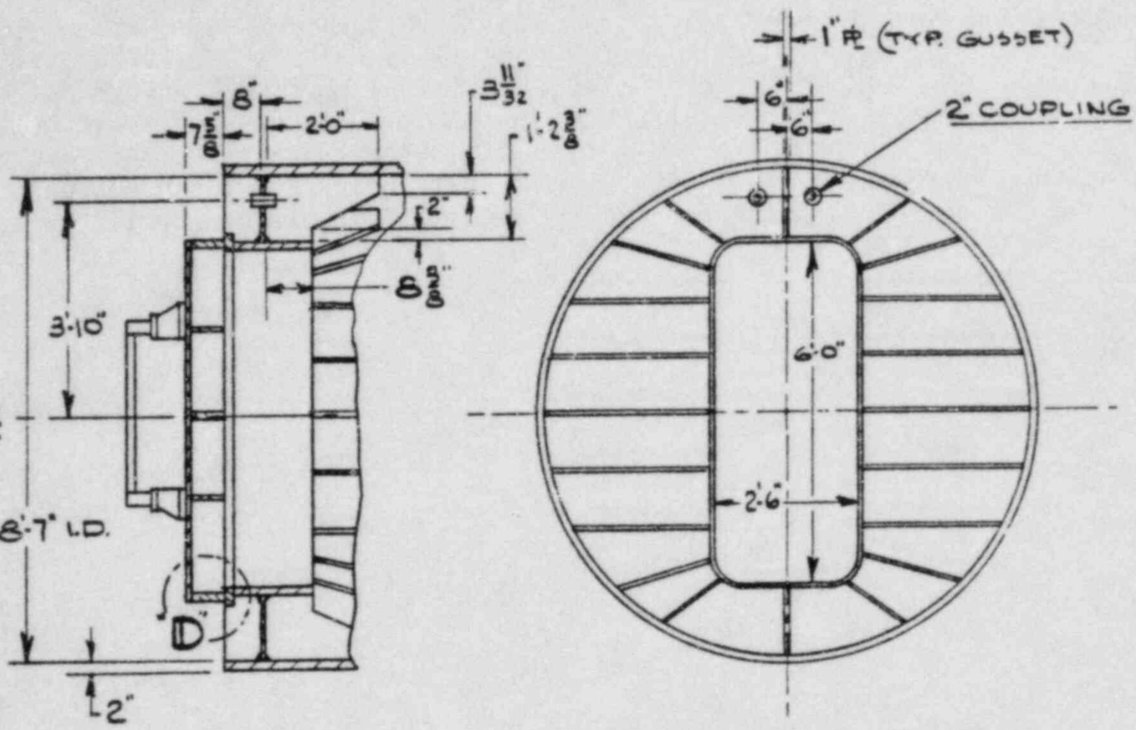
UNIT 1 FIG. 3 EQUIPMENT HATCH W/AIRLOCK
STEEL CONTAINMENT BWR MARK I
(SHT. #3 OF 4)



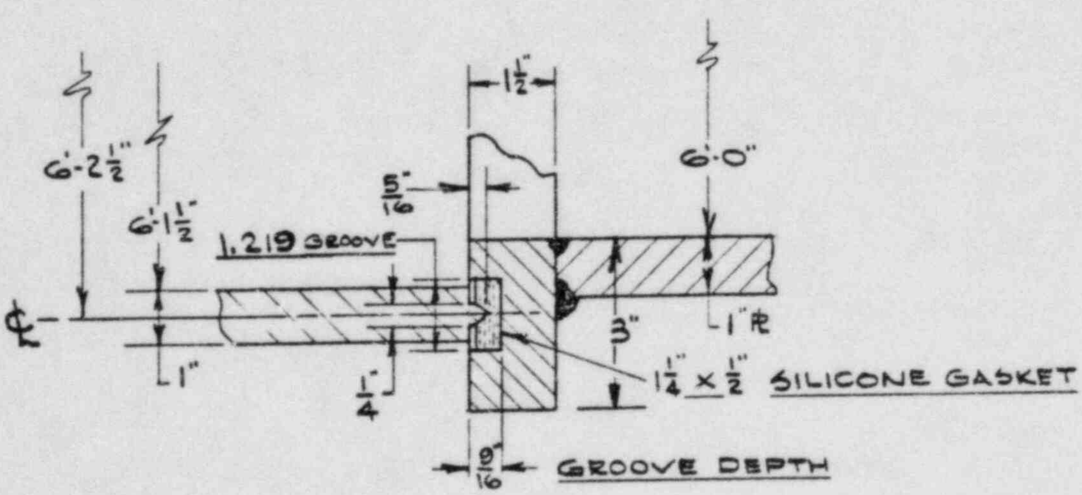


• DETAIL "C"

UNIT 1 FIG. 3 EQUIPMENT HATCH W/AIRLOCK
STEEL CONTAINMENT BWR MK. I
(SHT. #4 OF 4)



INTERIOR DOOR ASSEMBLY



•DETAIL "D"•

SURVEY DATA - STEEL CONTAINMENT BWR MARK I

UNIT 1 - EQUIPMENT HATCH

The equipment hatch provides a round clear opening in an insert plate installed in the spherical portion of the drywell. A sleeve that extends inwards and outwards, has been installed in this spherical insert plate. The equipment hatch opening is covered inside the drywell with a spherical shaped plate and pressure sealed at the edges with double tongue and groove gaskets to prevent leakage from the containment. The equipment hatch cover is held in position by 12 swing bolts mounted on the outer surface of the sleeve. The pressure inside the drywell provides the seating force for the equipment hatch seal. The equipment hatch dimensions and seal information are listed below.

Equipment Hatch	Unit 1, Figure 4
Clear opening	12 ft. 0 in.
Cover thickness	3 in.
Cover shape, spherical radius	9 ft. 6 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Insert Plate	
Thickness	1 3/4 in.
Chord length @ spherical radius of 31 ft. 6 in.	14 ft. 8 3/4 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Sleeve	
Internal diameter	12 ft. 0 in.
Thickness	3 1/2 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Gasket Type	
Gasket type	Double tongue & groove
Cross-section	Rectangular 3/4 in. wide x 1/2 in. thk
Length, inner	38 ft. 3 11/16 in.
Length, outer	38 ft. 10 1/16 in.
Material	Silicone rubber to MS-556B
Swing Bolts	
Number	12
Type	Eyebolt
Diameter	1 1/4 in.
Material	SA-320 (MS-505B)
Nuts	
Number	12
Type	Heavy hex with 8 UN thread
Diameter	1 1/4 in.
Material	SA-194 GR4 (MS-511B)

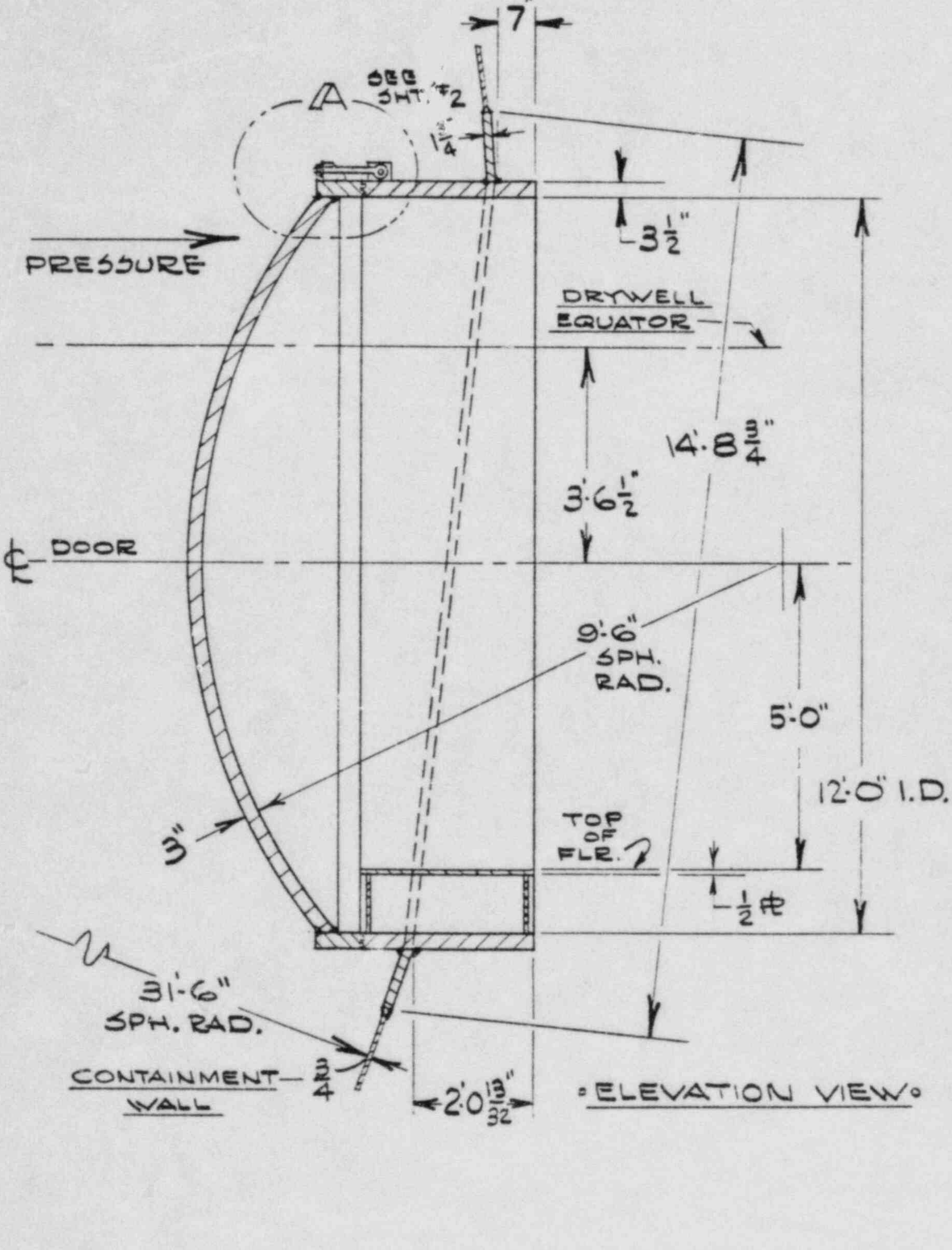
Pins

Number	12
Diameter	1 1/2 in.
Material	SA-M337 (MS-529B)

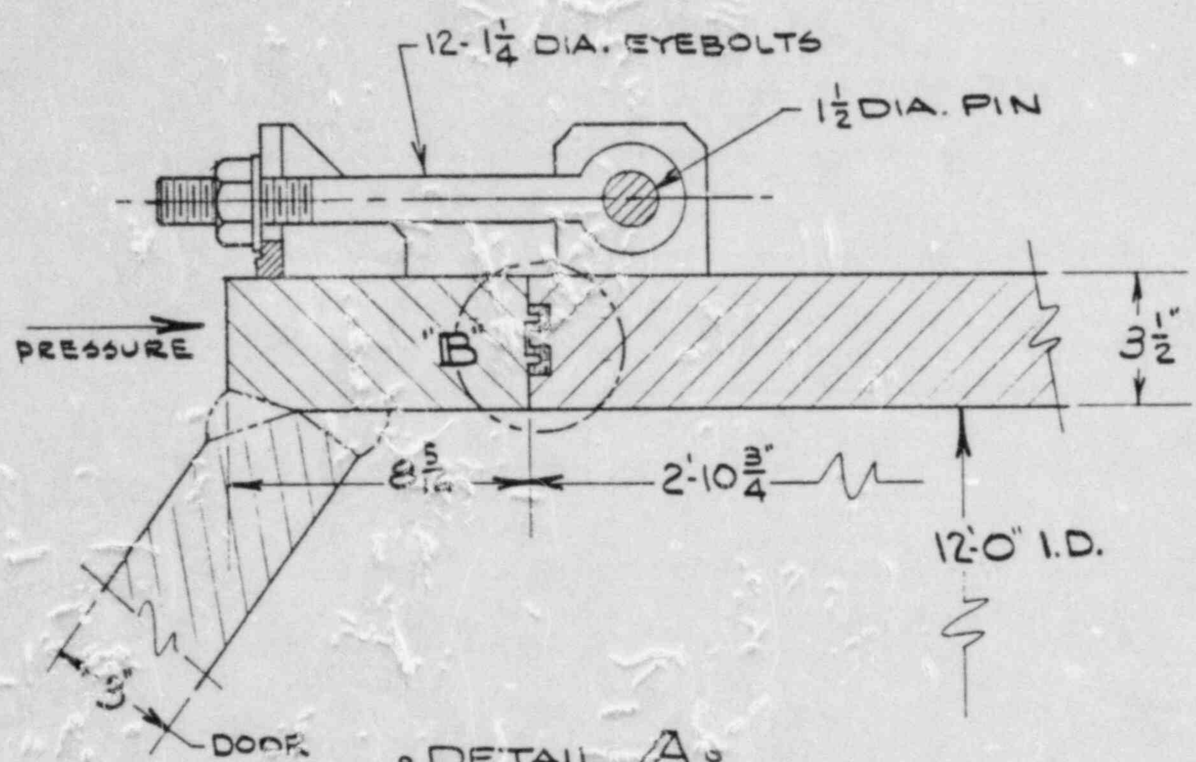
Location of Hatch

Hatch centerline elev.	762 ft. 6 in.
Hatch centerline azimuth	315°

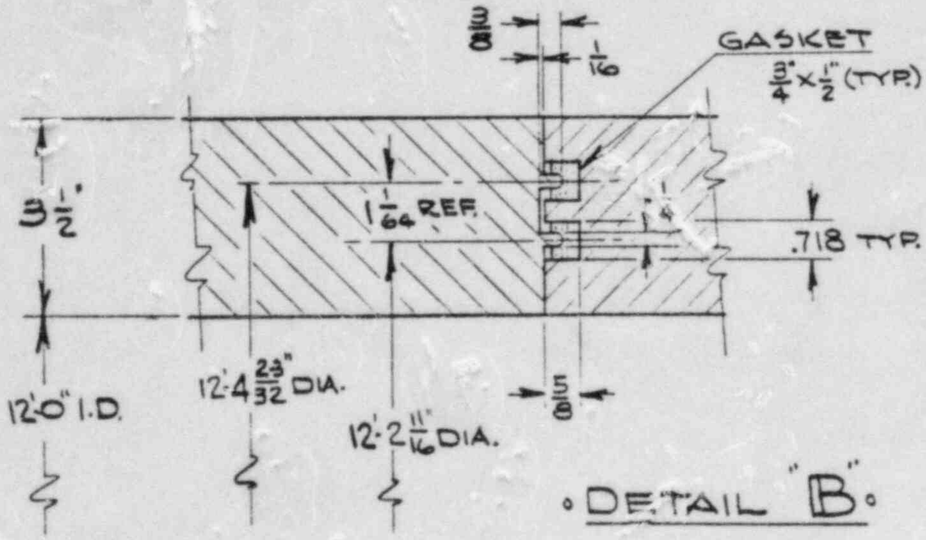
UNIT I FIG. 4 EQUIPMENT HATCH
STEEL CONTAINMENT BWR MARK I
(SHT. #1 OF 2)



UNIT I FIG. 4 EQUIPMENT HATCH
STEEL CONTAINMENT BWR MARK I
(SHT. #2 OF 2)



• DETAIL A •
(SEE SHT. #1)



• DETAIL "B" •

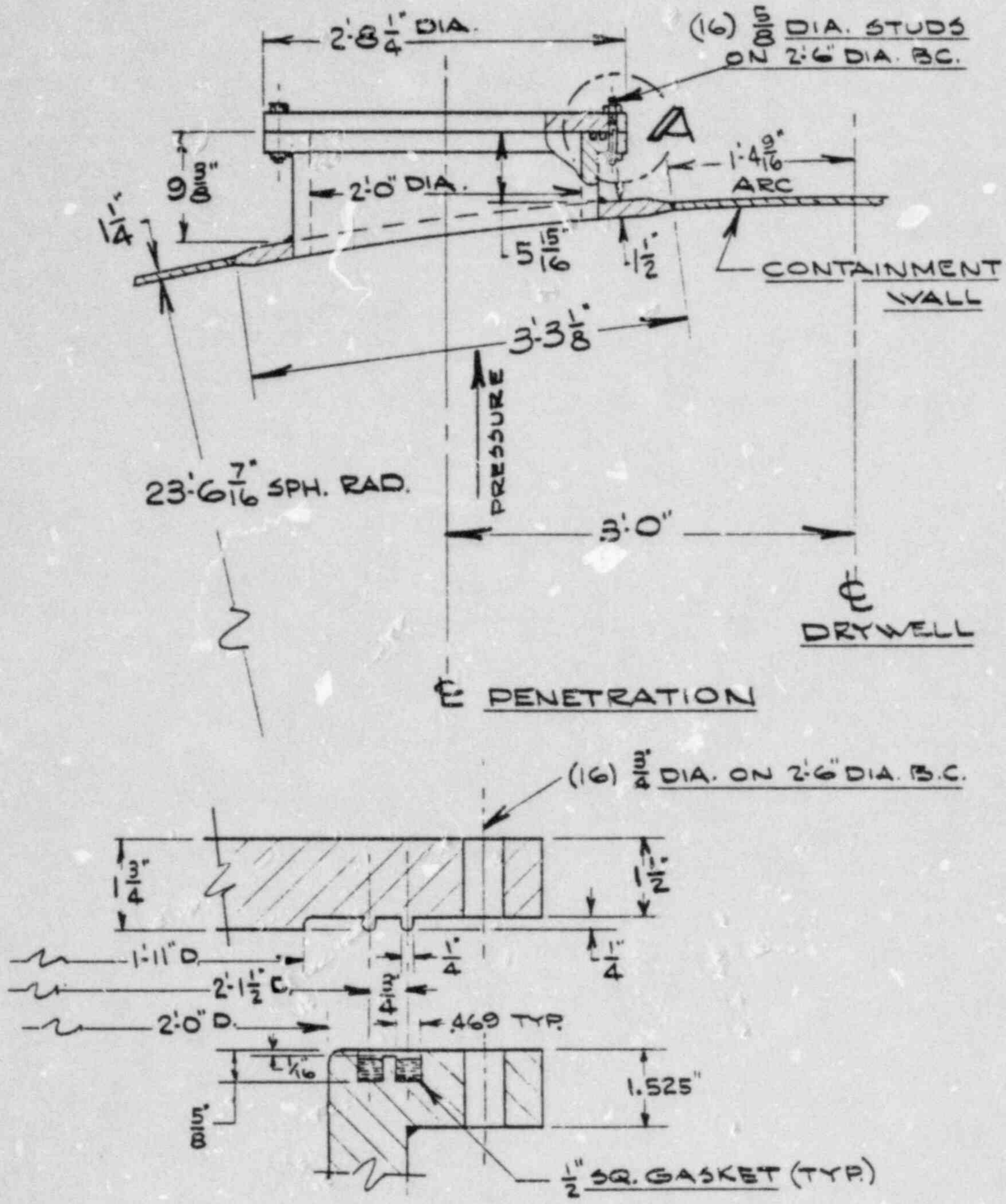
SURVEY DATA - STEEL CONTAINMENT BWR MARK I

UNIT 1 - DRYWELL HEAD ACCESS HATCH

The drywell head access hatch provides a round clear opening in the drywell head. A sleeve passing vertically through the drywell head is welded to a spherical insert plate installed in the drywell head. The outer end of this sleeve is a flanged ring with double grooves. The access hatch opening is covered with a round cover plate and pressure sealed with double tongue and groove gaskets to prevent leakage from the drywell. The access hatch cover is held in position by studs w/ nuts which provide the necessary pressure to form a seal. The drywell head access hatch dimensions and seal information are listed below.

Access Hatch	Unit 1, Figure 5
Clear opening	24 in.
Cover thickness	Varies 1 1/2 in to 1 3/4 in.
Cover shape, outer diameter	32 1/4 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Sleeve	
Inner diameter	24 in.
Thickness	1 1/2 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Insert Plate	
Thickness	Varies 1 1/2 in. to 1 1/4 in.
Spherical radius	23 ft. 6 3/8 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Gasket	
Type	Double tongue & groove
Cross-section	Square 1/2 in. wide x 1/2 in. thk
Length, inner	6 ft. 8 in.
Length, outer	7 ft. 0 10/16 in.
Material	Silicon garlock #8364 (MS-556B)
Studs	
Number	16
Diameter	5/8 in.
Material	SA 193 GRB7 (MS-529B)
Nuts	
Number	32
Type	Heavy SF Hex
Material	SA-194 GR4 or 7 (MS-511B)
Location of Hatch	
Hatch centerline elev.	Located in top head
Hatch centerline azimuth	270° (3 ft. 0 in. from of drywell)

UNIT I FIG. 5 DRYWELL HEAD ACCESS HATCH
STEEL CONTAINMENT BWR MARK I



•DETAIL A•

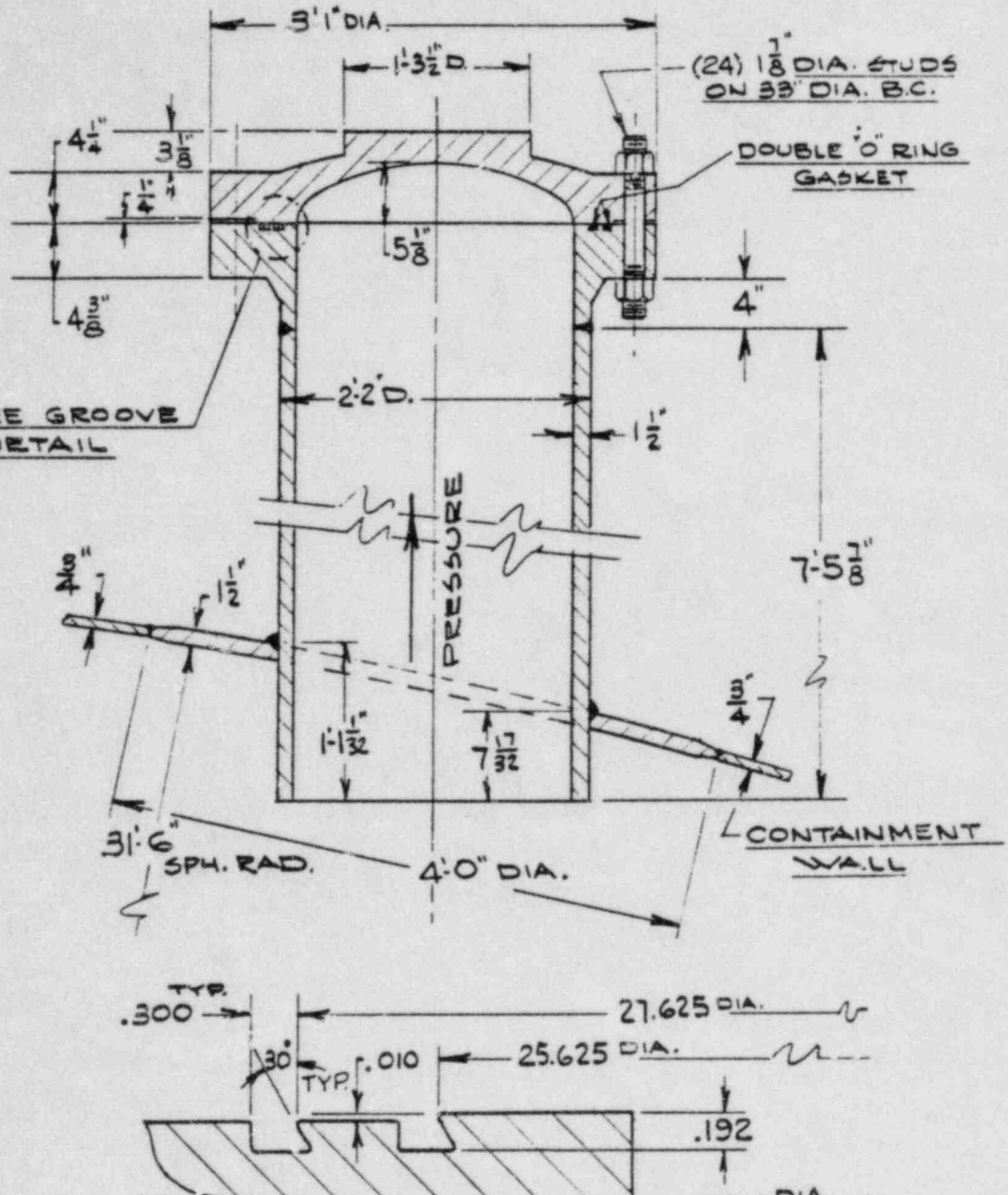
SURVEY DATA - STEEL CONTAINMENT BWR MARK I

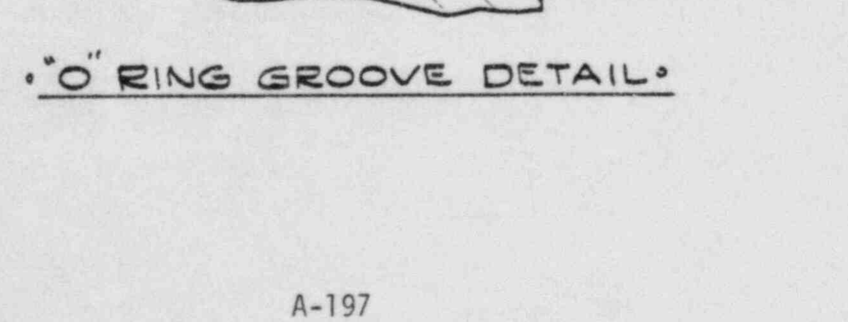
UNIT 1 - CRD REMOVAL HATCH

CRD removal hatch provides a round clear opening in the spherical portion of the drywell. A sleeve passing horizontally through the drywell is welded to a spherical reinforcing plate. The outer end of the sleeve is a flanged ring with double grooves. The hatch opening is covered with a round flanged cover plate and pressure sealed with double "O" rings seal to prevent leakage from the drywell. The hatch cover is held in position by 24 studs with nuts which provide the necessary pressure to form a seal. A davit arm assembly has been installed on the outer surface of the sleeve to facilitate opening and closing of the hatch cover. The CRD removal hatch dimensions and seal information are listed below.

Removal Hatch	Unit 1, Figure 5
Clear opening	23 in.
Cover thickness	Varies 4 1/4 in to 1 3/8 in.
Cover shape, outer diameter	37 in.
Material	SA 350 LFI (MS-543B)
Sleeve	
Inner diameter	23 in.
Thickness	1 1/2 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Sleeve Flange	
Inner diameter	23 in.
Outer diameter	37 in.
Thickness	4 3/8 in.
Material	SA-350 LFI (MS-543B)
Gasket	
Type	Double "O" rings
Cross-section, diameter	0.275 in.
Diameter, inner gasket	25.5 in.
Diameter, outer gasket	27.485 in.
Material	Parker silicone compound S 418-6 (Parker #5170)
Studs	
Number	24
Diameter	1 7/8 in.
Material	SA-193 GRB7 (MS-529B)
Nuts	
Number	48
Type	Heavy SF Hex
Material	A 194 GR 4 or 7 (MS-511B)
Location of Hatch	
Hatch centerline elev.	759 ft. 6 in.
Hatch centerline azimuth	249° 30'

UNIT 1 FIG. 6 CRD REMOVAL HATCH
STEEL CONTAINMENT BWR MK. I





• "O" RING GROOVE DETAIL •

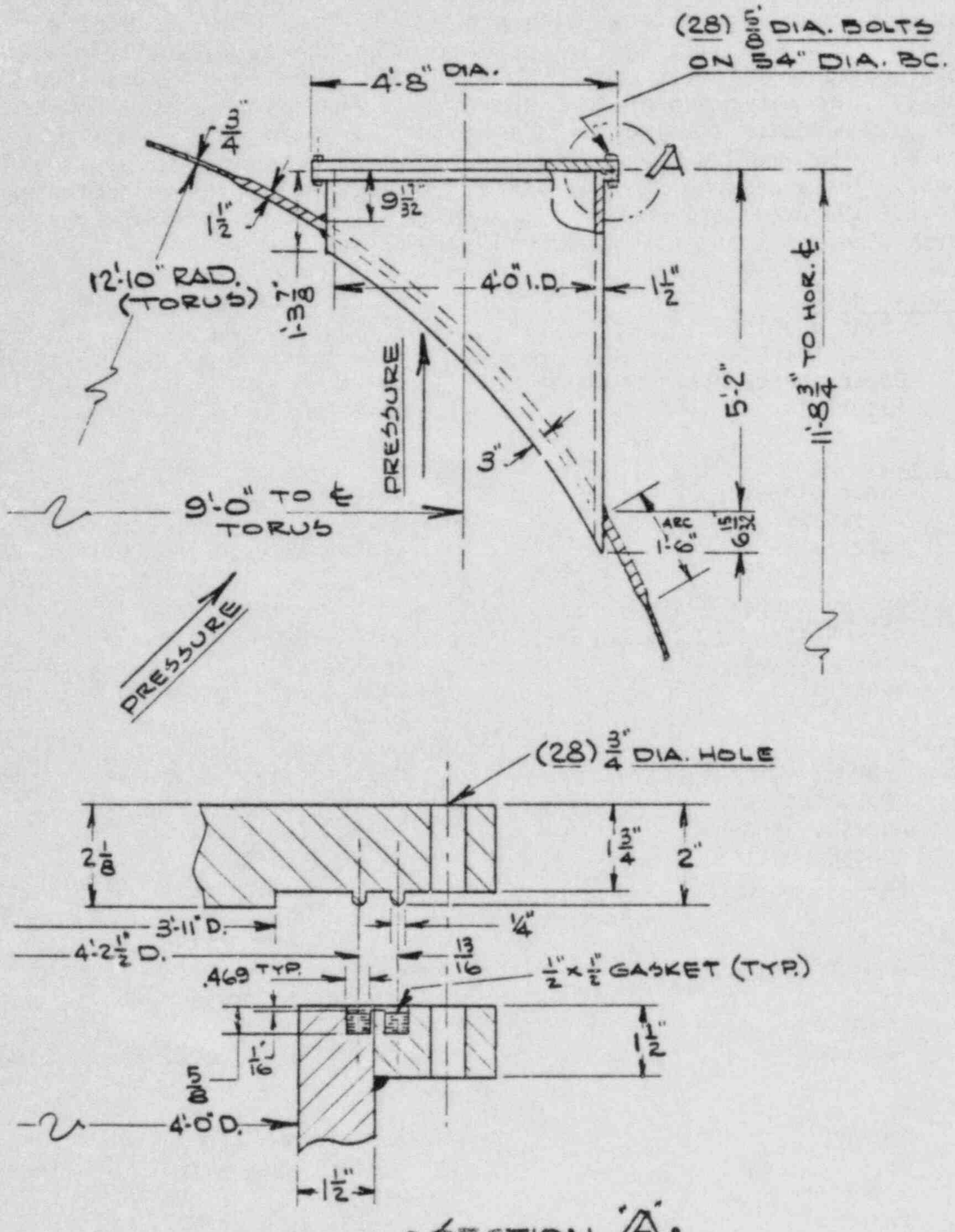
SURVEY DATA - STEEL CONTAINMENT BWR MARK I

UNIT 1 - SUPPRESSION CHAMBER ACCESS HATCHES

Their are two identical access hatches in the torus shell, 180° apart. The suppression chamber access hatch provides a round clear opening in the torus shell. A sleeve passing vertically through the torus shell is welded to a reinforcing insert plate rolled to the torus radius and welded into the torus shell. The outer end of this sleeve is a flanged ring with double grooves. The access hatch opening is covered with a round cover plate and pressure sealed with double tongue and groove gaskets to prevent leakage from the torus. The access hatch cover is held in position by 28 bolts with nuts which provide the necessary pressure to form a seal. The suppression chamber access hatch dimensions and seal information are listed below.

Access hatch	Unit 1, Figure 7
Clear opening	48 in.
Cover thickness	Varies 2 1/8 in to 1 3/4 in.
Cover shape, outer diameter	56 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Sleeve	
Inner diameter	48 in.
Thickness	1 1/2 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Reinforcing Insert Plate	
Thickness	1 1/2 in.
Plate radius	12 ft. 10 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Gaskets	
Type	Double tongue & groove
Cross-section	Square, 1/2 in. wide x 1/2 in thk
Length, inner	13 ft. 2 21/32 in.
Length, outer	13 ft. 7 3/4 in.
Material	Silicone Garlock #8364 (MS-556B)
Bolts	
Number	28
Type	Fin Hex bolts with UNC-2A thread
Diameter	5/8 in.
Material	SA-193 GRB7 (MS-529B)
Nuts	
Number	28
Type	Fin Hex nuts with UNC-2B thread
Diameter	5/8 in.
Material	SA-194 GR 4 or 7 (MS-511B)
Location of Hatch	
Hatch centerline elev.	741 ft. 6 11/16 in.
Hatch centerline azimuth	74° 50', 254° 50'

UNIT I FIG.7 SUPPRESSION CHAMBER ACCESS HATCH
STEEL CONTAINMENT BWR MARK I



• SECTION "A" •

SURVEY DATA - STEEL CONTAINMENT BWR MARK 1

UNIT 1 - VENT PIPES

Large vent pipes connect the drywell and the pressure suppression chamber. A total of 8 circular vent pipes are provided. These vent pipes are continuous from the drywell shell to the suppression chamber header. The vent pipes are provided with two ply expansion bellows to accommodate differential motion between the drywell and the suppression chamber. The drywell vent pipes are connected to vent header in the form of a torus which is contained within the air space of the suppression chamber. Projecting downward from the header are downcomer pipes which terminate not less than 4 feet below the water surface of the pool.

Each vent line starts from the drywell shell in the form of a short straight sleeve welded to an insert plate shaped to the spherical radius of the drywell. This is further reinforced by a thick plate ring welded to the sleeve and the insert plate. The vent line further consists of spherical and conical pipe transition pieces welded to straight pipe which is finally connected to the header inside the torus.

The penetration of the vent line through the torus consists of a sleeve welded to a spherical insert plate installed at the shell. The sleeve encloses the vent pipe and is connected to the pipe through an expansion bellows unit at the outer end.

The expansion bellows unit consists of three spool pieces connected by two bellows elements. Each bellows element consists of 4 convolutions of 2 plys of stainless steel. The bellows elements are welded to the spool pieces at each end.

The vent pipe/sleeve assembly dimensions and expansion bellows unit information are listed below:

Drywell Insert Plate	Unit 1, Figure 8
Thickness	1 1/2 in.
Spherical radius	31 ft. 6 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Drywell Reinforcing Plate Ring	
Thickness	1 1/4 in.
Inside diameter	5 ft. 11 1/2 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Sleeve at the Torus	
Thickness	1 3/8 in.
Inside diameter	5 ft. 3 1/2 in.
Material	SA-516 GR70 to SA-300 (MS-504B)
Torus Insert Plate	
Thickness	1 in.
Spherical radius	12 ft. 10 in.
Material	SA-516 GR70 to SA-300 (MS-504B)

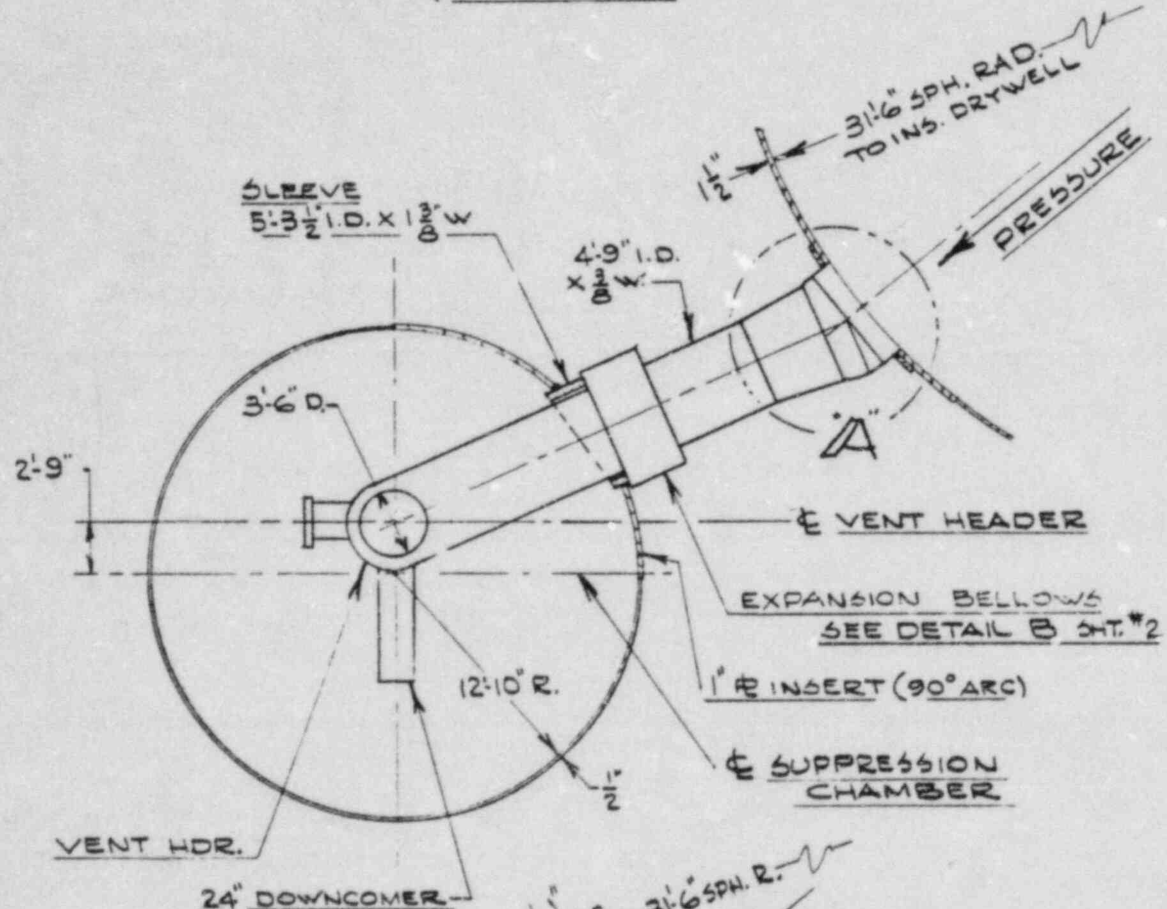
Expansion Bellows Unit

Size	64 in.
Make	Tube turns
Model	Series U, Cat. No. 64" U-W4-4W-C
Total unit length	38 5/8 in.
No. of spool pieces	3
Spool internal diameter	64 3/8 in.
Spool material	SA-516 GR70 to SA-300 (MS-504B)
No. of bellows elements	2
No. of convolutions in each bellows element	4
Convolution dimensions	2 in. deep x 1 1/2 in. wide
Element thickness	0. 078 in.
Element material	SA-240 TP 304 SS

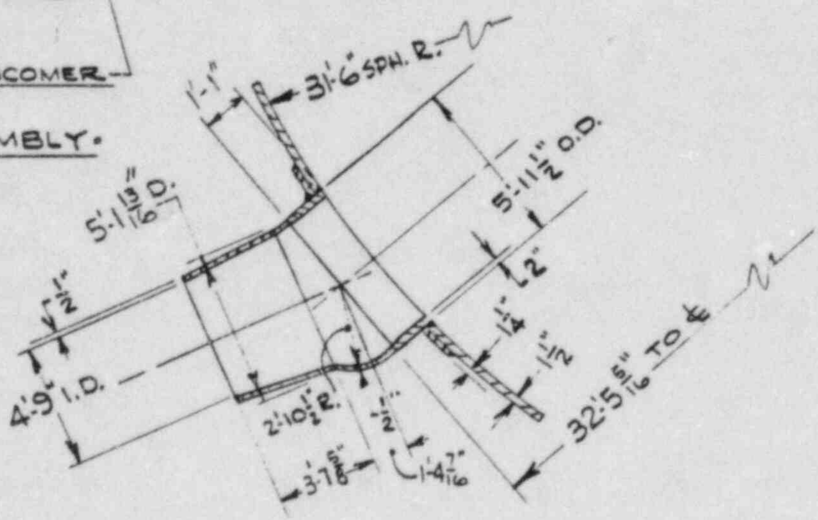
Vent Pipes Locations

Vent centerline elev. @ Drywell shell	746 ft. 3 in.
Vent centerline azimuth @ torus	22° 30', 67° 30', 112° 30', 157° 30' 202° 30', 247° 30', 292° 30', 337° 30'

UNIT 1 FIG. 8 VENT PIPE PENETRATIONS
STEEL CONTAINMENT BWR MK. I
(SHT. #1 OF 2)

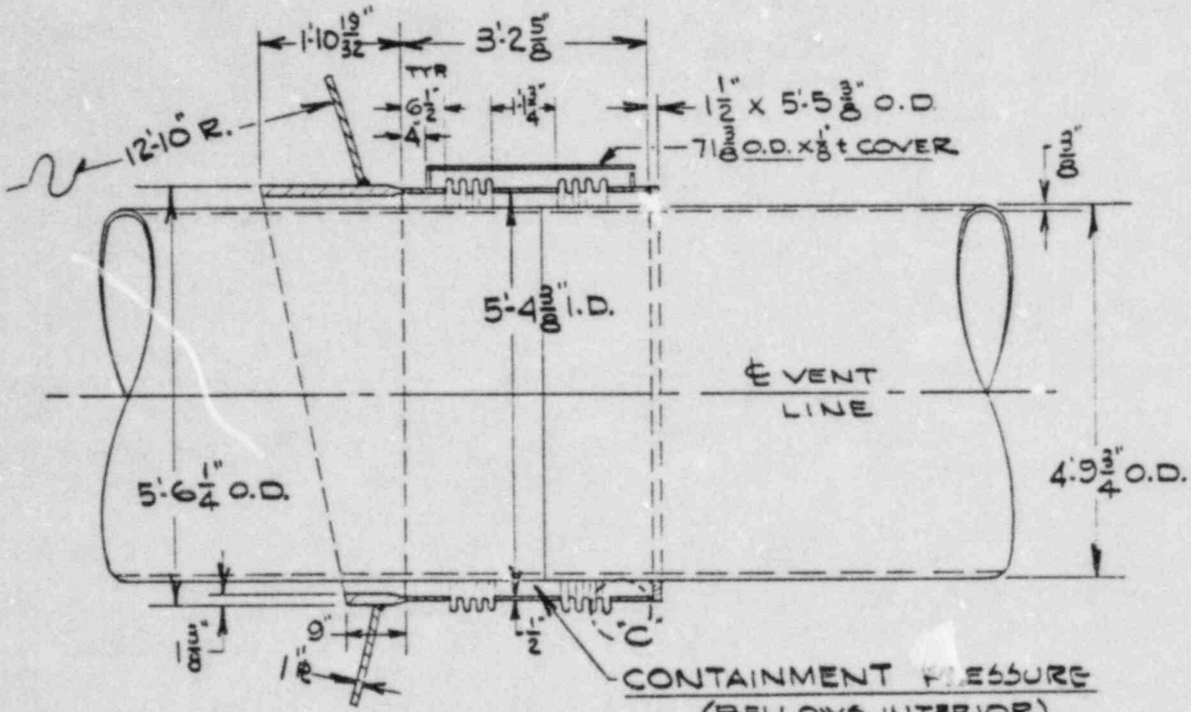


•VENT PIPE ASSEMBLY•

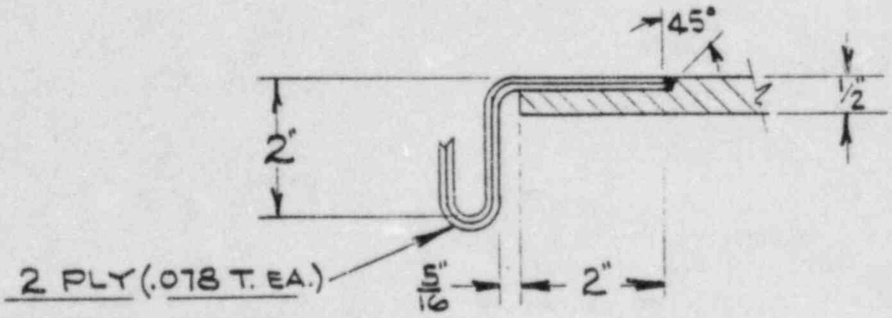


•DETAIL "A"•

UNIT 1 FIG. 8 VENT PIPE PENETRATIONS
STEEL CONTAINMENT BWR MARK I
(SHT. #2 OF 2)



• DETAIL "B" • (SEE SHT. #1)



• PARTIAL BELLOWS
DETAIL "C" •

SURVEY DATA - STEEL CONTAINMENT BWR MARK I

UNIT 1 - PROCESS PIPE PENETRATIONS WITH BELLOWS UNITS

This plant has a total of 15 process pipe penetrations which have expansion bellows to accommodate thermal movements between the pipe and the containment shell. These expansion bellows units serve as part of the primary containment.

The sketch indicates the details of a typical pipe penetration with bellows for one of the main steam lines. This penetration with bellows unit consists of the pipe at its outer end, being attached to a triple fluid head fitting as shown. A double expansion bellows unit at its outer end is attached to this multiple head fitting. The inner end of the bellows unit is welded to a penetration sleeve which is further welded to a thick reinforcing insert plate installed in the drywell. A guard pipe is installed between the process pipe and the bellows to prevent damage to the bellows in the unlikely event of process line rupture. The guard pipe is also attached at its outer end to the multiple head fitting. The process pipe is guided through pipe supports at the inner end of the penetration assembly to allow movement parallel to the penetration and to limit pipe reactions of the penetration to allowable stress levels. The sketch indicates an insert plate installed in the drywell shell. This insert plate is used for penetrations of four main steam lines, two feedwater lines and four other small process lines.

All the 15 expansion bellows units for the pipes were furnished by pathway and are all of the similar design. The major differences are the penetration sleeve diameters, the bellows element ply thickness, the lengths of the elements, the lengths of the center spool pieces, diameters of the bellows units and the number of convolutions in the bellows. All these characteristics of the 15 bellows units have been tabulated in Table 1.

Information on materials is listed below.

Insert Plate	Unit 1, Figure 9
Material	SA-516 GR70 to SA-300 (MS-504B)
Penetration Sleeve	
Material	SA-516 GR70 to SA-300 (MS-504B)
Expansion Bellows Unit	
Make	Pathway
Spool material (All excepting Reactor clean up, RCIC steam, Head spray)	SA-516 GR70
Spool material (RCIC steam, Head spray)	SA-106B
Spool material - inner end (Reactor clean up)	SA-358 TP304 CL.I
Spool material - center & outer ends	SA-106B
Element Material	SA-240T 304SS

Pipes Locations

Pipe Type	Centerline Elev. (Azimuth)
RCIC steam	775 ft. 9 in.
Reactor clean-up	800 ft. 0 in. (125°)
Header spray	800 ft. 0 in. (190°)
Core spray	800 ft. 0 in.
HPCI steam	774 ft. 0 in.
Main steam	762 ft. 10 in.
Feedwater	767 ft. 4 in.
RHR supply	761 ft. 9 1/2 in.
RHR return	761 ft. 9 1/2 in.

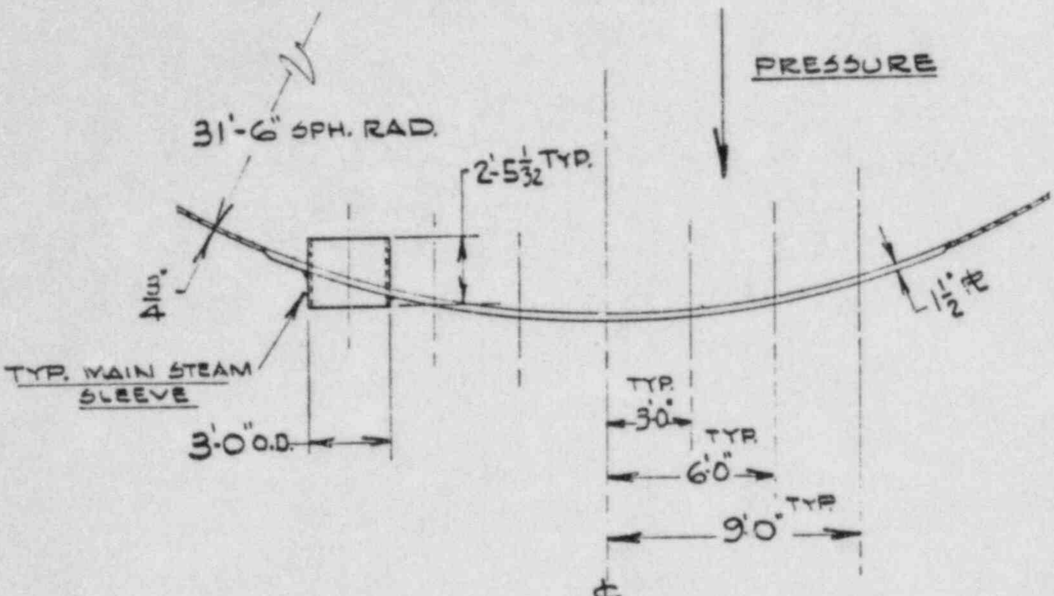
TABLE 1

BWR MARK I-UNIT 1
PROCESS-PIPING EXPANSION JOINTS

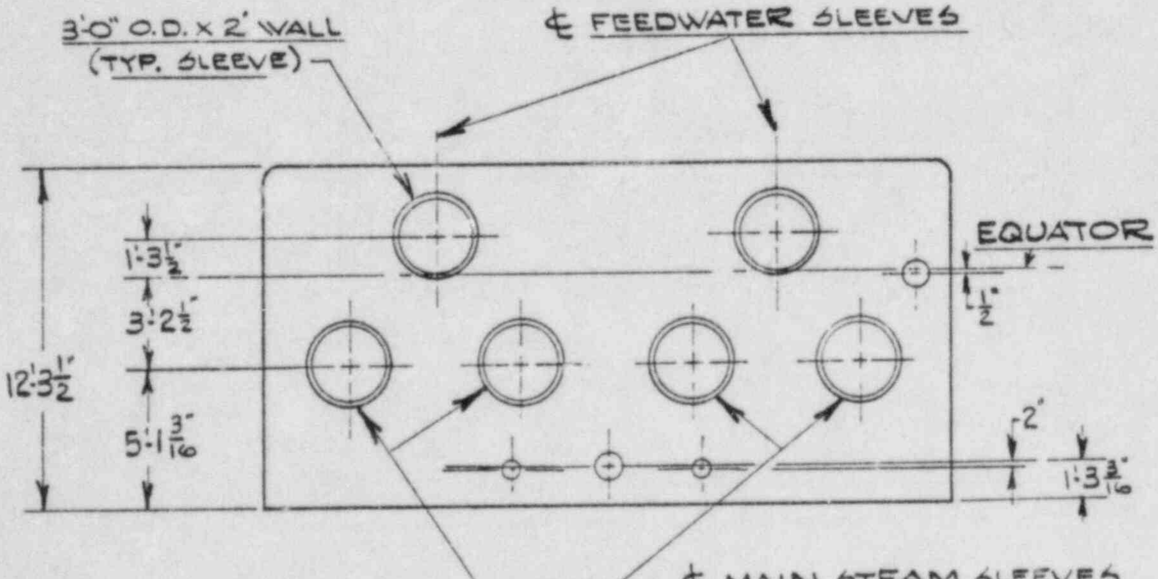
Process Pipe					Lengths		Diameters			
									Element	
(Qty)	Type	Nom. Dia.	No. of Conv. "N"	Ply thick. "t"	Cen. Spool "L_c"	Element "L_e"	Spool "D_a"	Bore "D_b"	"D_o"	"D_i"
(1)	RCIC Steam	4"	4	.050	26	3-7/8	18	17-1/2	19-1/2	17-1/4
(1)	Reactor Cleanup	4	3	.050	45	2-3/4	20	19-1/2	21-3/4	19-1/4
(1)	Head Spray	4	5	.050	24-3/4	4-7/8	20	19-1/2	21-3/4	19-1/4
(2)	Core Spray	8	8	.050	19	8	26	25-1/2	27-3/4	25-1/4
(1)	HPCI Steam	10	3	.050	34-3/8	2-3/4	28	27-1/2	29-3/4	27-1/4
(4)	Main Steam	20	4	.062	22	4	36	35-1/2	38	35-1/4
(2)	Feedwater	16	5	.062	18-3/4	5-1/8	36	35-1/2	38	35-1/4
(1)	RHR Supply	18	4	.062	22	4	36	35-1/2	38	35-1/4
(2)	RHR Return	20	4	.062	22	4	36	35-1/2	38	35-1/4

Note: All dimensions in inches.

UNIT I FIG.9 PIPE PENETRATIONS W/BELLOWS
STEEL CONTAINMENT BWR MARK I
(SHT. #1 OF 3)

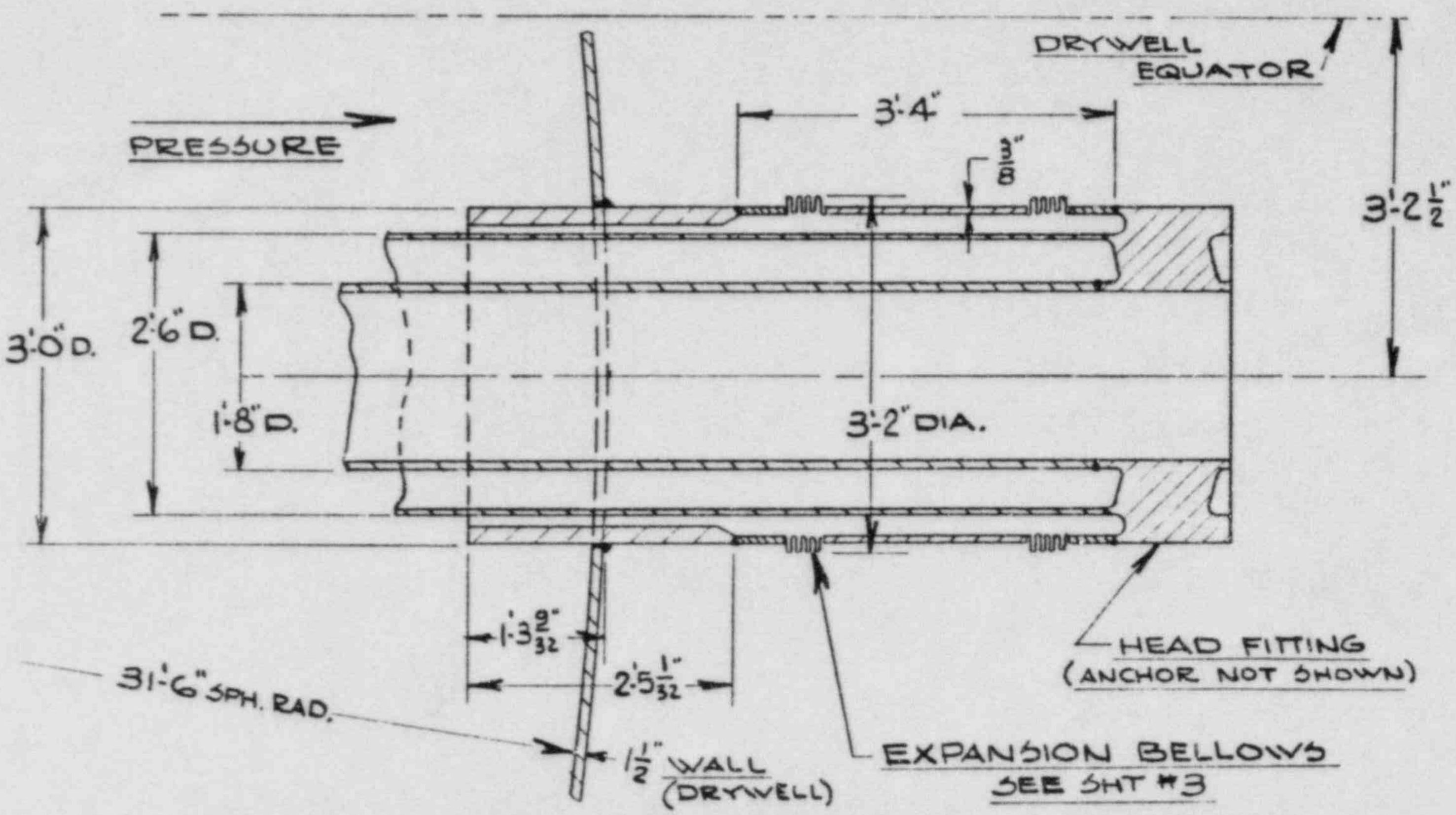


•PLAN VIEW•
(SEE FIG. 1)



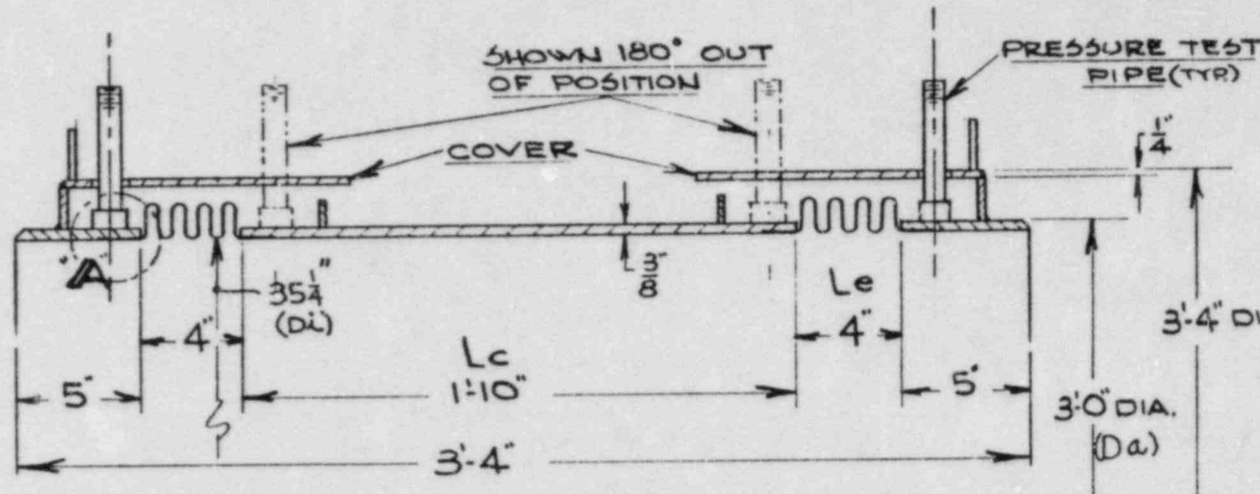
•MAIN STEAM/FEEDW. ER INSERT PLATE•

UNIT 1 FIG. 9 PIPE PENETRATIONS W/BELLOWS
STEEL CONTAINMENT BWR MARK I
(SHT. #2 OF 3)

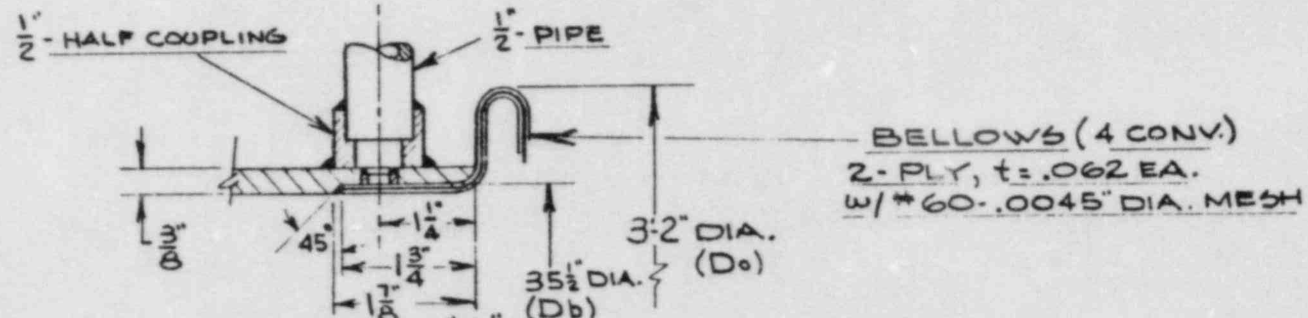


MAIN STEAMLINE PENETRATION

UNIT 1 FIG. 9 PIPE PENETRATIONS W/BELLOWS
STEEL CONTAINMENT BWR MARK I
(SHT. #3 OF 3)



EXPANSION BELLOWS UNIT
SEE SHT. #2 & TABLE 1



DETAIL "A"

UNITS 2 AND 3 - STEEL CONTAINMENT BWR MARK I

FSAR DESCRIPTION OF UNITS 2 AND 3 CONTAINMENT STRUCTURE

The primary containment system houses the reactor pressure vessel, the reactor coolant recirculation system and other branch connections of the reactor coolant system. The primary containment consists of a drywell, pressure suppression chamber (torus) and a connecting vent system between the drywell and the suppression chamber. Figure 1 is a simple configuration of a steel BWR Mark I.

The drywell is a steel pressure vessel in the shape of an inverted light bulb, with a spherical lower portion and a cylindrical upper portion. The top narrow cylindrical portion called the drywell head is made with a double tongue and groove seal which will permit periodic checks for tightness without pressurizing the entire vessel. The drywell head is removed during refueling operations. The head is bolted closed when primary containment integrity is required.

Dimensions of the containment structure are as follows:

Drywell	
Drywell head-diameter	34 ft. 8 in.
Cylindrical section-diameter	37 ft.
Spherical section-diameter	66 ft.
Drywell height (overall)	111 ft. 11 in.
Wall Plate Thickness	
Drywell top head	1-1/4 in. and 1-7/16 in.
Spherical section	varies 13/16 in. to 1-1/16 in.
Spherical shell to cylindrical neck	2-3/4 in.
Cylindrical section	varies 3/4 in. to 1-1/2 in.
Vent System	
Vent Pipes	
Number	8
Internal diameter	6 ft. 9 in.
Vent Header Internal Diameter	4 ft. 10 in.
Downcomer Pipes	
Number	96
Internal diameter	2 ft. 0 in.
Submergence below suppression pool water level	3.21 to 3.54 ft.
Pressure Suppression Chamber	
Chamber inner diameter	30 ft.
Torus major diameter	109 ft.

The primary containment is primarily fabricated of SA-212 GR B plates manufactured to A300 requirements. The drywell and the suppression chamber are both designed for an internal pressure of 56 psig coincident with a temperature of 281°F with applicable dead, live, and seismic loads imposed on the shell.

The drywell is enclosed in a reinforced concrete structure for shielding purposes. In areas where it backs up the drywell shell, this reinforced concrete provides additional resistance to deformation and buckling of the shell. Above the transition zone, and below the flange, the drywell is separated from the reinforced concrete by a gap of approximately 2 inches. Shielding over the top of the drywell is provided by removable, segmented, reinforced concrete shield plugs.

In addition to the drywell head, one double door personnel air lock, one bolted equipment hatch, one control rod drive removal hatch, and one bolted personnel drywell head access hatch are provided for access into the drywell.

The pressure suppression chamber is a steel pressure vessel in the shape of a torus located below and encircling the drywell. The pressure suppression chamber contains the suppression pool and the gas space above the pool. The suppression chamber is held on supports which transmit vertical and seismic loadings to the reinforced concrete foundation slab of the reactor building.

Large vent pipes connect the drywell and the presure suppression chamber. A total of 8 circular vent pipes are provided. The vent pipes are designed for the same pressure and temperature conditions as the drywell and the suppression chamber. The vent pipes are also fabricated of SA-212 GR B steel. The vent pipes are enclosed with sleeves and are provided with expansion joints to accommodate differential motion between the drywell and suppression chamber. The vent pipe bellows are designed and fabricated to the same criteria as the containment vessels.

The vent header in the suppression chamber has the same temperature and pressure design requirements as the vent pipes.

The double door personnel air lock on Units 2 and 3 is different from that of Unit 1 in regards to mounting arrangement of the lock assembly on the drywell. In Units 2 and 3, the personnel lock assembly is permanently welded to a sleeve installed in the drywell. Whereas in Unit 1, the lock assembly is bolted to an equipment hatch sleeve installed in the drywell. Thus, in Unit 1, the air lock assembly can be separated from the drywell whenever desired.

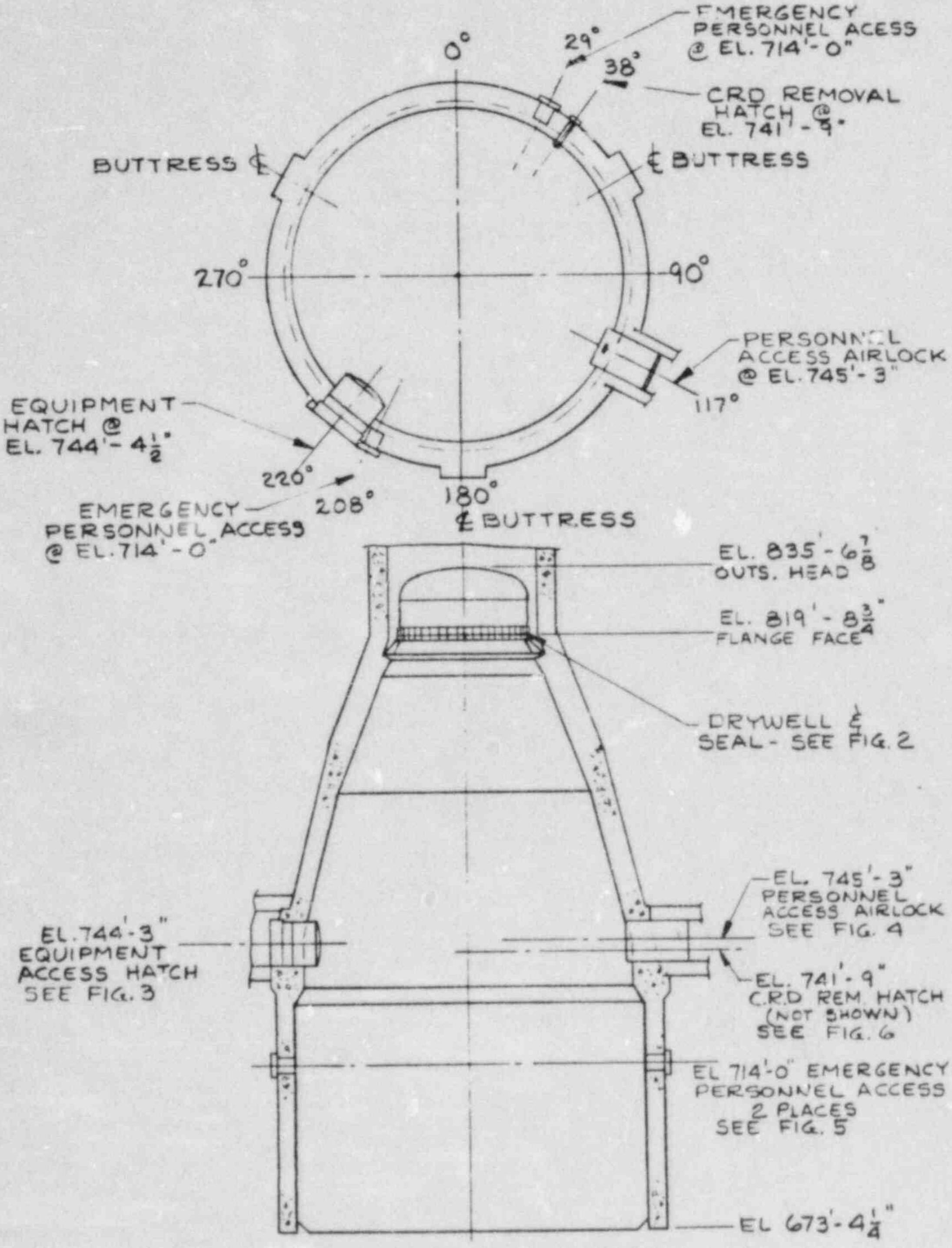
The drywell head access hatch on Units 2 and 3 is slightly different from that of Unit 1 in regards to the sleeve construction and the type of studs used to fasten the cover plate to the sleeve assembly.

The suppression chamber access hatch on Units 2 and 3 is similar to that of Unit 1 excepting that a Davit arm assembly arrangement has been provided on Units 2 and 3 to move the hatch cover plate.

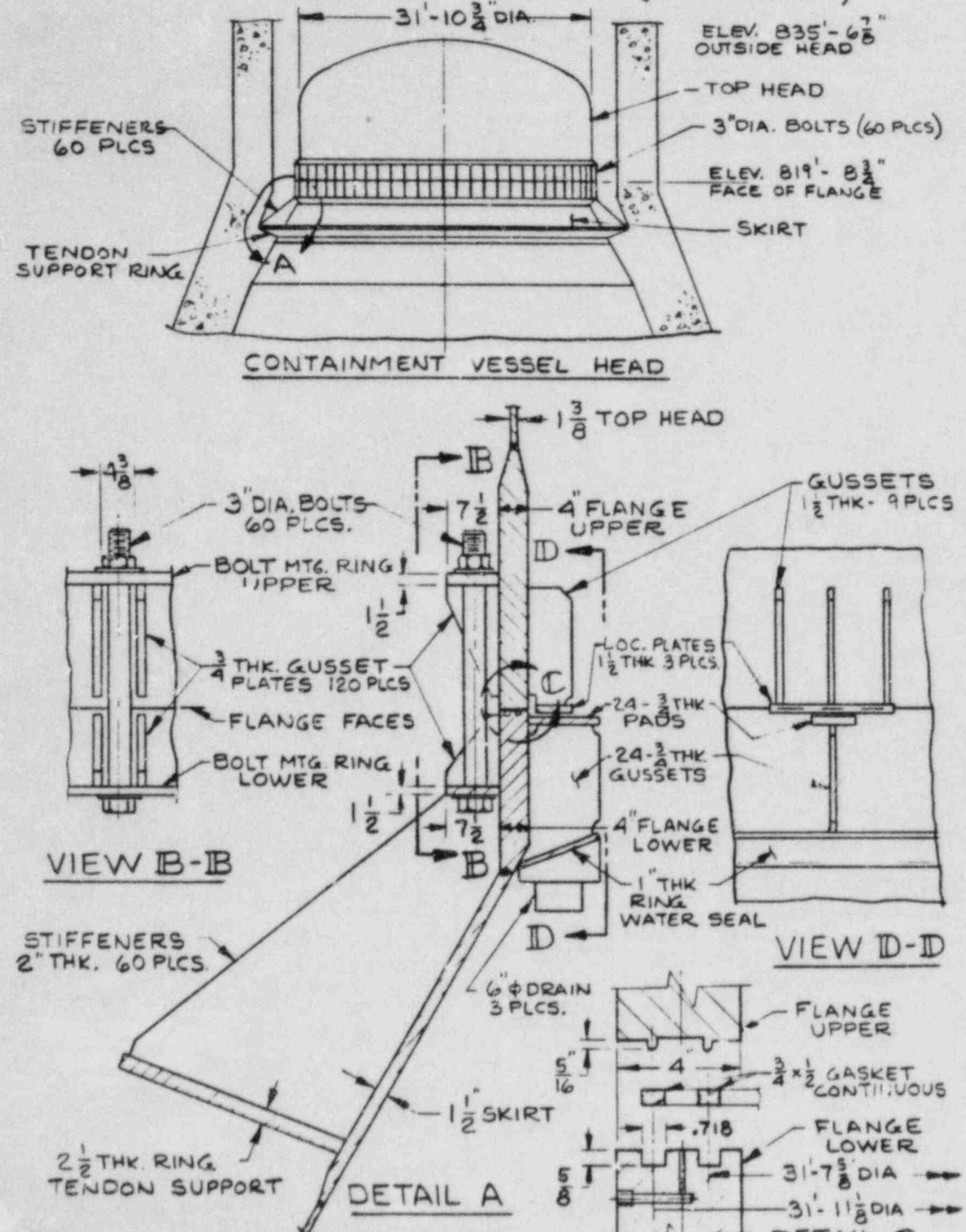
BWR MKII DATA SHEETS AND FSAR DESCRIPTION

To be included in August 1984 Report.

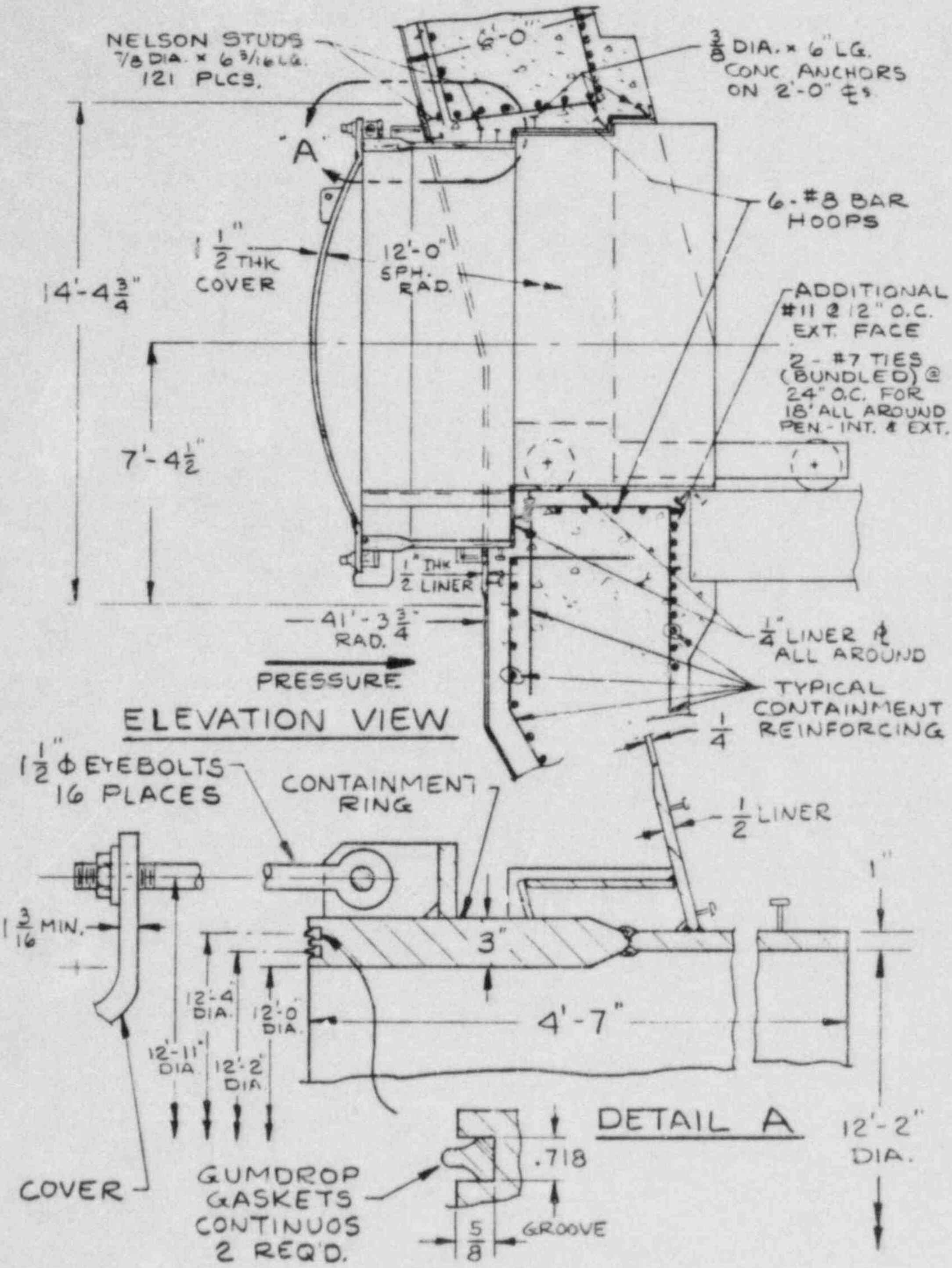
UNITS 1 & 2 FIG. 1 CONCRETE CONTAINMENT
BWR MARK II CONCRETE CONTAINMENT (STEEL LINER)



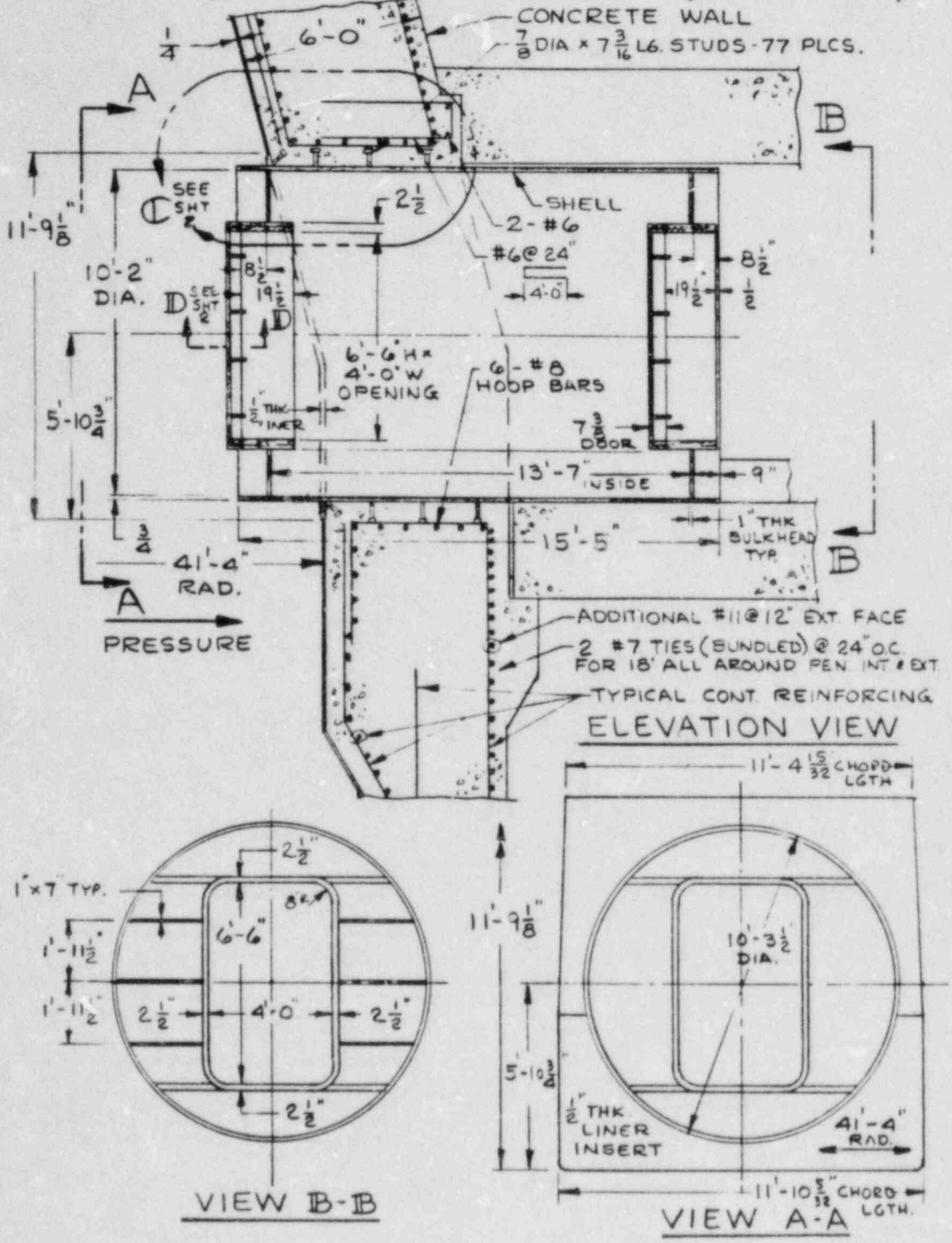
UNITS 1 & 2 FIG. 2 DRYWELL FLANGE & SEAL
BWR MARK II CONCRETE CONTAINMENT (STEEL LINER)



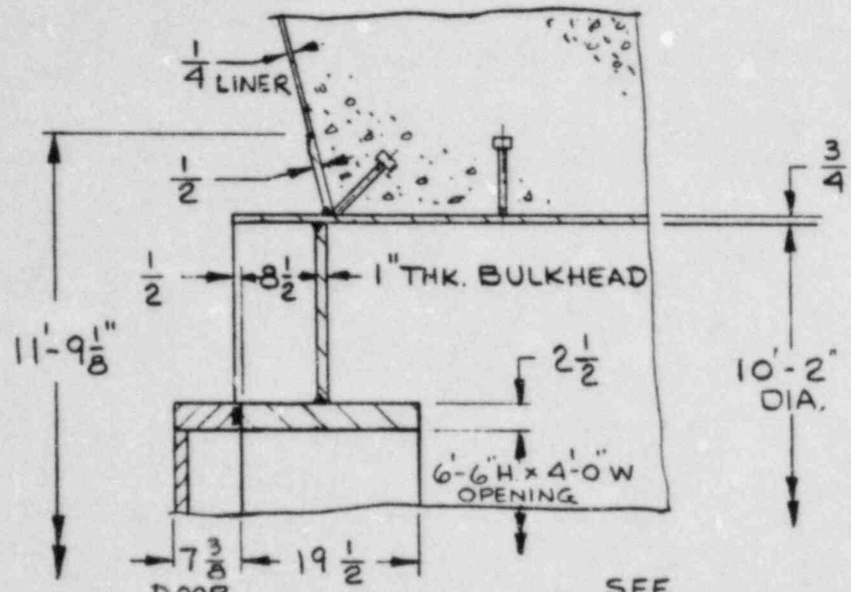
UNITS 1 & 2 FIG. 3 EQUIPMENT HATCH
BWR MARK II CONCRETE CONTAINMENT (STEEL LINER)



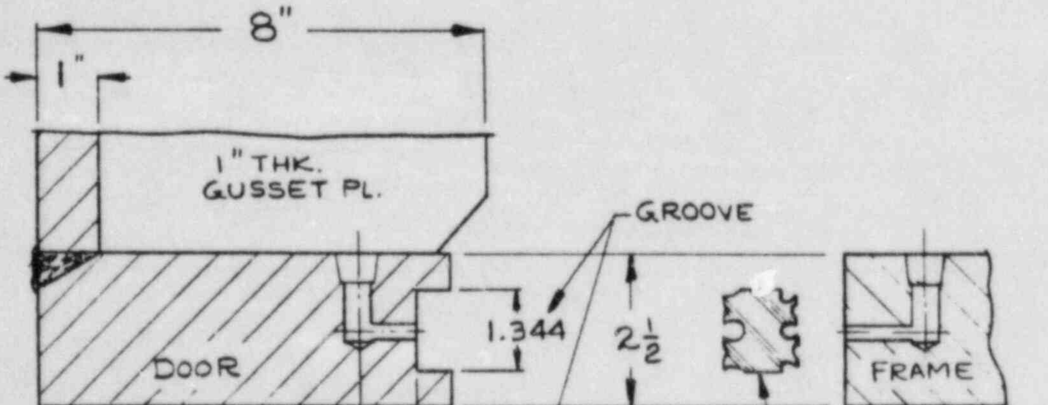
UNITS 1 & 2 FIG. 4 SHT. 1 OF 2 PERSONNEL AIRLOCK
BWR MARK II CONCRETE CONTAINMENT (STEEL LINER)



UNITS 1 & 2 FIG. 4 SHT. 2 of 2 PERSONNEL AIRLOCK
BWR MARK II CONCRETE CONTAINMENT (STEEL LINER)



DETAIL C SEE SHT. 1



SECT. D-D SEE SHT 1

UNITS 1 & 2 FIG. 5 PERSONNEL ACCESS HATCH
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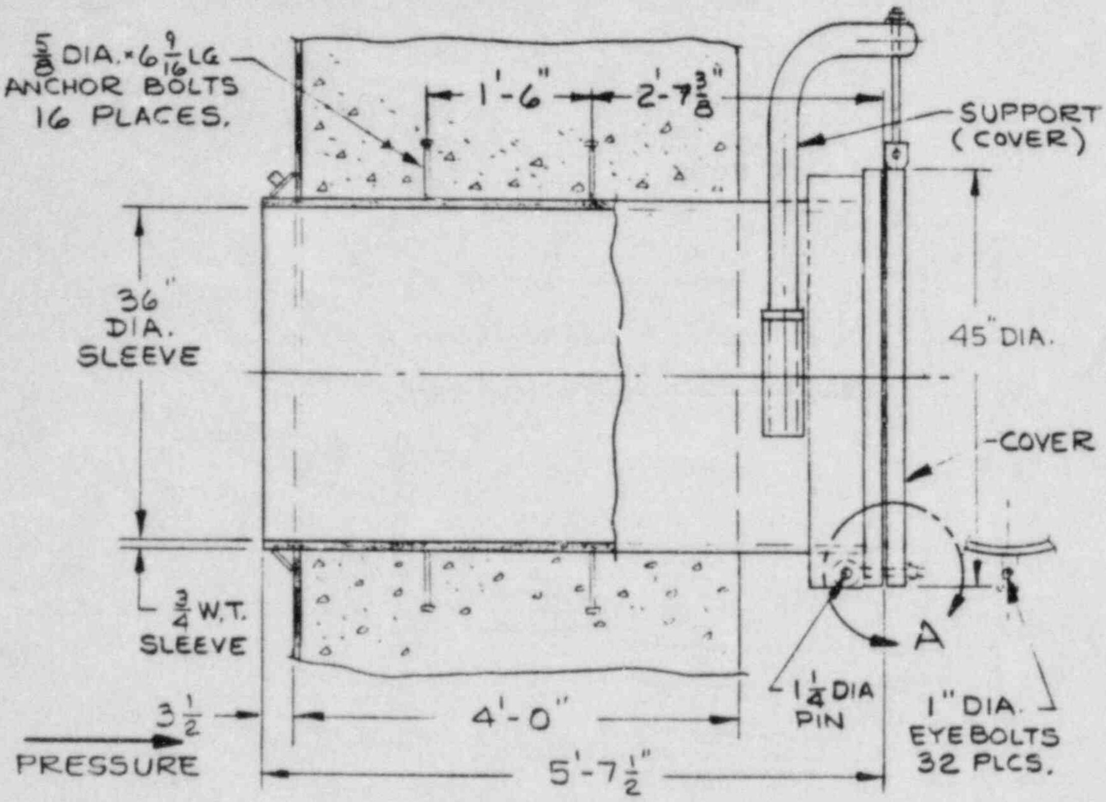
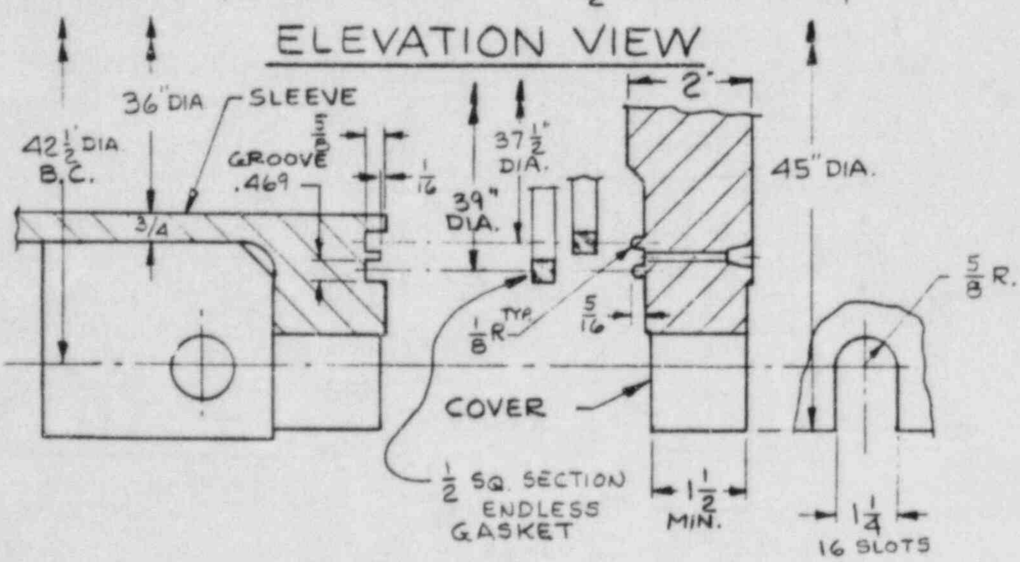
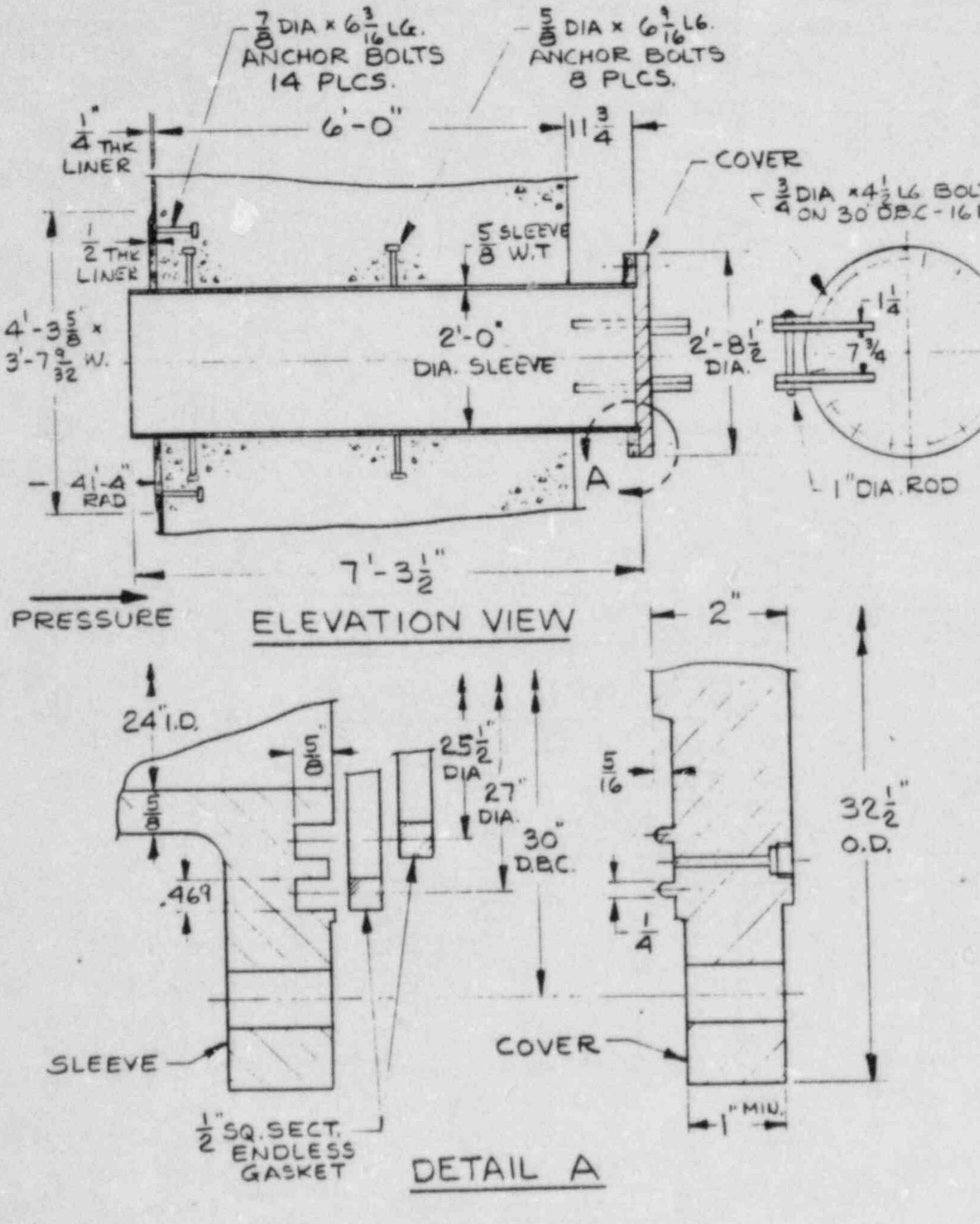


ELEVATION VIEW



DETAIL A

UNITS 1&2 FIG. 6 CONTROL ROD REMOVAL HATCH
CONCRETE CONTAINMENT (STEEL LINER)



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This report summarizes the survey work conducted by Argone National Laboratory on the design and details of major penetrations in 22 nuclear power plants. The survey includes all containment types and materials in current use. It also includes details of all types of penetrations (except for electrical penetration assemblies and valves) and the seals and gaskets used in them. The report provides a test matrix for testing major penetrations and for testing seals and gaskets in order to evaluate their leakage potential under severe accident conditions.

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