DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

June 14, 1988

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Subject: Catawba Nuclear Station, Units 1 and 2
Docket Nos. 50-413 and 50-414
NRC Request for Additional Information on
Performance Testing of Relief and Safety Valves

Gentlemen:

Dr. K. N. Jabbour's letter of July 31, 1987 transmitted a request for additional information regarding the performance testing of relief and safety valves (Item II.D.1 of NUREG-0737). These questions were based on Duke Power Company submittals dated October 26, 1983 and February 3, 1984. Duke Power provided responses to all questions other than Question No. 8 per my April 29, 1988 letter. Please find attached the response to Question No. 12 which was inadvertently left out of the April 29, 1988 submittal. A response to Question No. 8 was transmitted per my May 31, 1988 letter.

Very truly yours,

J W Hampton, for

Hal B. Tucker

JGT/32/sbn

xc: Dr. J. Nelson Grace, Regional Administration
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

Mr. P. K. Van Doorn
NRC Resident Inspector
Catawba Nuclear Station

A046
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Question 12(a):

Provide a detailed description of the methods used to perform the structural analysis. Identify the computer programs used for the analysis and how these programs were verified. The verification effort should include comparisons to EPRI/CE data or another benchmarked code.

RESPONSE:

Catawba Units 1 & 2

The structural analysis of the piping was performed using the SUPERPIPE computer program. Static Loads are analyzed by the direct stiffness method. A stiffness matrix is derived from the geometry of the piping and its components. Gravity loads and other distributed loads are included exactly by the program. In static analysis for thermal expansion considerations, hot and cold temperatures are specified and the program automatically determines the coefficients of expansion by interpolation of material property tables. Static analysis load cases considered in the analysis include effects for gravity, thermal, and seismic anchor movements.

The dynamic analysis consisted of a response spectrum analysis for seismic inertia loads and a force time history analysis for the valve discharge. For the response spectrum analysis, 1% damping and the grouping method for modal combination was used. Mass point spacing is explained in Question 12B.

Direct integration force time history analysis was used for evaluation of S/RV discharge events. In the direct integration analysis, the damping matrix is given as:

$$[c] = \alpha [m] + \beta [k]$$

in which,

[m] = Mass Matrix
[k] = Stiffness Matrix
α, β = Factors which control the amount of damping

The SUPERPIPE program required that two frequencies (F_1, F_2) and two corresponding damping ratios (λ_1, λ_2) be specified where:

F_1, F_2 = Lower and upper response frequencies of the piping system.

λ_1, λ_2 = Corresponding damping ratios to frequencies F_1 and F_2.

In the analysis, a damping ratio of .0. at 10 HZ and 100 HZ were specified.

Computer Programs used in Piping Analysis and Pipe Support Design:

a) Program: SUPERPIPE

Author: Impell Corporation (formally EDS Nuclear, Inc.)
455 North Wiget Lane
Walnut Creek, California 94598

Description: SUPERPIPE is a computer program for the structural analysis and code compliance evaluation of piping systems, with particular emphasis on Class 1, 2, and 3 nuclear power piping designed to meet the requirements of the ASME Boiler and Pressure Vessel Code, Section III.

Verification: The SUPERPIPE program has been bench-marked against the EDS program PISOL, NUPIPE, and PIPESD. This program has been verified by bench-marking to an ASME sample problem, by comparison to detailed analysis performed manually, by comparison to results achieved using similar programs, as described above, and by comparison to results achieved using the previous version of SUPERPIPE. The bench-mark problems specified in NUREG CR-1677 have been evaluated using this program and the results have been transmitted to the NRC.

The thermal-hydraulic analysis for the Catawba SRV qualification was performed using RELAP5/MOD1 CYCLE 14. EPRI report NP-2479, "Application of RELAP5/MOD1 for calculation of Safety and Relief Valve Discharge Piping Hydrodynamic Loads", released in December 1982, confirmed the applicability of RELAP5/MOD1 for the analysis of pressurizer relief line discharge loads. A post-processor called REFORC converted the hydrodynamic transient data into a force-time history format for input into the SUPERPIPE computer program.

Code: MCAUTO STRUDL

Author: McDonnel Douglas Architectural Engineering and Construction Co.
Box 516
St. Louis, MO 63166

Description: Large scale general purpose finite element program for structural analysis.

Extent and Limitation of its application: MCAUTO STRUDL is used to perform static elastic analysis of pipe supports.

Verification: MCAUTO STRUDL has been verified by comparison of the results with either hand calculations, closed form solutions found in standard text books or solutions from other programs.

Code: GTSTRUDL

Author: GTICES Systems Laboratory
Department of Civil Engineering
Georgia Institute of Technology
Atlanta, GA 30332

Description: Large scale general purpose finite element program for structural analysis.

Extent and Limitation of its application: GTSTRUDL is used to perform static elastic analysis of pipe supports.

Verification: GTSTRUDL has been verified by comparison of the results with either hand calculations, closed form solutions found in standard text books or solutions from other programs.

Code: BASEPLATE

Author: Jeff Swanson
Design Associates International
4105 Lexington Avenue North
Arden Hills, MN 55112

Description: The program BASEPLATE is a preprocessor/postprocessor to the Stardyne Computer Code for the specific purpose of analyzing flexible baseplates.

Extent and Limitation of its application: The BASEPLATE program is used to analyze support baseplates.

Verification: Control Data Corporation has verified BASEPLATE in accordance with their quality assurance program utilizing a comparison of program results to hand calculations, published analytical results, or another program which has similar capabilities.

Code: BASEPLATE II

Author: Richard S. Holland
Ernst, Armand, and Botti Associates, Inc.
60 Hickory Dr.
Waltham, MA 02154

Description: The program BASEPLATE II is a preprocessor/postprocessor to the ANSYS and Stardyne Computer Code for the specific purpose of analyzing flexible baseplates.

Extent and Limitation of its application: The BASEPLATE II program is used to analyze support baseplates.

Verification: The Control Data Corporation has verified BASEPLATE II in accordance with their quality assurance program utilizing a comparison of program results to hand calculations, published analytical results, or another program which has similar capabilities.

Code: ANSYS

Author: Swanson Analysis Systems, Inc.
PO Box 65
Houston, PA 15342

Description: Large-scale finite-element program for structural, heat transfer, and fluid-flow analysis. ANSYS performs linear and nonlinear elastic analysis of structures subjected to static loads (pressure, temperature, concentrated forces and prescribed displacements) and dynamic excitations (transient and harmonic). The program considers the effects of plasticity, creep, swelling and large deformations.

Transient and steady-state heat transfer analyses consider conduction, convection, and radiation effects. Coupled thermal-fluid, coupled thermal-electric, and wave-motion analysis capabilities are available. Structural and heat transfer analyses can be made in one, two, or three dimensions, including axisymmetric and plane problems.

Extent and Limitations of its application: The ANSYS computer program is used to perform static elastic finite element analysis on pipe support baseplates. ANSYS was used only in conjunction with BASEPLATE II.

Verification: The ANSYS program has been verified by a comparison of test problems with analytical results published in literature and hand calculations.

Code: STARDYNE

Author: STARDYNE Project Office
System Development Corporation
2500 Colorado Avenue
Santa Monica, CA 90406

Description: Finite element static and dynamic structural analysis. QA STARDYNE static analysis will predict the stress and deflections resulting from pressure, temperature, concentrated forces and enforced displacements. Dynamic analysis will predict the node displacements, velocities, accelerations, element forces and stresses from transient, harmonic, random or shock excitations. STARDYNE is user oriented, containing automatic node and element generation features that reduce the effort required to generate input. Plots of the original model and deformed structural shapes help the user evaluate results. Contour plots show surface stress for two-dimensional elements. The program creates time histories of element forces and stresses, and of node displacements, velocities, and accelerations.

Extent and Limitations of its application: The STARDYNE computer program is used to perform static elastic finite element analysis on pipe support baseplates. STARDYNE was used only in conjunction with BASEPLATE and BASEPLATE II.

Verification: The Control Data Corporation verified the computer program by a comparison of test problems with analytical results published in literature, hand calculations, or another program which has similar capabilities.

Question 12(b):

Provide a description of methods to model supports, the pressurizer and relief tank connections, and the safety valve bonnet assemblies and PORV actuator. Identify the time step and the mass point spacing used in the analysis model for various pipe sizes. Give the rationale for the choice of computation time step and mass point spacing.

RESPONSE:

Catawba 1 & 2

Types of supports modeled in the analysis include rigids, springs, and snubbers. The supports restrain only translation of the supported point. The supports were assumed to be rigid relative to the pipe. Rigid supports were active for gravity, thermal, and dynamic load cases, whereas, springs are active only for gravity and snubbers active only for dynamic load cases.

The pressurizer is modeled as a beam with nozzles connected to the centerline of the pressurizer by rigid members.

The connection to the pressurizer relief tank is modeled as a rigid lateral and torsion support, and as an axial support with a stiffness based on the stiffness of the tank. No bending support is modeled due to the relatively higher stiffness of the pipe compared to the tank. Also, since the 12"Ø relief valve discharge line passes through the tank shell, additional supports are included in the model to represent the gu des inside the tank.

For the PORV actuators, the moments of inertia were calculated based upon the fundamental frequencies. The total weight of the valve body + actuator was lumped at the centroid of the valve assembly. Safety valve bonnets are modeled as rigid members with the total weight of the valve body + bonnet lumped at the centroid of the total valve assembly.

For the mass point spacing, a mass point is placed at each data point on the piping model, and if necessary additional mass points are placed automatically between data points by the SUPERPIPE computer program, thus subdividing lengths of pipe between data points. If a long length of straight pipe is vibrating, each mode of vibration will contain a number of equally spaced nodes, and each length of pipe between nodes vibrates as a simple span beam. Hence, for a frequency of vibration, f_m, the simple span beam length will be l_m, where

$$l_m = \left(\frac{\pi}{2f_m}\right)^{0.5} \left(\frac{EI_g}{w}\right)^{0.25}$$

If a simple lumped mass idealization is used, and if an accurate determination of the mode shape and frequency is required for a simple span beam of this length, then the mass spacing should be no larger than S_m, where

$$S_m = 0.5\ l_m$$

The permissible maximum spacings are computed or specified at the time the component dimensions are specified.

With a frequency of f_m = 30cps, the following table gives the mass point spacings, S_m used in the analysis model.

Pipe Size	Schedule	"S_m" (Inches)
3/4"	40	27
3"	160	49
3" (Insulated)	160	43
6"	40	65
6"	160	64
12"	40	88
12"	xs	89

A time step of .002 seconds was used in the structural analysis, which is consistent with the output from the thermal hydraulic analysis.

Question 12(c):

Provide an identification of the load combinations performed in the analysis together with the allowable stress limits. Differentiate between load combinations used in the piping upstream and downstream of the valve and for the supports. Explain the mathematical methods used to perform the load combinations. If the load combinations and methods differ from those suggested in Reference 3, discuss how the load combinations used satisfy the FSAR commitment for the piping and supports. Identify the governing codes and standards used to determine adequacy of the piping upstream and downstream of the valves and the supports.

RESPONSE:

Load combinations for the piping and supports are as shown in the following tables:

Table 1.0 - Load Combinations and Stress Criteria for Upstream (Class 1) Piping.

Table 1.1 - Load Combinations and Stress Criteria for Downstream Piping (ANSI B31.1).

Table 1.2 - Load Combinations and Stress Criteria for Supports, Restraints and Anchors.

Table 1.3 - Codes and standards governing pipe support design.

These combinations are consistent with Reference 3 except the Safety and Relief Valve Transient load case used for all Service Levels is equivalent to the SOT_f case used in Reference 3 only for faulted. This is a simpler and more conservative approach.

Downstream piping is ANSI B31.1, but is qualified by load combinations and allowable stress limits of more conservative ASME (Class 2/3).

TABLE 1.0

Load Combinations and
Stress Criteria for
Upstream (Class 1) Piping

	LOAD COMBINATION	CRITERIA
1. Eq. 9 (Design)	Pressure +Weight +OBE Inertia +Relief Valve Transient	$\leq 1.5\ S_m$ ASME Sec. III Subsection NB
2. Eq. 9 (Faulted)	Pressure +Weight +SSE Inertia +Relief Valve Transient	$\leq 3.0\ S_m$ ASME Sec. III Subsection NB
3. Eq. 10	Pressure +Weight +Thermal Expansion +OBE Inertia +OBE Seismic Anchor Movements +Relief Valve Transient	$\leq 3.0\ S_m$ ASME Sec. III Subsection NB
4. Eq. 12	Thermal Expansion	$\leq 3.0\ S_m$ ASME Sec. III Subsection NB
5. Eq. 13	Pressure +Weight +OBE Inertia +Relief Valve Transient	$\leq 3.0\ S_m$ ASME Sec. III Subsection NB

NOTES: 1) Resultant moments for Weight Loads, Occasional Loads, and Thermal Expansion Loads are combined per code equations.

2) Occasional loads are OBE Inertia, OBE Seismic Anchor Movements, Relief Valve Transient, SSE Inertia, and SSE Seismic Anchor Movements. Occasional loads are unsigned. In Equation 9 (Design), OBE Inertia and Relief Valve Transient loads are absolutely summed. In Equation 9 (Faulted), SSE Inertia and Relief Valve Transient loads are absoultely summed. For Equation 10, OBE Inertia, OBE Seismic Anchor movements, and Relief Valve Transient loads are absolutely summed. For Equation 13, OBE Inertia and Relief Valve Transient loads are absolutely summed.

3) Relief Valve Transient = Maximum absolute value load from PORV discharge transient and Safety Relief Valve discharge transient.

TABLE 1.1

Load Combination and
Stress Criteria for
Downstream Piping (ANSI B31.1)

	LOAD COMBINATION	CRITERIA
1. Eq. 8	Pressure +Weight	$\leq 1.0\ S_h$ ASME Sec. III Subsection NC
2. Eq. 9 (Normal)	Pressure +Weight +OBE Inertia +OBE Seismic Anchor Movements +Relief Valve Transient	$\leq 1.2\ S_h$ ASME Sec. III Subsection NC
3. Eq. 9 (Faulted)	Pressure +Weight +SSE Inertia +SSE Seismic Anchor Movements +Relief Valve Transient	$\leq 2.4\ S_h$ ASME Sec. III Subsection NC
4. Eq. 10	Thermal Expansion +OBE Seismic Anchor Movements	$\leq S_a$ ASME Sec. III Subsection NC
5. Eq. 11	Pressure +Weight +Thermal Expansion	$\leq S_h + S_a$ ASME Sec. III Subsection NC

NOTES:

1) Resultant moments for Weight Loads, Occasional Loads, and Thermal Expansion Loads are combined per code equations.

2) Occasional loads are OBE Inertia, OBE Seismic Anchor Movements, Relief Valve Transient, SSE Inertia, and SSE Seismic Anchor Movements. Occasional loads are unsigned. In Equation 9 (Normal), OBE Inertia, Relief Valve Transient, and OBE Seismic Anchor Movements are absolutely summed. In Equation 9 (Faulted), SSE Inertia, Relief Valve Transient, and SSE Seismic Anchor Movements are absolutely summed.

3) Relief Valve Transient = Maximum absolute value load from PORV discharge transient and Safety Relief Valve discharge transient.

4) The OBE Seismic Anchor Movement load is included in either Eq. 9 or Eq. 10 per the Code requirements.

TABLE 1.2

Load Combinations and
Stress Criteria for
Supports, Restraints, and Anchors

		LOAD COMBINATION	CRITERIA
1.	Normal	Thermal Displacement Weight	AISC Normal Allowable Stress
2.	Upset	Thermal Displacement Weight OBE (Inertia) OBE Seismic Anchor Movements Relief Valve Transient	AISC Normal Allowable Stress
3.	Faulted	Thermal Displacement (1) Weight SSE (Inertia) SSE Seismic Anchor Movements Relief Valve Transient	1.5 x AISC Normal Allowable Stress with a 0.9 F_Y maximum

NOTES:

1) Criteria shown is for non-NF. For portions within the NF jurisdictional boundaries, the allowables specified in Subsection NF of the ASME BPVC, Section III, Division 1 are used.

2) Relief Valve Transient = Maximum absolute value load from PORV discharge transient and Safety Relief Valve discharge transient.

3) Loads on supports are combined in the following manner:

Normal (+) = Weight + Maximum positive thermal
Normal (-) = Weight + Maximum negative thermal
Upset (+) = Normal (+)+[absolute summation of OBE Inertia, OBE Seismic Anchor Movements, Relief Valve Transients]
Upset (-) = Normal (-) - [Absolute summation of OBE Inertia, OBE Seismic Anchor Movements, Relief Valve Transients]
Faulted (+) = Normal (-) + [Absolute summation of SSE Inertia, SSE Seismic Anchor Movements, Relief Valve Transients]
Faulted (-) = Normal (-) - [Absolute summation of SSE Inertia, SSE Seismic Anchor Movements, Relief Valve Transients]

TABLE 1.3

CODES AND STANDARDS FOR PIPE SUPPORT DESIGN

1. ASME Boiler and Pressure Vessel Code, Section III - Division 1, Rules for Construction of Nuclear Power Plant Components, 1974 Edition including all addenda through the Summer 1975 Addenda.

2. MSS SP-58, 1975, Pipe Hangers and Supports - Materials, Design and Manufacture.

3. AWS D1.1-73, Structural Welding Code - Steel.

4. AISC Manual of Steel Construction, Seventh Edition with Specification for the Design, Fabrication & Erection of Structural Steel for Buildings, together with Supplements #1, #2, and #3.

5. MSS SP-69, 1976, Pipe Hangers and Supports - Selection and Application.

Question 12(d):

Provide an evaluation of the results of the structural analysis. Present tables listing the worst case load or stress for the piping upstream and downstream of the valve and for the supports compared to the combination equation. Indicate the piping model (i.e., node number) requested in Question 12(e). Discuss the modifications made to the piping or supports, if any, and clarify when the modifications were completed.

RESPONSE:

Results listing the worst case load or stress for the piping and supports are as shown in the following tables:

Table 2.0 - Unit 1 Upstream Piping (Class 1) Stresses.

Table 2.1 - Unit 1 Downstream Piping (ANSI B31.1) Stresses.

Table 2.2 - Unit 2 Upstream Piping (Class 1) Stresses.

Table 2.3 - Unit 2 Downstream Piping (ANSI B31.1) Stresses.

Table 2.4 - Unit 1 Duke Class A Support Loads and Capacities (Upstream of Safety Relief Valve).

Table 2.5 - Unit 1 (ANSI B31.1) Code Support Loads and Capacities (Downstream of Safety Relief Valve).

Table 2.6 - Unit 2 Duke Class A Support Loads and Capacities (Upstream of Safety Relief Valve).

Table 2.7 - Unit 2 (ANSI B31.1) Code Support Loads and Capacities (Downstream of Safety Relief Valve).

Any required modifications to the piping or supports were made prior to the initial installation of the supports.

TABLE 2.0

UNIT 1

UPSTREAM PIPING (CLASS 1)
MAXIMUM STRESSES

CONDITION	COMPONENT DESCRIPTION	JOINT NAME	STRESS RESULTS	ALLOWABLE STRESS	RATIO
Eq. 9 (Design)	6" Elbow	31	19431	24120	0.806
Eq. 9 (Faulted)	6" Elbow	31	38773	48240	0.804
Eq. 10	6"x6"x3" TEE	96	92387	48480	1.906* (See Note 1)
Eq. 12	AWTT TEE	127	36837	48216	0.764
Eq. 13	AWTT Valve	122	45520	48180	0.945
Fatigue Usage Factor	6"x6"x3" TEE	96		1.0	0.039

Notes: 1) Acceptable since equations 12 & 13 are satisfied.
2) AWTT = As-Welded Tapered Transition Joint.

TABLE 2.[illegible]

UNIT 1

DOWNSTREAM PIPING (CLASS 2/3)
MAXIMUM STRESSES

CONDITION	COMPONENT DESCRIPTION	JOINT NAME	STRESS RESULTS	ALLOWABLE STRESS	RATIO
Eq. 8 (Sustained)	12" Elbow	86	6903	15900	0.434
Eq. 9 (Upset)	6"x1" Branch	37AA	16252	19080	0.852
Eq. 9 (Faulted)	6"x1" Branch	37AA	27253	38160	0.714
Eq. 10 (Thermal Exp.)	6"x4" Reducer	107	31559	27350	1.154* (See Note 1)
Eq. 11 (Sustained + Thermal Exp.)	6"x4" Reducer	107	36794	43250	0.851

Notes: 1) Acceptable since Eq. 11 is satisfied.

TABLE 2.2

UNIT 2

UPSTREAM PIPING (CLASS 1)
MAXIMUM STRESSES

CONDITION	COMPONENT DESCRIPTION	JOINT NAME	STRESS RESULTS	ALLOWABLE STRESS	RATIO
Eq. 9 (Design)	6" Elbow	31	22418	24120	0.[illegible]9
Eq. 9 (Faulted)	6" Elbow	31	31900	48240	0.6[illegible]
Eq. 10	6"x3" Reducer	98	75370	48480	1.555* (See Note 1)
Eq. 12	6"x6"x3" TEE	96	32401	48240	0.672
Eq. 13	6"x3" Reducer	99	47387	48480	0.977
Usage	6"x6"x3" TEE	96	u = .042	1.0	0.042

*Note 1: Acceptable since equations 12 & 13 are satisfied.

TABLE 2.3

UNIT 2

DOWNSTREAM PIPING (ANSI B31.1)
MAXIMUM STRESSES

CONDITION	COMPONENT DESCRIPTION	JOINT NAME	STRESS RESULTS	ALLOWABLE STRESS	RATIO
Eq. 8 (Sustained)	6"x4" Reducer	107	10564	15900	0.664
Eq. 9 (Upset)	AWTT Valve	51	18898	19080	.990
Eq. 9 (Faulted)	AWTT Valve	37	28136	38160	0.737
Eq. 10 (Thermal Exp.)	6"x4" Reducer	107	24625	27350	0.900

Notes: 1) AWTT = As-Welded Tapered Transition Joint.

TABLE 2.4
UNIT 1
S/R APPLIED LOADS AND CAPACITIES
DUKE CLASS A SUPPORTS
(UPSTREAM OF SAFETY RELIEF VALVE)

DCP	S/R NUMBER	WORST LOAD CASE	APPLIED LOAD (KIPS)	RATIO OF APPLIED LOAD TO CAPACITY	S/R TYPE
57AA	1-R-NC-1611	FAULTED	19.8	.840	SNUBBER
111B	1-R-NC-1619	FAULTED	0.61	.161	SNUBBER
122A	1-R-NC-1620	FAULTED	0.80	.308	SNUBBER
130A	1-R-NC-1621	FAULTED	2.0	.769	SNUBBER
104A	1-R-NC-1622	FAULTED	3.1	.704	SNUBBER
97B	1-R-NC-1623	FAULTED	2.7	.870	SNUBBER
32AA	1-R-NC-1625	FAULTED	11.3	.741	SNUBBER
96	1-R-NC-1633	FAULTED	4.0	.645	SNUBBER
99A	1-R-NC-1634	NORMAL	0.58	.877	CONSTANT SPRING
113A	1-R-NC-1635	FAULTED	4.8	.417	SNUBBER
115A	1-R-NC-1636	FAULTED	3.3	.769	SNUBBER
115A	1-R-NC-1637	FAULTED	5.8	.735	SNUBBER
117A	1-R-NC-1638	NORMAL	0.68	.917	CONSTANT SPRING
127B	1-R-NC-1639	FAULTED	4.1	.833	SNUBBER
127A	1-R-NC-1640	NORMAL	1.2	.926	CONSTANT SPRING
V9A	1-R-NC-1642	FAULTED	0.78	.781	SNUBBER
V9A	1-R-NC-1643	FAULTED	0.53	.529	SNUBBER
V13A	1-R-NC-1644	FAULTED	1.0	1.000	SNUBBER
V13A	1-R-NC-1645	FAULTED	1.0	1.000	SNUBBER
V17A	1-R-NC-1646	FAULTED	0.76	.758	SNUBBER
V17A	1-R-NC-1647	FAULTED	0.71	.709	SNUBBER
5A	1-R-NC-1651	FAULTED	14.3	.763	SNUBBER
31A	1-R-NC-1653	FAULTED	20.4	.862	SNUBBER
44A	1-R-NC-1655	FAULTED	34.3	.917	SNUBBER

TABLE 2.5

UNIT 1

S/R APPLIED LOADS AND CAPACITIES

ANSI B31.1 CODE SUPPORTS

(DOWNSTREAM OF SAFETY RELIEF VALVE)

DCP	S/R NUMBER	WORST LOAD CASE	APPLIED LOAD (KIPS)	RATIO OF APPLIED LOAD TO CAPACITY	S/R TYPE
78A	1-R-NC-1591	UPSET	11.6	.741	RIGID
72B	1-R-NC-1592	UPSET	11.8	.877	RIGID
76A	1-R-NC-1593	UPSET	20.9	.690	SNUBBER
71A	1-R-NC-1594	UPSET	11.3	1.000	SNUBBER
72A	1-R-NC-1595	NORMAL	0.96	.617	VARIABLE SPRING
78AA	1-R-NC-1596	UPSET	11.1	.735	RIGID
78C	1-R-NC-1597	UPSET	22.1	.885	SNUBBER
80A	1-R-NC-1598	UPSET	16.9	.943	RIGID
83A	1-R-NC-1599	FAULTED	28.5	.813	RIGID
70A	1-R-NC-1600	NORMAL	2.6	.787	CONSTANT SPRING
68C	1-R-NC-1601	UPSET	11.8	.990	SNUBBER
68B	1-R-NC-1602	UPSET	7.6	.794	SNUBBER
66A	1-R-NC-1603	UPSET	22.3	.962	SNUBBER
64C	1-R-NC-1604	UPSET	7.5	.758	SNUBBER
64C	1-R-NC-1605	UPSET	5.0	.893	RIGID
64B	1-R-NC-1606	UPSET	5.9	.870	RIGID
62B	1-R-NC-1607	UPSET	17.5	.909	SNUBBER
62A	1-R-NC-1608	NORMAL	5.1	.833	CONSTANT SPRING
60AA	1-R-NC-1609	UPSET	7.8	.775	SNUBBER
60A	1-R-NC-1610	UPSET	2.3	1.000	RIGID
27A/13B	1-R-NC-1613	UPSET	0.15 (LOCAL X)	.179	RIGID
		UPSET	0.05 (LOCAL Z)	.179	RIGID
39BB	1-R-NC-1615	FAULTED	8.1	1.000	SNUBBER
138D	1-R-NC-1616	FAULTED	3.4	1.000	SNUBBER

TABLE 2.5

UNIT 1

S/R APPLIED LOADS AND CAPACITIES

ANSI B31.1 CODE SUPPORTS

(DOWNSTREAM OF SAFETY RELIEF VALVE)

DCP	S/R NUMBER	WORST LOAD CASE	APPLIED LOAD (KIPS)	RATIO OF APPLIED LOAD TO CAPACITY	S/R TYPE
17A	1-R-NC-1617	UPSET	1.3	.870	SNUBBER
14B	1-R-NC-1618	UPSET	4.6	.980	SNUBBER
21D	1-R-NC-1624	UPSET	2.4	.893	SNUBBER
11B	1-R-NC-1626	FAULTED	4.7	.351	SNUBBER
11A	1-R-NC-1627	NORMAL	1.3	.926	CONSTANT SPRING
14A	1-R-NC-1628	FAULTED	2.3	.855	SNUBBER
14A	1-R-NC-1629	FAULTED	1.4	.610	SNUBBER
37A	1-R-NC-1630	NORMAL	2.7	.962	CONSTANT SPRING
39AA	1-R-NC-1631	FAULTED	2.8	.667	SNUBBER
51B	1-R-NC-1632	NORMAL	2.3	.962	CONSTANT SPRING
138A	1-R-NC-1641	NORMAL	3.9	.870	CONSTANT SPRING
17B	1-R-NC-1648	FAULTED	7.6	.855	SNUBBER
37XX	1-R-NC-1649	FAULTED	12.2	.926	SNUBBER
143N	1-R-NC-1650	FAULTED	3.8	.885	SNUBBER
13A	1-R-NC-1652	FAULTED	8.4	.901	SNUBBER
140	1-R-NC-1654	FAULTED	6.9	.855	SNUBBER
51A	1-R-NC-1656	FAULTED	6.4	1.000	SNUBBER
137	1-R-NC-1657	FAULTED	3.9	.781	SNUBBER
38ZY	1-R-NC-2208	FAULTED	4.9	.613	SNUBBER
57A	1-R-NC-2209	UPSET	16.6	1.000	SNUBBER

TABLE 2.6

UNIT 2

S/R APPLIED LOADS AND CAPACITIES

DUKE CLASS A SUPPORTS

(UPSTREAM OF SAFETY RELIEF VALVE)

DCP	S/R NUMBER	WORST LOAD CASE	APPLIED LOAD (KIPS)	RATIO OF APPLIED LOAD TO CAPACITY	S/R TYPE
5A	2-R-NC-1667	FAULTED	14.3	.962	SNUBBER
31A	2-R-NC-1674	FAULTED	20.4	1.000	SNUBBER
32AA	2-R-NC-1675	FAULTED	11.3	.926	SNUBBER
44A	2-R-NC-1680	UPSET	20.8	.833	SNUBBER
57AA	2-R-NC-1681	FAULTED	16.3	.870	SNUBBER
96	2-R-NC-1687	FAULTED	4.0	.625	SNUBBER
127B	2-R-NC-1688	UPSET	2.4	.585	SNUBBER
127A	2-R-NC-1689	NORMAL	1.2	.926	CONSTANT SPRING
130A	2-R-NC-1690	FAULTED	2.0	.588	SNUBBER
V17A	2-R-NC-1691	FAULTED	0.35 (LOCAL X)	.455	SNUBBER
		FAULTED	0.48 (LOCAL Z)	.625	SNUBBER
97B	2-R-NC-1693	FAULTED	2.7	.840	SNUBBER
99A	2-R-NC-1694	NORMAL	0.58	.909	CONSTANT SPRING
111B	2-R-NC-1695	FAULTED	0.61	.190	SNUBBER
113A	2-R-NC-1696	FAULTED	4.8	.448	SNUBBER
117A	2-R-NC-1697	NORMAL	0.68	.909	CONSTANT SPRING
115A	2-R-NC-1698	UPSET	2.9 (LOCAL X)	.526	SNUBBER
		UPSET	0.47 (LOCAL Z)	.535	SNUBBER
122A	2-R-NC-1699	FAULTED	1.6	.472	SNUBBER
V13A	2-R-NC-1700	FAULTED	0.33 (LOCAL X)	.375	SNUBBER
		FAULTED	0.38 (LOCAL Z)	.431	SNUBBER
V9A	2-R-NC-1705	FAULTED	0.34 (LOCAL X)	.452	SNUBBER
		FAULTED	0.40 (LOCAL Z)	.535	SNUBBER
104A	2-R-NC-1707	UPSET	2.5	.325	SNUBBER

TABLE 2.7

UNIT 2

S/R APPLIED LOADS AND CAPACITIES

ANSI B31.1 CODE SUPPORTS

(DOWNSTREAM OF SAFETY RELIEF VALVE)

DCP	S/R NUMBER	WORST LOAD CASE	APPLIED LOAD (KIPS)	RATIO OF APPLIED LOAD TO CAPACITY	S/R TYPE
11B	2-R-NC-1668	UPSET	2.7	.474	SNUBBER
13A	2-R-NC-1669	FAULTED	8.4	.730	SNUBBER
14A	2-R-NC-1670	FAULTED	1.4 (LOCAL X)	.775	SNUBBER
		FAULTED	2.4 (LOCAL Z)	.775	SNUBBER
14B	2-R-NC-1671	UPSET	4.6	.806	SNUBBER
17A	2-R-NC-1672	UPSET	1.3	.685	SNUBBER
17B	2-R-NC-1673	UPSET	6.7	.767	SNUBBER
37XX	2-R-NC-1676	FAULTED	10.3	1.000	SNUBBER
37A	2-R-NC-1677	NORMAL	2.7	.901	CONSTANT SPRING
39AA	2-R-NC-1678	FAULTED	2.8	.610	SNUBBER
39BB	2-R-NC-1679	UPSET	6.2	.787	SNUBBER
51A	2-R-NC-1682	FAULTED	6.0	1.000	SNUBBER
51B	2-R-NC-1683	NORMAL	2.3	.909	CONSTANT SPRING
57A	2-R-NC-1684	UPSET	15.6	.962	SNUBBER
21D	2-R-NC-1685	UPSET	3.4	.568	SNUBBER
11A	2-R-NC-1686	NORMAL	1.3	1.000	CONSTANT SPRING
137	2-R-NC-1692	FAULTED	3.2	.917	SNUBBER
138A	2-R-NC-1701	NORMAL	3.9	.926	CONSTANT SPRING
38ZY	2-R-NC-1702	FAULTED	4.4	.602	SNUBBER
138C	2-R-NC-1703	FAULTED	3.4	.775	SNUBBER
140	2-R-NC-1704	FAULTED	6.9	.538	SNUBBER
143N	2-R-NC-1706	UPSET	3.0	1.000	SNUBBER
60A	2-R-NC-1708	FAULTED	3.2	.680	RIGID

TABLE 2.7

UNIT 2

S/R APPLIED LOADS AND CAPACITIES

ANSI B31.1 CODE SUPPORTS

(DOWNSTREAM OF SAFETY RELIEF VALVE)

DCP	S/R NUMBER	WORST LOAD CASE	APPLIED LOAD (KIPS)	RATIO OF APPLIED LOAD TO CAPACITY	S/R TYPE
60AA	2-R-NC-1709	UPSET	7.8	.714	SNUBBER
62A	2-R-NC-1710	NORMAL	5.1	.909	CONSTANT SPRING
62B	2-R-NC-1711	UPSET	18.3	.980	SNUBBER
64B	2-R-NC-1712	UPSET	5.9	.735	RIGID
64C	2-R-NC-1713	FAULTED	8.0	.629	SNUBBER
64A	2-R-NC-1714	FAULTED	6.2	1.000	RIGID
66A	2-R-NC-1715	UPSET	21.6	.901	SNUBBER
68B	2-R-NC-1716	FAULTED	8.0	.571	SNUBBER
68C	2-R-NC-1717	UPSET	11.8	.813	SNUBBER
70A	2-R-NC-1718	NORMAL	2.6	.926	CONSTANT SPRING
78AA	2-R-NC-1719	NORMAL	2.7	.962	RIGID
78A	2-R-NC-1720	UPSET	11.9	.787	RIGID
76A	2-R-NC-1721	UPSET	20.9	.840	SNUBBER
72B	2-R-NC-1722	UPSET	11.8	.752	RIGID
72A	2-R-NC-1723	NORMAL	0.96	.800	VARIABLE SPRING
71A	2-R-NC-1724	UPSET	11.3	.930	SNUBBER
78C	2-R-NC-1725	UPSET	22.1	.990	SNUBBER
80A	2-R-NC-1726	UPSET	17.3	.980	RIGID
83A	2-R-NC-1727	UPSET	23.2	.855	RIGID
27A/13B	2-R-NC-1853	UPSET	0.15 (LOCAL X)	.179	RIGID
		UPSET	0.05 (LOCAL Z)	.179	RIGID

Question 12(e):

Provide a sketch of the structural model showing lumped mass locations, pipe sizes, support locations and application points of fluid forces.

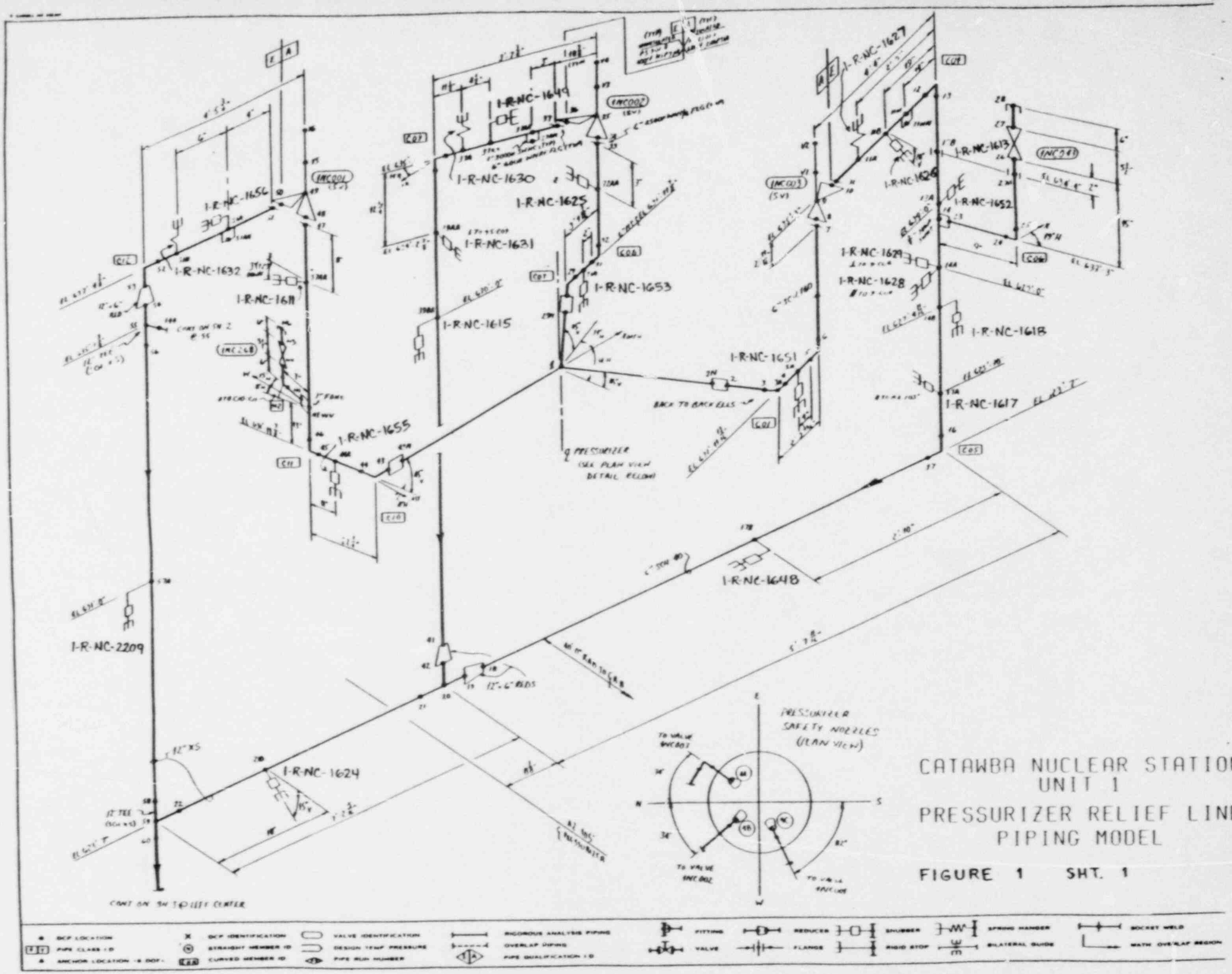
RESPONSE:

Masses are lumped at points of discontinuity and at a maximum spacing of "S_m" in straight pipe as explained in question 12(b). Sketches showing discontinuity points, pipe sizes, and support locations are found on the following drawings:

Figure 1 - Unit 1 (3 sheets)
Figure 2 - Unit 2 (3 sheets)

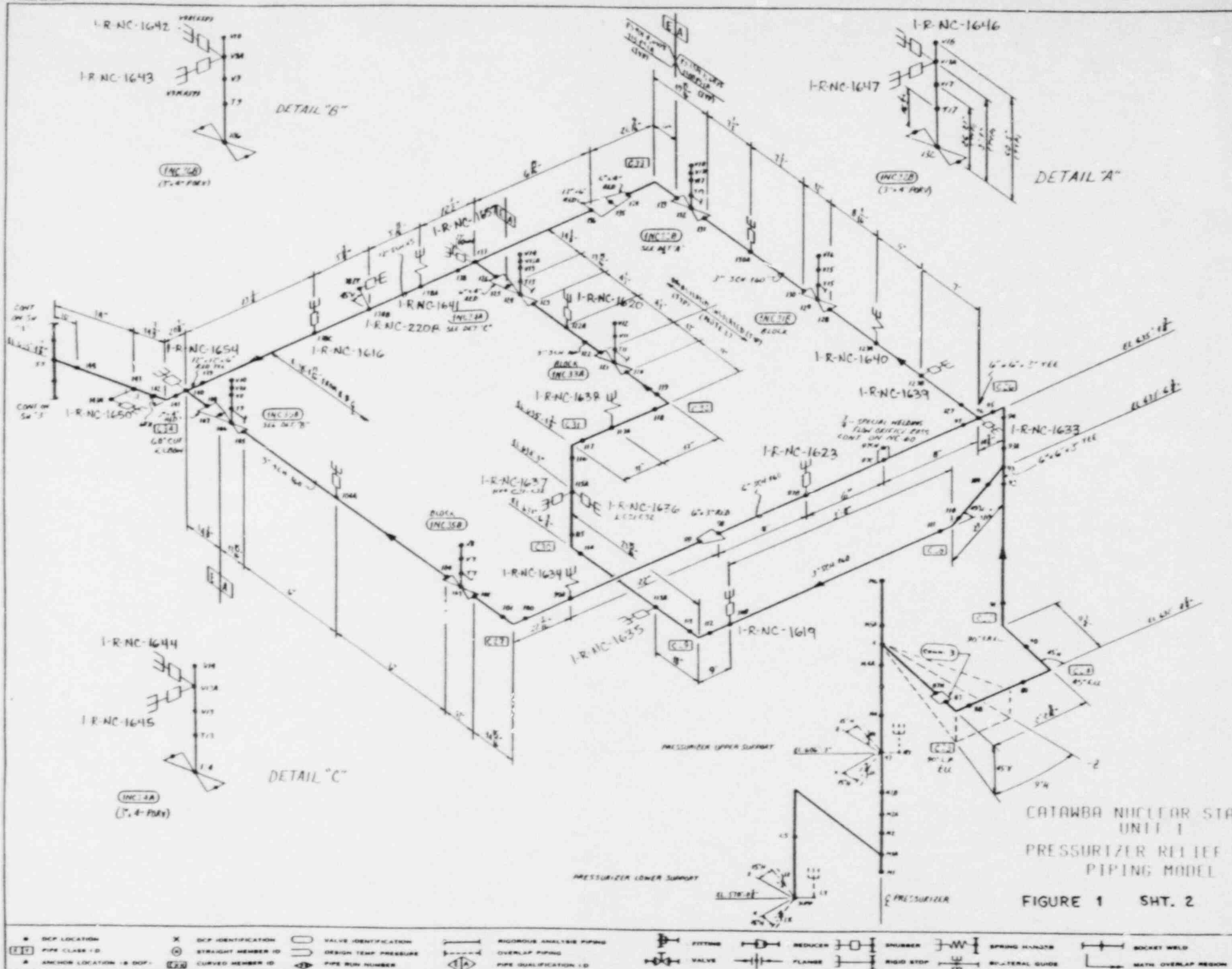
Application points of fluid forces are found on the following drawing:

Figure 3 - Units 1 and 2 (3 sheets)



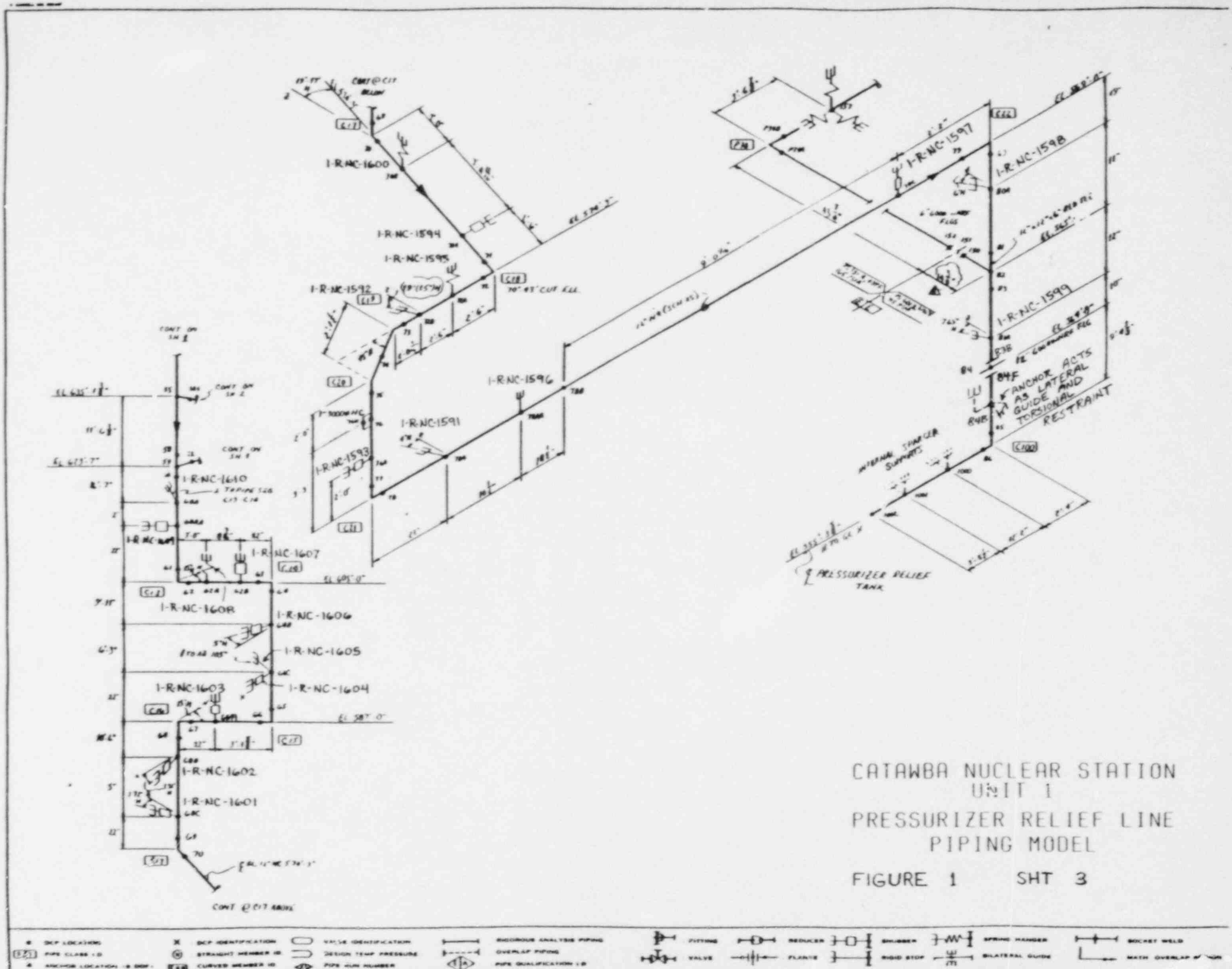
CATAWBA NUCLEAR STATION
UNIT 1
PRESSURIZER RELIEF LINE
PIPING MODEL

FIGURE 1 SHT. 1



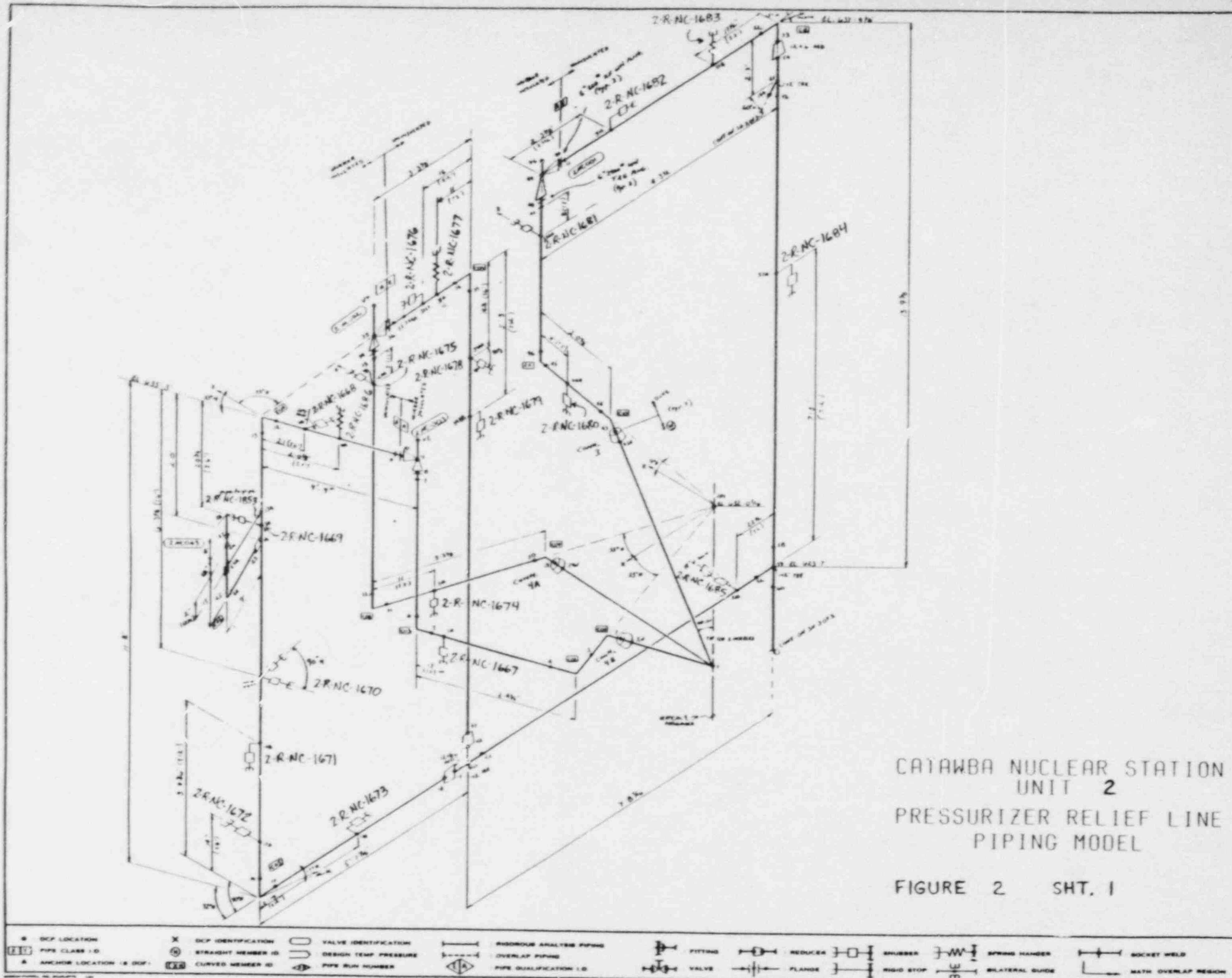
CATAWBA NUCLEAR STATION
UNIT 1
PRESSURIZER RELIEF LINE
PIPING MODEL

FIGURE 1 SHT. 2



CATAWBA NUCLEAR STATION
UNIT 1
PRESSURIZER RELIEF LINE
PIPING MODEL

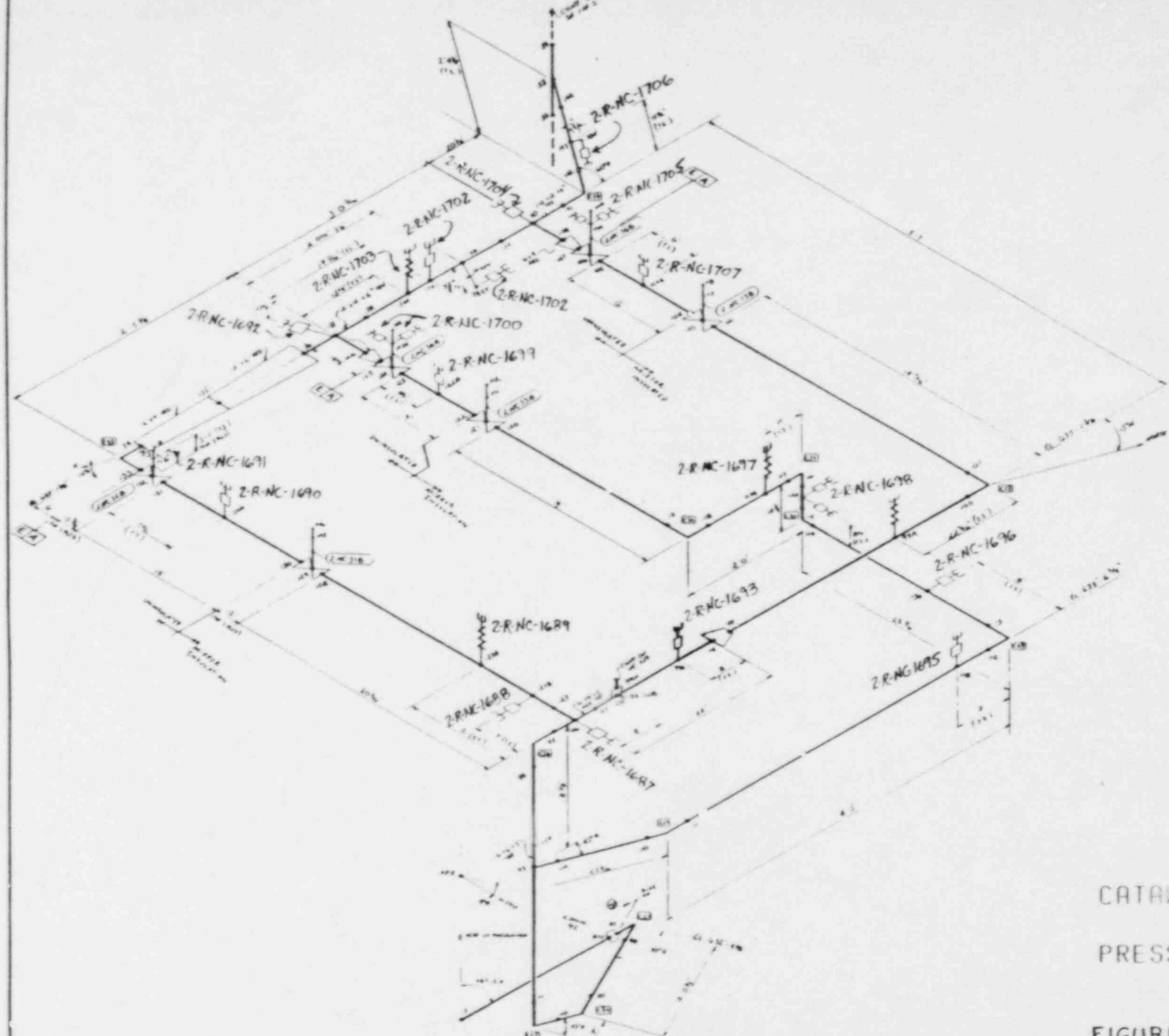
FIGURE 1 SHT 3



CATAWBA NUCLEAR STATION
UNIT 2

PRESSURIZER RELIEF LINE
PIPING MODEL

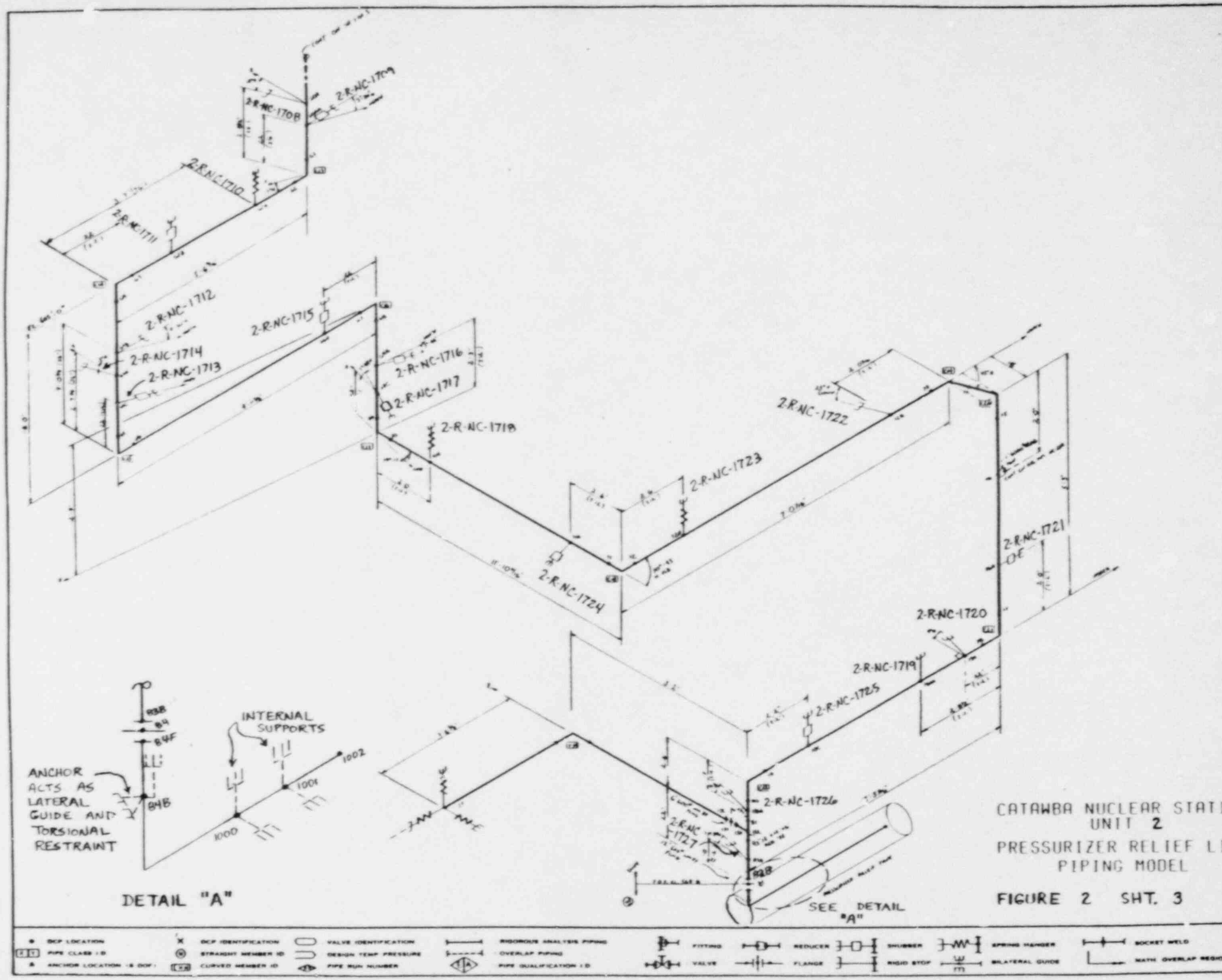
FIGURE 2 SHT. 1



CATAWBA NUCLEAR STATION
UNIT 2

PRESSURIZER RELIEF LINE
PIPING MODEL

FIGURE 2 SHT. 2



CATAWBA NUCLEAR STATION
UNIT 2
PRESSURIZER RELIEF LINE
PIPING MODEL

FIGURE 2 SHT. 3

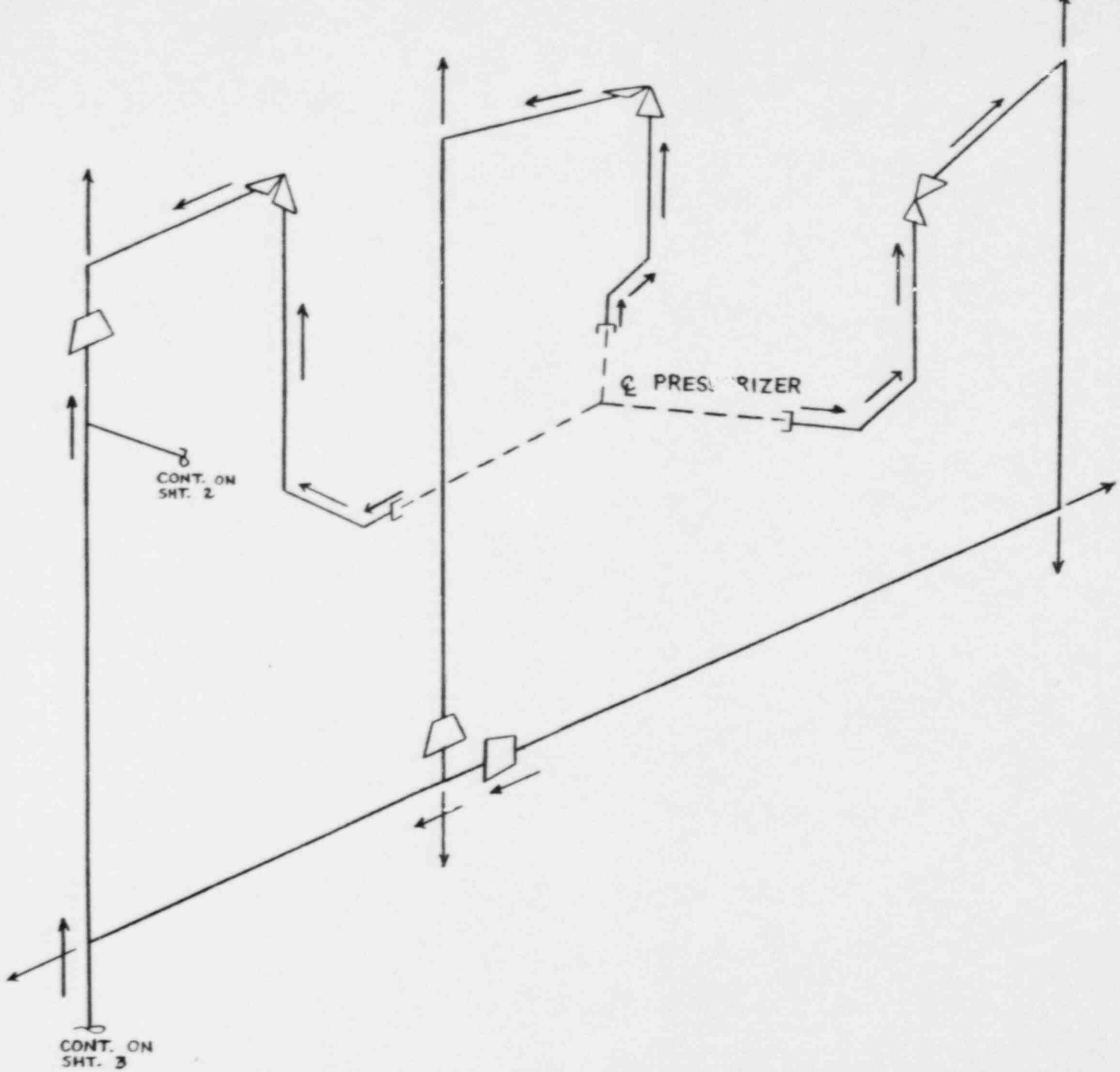


FIGURE 3 SHT. 1
FLUID FORCES &
APPLICATION PTS.
PRESSURIZER RELIEF LINE

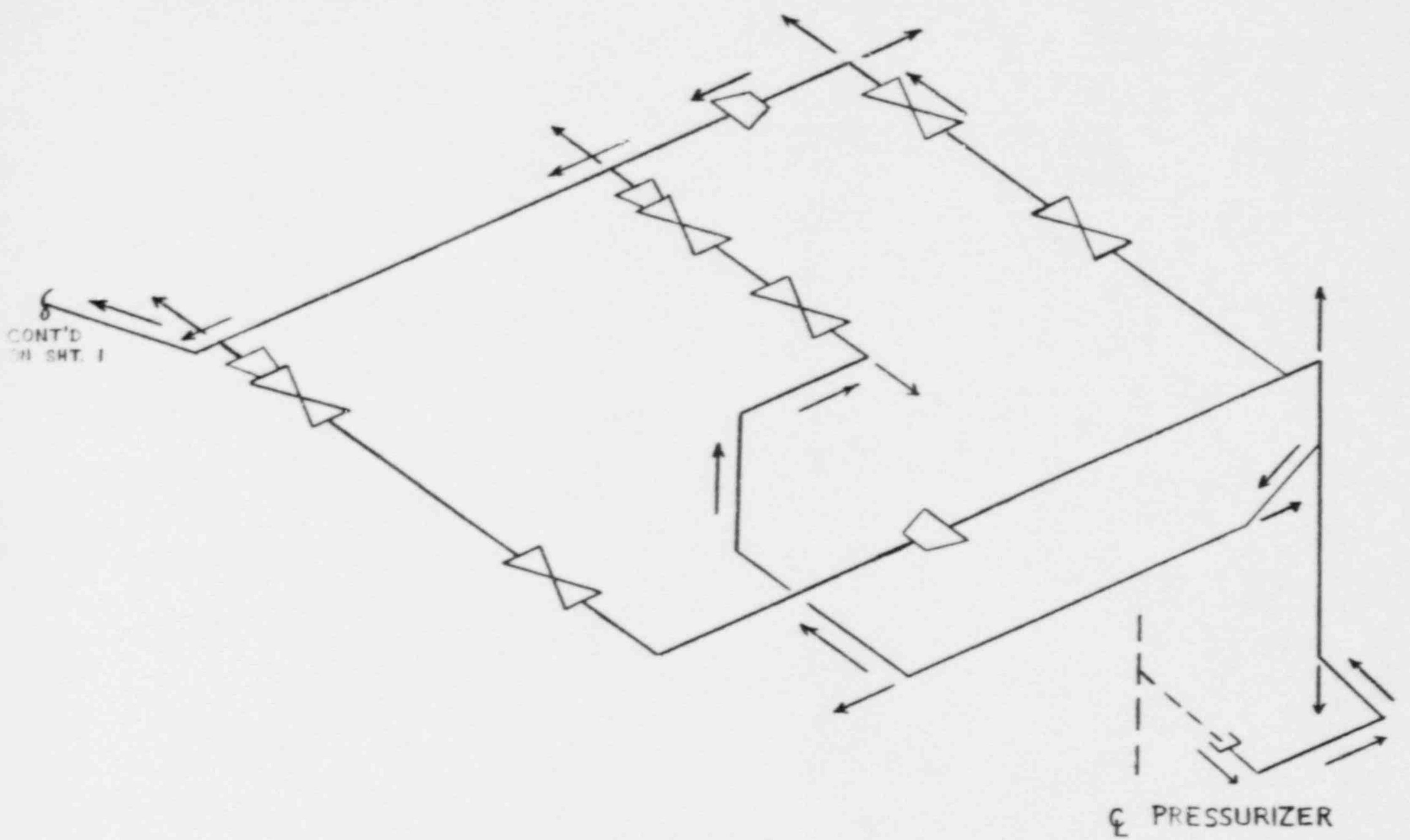


FIGURE 3 SHT. 2
FLUID FORCES &
APPLICATION PTS.
PRESSURIZER RELIEF LINE

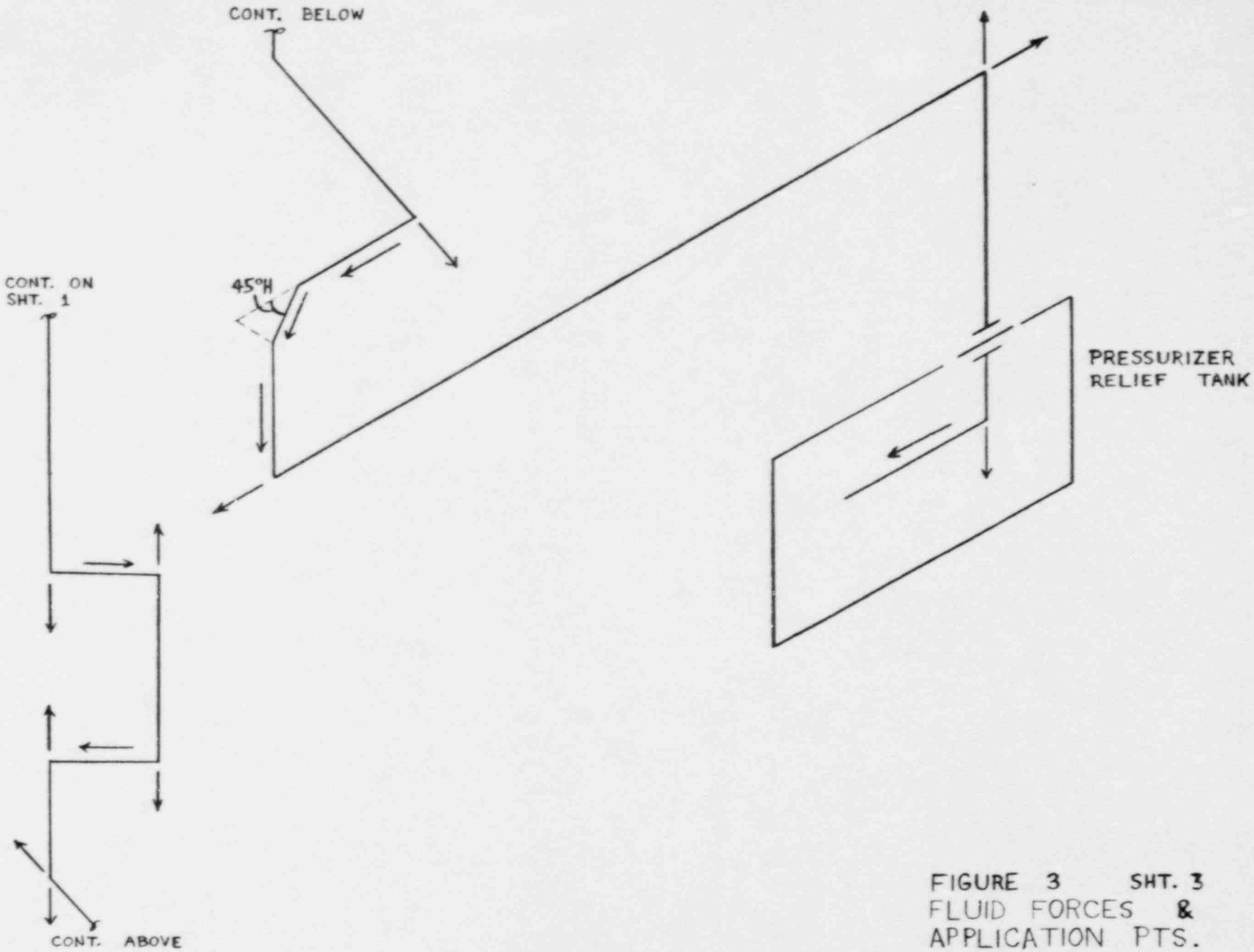


FIGURE 3 SHT. 3
FLUID FORCES & APPLICATION PTS.
PRESSURIZER RELIEF LINE

Question 12(f):

Provide a copy of the structural analysis report.

RESPONSE:

A summary of the results of the structural analysis has been provided in this report. Due to the large volume of computer printouts and drawings, it is not practical to provide a copy of the structural analysis report. Details are available at the Duke Power general office.