THE CLEVELAND ELECTRIC ILLUMINATING CO.

PRELIMINARY EVALUATION OF THE PERRY NUCLEAR POWER PLANT HYDROGEN CONTROL SYSTEM

Docket Nos. 50-440
50-441

March 1, 1985

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1.0 INTRODUCTION

The Perry Nuclear Power Plant (PNPP) Combustible Gas Control System, as described in FSAR Subsection 6.2.5, is a redundant safety-grade system designed to meet the requirements previously set forth in 10 C.F.R. 50.44 (i.e., prior to recent amendments discussed below.) It consists of two 100% capacity hydrogen recombiners, a drywell purge system, and a backup containment purge system. The system provides the capability to control the hydrogen which may be generated from a postulated design basis accident.

The accident which occurred at TMI Unit 2 resulted in the generation of hydrogen beyond the limits previously specified in 10 CFR 50.44. This excessive hydrogen generation was primarily due to premature termination of the emergency core cooling system. Measures taken subsequent to the TMI-2 accident, (e.g. compliance with NUREG-0737 requirements) along with the inherent resistance of the BWR 6/Mark III plant to events which could result in a degraded core, effectively precludes the need for other systems to prevent or mitigate the consequences of the generation of large amounts of hydrogen.

The PNPP BWR 6/Mark III design features which provide inherent resistance to degraded core events and protection against plant damage and release of radioactivity in excess of 10 CFR Part 100 limits are:

a. Numerous automatic high and low pressure pumps which provide makeup water to the reactor vessel.

b. Rapid depressurization capability via the Automatic Depressurization System.

c. Natural circulation internal to the reactor vessel.

d. Two above core spray systems for core cooling.

e. Direct reactor vessel water level measurement.

f. The capability to vent noncondensible gases from the reactor vessel.

g. A large suppression pool heat sink for decay heat removal.

h. Suppression pool scrubbing of fission products.

i. Secondary containment providing an additional barrier to radioactive releases.

Recently, the Nuclear Regulatory Commission amended the hydrogen control requirements of 10 C.F.R. Part 50.44 (50 Federal Register 3498, January 25, 1985) to require improved hydrogen control systems for Mark III containments to handle large amounts of hydrogen during and following an accident. The new rule requires that prior to exceeding 5% reactor power, a licensee "shall provide its nuclear reactor with a hydrogen control system justified by a suitable program of experiment and analysis. The hydrogen control system must be capable of handling without loss of containment structural integrity an amount of hydrogen equivalent to that generated from a metal-water reaction involving 75% of the fuel cladding surrounding the active fuel region." [Section 50.44(c)(3)(iv)(A)]. "Completed final analyses are not necessary for a staff determination that a plant is safe to operate at full power provided that prior to such operation an applicant has provided a preliminary analysis which the staff has determined provides a satisfactory basis for a decision to support interim operation at full power until the final analysis has been completed." [Section 50.44(c)(3)(vii)(B)]

The Cleveland Electric Illuminating Co. (CEI) has evaluated a number of possible system concepts for controlling the generation of large amounts of hydrogen. The technical criteria used to assess these various options considered the mitigation effectiveness, consequences of intended or inadvertent operation, reliability, testability, availability of design and equipment, and impact on the public health and safety (if any). CEI chose a hydrogen combustion system as the most viable concept for PNPP. A hydrogen ignition system has been designed and is being installed at PNPP. The system will be tested and operable prior to exceeding 5% reactor power.

This document provides a preliminary evaluation which meets and exceeds the preliminary analysis requirements of the new hydrogen rule. A detailed description of the PNPP Hydrogen Control System (HCS) is provided in Section 2.0 of the document. A significant amount of plant specific analysis has been conducted to support the preliminary evaluation. This includes analyses of the containment pressure capacity, discussed in Section 3.0 of this document, and analyses of the containment pressure and temperature response to hydrogen combustion, discussed in Section 4.0. Section 5.0 of this document provides a comparison of the PNPP HCS key design features and supporting analyses to those of the Mississippi Power & Light (MP&L) Grand Gulf Nuclear Station (GGNS), which the NRC has licensed for full power operation on an interim basis. This comparison establishes the similarity of systems and provides additional basis for a decision by the NRC to support full power operation for PNPP.

2.0 HYDROGEN CONTROL SYSTEM DESCRIPTION

2.1 INTRODUCTION

The Hydrogen Control System at PNPP is an ignition system, which consists of igniter assemblies distributed throughout the drywell, wetwell and upper containment regions of the plant. It is designed to handle, without loss of containment structural integrity, an amount of hydrogen equivalent to that generated from a metal-water reaction involving up to 75% of the fuel cladding surrounding the active fuel region. This is accomplished by burning hydrogen at low concentrations, thereby maintaining the concentration of hydrogen below the detonable limits and preventing containment overpressurization failure.

The potential for significant pocketing of hydrogen will be precluded by:

a. utilization of distributed ignition sources,

b. operation of containment sprays,

c. mixing caused by turbulance resulting from localized burns.

The hydrogen ignition system is designed with suitable redundancy to assure that no single active component failure, including power supply failures, will prevent functioning of the system. The system is designed as a safety grade system, and is capable of operating for the duration of the hydrogen generation event.

2.2 EQUIPMENT DESIGN CRITERIA

The Hydrogen Control System igniter assemblies are classified as electrical safety Class 1E and seismic Category I. This equipment is designed, manufactured, tested, and certified in accordance with the following standards:

1. American National Standards Institute (ANSI) N45.2.2 - 1972 "Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants (during the construction phase)."

2. Institute of Electrical and Electronic Engineers (IEEE) Standards:

    a. IEEE-308, (1974) "Standard Criteria for Class IE Power Systems for Nuclear Power Generation Stations."

b. IEEE-323, (1974) "Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations."

c. IEEE-344, (1975) "Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations."

d. IEEE-383, (1974) "Standard for Type Test of 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations."

3. U.S. Nuclear Regulatory Commission Regulatory Guide NUREG-0588, Revision I, Category 1, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment."

4. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code:

   a. Section II, "Material Specifications," 1980 Edition through Summer 1982 Addenda.

   b. Section IX, "Welding and Brazing Qualifications," 1980 Edition through Summer 1982 Addenda.

2.3 IGNITER DESCRIPTION

The igniter assemblies used in the Hydrogen Control System are divided into two components:

a. the igniter enclosure which partially encloses the igniter and contains the terminal block, transformer, and associated electrical wiring, and

b. the junction box which contains the cable termination.

The assembly is depicted in Figure 2.3-1. Spray shields are provided for igniter assembly protection in areas where the igniter may be exposed to containment sprays.

The igniter enclosure, junction box, and spray shield are constructed of stainless steel. The enclosure is 1/8 inch thick, the junction box is 14 gauge. Gasketing material and sealant is provided to ensure leak-tightness of the igniter enclosure and junction box.

The entire igniter assembly used at PNPP is identical to that used at the Grand Gulf Nuclear Station. The igniter, shown on Figure 2.3-2, is a General Motors AC Division, Model 7G glow plug. The transformer is a 0.2 KVA Dongan Model 52-20-472,120± 10% VAC, 60 Hz primary with multiple secondary taps. The igniter assembly is manufactured by Power Systems Division of Morrison Knudsen.

2.4 IGNITER LOCATIONS

Igniter assembly design locations have been finalized and are given on Table 2.4-1. As-built igniter locations will be established during installation depending on availability of supports and interferences in the areas identified. The igniter locations are based on the following criteria:

a. Hydrogen can be released directly to the containment atmosphere through the safety relief valves which exhaust to the suppression pool. Igniter assemblies are located in a ring at elevation 619'-6", which is above the suppression pool, directly below the HCU floor. This assures combustion of the hydrogen release close to the pool surface (elevation 593').

b. In open areas of the containment up to the refueling floor and for all areas of the drywell, except for the post-LOCA reflood area, the igniter assemblies were located using the following criteria:

   1. Assuming only one Engineered Safety Feature (ESF) power division is functional following an accident, a distance of 60 feet exists between operable igniters. In some cases, the distance may be up to 70' feet if supports are not available or interferences exist in the areas identified.

   2. Assuming both ESF power divisions are functional following an accident, a distance of 30 feet exists between operable igniters. In some cases, the distance may be up to 35' if supports are not available or interferences exist in the areas identified.

c. For enclosed containment areas which could accumulate hydrogen, two igniters are located in each room. A separate ESF power division supplies each igniter.

d. Hydrogen can be released directly to the drywell atmosphere via a small pipe break in the drywell. Igniter assemblies are located throughout the drywell.

e. Igniter locations in the drywell take full advantage of existing steel as protection against jet impingement loads and are spaced so that one jet cannot impair more than one igniter.

Based on the above criteria, 102 locations in the containment and drywell will have igniter assemblies. The number and arrangement of igniter assemblies are similar to those at the Grand Gulf Nuclear Station. Figures 2.4-1 through 2.4-11 show the location of PNPP igniter assemblies in the containment as well as their relative location to major equipment or structures. Figures 2.4-12 through 2.4-16 show PNPP cross-sectional containment flow areas at different elevations within containment.

2.5 POWER SUPPLY AND CONTROLS

The hydrogen igniters are powered from 120VAC, 60 Hz, Class 1E power distribution panels M56-P003 through P008. These power panels receive their power from Class 1E 480V motor control centers (EF1A08 or EF1C08) through 15 KVA transformers, rated 480-208/120VAC, 60 Hz, 3-phases with grounded neutrals, and a fuse panel (M56-P001 or P002). The fuse panel consists of a 40 amp and 45 amp fuse in series for each line to the 120 volt distribution power panels. Each transformer is fed from a Class 1E MCC breaker from a Class 1E bus which is capable of being powered from one of the Standby Diesel Generators.

The 102 igniters are divided into six groups of approximately equal number, three groups in Division I and three groups in Division II. Each group is powered from a separate distribution power panel. The power panel disconnect switches are provided for maintenance and are normally closed so the igniters can be energized by operating control room handswitches.

The igniters are manually energized by means of two handswitches located in the control room on Panel H13-P800. One for the three Division I groups (M56-S1) and one for the three Division II groups (M56-S2). The switch positions are ON-OFF with red-green indication lights. Input is provided to the hydrogen control system out-of-service annunciator at panel H13-P800 on loss of control or motive power.

Table 2.4-1 lists the divisional power supply to each igniter and Figure 2.5-1 contains a simplified electrical schematic for the Hydrogen Control System.

2.6 TESTING

2.6.1 Preoperational

The Hydrogen Control System will be preoperationally tested to ensure correct functioning of all controls, instrumentation, wiring, and the transformers and igniters. The test will include energizing one of the two divisions from the control room and verifying that all igniters powered from the associated panel are functional. Identical procedures will be followed for the remaining igniters powered off of the other division. Functional testing of the system will include verification of the following:

1. Surface temperature of each igniter is operating at or above 1700°F with 120 VAC±10%, 60 Hz applied to the igniter assembly.

2. The 480-208/120 volt transformers (M56-S201 and S202) are capable of providing satisfactory secondary voltages of 120±12 VAC and of meeting the minimum load requirement of 15 KVA.

3. All hydrogen igniter transformers are capable of providing satisfactory hydrogen igniter voltages of 12.0±1.2 VAC.

2.6.2 Surveillance

The HCS surveillance requirements will be included in the PNPP Technical Specifications.

2.6.3 Qualification

The qualification of the hydrogen igniter assembly is in accordance with the PNPP equipment qualification program described in FSAR sections 3.10 and 3.11. The hydrogen igniter qualification program meets the requirements of the following documents:

- IEEE Std. 323-1974, "IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations" (including the November 21, 1975 Supplement) and USNRC Regulatory Guide 1.89.

- IEEE Std. 344-1975, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations" and USNRC Regulatory Guide 1.100.

- IEEE Std. 381-1977, "IEEE Standard for Type Tests of Class 1E Modules Used in Nuclear Power Generating Stations".

- IEEE Std. 627-1980, "IEEE Standard for Design Qualification of Safety Equipment Used in Nuclear Power Generating Stations".

- USNRC NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electric Equipment".

- 10 C.F.R. Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants".

- ANSI/ASME NQA-1-1983, Quality Assurance Program Requirements for Nuclear Power Plants.

- ANSI/ASME N45.2-1977, Quality Assurance Program Requirements for Nuclear Facilities.

The qualification program used to meet these requirements is described below. The program includes testing to simulate aging, followed by radiation exposure, a seismic test and accident conditions tests. The test sequence is presented below:

- Inspection of Equipment
- Baseline Functional Test
- Thermal Aging
- Post-Thermal Functional Test
- Radiation Exposure
- Post-Radiation Functional Test
- Wear Aging Test
- Post-Wear Functional Test
- Seismic Test
- Post-Seismic Functional Test
- Accident Conditions Tests
- LOCA Test
- Post LOCA Functional Test
- Low Pressure Transient Test
- Post LPT Functional Test
- Submergence Test
- Post Submergence Functional Test

After thermal aging to a 40 year design life, the igniters are irradiated to achieve accident condition neutron and gamma integrated doses. They are then subjected to vibration and seismic tests. The igniters are energized during these tests. Each component of the hydrogen igniter, including subvendor subcomponents, is designed to withstand the maximum acceleration created by the appropriate load combinations provided in FSAR section 3.10.

The igniter assembly is tested in accordance with a LOCA environmental test profile which meets or exceeds the PNPP Environmental conditions specified in FSAR Section 3.11 Tables. The test sample is operated during the LOCA test to verify operability under the actual environmental conditions expected to occur in service including sprays. Functional tests are performed following the LOCA testing.

Following the LOCA test, the test sample is placed inside a smaller pressure vessel to simulate the negative pressure transient postulated to occur as part of the accident conditions. The pressure is reduced from 9 psig to -14 psig at a rate of 20 psi/sec. The pressure remains at -14 psig for approximately two seconds after which time it will return to atmospheric pressure at a rate of 4.5 psi/sec. The igniters are not operating during this test. An inspection is performed to determine if the pressure transient test caused any deformation of the hydrogen igniters. A functional test is performed after this portion of the test.

The test sample is subjected to a water submergence test following the pressure transient test. The igniter is arranged in a test fixture to allow the igniter to be submerged rapidly. The igniter is submerged, while operating, for a period of approximately five seconds. The igniter is removed and a complete functional test performed.

2.7 SYSTEM OPERATION

The Hydrogen Control System is placed in service in accordance with the generic emergency procedure guidelines when the reactor water level reaches the top of the active fuel. The igniters are energized by two ON-OFF handswitches (M56-S1 and M56-S2) located in the control room on panel H13-P800. Red-green indication lights for each handswitch are provided. There are no interlocks associated with the Hydrogen Control System.

After manual initiation, the igniters are powered continuously for up to seven days. The system is manually de-energized by the operator turning both handswitches (M56-S1 and M56-S2) to "OFF" when the hydrogen generation event has passed.

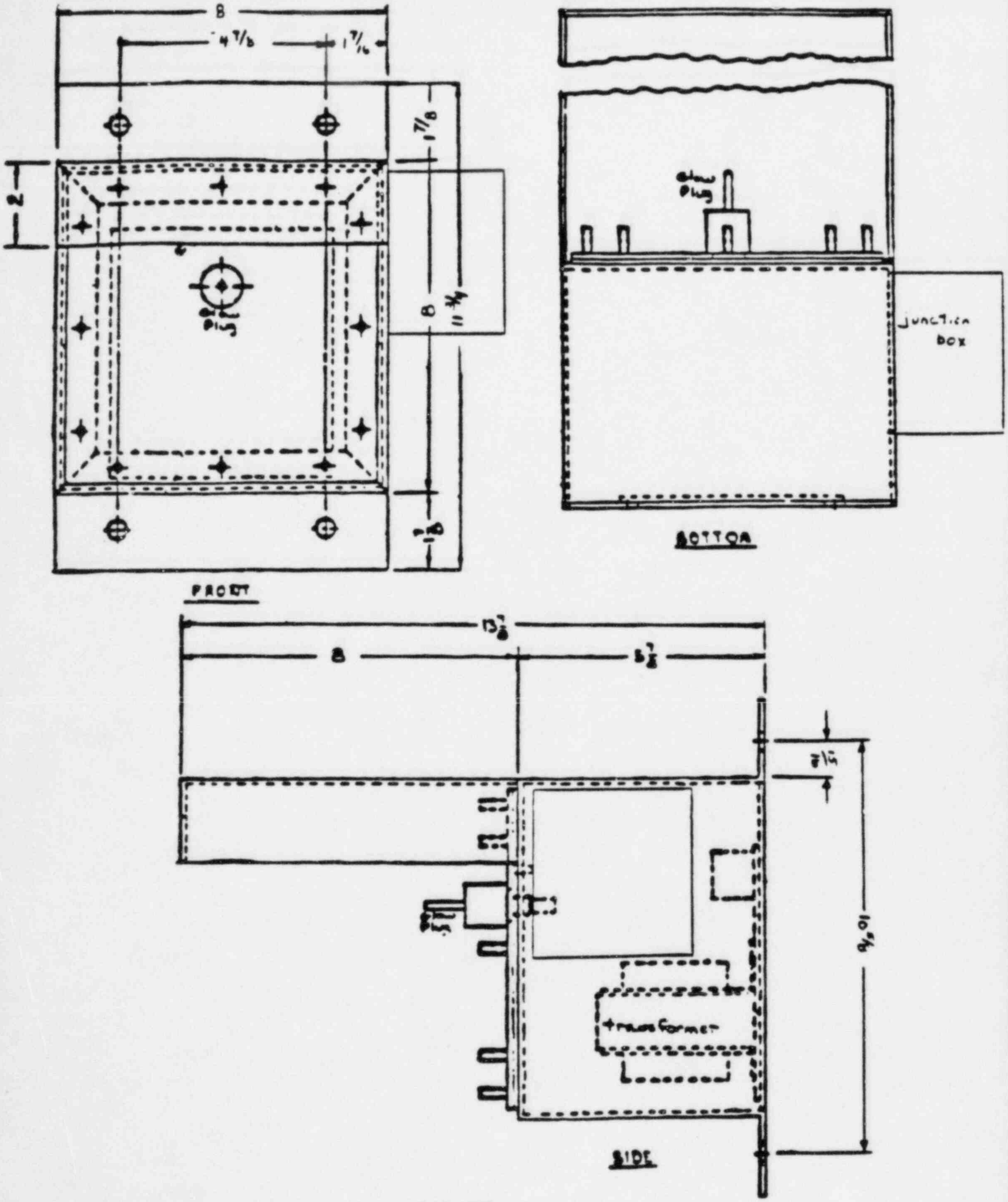


FIGURE 2.3-1

GENERAL ASSEMBLY
HYDROGEN IGNITER

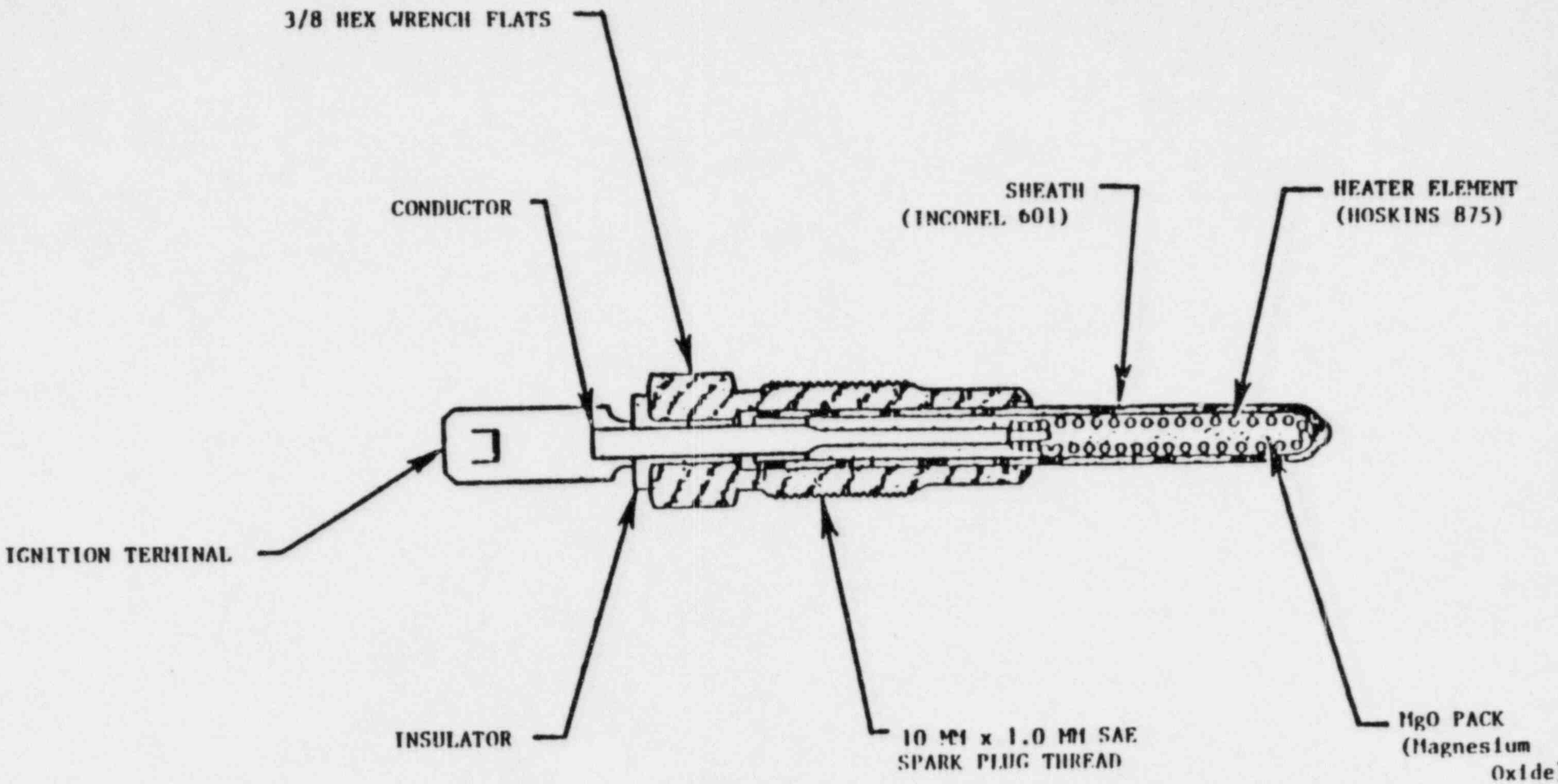


FIGURE 2.3-2
GMAC MODEL 7G GLOW PLUG

TABLE 2.4-1

HYDROGEN IGNITER LOCATIONS

IGNITER #	ESF POWER DIVISION	ELEVATION	AZIMUTH	DIMENSION TO CENTERLINE OF CONTAINMENT
IM56-001	1	613'4"	355°	49'0"
IM56-002	2	613'4"	5°	51'0"
IM56-003	2	619'6"	63°	51'8"
IM56-004	1	619'6"	89°	52'0"
IM56-005	1	664'0"	34°	57'0"
IM56-006	2	689'0"	34°	52'0"
IM56-008	1	629'1½"	11°58'	36'-6"
IM56-009	2	637'0"	41°5'	36'6"
IM56-010	1	636'3½"	90°	36'-6"
IM56-011	2	636'7"	137°	36'-6"
IM56-012	1	632'3"	180°	36'-6"
IM56-013	2	631'5"	221°	36'-6"
IM56-014	1	636'10"	273°	36'-6"
IM56-015	2	630'9½"	322°	36'-6"
IM56-016	2	660'0"	0°	31'6"
IM56-017	1	659'8"	57°	29'6"
IM56-018	1	659'8"	114°	30'-0"
IM56-019	2	659'8"	172°	30'-0"
IM56-020	1	659'8"	225°	28'0"
IM56-021	2	660'0"	280°	30'-0"
IM56-022	1	660'0"	317°	31'0"
IM56-023	1	619'6"	54°	52'0"
IM56-024	2	619'6"	118°	51'8"
IM56-025	1	619'6"	152°	51'0"
IM56-026	2	619'6"	186°	52'0"
IM56-027	1	619'6"	221°	51'8"
IM56-028	2	619'6"	255°	51'4"
IM56-029	1	619'9"	289°	52'0"
IM56-030	2	619'0"	322°30'	51'11"
IM56-031	2	638'0"	358°30'	41'-6"
IM56-032	2	640'0"	155°	46'0"
IM56-033	1	640'0"	186°30'	46'0"
IM56-034	1	640'-0"	324°	53'6"
IM56-035	2	640'4 3/4"	61°	51'6"
IM56-036	1	640'5½"	118°	51'6"
IM56-037	2	640'5"	227°	46'0"
IM56-038	1	639'4½"	260°30'	54'0"
IM56-039	1	651'1"	286°-30'	41'-6"
IM56-040	1	647'4"	2°	41'6"
IM56-041	1	650'6 3/4"	41°	50'-6"
IM56-042	2	650'6"	87°	49'0"
IM56-043	1	651'-0"	101°	49'-0"

TABLE 2.4-1 (Continued)
HYDROGEN IGNITER LOCATIONS

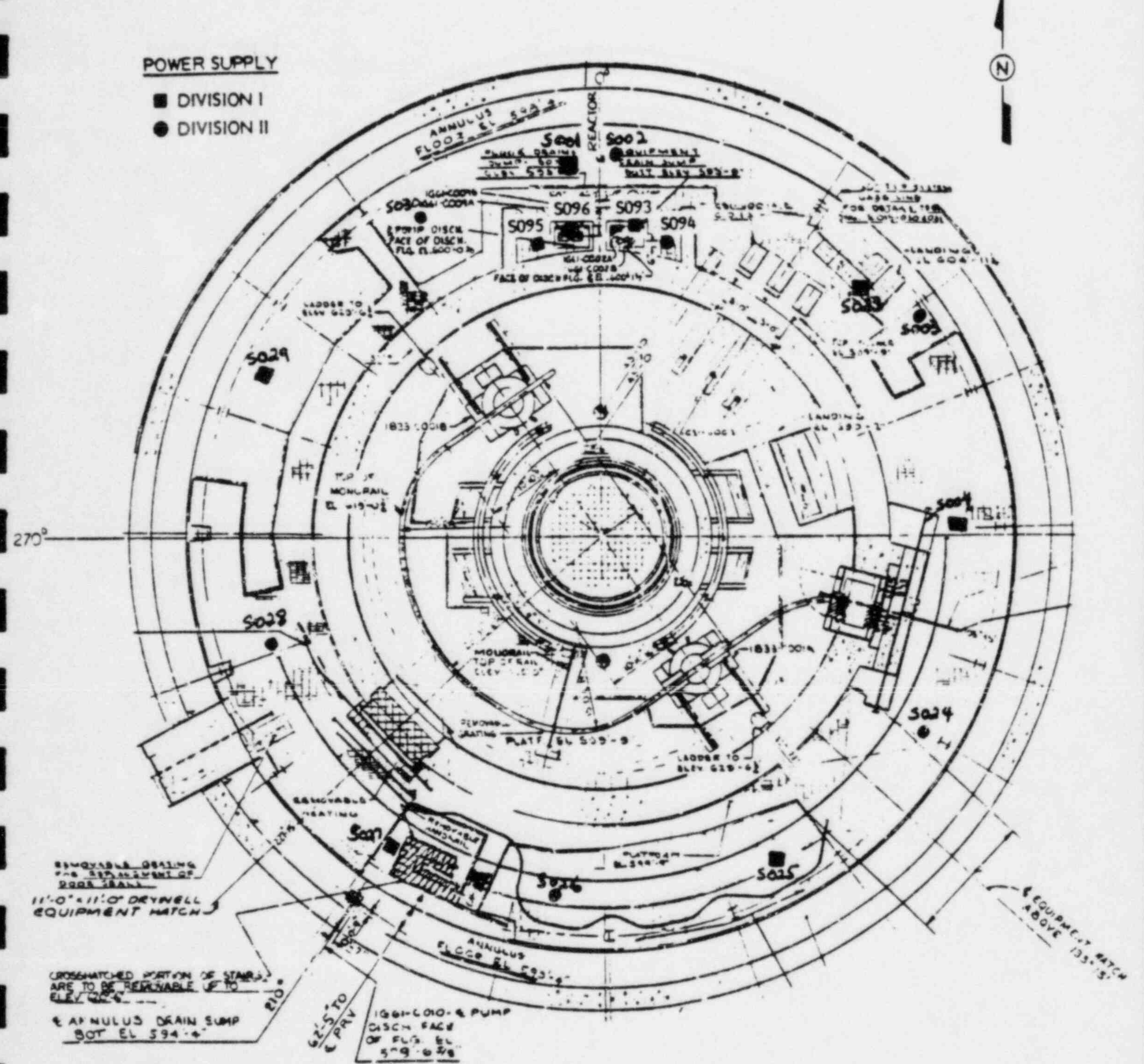
IGNITER #	ESF POWER DIVISION	ELEVATION	AZIMUTH	DIMENSION TO CENTERLINE OF CONTAINMENT
IM56-044	1	660'0"	86°30"	44'6"
IM56-045	2	660'6"	95°	48'-6"
IM56-046	2	664'0"	54°	51'0"
IM56-047	1	665'-0"	114°	52'0"
IM56-048	2	662'6"	147°	53'-0"
IM56-049	1	662'7 3/4"	218°	51'0"
IM56-050	2	664'7"	251°	49'6"
IM56-051	1	661'6"	289°	50'
IM56-052	2	661'6"	324°	49'6"
IM56-053	1	669'-6"	0°	54'6"
IM56-054	2	684'-9"	355°	52'-6"
IM56-055	1	686'-0"	75°	48'-0"
IM56-056	2	686'-0"	85°	47'-0"
IM56-057	2	686'-0"	95°	47'-0"
IM56-058	1	686'-0"	105°	48'-0"
IM56-059	1	686'-0"	75°	35'-0"
IM56-060	2	686'-0"	105°	35'-0"
IM56-061	1	689'-6"	45°	48'-0"
IM56-062	2	689'-06"	133°-15'	41'-0"
IM56-063	1	689'-6"	229°	48'-0"
IM56-064	2	689'-6"	252°	43'-6"
IM56-065	1	689'-6"	289°	43'-0"
IM56-066	2	689'-6"	310°	48'-6"
IM56-067	1	715'-6"	358°-51'	58'-9"
IM56-068	2	715'-6"	27°-8'	58'-9"
IM56-069	1	715'-6"	61°-47'	58'-9"
IM56-070	2	715'-6"	87°-32'	58'-9"
IM56-071	1	715'-6"	119°-27'	58'-9"
IM56-072	2	715'-6"	150°-33'	58'-9"
IM56-073	1	715'-6"	178°-46'	58'-9"
IM56-074	2	715'-6"	209°-27'	58'-9"
IM56-075	1	715'-6"	240°-35'	58'-9"
IM56-076	2	715'-6"	273°-9'	58'-9"
IM56-077	1	715'-6"	300°-26'	58'-9"
IM56-078	2	715'-6"	331°-38'	58'-9"
IM56-079	1	745'-6"	358°-48"	48'-0"
IM56-080	2	745'-6"	34°	48'-0"
IM56-081	1	745'-6"	72°	48'-0"
IM56-082	2	745'-6"	102°	48'-0"
IM56-083	1	745'-6"	143°	48'-0"
IM56-084	2	745'-6"	180°	48'-0"
IM56-085	1	745'-6"	216°	48'-0"
IM56-086	2	745'-6"	252°	48'-0"
IM56-087	1	745'-6"	287°	48'-0"

TABLE 2.4-1 (Continued)
HYDROGEN IGNITER LOCATIONS

IGNITER #	ESF POWER DIVISION	ELEVATION	AZIMUTH	DIMENSION TO CENTERLINE OF CONTAINMENT
IM56-088	2	745'-6"	324°	48'-0"
IM56-089	2	757'-0"	0°	1'-0"
IM56-090	2	757'-0"	180°	1'-0"
IM56-091	1	645'7"	168°	60'0"
IM56-092	2	645'-0"	172°	58'-0"
IM56-093	1	613'-4"	7°	44'-0"
IM56-094	2	612'5"	12°30'	42'8"
IM56-095	1	612'6"	343°-30'	42'6"
IM56-096	2	612'3"	350°-30'	43'6"
IM56-097	2	638'8"	289°	49'6"
IM56-098	1	658'6"	342°	53'-0"
IM56-099	2	685'-6"	17°	50'6"
IM56-100	2	686'-0"	75°	25'-0"
IM56-101	1	686'-0"	105°	25'-0"
IM56-102	1	670'-0"	350°	13'0"
IM56-103	2	670'-0"	4°	13'0"

NOTE: 1 M56-007 not used.

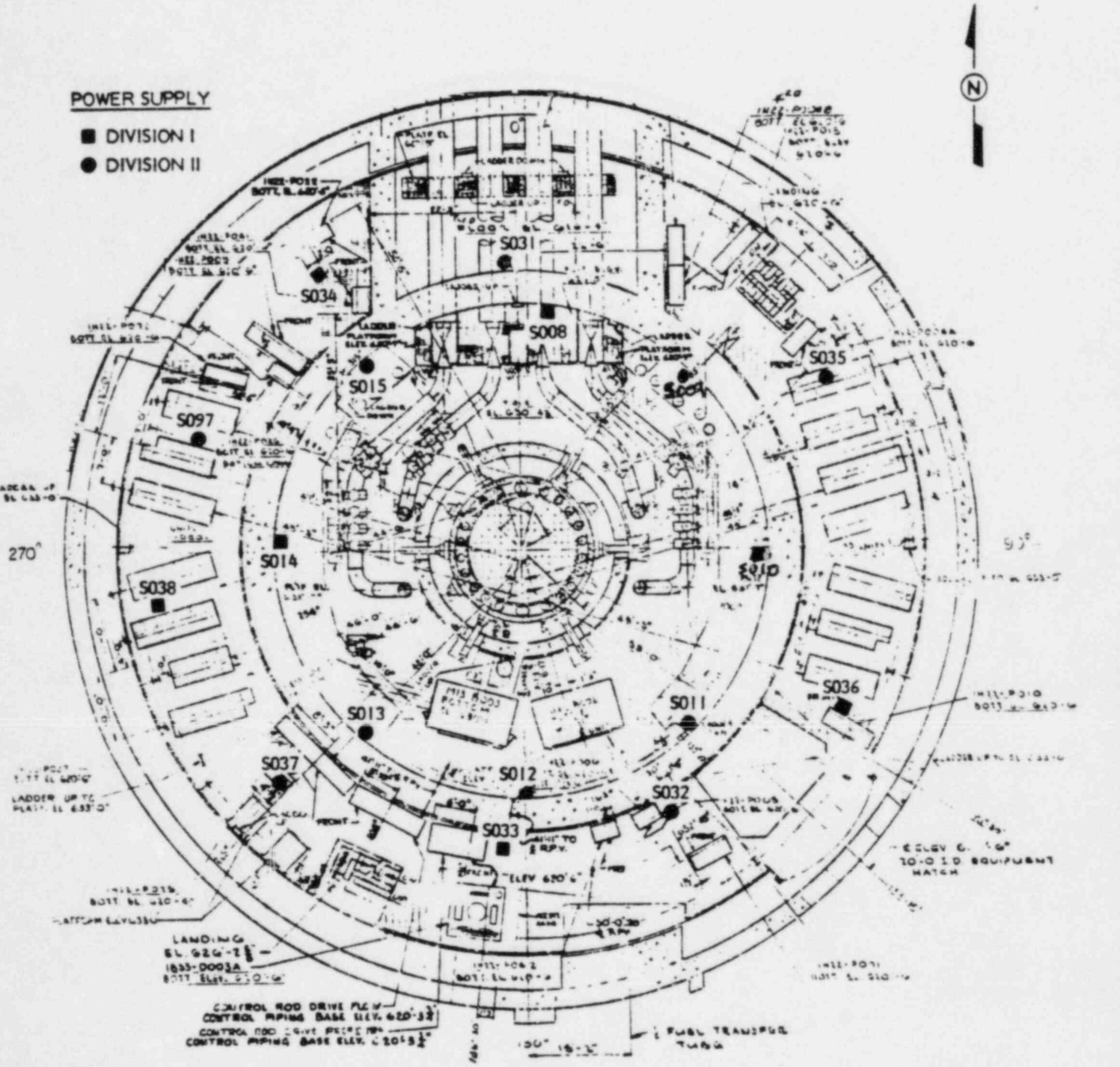
Figure 2.4-1



NOTE: 1) ALL IGNITER NUMBERS PREFIXED BY 1M56

PNPP UNIT 1 IGNITER LOCATION
REACTOR BUILDING
PLAN ELEV. 593'-6"

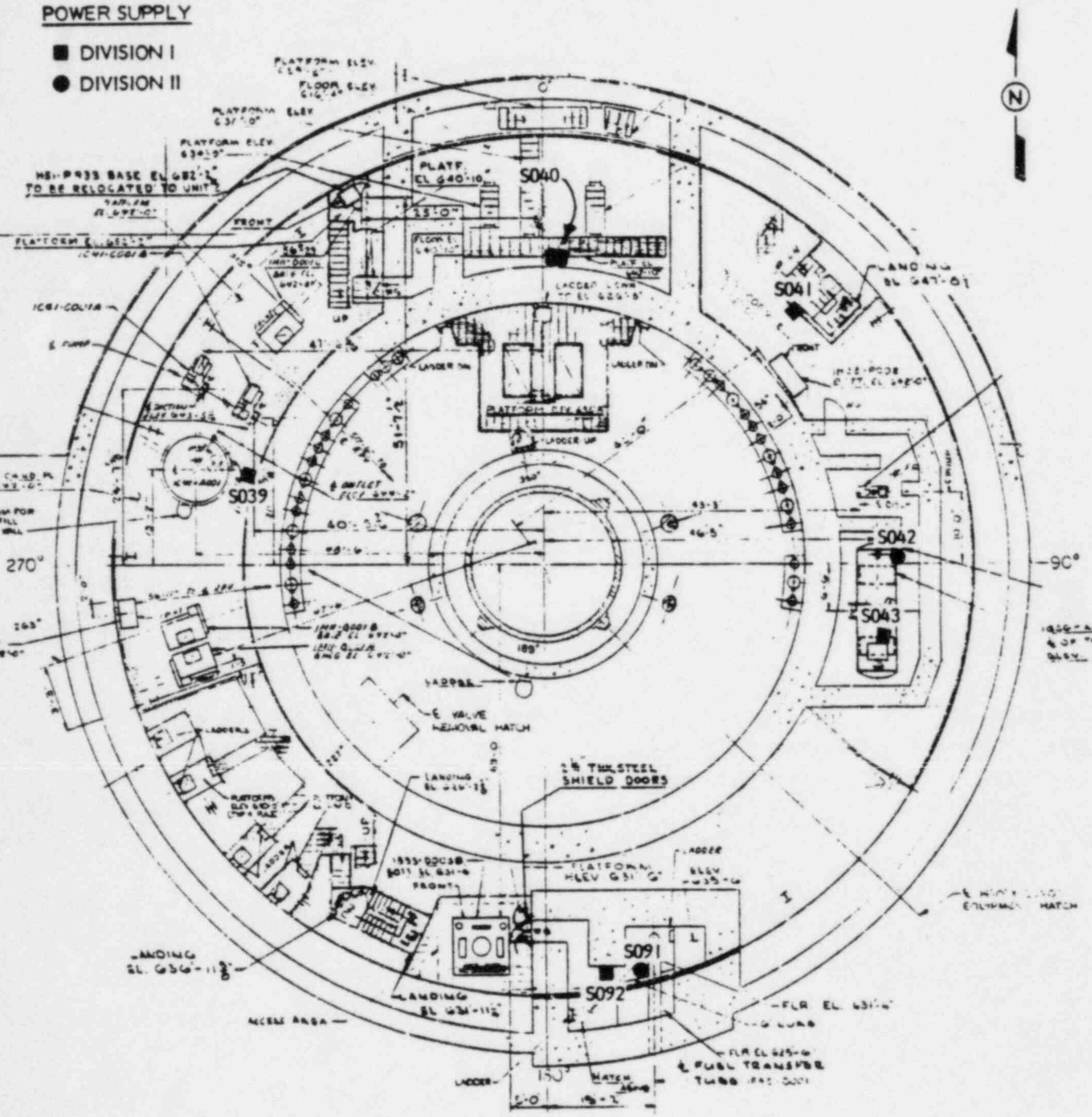
Figure 2.4-2



NOTE: 1) ALL IGNITER NUMBERS PREFIXED BY 1M56

PNPP UNIT 1 IGNITER LOCATION
REACTOR BUILDING
PLAN ELEV. 620'-6"

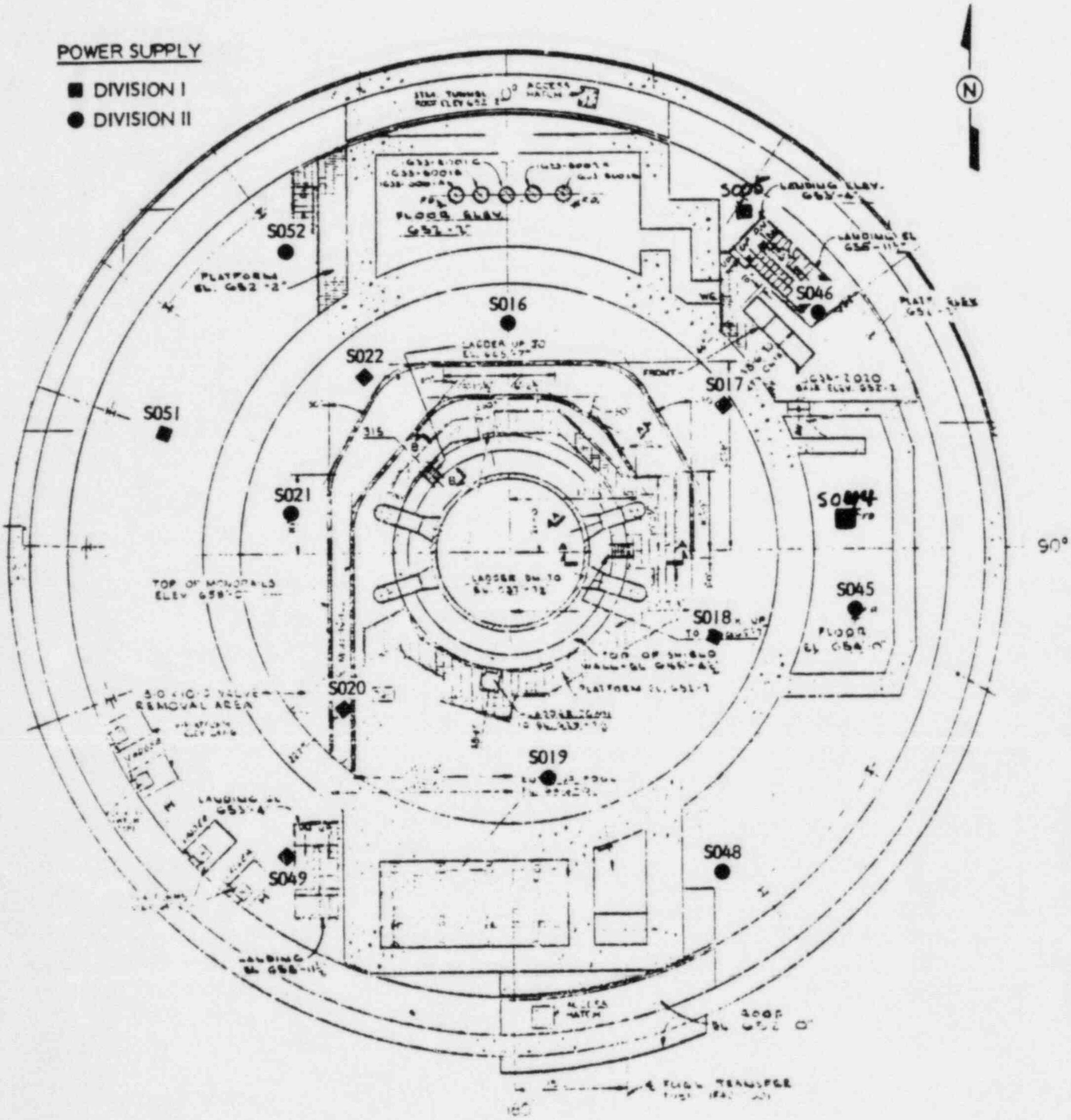
Figure 2.4-3



NOTE: ALL IGNITER NUMBERS PREFIXED BY 1M56

PNPP UNIT 1 IGNITER LOCATION
REACTOR BUILDING
PLAN ABOVE ELEV. 642'-0"

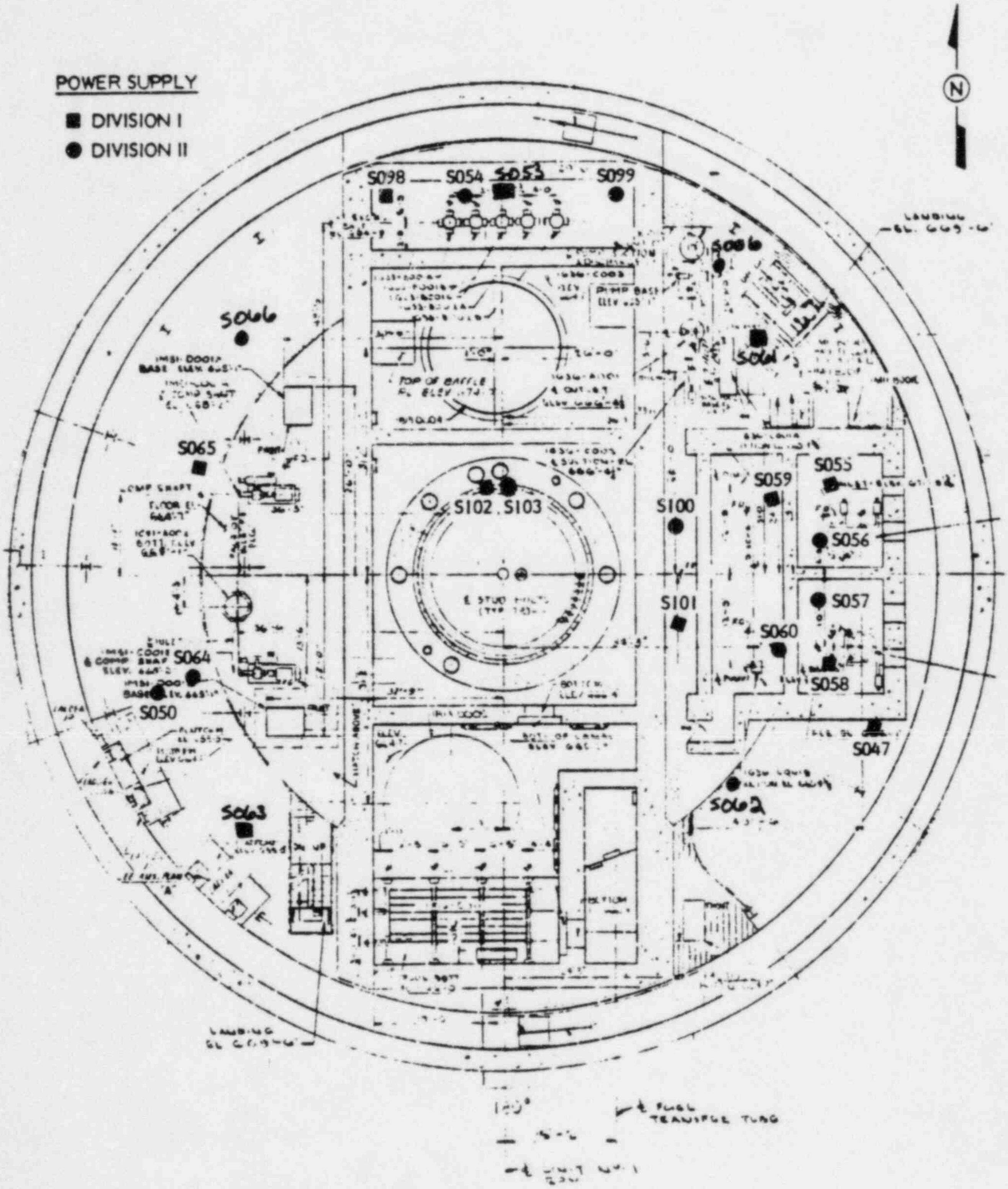
Figure 2.4-4



NOTE: ALL IGNITER NUMBERS PREFIXED BY 1M56

PNPP UNIT 1 IGNITER LOCATION
REACTOR BUILDING
PLAN ABOVE ELEV. 652'-6"

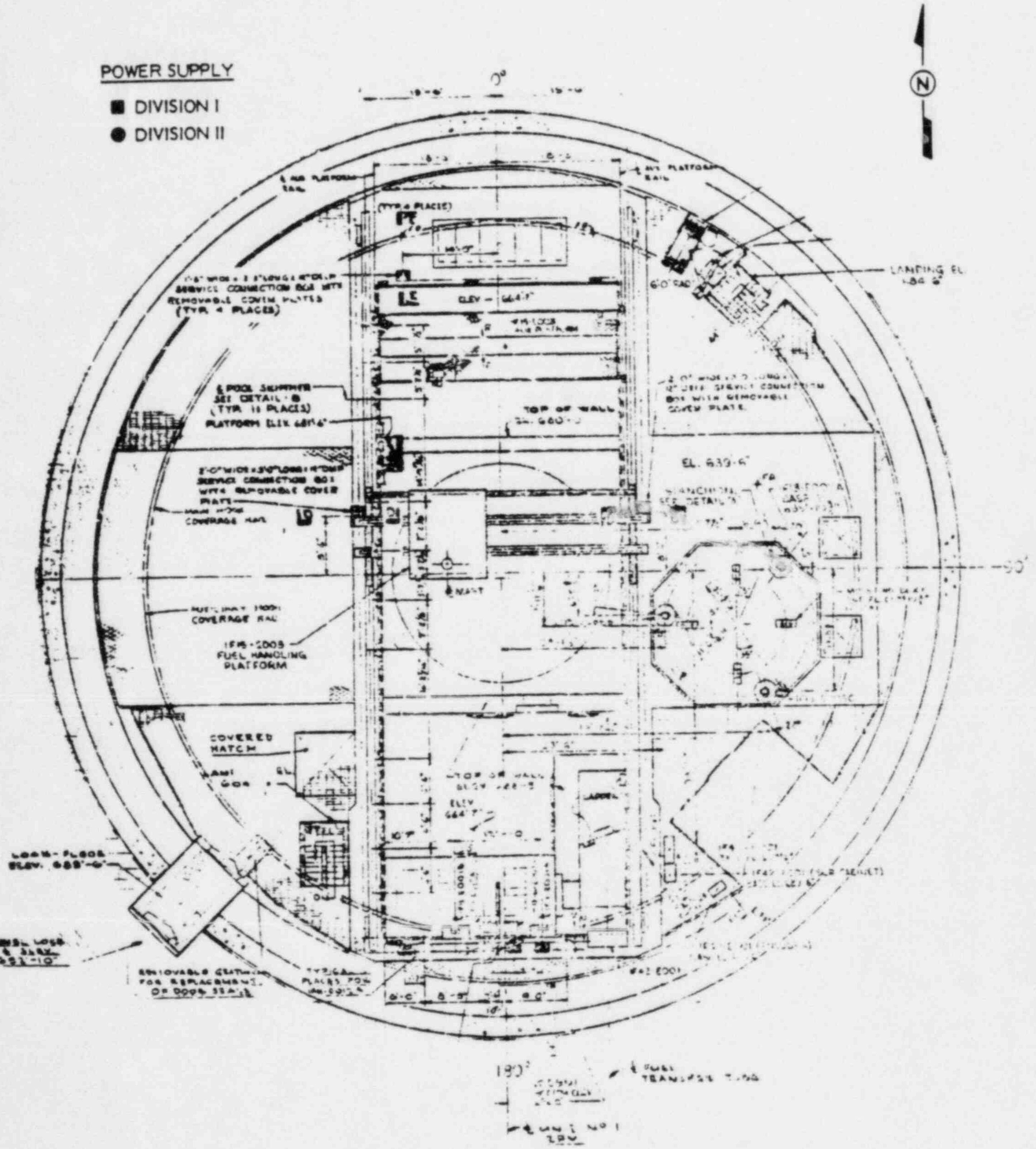
Figure 2.4-5



NOTE: ALL IGNITER NUMBERS PREFIXED BY 1M56

PNPP UNIT 1 IGNITER LOCATION
REACTOR BUILDING
PLAN ELEV. 664'-7"

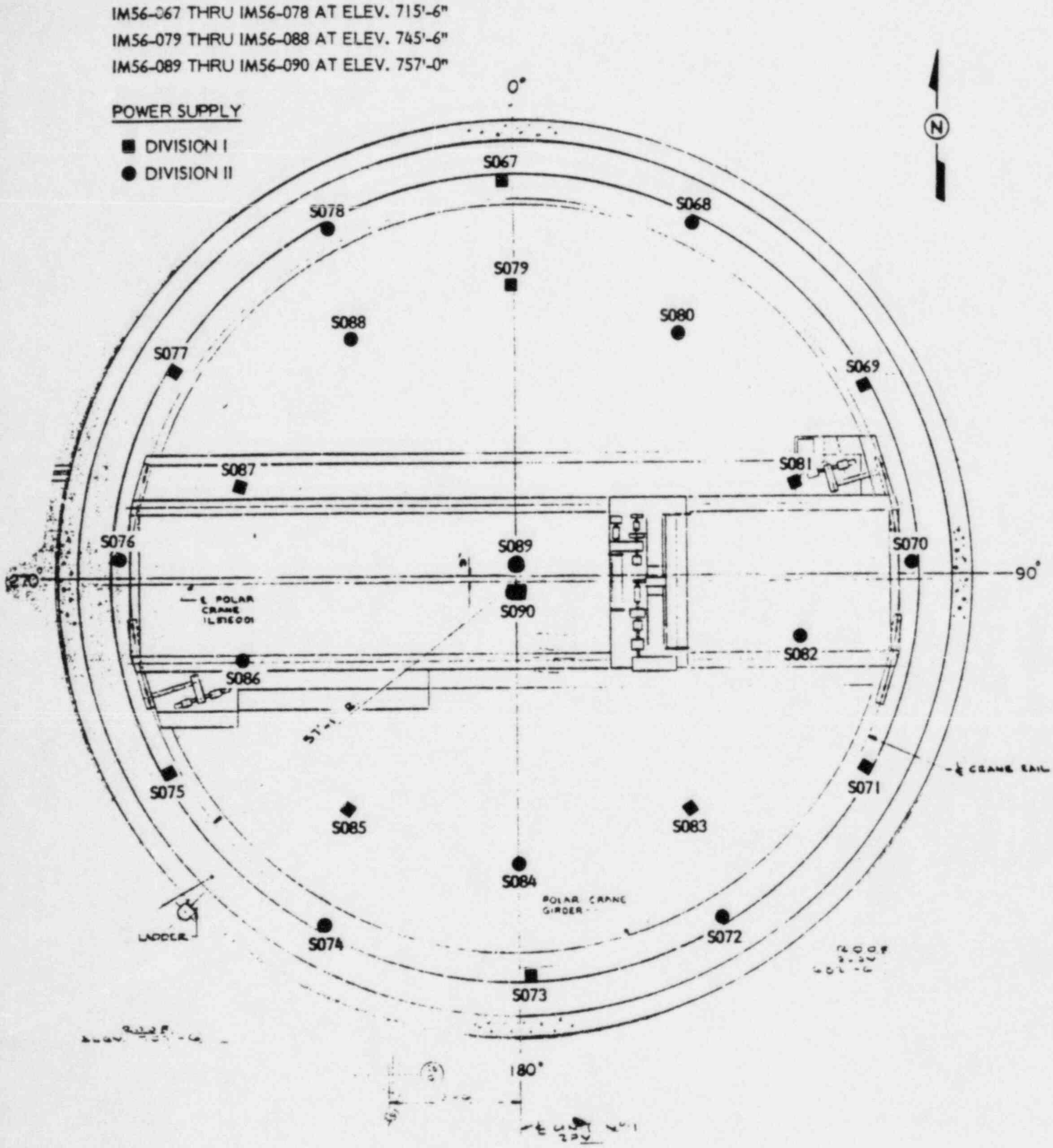
Figure 2.4-6



NOTE: ALL IGNITER NUMBERS PREFIXED BY 1M56

PNPP UNIT 1 IGNITER LOCATION
REACTOR BUILDING
PLAN ELEV. 694'-6"

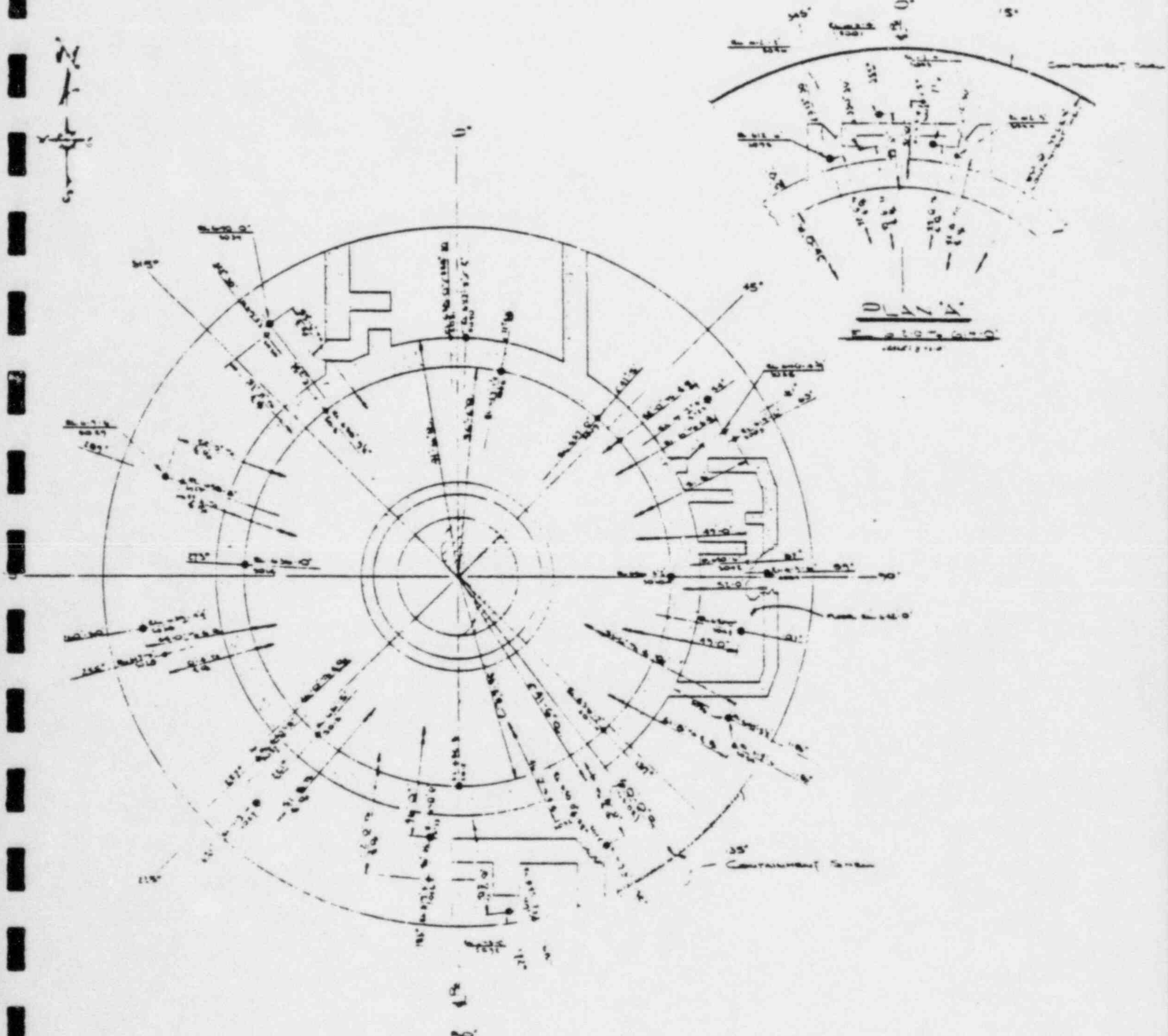
Figure 2.4-7



NOTE: ALL IGNITER NUMBERS PREFIXED BY IM56

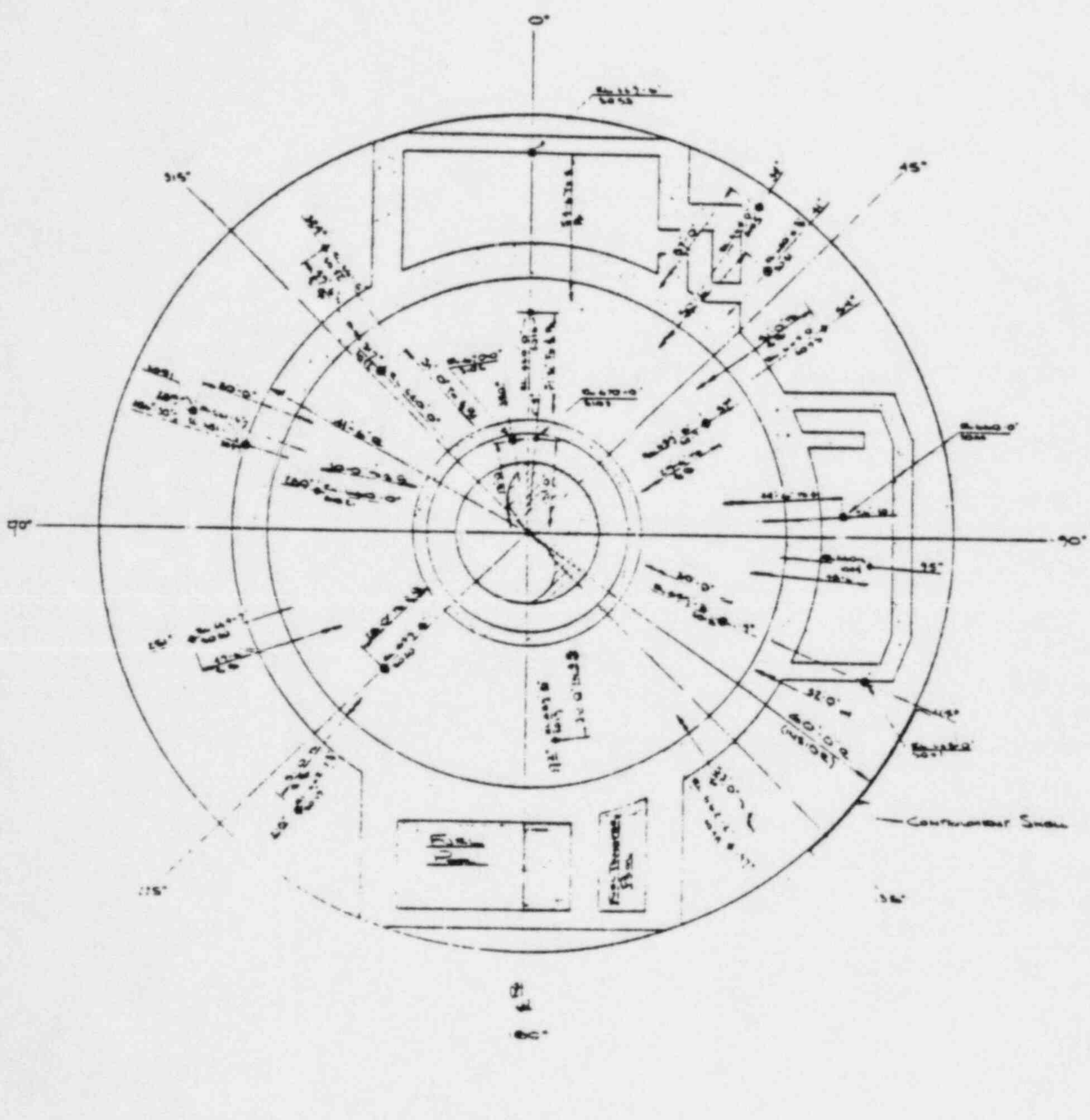
PNPP UNIT I IGNITER LOCATION
REACTOR BUILDING
PLAN ELEV. 721'-0"

Figure 2.4-8



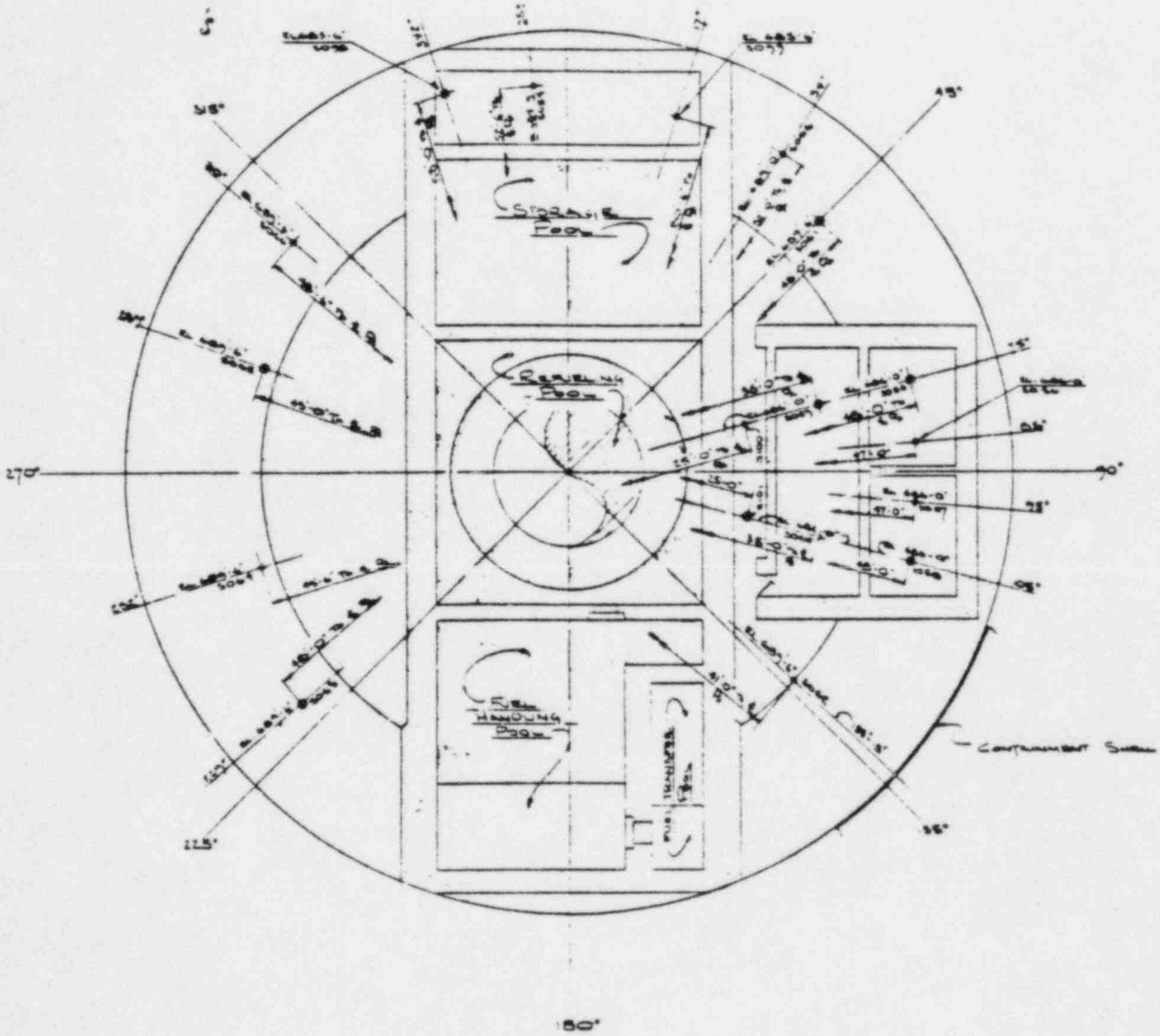
PLAN VIEW "B"
EL. 617'-0" to 649'-0"

Figure 2.4-9



PLAN VIEW "C"
EL. 649'-0" to 680'-0"

Figure 2.4-10

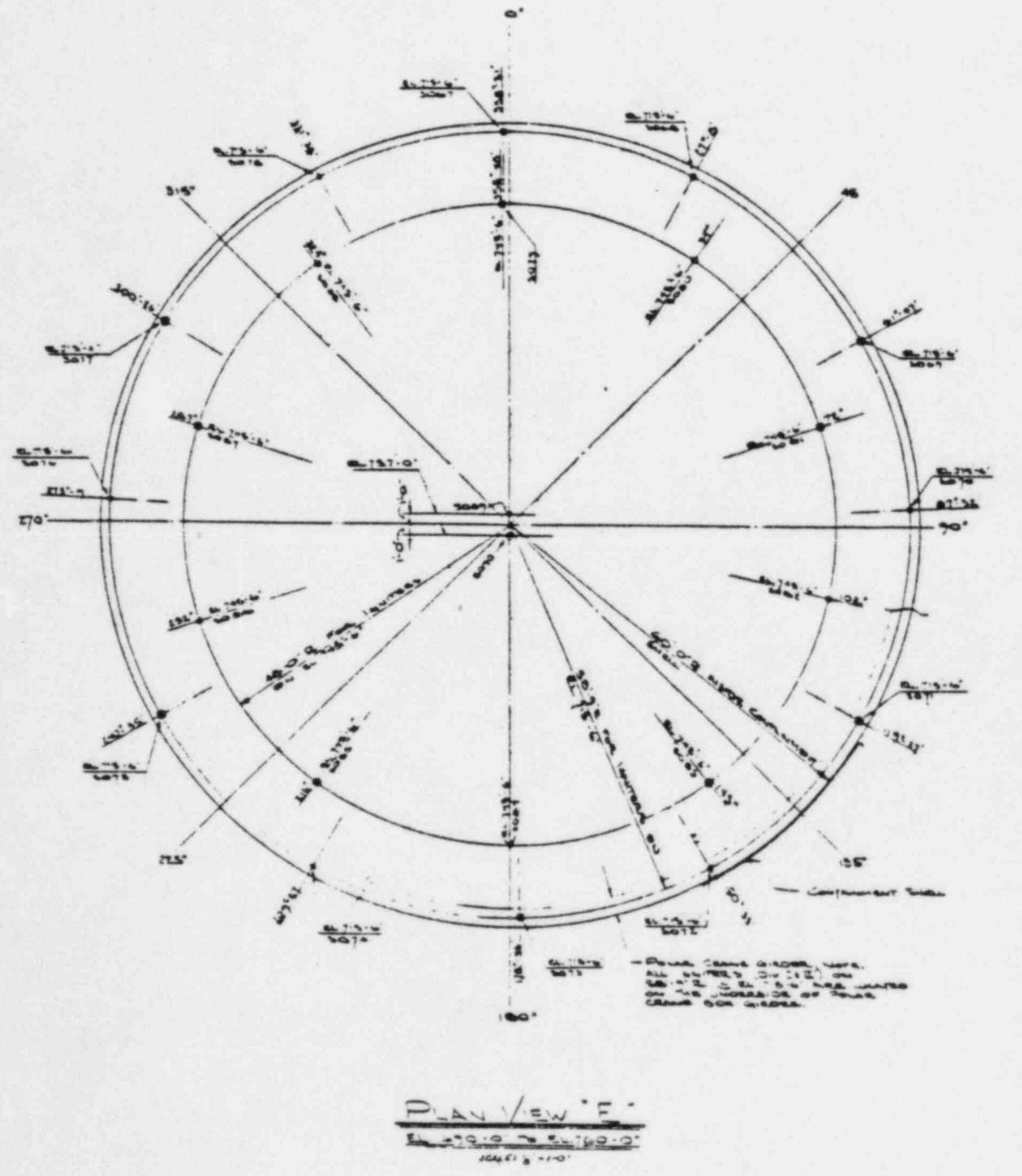


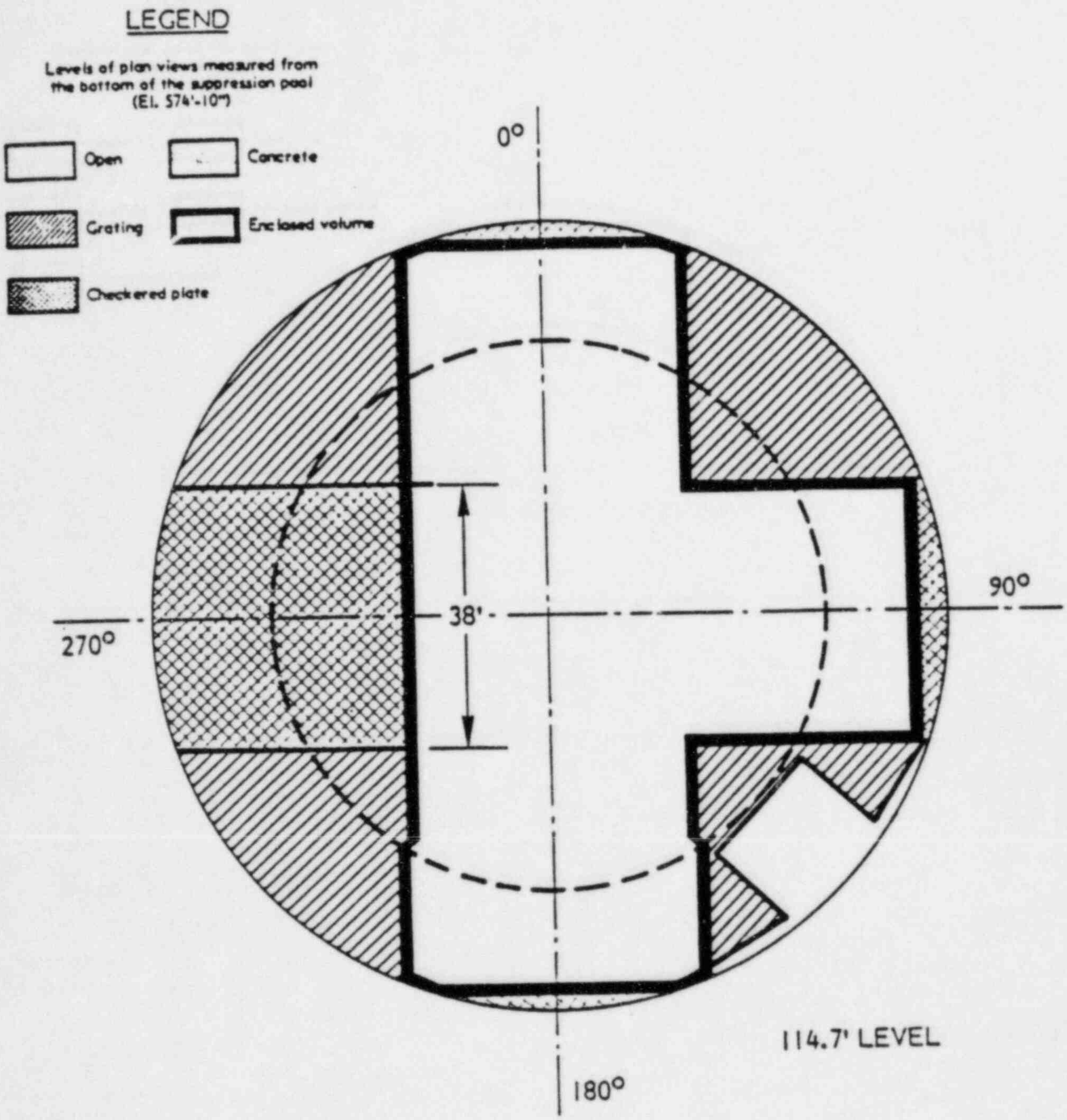
PLAN VIEW "D"

EL 680'-0" TO 670'-0"

SCALE 1/8" = 1'-0"

Figure 2.4-11

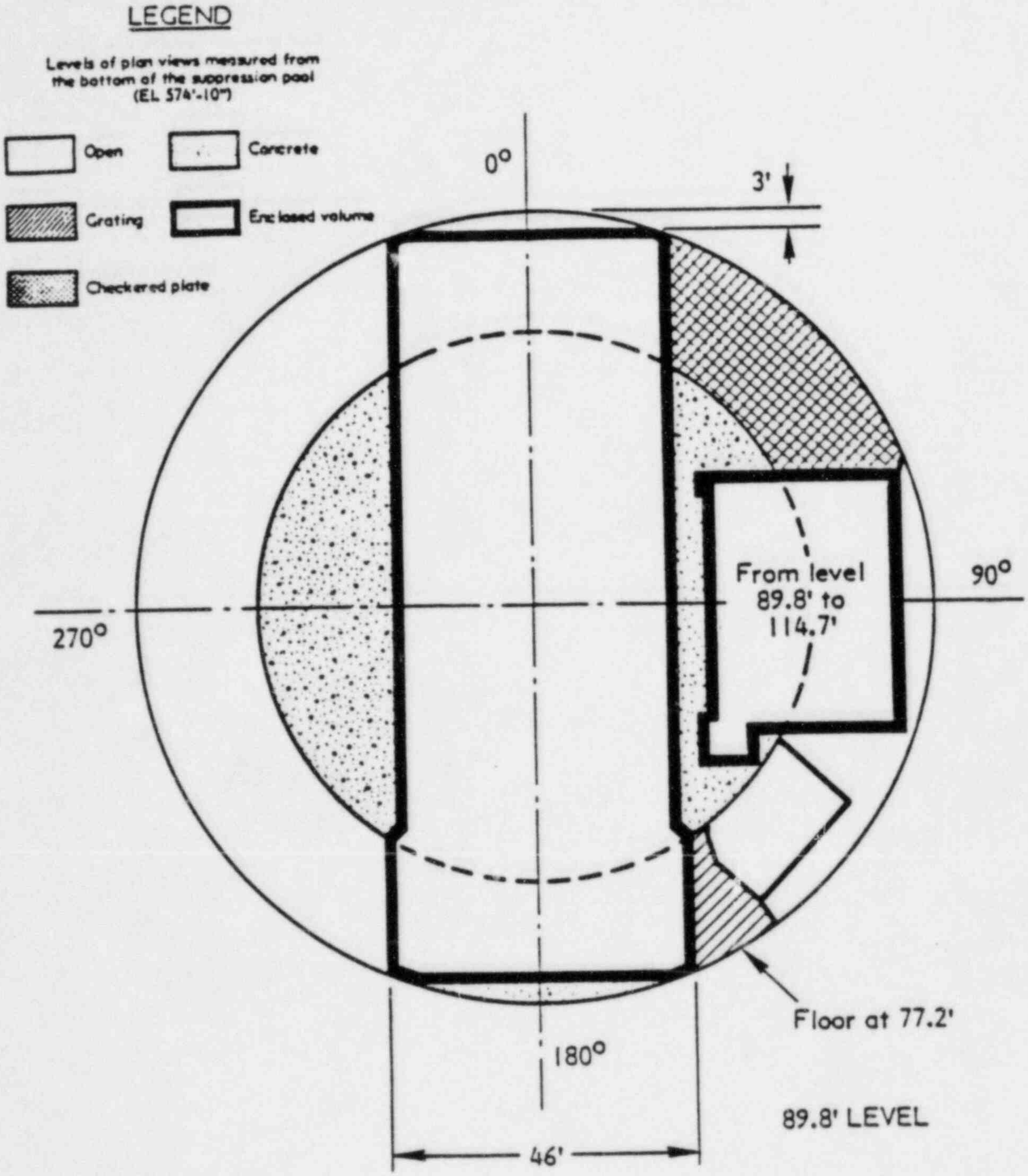




CROSS-SECTIONAL CONTAINMENT FLOW AREA 2778 ft^2

PNPP UNIT 1
REACTOR BUILDING CROSS-SECTION
PLAN ABOVE ELEV. 689'-6"

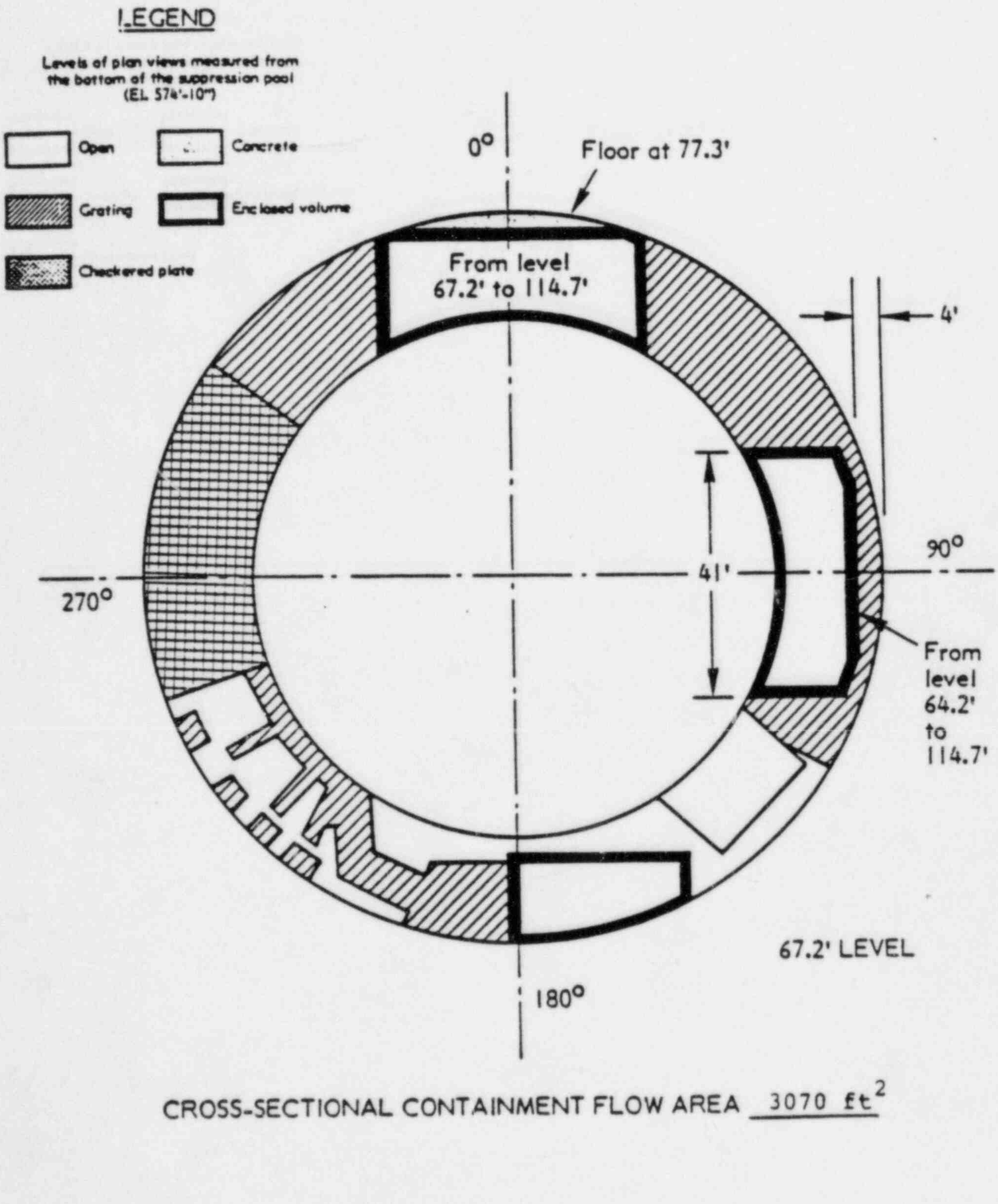
Figure 2.4-13



CROSS-SECTIONAL CONTAINMENT FLOW AREA 2534 ft^2

PNPP UNIT I
REACTOR BUILDING CROSS-SECTION
PLAN ABOVE ELEV. 664'-7"

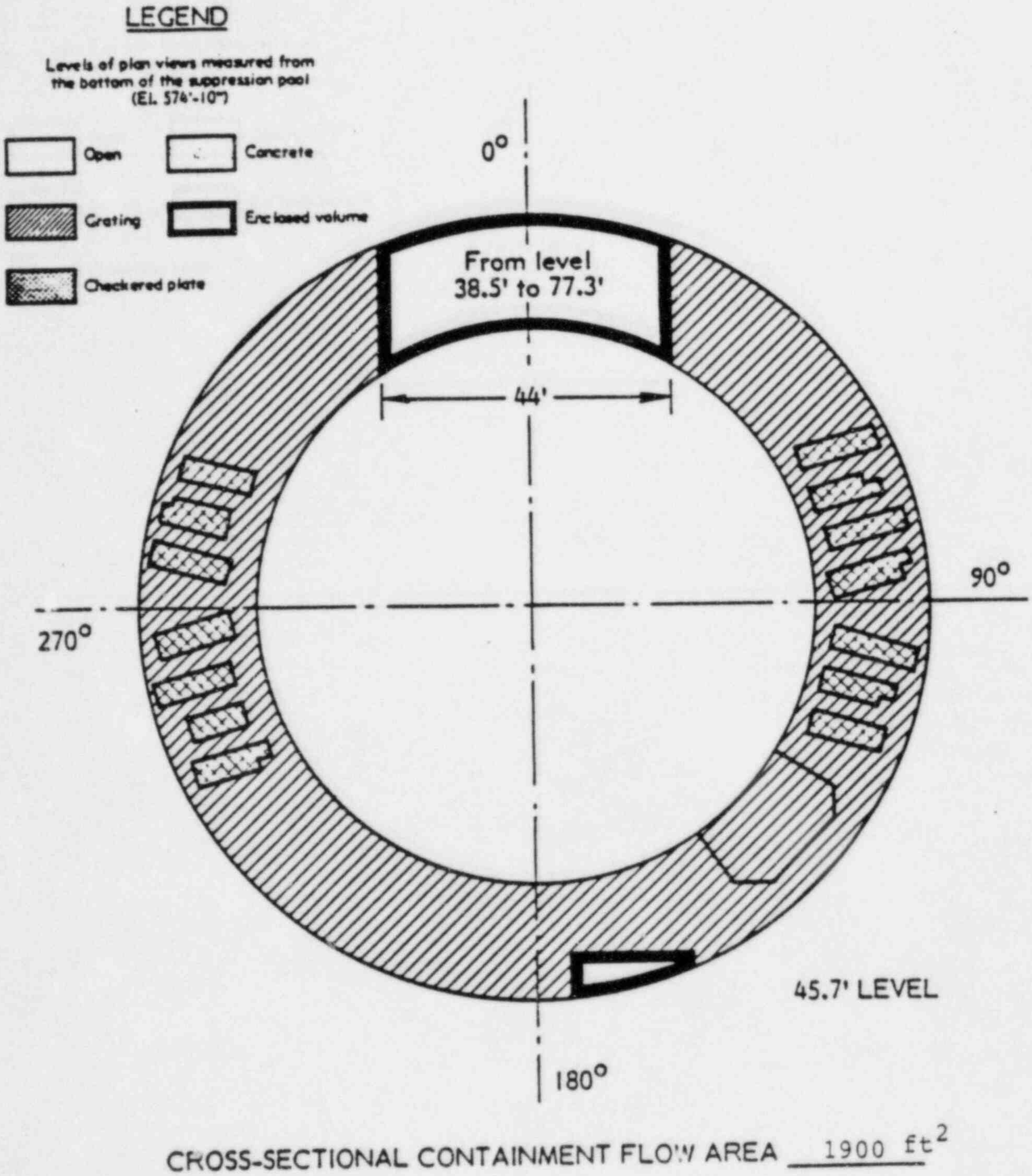
Figure 2.4-14



CROSS-SECTIONAL CONTAINMENT FLOW AREA 3070 ft^2

PNPP UNIT I
REACTOR BUILDING CROSS-SECTION
PLAN ABOVE ELEV. 642'-0"

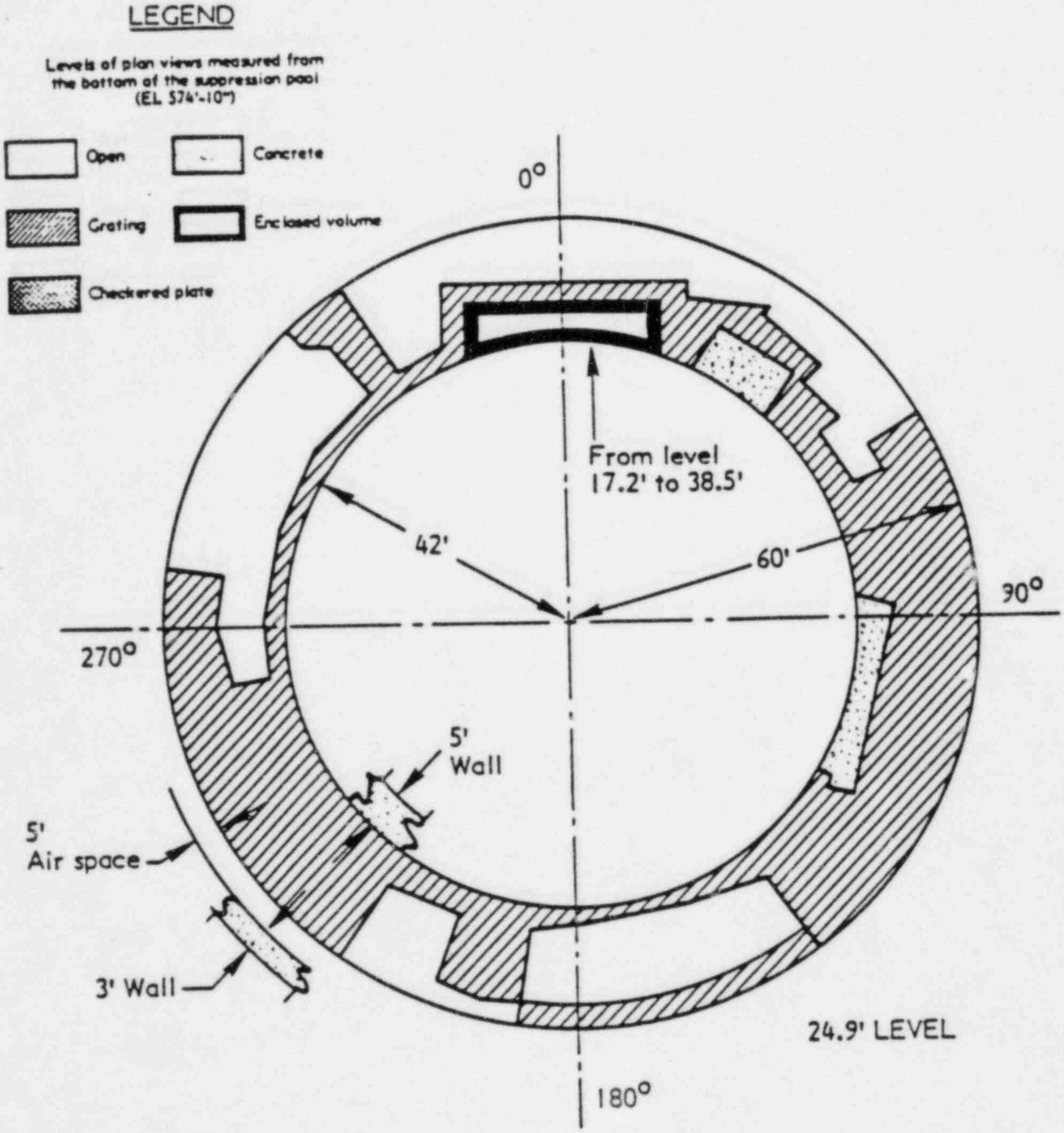
Figure 2.4-15



CROSS-SECTIONAL CONTAINMENT FLOW AREA 1900 ft^2

PNPP UNIT I
REACTOR BUILDING CROSS-SECTION
PLAN ABOVE ELEV. 620'-6"

Figure 2.4-16



CROSS-SECTIONAL CONTAINMENT FLOW AREA 3525 ft²

PNPP UNIT I
REACTOR BUILDING CROSS-SECTION
PLAN ABOVE ELEV. 593'-6"

Figure 2.5-1

ONE-LINE DIAGRAM
(ONE DIVISION ONLY)

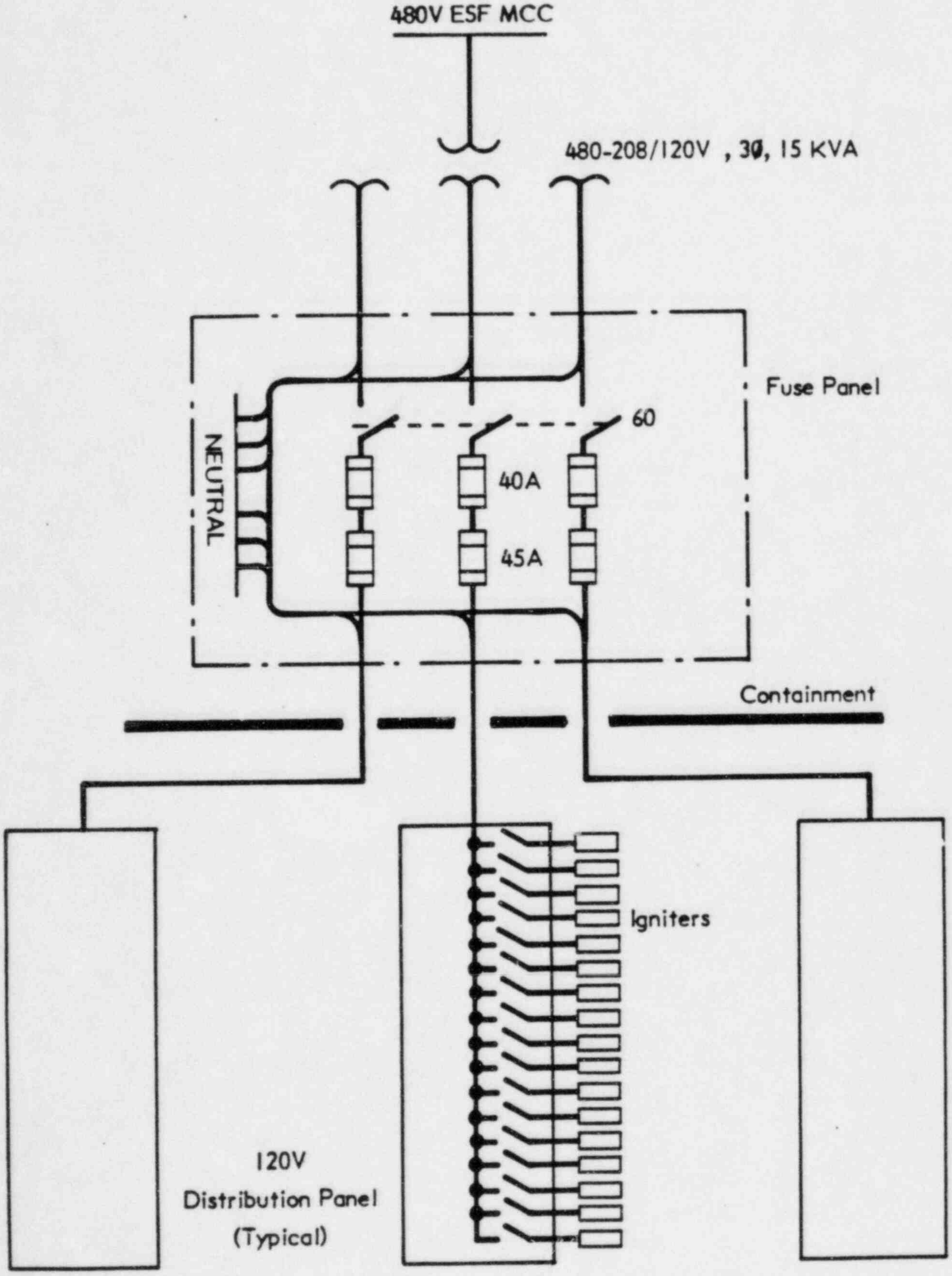


FIGURE
HYDROGEN IGNITER POWER SUPPLY

3.0 CONTAINMENT AND DRYWELL ULTIMATE CAPACITIES

3.1 CONTAINMENT ULTIMATE CAPACITY

The ultimate structural capacity analysis of positive internal pressure for the PNPP Mark III containment has been evaluated. The results were transmitted to the NRC in letters dated January 25, 1982 (D.R. Davidson to R.L. Tedesco) and February 11, 1985 (M.R. Edelman to B.J. Youngblood). Local regions of the containment vessel, equipment hatch, personnel air locks, and the main steam penetrations were evaluated for static loads. The actual material strengths of ASME-SA-516, Grade 70 steel were used in the analysis to determine the mean, lower bound and upper bound values of the material yield strength and ultimate strength. Based on these material properties, the capacity of the general shell to resist statically applied pressure was determined to be 78 psig lower bound strength and 94 psig mean value strength. The limiting region of the containment shell for the analysis was found to be the dome knuckle.

The maximum allowable pressure to meet the ASME Service Level C limits was determined to be 50 psig for the most limiting containment penetration. However, use of ASME Service Level D limits (defined in the ASME Code as "limits which are permitted for combinations of conditions associated with extremely low probability postulated events") is a more realistic evaluation of the containment pressure capability, considering the nature and probability of the hydrogen generation event. Utilizing Service Level D stress limits, the maximum allowable pressure for the most limiting containment penetration was determined to be 56 psig.

PNPP Safety Evaluation Report, Supplement 1, (NUREG-0887) Section 3.8.2 discussed the results of the containment ultimate capacity analysis. The SER noted that the dome knuckle area contols the ultimate capacity at the containment vessel which starts to yield at 68 psig. Containment shell pressure capacity can be increased to 78 psig, the pressure at which hoop buckling occurs in the knuckle region, since yielding occurs at one point along the meridian at 68 psig. However, as previously discussed, the most limiting penetration establishes the ultimate capacity value for the containment.

Previous analyses performed by the Hydrogen Control Owners Group (HCOG) Mark III member utilities have demonstrated that significant margins exist between the containment ultimate positive and negative pressure capacity and the positive and negative pressures postulated as a result of hydrogen combustion. At the Grand Gulf Nuclear Station (GGNS), the ultimate capacity versus design levels are 56 psig versus 15 psig for containment positive pressure and the capability for containment negative pressure has been established at -10 psid versus the -3 psid design value.

The PNPP margin, i.e. ultimate capacity versus design values, is similar to that of GGNS (56 psig versus 15 psig for PNPP containment positive pressure). Similarly, actual ultimate capacity over the 0.8 psid design negative capacity at PNPP can be expected. Further negative pressure capability is provided in the PNPP design, which includes two 24-inch nominal diameter vacuum relief lines to assure that the negative pressure inside containment does not exceed the design value of -0.8 psid. Two additional 24-inch lines are provided for redundancy. The vacuum breaker check valves begin to open under a negative pressure differential of 0.1 psid and they become fully effective in limiting the negative containment pressure within about one-half second.

In the design of the containment vacuum relief capacity, two limiting initiating events were considered for the vacuum relief line sizing: (1) inadvertent spray actuation following a 6 inch RWCU line break, and (2) inadvertent spray actuation during normal plant operations. In this design basis analysis (see FSAR Section 6.2.1.1.4.2), the following conservative assumptions were made to maximize the rate of cooldown due to the evaporative cooling process for case (2), which results in the lowest containment pressure:

a. Spray efficiency is 100%.

b. All of the spray water entering the containment is immediately vaporized and forms a homogeneous mixture with the containment atmosphere.

c. No heat is transferred into the containment atmosphere from the structures during the transient.

d. Maximum temperature in containment during normal operation - 105°F.

e. Minimum relative humidity in containment during normal operation -30 percent.

f. Minimum spray water temperature - 60°F.

g. Spray system flow rate - 10,500 gpm

Taking credit for only two of the four vacuum relief lines, and using the above conservative assumptions, resulted in a maximum negative pressure of -0.72 psid, or a 10% margin from the design negative pressure value of -0.8 psid.

The margin is substantially larger when credit is taken for all four vacuum relief lines and when the ultimate (rather than the design) containment negative pressure capacity is considered. This actual negative pressure capability at PNPP bounds the negative pressure resulting from the hydrogen burn (oxygen depletion), and the subsequent cooling of the containment atmosphere.

Therefore, considering the ultimate capacity margins that exist for structures and the redundant containment vacuum breaker capacity design, an additional analysis to calculate the ultimate negative pressure capacity of the PNPP containment is not warranted.

3.2 DRYWELL ULTIMATE CAPACITY

Previous analyses performed by the HCOG member utilities have also shown that significant margins exist between ultimate and design capacity of the drywell for differential pressures (both positive and negative) resulting from hydrogen combustion. A PNPP plant-specific ultimate capacity analysis of the drywell is not warranted, based on the following conclusions based on comparisons of PNPP and GGNS, which show, A) the drywell designs show similarity in structural details; and B) the CLASIX-3 containment response analyses show similarity in differential pressures resulting from hydrogen combustion for both plants.

A) The PNPP drywell is designed as a reinforced concrete structure. The primary drywell structure consists of four major components:

1. A flat, circular reinforced concrete foundation.

2. A right, vertical cylinder. The cylindrical wall is 83'x 0" outside diameter, 85'-9" high, and 5'-0" thick. The lower 26'-2" of the drywell is the vent region, composed of steel and concrete composite construction. This region consists of two concentric cylinders, with the annulus between the cylinders stiffened vertically by radial steel plates and filled with 5000 psi concrete. The upper drywell region is designed as a reinforced concrete cylinder connected to the lower vent region by cadwelding all vertical and diagonal rebars to the ring girder.

   This upper wall is heavily reinforced with No. 18 vertical and hoop rebars and No. 14 diagonal rebars. On the outside face of the cylinder, additional No. 11 vertical rebars are provided. The upper drywell wall is integrally connected to the 4'-0" thick drywell top slab.

3. A flat, horizontal, circular, reinforced concrete drywell top slab. The top slab contains a central circular opening of 31'-11.5" diameter which is closed by the drywell head.

4. The 14'-9.25" deep steel ellipsoidal drywell head, which forms part of the drywell pressure retention boundary.

The general arrangement and design details of the PNPP drywell structure are consistent with those previously evaluated for the GGNS. The primary drywell structure of the GGNS drywell consists of four major components:

1. A flat, circular reinforced concrete foundation.

2. A right, vertical cylinder. The cylinder wall is 75'-0" outside diameter, 91'-6" high, and 5'-0" thick. The lower 24'-10" portion of the wall, i.e., the vent region, is of heavily reinforced, concrete composite construction. This lower region has two stiffened steel, concentric, cylindrical surface plates. The annulus between the surface plates is stiffened by vertical, radial plates and is filled with concrete. The upper wall is designed as a reinforced concrete cylinder which is supported by the steel, lower wall section and internal concrete. The lower steel section is connected integrally with the upper wall vertical and diagonal reinforcement.

c. A flat, horizontal, circular, reinforced concrete drywell roof slab, containing a central circular opening of about 32 feet. This opening is closed by the drywell head.

d. A steel ellipsoidal drywell head, approximately 15'-6" deep, which forms part of the drywell pressure retention boundary.

The structural design aspects of the GGNS and PNPP drywells are functionally similar. Additionally, the drywell positive and negative design pressures for PNPP and GGNS are consistent in all material respects. See Section 5.4 of this report for a comparison of these values.

B) The base case PNPP CLASIX-3 analyses and the CLASIX-3 sensitivity studies performed for GGNS provide indications of the anticipated peak positive and negative drywell pressures resulting from hydrogen combustion. The assumptions and input parameters used for the PNPP analysis are similar to those used for the GGNS sensitivity studies. The key PNPP assumptions and input parameters (such as burn parameters) were the same as the corresponding GGNS cases. As discussed in Section 5.5 of this report, the results of both the PNPP and GGNS SORV and drywell break analyses are similar. This is expected due to the similarity in containment design (i.e. drywell, wetwell and containment volumes and heat sinks) and containment systems design (i.e. containment spray flow rates).

The differential pressures (drywell minus containment) calculated from the CLASIX-3 studies for GGNS, which are comparable to those for PNPP, were approximately +9 psid and -18 psid. These differential pressures are significantly lower than the ultimate capacity of the GGNS drywell which was determined to be +67 psid from the drywell to containment. The negative pressure capability is higher than the positive pressure capability. The drywell head is capable of withstanding -89 psid. Differential pressures range from +7 psid to -11 psid for the PNPP drywell break analysis. Given the similar drywell structural designs at GGNS and PNPP, similar margins between these calculated differential pressures and the positive and negative drywell capability are anticipated to exist for PNPP.

In summary, GGNS and PNPP are similar in arrangement and design details, and in the containment/drywell pressure and temperature response to hydrogen combustion. Thus, the pressure capability of the PNPP drywell structure is expected to be comparable to GGNS values. Also, the Mark III design results in a pressure capacity on the order of 2-3 times that required to withstand the maximum drywell pressure differentials resulting from hydrogen combustion. For these reasons, substantial margin and capability above required capacities are expected for the PNPP drywell with respect to its ability to withstand positive and negative pressures associated with hydrogen burn events.

4.0 CONTAINMENT ANALYSIS

4.1 INTRODUCTION

The Hydrogen Control System is designed to burn hydrogen in small concentrations, preventing large concentrations of hydrogen from accumulating which might ignite and threaten containment integrity. As indicated in section 2.0, there are 102 igniters distributed throughout the drywell and containment, which will burn hydrogen in small concentrations and prevent pocketing.

CEI has conducted a preliminary evaluation using the CLASIX-3 computer code. Two analyses were performed for PNPP to investigate the containment temperature and pressure response to postulated degraded core events with deflagration burning. Numerous risk assessment studies have shown that transient-initiated events, as compared to accident-initiated events, are the most probable in terms of core melt frequency. For transient-initiated events which result in a postulated recoverable degraded core, the hydrogen release is directly into the suppression pool through a stuck open relief valve (SORV). This event has been chosen as the base case for the preliminary evaluation of hydrogen combustion. In order to evaluate the effect of hydrogen released directly to the drywell, the less probable small line break in the drywell (DWB) is also evaluated.

The detailed report "Containment Pressure and Temperature Response to Hydrogen Combustion for Cleveland Electric Illuminating Perry Nuclear Power Plant," OPS-38A92, is attached as Appendix A. The report includes a description of the scenarios considered, the input assumptions, and the results, including the pressure and temperature response. This section discusses the OPS-38A92 analysis and the results.

Determination and evaluation of the containment thermal environment due to hydrogen combustion for higher hydrogen release rates associated with diffusion burning will be addressed in the final analysis.

4.2 EVENT SCENARIO

To evaluate the role of igniters in accident mitigation, CEI has undertaken a preliminary analytical effort to determine the effectiveness of the igniter system in reducing the threat to containment integrity caused by the combustion of hydrogen generated following postulated degraded-core accidents. Additional analysis and testing will continue as part of the long-term program to support the final analysis of the HCS.

The preliminary evaluation of the HCS is based on the analyses of two degraded-core accident scenarios: (1) a small break loss-of-coolant accident (LOCA) with temporary failure of emergency core cooling (ECC) injection, and (2) a transient with a stuck-open relief valve (SORV) accompanied by a failure of the ECC system.

The SORV was chosen as the base case recoverable degraded-core event, because of risk studies showing that it has a higher core melt frequency than the LOCA event. The small break LOCA was included for evaluation in order to consider the potential consequence of hydrogen release directly to the drywell.

In order to perform analyses of the containment atmosphere pressure and temperature response resulting from a degraded-core accident, the releases from the reactor coolant primary system, including steam and hydrogen release rates, must be established. The PNPP containment response analysis was based on the reactor coolant system response and releases using results from the MARCH computer code.

MARCH models the release of hydrogen and steam from the openings in the primary system appropriate for the scenario (SORV or small line break). The two sequences evaluated in the PNPP preliminary evaluation used identical mass and energy releases. For the small break LOCA, hydrogen and steam enter the drywell, as well as the suppression pool through the safety relief valves. For the SORV event, hydrogen and steam are directly introduced into the suppression pool through the safety relief valves.

This combination of releases is representative of a variety of recoverable degraded core situations in which hydrogen is a factor. As in the GGNS analyses, quenching and recovery were not mechanistically calculated since mechanistic scenarios cannot produce recoverable events with 75% metal water reaction. The hydrogen reaction was terminated when 75% oxidation of the cladding was reached consistent with the new hydrogen rule. The fraction of fuel clad oxidized in the calculation (75%) exceeds that estimated to have occurred in the TMI-2 accident (45-50%).

The MARCH steam, hydrogen, and fission product energy releases calculated for GGNS were used for both PNPP and GGNS containment response analyses and are shown in Tables 1, 2 and 3 of Appendix A. The MARCH releases based on Grand Gulf are conservative for PNPP, since there was no reduction in hydrogen releases to account for the fact that PNPP has fewer fuel bundles and less total active cladding to produce hydrogen.

4.3 CONTAINMENT RESPONSE TO HYDROGEN COMBUSTION

CEI, using the hydrogen and steam releases obtained from the MARCH code analyses for Grand Gulf, analyzed the containment atmosphere transient using the CLASIX-3 code. The CLASIX-3 code is a modification of the original CLASIX code that was developed to perform hydrogen combustion analyses for an ice-condenser containment. The CLASIX-3 code is identical to the CLASIX code in that it is a multivolume containment code, which calculates the containment pressure and temperature response in the separate compartments. CLASIX-3, however, has the capacity to model features of the system unique to a Mark III containment plant (including the suppression pool, refueling pool, vacuum breakers, and drywell purge system) while tracking the distribution of the atmosphere constituents, i.e., oxygen, nitrogen, hydrogen, and steam. The code also has the capacity of modeling containment sprays and structural heat sinks.

The CLASIX-3 model for the PNPP analysis is identical to that used for the initial GGNS analyses and sensitivity studies submitted by HCOG letter HGN-001, dated January 15, 1982.

A diagram of the Mark III containment and a schematic diagram of the Perry CLASIX-3 model used in this analysis are given in Appendix A, Figures 1 and 2, respectively. There are three compartments in this model: the drywell, wetwell and containment. Also included are the suppression pool, containment spray system, upper pool, and drywell purge system. The arrows in Figure 2 represent flow paths between compartments with the arrow pointing in the direction of allowed flow.

Mass and energy released to the containment atmosphere in the form of steam and hydrogen are input to the code. The burning of hydrogen is calculated in the code with provision to vary the conditions under which hydrogen is assumed to burn and conditions at which the burn will propagate to other compartments.

Two CLASIX-3 runs were made for the PNPP. The input for these two cases was identical except for suppression pool drawdown and the location of the steam, hydrogen and fission product energy releases. In the stuck open relief valve (SORV) case, the releases entered directly into the wetwell side of the suppression pool over the entire transient. Twenty minutes into the transient, the igniters and two Combustible Gas Control System (CGCS) compressors were manually activated and began pumping gasses from the containment to the drywell. After thirty minutes into the transient, the upper pool began dumping water to the suppression pool through one line and continued dumping for 8.67 minutes. The drawdown of the suppression pool (reinstatement of injection systems) was initiated at

6500 seconds into the transient. Releases in both cases were continued until hydrogen equivalent to a 75% fuel clad metal-water reaction was released from the primary system. At this time, the SORV transient was terminated. The DWB transient was continued in order to allow the remaining hydrogen to burn although the concentration was less than 8 v/o.

Appendix A to this report provides a detailed description of the CLASIX-3 model, input assumptions, plant-specific parameters used and the results. A summary of the results of the two PNPP cases is given in Table 17 of Appendix A. Temperature and pressure information is given in Figures 3-9 for the stuck open relief valve (SORV) case and Figures 22-28 for the drywell break (DWB) case. Volume fractions of oxygen, nitrogen, hydrogen, and steam are shown in Figures 10-21 for the SORV case and Figures 29-40 for the DWB case. Table 18 compares the results of two similar analyses performed as part of the sensitivity studies for GGNS.

5.0 DESIGN COMPARISON TO GRAND GULF

5.1 INTRODUCTION

CEI has conducted a significant amount of plant specific analyses justifying the PNPP HCS, as described in the previous sections. Further justification is provided by the similarities between PNPP and GGNS hydrogen control systems and containment designs and the fact that the NRC staff has reviewed the GGNS hydrogen control system and approved a full power operating license on an interim basis.

This section demonstrates that the GGNS and PNPP designs are similar in all material respects related to hydrogen control. This section provides a design comparison between GGNS and PNPP for: the igniter system, the containment ultimate capacity, the containment systems, the containment response analysis, and the list of equipment required to survive a hydrogen generation event. This report references FSAR figures and tables for both GGNS and PNPP. A list of FSAR tables cross-referenced to the tables included in this report is provided in Table 5.1-1.

5.2 IGNITER SYSTEM DESIGN

The PNPP HCS design is described in detail in section 2.0 of this report. The GGNS igniter system design has been described in several letters to the NRC; the important aspects of the design are summarized in Supplement 3 to the GGNS Safety Evaluation Report (SER), NUREG-0831. A comparison of the most significant design features is included in Table 5.2-1.

PNPP and GGNS have approximately the same number of igniters located throughout the drywell, wetwell and upper containment (PNPP has 12 more). The locations of the igniters at the two plants are similar because the same location criteria were used and because the internal containment configurations are similar, as shown in Figures 1.2-3 through 1.2-10, and Figures 1.2-2 through 1.2-7 of the PNPP and GGNS FSAR's, respectively.

The igniter selected for PNPP is a glow plug, Model 7G, manufactured by General Motors AC Division, and is identical to that installed in GGNS. In both designs the igniter is powered directly from a 120/12 VAC transformer.

The igniter assembly design is identical to the GGNS assembly and includes the igniter enclosure and the junction box. The igniter enclosure consists of a stainless steel box with 1/8 in. thick walls, which houses the transformer and associated electrical connections and partially encloses the igniter. The sealed box uses a hooded spray shield to reduce water impingement on the glow plug.

At both GGNS and PNPP, the igniters are powered from Class 1E power panels that are supplied from Engineered Safety Features (ESF) buses through Class 1E motor control centers. In the event of a loss of offsite power, the igniters would be powered from the emergency diesel generators. The HCS is designed as a seismic Category I system.

At both plants, the HCS is designed so that it can be manually activated from the control room following the start of an accident, and remain activated until the threat to containment integrity resulting from hydrogen release has passed. PNPP, like GGNS, uses a conservative seven day criterion for duration of HCS continuous operation. The system has two control switches, one for each electrical division, for actuating the igniters upon indication that the reactor vessel water level has dropped to top of the active fuel.

To ensure that the HCS will function as intended, PNPP, like GGNS, is implementing preoperational and surveillance testing programs. Preoperational testing is performed to verify the proper functioning of controls, wiring, instrumentation, and critical components of the HCS. As at GGNS, testing at PNPP will assure that the surface temperature of the operating igniter is equal to or greater than 1700°F. The current in each circuit was measured during preoperational testing at GGNS in order to provide baseline data for determining igniter operability during plant operation. The need for such data depends upon the surveillance requirements in the technical specifications. The PNPP Technical Specifications are currently under development and will be finalized prior to fuel load.

The actuation criteria for the drywell purge compressors, containment sprays and igniters at GGNS were implemented as preliminary procedural requirements prior to development of the generic emergency procedure guidelines. Operations of the HCS and associated containment systems at PNPP will be in accordance with the generic emergency procedure guidelines.

5.3 CONTAINMENT STRUCTURAL CAPACITY

Analyses have been performed at both PNPP and GGNS to determine the ultimate structural capacity of their Mark III containments. The ultimate structural capacity was defined as the pressure at which a general yield state is reached at a critical structural section.

CEI determined that the capacity of the PNPP containment shell to resist statically applied pressure is 78.0 psig, based upon the lower bound vessel strength, and 94.0 psig, based upon the mean vessel strength. The most limiting penetration can withstand 50 psig based on ASME Service Level C limits. Based on more realistic Service Level D limits, the most limiting penetration can withstand a 56 psig internal pressure.

GGNS determined the ultimate capacity of its Mark III containment by taking into account the strength of the steel liner, and by considering actual steel material strengths. The lower bound vessel capacity was 62 psig and the mean containment capacity was determined to be 67 psig. Based on code specified material strengths, the ultimate capacity was determined to be 56 psig. The most limiting penetration can withstand 56 psig internal pressure.

These ultimate containment capacity values for both the PNPP and GGNS, demonstrate a margin of 2 to 3 times the calculated peak containment pressure following a hydrogen burn. The calculated peak pressures were 21 psig and 24 psig for PNPP and GGNS respectively, based on the SORV initiating event scenario.

5.4 CONTAINMENT SYSTEMS DESIGN

The containment systems relevant to the analysis of the HCS include the containment structure, containment heat removal systems, combustible gas control system, and the suppression pool make-up system.

5.4.1 Containment Structure

Both PNPP and GGNS are Mark III pressure suppression containments. The internal arrangement of major equipment and structures are similar as indicated in GGNS FSAR Figures 1.2-2 to 1.2-7, and PNPP FSAR Figures 1.2-3 to 1.2-10.

The major difference between the two containment designs is that GGNS has a reinforced concrete containment and PNPP has a free standing steel containment. Additionally, the PNPP containment is slightly smaller due to the lower reactor power level of 3579 MW_t versus 3833 MW_t at GGNS.

The volumes of the drywell and containment are comparable as indicated below:

	Drywell (ft^3)	Containment (ft^3)
PNPP	277,685	1,141,014
GGNS	270,000	1,400,000

Both containments are designed for 15 psig and 185°F. GGNS is designed for 3.0 psid external pressure differential, while PNPP is designed for 0.8 psid external pressure differential. However, PNPP has redundant safety related containment vacuum breakers to maintain pressure within the design external differential pressure.

Other key containment design features shared by GGNS and PNPP are shown in PNPP FSAR Tables 6.2-1 through 6.2-9 and GGNS FSAR Tables 6.2-1 through 6.2-9, which are included as Tables 5.4-1 through 5.4-9 and 5.4-10 through 5.4-18, respectively.

5.4.2 Containment Heat Removal System

The containment heat removal system, consisting of the suppression pool cooling and containment spray systems, is an integral part of the Residual Heat Removal (RHR) system at both GGNS and PNPP. The purpose of this system is to prevent excessive containment temperatures and pressures to maintain containment integrity following an accident. To fulfill this purpose, the containment heat removal systems at both GGNS and PNPP meet the following safety design bases:

a. The system shall limit the long term bulk temperature of the suppression pool to 185°F without spray operation when considering the energy additions to containment following a LOCA.

b. The single failure criteria applies to the system.

c. The system is designed to safety grade requirements including the capability to perform its function following a Safe Shutdown Earthquake.

d. The system shall maintain operation during those environmental conditions imposed by the LOCA.

e. Each active component of the system is testable during normal operation of the nuclear power plant.

During system operation, water is drawn from the suppression pool, pumped through one or both RHR heat exchangers and delivered to the suppression pool or to the containment spray header. Water from the safety service water systems is pumped through the tube side of heat exchangers to cool the suppression pool water.

At both plants, the containment spray system can be started manually or automatically. The containment spray system is initiated automatically on high containment pressure of 9 psig, with an interlock to delay initiation until 10 minutes after a LOCA initiation signal.

The important design parameters for the GGNS and PNPP containment heat removal system are provided in Tables 5.4-11 and 5.4-3, respectively. The key parameters are comparable, differing only to account for the smaller PNPP reactor power level. The piping design of the RHR system for PNPP and GGNS is shown in FSAR Figures 5.4-13 and 5.4-14, respectively. The design is essentially the same with the exception that PNPP includes an additional isolation valve on each subsystem.

Although not part of the containment heat removal systems, the key design features of the Emergency Core Cooling Systems (ECCS) are provided in Tables 5.4-20 for GGNS and 5.4-19 for PNPP. The piping design for the High Pressure Core Spray (HPCS) and Low Pressure Core Spray (LPCS) are shown in FSAR Figures 6.3-1, 6.3-4 for GGNS, and 6.3-7, 6.3-8 for PNPP. The piping design and design values are essentially the same, sized appropriately for the smaller PNPP reactor power.

5.4.3 Combustible Gas Control

The combustible gas control system (CGCS) is provided to control the concentration of hydrogen which may be released in the drywell and containment following a postulated design basis accident (LOCA). At both GGNS and PNPP, the system is composed of three major subsystems: drywell purge, hydrogen recombiner, and a backup containment purge system. Since the backup containment purge system is not relevant to degraded core hydrogen control, only the first two subsystems will be discussed. The key design and performance characteristics of the GGNS and PNPP CGCS's are provided in Tables 5.4-21 and 5.4-22, respectively. The piping diagrams are shown in FSAR Figures 6.2-81 for CGNS and 6.2-62 for PNPP.

For both GGNS and PNPP, the drywell purge subsystem consists of two redundant 100% capacity compressors and associated components. The compressor draws air from the containment volume and discharges into the drywell, causing flow of the drywell atmosphere through the horizontal vent system, through the suppression pool and back into the containment. The only significant difference between the two designs are:

a. PNPP compressors are rated at 546 scfm versus the 500 scfm (minimum) at GGNS (1000 scfm per GGNS Technical Specification 3/4.6.7.3).

b. The PNPP drywell purge system is manually operated, while the GGNS system is initiated either manually or automatically (LOCA signal and drywell pressure within 1.0 psid of containment pressure) due to the additional function of post-LOCA drywell vacuum relief.

c. The PNPP drywell purge discharge penetrates the drywell through the same penetration as the drywell vacuum breakers. The GGNS design has separate penetration for the post-LOCA vacuum breaker lines.

d. The GGNS drywell purge discharge lines include vaccum breakers for additional vacuum relief once the system is initiated. The PNPP design does not include this feature.

None of the differences identified above would have a significant effect on the analysis of the HCS. Plant specific differences in system design values were included in the containment analysis as discussed in sections 4.0 and 5.5.

Both GGNS and PNPP include two 100%-capacity hydrogen recombiners inside the containment. The hydrogen recombiners are thermal recombiners manufactured by Westinghouse, each having a capacity of 100 scfm and a power rating of 75KW. The hydrogen recombiner subsystem designs for both PNPP and GGNS are similar.

5.4.4 Suppression Pool Makeup System

The designs of the Suppression Pool Makeup System (SPMS) are essentially the same at GGNS and PNPP. The SPMS provides water from the upper containment pool to the suppression pool by gravity flow following a design basis accident (LOCA). The piping system consists of two lines, with two normally closed motor operated valves in series in each line. The piping diagram for each system is shown in PNPP FSAR Figure 6.2-67 and GGNS FSAR Figure 6.2-82.

Both GGNS and PNPP systems are initiated either manually or automatically following LOCA signals and low-low suppression pool water level or 30 minutes, whichever occurs first. The quantity of water added to the suppression pool is approximately 36,400 and 32,800 cubic feet for GGNS and PNPP, respectively.

For both PNPP and GGNS, the SPMS volume is drained down in less than 10 minutes. For both plant designs, the SPMS will accomplish its safety function prior to the generation of significant amounts of hydrogen. Therefore, the minor system differences discussed above are not pertinent to this evaluation.

5.5 CONTAINMENT RESPONSE ANALYSIS

GGNS and PNPP used the CLASIX-3 computer code to evaluate the containment pressure and temperature response to hydrogen deflagration. Both plant analyses used the hydrogen and steam releases obtained from the MARCH code. The MARCH release rates used for PNPP, were conservatively overstated by using the GGNS hydrogen and steam release rates without any reduction to account for the smaller core size (PNPP has 748 fuel bundles versus the 800 at GGNS).

Both GGNS and PNPP evaluated the results of two types of hydrogen generation events: the more probable transient initiated stuck open relief valve (SORV) event and a drywell small line break case (DWB). The PNPP analysis is included as Appendix A. The comparable GGNS analysis (cases SA1 and DA4) was submitted to the NRC as part of the CLASIX-3 sensitivity studies, by HCOG letter HGN-001, dated January 15, 1982. Both plant analyses use essentially the same model and input assumptions, adjusted for plant specific containment parameters. In addition to using the exact same MARCH hydrogen and steam release histories, the key input assumptions used by both analyses included:

a) Igniters and drywell purge system activated at 20 minutes into the transient.

b) Only one of two containment spray trains initiated after the first hydrogen burn.

c) Burn parameters of:

1)	H_2 V/F for ignition	0.08
2)	H_x V/F for propogation	0.08
3)	H_2 fraction burned	0.85
4)	Minimum$_2$ V/F for ignition	0.05
5)	Minimum 0^2 V/F to support combustion	0.00
6)	Flame speed	6 ft./sec.

d) 50/50 split for LOCA vent/SRV in DWB cases.

e) Suppression pool drawdown.

f) Initiation of drywell spray (simulating water from the small line break as a coarse spray) with an initial temperature of 175°F.

g) Hydrogen release equivalent to 75% metal water reaction of active fuel cladding at GGNS.

A comparison of the results of the PNPP and GGNS cases is provided as Table 18 of Appendix A. Figures 3 through 40 of Appendix A provide the plotted results of the PNPP CLASIX-3 analysis. The comparable results for GGNS are included as Figures 5.5-1 through 5.5-57.

The results of both the PNPP and GGNS SORV analyses are similar. The containment volume at PNPP is smaller than at GGNS by 23%. This contributes to the extra containment burn in the PNPP transient. However, PNPP has a 20% larger initial wetwell volume than GGNS, which results in fewer wetwell burns in the PNPP transient.

For the PNPP SORV case, peak temperatures and pressures occurred in all compartments during the first of the two containment burns, at approximately 6900 seconds into the transient. The first containment burn resulted in the most severe pressure and temperature excursion because wetwell ignition occurred just before and during the containment burn. No wetwell ignition occurred during the second containment burn due to a lack of oxygen.

Four additional wetwell temperature peaks (at approximately 4445, 6555, 6965, and 7220 seconds) are notable. Sprays are not initiated until after the first wetwell burn, which explains why the first wetwell temperature peak is higher than those which immediately follow. The other three above average wetwell temperature peaks occur because ignition takes place at increased hydrogen concentrations due to insufficient oxygen concentration when the hydrogen concentration reached the $8^{v}/o$ setpoint.

Peak pressures and temperatures for the PNPP SORV case are comparable in magnitude to those of the GGNS SORV case, except for the wetwell peak temperature. The PNPP wetwell temperature is higher due to the coincident combustion in the wetwell and containment, which did not occur in the GGNS SORV case.

The results of the PNPP DWB case are also similar to the corresponding GGNS case. Again, fewer wetwell burns are evident for the PNPP DWB case due to the larger wetwell volume. The only other notable difference between the results for the two plants relates to the containment burn. The PNPP DWB case originally did not have a containment burn associated with the final drywell and wetwell burn. The volume fraction of hydrogen in the containment just prior to the final burn was 0.065. The volume fraction of hydrogen required for ignition is 0.08. To be conservative, it was decided to force a containment burn at this point to obtain peak temperatures and pressures. This reduced concentration forced burn resulted in lower peak temperatures and pressures for the PNPP DWB case.

The total amount of hydrogen burned in the PNPP SORV transient was 2011 lbs. and in the DWB transient was 2290 lbs. These values correspond to 77.0% and 87.6%, respectively, of the total amount of hydrogen that was available. The similar GGNS cases show the SORV case burning 2332 lbs. and the DWB case burning 2243 lbs., which are 89.3% and 85.8% of the total hydrogen releases, respectively. The difference between the percentage of hydrogen burned in the PNPP and GGNS SORV cases is due to the greater number of wetwell burns in the GGNS case.

In summary, the CLASIX-3 model, MARCH hydrogen and steam release rates, and key input assumptions were essentially the same for the PNPP containment analysis and GGNS cases SA1 and DA4. A comparison between the PNPP and GGNS analysis shows the SORV and DWB transients to be substantially similar. The only notable differences are in peak temperatures and pressure, which are explained by plant geometry, the forced containment burn at a lower hydrogen concentration in the PNPP DWB case, and coincident combustion in the wetwell and containment during the PNPP SORV case. Other than these differences discussed above, the burn temperature and pressures are approximately the same. In addition for PNPP, the number of burns in the wetwell is less than GGNS, with more spacing between burns. For both PNPP and GGNS the peak pressures are well within structural capability. For PNPP, the increase in the peak burn temperature over GGNS will have little effect on equipment survivability due to the short duration of each burn. Further, fewer burns in the wetwell for PNPP with approximately the same peak temperature as GGNS should result in a lower average temperature and a lower equipment temperature.

5.6 SURVIVABILITY OF ESSENTIAL EQUIPMENT

A consequence of controlling excessive hydrogen generation by deliberate ignition is high peak containment atmosphere temperatures. A preliminary evaluation has been performed to identify equipment inside containment required to survive a hydrogen burn.

The identification of the equipment that has to survive the hydrogen burn environment was based on its function during and after postulated degraded core accidents. In general, equipment located in the containment in the following four categories was considered to be essential for safety of the plant:

1. systems mitigating the consequences of the accident;

2. systems needed for maintaining integrity of the containment pressure boundary;

3. systems needed for maintaining the core in a safe condition;

4. systems needed for monitoring the course of the accident

Using these criteria, for the preliminary evaluation PNPP has prepared a list of equipment inside containment and drywell required to survive a hydrogen burn. This list is presented in Table 5.6-1 and 5.6-2 for PNPP drywell and containment equipment, respectively. For comparative purposes, the GGNS equipment survivability lists which were provided to NRC by letter dated October 17, 1983 (AECM-83/0671) are included in Tables 5.6-3 and 5.6-4.

Both plant lists contain similar components that have similar functions. Evaluation of the equipment required to survive hydrogen combustion events against the thermal environment will be addressed in the final analysis.

Table 5.1-1

Preliminary Evaluation Table No.	PNPP/GGNS FSAR Reference
5.2-1	N/A
5.4-1	PNPP Table 6.2-1
5.4-2	PNPP Table 6.2-2
5.4-3	PNPP Table 6.2-3
5.4-4	PNPP Table 6.2-4
5.4-5	PNPP Table 6.2-5
5.4-6	PNPP Table 6.2-6
5.4-7	PNPP Table 6.2-7
5.4-8	PNPP Table 6.2-8
5.4-9	PNPP Table 6.2-9
5.4-10	GGNS Table 6.2-1
5.4-11	GGNS Table 6.2-2
5.4-12	GGNS Table 6.2-3
5.4-13	GGNS Table 6.2-4
5.4-14	GGNS Table 6.2-4
5.4-15	GGNS Table 6.2-5
5.4-16	GGNS Table 6.2-6
5.4-17	GGNS Table 6.2-7
5.4-18	GGNS Table 6.2-8
5.4-19	PNPP Table 6.3-1
5.4-20	GGNS Table 6.3-2
5.4-21	GGNS Table 6.2-45

5.4-22	PNPP Table 6.2-37
5.6-1 & 5.6-2	N/A (PNPP Equipment Lists)
5.6-3 & 5.6-4	N/A (GGNS Equipment Lists)

TABLE 5.2-1

PNPP/GGNS HCS Design Comparison

		PNPP	GGNS
1.	Number of Igniters		
	o Drywell	17	18
	o Wetwell	12	11
	o Enclosed Area	22	16
	o Containment	51	45
	Total	102	90
2.	Igniter Location Criteria (except drywell below weir wall and containment above refueling floor)	1 ESF Division operable: 60 ft not to exceed 70 ft.	60 ft. not to exceed 70 ft.
		2 ESF Divisions operable: 30 ft. not to exceed 35 ft.	30 ft. not to exceed 35 ft.
3.	Igniter Assembly Maufacturer	Power Systems Division of Morris Knudson GMAC Model 7G	Power Systems Division of Morris Knudson GMAC Model 7G
4.	Igniter Operating Temperature	1700° 12 VAC	1700°F 12 VAC
5.	Igniter Transformer	0.2 KVA Dongan Model 52-20-472	0.2 KVA Dongan Model 52-20-472
6.	Igniter Qualification Temperature	In progress	330°F for 3 hrs.
7.	Igniter Qualification Pressure	In progress	70 psig
8.	System Operation	Manually via 2 control room handswitches (1 switch per	Manually via 2 control room handswitches (1 switch per

		division)	division)
9.	Power Supply	120 VAC ± 10% from ESF Power Panels powered off of motor control centers from ESF buses (on site and offset AC power supplies)	120 VAC ± 10% from ESF Power Panels powered off of motor control centers from ESF buses (on site and offset AC power supplies)

TABLE 5.4-1

KEY DESIGN AND MAXIMUM ACCIDENT PARAMETERS FOR PRESSURE SUPPRESSION CONTAINMENT

Parameter	Design Value	Maximum Calculated Accident Value
Containment Pressure, psig	15	12.0
Containment Temperature, °F	185	184.6
Drywell Pressure, psig	30	22.1
Drywell Temperature, °F	330	330

TABLE 5.4-2

CONTAINMENT DESIGN PARAMETERS

	Drywell	Containment
Drywell and Containment		
Negative Design Pressure, psig	-21.0	-0.8
Positive Design Pressure, psig	30	15
Design Temperature, °F	330	185
Net Free Volume, ft^3	277,685	1,141,014
Maximum Allowable Leak Rate	5,843 SCFM @ 2.5 psig 32,645 SCFM @ 30 psig	0.2%/day
Suppression Pool Water Volume, ft^3		
Low Level	11,155	105,950
High Level	11,395	108,750
Suppression Pool Surface Area, ft^2	482	5,900
Suppression Pool Depth, ft		
Low Level	18.0	18.0
High Level	18.5	18.5
Upper Pool Makeup Volume, ft^3	-	32,830

TABLE 5.4-2 (continued)

	Containment
Vent System	
Number of Vents	120
Nominal Vent Diameter, ft	2.29
Total Vent Area, ft^2	495
Vent Centerline Submergence (low level), ft	
Top Row	7
Middle Row	11.5
Bottom Row	16
Vent Loss Coefficient (varies with number of vents open)	2.5-3.5

TABLE 5.4-3

ENGINEERED SAFETY FEATURE SYSTEMS
PERFORMANCE PARAMETERS FOR CONTAINMENT RESPONSE ANALYSES

	Full Capacity	Containment Analysis Value Case A	Containment Analysis Value Case B
Containment Spray			
Number of RHR Pumps	2	0	0
Number of Lines	2	0	0
Number of Heaters	2	0	0
Flow Rate, gpm/pump	5250	0	0
Containment Cooling System			
Number of RHR Pumps	2	2	1
Pump Capacity, gpm/pump	7100	7100	7100
RHR Heat Exchangers			
Type	Inverted U-tube, single pass shell, multipress tube, vertical mounting		
Number	2	2	1
Heat Transfer Area, ft^2/unit	14,850	-	-
Overall Heat Transfer Coefficient, Btu/hr-ft^2-°F/unit	200	-	-
Service Water Flow Rate, gpm/unit	7300	7300	7300
Service Water Temperature, °F			
Minimum Design	32	-	-
Maximum Design	80	80	80
Containment Heat Removal Capability (using 80°F service water and 185° pool temperature) Btu/hr/unit	166.4×10^6	-	-

TABLE 5.4-4

ACCIDENT ASSUMPTIONS AND INITIAL CONDITIONS FOR CONTAINMENT RESPONSE ANALYSES

Components of Effective Break Area (recirculation line break), ft^2	
Recirculation Line	2.127
Cleanup Line	0.062
Jet Pumps	0.461
Primary Steam Energy Distribution(1), 10^6 Btu	
Steam Energy	25.59
Liquid Energy	722.3
Sensible Energy	
Reactor Vessel	98.25
Reactor Internals (less core)	40.49
Primary System Piping	45.40
Fuel(2)	7.2
Other Assumptions Used in Analysis	
Main Steam Closure Time, sec	
Recirculation Break	3.5
Main Steam Line Break	5.5
Scram Time, sec	<1

NOTES:

1. All energy values, except fuel, are based upon a 32°F datum.

2. Fuel energy is based upon a datum of 285°F.

TABLE 5.4-5

INITIAL CONDITIONS EMPLOYED IN CONTAINMENT RESPONSE ANALYSES

Reactor Coolant System[1]

Reactor Power Level, MWt	3,651
Average Coolant Pressure, psia	1,040
Average Coolant Temperature, °F	549
Mass of Reactor Coolant System Liquid, lbm	544,540
Mass of Reactor Coolant System Steam, lbm	21,530
Volume of Liquid in Reactor Pressure Vessel, ft^3	11,838.3
Volume of Steam in Reactor Pressure Vessel, ft^3	9,189.2
Volume of Liquid in Recirculation Loops, ft^3	742
Volume of Steam in Steam Lines, ft^3	1,454
Volume of Liquid in Feedwater System, ft^3	24,303
Volume of Liquid in Miscellaneous Lines, ft^3	84

Drywell and Containment

	Drywell	Containment
Pressure, psig	0	0
Air Temperature, °F	135	90
Relative Humidity, %	40	50
Suppression Pool Water Temperature, °F	90	90
Suppression Pool Water Volume, ft^3	8,680	105,950
Top Row Vent Centerline, ft	7.0	7.0

TABLE 5.4-5 (continued)

Drywell and Containment (Cont'd)

	Drywell	Containment
Upper Pool Water Temperature, °F	-	100
Upper Pool Makeup Water Volume, ft^3	-	32,830

NOTE:

1. Reactor coolant system at 102 percent of rated power and normal liquid levels.

TABLE 5.4-6

SUMMARY OF SHORT TERM CONTAINMENT RESPONSES TO RECIRCULATION LINE AND MAIN STEAM LINE BREAKS (MINIMUM ECCS)

	Recirculation Line Break	Main Steam Line Break
Peak Drywell Pressure, psig	21.26	22.1
Peak Drywell Differential Pressure, psid	20.26	21.05
Time of Peak Pressure, sec	1.89	1.8
Peak Drywell Temperature, °F	248.8	324
Peak Wetwell Pressure, psig	9.82	10.36
Time of Peak Wetwell Pressure, sec	462.5	691.6
Peak Suppression Pool Temperature during Blowdown, °F	155.8	157.8
Calculated Drywell Margin, %	29	26.33
Energy Released to Containment at Time of Peak Pressure, 10^6 Btu	9.0	9.0
Energy Absorbed by Passive Heat Sinks at Time of Peak Pressure, 10^6 Btu	0	0

TABLE 5.4-7

SUMMARY OF LONG TERM CONTAINMENT RESPONSES TO RECIRCULATION LINE OR MAIN STEAM LINE BREAK

	Case A	Case B
Peak Containment Pressure, psig	8.58	11.31
Time of Peak Containment Pressure, sec	4,167	11,128
Peak Suppression Pool Temperature, °F	170.5	184.6
Calculated Containment Margin, %	42.8	24.6
HPCS Flow Rate, gpm	6,000	6,000
LPCS Flow Rate, gpm	7,100	7,100
RHRS Flow Rate, gpm	14,200	7,100

TABLE 5.4-8

ENERGY BALANCE FOR
MAIN STEAM LINE BREAK ACCIDENT

	Energy (BTU)			
	Initial (time zero)	Drywell Peak Pressure	End of Blowdown	Long Term Peak Wetwell Pressure
Reactor Coolant	3.2+8	3.1+8	7.5+7	2.0+8
Fuel and Cladding				
Fuel	7.2+6	7.2+6	0	0
Cladding	3.4+6	3.4+6	1.7+6	1.2+6
Core Internals	1.0+8	1.0+8	9.9+7	3.6+7
Reactor Vessel Metal	9.1+7	9.1+7	8.8+7	3.1+7
Reactor Coolant System Piping, Pumps, and Valves	Included in "Core Internals", above.			
Blowdown Enthalpy				
Liquid	0	9.1+5	7.8+8	4.4+9
Steam	0	1.0+7	9.9+7	9.9+7
Decay Heat	0	3.0+6	8.6+7	7.5+8
Metal-Water Reaction Heat	0	1.4+4	1.6+6	1.6+6
Drywell Structures	0	0	0	0
Drywell Air	1.8+6	2.1+6	1.2+0	1.3+6
Drywell Steam	8.4+5	1.0+7	2.1+7	9.0+6
Containment Air	7.6+6	7.7+6	1.0+7	9.5+6
Containment Steam	1.3+6	2.5+6	1.5+7	2.6+7
Suppression Pool Water	4.2+8	4.2+8	1.1+9	1.2+9
Upper Pool Dump Inventory	1.4+8	1.4+8	1.4+8	0
Energy Transferred by Heat Exchangers	0	0	0	3.9+8
Passive Heat Sinks	0	0	0	0

480.37

TABLE 5.4-9

ACCIDENT CHRONOLOGY FOR
MAIN STEAM LINE BREAK ACCIDENT

Event	Time (sec) All ECCS in Operation	Time (sec) Minimum ECCS Available
First Row Vent Cleared	0.897	0.897
Second Row Vent Cleared	1.104	1.104
Third Row Vent Cleared	1.511	1.511
Drywell Reaches Peak Pressure	1.8	1.8
Maximum Positive Differential Pressure Occurs	1.8	1.8
Initiation of ECCS Operation	30	30
Third Row Vent Recovered	32	32
Second Row Vent Recovered	53	53
End of Blowdown	322	416
Reactor Pressure Vessel Reflooded	309	696
First Row Vent Recovered	730	730
Initiation of RHR Heat Exchanger Operation	1,980	1,980
Containment Peak Pressure Reached	4,167	11,128

TABLE 5.4-10

CONTAINMENT DESIGN PARAMETERS

	Drywell	Containment
A. Drywell and Containment		
Internal pressure, psig	30	15
External design pressure differential, psid	21	3.0
Design temperature, F	330	185
Net free volume, ft^3	270,000	1,400,000
Maximum allowable leak rate, %/day	NA	.35%**
Suppression pool water volume		
Minimum, ft^3	13041*	122250
Maximum, ft^3	13303*	125398
Pool cross-section area, ft^2	554	6666
Pool depth (normal)	18'7"	18'7"

* Including horizontal vents

** Based on containment free air volume @ 11.5 psig. Combining this value with the MSIV leakage criteria of 100 scfh (total for four steam lines) yields an overall leakage criteria, based on total volume of containment and drywell, of 0.437%/day.

TABLE 5.4-10 (continued)

		Containment
B.	Vent System	
	1. No. of vents	135
	2. Nominal vent diameter, ft	2.33
	3. Total vent area, ft^2 (gross)	577.3
	4. Net vent area, ft^2 (unobstructed)	552.0
	5. Vent centerline elevation	
	Top row	11'4"
	Middle row	7'2"
	Bottom row	3'0"
	Pool bottom (assumed datum)	0'0"
	6. Vent loss coefficient (fL/D)	
	Varies with the number of vents open	2.5 - 3.5

TABLE 5.4-11

ENGINEERED SAFETY SYSTEMS INFORMATION
FOR CONTAINMENT RESPONSE ANALYSES

	Full Capacity	Containment Analysis Value Case A	Case B
A. Suppression Pool Cooling (RHR system)			
1. No. of pumps	2	2	1
2. No. of lines	2	2	1
3. Flow rate, gpm/pump	7450	7450	7450
B. Emergency Cooling Water System			
1. Number of pumps	2	2	1
2. Flow capacity, gpm/loop min	7450	7450	7450
3. RHR heat exchangers			
a. Type - Inverted U-tube, single pass shell, multi-pass tube, vertical mounting			
b. Number	2	2	1

* Cases A and B defined in Table 6.2-6

TABLE 5.4-11 (continued)

	Full Capacity	Containment Analysis Value Case A	Case B
B.3 (Cont.)			
c. Heat transfer area, ft^2/unit	21250	21250	21250
d. Overall heat transfer coefficient Btu/hr - ft^2 - F	212		
e. Secondary coolant flow rate per exchanger, lb/hr	3.95×10^6	3.95×10^6	3.95×10^6
f. Design standby service water temperature			
Maximum, F	90	90	90
Minimum, F	40		
g. Containment heat removal capability per loop, using 90 F service water and 185 F pool temperature; and at rated flow	184.7×10^6 Btu/Hr		
C. ECCS System			
1. High pressure core spray (HPCS)			
a. No. of pumps	1	1	1
b. No. of lines	1	1	1
c. Flow rate, gpm	7115	7115	7115
2. Low pressure core spray (LPCS)			
a. No. of pumps	1	1	1
b. No. of lines	1	1	1
c. Flow rate, (rated, gpm/line)	7115	7115	7115
3. Low pressure coolant injection (LPCI)			
a. No. of pumps	3	3	1

TABLE 5.4-11 (continued)

	Full Capacity	Containment Analysis Valu[e] Case A	Case B
C.3 (Cont.)			
b. No. of lines	3	3	1
c. Flow rate, gpm/line	7450	7450	7450
D. Automatic Depressurization System			
1. Total number of safety/ relief valves	20		
2. No. actuated on ADS	8		

TABLE 5.4-12

ACCIDENT ASSUMPTIONS AND INITIAL CONDITIONS FOR LARGE LINE BREAKS

A.	Effective accident break area (total), recirculation line break, ft^2	3.181
B.	Effective accident break area, main steam line break, ft^2	3.538
C.	Components of effective break area (recirculation line break):	
	1. Recirculation line area, ft^2	2.598
	2. Cleanup line area, ft^2	.080
	3. Jet pump area, ft^2	.503
D.	Primary steam energy distribution [(1)]	
	1. Steam energy, 10^6 Btu	31.4
	2. Liquid energy, 10^6 Btu	341.4
	3. Sensible energy, 10^6 Btu	
	a. Reactor vessel	111.0
	b. Reactor internals (less core)	58.1
	c. Primary system piping	37.7
	d. Fuel[(2)]	27.6
E.	Other assumptions used in analysis	
	1. Deleted	
	2. MSIV closure time (sec)	5.5
	3. Scram time (sec)	< 1
	4. Liquid carryover, %	100

[(1)] All energy values except fuel are based on a 32 F datum.

[(2)] Fuel energy is based on a datum of 235 F.

TABLE 5.4-13

INITIAL CONDITIONS EMPLOYED IN CONTAINMENT RESPONSE ANALYSES

A. Reactor Coolant System (at design overpower of 105% and at normal liquid levels)

1.	Reactor power level, MWT	3995
2.	Average coolant pressure, psia	1060
3.	Average coolant temperature, F	551
4.	Mass of reactor coolant system liquid, lbm	6.815×10^5
5.	Mass of reactor coolant system steam, lbm	24,000
6.	Liquid plus steam energy, Btu	372.8×10^6
7.	Volume of liquid in vessel, ft^3	3,771
8.	Volume of steam in vessel, ft^3	9,295
9.	Volume of liquid in recirculation loops, ft^3	827
10.	Total reactor coolant volume, ft^3	25,820

TABLE 5.4-14

B. Containment

		Drywell	Containment
1.	Pressure, psig	0.0	0.0
2.	Inside temperature	135	95
3.	Relative humidity, %	20 to 90	60
4.	Service water temperature, F	90	90

TABLE 5.4-15

SUMMARY OF SHORT-TERM ACCIDENT RESULTS FOR CONTAINMENT RESPONSE TO RECIRCULATION LINE AND STEAM LINE BREAKS

A. Accident Parameters

	Recirculation Line Break[1]	Steam Line Break	
1. Peak drywell pressure, psig	19.4	22.0	
2. Time(s) of peak pressures, sec	1.09	1.09	53
3. Peak drywell temperature, F	240	330	
4. Peak suppression pool temperature during blowdown, F	120	120	
5. Calculated drywell margin, %	35	27	
6. Energy released to containment at time of short-term peak pressure, 10^6 Btu	240	240	53
7. Energy absorbed by passive heat sinks at time of peak pressure, 10^6 Btu	0	0	

[1] See Figures 6.2-2 and 6.2-5 for plots of pressures vs time.

See Figures 6.2-3 and 6.2-7 for plots of temperatures vs time.

TABLE 5.4-16

LOSS OF COOLANT ACCIDENT LONG TERM
PRIMARY CONTAINMENT RESPONSE SUMMARY

Case*	LPCI/LPCS Pumps	Service Water Pumps	Containment Spray (gal/min)	HPCS (gal/min)	LPCI/LPCS (gal/min)	Peak Pool Temp. F	Secondary Peak Pressure (psig)
A	3/1	2	0	7115	7450/7115	155.5	7.6
B	1/1	1	0	7115	7450/7115	171.3	9.9

*A - Assumes offsite power available
B - Assumes loss of offsite power

TABLE 5.4-17

ENERGY BALANCE FOR DESIGN BASIS RECIRCULATION LINE BREAK

Energy Levels vs Time
(Minimum ECCS - Missile Break)
Energy in 10^6 Btu

Parameter	Initial (t = 0)	Peak Δp (t=1.1865 sec)	End Blowdown (t=130.62 sec)	Maximum Containment Pressure (t=18305.7 sec)
Reactor coolant	390.0	377.0	29.2	174.0
Fuel	39.6	40.3	5.86	3.75
Cladding	3.14	3.14	1.30	0.831
Reactor vessel	101.0	101.0	88.3	26.7
Reactor internals	96.3	96.3	85.9	25.5
Drywell air	1.70	2.02	~0.	1.31
Drywell steam	0.817	13.3	16.8	3.76
Drywell liquid	0.	1.33	26.7	530.0
Containment air	8.95	9.14	11.3	8.53
Containment steam	3.61	3.63	9.98	24.1
Containment liquid suppression pool	1200.	1200.	1610.	1370.
Decay heat	0.	0.380	23.5	932.0
Metal water heat	0.	~0.	0.035	0.463
Pump heat	0.	0.	0.512	88.3
Heat transferred RHR heat exchanger	0.	0.	0.	634.

TABLE 5.4-18

ACCIDENT CHRONOLOGY-DESIGN
BASIS RECIRCULATION LINE BREAK ACCIDENT

	Event	Time (sec) Case A All ECCS in Operation	Time (sec) Case B Min ECCS Available
1.	1st row vent cleared	.86	.86
2.	2nd row vent cleared	1.08	1.08
3.	3rd row vent cleared	1.44	1.44
4.	Drywell reaches peak pressure	1.09	1.09
5.	Maximum positive differential pressure occurs	1.08	1.08
6.	3rd row vent recovered	29	29
7.	Initiation of the ECCS	30	30
8.	2nd row vent recovered	40	40
9.	1st row vent recovered	99	99
10.	End of blowdown	99	99
11.	Vessel reflooded	279	455
12.	Initiation of RHR heat exchanger loop	1800	1800
13.	Containment reaches peak pressure	4936	23176

TABLE 5.4-19

SIGNIFICANT INPUT VARIABLES USED IN THE LOSS-OF-COOLANT ACCIDENT ANALYSIS

Variable	Units	Value
A. PLANT PARAMETERS		
Core thermal power	MW_t	3729
Vessel steam output	lb_m/hr	16.2×10^6
Corresponding percent of rated steam flow	%	105
Vessel steam dome pressure	psia	1060
Maximum recirculation line break area	ft^2	2.7
B. EMERGENCY CORE COOLING SYSTEM PARAMETERS		
B.1 Low Pressure Coolant Injection System		
Vessel pressure at which flow may commence	psid (vessel to drywell)	225
Minimum rated flow at vessel pressure	GPM psid (vessel to drywell)	19500 20
Initiating Signals		
low water level	ft. above top of active fuel	$\geq$1.0
or		
high drywell pressure	psig	$\leq$2.0
Maximum allowable time delay from initiating signal to pumps at rated speed	sec	27
Injection valve fully open	sec. after DBA	$\leq$40

TABLE 5.4-19 (continued)

Variable	Units	Value
B.2 Low Pressure Core Spray System		
Vessel pressure at which flow may commence	psid (vessel to drywell)	289
Minimum rated flow at vessel pressure	gpm psid (vessel to drywell)	6000 122
Initiating Signals		
low water level or	ft. above top of active fuel	≥1.0
high drywell pressure	psig	≤2.0
Maximum allowed (runout) flow	gpm	7800
Maximum allowed delay time from initiating signal to pump at rated speed	sec	27.0
Injection valve fully open	sec. after DBA	≤40
B.3 High Pressure Core Spray		
Vessel pressure at which flow may commence	psid	1177
Minimum rated flow available at vessel pressure	gpm psid (vessel to pump suction)	517 1550 6000 1177 1147 200
Initiating Signals		
low water level or	ft. above top of active fuel	≥10.9
high drywell pressure	psig	≤2.0
Maximum allowed (runout) flow	gpm	7800
Maximum allowed delay time from initiating signal to rated flow available and injection valve wide open	sec	27.0

TABLE 5.4-19 (continued)

Variable	Units	Value
B.4 Automatic Depressurization System		
Total number of relief valves with ADS function		8
Total minimum flow capacity	lb/hr	6.4×10^6
at vessel pressure	psig	1125
Initiating Signals		
low water level and	ft. above top of active fuel	≥ 1.0
high drywell pressure	psig	≤ 2.0
Delay time from all initiating signals completed to the time valves are open	sec	≤ 120
C. FUEL PARAMETERS		
Fuel type		Initial core
Fuel bundle geometry		8 x 8
Lattice		C
Number of fueled rods per bundle		62
Peak technical specification linear heat generation rate	kW/ft	13.4
Initial minimum critical power ratio		1.17
Design axial peaking factor		1.4

TABLE 5.4-20

SIGNIFICANT INPUT PARAMETERS TO THE

LOSS-OF-COOLANT ACCIDENT ANALYSIS

Plant Parameters			
o	Core Thermal Power	MWt	3993
o	Vessel Steam Output	LB_m/hr	17.3×10^6
o	Corresponding percent of rated steam flow	percent	105
o	Vessel Steam Dome Pressure	psia	1060
o	Maximum Recirculation Line Break Area	ft^2	3.1
Emergency Core Cooling System Parameters			
	Low-Pressure Coolant Injection System		
o	Vessel Pressure at which flow may commence	psid (vessel to drywell)	225
o	Minimum Rated Flow at Vessel Pressure	GPM psid (vessel to drywell)	22000 20
o	Initiating signals low-low-low water level or high drywell pressure	 ft above top of active fuel psig	 ≧1.0 ≦2.0
o	Maximum allowable time delay from initiating signal to pumps at rated speed	sec	27.0
o	Injection valve fully open	sec after DBA	≦40.0
	Low-Pressure Core Spray System		
o	Vessel pressure at which flow may commence	psid (vessel to drywell)	289
o	Minimum rated flow at Vessel Pressure	GPM paid (vessel to drywell	7000 122

TABLE 5.4-20 (continued)

o	Initiating signals low-low-low water level or high drywell pressure	ft. above top of active fuel psig	≧1.0 ≦2.0
o	Maximum allowed (runout) flow	GPM	9100
o	Maximum allowed delay time from initiating signal to pump at rated speed	sec	27.0
o	Injection valve fully open	sec after DBA	≦40.0
	High-Pressure Core Spray		
o	Vessel pressure at which flow may commence	psid	1177
o	Minimum flow available at vessel to pump suction head		See Figure 6.3-3
o	Initiating signals low-low water level or high drywell pressure	ft. above top of active fuel psig	≧10.5 ≦2.0
o	Maximum allowed (runout) flow	GPM	9100
o	Maximum allowed delay time from initiating signal to rated flow available and injection valve wide open	sec	27.0
	Automatic Depressurization System		
o	Total number of valves installed		8
o	Number of valves used in analysis		8[1]
o	Minimum Flow Capacity of 8 valves at vessel pressure	lb/hr psid (vessel suppression pool)	6.4×10^6 1125

---

(1) Additional LOCA analyses in Section 6.3.3.7.8 with seven ADS valves justify one ADS valve out of service for an extended period of time.

TABLE 5.4-20 (continued)

o	Initiating signals low-low-low water level and high drywell pressure and	ft above top of active fuel psig	≧1.0 ≦2.0
o	Delay time from all initiating signals completed to the time valves are open	sec	≦120

FUEL PARAMETERS

o	Fuel type	--	Initial Core
o	Fuel Bundle Geometry	--	P 8 x 8 R
o	Lattice		C
o	Number of fueled rods		62
o	Peak Technical Specification Linear Heat Generation Rate	kw/ft	13.4
o	Initial Minimum Critical Power Ratio	--	1.17

TABLE 5.4-21

COMBUSTIBLE GAS CONTROL SYSTEM
COMPONENT DESCRIPTION

Drywell Purge Compressors	
Quantity	2-100% capacity units
Capacity (minimum), scfm	500
Static pressure, psig	10
Drive	Direct
Motor, hp	100
Manufacturer	Turbonetics
Hydrogen Recombiners	
Type	Thermal
Quantity	2-100% capacity units
Capacity, scfm - air	100
Process rate, scfm - hydrogen	4 (approx)
Power required, kW	75 each
Manufacturer	Westinghouse
Containment Purge Compressor	
Type	Liquid ring
Quantity	1
Capacity, scfm	65
Static pressure, psig	10
Drive	Direct
Motor, hp	15
Manufacturer	Nash

TABLE 5.4-22

COMBUSTIBLE GAS CONTROL SYSTEM
EQUIPMENT DESIGN AND PERFORMANCE DATA

a. Combustible Gas Purging Units (Mixing)

1. Compressor	Centrifugal
Max inlet pressure, psia	23.3
Max discharge pressure, psia	29.13
Max inlet temperature, °F	185
Max discharge temperature, °F	238
Relative humidity (inlet), %	100
Capacity, scfm	546
Power requirement, BHP	41
2. Heat Exchanger	
Design Pressure (tube side), psig	500
Air Temperature in/out, °F	238/190
Cooling Water Temp. in/out, °F	140/170
3. Material	
Compressor	
Casing	cast steel
Shroud	aluminum
impeller	174 PH S.S.
Heat Exchanger	
Tube	304 S.S.

TABLE 5.4-22 (continued)

4. Manufacturer	Turbonetics
b. Isolation Valves	
Type	globe
Body	Bronze
Stem	Bronze
Disc	Hardened 304 S.S.
Disc Type	Swivel plug
Seats	Renewable hardened 304 S.S.
c. Hydrogen Recombiner	
1. Material	
Outer Structure	Type 300 series S.S.
Inner Structure	Inconel 600
Heater Element Sheath	Inconel 800
Base Skid	Carbon Steel, painted
2. Power	
Maximum, kW	75
Nominal, kW	50
3. Capacity, scfm	100 to 120 at 1 atm
4. Temperatures	
Gas in, °F	150
Outlet of heater section, °F	1,150 to 1,400
Exhaust, °F	50 above ambient

TABLE 5.4-22 (continued)

5. Heaters	
Number	5 banks
Max. heat flux, watts/in^2	5.8
Max. sheath temperature, °F	1,550
6. Manufacturer	Westinghouse
d. Piping	
Material	Carbon Steel

Figure 5.5-1

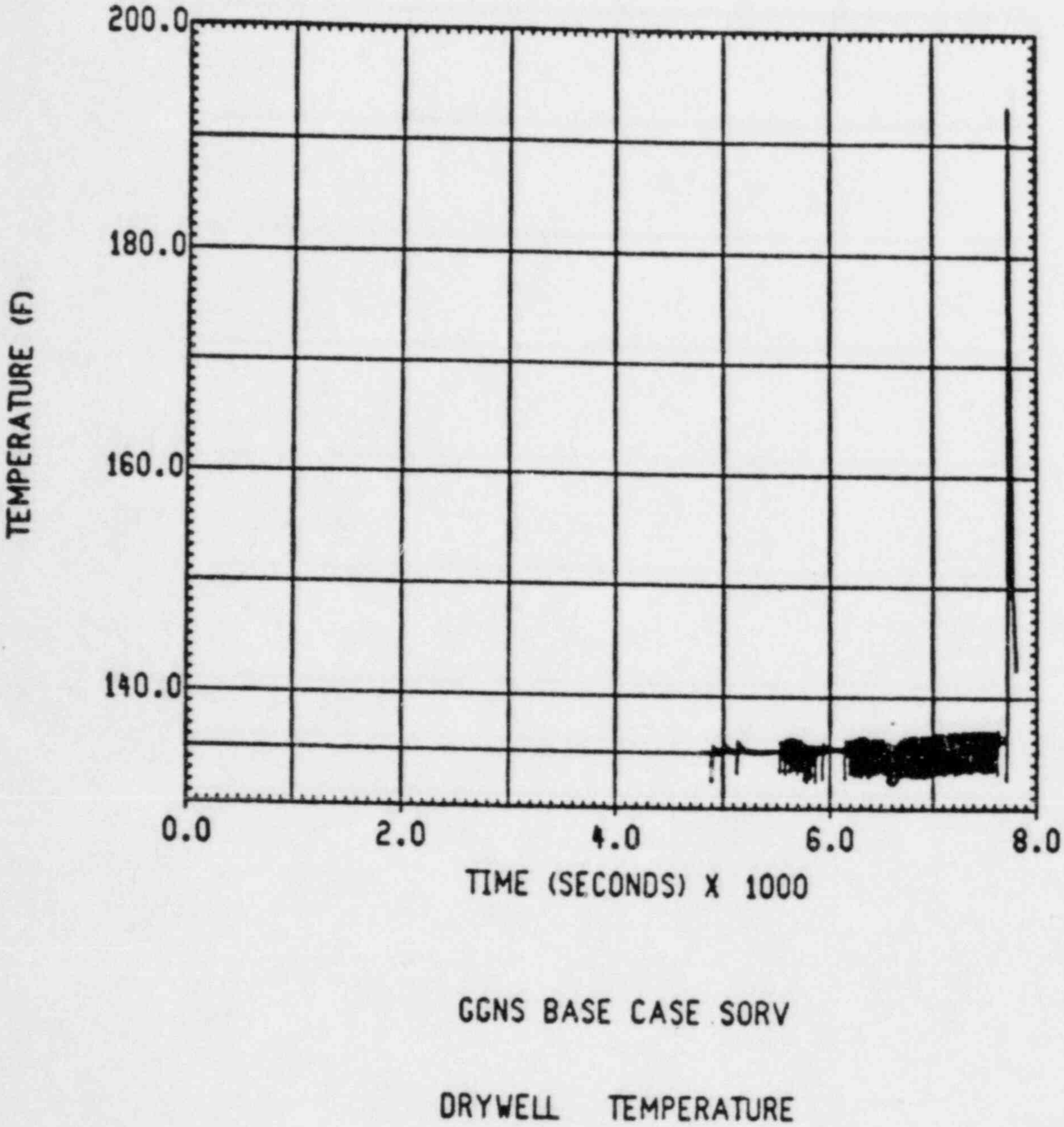


Figure 41

Figure 5.5-2

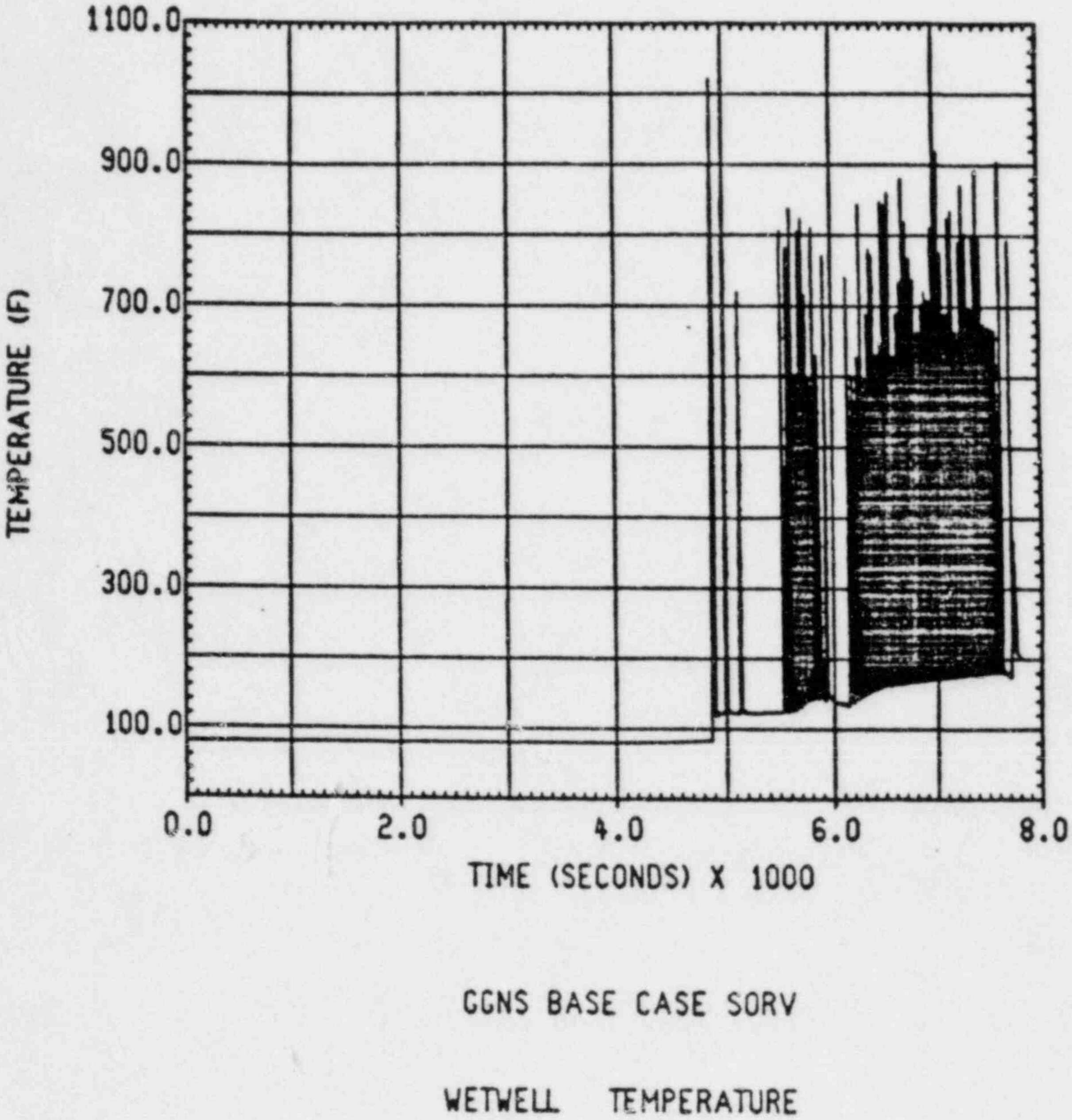
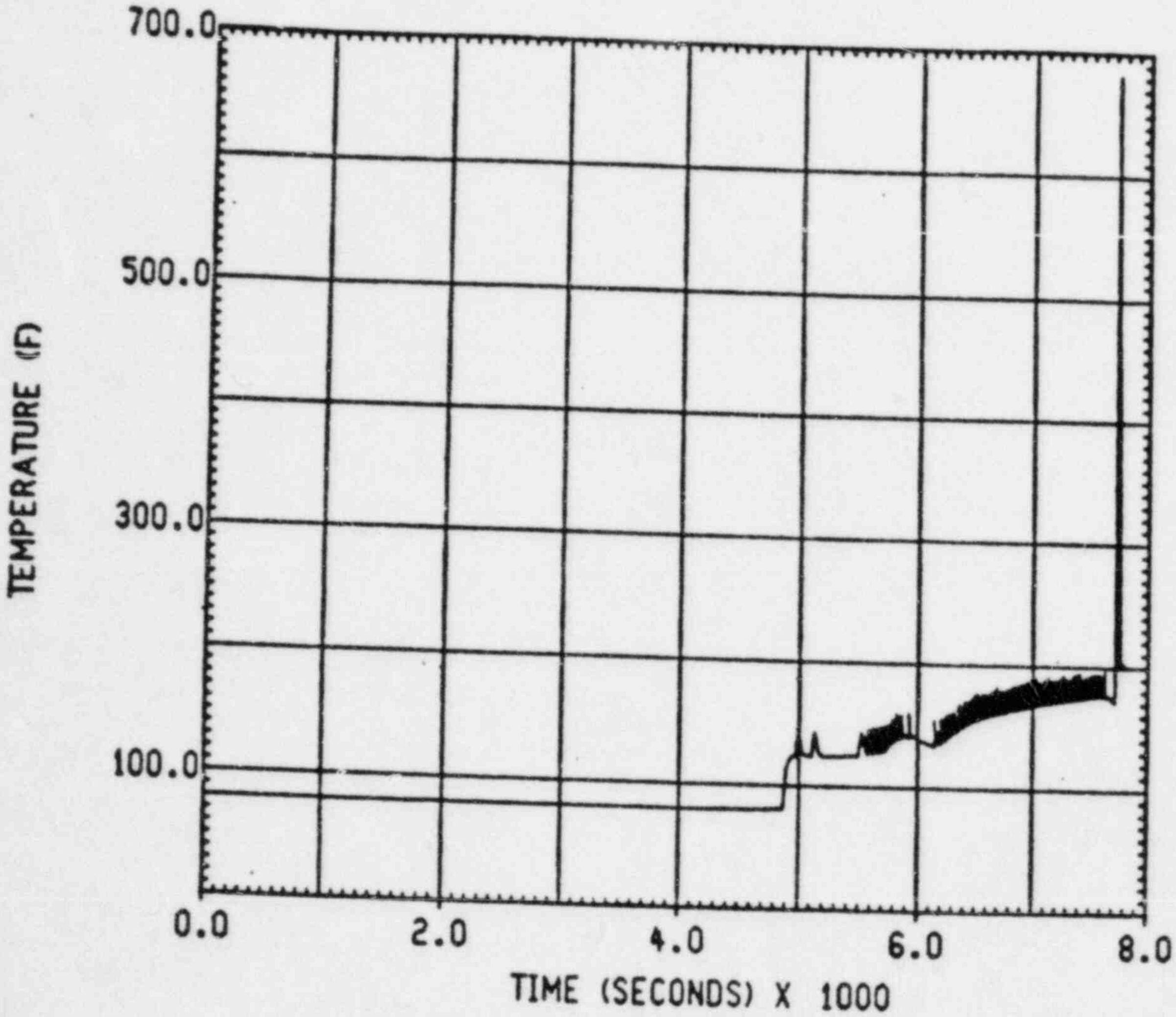


Figure 42

Figure 5.5-3

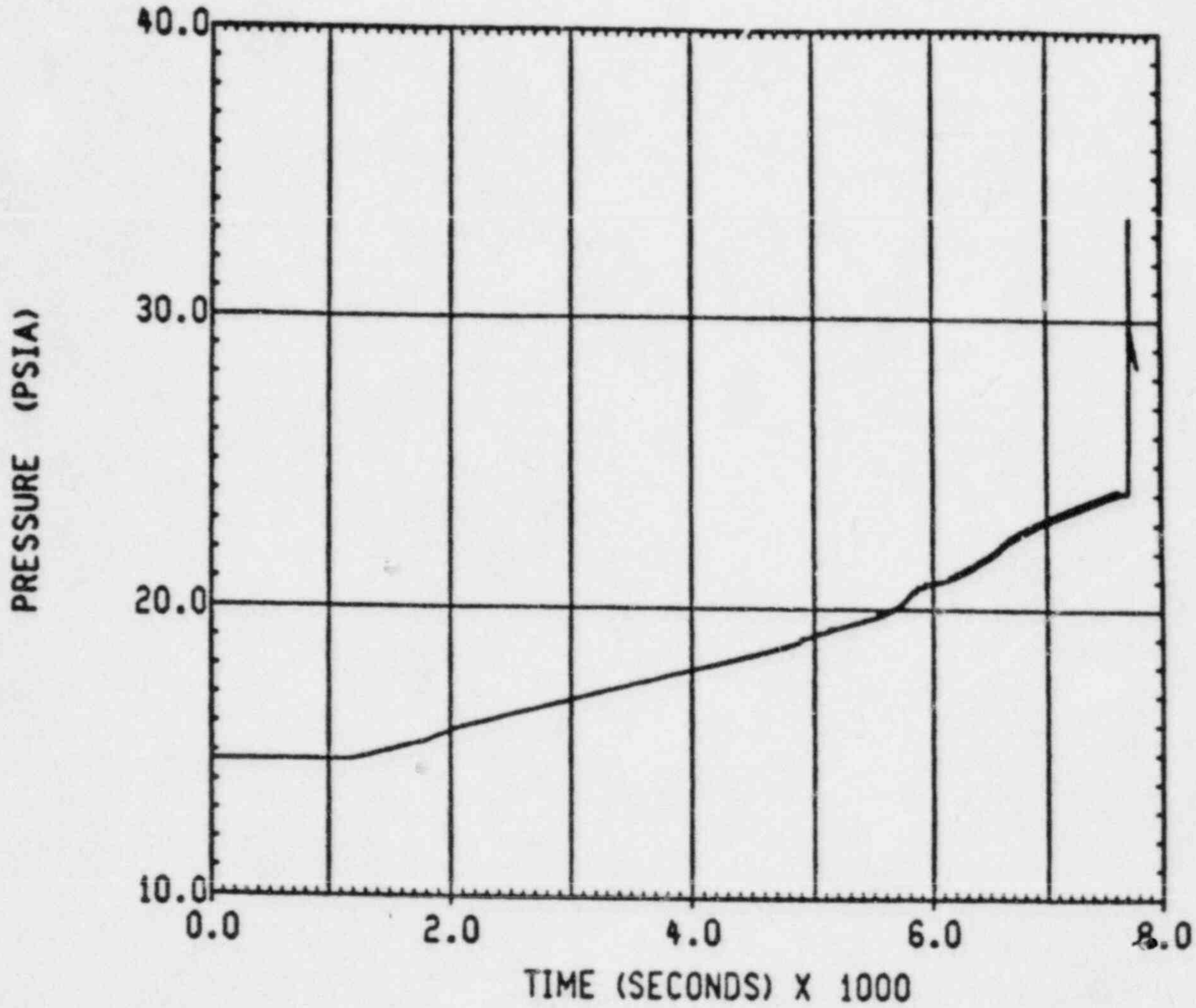


GGNS BASE CASE SORV

CONTAINMENT TEMPERATURE

Figure 43

Figure 5.5-4



GGNS BASE CASE SORV

DRYWELL PRESSURE

Figure 44

Figure 5.5-5

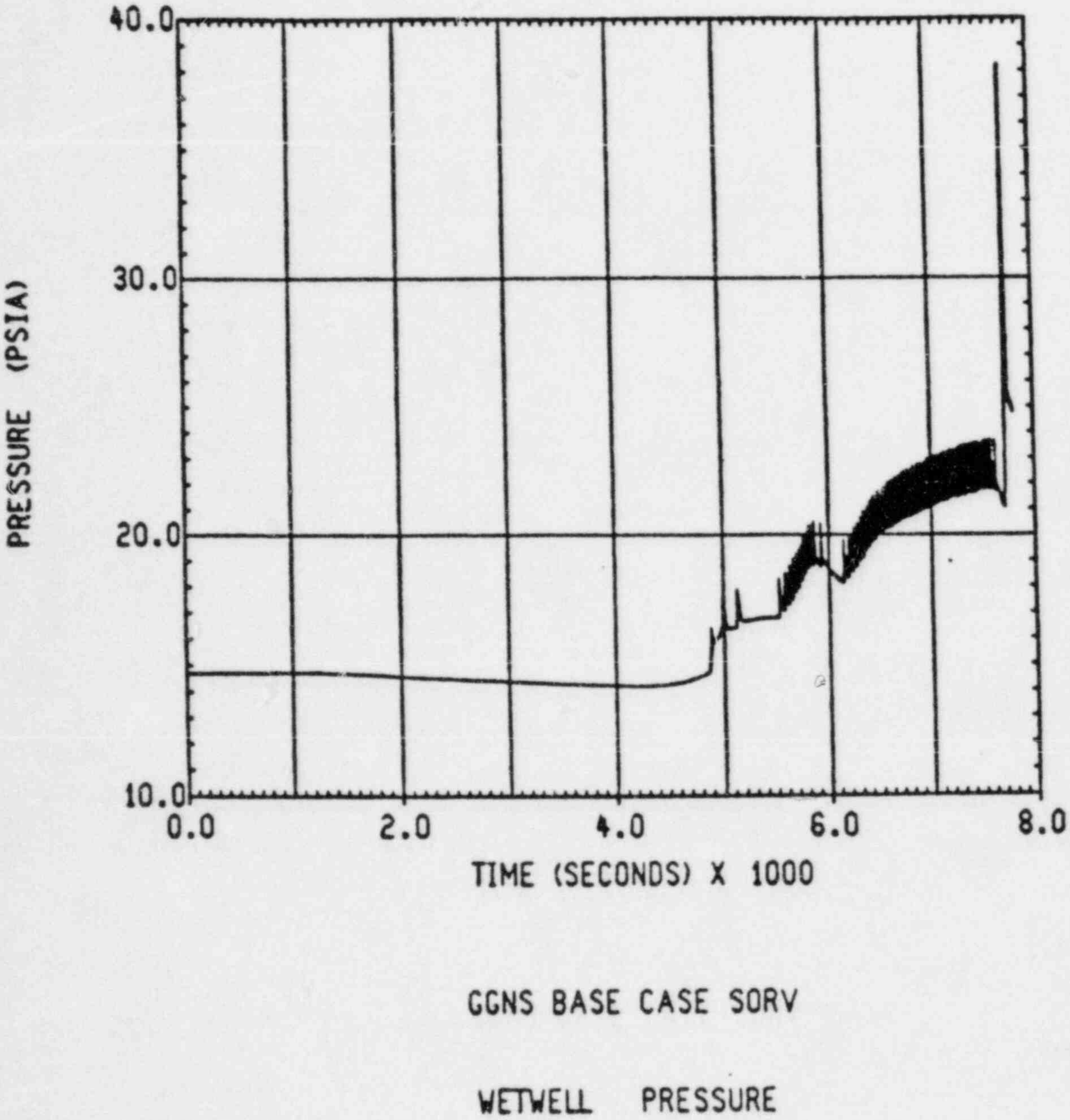
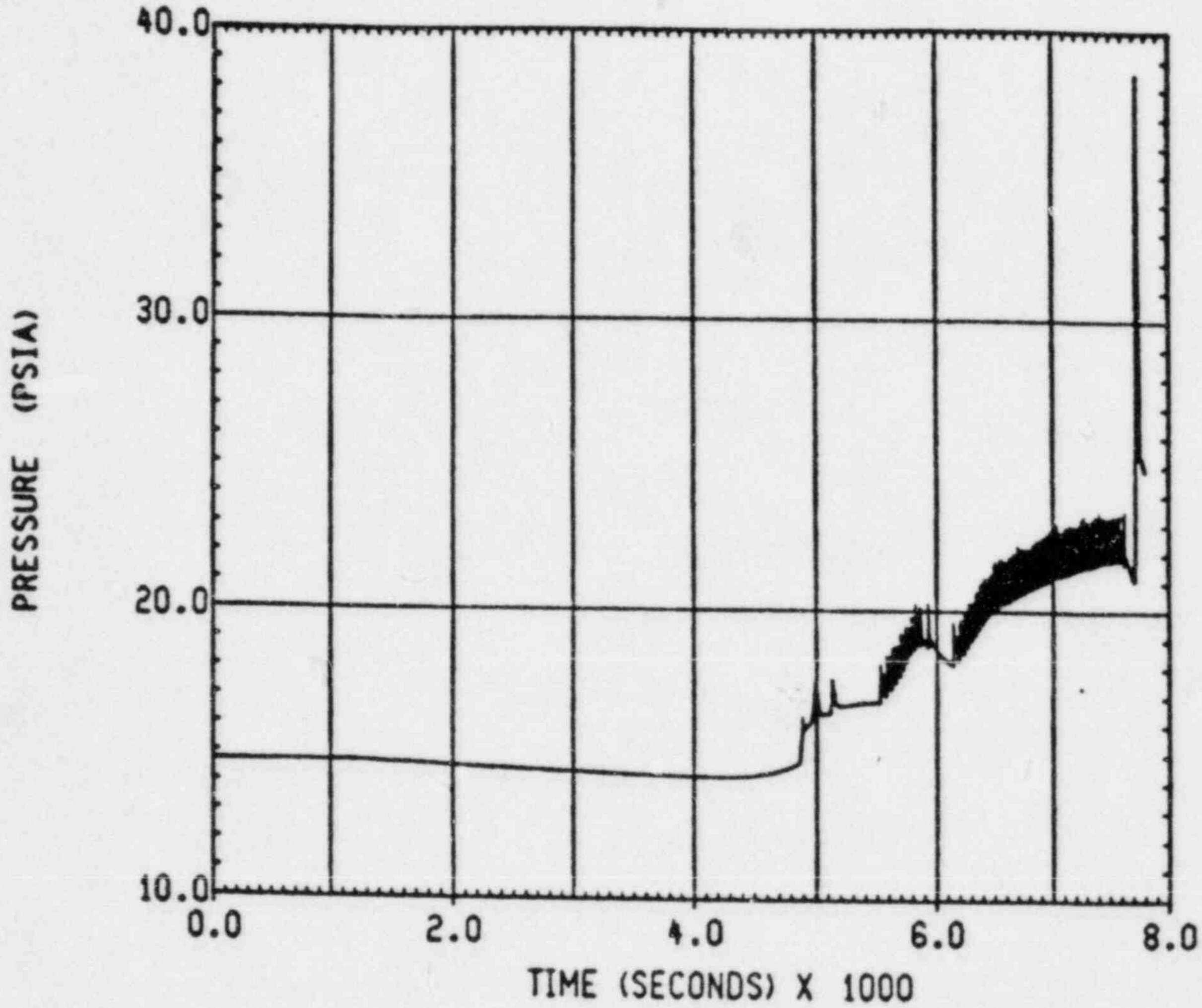


Figure 45

Figure 5.5-6

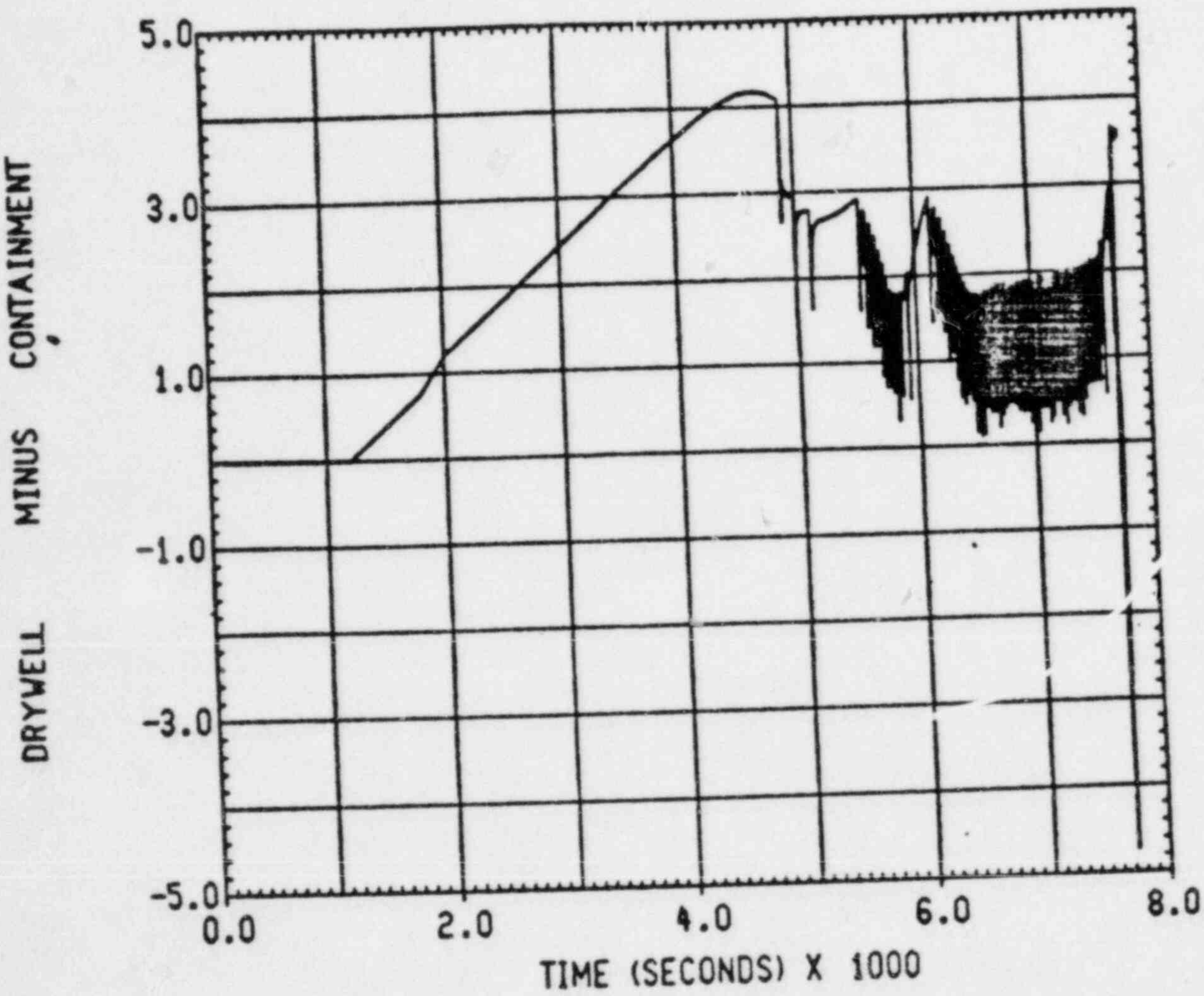


GGNS BASE CASE SORV

CONTAINMENT PRESSURE

Figure 46

Figure 5.5-7

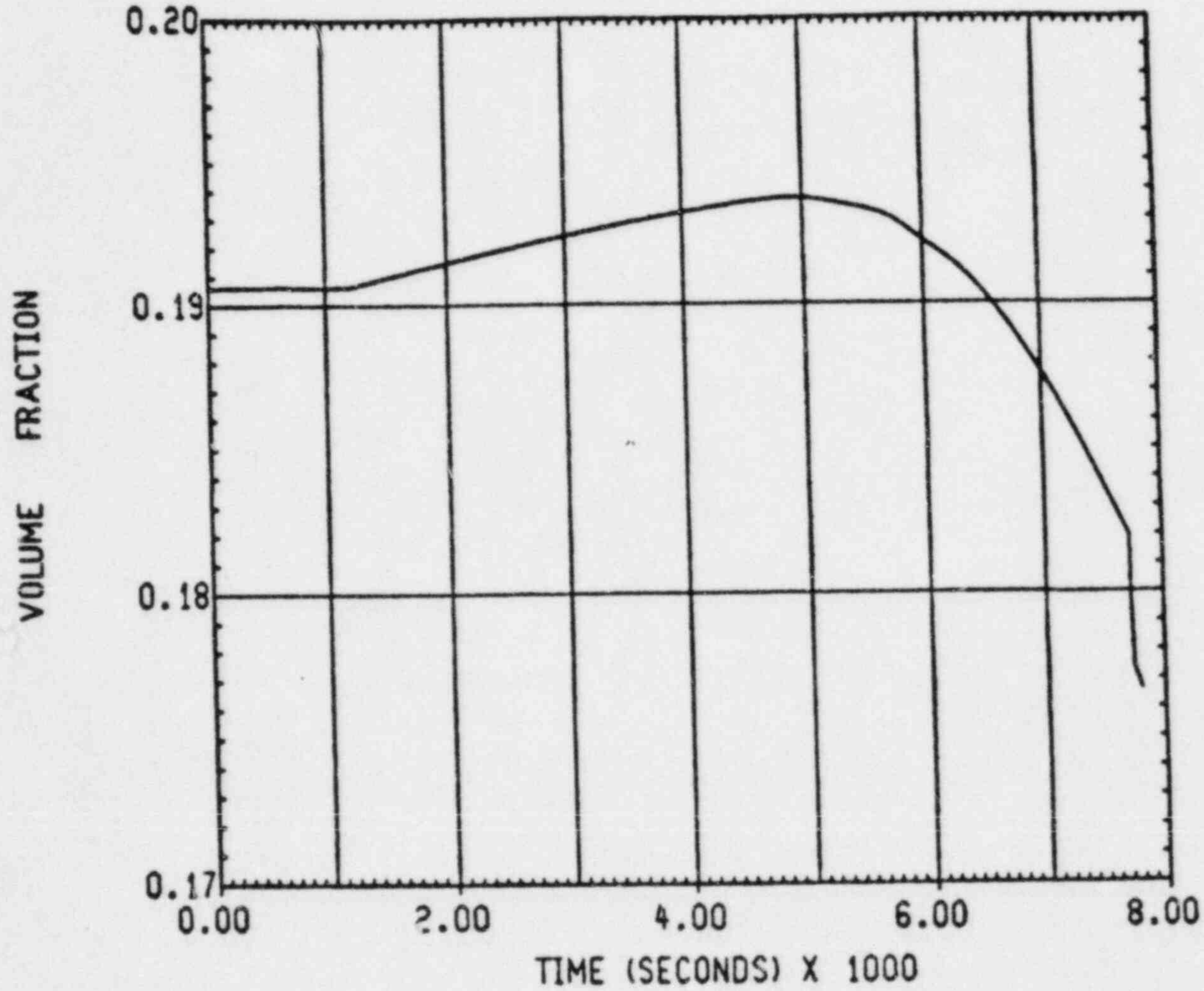


GGNS BASE CASE SORV

DIFFERENTIAL PRESSURE

Figure 47

Figure 5.5-8

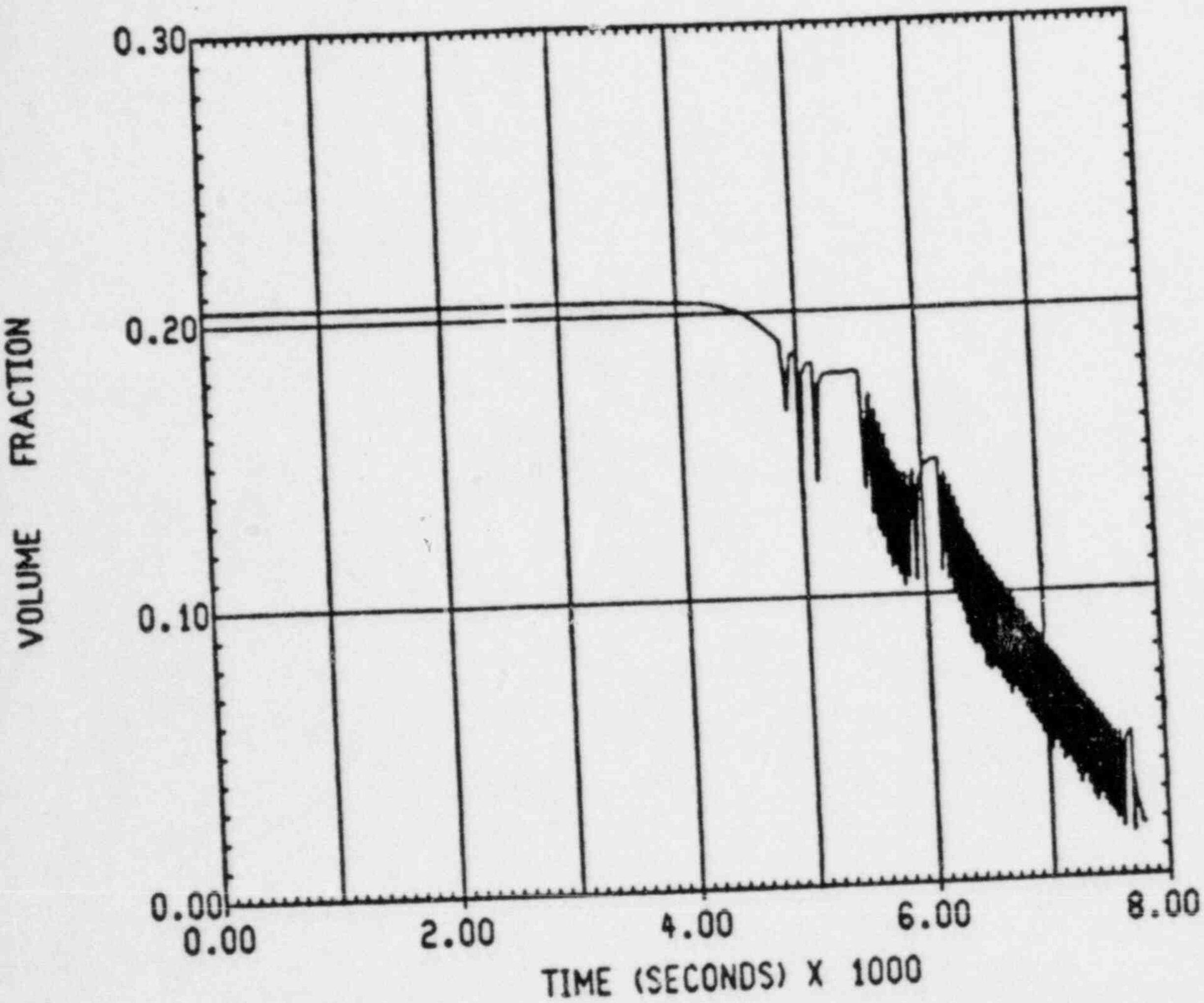


GGNS BASE CASE SORV

DRYWELL O2 GAS CONCENTRATION

Figure 48

Figure 5.5-9

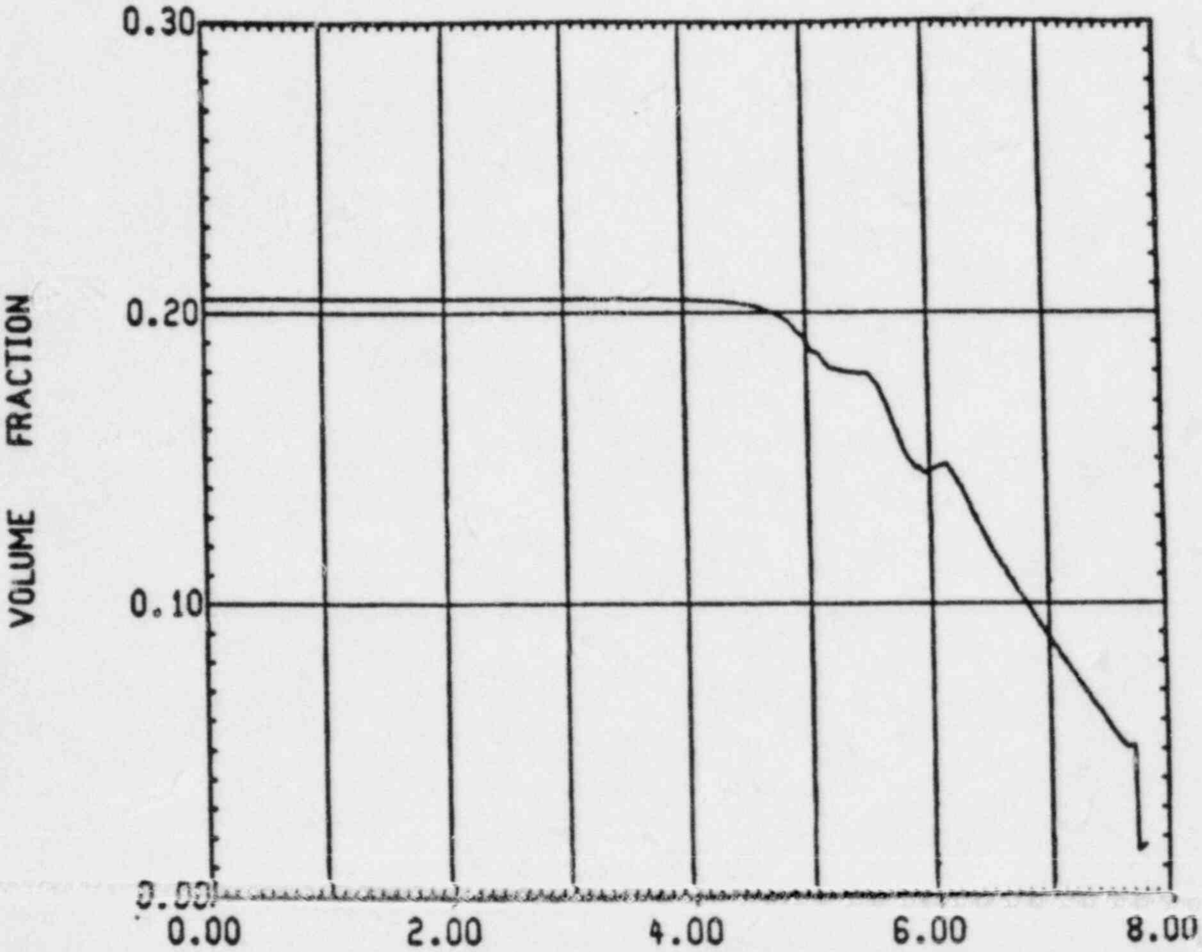


GGNS BASE CASE SORV

WETWELL O2 GAS CONCENTRATION

Figure 49

Figure 5.5-10

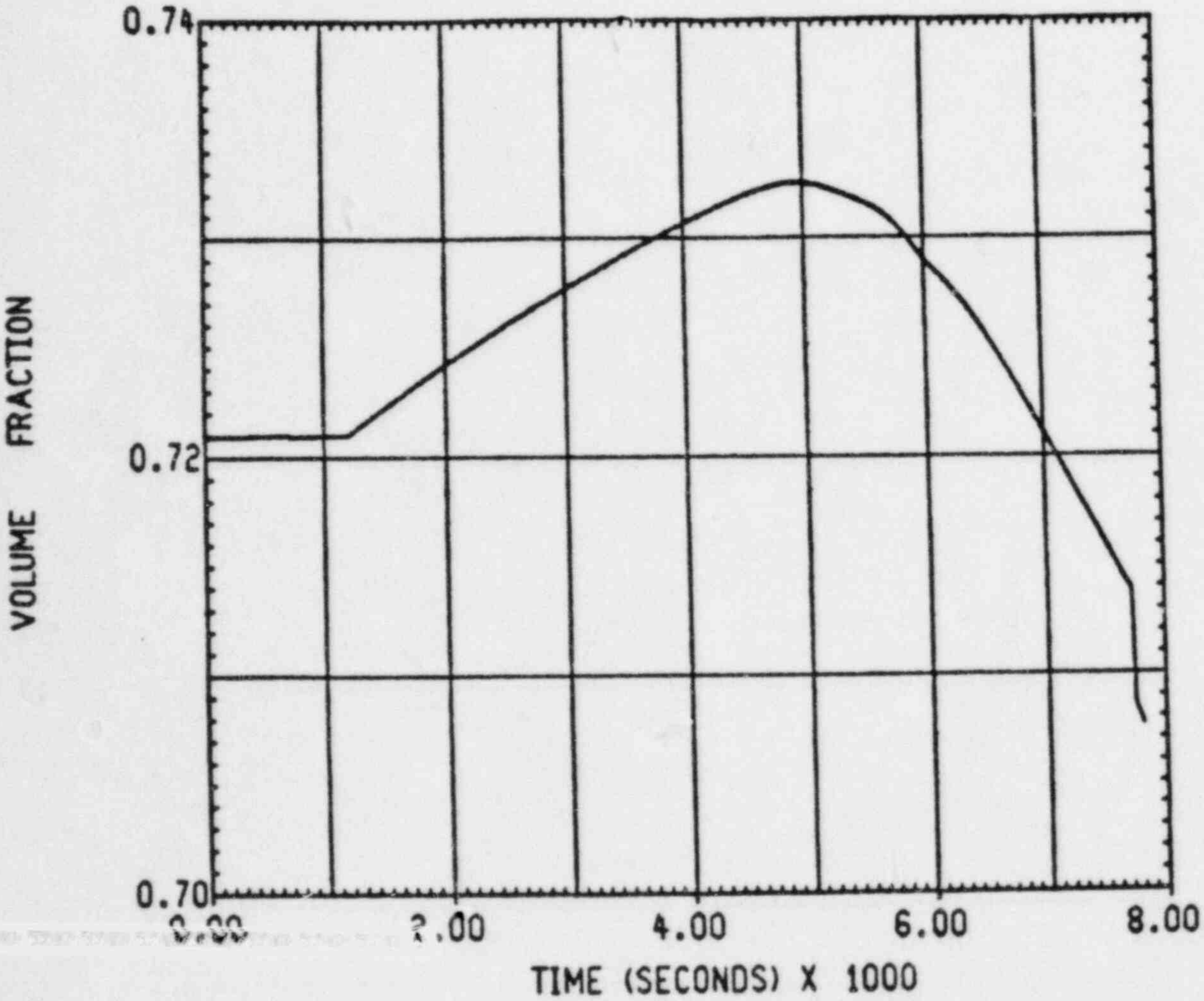


GGNS BASE CASE SORV

CONTAINMENT 02 GAS CONCENTRATION

Figure 50

Figure 5.5-11

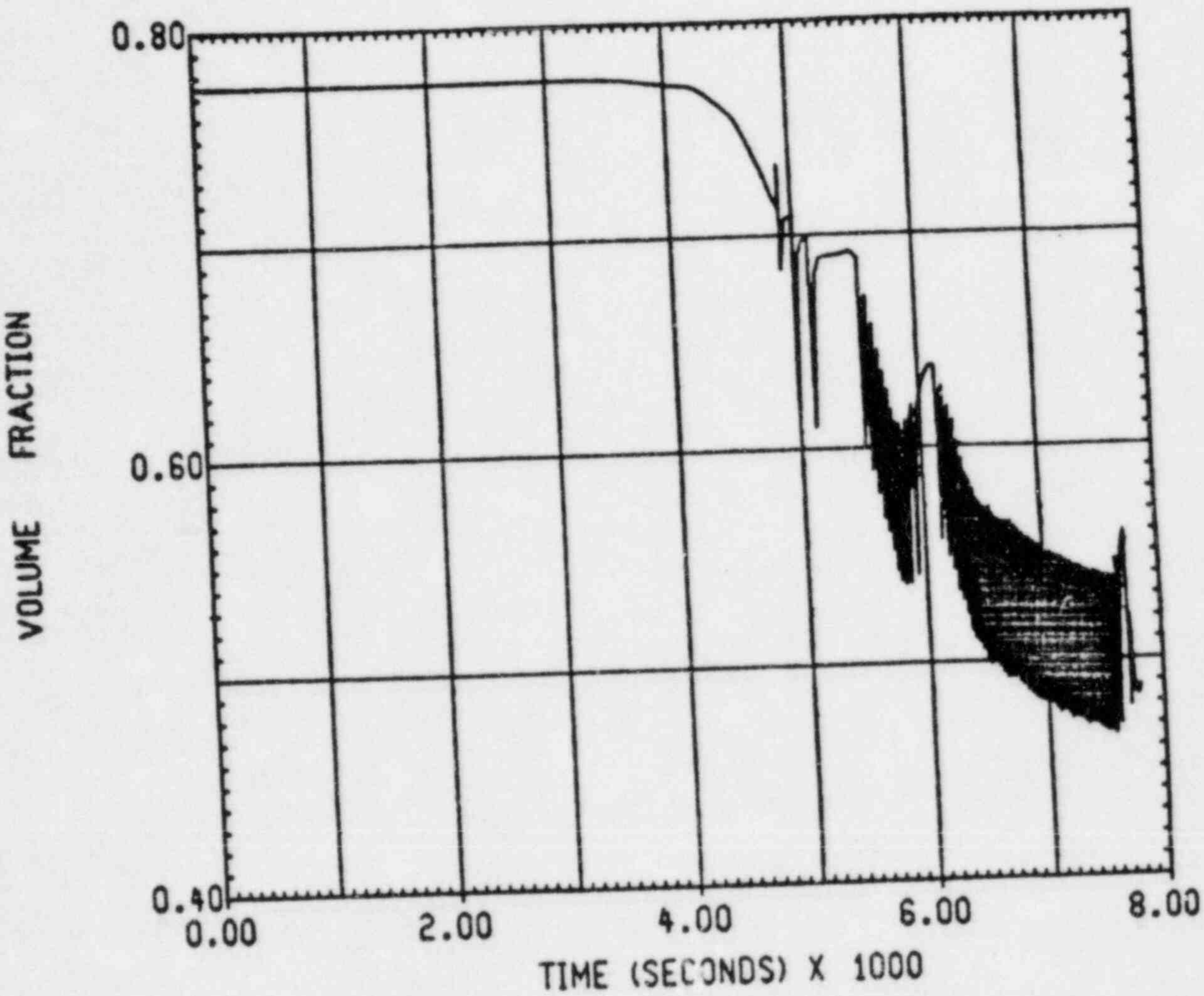


GGNS BASE CASE SORV

DRYWELL N2 GAS CONCENTRATION

Figure 51

Figure 5.5-12

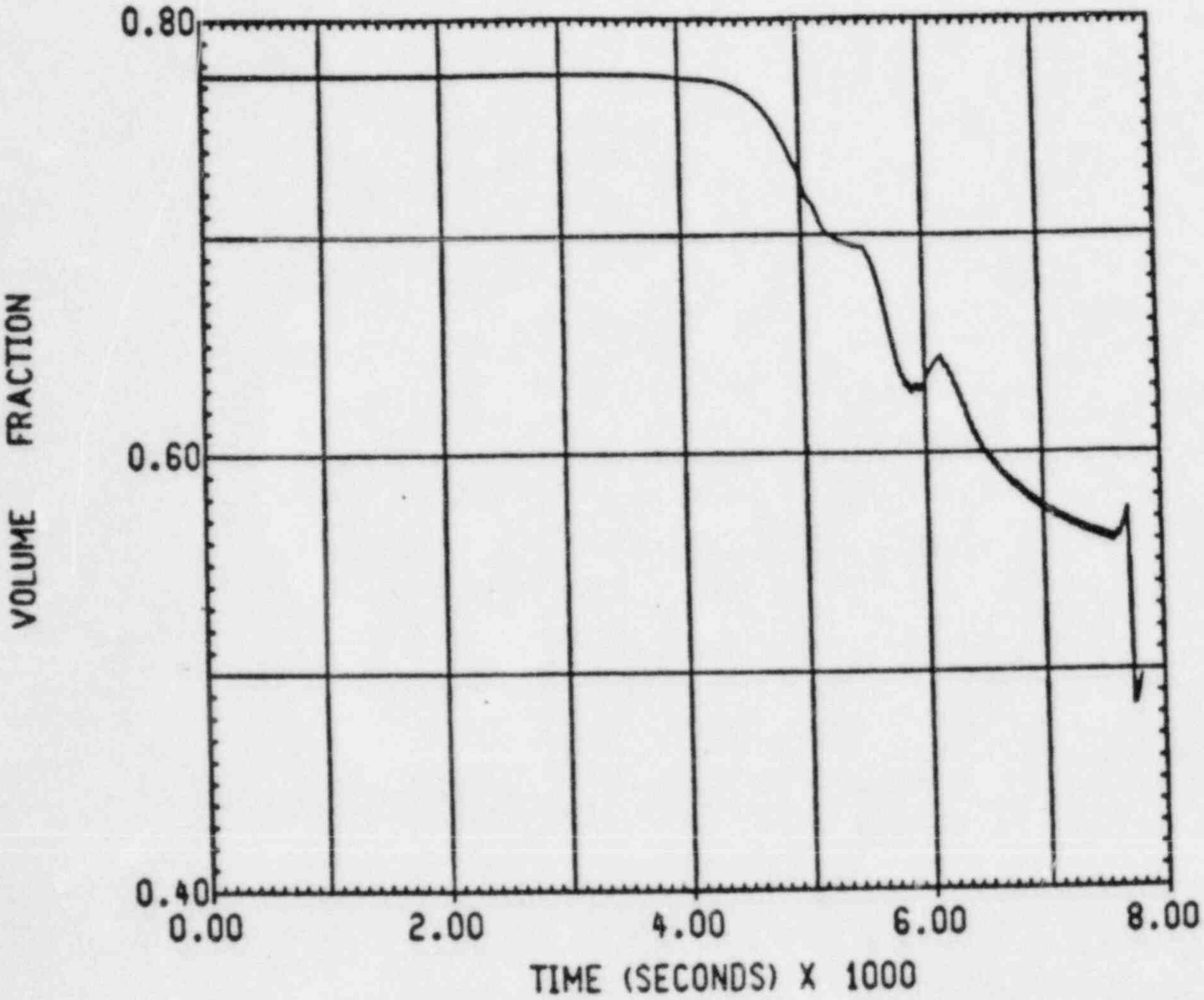


GGNS BASE CASE SORV

WETWELL N2 GAS CONCENTRATION

Figure 52

Figure 5.5-13

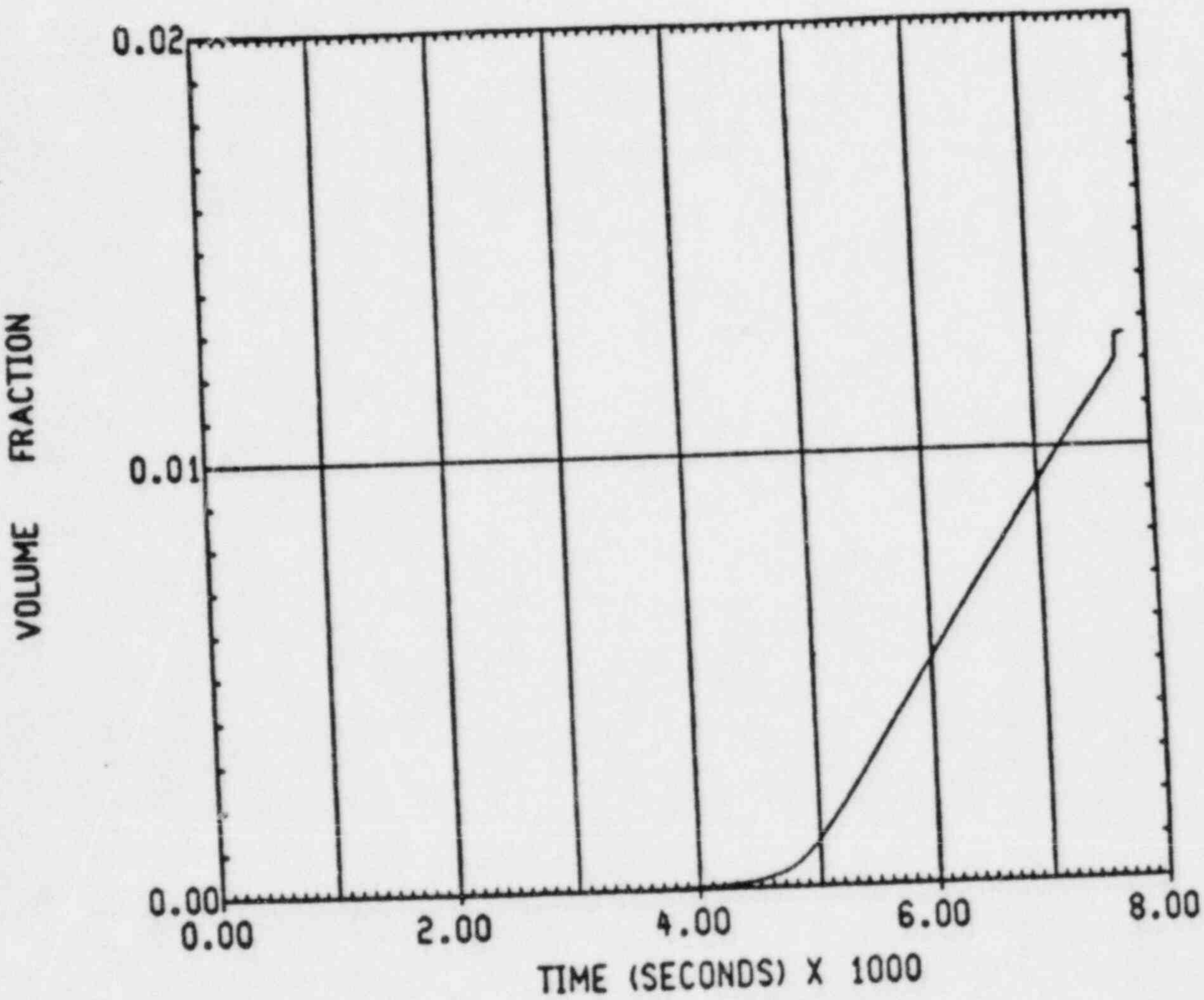


GGNS BASE CASE SORV

CONTAINMENT N2 GAS CONCENTRATION

Figure 53

Figure 5.5-14

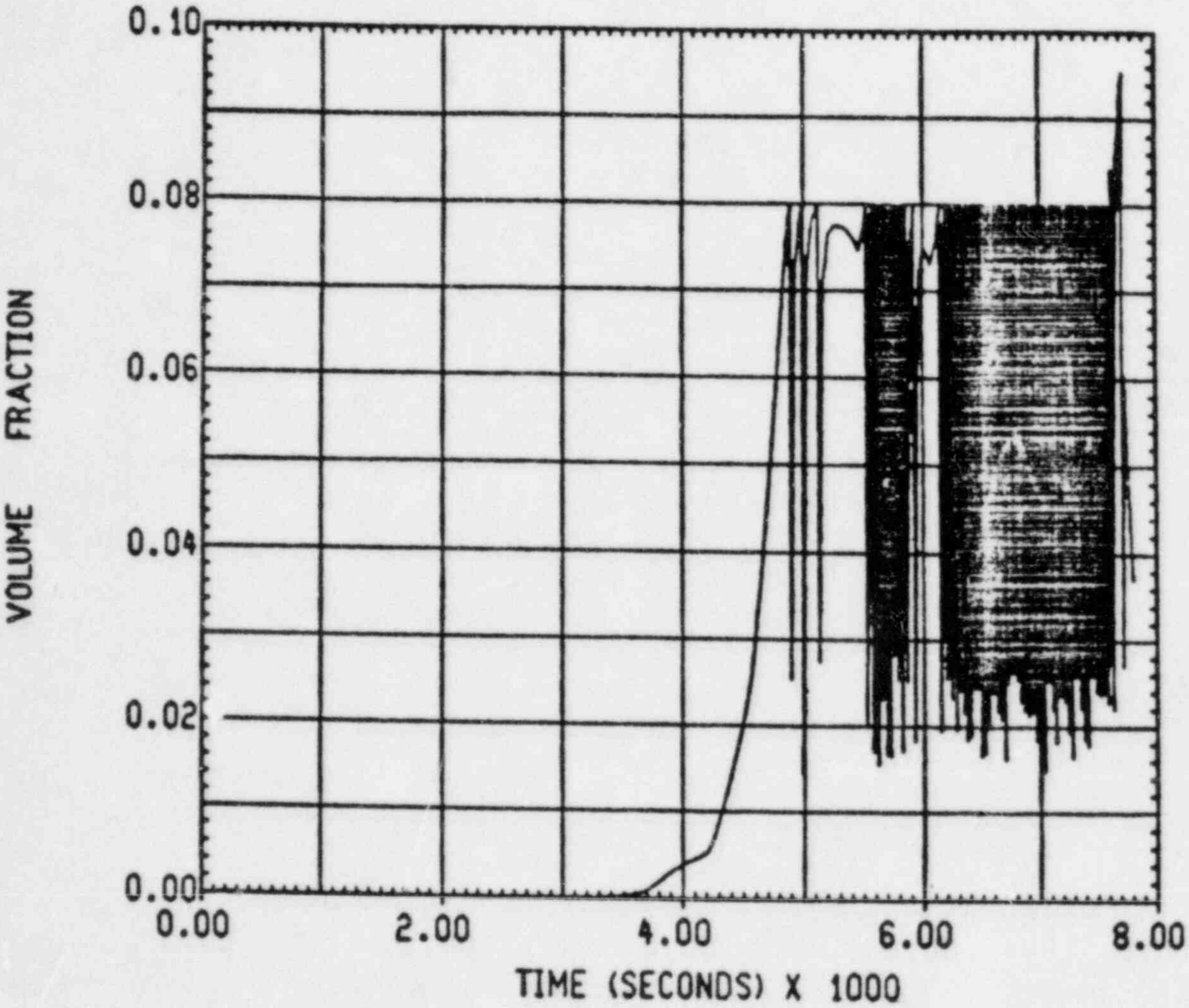


GGNS BASE CASE SORV

DRYWELL H2 GAS CONCENTRATION

Figure 54

Figure 5.5-15

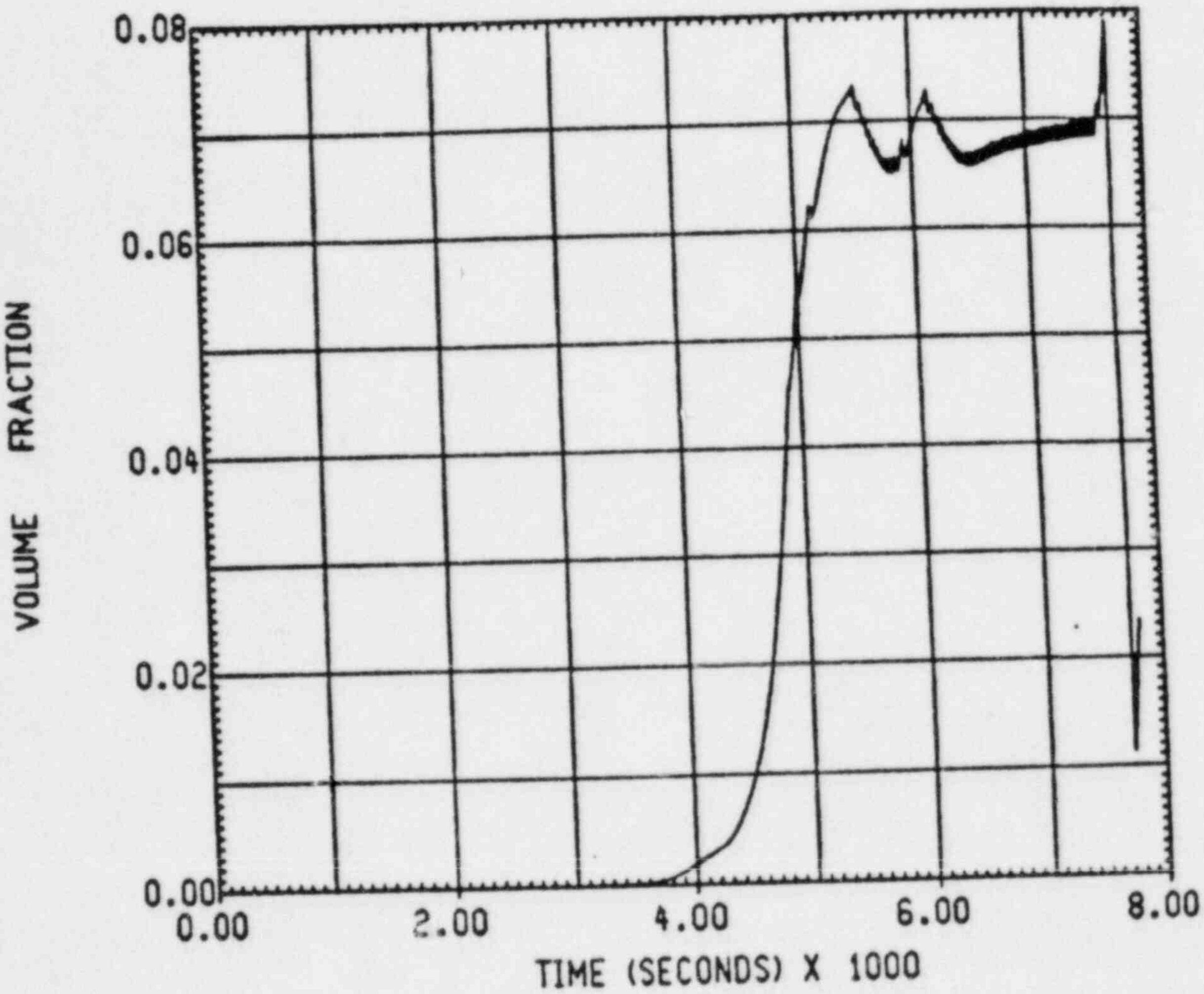


GCNS BASE CASE SORV

WETWELL H2 GAS CONCENTRATION

Figure 55

Figure 5.5-16

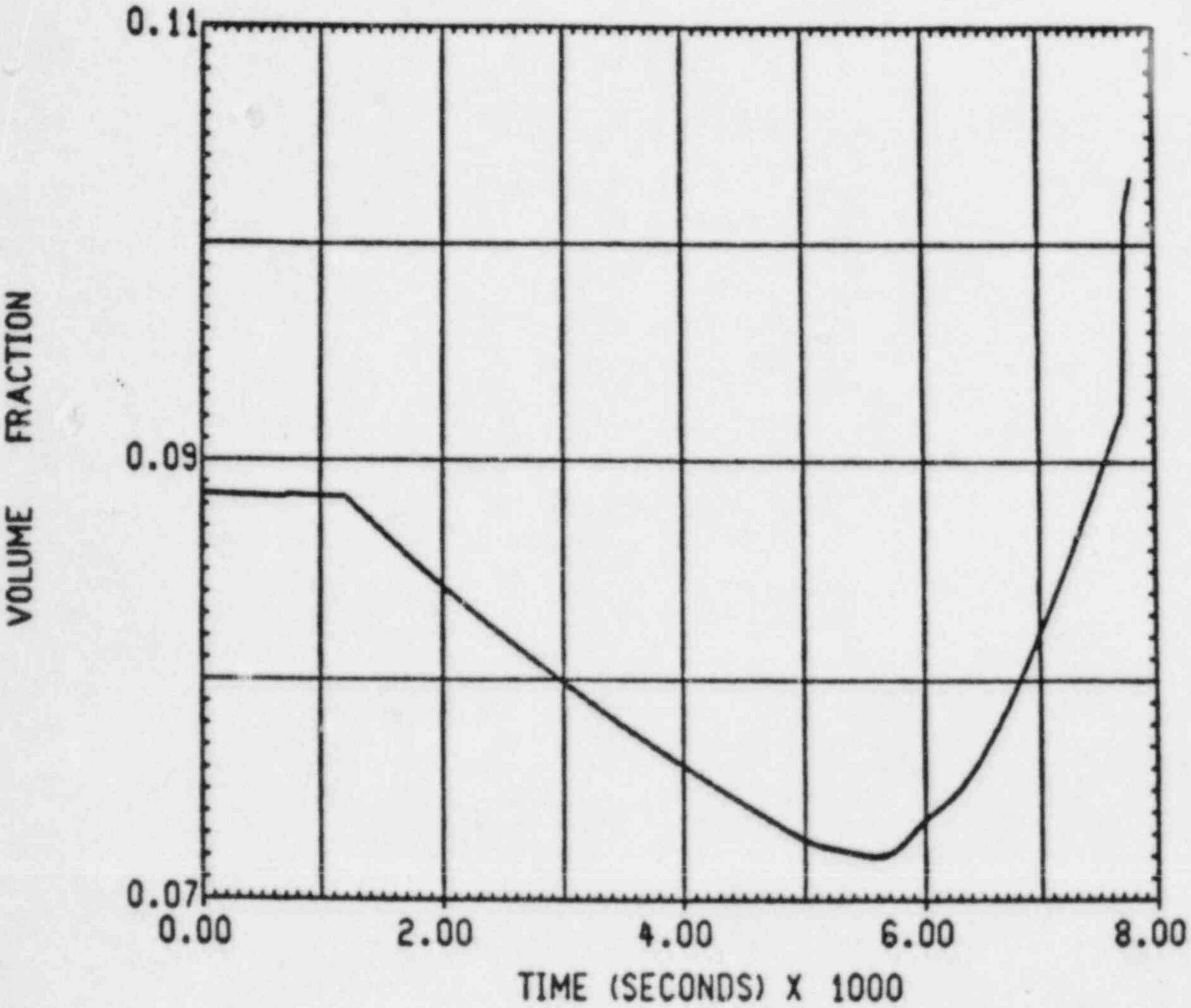


GGNS BASE CASE SORV

CONTAINMENT H2 GAS CONCENTRATION

Figure 56

Figure 5.5-17

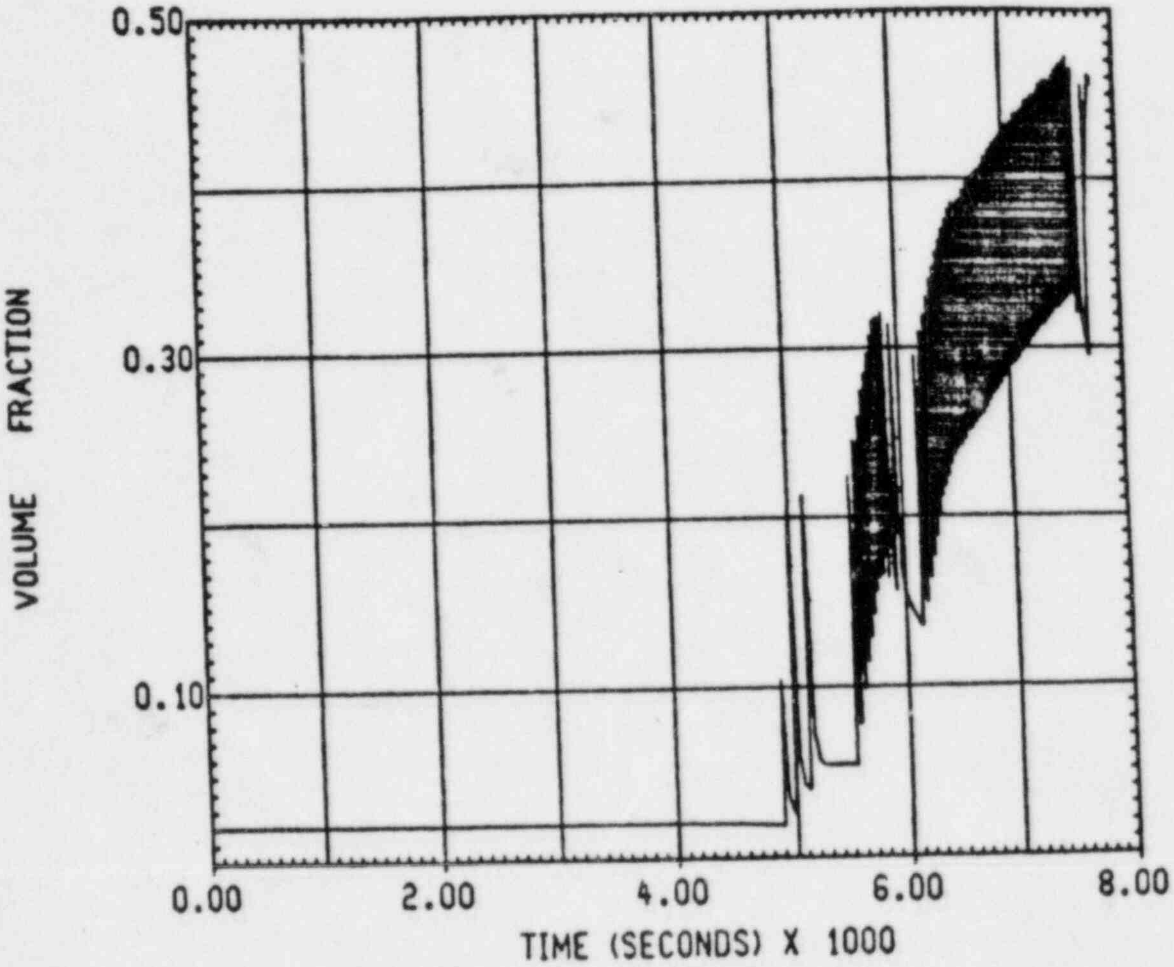


GGNS BASE CASE SORV

DRYWELL STEAM GAS CONCENTRATION

Figure 57

Figure 5.5-18



GGNS BASE CASE SORV

WETWELL STEAM GAS CONCENTRATION

Figure 58

Figure 5.5-19

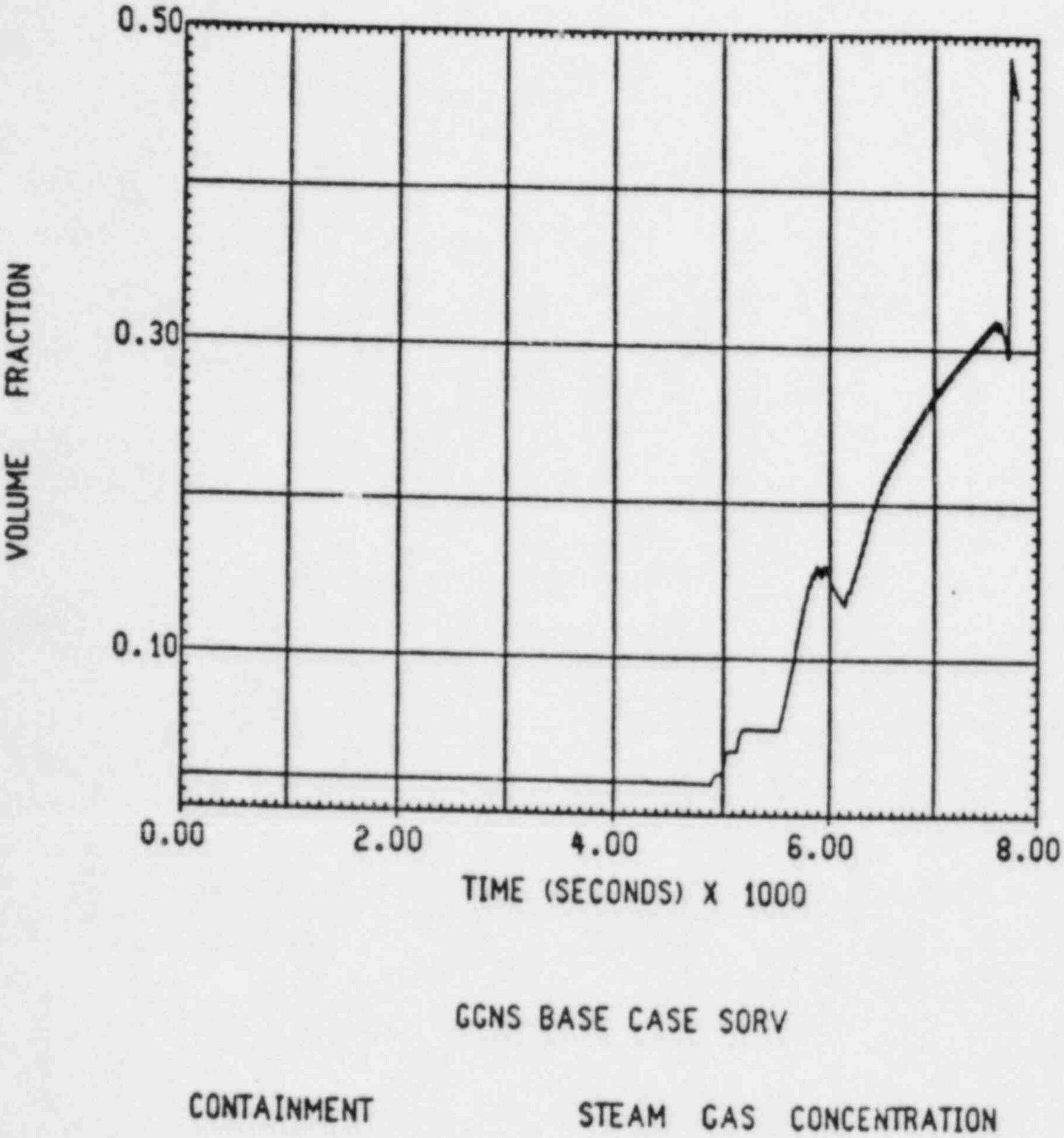
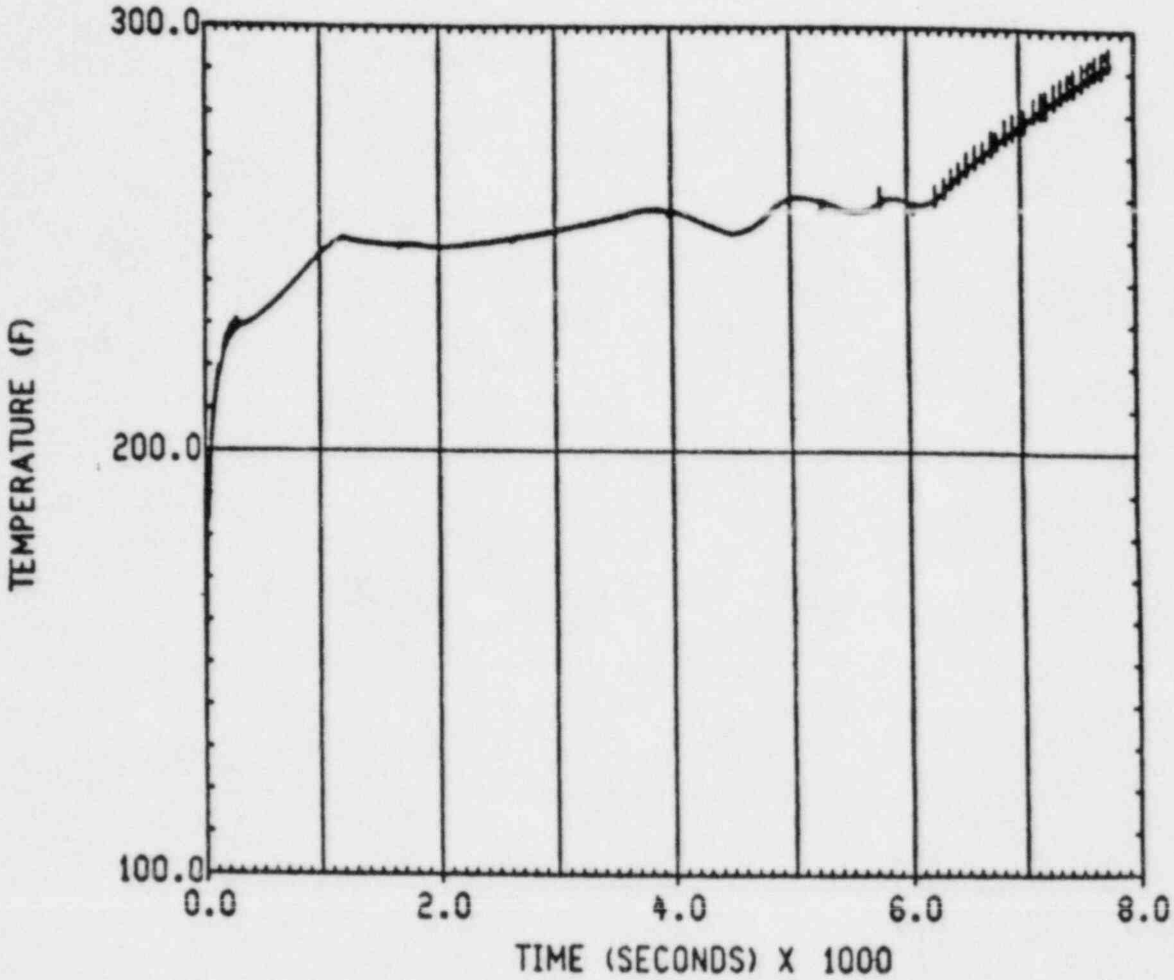


Figure 59

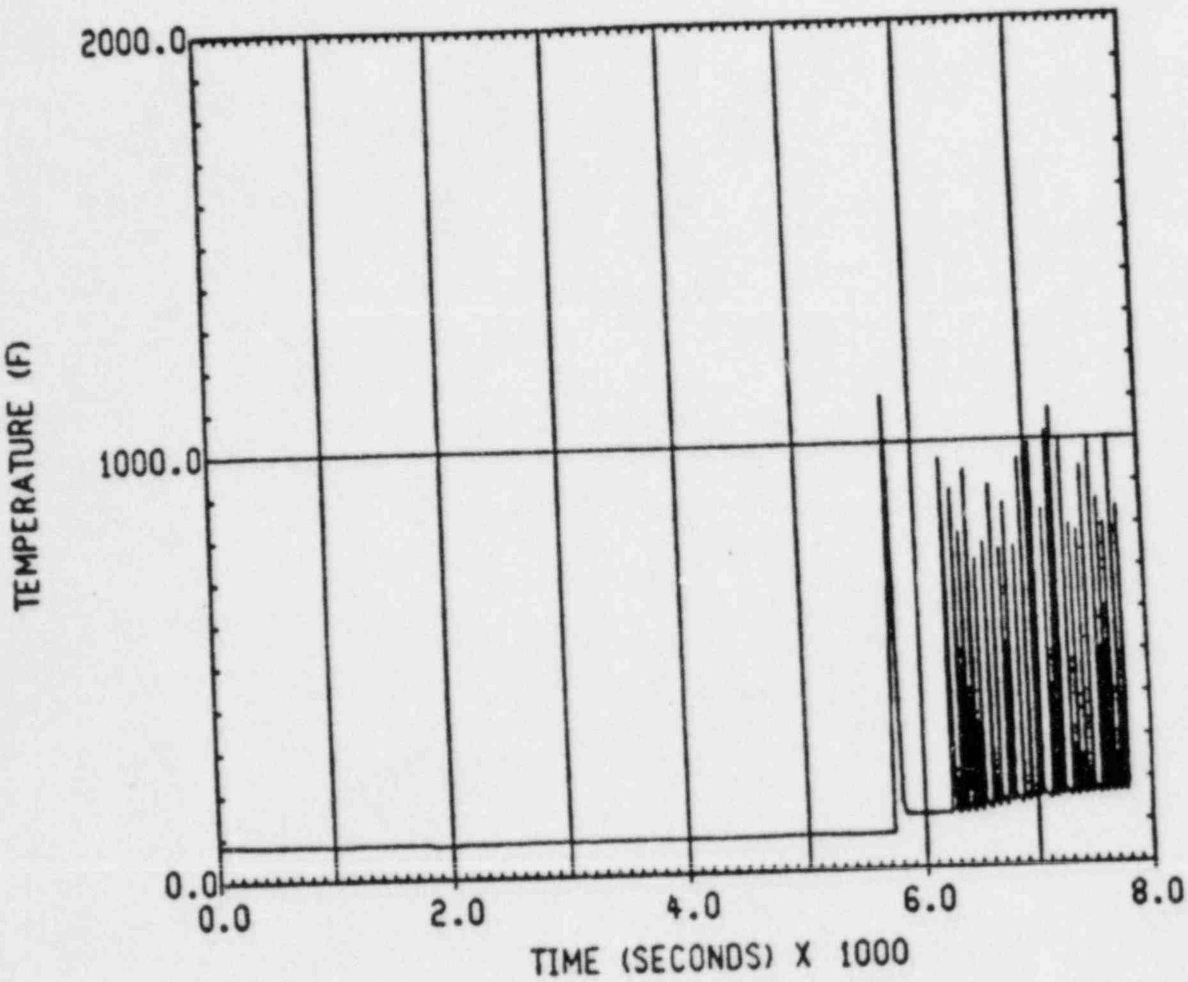
Figure 5.5-20



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL TEMPERATURE

Figure 136

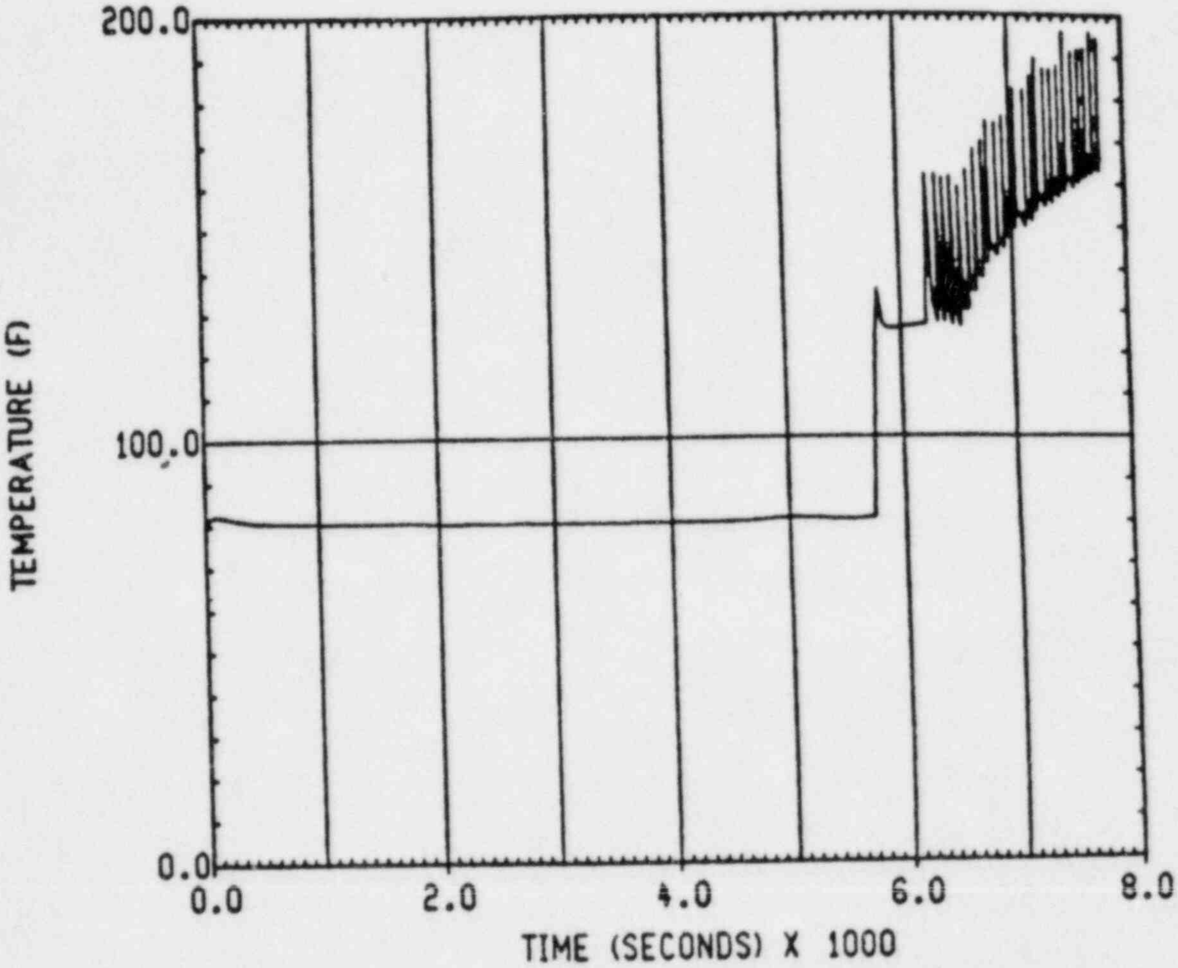
Figure 5.5-21



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL TEMPERATURE

Figure 137

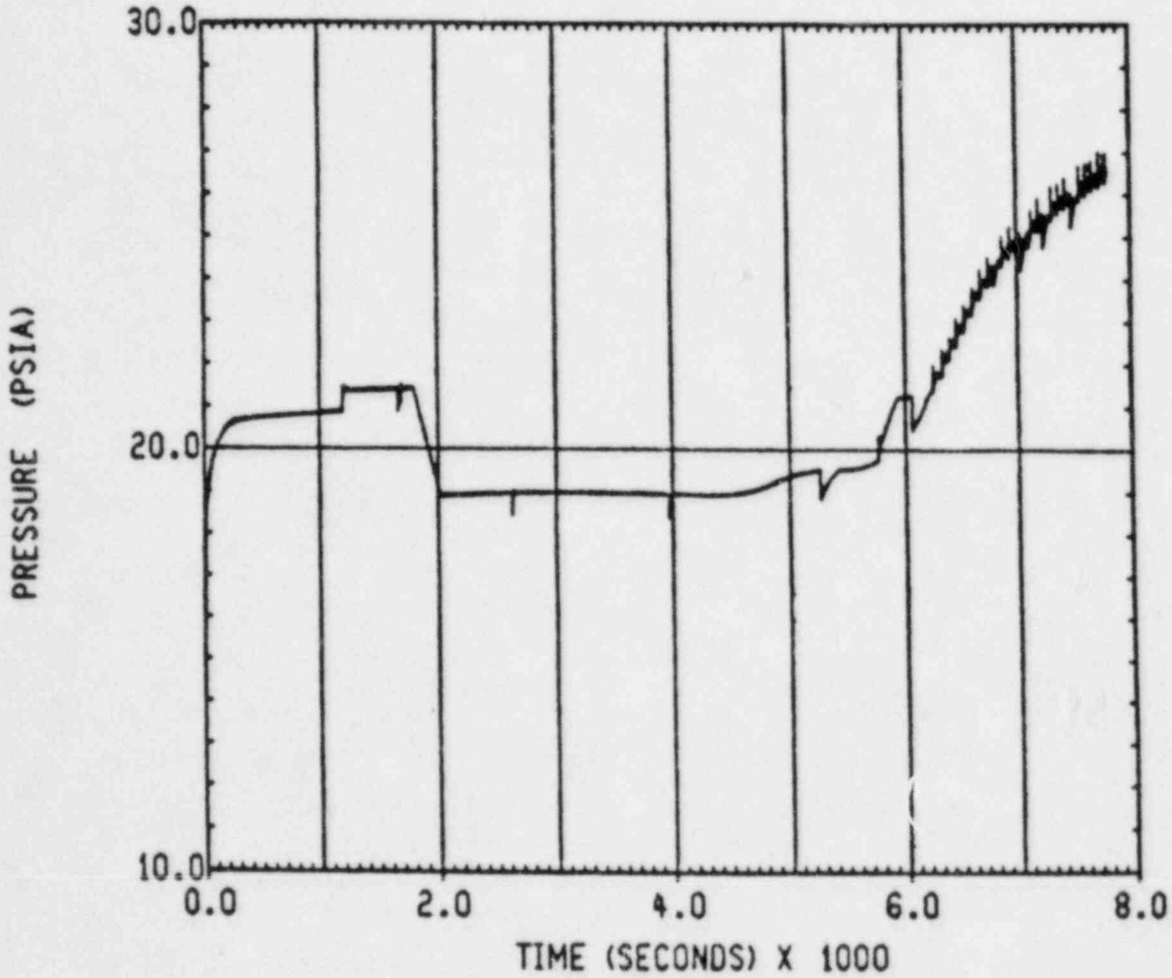
Figure 5.5-22



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT TEMPERATURE

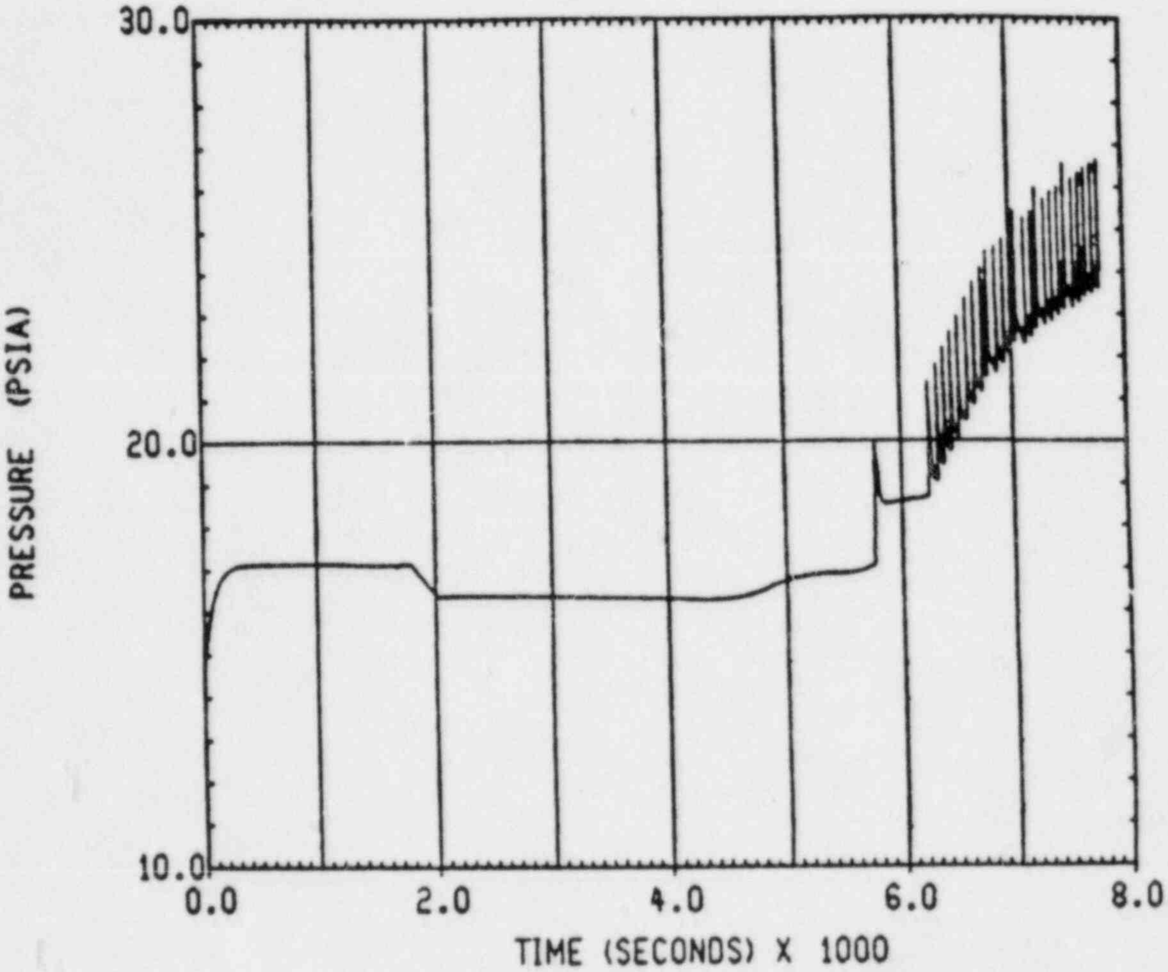
Figure 138

Figure 5.5-23



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL PRESSURE

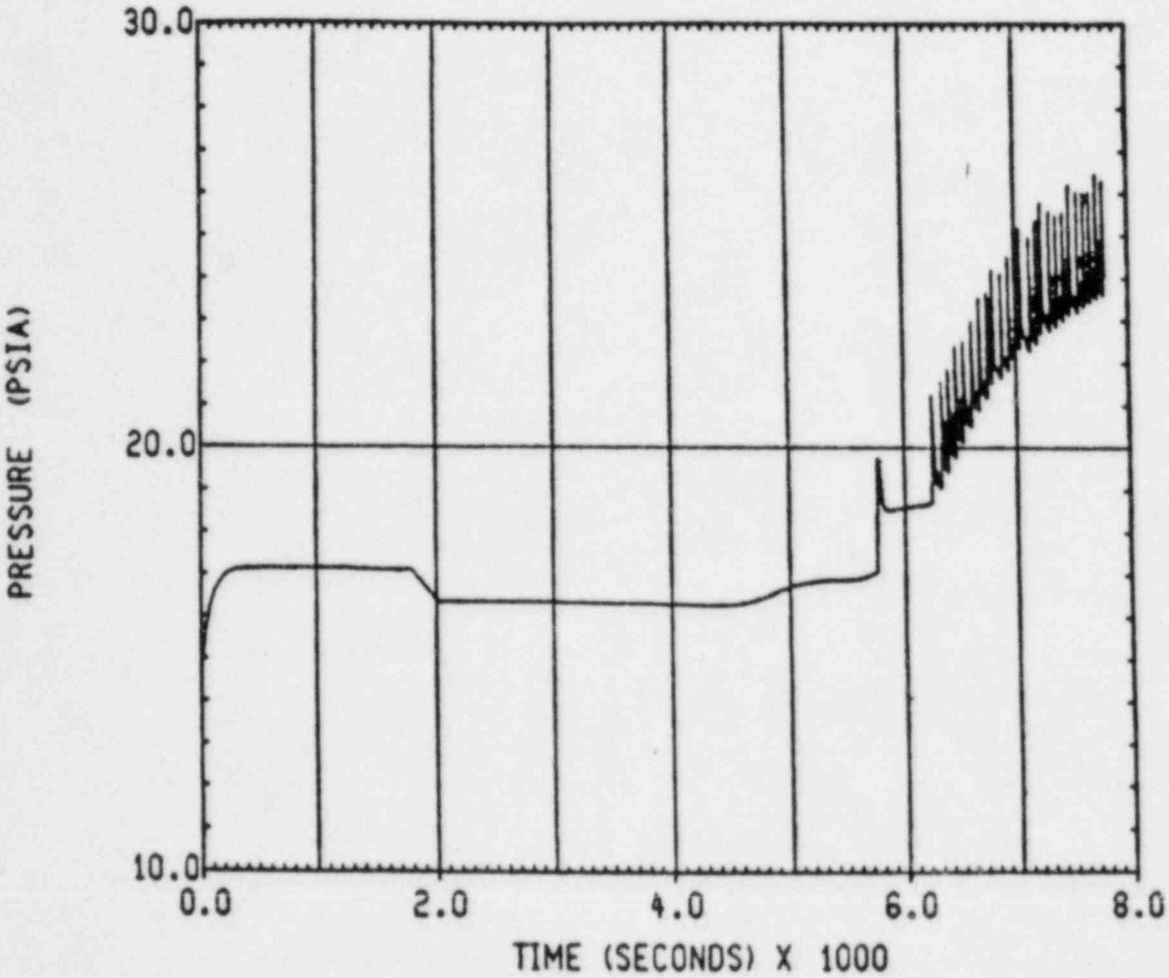
Figure 5.5-24



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL PRESSURE

Figure 140

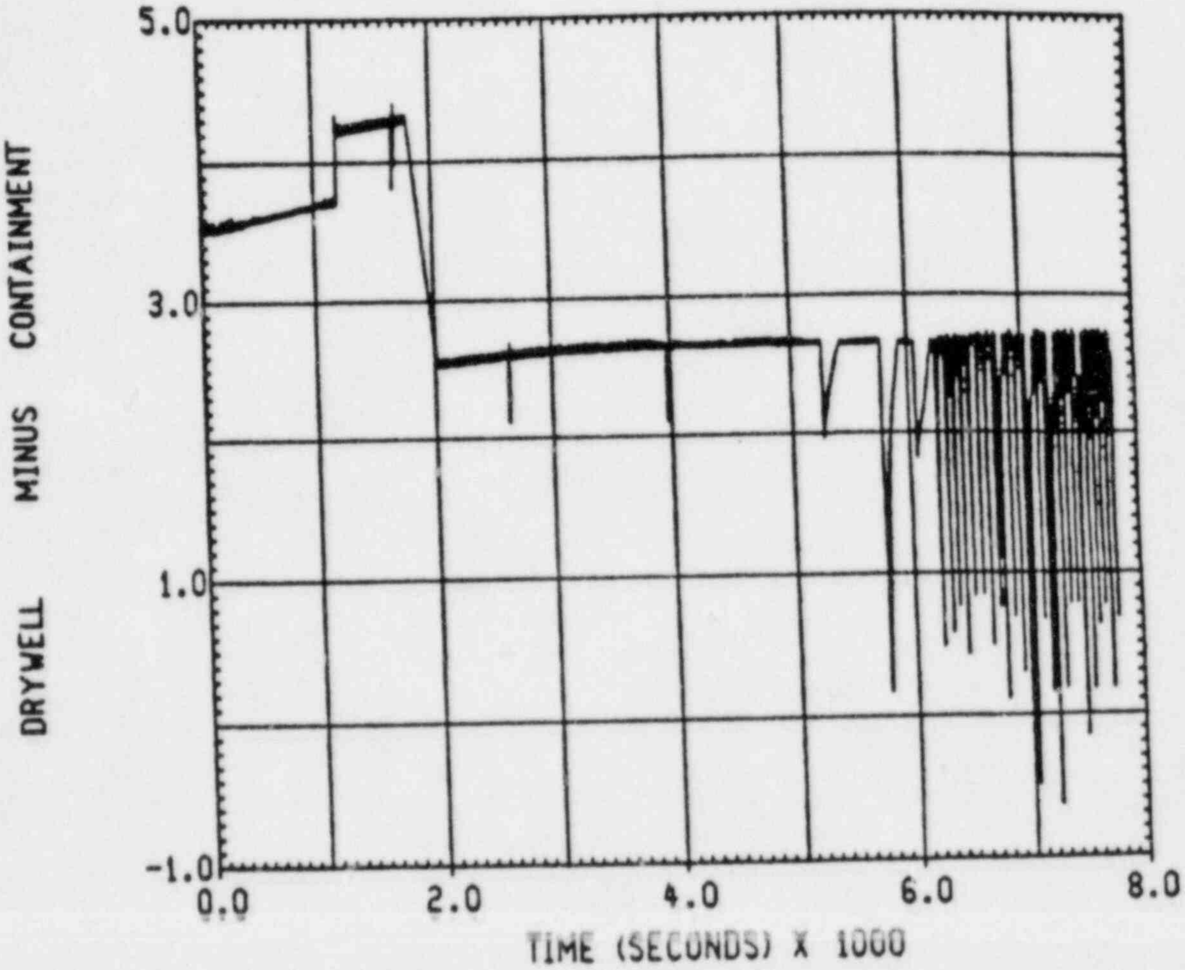
Figure 5.5-25



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT PRESSURE

Figure 141

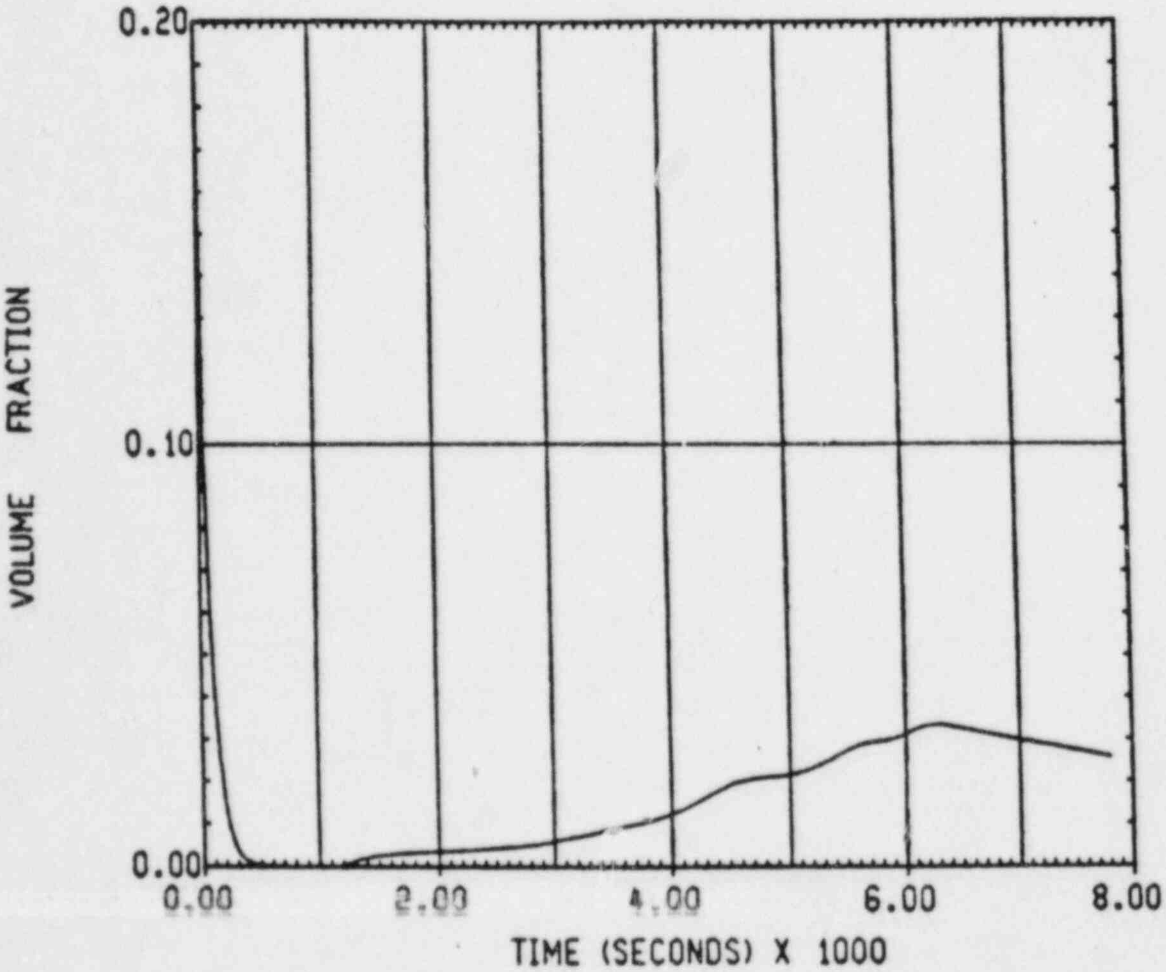
Figure 5.5-26



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DIFFERENTIAL PRESSURE

Figure 142

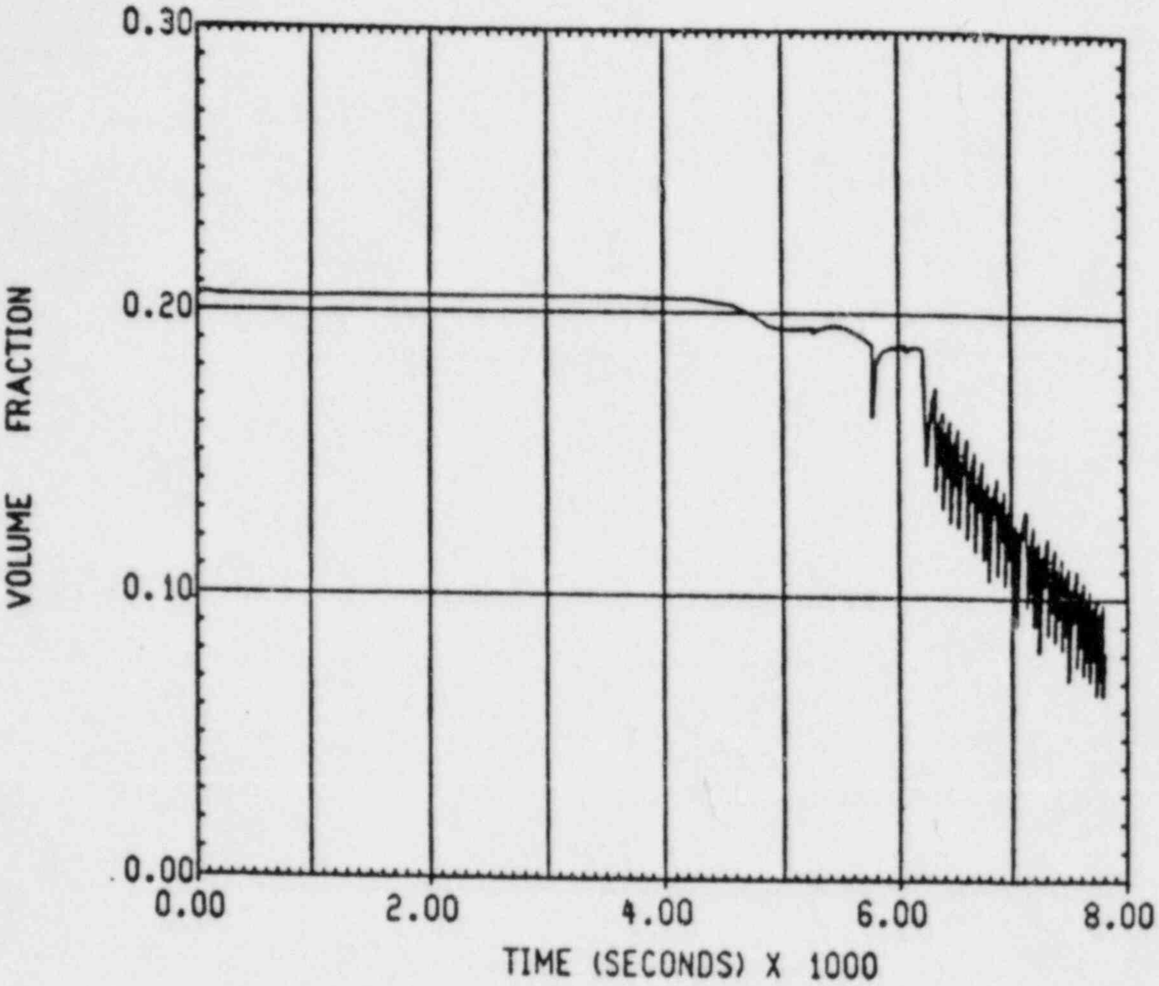
Figure 5.5-27



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL O2 GAS CONCENTRATION

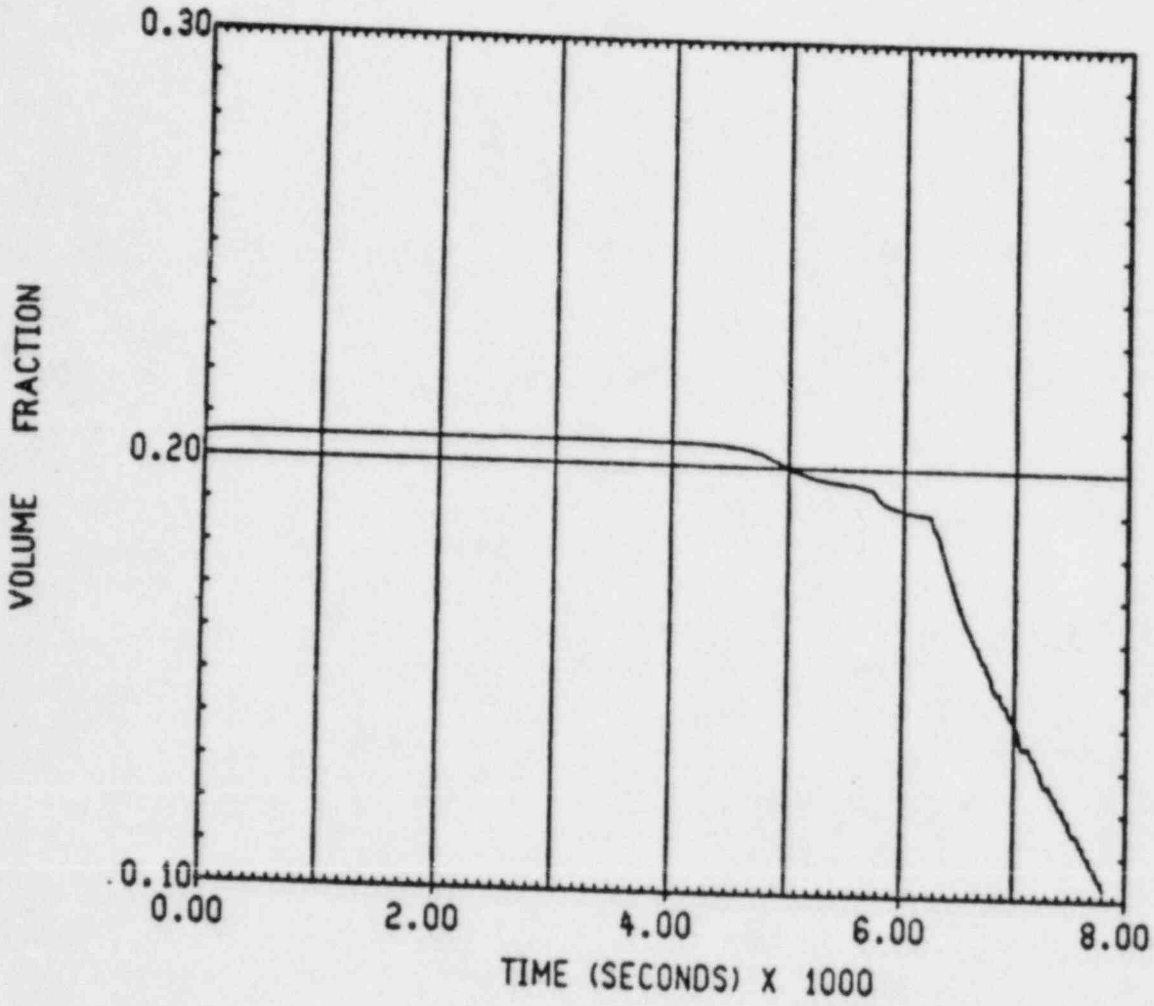
Figure 143

Figure 5.5-28



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL 02 GAS CONCENTRATION

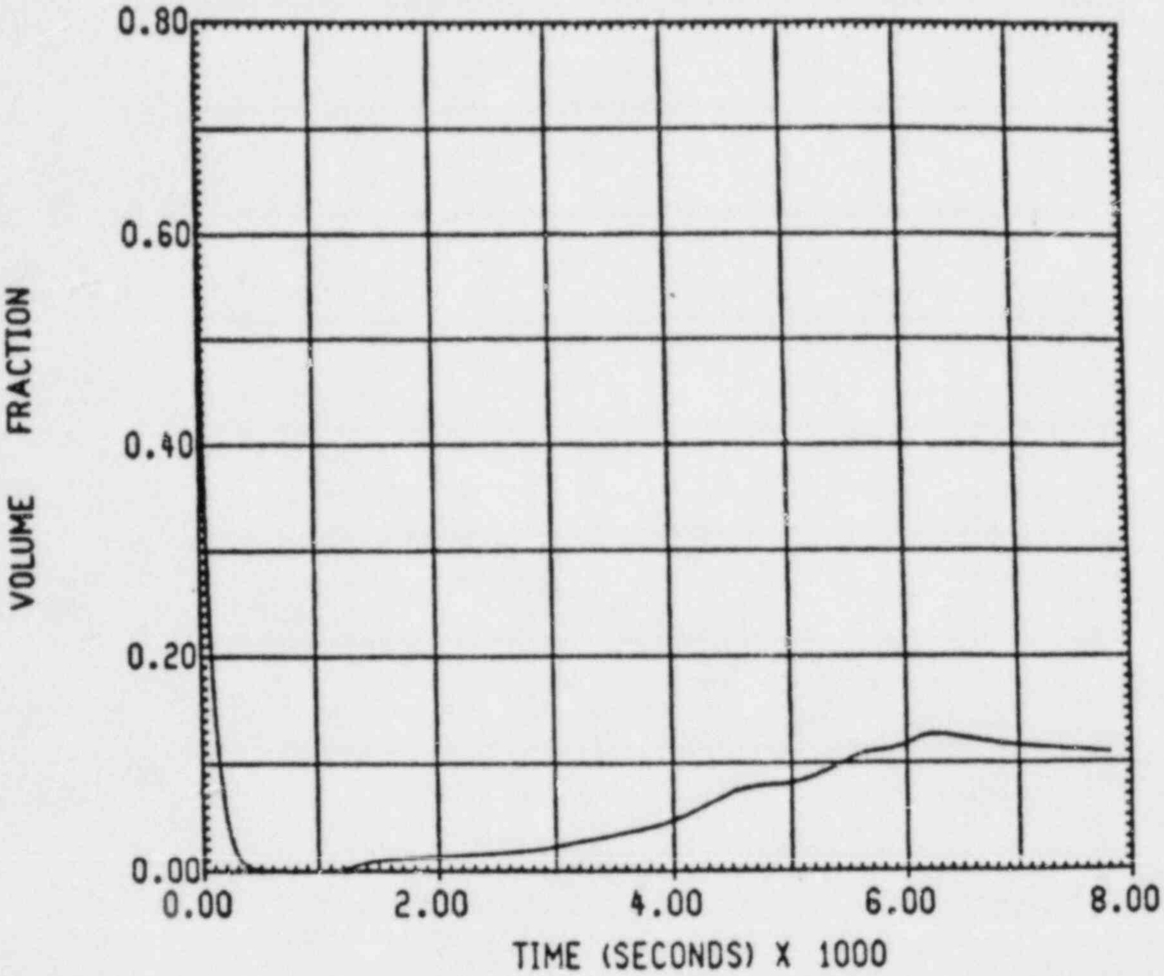
Figure 5.5-29



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT 02 GAS CONCENTRATION

Figure 145

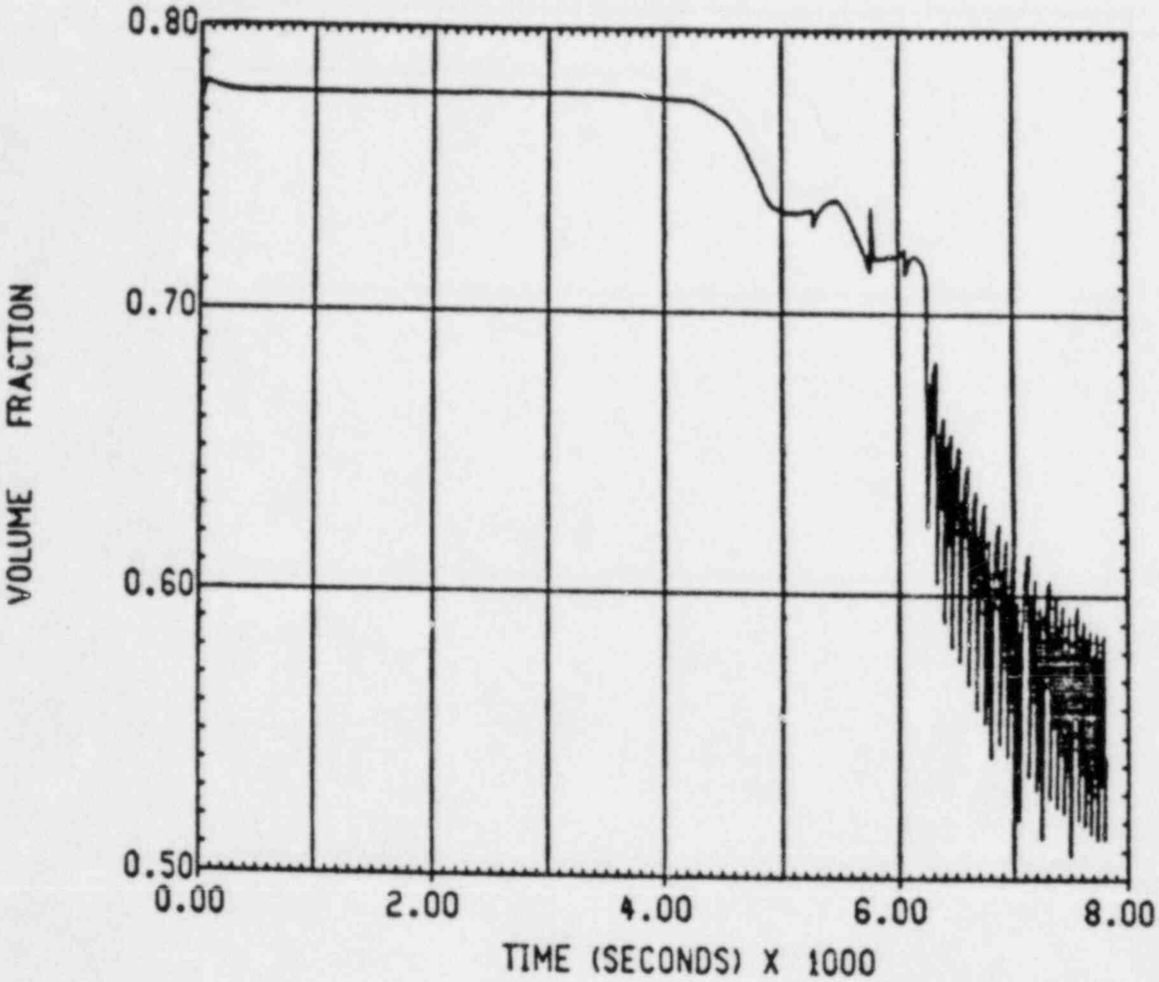
Figure 5.5-30



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL N2 GAS CONCENTRATION

Figure 146

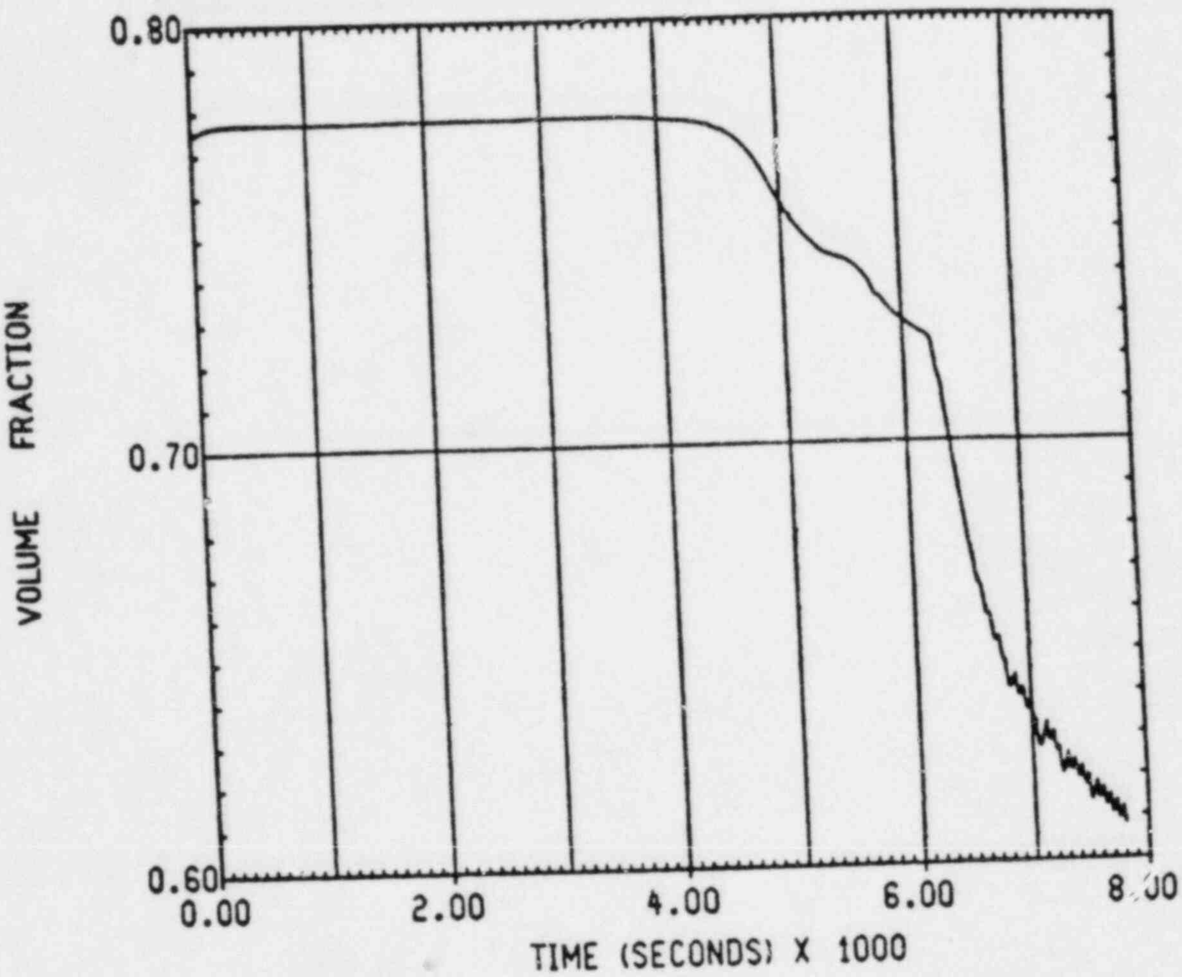
Figure 5.5-31



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL N2 GAS CONCENTRATION

Figure 147

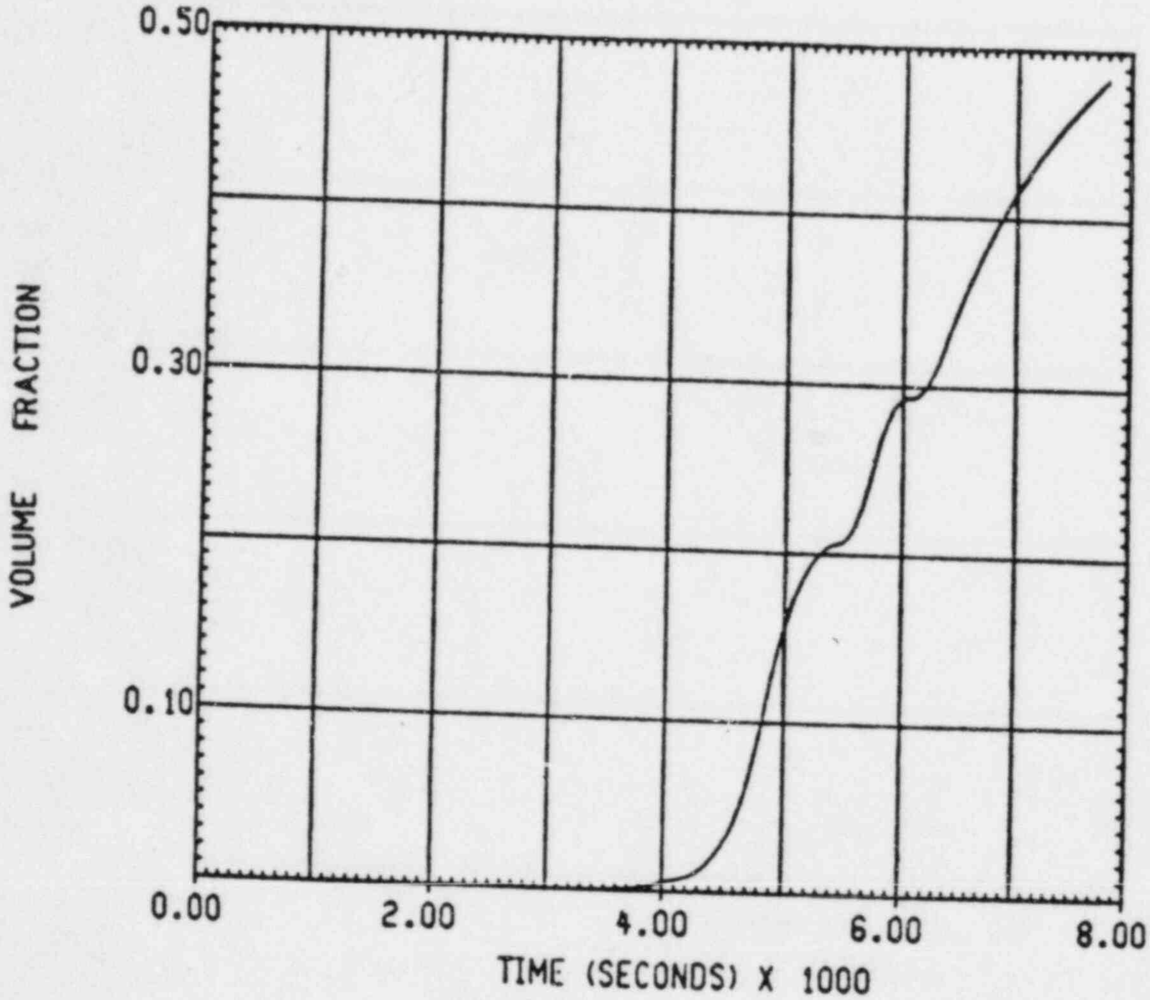
Figure 5.5-32



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT N2 GAS CONCENTRATION

Figure 148

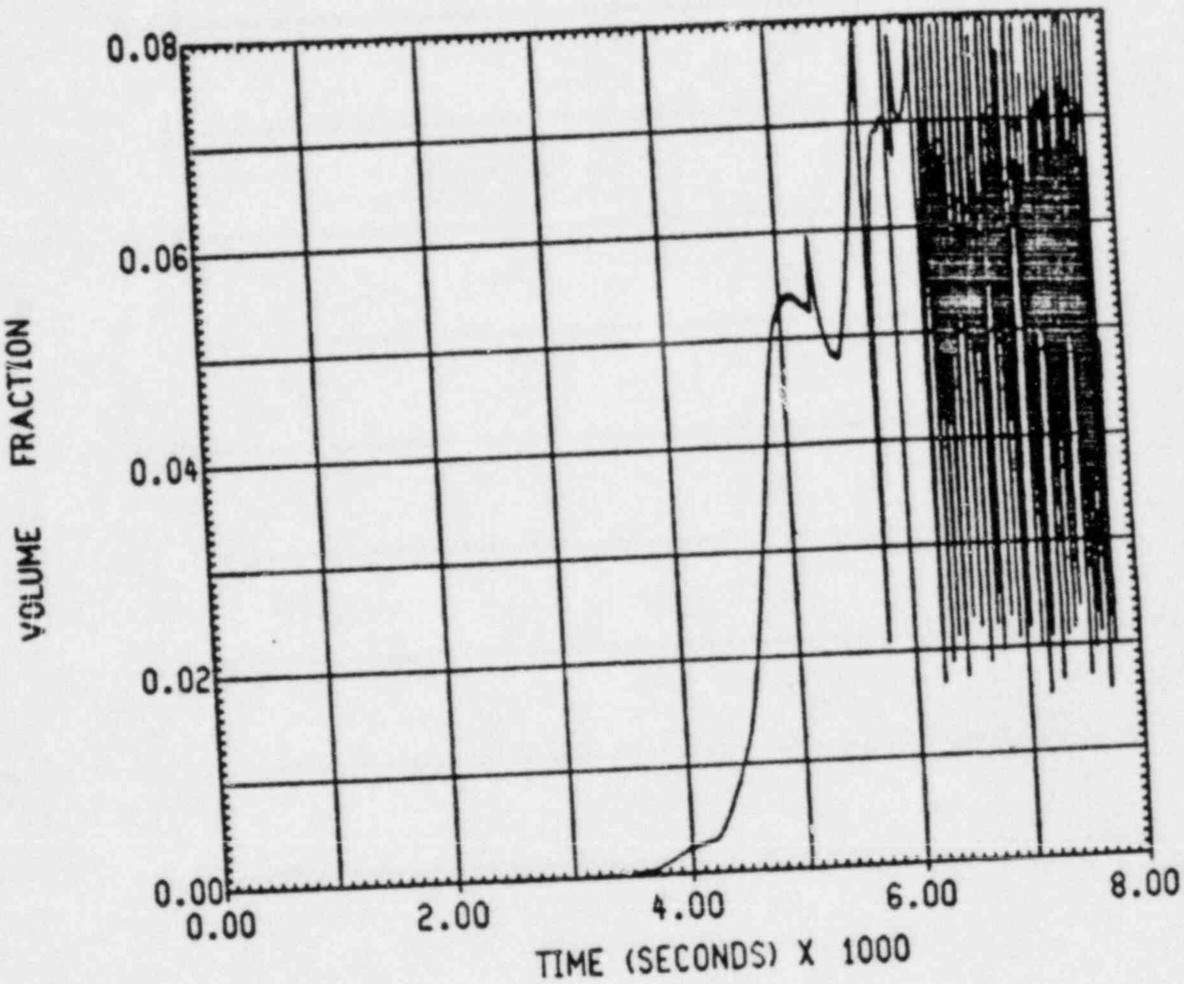
Figure 5.5-33



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL H2 GAS CONCENTRATION

Figure 149

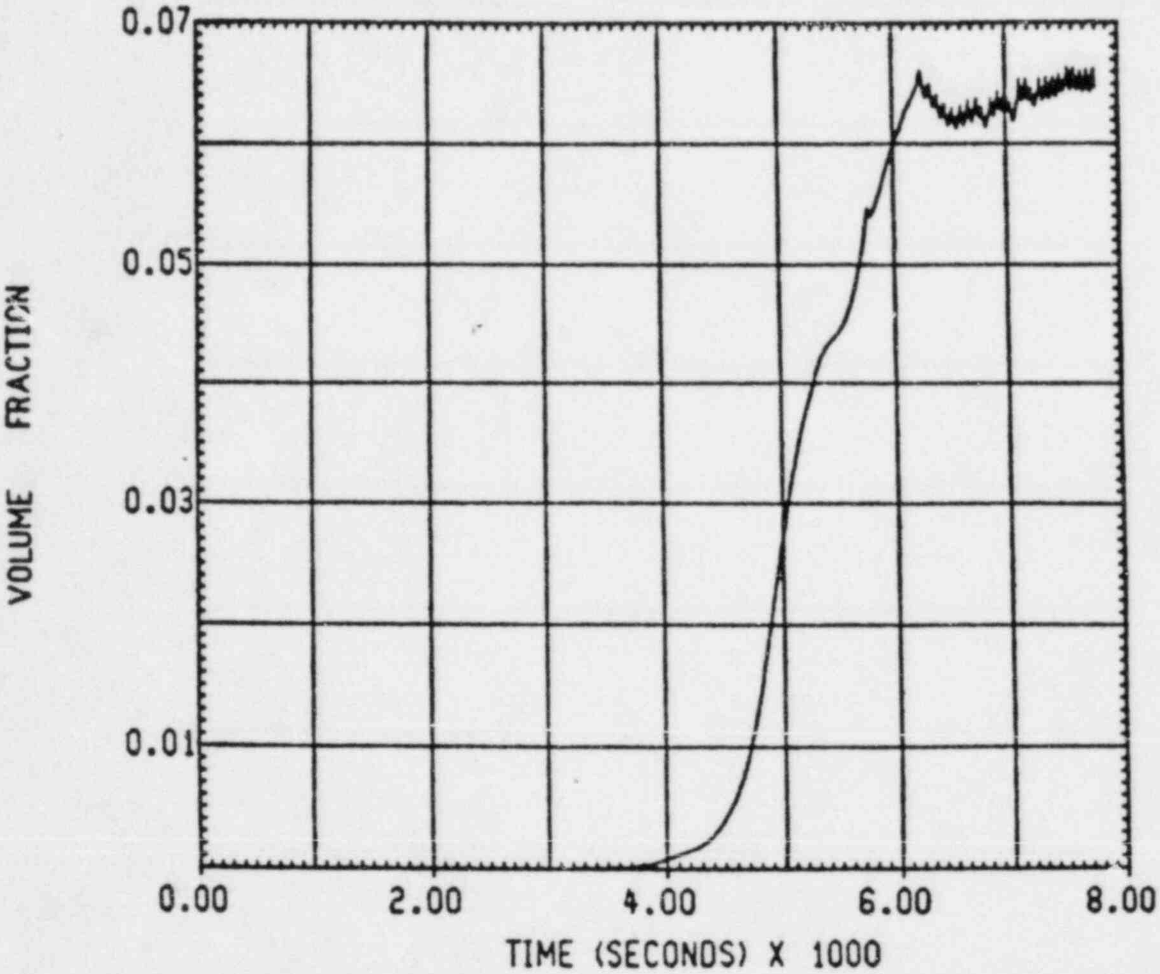
Figure 5.5-34



GCNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL H2 GAS CONCENTRATION

Figure 150

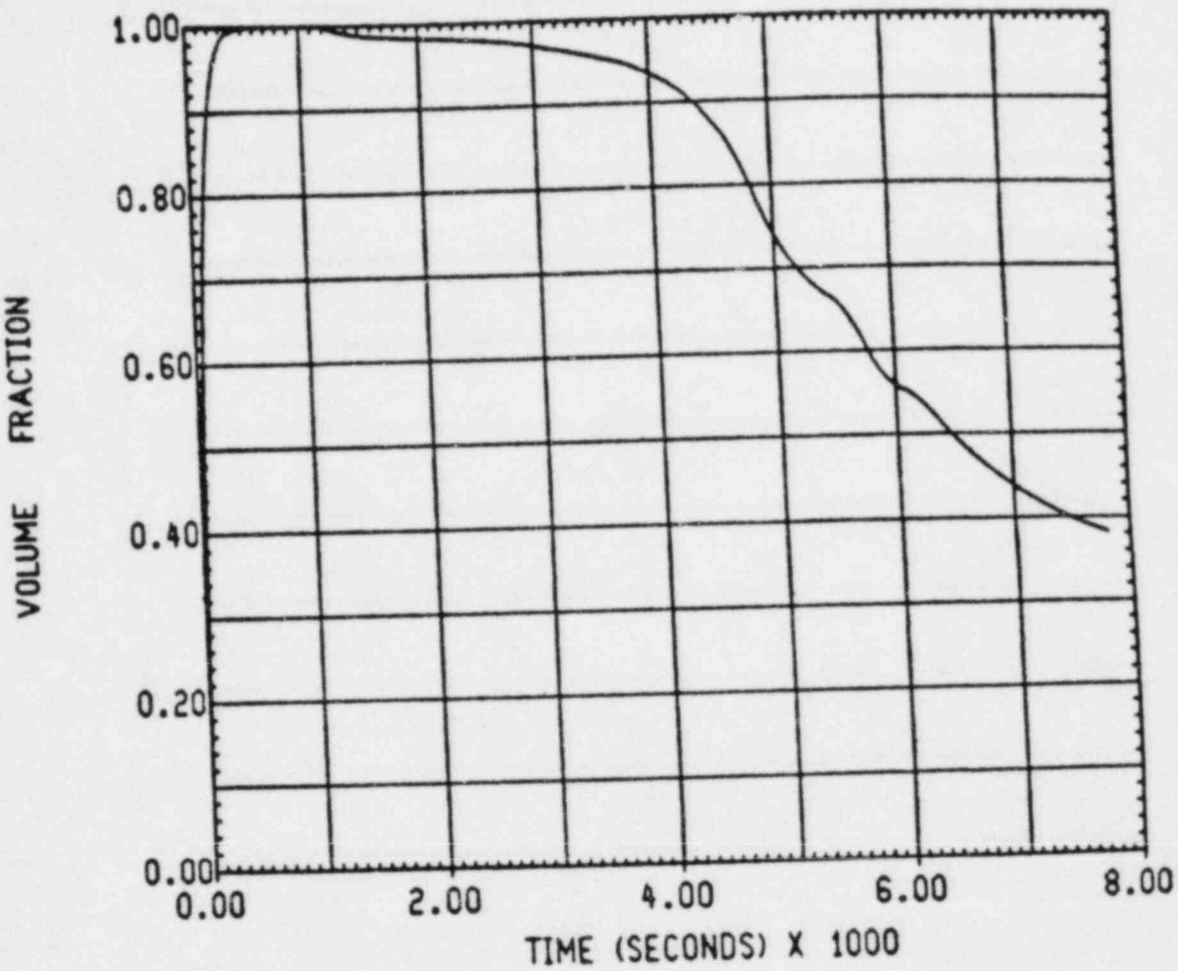
Figure 5.5-35



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT H2 GAS CONCENTRATION

Figure 151

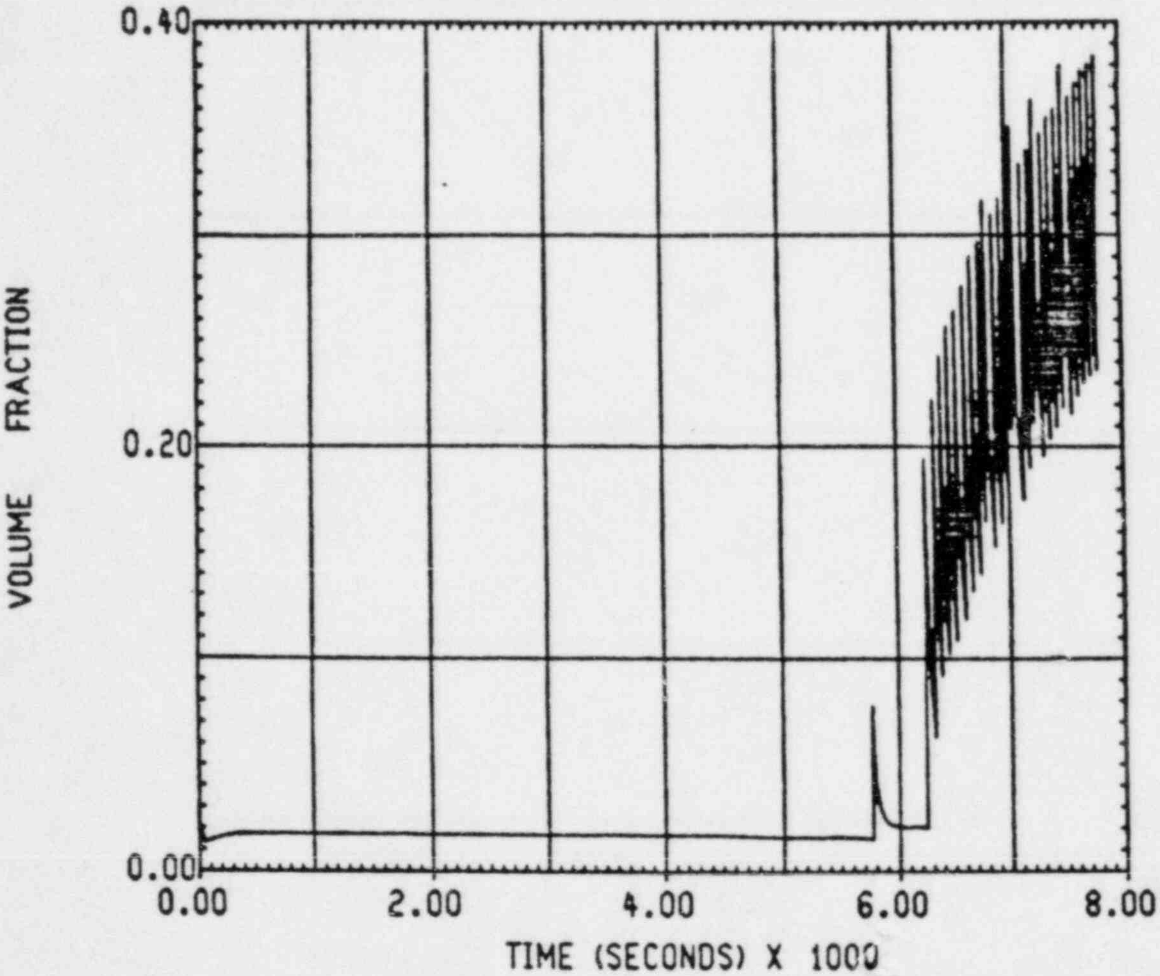
Figure 5.5-36



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL STEAM GAS CONCENTRATION

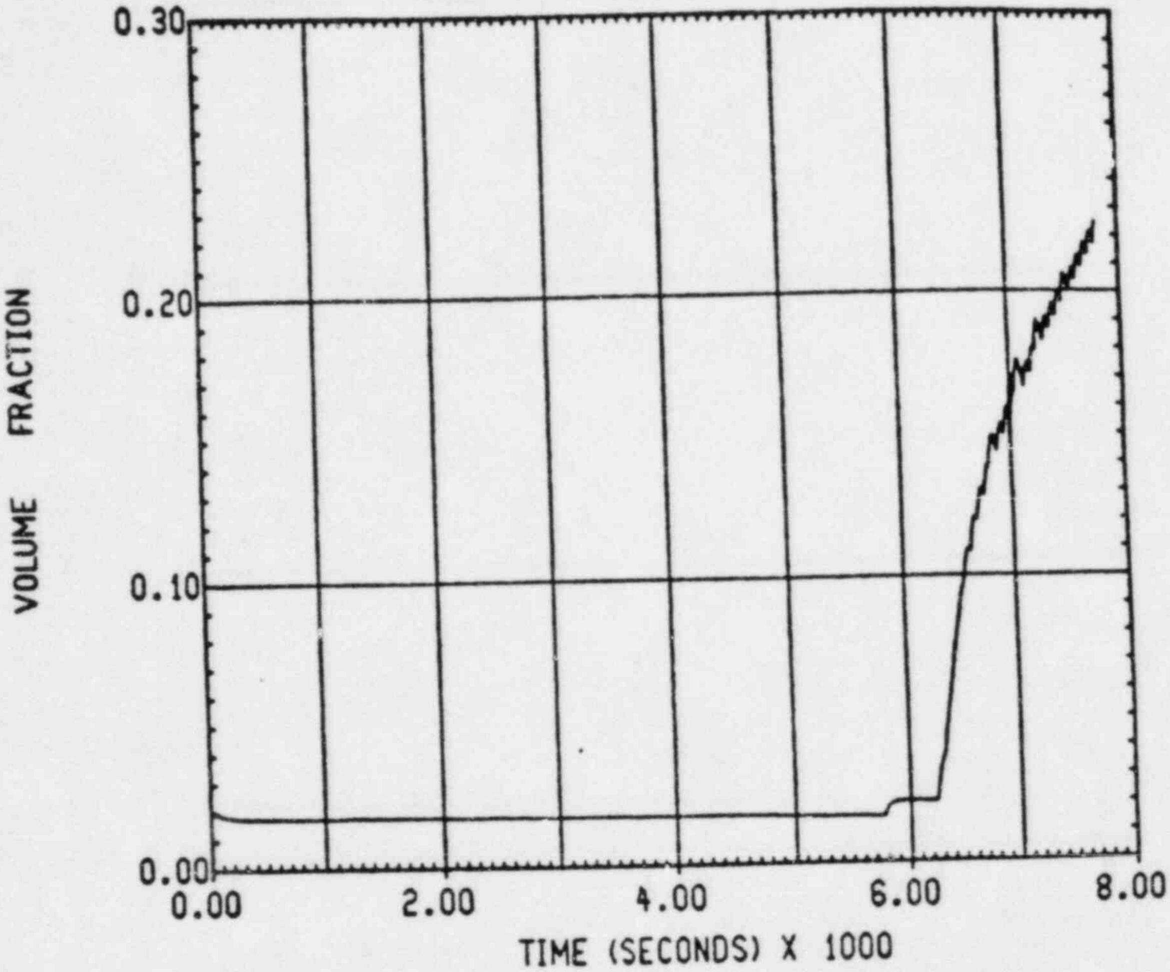
Figure 152

Figure 5.5-37



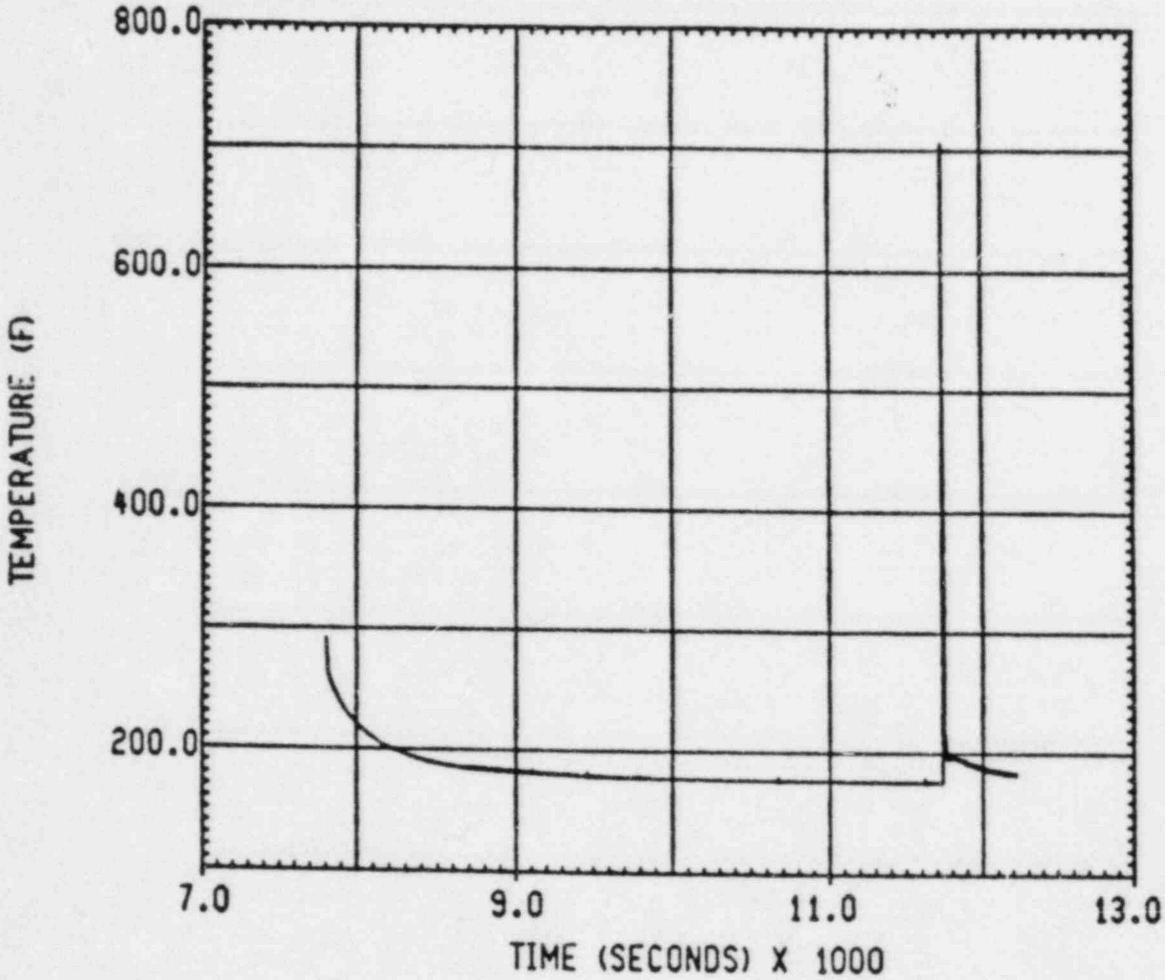
G^'S BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL STEAM GAS CONCENTRATION

Figure 5.5-38



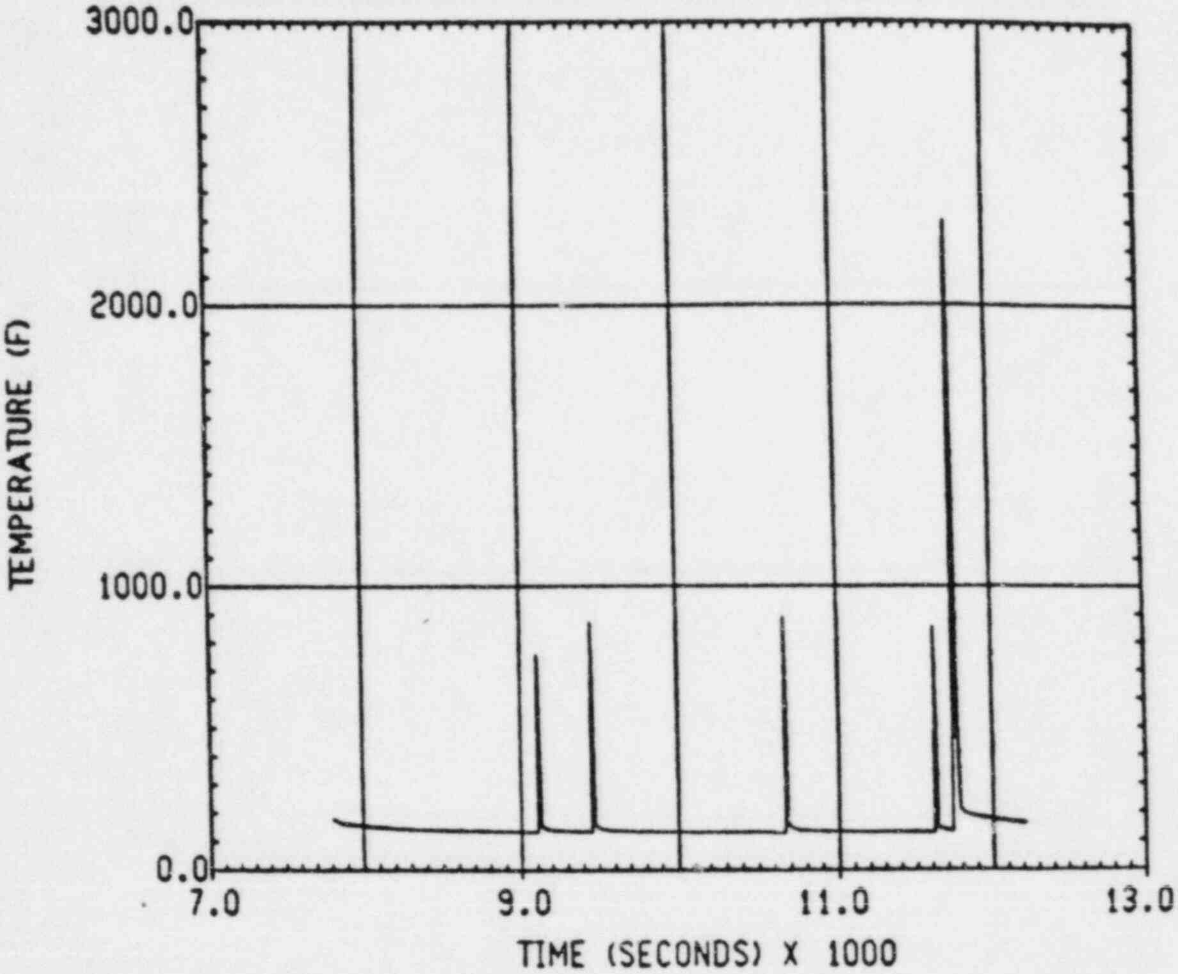
GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT STEAM GAS CONCENTRATION

Figure 5.5-39



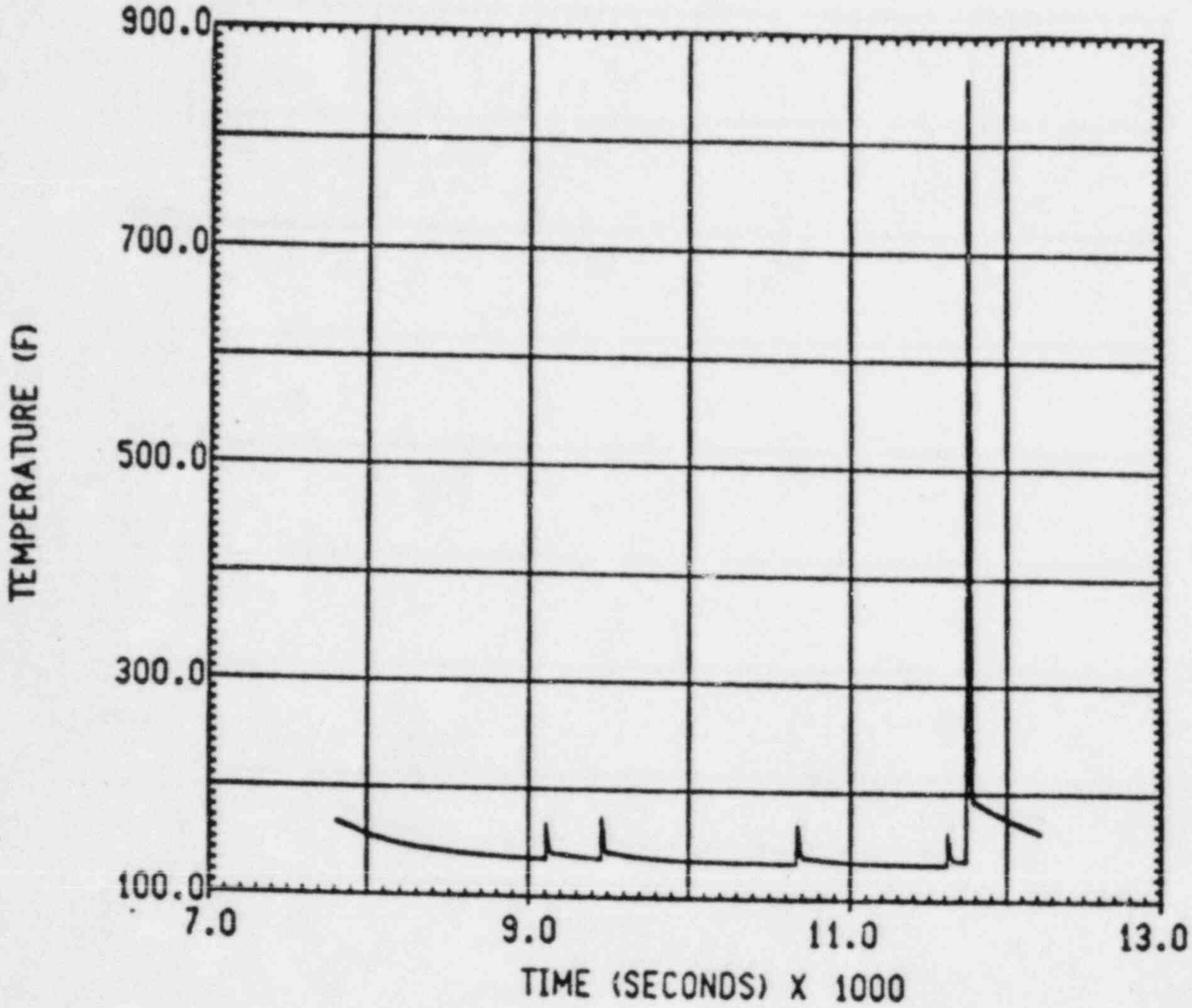
GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL TEMPERATURE

Figure 5.5-40



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL TEMPERATURE

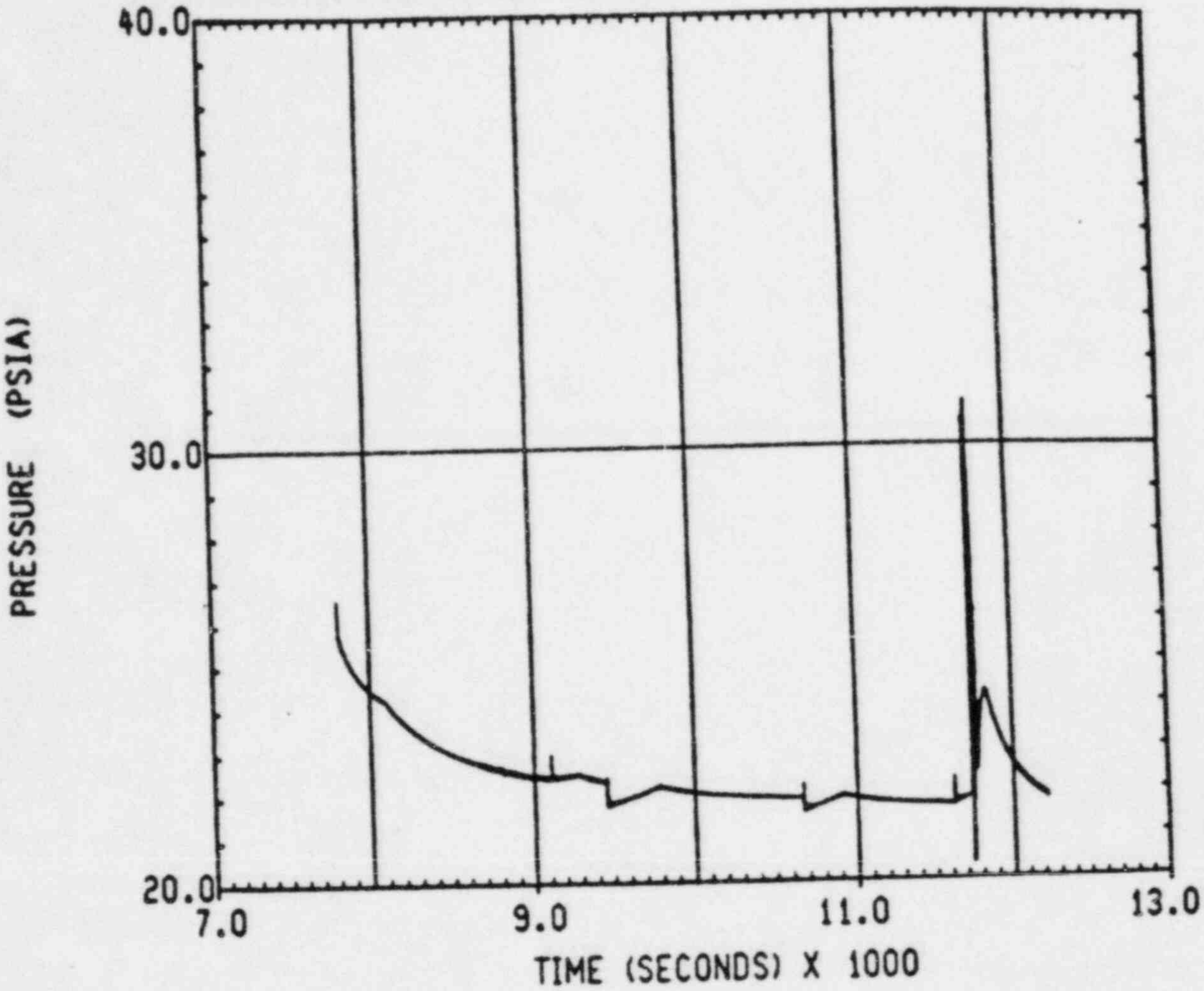
Figure 5.5-41



CGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT TEMPERATURE

Figure 157

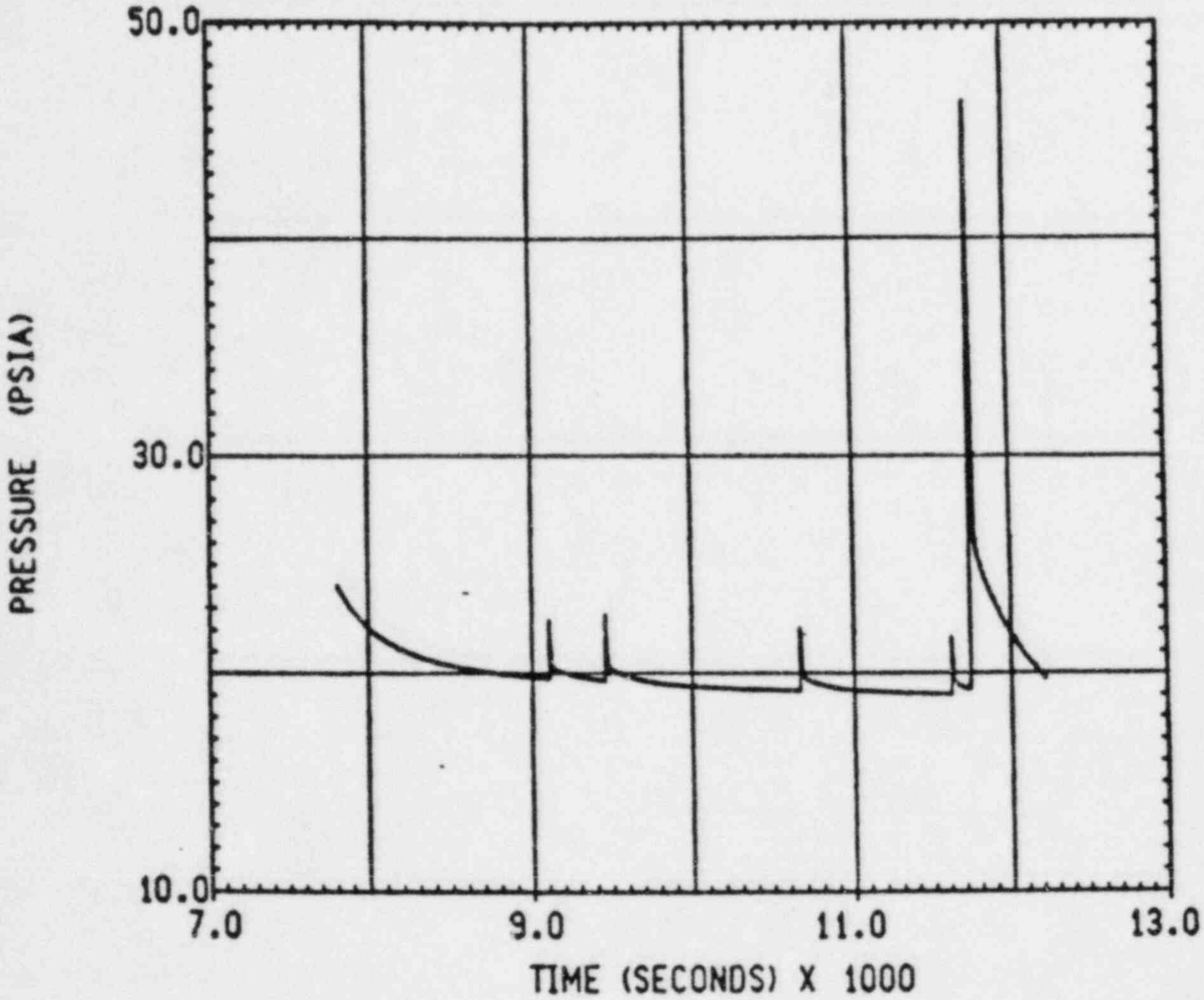
Figure 5.5-42



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL PRESSURE

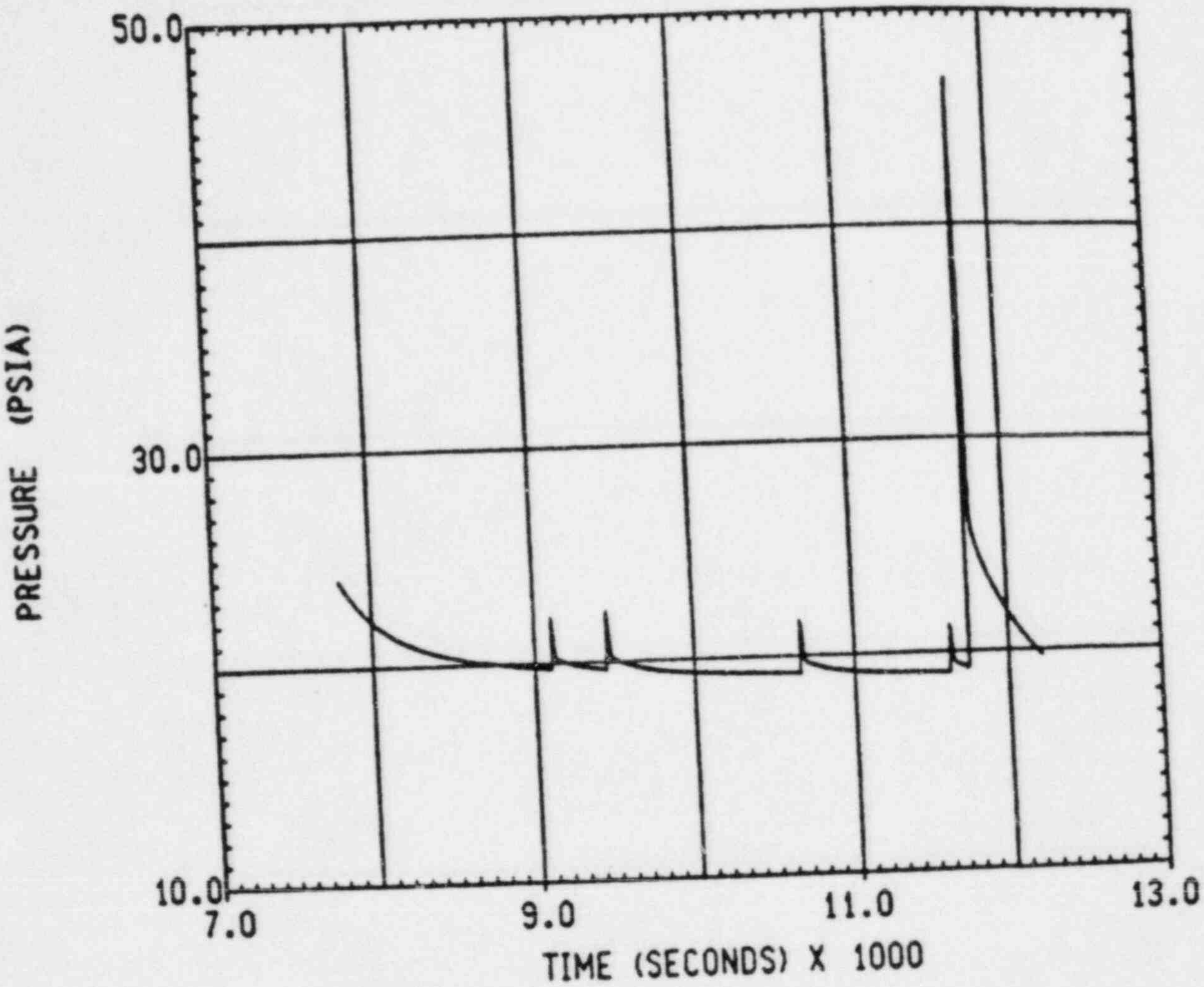
Figure 158

Figure 5.5-43



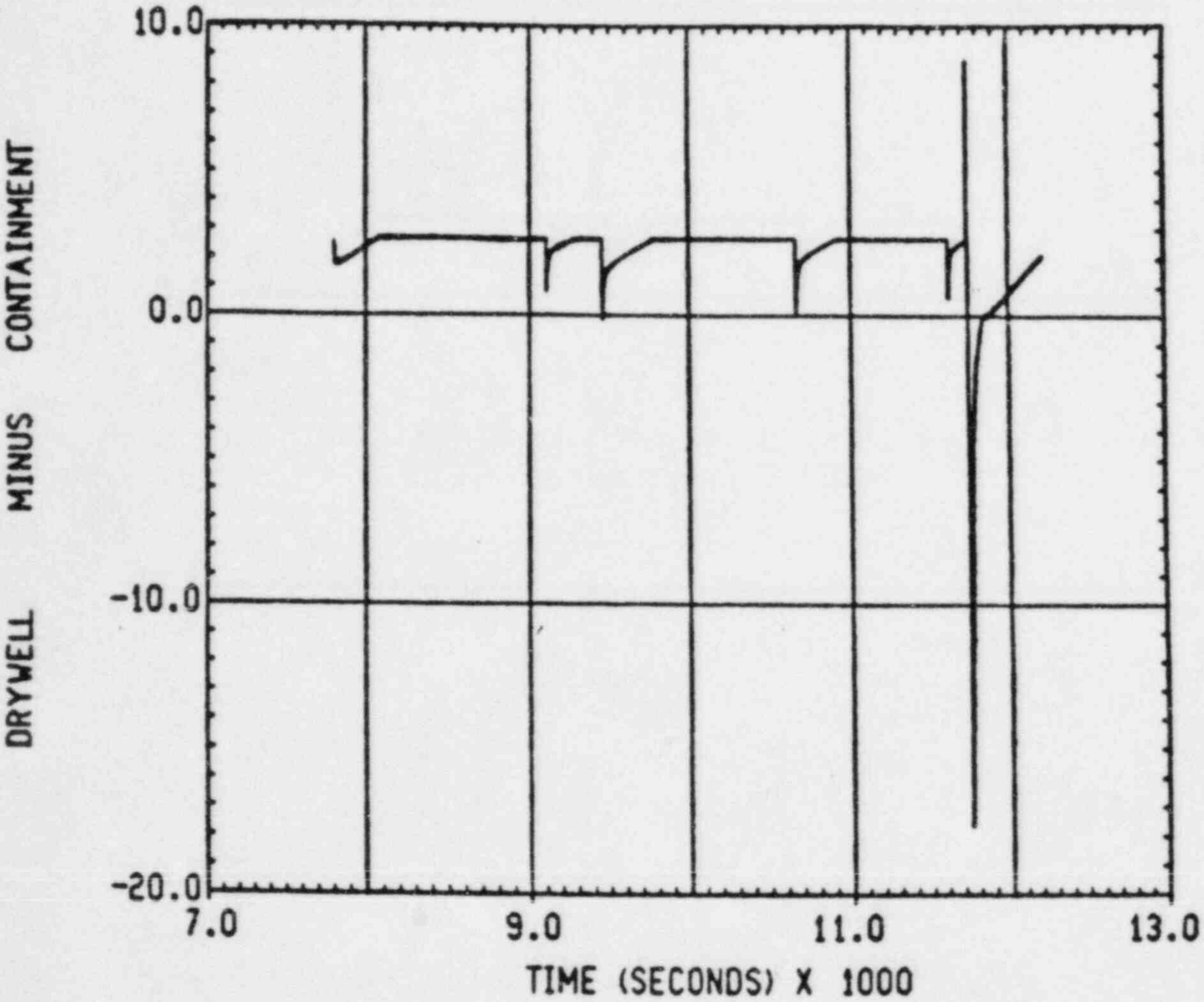
GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL PRESSURE

Figure 5.5-44



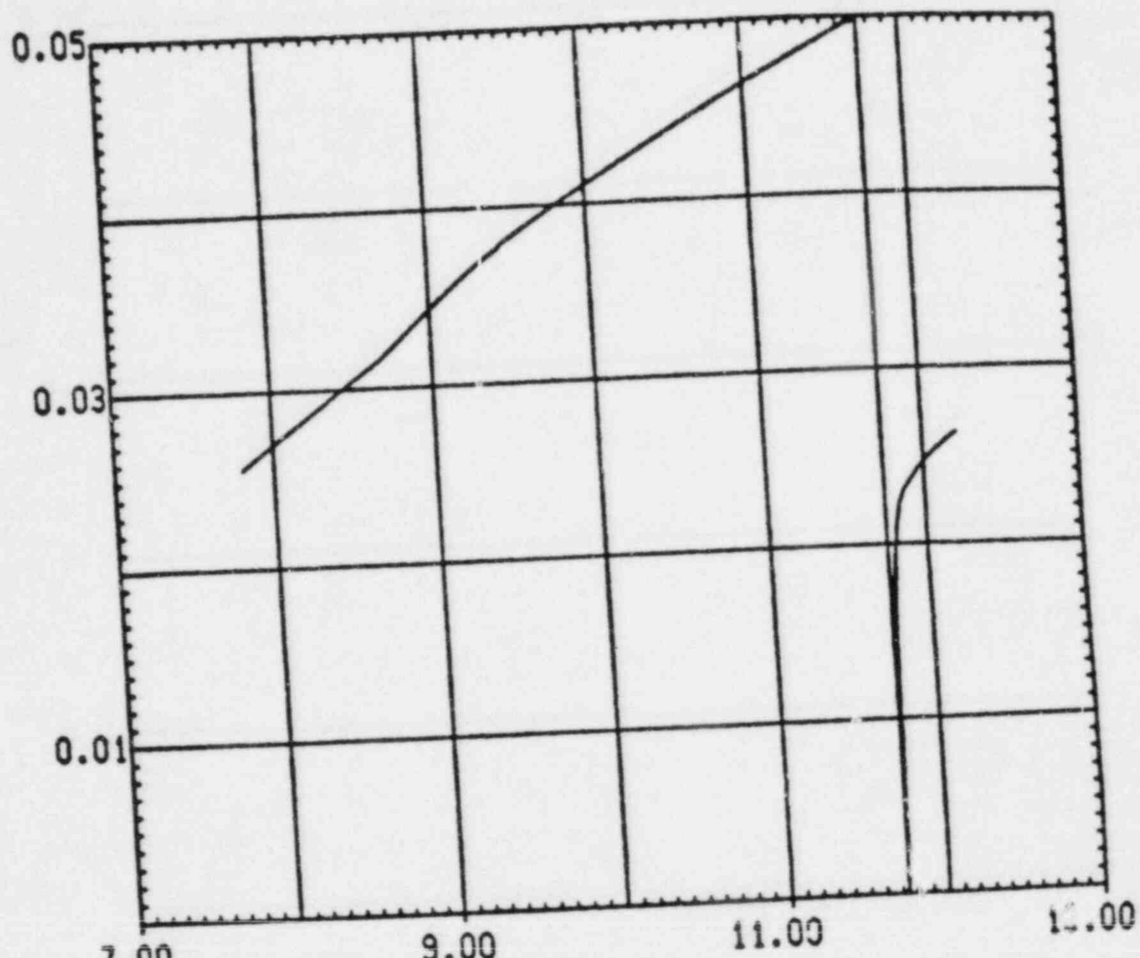
CGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT PRESSURE

Figure 5.5-45



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DIFFERENTIAL PRESSURE

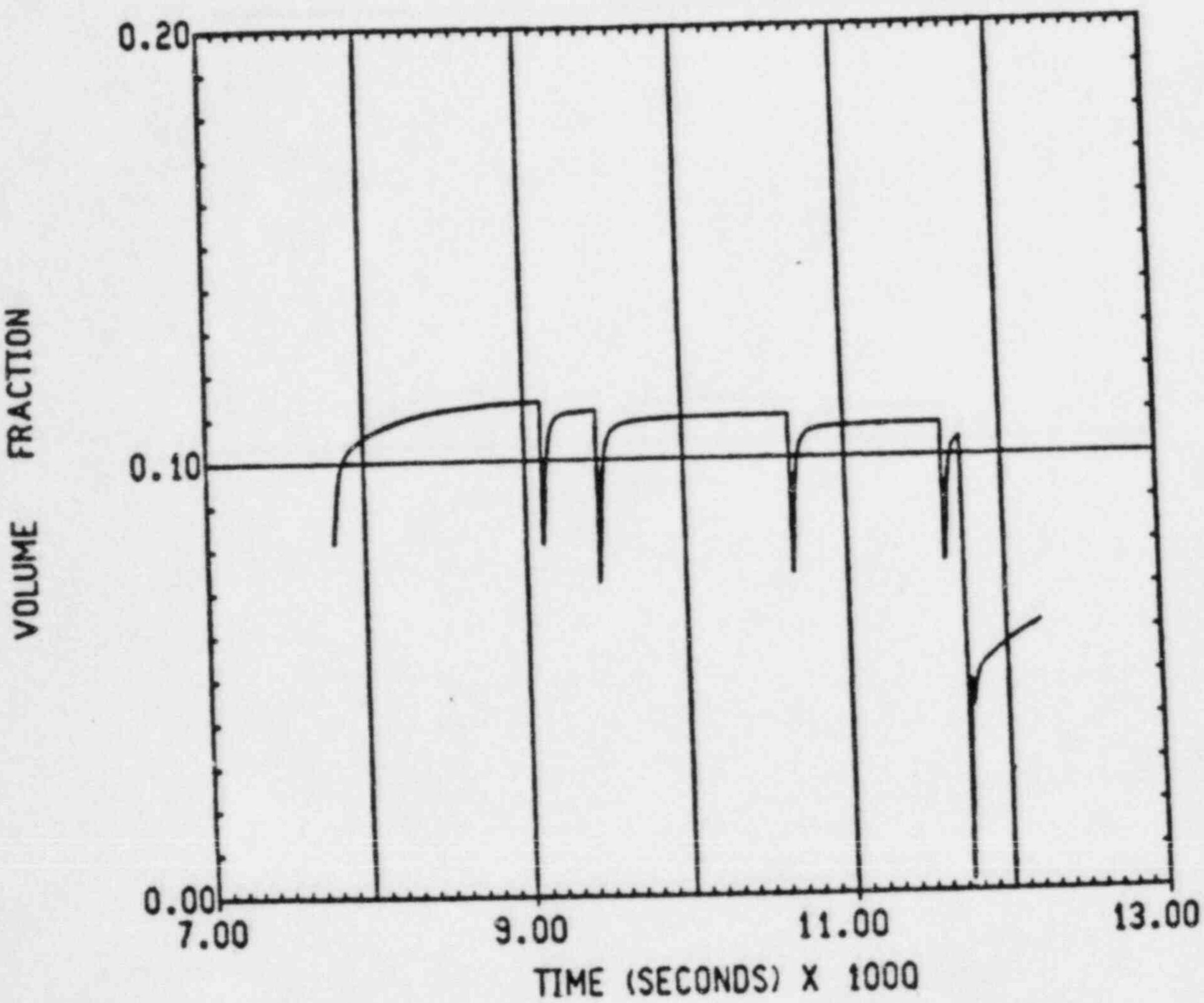
Figure 5.5-46



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL 02 GAS CONCENTRATION

Figure 162

Figure 5.5-47



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL O2 GAS CONCENTRATION

Figure 5.5-48

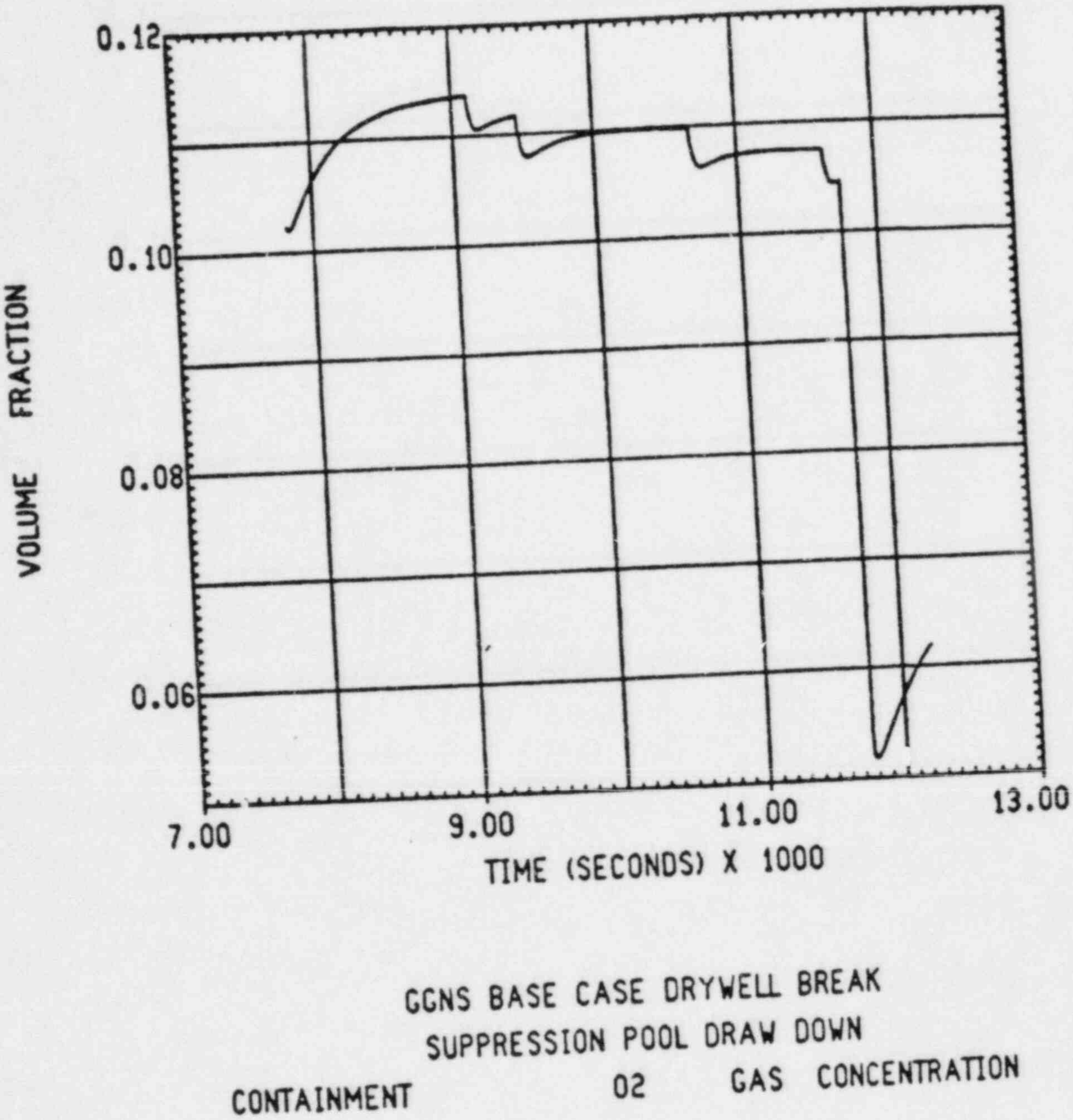
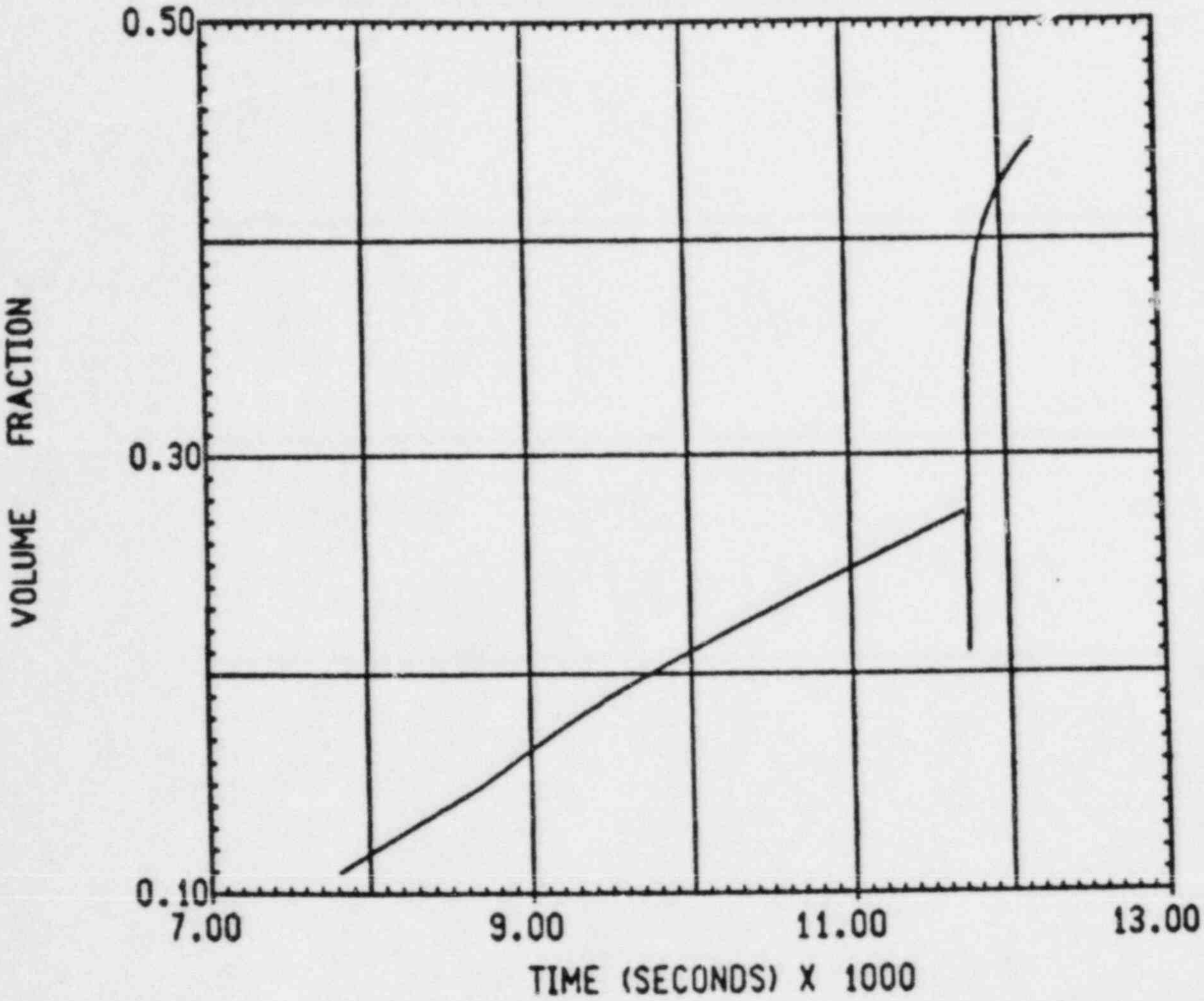

0.12
0.10
0.08
0.06
VOLUME FRACTION
7.00
9.00
11.00
13.00
TIME (SECONDS) X 1000
GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT 02 GAS CONCENTRATION

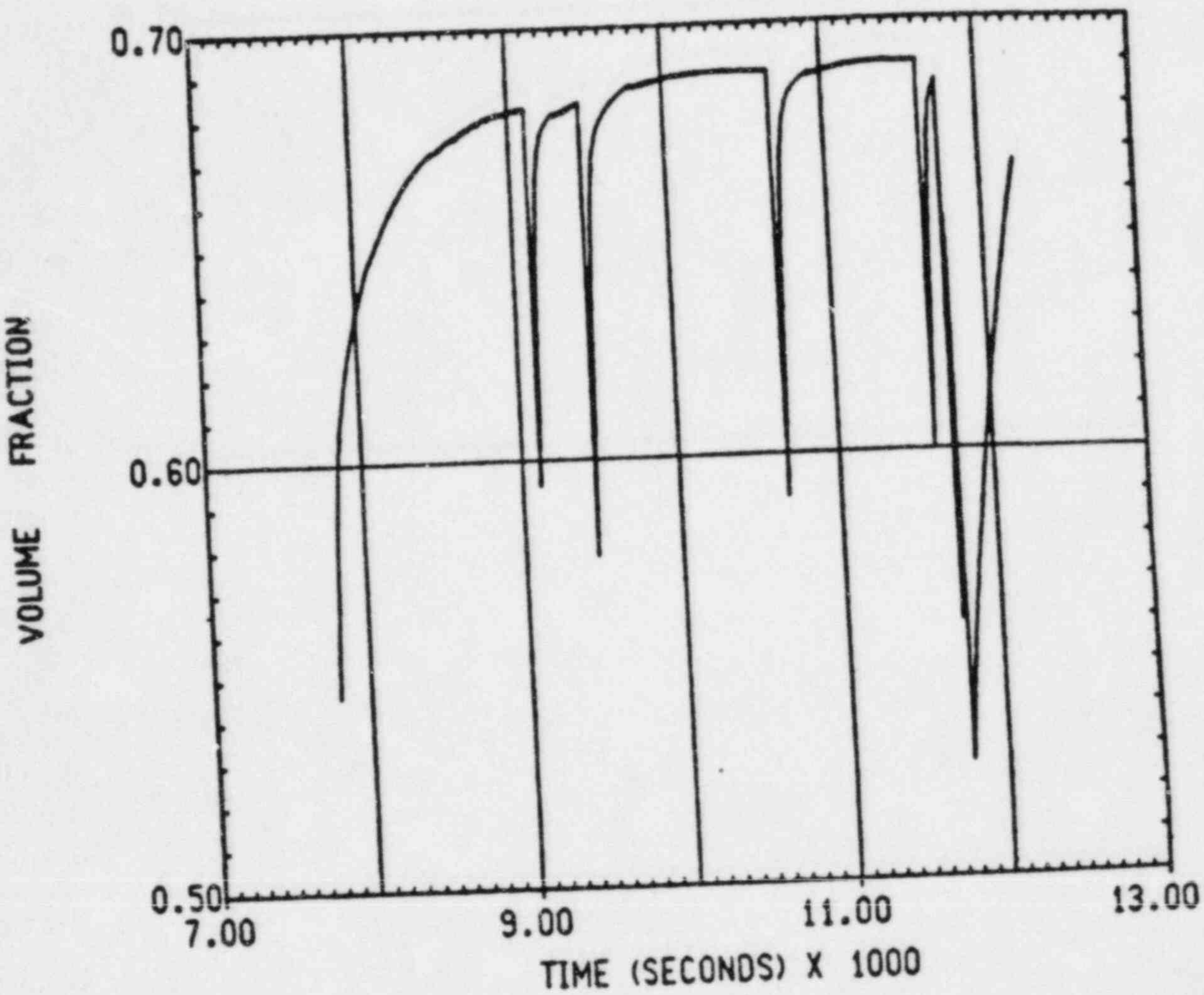
Figure 5.5-49



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL N2 GAS CONCENTRATION

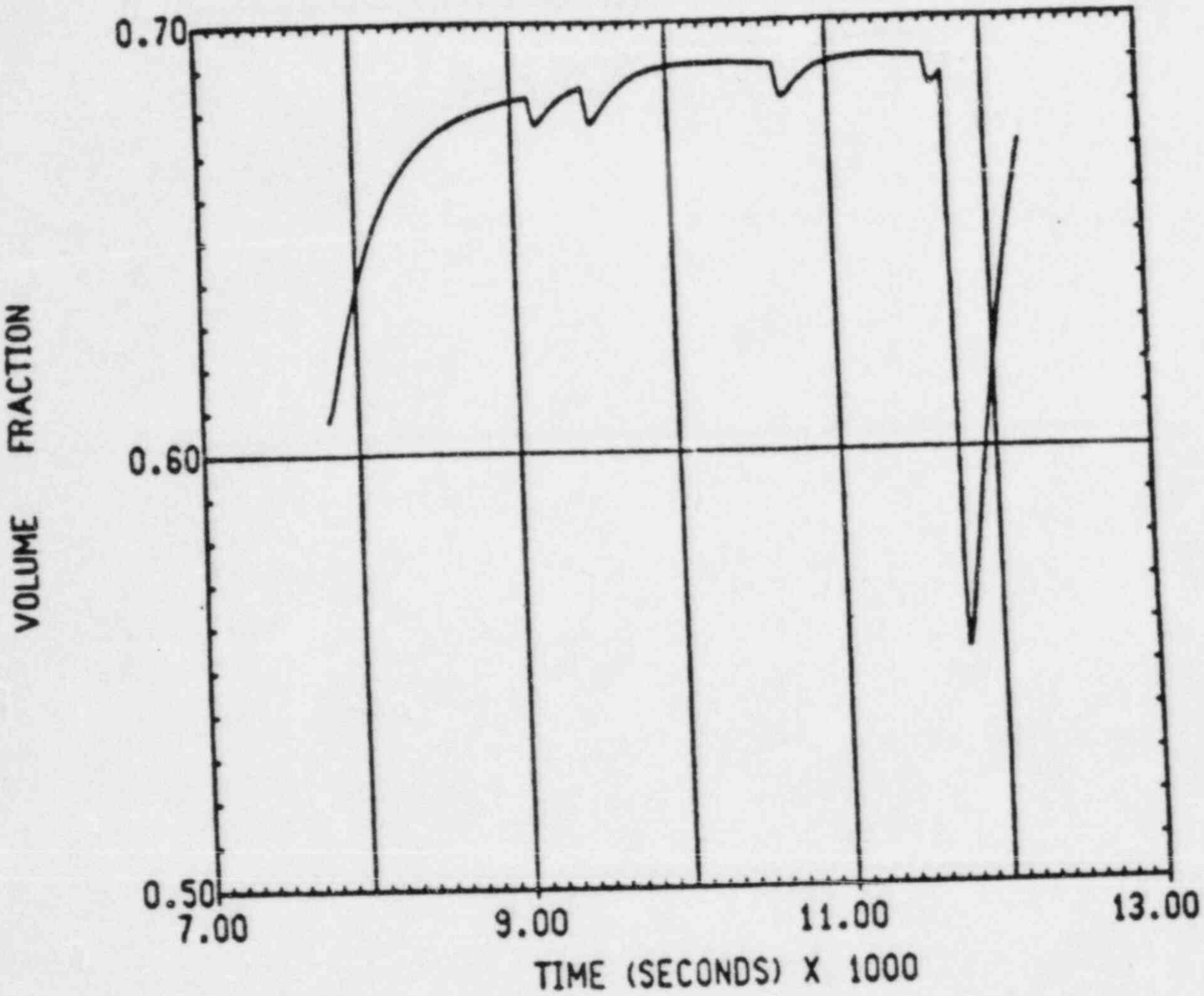
Figure 165

Figure 5.5-50



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL N2 GAS CONCENTRATION

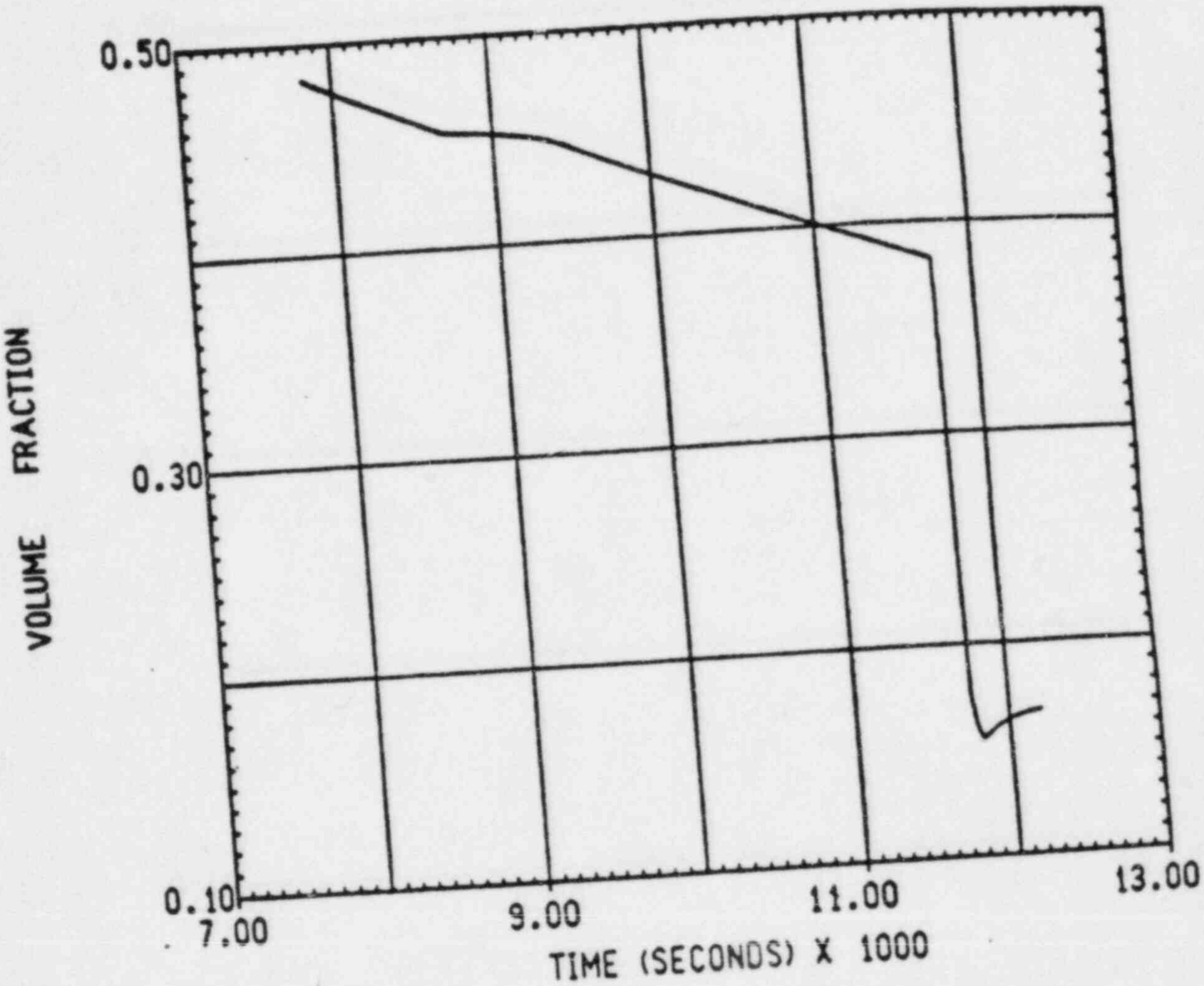
Figure 5.5-51



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT N2 GAS CONCENTRATION

Figure 167

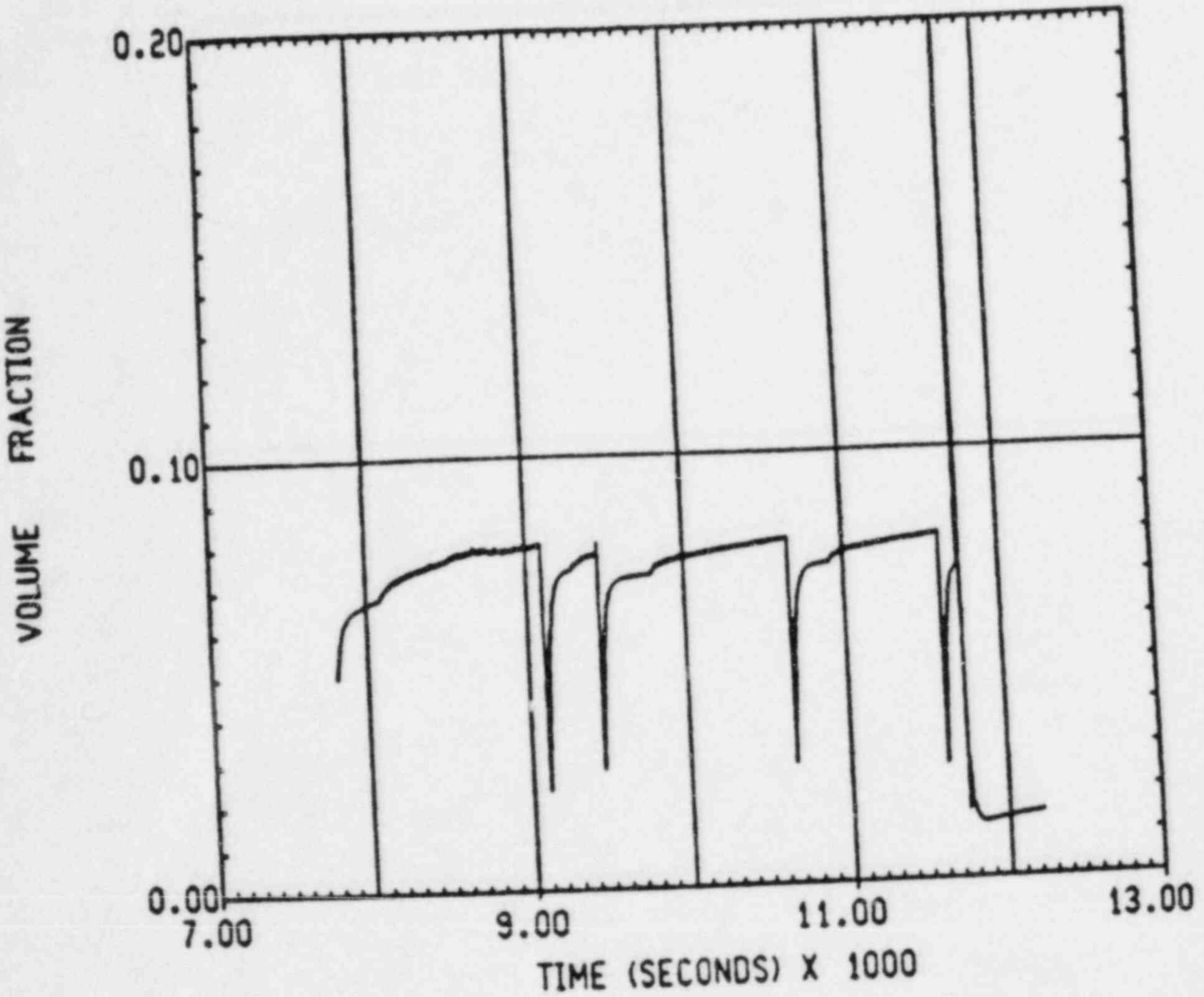
Figure 5.5-52



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL H2 GAS CONCENTRATION

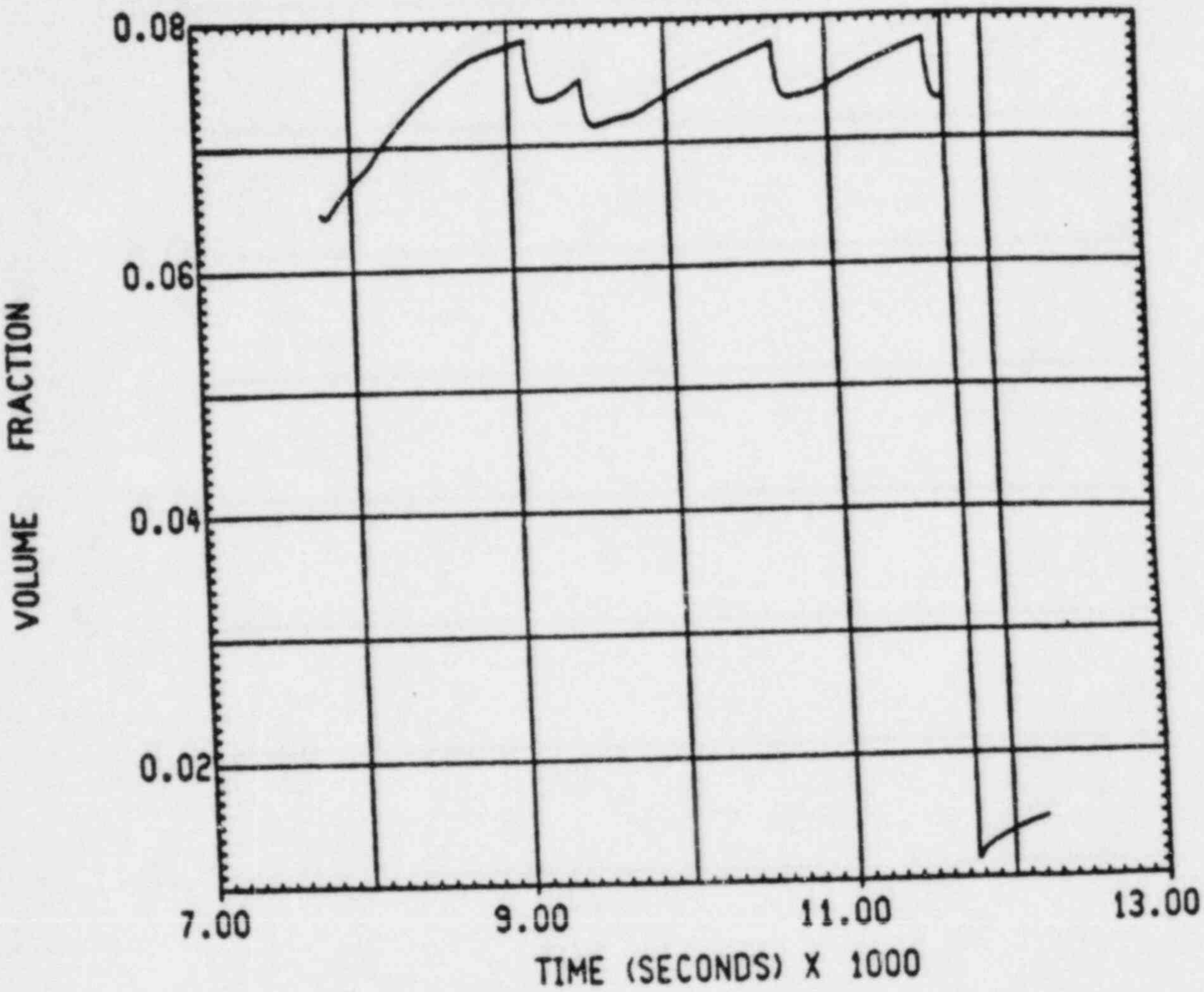
Figure 168

Figure 5.5-53



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL H2 GAS CONCENTRATION

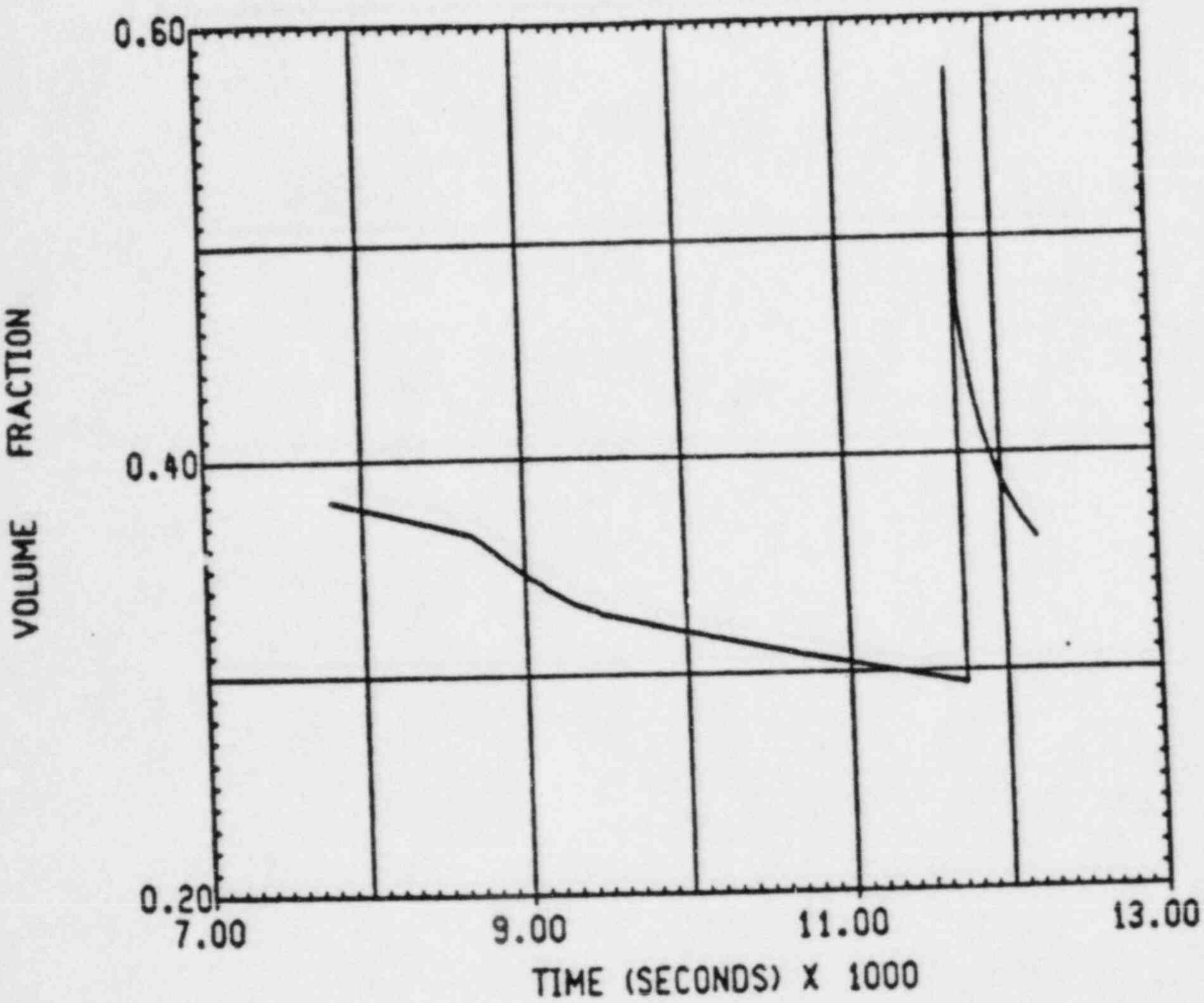
Figure 5.5-54



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT H2 GAS CONCENTRATION

Figure 170

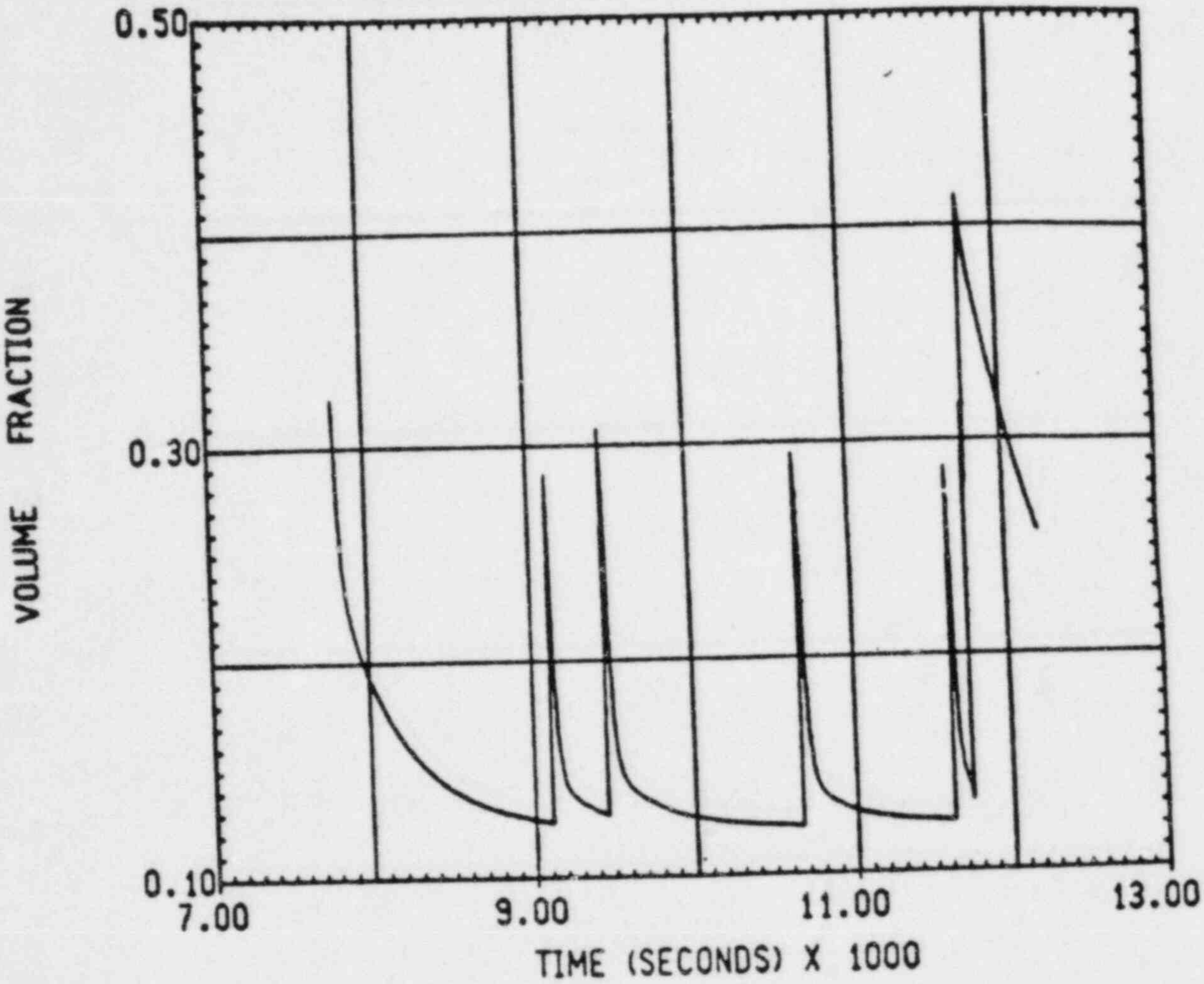
Figure 5.5-55



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
DRYWELL STEAM GAS CONCENTRATION

Figure 171

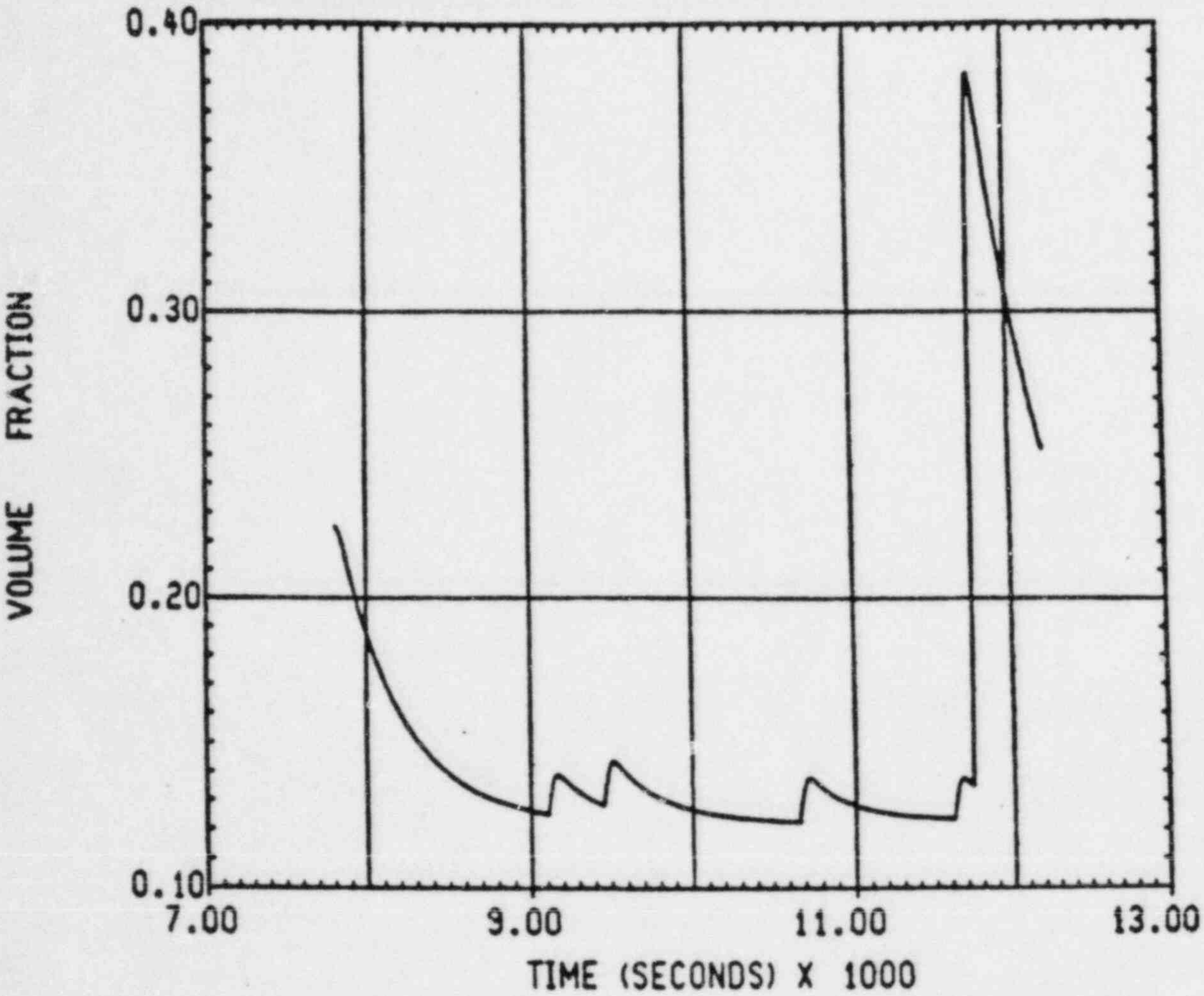
Figure 5.5-56



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
WETWELL STEAM GAS CONCENTRATION

Figure 172

Figure 5.5-57



GGNS BASE CASE DRYWELL BREAK
SUPPRESSION POOL DRAW DOWN
CONTAINMENT STEAM GAS CONCENTRATION

Figure 173

DRYWELL EQUIPMENT SURVIVABILITY LIST

TABLE 5.6-1

EQUIPMENT IDENTIFICATION NUMBER	EQUIPMENT DESCRIPTION	FUNCTION	ELEVATION	AZI-MUTH	Rx CEN-TERLINE DISTANCE	QUALIFICATION TEMP(F)	QUALIFICATION DURATION	MANUF.	MODEL
1B21F0041A	Automatic Depressurization System Valve	RPV Pressure Relief/ADS	636' 5"	51	20'	355	3 hrs	Dikkers	G471-6/125.04
1B21F0041B	" "	" "	636' 5"	277	26'	"	"	"	"
1B21F0041E	" "	" "	636' 5"	31	21'	"	"	"	"
1B21F0041F	" "	" "	636' 5"	289	26'	"	"	"	"
1B21F0047D	" "	" "	636' 5"	308	20	"	"	"	"
1B21F0047H	" "	" "	636' 5"	322	21'	"	"	"	"
1B21F0051C	" "	" "	636' 5"	88	25'	"	"	"	"
1B21F0051G	" "	" "	636' 5"	71	26'	"	"	"	"
1B21F0410A	Automatic Depressurization System Valve Solenoid	" "	Location Same as Valves			Qualification in Progress		Seitz	6A33
1B21F0410B	" "	" "	"	"	"	"	"	"	"
1B21F0411A	" "	" "	"	"	"	"	"	"	"
1B21F0411B	" "	" "	"	"	"	"	"	"	"
1B21F0414A	" "	" "	"	"	"	"	"	"	"
1B21F0414B	" "	" "	"	"	"	"	"	"	"
1B21F0415A	" "	" "	"	"	"	"	"	"	"
1B21F0415B	" "	" "	"	"	"	"	"	"	"
1B21F0422A	" "	" "	"	"	"	"	"	"	"
1B21F0422B	" "	" "	"	"	"	"	"	"	"
1B21F0425A	" "	" "	"	"	"	"	"	"	"
1BS1F0425B	" "	" "	"	"	"	"	"	"	"
1B21F0442A	" "	" "	"	"	"	"	"	"	"
1B21F0442B	" "	" "	"	"	"	"	"	"	"
1B21F0444A	" "	" "	"	"	"	"	"	"	"
1B21F0444B	" "	" "	"	"	"	"	"	"	"
1D23N0100A	Drywell RTD	Drywell Temp. Monitoring	642'	315	17'	485	3 hrs	Weed	611
1D23N0100B	" "	" "	642'	135	16'	"	"	"	"
1D23N0110A	" "	" "	620' 6"	308	36' 6"	"	"	"	"
1D23N0110B	" "	" "	620' 6"	145	36' 6"	"	"	"	"
1D23N0120A	" "	" "	599' 9"	308	36' 6"	"	"	"	"
1D23N0120B	" "	" "	599' 9"	150	36' 6"	"	"	"	"

DRYWELL EQUIPMENT SURVIVABILITY LIST

TABLE 5.6-1 (Cont.)

EQUIPMENT IDENTIFICATION NUMBER	EQUIPMENT DESCRIPTION	FUNCTION	ELEVATION	AZI-MUTH	Rx CEN-TERLINE DISTANCE	QUALIFICATION TEMP(F)	QUALIFICATION DURATION	MANUF.	MODEL
1M56S008	Hydrogen Ignition System	Hydrogen Ignition	629' 1-1/2"	12	36' 6"	345	3 hrs	Power Systems	6043
1M56S009	" "	"	637' 0"	41	36' 6"	"	"	"	"
1M56S010	" "	"	636' 3-1/2"	90	36' 6"	"	"	"	"
1M56S011	" "	"	636' 7"	137	36' 6"	"	"	"	"
1M56S012	" "	"	632' 3"	180	36' 6"	"	"	"	"
1M56S013	" "	"	631' 5"	221	36' 6"	"	"	"	"
1M56S014	" "	"	636' 10"	273	36' 6"	"	"	"	"
1M56S015	" "	"	630' 9-1/2"	322	36' 6"	"	"	"	"
1M56S016	" "	"	660' 0"	0	31' 6"	"	"	"	"
1M56S017	" "	"	659' 8"	57	29' 6"	"	"	"	"
1M56S018	" "	"	659' 8"	114	30' 0"	"	"	"	"
1M56S019	" "	"	659' 8"	172	30' 0"	"	"	"	"
1M56S020	" "	"	659' 8"	225	28' 0"	"	"	"	"
1M56S021	" "	"	660' 0"	280	30' 0"	"	"	"	"
1M56S022	" "	"	660' 0"	317	31' 0"	"	"	"	"
1M56S102	" "	"	670' 0"	350	13' 0"	"	"	"	"
1M56S103	" "	"	670' 0"	4	13' 0"	"	"	"	"
	Control Cable and Small Power Cable		Drywell (Various Locations)			346	"	Rockbestos	Firewall III
	Instrument Cable		"	"		385	"	Brand-Rex	16 & 20 AWG
	Drywell Personnel Airlock Seal		603' 1"	105	36' 6"		In Progress	W. J. Wooley	
	Drywell Equipment Hatch Seal		605'	227	36' 6"		"	"	

CONTAINMENT EQUIPMENT SURVIVABILITY LIST
TABLE 5.6-2

EQUIPMENT IDENTIFICATION NUMBER	EQUIPMENT DESCRIPTION	FUNCTION	ELEVATION	AZI-MUTH	Rx CEN-TERLINE DISTANCE	QUALIFICATION TEMP(F)	QUALIFICATION DURATION	MANUF.	MODEL
1D23N0130A	Containment RTD	Containment Temperature Monitoring	689' 0"	272	60'	485	"	Weed	611
1D23N0130B	"	"	720' 0"	95	60'	"	"	"	"
1D23N0140A	"	"	664' 0"	45	60'	"	"	"	"
1D23N0140B	"	"	664' 0"	210	60'	"	"	"	"
1D23N0150A	"	"	642' 0"	55	60'	"	"	"	"
1D23N0150B	"	"	642' 0"	250	60'	"	"	"	"
1D23N0160A	"	"	599' 9"	67	60'	"	"	"	"
1D23N0160B	"	"	599' 9"	250	60'	"	"	"	"
1E12F0028A	Containment Spray Isolation Valve (MO)	Containment Spray	643' 6"	37	48' 6"	340	"	Limitorque	SMB
1E12F0028B	" "	"	643' 9"	335	42' 9"	"	"	"	"
1E12F0042A	RHR LPCI Inboard Isolation Valve (MO)	Low Pressure Coolant Injection	624' 0"	41	44' 0"	"	"	"	SMB
1E12F0042B	" "	"	620' 0"	315	55' 0"	"	"	"	"
1E12F0537A	Containment Spray Isolation Valve (MO)	Containment Spray	689' 0"	40	58' 0"	"	"	"	"
1E12F0537B	" "	"	689' 0"	320	58' 0"	"	"	"	"
1M16F0010A	Drywell Vacuum Relief System	Drywell Isolation Butterfly Valve	652'	325	36' 6"	250	"	Henry Pratt	NRS
1M16F0010B	" "	" "	652'	222	36' 6"	250	"	"	"
1M16F0020A	" "	Drywell Isolation Check Valve	652'	324	36' 6"	250	"	GPE Controls	LD240-339
1M16F0020B	" "	" "	652'	225	36' 6"	250	"	"	"
1M17F0010	Containment Vacuum Relief System	Containment Vacuum Releif Check Valve	664'	58	60'	250	"	"	LD240-337
1M17F0020	" "	" "	664'	150	60'	250	"	"	"
1M17F0030	" "	" "	664'	302	60'	250	"	"	"
1M17F0040	" "	" "	664'	315	60'	250	"	"	"

CONTAINMENT EQUIPMENT SURVIVABILITY LIST
TABLE 5.6-2 (Cont'd)

EQUIPMENT IDENTIFICATION NUMBER	EQUIPMENT DESCRIPTION	FUNCTION	ELEVATION	AZIMUTH	Rx CENTERLINE DISTANCE	QUALIFICATION TEMP(F)	QUALIFICATION DURATION	MANUF.	MODEL
1M51C0001A	Hydrogen Mixing Compressor and Motor	Hydrogen Mixing	664'	300	24'	192	2 days	Turbonetics Compressor Reliance Motor	SC-6 Type P
1M51C0001B	" "	" "	664'	245	25'	192	"	"	"
1M51D0001A	Hydrogen Recombiner	Removal of Hydrogen by Hydrogen and Oxygen Recombination	664'	304	37'	1700-1750 (Heater Element)	21 days	Westinghouse	Model A
1M51D001B	" "	"	664'	236	37'	"	"	"	"
1M51F0010A	Hydrogen Mixing Compressor Isolation Valve (MO)	Isolation Valve for Drywell Purge Compressor	670'	309	25'	340	3 hrs	Limitorque	SMB-00-5
1M51F0010B	" "	"	670'	245	20'	340	"	"	"
1M51F0501A	Hydrogen Mixing Compressor Check Valve	Check Valve for for Drywell Purge Compressor	664'	305	25'	350	"	TRW Mission	K15ACEFV73
1M51F0501B	" "	"	"	250	21'	350	"	"	"
1M56S001	Hydrogen Igniter System	Hydrogen Ignition	613' 4"	355	49' 0"	345	3 hrs	Power Sys. Division	6043
1M56S002	" "	" "	613' 4"	5	51' 0"	"	"	"	"
1M56S003	" "	" "	619' 6"	63	51' 8"	"	"	"	"
1M56S004	" "	" "	619' 6"	89	52' 0"	"	"	"	"
1M56S005	" "	" "	664' 0"	34	57' 0"	"	"	"	"
1M56S006	" "	" "	689' 0"	34	52' 0"	"	"	"	"
1M56S023	" "	" "	619' 6"	34	52' 0"	"	"	"	"
1M56S024	" "	" "	619' 6"	118	51' 8"	"	"	"	"
1M56S025	" "	" "	619' 6"	152	51' 0"	"	"	"	"
1M56S026	" "	" "	619' 6"	186	52' 0"	"	"	"	"
1M56S027	" "	" "	619' 6"	221	51' 8"	"	"	"	"
1M56S028	" "	" "	619' 6"	255	51' 4"	"	"	"	"
1M56S029	" "	" "	619' 6"	289	52' 0"	"	"	"	"

CONTAINMENT EQUIPMENT SURVIVABILITY LIST
TABLE 5.6-2 (Cont'd)

EQUIPMENT IDENTIFICATION NUMBER	EQUIPMENT DESCRIPTION	FUNCTION	ELEVATION	AZI-MUTH	Rx CEN-TERLINE DISTANCE	QUALIFICATION TEMP(F)	QUALIFICATION DURATION	MANUF.	MODEL
1M56S030	Hydrogen Igniter System	Hydrogen Ignition	619' 6"	322	51' 11"	345	3 hrs	Power Systems Division	6043
1M56S031	" "	" "	638' 0"	358	41' 6"	"	"	"	"
1M56S032	" "	" "	640' 0"	155	46' 0"	"	"	"	"
1M56S033	" "	" "	640' 0"	186	46' 0"	"	"	"	"
1M56S034	" "	" "	640' 0"	324	53' 6"	"	"	"	"
1M56S035	" "	" "	640' 4-3/4"	61	51' 6"	"	"	"	"
1M56S036	" "	" "	640' 5-1/2"	118	51' 6"	"	"	"	"
1M56S037	" "	" "	640' 5"	227	46' 0"	"	"	"	"
1M56S038	" "	" "	639' 4"	260	54' 0"	"	"	"	"
1M56S039	" "	" "	651' 1"	286	41' 6"	"	"	"	"
1M56S040	" "	" "	647' 4"	2	41' 6"	"	"	"	"
1M56S041	" "	" "	650' 6-3/4"	41	50' 6"	"	"	"	"
1M56S042	" "	" "	650' 6"	87	49' 0"	"	"	"	"
1M56S043	" "	" "	651' 0"	101	49' 0"	"	"	"	"
1M56S044	" "	" "	660' 0"	86	44' 6"	"	"	"	"
1M56S045	" "	" "	660' 6"	95	48" 6"	"	"	"	"
1M56S046	" "	" "	664' 0"	54	51' 0"	"	"	"	"
1M56S047	" "	" "	665' 0"	114	52' 0"	"	"	"	"
1M56S048	" "	" "	662' 6"	147	53' 0"	"	"	"	"
1M56S049	" "	" "	662' 7-3/4"	218	51' 0"	"	"	"	"
1M56S050	" "	" "	664' 7"	251	49' 6"	"	"	"	"
1M56S051	" "	" "	661' 6"	289	50' 0"	"	"	"	"
1M56S052	" "	" "	661' 6"	324	49' 6"	"	"	"	"
1M56S053	" "	" "	669' 6"	0	54' 6"	"	"	"	"
1M56S054	" "	" "	684' 9"	355	52' 6"	"	"	"	"
1M56S055	" "	" "	686' 0"	75	48' 0"	"	"	"	"
1M56S056	" "	" "	686' 0"	85	47' 0"	"	"	"	"
1M56S057	" "	" "	686' 0"	95	47' 0"	"	"	"	"
1M56S058	" "	" "	686' 0"	105	48' 0"	"	"	"	"
1M56S059	" "	" "	686' 0"	75	35' 0"	"	"	"	"
1M56S060	" "	" "	686' 0"	105	35' 0"	"	"	"	"
1M56S061	" "	" "	689' 6"	45	48' 0"	"	"	"	"

CONTAINMENT EQUIPMENT SURVIVABILITY LIST
TABLE 5.6-2 (Cont'd)

EQUIPMENT IDENTIFICATION NUMBER	EQUIPMENT DESCRIPTION	FUNCTION	ELEVATION	AZI-MUTH	Rx CEN-TERLINE DISTANCE	QUALIFICATION TEMP(F)	QUALIFICATION DURATION	MANUF.	MODEL
1M56 062	Hydrogen Igniter System	Hydrogen Ignition	689' 6"	130	41' 0"	345	3 hrs	Power Systems Division	6043
1M56S063	" "	" "	689' 6"	229	48' 0"	"	"	"	"
1M56S064	" "	" "	689' 6"	252	43' 6"	"	"	"	"
1M56S065	" "	" "	689' 6"	289	43' 0"	"	"	"	"
1M56S066	" "	" "	689' 6"	310	48' 6"	"	"	"	"
1M56S067	" "	" "	715' 6"	359	58' 9"	"	"	"	"
1M56S068	" "	" "	715' 6"	27	58' 9"	"	"	"	"
1M56S069	" "	" "	715' 6"	62	58' 9"	"	"	"	"
1M56S070	" "	" "	715' 6"	87	58' 9"	"	"	"	"
1M56S071	" "	" "	715' 6"	119	58' 9"	"	"	"	"
1M56S072	" "	" "	715' 6"	151	58' 9"	"	"	"	"
1M56S073	" "	" "	715' 6"	178	58' 9"	"	"	"	"
1M56S074	" "	" "	715' 6"	209	58' 9"	"	"	"	"
1M56S075	" "	" "	715' 6"	241	58' 9"	"	"	"	"
1M56S076	" "	" "	715' 6"	273	58' 9"	"	"	"	"
1M56S077	" "	" "	715' 6"	300	58' 9"	"	"	"	"
1M56S078	" "	" "	715' 6"	331	58' 9"	"	"	"	"
1M56S079	" "	" "	745' 6"	359	48' 0"	"	"	"	"
1M56S080	" "	" "	745' 6"	34	48' 0"	"	"	"	"
1M56S081	" "	" "	745' 6"	72	48' 0"	"	"	"	"
1M56S082	" "	" "	745' 6"	102	48' 0"	"	"	"	"
1M56S083	" "	" "	745' 6"	143	48' 0"	"	"	"	"
1M56S084	" "	" "	745' 6"	180	48' 0"	"	"	"	"
1M56S085	" "	" "	745' 6"	216	48' 0"	"	"	"	"
1M56S086	" "	" "	745' 6"	252	48' 0"	"	"	"	"
1M56S087	" "	" "	745' 6"	287	48' 0"	"	"	"	"
1M56S088	" "	" "	745' 6"	324	48' 0"	"	"	"	"
1M56S089	" "	" "	757' 0"	0	1' 0"	"	"	"	"
1M56S090	" "	" "	757' 0"	180	1' 0"	"	"	"	"
1M56S091	" "	" "	645' 7"	168	60' 0"	"	"	"	"
1M56S092	" "	" "	645' 0"	172	58' 0"	"	"	"	"
1M56S093	" "	" "	613' 4"	7	44' 0"	"	"	"	"

CONTAINMENT EQUIPMENT SURVIVABILITY LIST
TABLE 5.6-2 (Cont'd)

EQUIPMENT IDENTIFICATION NUMBER	EQUIPMENT DESCRIPTION	FUNCTION	ELEVATION	AZI-MUTH	Rx CEN-TERLINE DISTANCE	QUALIFICATION TEMP(F)	QUALIFICATION DURATION	MANUF.	MODEL
1M56-094	Hydrogen Igniter System	Hydrogen Ignition	612' 5"	13	42' 8"	345	3 hrs	Power Systems Division	6043
1M56B095	" "	"	612' 6"	344	42' 6"	"	"	"	"
1M56S096	" "	"	612' 3"	351	43' 6"	"	"	"	"
1M56S097	" "	"	638' 8"	289	49' 6"	"	"	"	"
1M56S098	" "	"	685' 6"	342	53' 0"	"	"	"	"
1M56S099	" "	"	685' 6"	17	50' 6"	"	"	"	"
1M56S100	" "	"	636' 0"	75	25' 0"	"	"	"	"
1M56S101	" "	"	686' 0"	105	25' 0"	"	"	"	"
1R72S0001	Electrical Penetrations	Containment Boundary	659' 0"	221	60'	340	3 hrs	Westinghouse	WX33328
1R72S0002	" "	"	659' 0"	228	"	"	"	"	WX33328
1R72S0003	" "	"	656' 3"	221	"	"	"	"	WX33329
1R72S0004	" "	"	657' 1-1/2'	248	"	"	"	"	WX33329
1R72S0005	" "	"	656' 3"	228	"	"	"	"	WX33330
1R72S0006	" "	"	657' 1-1/2"	242	"	"	"	"	WX33331
1R72S0007	" "	"	651' 6"	221	"	"	"	"	WX33332
1R72S0008	" "	"	649' 9"	221	"	"	"	"	WX33333
1R72S0009	" "	"	651' 6"	248	"	"	"	"	WX33332
1R72S0010	" "	"	649' 9"	248	"	"	"	"	WX33333
1R72S0011	" "	"	657' 1-1/2"	235	"	"	"	"	WX33334
1R72S0012	" "	"	651' 6"	228	"	"	"	"	WX33335
1R72S0013	" "	"	649' 9"	228	"	"	"	"	WX33333
1R72S0014	" "	"	651' 6"	242	"	"	"	"	WX33335
1R72S0015	" "	"	649' 9"	242	"	"	"	"	WX33333
1R72S0016	" "	"	643' 3"	221	"	"	"	"	WX33336
1R72S0017	" "	"	641' 6"	221	"	"	"	"	WX33337
1R72S0018	" "	"	643' 3"	228	"	"	"	"	WX33338
1R72S0019	" "	"	641' 6"	228	"	"	"	"	WX33339
1R72S0020	" "	"	643' 3"	248	"	"	"	"	WX33336
1R72S0021	" "	"	641' 6"	241	"	"	"	"	WX33363
1R72S0022	" "	"	643' 3"	242	"	"	"	"	WX33340
1R72S0023	" "	"	641' 6"	248	"	"	"	"	WX33341

CONTAINMENT EQUIPMENT SURVIVABILITY LIST
TABLE 5.6-2 (Cont'd)

EQUIPMENT IDENTIFICATION NUMBER	EQUIPMENT DESCRIPTION	FUNCTION	ELEVATION	AZI-MUTH	Rx CEN-TERLINE DISTANCE	QUALIFICATION TEMP(F)	QUALIFICATION DURATION	MANUF.	MODEL
1R72S0024	Electrical Penetrations	Containment Boundary	643' 3"	235	60'	340	3 hrs	Westinghouse	WX33342
1R72S0025	" "	"	651' 6"	235	"	"	"	"	WX33337
1R72S0026	" "	"	638' 4"	221	"	"	"	"	WX33343
1R72S0027	" "	"	638' 4"	228	"	"	"	"	WX33344
1R72S0028	" "	"	641' 6"	223	"	"	"	"	WX33345
1R72S0029	" "	"	656' 3"	223	"	"	"	"	W-34147
1R72S0030	" "	"	643' 3"	223	"	"	"		W34488
1R72S0031	" "	"	649' 9"	223	"	"	"	"	W-34489
1R72S0033	" "	"	649' 9"	235	"	"	"	"	W-34490
1R72S0035	" "	"	641' 6"	242	"	"	"	"	W-34491
1R72S0036	" "	"	649' 9"	241	"	"	"	"	W-34492
1R72S0038	" "	"	651' 6"	241	"	"	"	"	W-34493
	Upper Personal Airlock Seals	"	692' 10"	225	60'	Qualification In Progress		J. Wooley	
	Lower Personal Airlock Seals	"	603' 1"	241	"		"	"	
	Equipment Hatch Seals		629' 6"	133	"		"	"	
	Terminal and Fuse Block Assemblies		Containment (Various Locations)			346	3 hrs	Buchanan	NBQ, NQO, NQO-361
	Control Cable and Small Power Cable		"			346	"	Rockbestos	Firewall III
	Instrument Cable		"			385	"	Brand-Rex	16 and 20 AWG
	Pressure/Level/DP Transmitters		"			318	"	Rosemont	1153
	Pressure/Level/DP Transmitter		"			232	"	Rosemont	1152

TABLE 5.6-3
GRAND GULF NUCLEAR STATION

DRYWELL EQUIPMENT REQUIRED TO SURVIVE A HYDROGEN BURN

Equipment Identification	Function	Elevation	Azimuth	Dist. from Center Line of Reactor	Qualification or Design Temperature	Duration
Combustible Gas Control System (CGCS)						
E61-D106	Hydrogen Igniters	146'-3 7/8"	0	22'-10"	330°F	3 Hours
E61-D107	Hydrogen Igniters	145'-7"	63	29'-3"	330°F	3 Hours
E61-D108	Hydrogen Igniters	146'-2"	120	29'-8"	330°F	3 Hours
E61-D109	Hydrogen Igniters	147'-1"	180	26'-3"	330°F	3 Hours
E61-D110	Hydrogen Igniters	148'-7"	240	29'-1 1/2"	330°F	3 Hours
E61-D111	Hydrogen Igniters	145'-7"	313	25'-1 1/4"	330°F	3 Hours
E61-D112	Hydrogen Igniters	160'-7 7/8"	0	27'-3 3/8"	330°F	3 Hours
E61-D113	Hydrogen Igniters	160'-11 3/4"	60	29'-8 3/4"	330°F	3 Hours
E61-D114	Hydrogen Igniters	160'-4"	135	27'-0 3/8"	330°F	3 Hours
E61-D115	Hydrogen Igniters	160'-11 1/2"	180	26'-10"	330°F	3 Hours
E61-D116	Hydrogen Igniters	160'-6"	232	26'-1"	330°F	3 Hours
E61-D117	Hydrogen Igniters	160'-6"	324	26'-4 5/8"	330°F	3 Hours
E61-D118	Hydrogen Igniters	179'-0"	0	26'-4 5/8"	330°F	3 Hours
E61-D119	Hydrogen Igniters	179'-0"	65	26'-3 3/4"	330°F	3 Hours
E61-D120	Hydrogen Igniters	179'-0"	125	26'-3 3/4"	330°F	3 Hours
E61-D121	Hydrogen Igniters	179'-0"	185	26'-3 3/4"	330°F	3 Hours
E61-D122	Hydrogen Igniters	179'-0"	245	26'-3 3/4"	330°F	3 Hours
E61-D123	Hydrogen Igniters	179'-0"	305	26'-3 3/4"	330°F	3 Hours
	Transformers for Igniters	Respective Locations			400°F(1)	--
Nuclear Boiler System (NBS)						
B21-F047A	ADS (A.O.)	154'-0"	34	22'-0"	349°F	4 Days
B21-F041D	ADS (A.O.)	154'-0"	315	21'-0"	349°F	4 Days
B21-F047L	ADS (A.O.)	154'-0"	53	27'-6"	349°F	4 Days
B21-F041F	ADS (A.O.)	154'-0"	288	26'-6"	349°F	4 Days
B21-F041K	ADS (A.O.)	154'-0"	304	27'-0"	349°F	4 Days
B21-F051A	ADS (A.O.)	154'-0"	45	22'-0"	349°F	4 Days
B21-F051B	ADS (A.O.)	154'-0"	272	25'-6"	349°F	4 Days
B21-F051C	ADS (A.O.)	154'-0"	77	26'-0"	349°F	4 Days

DRYWELL EQUIPMENT REQUIRED TO SURVIVE A HYDROGEN BURN

Equipment Identification	Function	Elevation	Azimuth	Dist. from Center Line of Reactor	Qualification or Design Temperature	Duration
Residual Heat Removal System						
E12-F009	Isolation Valve (M.O).	124'-7"	0	25'-0"	340°F	--
	Motor Operator	Same as Valve			340°F	--
	Position Indication Switches	Same as Valve			340°F	--
Area Radiation Monitoring System						
D21-RE-N048A	Radiation Monitors	161'-10"	0	36'-0"	340°F	6 Hours
D21-RE-N048D		161'-10"	183	36'-0"	340°F	6 Hours
Containment and Drywell Instrumentation and Control System						
M71-TE-N008A	Temperature Monitors	161'-10"	40	36'-0"	340°F	6 Hours
M71-TE-N008B		161'-0"	250	36'-0"	340°F	6 Hours
M71-TE-N008C		161'-0"	135	36'-0"	340°F	6 Hours
M71-TE-N008D		161'-0"	310	36'-0"	340°F	6 Hours
M71-TE-N013A		94'-6"	55	10'-7"	340°F	6 Hours
M71-TE-N013B		94'-6"	225	10'-7"	340°F	6 Hours
M71-TE-N013C		94'-0"	112	10'-3"	340°F	6 Hours
M71-TE-N013D		94'-6"	280	10'-7"	340°F	6 Hours
Containment Hatches and Lock						
M23-Y005N	Drywell Personnel Lock	124'-8"	60	36'-6"	330°F	--
M23-Y009	Drywell Equipment Hatch	117'-4"	220	36'-6"	330°F	--

TABLE 5.6-3 (Continued)
GRAND GULF NUCLEAR STATION

DRYWELL EQUIPMENT REQUIRED TO SURVIVE A HYDROGEN BURN

Equipment Identification	Function	Elevation	Azimuth	Dist. from Center Line of Reactor	Qualification or Design Temperature	Duration
Various Systems	Power Cable	(2)	(2)	(2)	346°F	3 Hours, 20 Minutes
	Control Cable	(2)	(2)	(2)	346°F	3 Hours, 20 Minutes
	Instrument Cable	(2)	(2)	(2)	340°F	6 Hours
	Thermocouple Ext. Wire	(2)	(2)	(2)	340°F	5½ Hours
	Terminal Boxes and Blocks	(2)	(2)	(2)	340°F	5½ Hours

NOTES:
A.O. = Air Operated
M.O. = Motor Operated

(1) Underwriters Laboratory approved maximum temperature for continuous operation at rate electrical load.
(2) Specific routing will be evaluated on a case by case basis.

TABLE 5.6-4
GRAND GULF NUCLEAR STATION

CONTAINMENT EQUIPMENT (OUTSIDE DRYWELL)
REQUIRED TO SURVIVE A HYDROGEN BURN

Equipment Identification	Function	Elevation	Azimuth	Dist. from Center Line of Reactor	Qualification or Design Temperature	Duration
Residual Heat Removal System (RHR)						
E12-F042A(1)	LPCI-A Injection Valve (M.O.)	144'-3"	39	46'-0"	200°F	200 Hours
E12-F028A(1)	Containment Spray Valve (M.O.)	170'-9"	30	59'-0"	200°F	200 Hours
E12-F042B(1)	LPCI-B Injection Valve (M.O.)	137'-10"	325	59'-0"	200°F	200 Hours
E12-F028B(1)	Containment Spray Valve (M.O.)	170'-9"	330	59'-0"	200°F	200 Hours
Combustible Gas Control System (CGGS)						
E61-C003A	Recombiner	208'-10"	130	57'-0"	316°F	330 Days
E61-C003B	Recombiner	208'-10"	330	57'-0"	316°F	330 Days
E61-C001A	Purge Compressor	184'-6"	135	37'-0"	192°F(3)	22 Hours
E61-C001B	Purge Compressor	184'-6"	300	33'-0"	192°F(3)	22 Hours
E61-F004A	Swing Check Valve Vacuum Relief	194'-0"	220	33'-0"	350°F	
E61-F004B	Swing Check Valve Vacuum Relief	194'-0"	220	33'-0"	350°F	
E61-F005A	Butterfly Valve (M.O.)	194'-0"	240	33'-0"	200°F	200 Hours
E61-F005B	Butterfly Valve (M.O.)	194'-0"	240	33'-0"	200°F	200 Hours
E61-F001A	Check Valve Vacuum Breaker	195'-1"	135	37'-0"	200°F	200 Hours
E61-F001B	Check Valve Vacuum Breaker	199'-6"	300	33'-0"	200°F	200 Hours
E61-F002A	Check Valve	195'-1"	135	37'-0"	200°F	200 Hours
E61-F002B	Check Valve	198'-7"	298	30'-0"	200°F	200 Hours
E61-F003A	Butterfly Valve (M.O.)	195'-1"	135	33'-0"	200°F	200 Hours
E61-F003B	Butterfly Valve (M.O.)	198'-3"	298	28'-0"	200°F	200 Hours
E61-D124	Hydrogen Igniter	136'-0"	20	51'-9"	330°F	3 Hours
E61-D125	Hydrogen Igniter	132'-11"	47	53'-0"	330°F	3 Hours
E61-D126	Hydrogen Igniter	134'-4"	75	51'-9"	330°F	3 Hours
E61-D127	Hydrogen Igniter	134'-4"	107	51'-9"	330°F	3 Hours
E61-D128	Hydrogen Igniter	132'-10"	135	51'-9"	330°F	3 Hours

TABLE 5.6-4 (Continued)
GRAND GULF NUCLEAR STATION

CONTAINMENT EQUIPMENT (OUTSIDE DRYWELL)
REQUIRED TO SURVIVE A HYDROGEN BURN

Equipment Identification	Function	Elevation	Azimuth	Dist. from Center Line of Reactor	Qualification or Design Temperature	Duration
Combustible Gas Control System (CGGS) (Cont'd)						
E61-D129	Hydrogen Igniter	132'-10"	165	51'-9"	330°F	3 Hours
E61-D130	Hydrogen Igniter	132'-10"	195	51'-9"	330°F	3 Hours
E61-D131	Hydrogen Igniter	145'-7"	220	60'-0"	330°F	3 Hours
E61-D132	Hydrogen Igniter	134'-4"	253	51'-9"	330°F	3 Hours
E61-D133	Hydrogen Igniter	134'-4"	285	51'-9"	330°F	3 Hours
E61-D134	Hydrogen Igniter	134'-2"	317	52'-8"	330°F	3 Hours
E61-D135	Hydrogen Igniter	136'-0"	349	51'-9"	330°F	3 Hours
E61-D136	Hydrogen Igniter	166'-0"	16	51'-9"	330°F	3 Hours
E61-D137	Hydrogen Igniter	160'-4"	36	53'-6"	330°F	3 Hours
E61-D138	Hydrogen Igniter	157'-10"	70	51'-9"	330°F	3 Hours
E61-D139	Hydrogen Igniter	157'-10"	100	51'-9"	330°F	3 Hours
E61-D140	Hydrogen Igniter	160'-4"	135	51'-2"	330°F	3 Hours
E61-D141	Hydrogen Igniter	155'-10"	164	51'-9"	330°F	3 Hours
E61-D142	Hydrogen Igniter	155'-10"	196	51'-9"	330°F	3 Hours
E61-D143	Hydrogen Igniter	165'-0"	226	61'-4"	330°F	3 Hours
E61-D144	Hydrogen Igniter	160'-4"	260	54'-2"	330°F	3 Hours
E61-D145	Hydrogen Igniter	159'-4"	285	51'-5"	330°F	3 Hours
E61-D146	Hydrogen Igniter	159'-4"	321	51'-5"	330°F	3 Hours
E61-D147	Hydrogen Igniter	166'-0"	344	51'-9"	330°F	3 Hours
E61-D148	Hydrogen Igniter	182'-10"	30	61'-0"	330°F	3 Hours
E61-D149	Hydrogen Igniter	167'-8"	41	37'-0"	330°F	3 Hours
E61-D150	Hydrogen Igniter	168'-10"	70	46'-2"	330°F	3 Hours
E61-D151	Hydrogen Igniter	168'-10"	109	51'-6"	330°F	3 Hours
E61-D152	Hydrogen Igniter	178'-10"	70	46'-2"	330°F	3 Hours
E61-D153	Hydrogen Igniter	178'-10"	109	51'-6"	330°F	3 Hours
E61-D154	Hydrogen Igniter	182'-4"	136	51'-9"	330°F	3 Hours
E61-D155	Hydrogen Igniter	182'-4"	254	55'-9"	330°F	3 Hours
E61-D156	Hydrogen Igniter	183'-4"	278	47'-8"	330°F	3 Hours
E61-D157	Hydrogen Igniter	182'-4"	293	58'-11"	330°F	3 Hours
E61-D158	Hydrogen Igniter	183'-4"	320	53'-2"	330°F	3 Hours
E61-D159	Hydrogen Igniter	202'-0"	21	50'-4"	330°F	3 Hours

TABLE 5.6-4 (Continued)
GRAND GULF NUCLEAR STATION

CONTAINMENT EQUIPMENT (OUTSIDE DRYWELL)
REQUIRED TO SURVIVE A HYDROGEN BURN

Equipment Identification	Function	Elevation	Azimuth	Dist. from Center Line of Reactor	Qualification or Design Temperature	Duration
Combustible Gas Control System (CGGS) (Cont'd)						
E61-D160	Hydrogen Igniter	202'-0"	32	42'-0"	330°F	3 Hours
E61-D161	Hydrogen Igniter	207'-9"	59	44'-2"	330°F	3 Hours
E61-D162	Hydrogen Igniter	202'-0"	74	55'-8"	330°F	3 Hours
E61-D163	Hydrogen Igniter	202'-0"	88	48'-0"	330°F	3 Hours
E61-D164	Hydrogen Igniter	202'-0"	92	48'-0"	330°F	3 Hours
E61-D165	Hydrogen Igniter	202'-0"	106	55'-8"	330°F	3 Hours
E61-D166	Hydrogen Igniter	202'-0"	0	45'-0"	330°F	3 Hours
E61-D167	Hydrogen Igniter	202'-0"	0	37'-0"	330°F	3 Hours
E61-D168	Hydrogen Igniter	202'-0"	0	34'-0"	330°F	3 Hours
E61-D169	Hydrogen Igniter	202'-0"	0	11'-0"	330°F	3 Hours
E61-D170	Hydrogen Igniter	207'-8"	135	49'-10"	330°F	3 Hours
E61-D171	Hydrogen Igniter	208'-5"	210	49'-6"	330°F	3 Hours
E61-D172	Hydrogen Igniter	204'-11"	242	26'-8"	330°F	3 Hours
E61-D173	Hydrogen Igniter	204'-0"	256	53'-9"	330°F	3 Hours
E61-D174	Hydrogen Igniter	204'-11"	284	53'-9"	330°F	3 Hours
E61-D175	Hydrogen Igniter	204'-11"	298	26'-8"	330°F	3 Hours
E61-D176	Hydrogen Igniter	207'-9"	310	56'-6"	330°F	3 Hours
E61-D177	Hydrogen Igniter	202'-0"	341	55'-1"	330°F	3 Hours
E61-D178	Hydrogen Igniter	262'-0"	5	55'-5"	330°F	3 Hours
E61-D179	Hydrogen Igniter	262'-0"	48	55'-5"	330°F	3 Hours
E61-D180	Hydrogen Igniter	262'-0"	91	55'-5"	330°F	3 Hours
E61-D181	Hydrogen Igniter	262'-0"	140	55'-5"	330°F	3 Hours
E61-D182	Hydrogen Igniter	262'-0"	183	55'-5"	330°F	3 Hours
E61-D183	Hydrogen Igniter	262'-0"	225	55'-5"	330°F	3 Hours
E61-D184	Hydrogen Igniter	262'-0"	268	55'-5"	330°F	3 Hours
E61-D185	Hydrogen Igniter	262'-0"	323	55'-5"	330°F	3 Hours
E61-D186	Hydrogen Igniter	283'-10"	349	39'-9"	330°F	3 Hours
E61-D187	Hydrogen Igniter	283'-10"	34	39'-9"	330°F	3 Hours
E61-D188	Hydrogen Igniter	283'-10"	81	39'-9"	330°F	3 Hours
E61-D189	Hydrogen Igniter	283'-10"	128	39'-9"	330°F	3 Hours
E61-D190	Hydrogen Igniter	283'-10"	152	39'-9"	330°F	3 Hours

TABLE 5.6-4 (Continued)
GRAND GULF NUCLEAR STATION

CONTAINMENT EQUIPMENT (OUTSIDE DRYWELL)
REQUIRED TO SURVIVE A HYDROGEN BURN

Equipment Identification	Function	Elevation	Azimuth	Dist. from Center Line of Reactor	Qualification or Design Temperature	Duration
Combustible Gas Control System (CGGS) (Cont'd)						
E61-D191	Hydrogen Igniter	283'-10"	199	39'-9"	330°F	3 Hours
E61-D192	Hydrogen Igniter	283'-10"	242	39'-9"	330°F	3 Hours
E61-D193	Hydrogen Igniter	283'-10"	286	39'-9"	330°F	3 Hours
E61-D194	Hydrogen Igniter	295'-0"	349	15'-3"	330°F	3 Hours
E61-D195	Hydrogen Igniter	295'-0"	159	15'-3"	330°F	3 Hours
	Transformers for Igniters	Respective Locations			400°F(1)	
Containment and Drywell Instrumentation and Control System						
M71-TE-N007A	Temperature Monitor	135'-4"	40	57'-0"	340°F	6 Hours
M71-TE-N007B	Temperature Monitor	135'-4"	205	57'-0"	340°F	6 Hours
M71-TE-N007C	Temperature Monitor	135'-4"	130	57'-0"	340°F	6 Hours
M71-TE-N007D	Temperature Monitor	135'-4"	307	59'-0"	340°F	6 Hours
M71-TE-N009A	Temperature Monitor	133'-0"	45	57'-0"	340°F	6 Hours
M71-TE-N009B	Temperature Monitor	133'-0"	214	57'-0"	340°F	6 Hours
M71-TE-N009C	Temperature Monitor	133'-0"	125	57'-0"	340°F	6 Hours
M71-TE-N009D	Temperature Monitor	133'-0"	305	57'-0"	340°F	6 Hours
Area Radiation Monitoring System						
D21-RE-N048B	Area Radiation Monitoring	208'-10"	275	62'-0"	340°F	6 Hours
D21-RE-N048C	Area Radiation Monitoring	208'-10"	95	62'-0"	340°F	6 Hours
Containment Hatches and Locks						
M23-Y002N	Containment Personnel Lock	212'-8"	140	62'-0"		
M23-Y001N	Containment Personnel Lock	124'-8"	130	62'-0"		
M23-Y003	Equipment Hatch	172'-3"	240	62'-0"		

TABLE 5.6-4 (Continued)
GRAND GULF NUCLEAR STATION

**CONTAINMENT EQUIPMENT (OUTSIDE DRYWELL)
REQUIRED TO SURVIVE A HYDROGEN BURN**

Equipment Identification	Function	Elevation	Azimuth	Dist. from Center Line of Reactor	Qualification or Design Temperature	Duration
Various Systems						
	Level Transmitter	(2)	(2)	(2)	350°F	10 Min.
	Temp. Transmitter	(2)	(2)	(2)		
	Press. Transmitter	(2)	(2)	(2)	318°F	26 Min.
	Control Cables				346°F	3 Hours, 20 Min.
	Instrument Cables				340°F	6 Hours
	Power Cables				346°F	3 Hours, 20 Min.
	Thermocouple Ext. Wire				340°F	5½ Hours
	Terminal Blocks				340°F	5½ Hours

NOTES:

A.O. = Air Operated
M.O. = Motor Operated

(1) Underwriters Laboratory approved maximum temperature for continuous operation at rate electrical load.
(2) In various locations above the HCU floor.
(3) After 22 hours in a 192°F ambient, the steady state temperatures of various components are substantially below the maximum recommended temperatures. It is concluded that a 200°F ambient is still acceptable.

Appendix A

CONTAINMENT PRESSURE AND TEMPERATURE RESPONSE TO HYDROGEN COMBUSTION FOR CLEVELAND ELECTRIC ILLUMINATING CO. PERRY NUCLEAR POWER PLANT

OPS 38A92

WESTINGHOUSE

Offshore Power Systems

CONTAINMENT PRESSURE AND TEMPERATURE RESPONSE TO HYDROGEN COMBUSTION FOR CLEVELAND ELECTRIC ILLUMINATING PERRY NUCLEAR POWER PLANT

OPS-38A92

OCTOBER 7, 1982

Offshore Power Systems

COVER SHEET

ORDER NO.	DOCUMENT NUMBER	REVISION	DATED	LEVEL & CONTROL
A487	OPS-38A92	A	10/7/82	C

TITLE

CONTAINMENT PRESSURE AND TEMPERATURE RESPONSE TO HYDROGEN COMBUSTION FOR CLEVELAND ELECTRIC ILLUMINATING PERRY NUCLEAR PLANT

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NUCLEAR SAFETY RELATED

YES ☒ NO ☐

APPROVAL

SIGNATURE/DATE

PROJECT COORDINATOR		AUTHOR		MANAGER	
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FORM 796

Page ___ of ___

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont'd)

INTRODUCTION

At the request of Cleveland Electric Illuminating, two analyses were performed for the Perry Nuclear Power Plant to investigate containment pressure and temperature responses to degraded core events with hydrogen releases and deflagration. The two analyses differed in that one was a stuck open relief valve loss of coolant accident (LOCA) and the second one was a drywell break LOCA. Details of these two cases are given later in this report. The CLASIX-3 program utilized for these analyses is the same as that used for Mississippi Power and Light in support of their licensing activities for the Grand Gulf Nuclear Station.

MODEL

A diagram of the Mark III Containment and a schematic diagram of the Perry CLASIX-3 model used in this analysis are given in Figures 1 and 2, respectively. There are three compartments in this model: the drywell, wetwell and containment. Also included is the suppression pool, containment spray system, upper pool, and drywell purge system. The arrows in Figure 2 represent flow paths between compartments with the arrowhead pointing in the direction of allowed flow.

CASE DESCRIPTION

Two CLASIX-3 runs were made for the Perry Nuclear Plant. The input for these two cases were identical except for drawdown and the location of the steam, hydrogen and fission product energy releases. In the stuck open relief valve (SORV) LOCA case, the releases entered directly into the wetwell side of the suppression pool over the entire transient. In the drywell break (DWB) LOCA case the releases initially entered only the drywell. At twenty minutes after initiation of the transient the steam, hydrogen and fission product energy releases were split, with half of the releases entering the wetwell side of the suppression pool via the relief valves and the other half entering the drywell. Although more than half of the releases are expected to discharge to the suppression pool through the depressurization system, this 50/50 split was used as an estimate. Also at twenty minutes into the transient, the two Combustible Gas Control System (CGCS) compressors were manually activated and began pumping gasses from the containment to the drywell. After thirty minutes of transient, the upper pool began dumping water to the suppression pool through one line and continued dumping for 8.67 minutes. The drawdown of the suppression pool (reinstatement of injection systems) was initiated at 6500 seconds into the transient. Releases in both cases were continued until hydrogen equivalent to a 75% fuel clad metal-water reaction was released from the primary system. At this time, the SORV transient was terminated but the DWB transient was continued in order to allow for a drywell burn.

INPUT INFORMATION

Unless otherwise stated, Gilbert Commonwealth supplied all of the input information which is presented in this section. The input parameters are specific to the Perry Plant but in many cases are similar to those used in the CLASIX-3 analyses of the Grand Gulf Nuclear Station.

Steam, hydrogen and fission product energy releases were taken from a MARCH computer code run provided by Battelle-Memorial Institute of Columbus. The MARCH results were modified as discussed in Reference 1, Section III. These data were the same as that used in a similar analysis performed for the Mississippi Power and Light Grand Gulf Nuclear Station and are shown in Tables 1, 2, and 3.

Burn parameters are given in Table 4. These control when, where and how much burning occurs. Burns can be ignited in any of the three compartments and are allowed to propagate from adjoining compartments through connecting flow paths. These burn parameters are the hydrogen volume fraction required for ignition, the hydrogen volume fraction required for propagation of a burn, the fraction of hydrogen burned, the minimum oxygen volume fraction required for ignition, the minimum oxygen volume fraction required to support combustion, the burn time and the propagation delay time (which is flow path dependent). The burn parameters for this analysis were suggested by Offshore Power Systems, agreed to by Gilbert Commonwealth and are typical of previous analyses.

Parameters for the compartment initial conditions are given in Table 5. These include the net free gas volumes, the temperatures, and the oxygen, nitrogen and steam partial pressures. Partial pressures were calculated from compartment temperatures, pressures and relative humidities assuming the containment atmosphere consisted of a mixture of standard air and steam.

There are two flow paths included in this model: wetwell to containment (WW-CT) and containment to drywell (CT-DW). The maximum flow area, flow loss coefficient, and burn propogation delay time for the WW-CONT flow path are given in Table 6. The CT-DW flow path consists of the drywell purge system. The drywell purge system parameters are given in Table 7. These include the suction compartment, sink compartment and initiation time. Compressor head/flow curves are given to allow for a variable flow rate depending on the pressure differential between the containment and drywell. The containment vacuum relief valves are not modeled in the Perry analyses. Prior analyses show that the containment pressure never goes below atmospheric pressure, therefore the containment vacuum relief valves would not operate if they were modeled.

Table 8 gives the suppression pool parameters, including the initial pool water density, mass, temperature and heat capacity. Geometry related pool parameters are the number of vents, the flow area and length of each vent, the submergence depth to the bottom of the vent, turning loss coefficients, gas loss coefficients and additional vent lengths to account for fluid acceleration. The pool surface areas in the drywell and wetwell are also included. The weir height above the water level and the drywell holdup volume and surface area are necessary input parameters for the analysis of reverse flow through the suppression pool. During reverse flow, water from the suppression pool can overflow the weir wall and remain in the drywell.

The spray system provides spray to the containment with part of the spray continuing through the wetwell. Some of this wetwell spray is in droplet form while another fraction falls from ledges as a sheet of water.

The remaining fraction of the containment spray cannot enter the wetwell because it collects in the upper pool and is drained directly into the suppression pool. A ratio of areas is used to calculate the rates of flow for the drain, droplet and sheet. The spray flow entering the wetwell as a sheet will be less effective than the droplet flow but can be expected to have some cooling capability. It was assumed for this analysis that the sheet flow is half as effective as the droplet flow. Table 9 gives the input parameters for the spray system. The drop diameter, spray temperature, and spray flow rate for the containment spray are specified. The drop size and flow rate exiting the containment were used as the spray conditions for the wetwell. Only the fall time and film coefficient are specified for the wetwell spray. The fall times were based on a terminal velocity of 4.2 feet per second and the average spray fall height. Initiation of the spray occurs after the first burn and continues throughout the transient.

Simulation of a drywell spray was used during the DWB case. The spray was initiated after all of the hydrogen was released and modeled safety injection flow out of the break. This cools the drywell atmosphere faster (and more economically) than running CLASIX-3 to cool the atmosphere by heat sinks only. This cooling condensed the steam and allowed a final hydrogen burn in the drywell. Table 9 shows the spray parameters.

The passive heat sink data are given in Tables 10 to 14 inclusive. The compartment dependent heat sink parameters are found in Table 10. Included are the initial heat sink temperatures and radiant heat transfer beam lengths, which are based on general geometery considerations and containment dimensions. Table 11 gives the material dependent heat sink parameters which are the emissivity, thermal conductivity, volumetric heat capacity and exit heat transfer coefficient. Tables 12, 13 and 14 give the passive heat sinks for the drywell, wetwell and containment respectively. The number of nodes per layer of passive heat sink is based on the following criteria.

1. All coating layers have two nodes.

2. All other layers have a minimum of three nodes with the actual number being based on the thickness.

3. Steel walls have a spacing of approximately .02 inch per node for all thicknesses.

4. Concrete walls have spacings of about one inch per node for the first six inches, two inches per node for the next twelve inches and six inches per node for the next one and a half feet. Beyond this, the wall is assumed to be adiabatic.

For conservatism, the outer containment and wetwell wall is assumed to be adiabatic after the steel layer.

The upper pool and related parameters are given in Table 15. These include the location of the upper pool, the volume dumped, the temperature of the pool water, the dump flow rate and time of initiation of the dump. The dump flow rate is based on an 8.67 minute dump time through one line.

The drawdown parameters are given in Table 16. These include the destination of the flow, the volume of water removed, and the starting and completion times of the drawdown. The drawdown for the DWB case was simulated by first filling the reactor vessel then filling the holdup volume. The drawdown for the SORV case was simulated by filling the reactor vessel only.

RESULTS

A summary of the results of the two cases is given in Table 17. Temperature and pressure information is given in Figures 3-9 for the SORV (stuck open relief valve) case and Figures 22-28 for the DWB (drywell break) case. Plots of the volume fractions of oxygen, nitrogen, hydrogen, and steam are shown in Figures 10-21 for the SORV case and Figures 29-40 for the DWB case. Table 18 gives the results of two similar analyses performed as part of the sensitivity study of the Grand Gulf Nuclear Station (see Reference 1). The sensitivity cases in Reference 1 are considered to be generally applicable to BWR Mark III containments.

The results of both the Perry and Grand Gulf SORV cases are similar. See Table 18. The containment volume in the Perry Plant is smaller than Grand Gulf by 23%. This contributes to the extra containment burn in the Perry transient. However, the Perry Plant has a 20% larger initial wetwell volume than Grand Gulf which results in fewer wetwell burns in the Perry transient.

For the Perry SORV case, peak temperatures and pressures occurred in all compartments during the first of the two containment burns, at approximately 6900 seconds into the transient. The first containment burn resulted in the most severe pressure and temperature excursion because wetwell ignition occurred just before and during the containment burn. No wetwell ignition occurred during the second containment burn due to a lack of oxygen.

Referring to Figure 4, four additional wetwell temperature peaks (at approximately 4445, 6555, 6965, and 7220 seconds) stand out above the rest. Sprays are not initiated until after the first wetwell burn, which explains why the first wetwell temperature peak is higher than those which immediately follow. The other three "above average" wetwell temperature peaks occur because ignition takes place at increased hydrogen concentrations due to insufficient oxygen concentration when the hydrogen concentration reached the 8 $^{v}/_{o}$ setpoint.

Peak pressures and temperatures for the Perry SORV case are comparable in magnitude to those of the Grand Gulf SORV case, except for the wetwell peak temperature. The Perry wetwell temperature is significantly higher due to the previously discussed coincident combustion in the wetwell and containment, which did not occur in the Grand Gulf SORV case.

The results of the Perry DWB case are also quite similar to the corresponding Grand Gulf case, as shown in Table 18. Again, fewer wetwell burns are evident for the Perry DWB case due to the larger wetwell volume. The only other significant difference between the results for the two plants relates to the containment burn. The Perry DWB case originally did not have a containment burn associated with the final drywell and wetwell burn. The volume fraction of hydrogen in the containment just prior to the final burn was 0.065. See Figure 37. The volume fraction of hydrogen required for ignition is 0.08. To be conservative, it was decided to force a containment burn at this point to obtain peak temperatures and pressures. This reduced concentration forced burn resulted in lower peak temperatures and pressures for the Perry DWB case.

The total amount of hydrogen burned in the Perry SORV transient was 2011 lbs. and in the DWB transient was 2290 lbs. These values correspond to 77.0% and 87.6%, respectively, of the total amount of hydrogen that was available. The similar Grand Gulf cases show the SORV case burning 2332 lbs. and the DWB case burning 2243 lbs., which are 89.3% and 85.8% of the total hydrogen releases, respectfully. The difference between the percentage of hydrogen burned in the Perry and Grand Gulf SORV cases is due to the significantly larger number of wetwell burns in the Grand Gulf case.

SUMMARY

For the two Perry cases analyzed, the peak calculated containment pressure was approximately 21 psig, and brief duration temperature peaks ranged from 643°F in the drywell to 760°F in the containment to 1762°F in the wetwell. Comparison between the Perry and Grand Gulf analyses show the SORV and DWB transients to be similar with the differences explained by plant geometry, the forced containment burn at a lower hydrogen concentration in the Perry DWB case, and coincident combustion in the wetwell and containment during the Perry SORV case.

REFERENCES

1. "CLASIX-3 Containment Response Sensitivity Analysis for the Mississippi Power and Light Grand Gulf Nuclear Station", A. D. Gunter and Dr. G.M. Fuls, Report Number OPS-37A15, December 1982.

TABLE 1

Perry CLASIX-3 Input

MARCH Reactor Coolant Mass and Energy Release Rates

TPE Sequence

Time (seconds)	Steam Release Rate (lbm/sec)	Energy Release Rate (Btu/sec)
0	220	260000.0
602	183.33	219450.0
902	188.23	226316.67
1204	130.12	157050.82
1789	122.8	148670.43
1803	120.82	146396.67
2707	74.79	93053.33
2994	48.35	62419.85
3601	27.71	38470.73
3631	30.51	42323.33
4201	4.72	6501.99
4504	2.40	3206.05
4541	6.919	10793.33
4858	6.87	12699.55
5158	2.28	3556.80
5458	0.14	202.05
5758	1.08	2015.3
6058	0.10	153.21
6359	4.25	6601.6
7807.13	4.25	6601.6
7807.14	0	0

TABLE 2

Perry CLASIX-3 Input

MARCH Hydrogen Release Rates and Temperatures

TPE Sequence

Time (seconds)	Hydrogen Release Rate (lbm/sec)	Temperature (°F)
0	0	61.24
1803	0	61.24
2707	1.225×10^{-8}	525.36
2995	3.85×10^{-6}	606.09
3295	6.00×10^{-4}	694.34
3601	0.0071	784.66
3631	0.0089	788.80
3901	0.0479	880.29
4201	0.0486	753.07
4541	0.3186	1115.69
4858	1.0415	1693.75
5158	0.4905	1109.04
5458	0.0691	875.86
5758	1.0177	1702.01
6058	0.0556	1039.08
6359	1.0415	1808.8
7807.13	1.0415	1808.8
7807.14	0	61.24

TABLE 3

Perry CLASIX-3 Input

MARCH Fission Product Energy Release Rates

TPE Sequence

Time (seconds)	Energy Release Rate (Btu/sec)
0	0
3631	0
4541	246.47
5458	1097.76
6358	1530.3
6359	1530.7
7807.13	1530.7
7807.14	0

TABLE 4

Perry CLASIX-3 Input

<u>Burn Parameters*</u>

H_2 $^v/F$ for ignition	0.08
H_2 $^v/F$ for propagation	0.08
H_2 fraction burned	0.85
Minimum O_2 $^v/F$ for ignition	0.05
Minimum O_2 $^v/F$ to support combusion	0.0
Burn time (sec)**	6.45/2.26/11.25

*If one number is present, parameters are the same in all compartments; otherwise they are listed by drywell/wetwell/containment.

**Based on flame speed of 6 ft/s.

TABLE 5

Perry CLASIX-3 Input

Compartment Initial Conditions

	Drywell	Wetwell	Containment
Volume (ft^3)	277,685	181,626	959,388
Temperature (^oF)	134	90	90
O_2 Pressure (psia)	2.83	3.01	3.01
N_2 Pressure (psia)	10.63	11.34	11.34
H_2O Pressure (psia)	1.24	.349	.349

TABLE 6

Perry CLASIX-3 Input

Flow Path Parameters

	WW-CONT	CONT-DW
Maximum Flow Area (ft^2)	3187	See Table 7
Flow Loss Coefficient	5.0	" "
Burn Propagation Delay Time (sec)*	1.0	" "

*Based on flame speed of 6 ft/sec.

TABLE 7

Perry CLASIX-3 Input

Drywell Purge System Parameters

Suction Compartment	Containment
Sink Compartment	Drywell
Initiation*	

Head (inches of H_2O)	Flow Rate** (CFM)
84.830	790
112.847	755
136.973	725
152.149	695
170.438	660
177.054	625
184.836	580
192.619	547
198.456	495
198.456	467
196.510	410
200.401	377
202.347	340
202.347	315
205.460	287

*Manual initiation when hydrogen accumulates in the drywell to a concentration of 3.0 percent by volume or 20 minutes post LOCA, whichever comes first.

**This flow rate is for one compressor. When both compressors are activated, this table is multiplied by two.

TABLE 9

Perry CLASIX-3 Input

Spray System Parameters

	Cont/Wetwell	Drywell
Flow rate (GPM)	5250	14077
Temperature (°F)	132	175
Drop diameter (microns)	370	6350
Fall time (seconds)	13.1/3.1	20
Heat transfer coefficient (BTU/HR - Ft^2 °F)	20	10
Containment to Wetwell Carry Over Fraction	.4669	
Initiation	*	**

*Initiation occurs after first burn.

**Initiation occurs after hydrogen release stops. (Drywell break case only.)

TABLE 10

Perry CLASIX-3 Input

Compartment Dependent Passive Heat Sink Parameters

Parameter	Compartment	Value
Temperature	Drywell	130°F
	Pedestal	136°F
	Biological Shield Wall	170°F
	Wetwell	90°F
	Containment	90°F
Radiant Heat Transfer Beam Length	Drywell (vertical) Platforms, grating, weir mat	25.69 ft
	Drywell slab	51.39 ft
	Drywell (horizontal)	
	Weir Wall (inside)	11.36 ft
	Weir Wall (outside), vent structure	1.44 ft
	Pedestal Walls	13.06 ft
	Biological Shield Wall, Drywell Wall	13.81 ft
	Wetwell (vertical)	
	Platforms, grating	17.78 ft
	Wetwell (horizontal)	
	Columns, vessel, personnel lockwell, drywell wall, vent structure	12.33 ft

TABLE 10 (Cont'd)

Perry CLASIX-3 Input

Compartment Dependent Passive Heat Sink Parameters

Parameter	Compartment	Value
Radiant Heat Transfer Beam Length (cont'd)	Containment (vertical)	
	Drywell Slab, platforms, grating, misc.	44.83 ft
	Containment (horizontal)	
	Drywell wall, columns, personnel lock shielding	12.33 ft
	Vessel	62.42 ft

TABLE 11

Perry CLASIX-3 Input

Material Dependent Passive Heat Sink Parameters

Parameter	Material	Value
Emissivity	Chemtree	0.8
	Concrete	0.8
	Stainless Steel	0.5
	Carbon Steel	0.8
	Galvanized Steel	0.5
	Coating	0.8
Thermal Conductivity (Btu/hr-ft-^{o}F)	Chemtree	1.965
	Concrete	0.8
	Stainless Steel	9.4
	Carbon Steel	26.0
	Galvanized Steel	26.0
	Coating	0.4
Volumetric Heat Capacity (Btu/ft^{3}-^{o}F)	Chemtree	64.5
	Concrete	29.0
	Stainless Steel	53.7
	Carbon Steel	53.9
	Galvanized Steel	53.9
Exit Heat Transfer Coefficient (Btu-hr-ft^{2}-^{o}F)	Coating to Steel	$4X10^4$
	Coating to Concrete (or Chemtree)	$4X10^4$
	Steel to Concrete (or Chemtree)	10.0
	Concrete (or Chemtree) to Concrete (or Chemtree)	10^8
	Steel to Steel	10^8
	Last Layer Adiabatic Wall	0

TABLE 12

Perry CLASIX-3 Input

Drywell Passive Heat Sinks

Description	Surface Area (FT^2)	Layer Number	Layer Material	Layer Thickness (FT)
Platform Structural Steel	24,500	1	Coating	$6.667X10^{-4}$
		2	Carbon Steel	$3.125X10^{-2}$
Grating	45,800	1	Galvanized Steel	$1.042X10^{-2}$
Weir Mat	2,603	1	Coating	$2.629X10^{-3}$
		2	Concrete	0.5
		3	Concrete	1.0
		4	Concrete	1.5
Weir Wall, Inside	3,198	1	Coating	$2.629X10^{-3}$
		2	Concrete	0.75
Weir Wall, Outside	1,225	1	Stainless Steel	$2.083X10^{-2}$
		2	Concrete	$7.292X10^{-1}$
Pedestal Walls	3,410	1	Coating	$6.667X10^{-4}$
		2	Carbon Steel	$8.333X10^{-2}$
		3	Chemtree	0.5
		4	Chemtree	1.0
		5	Chemtree	1.417
Biological Shield Wall	9,665	1	Coating	$6.667X10^{-4}$
		2	Carbon Steel	$8.333X10^{-2}$
		3	Chemtree	$9.167X10^{-1}$
Vent Structure	1,760	1	Stainless Steel	$8.333X10^{-3}$
		2	Carbon Steel	$7.50X10^{-2}$
		3	Concrete	0.5
		4	Concrete	1.917
Drywell Wall and Drywell Slab	16,700	1	Coating	$6.667X10^{-4}$
		2	Carbon Steel	$2.083X10^{-2}$
		3	Concrete	0.5
		4	Concrete	1.877

TABLE 13

Perry CLASIX-3 Input

Wetwell Passive Heat Sinks

Description	Surface Area (FT^2)	Layer Number	Layer Material	Layer Thickness (FT)
Steel Columns, Platform Structural Steel, Containment Vessel	56,092	1	Coating	$6.667X10^{-4}$
		2	Carbon Steel	$5.199X10^{-2}$
Steel Columns, lower 20'	2,074	1	Stainless Steel	$2.083X10^{-2}$
		2	Carbon Steel	$9.167X10^{-2}$
Grating	37,230	1	Galvanized Steel	$1.042X10^{-2}$
Containment Vessel, lower 5'	1,885	1	Stainless Steel	$1.25X10^{-1}$
		2	Carbon Steel	$1.125X10^{-1}$
Personnel Lock Well, Drywell Wall	5,498	1	Coating	$7.125X10^{-3}$
		2	Concrete	0.5
		3	Concrete	2.0
Personnel Lock Well	753	1	Coating	$6.667X10^{-4}$
		2	Carbon Steel	$8.333X10^{-2}$
		3	Concrete	0.5
		4	Concrete	2.0
Vent Structure	1,540	1	Stainless Steel	$8.333X10^{-3}$
		2	Carbon Steel	$7.50X10^{-2}$
		3	Concrete	0.5
		4	Concrete	1.917

TABLE 14

Perry CLASIX-3 Input

Containment Passive Heat Sinks

Description	Surface Area (FT^2)	Layer Number	Layer Material	Layer Thickness (FT)
Drywell Wall, Drywell Slab, Fuel Transfer Floor, etc.	37,891	1	Coating	2.780×10^{-3}
		2	Concrete	0.5
		3	Concrete	1.0
		4	Concrete	1.259
Steel Columns, Chk'd Plate	11,015	1	Coating	6.667×10^{-4}
		2	Carbon Steel	6.25×10^{-2}
Platform Structural Steel	38,275	1	Coating	6.667×10^{-4}
		2	Carbon Steel	2.292×10^{-2}
Grating	21,830	1	Galvanized Steel	1.042×10^{-2}
Containment Vessel	66,787	1	Coating	6.667×10^{-4}
		2	Carbon Steel	1.250×10^{-1}
Fuel Transfer Floor Slab	370	1	Stainless Steel	2.083×10^{-2}
		2	Concrete	0.5
		3	Concrete	1.0
		4	Concrete	1.5
Personnel Lock Shielding	610	1	Coating	6.667×10^{-4}
		2	Carbon Steel	2.083×10^{-2}
		3	Chemtree	0.5
		4	Chemtree	1.0
		5	Chemtree	1.5

TABLE 15

Perry CLASIX-3 Input

Upper Pool Parameters

Location	Containment
Volume Dumped (ft^3)	32,830
Temperature (^oF)	100
Dump Flow Rate (ft^3/min)	3,787
Initiation	*

*Initiation occurs at 30 minutes after LOCA signal.

TABLE 16

Perry CLASIX-3 Input

Drawdown Parameters

Destination of Drawdown Flow	Reactor Vessel	Drywell*
Volume Removed (ft^3)	13,939	40,564
Starting Time (sec)	6,500	6,952.5
Completion Time (sec)	6,952.5	8,269.5

*Drawdown to the drywell only occurs in the DWB case.

TABLE 17

Perry CLASIX-3 Results

		SORV	DWB
Number of burns	DW*	0	0 [1]
	WW	32	30 [8]
	CT	2	0 [1]
Total H_2 Burned (lbm)	DW	0	0 [117]
	WW	1220	1361 [472]
	CT	791	0 [340]
H_2 Remaining (lbm)	DW	15	692 [203]
	WW	293	151 [41]
	CT	294	409 [81]
Peak Temp. (^{o}F)	DW	191 (154)	251 [643]
	WW	1762 (1364)	1201 [1763]
	CT	760 (236)	192 [587]
Peak Pressure (psig)	DW	15.9 (10.7)	13.8 [17.3]
	WW	21.1 (12.6)	12.2 [19.4]
	CT	21.2 (9.9)	10.9 [19.4]

*Drywell, wetwell, and containment are abbreviated as DW, WW, and CT.

( )Maxima due to wetwell burns.

[ ]Values due to extension past end of hydrogen release.

TABLE 18

CLASIX-3 Results Comparison

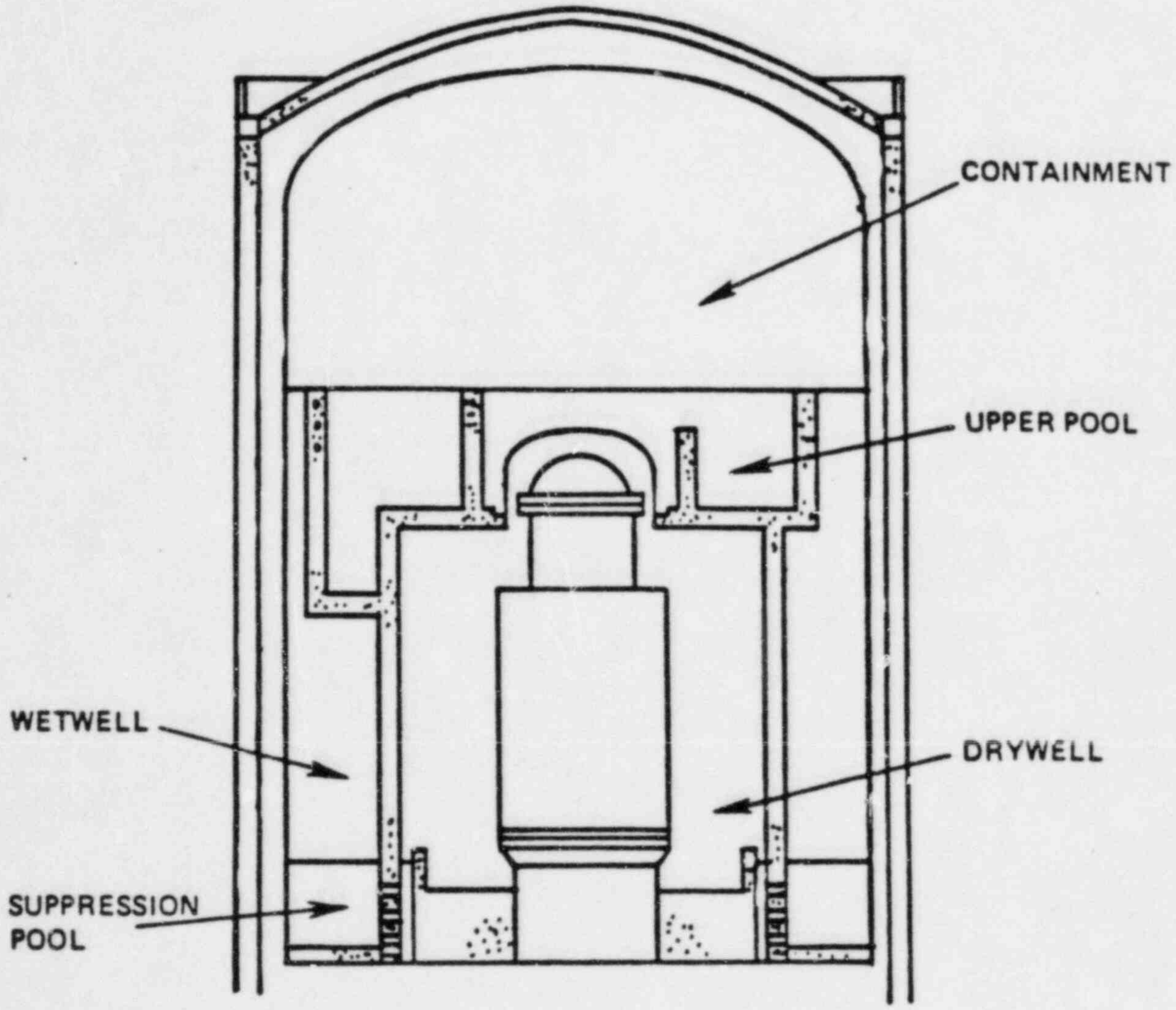
		Perry Results		Grand Gulf Results**	
		SORV	DWB	SORV	DWB
Number of burns	DW*	0	0 [1]	0	0 [1]
	WW	32	3[illegible] [8]	59	26 [6]
	CT	2	0 [1]	1	0 [1]
Total H_2 Burned (lbm)	DW	0	0 [117]	0	0 [104]
	WW	1220	1361 [472]	1820	1233 [319]
	CT	791	0 [340]	512	0 [587]
H_2 Remaining (lbm)	DW	15	692 [203]	25	712 [240]
	WW	293	151 [41]	40	21 [15]
	CT	294	409 [81]	207	629 [114]
Peak Temp. (^{o}F)	DW	191 (154)	251 [643]	193 (137)	296 [707]
	WW	1762 (1364)	1201 [1763]	1020 (1020)	1110 [2295]
	CT	760 (236)	192 [587]	681 (197)	196 [860]
Peak Pressure (psig)	DW	15.9 (10.7)	13.8 [17.3]	18.9 (9.6)	12.3 [16.3]
	WW	21.1 (12.6)	12.2 [19.4]	23.5 (9.0)	11.9 [31.6]
	CT	21.2 (9.9)	10.9 [19.4]	23.9 (8.8)	11.7 [32.1]

*Drywell, wetwell, and containment are abbreviated as DW, WW, and CT.

( )Maxima due to wetwell burns.

[ ]Values due to extension past end of hydrogen release.

**See Reference 1, cases SA1 and DA4.



MARK III CONTAINMENT

FIGURE 1

PERRY CLASIX-3 MODEL

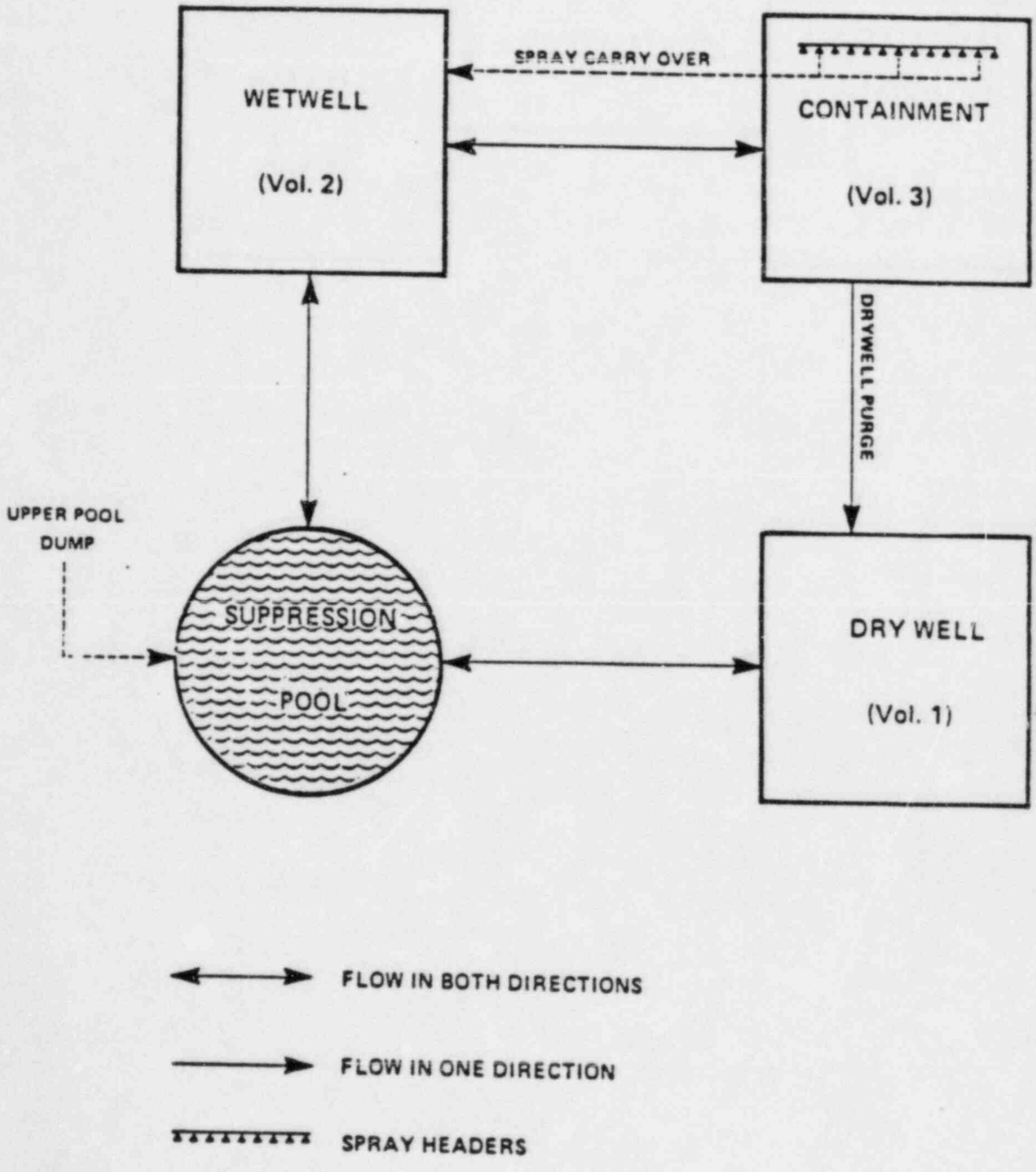
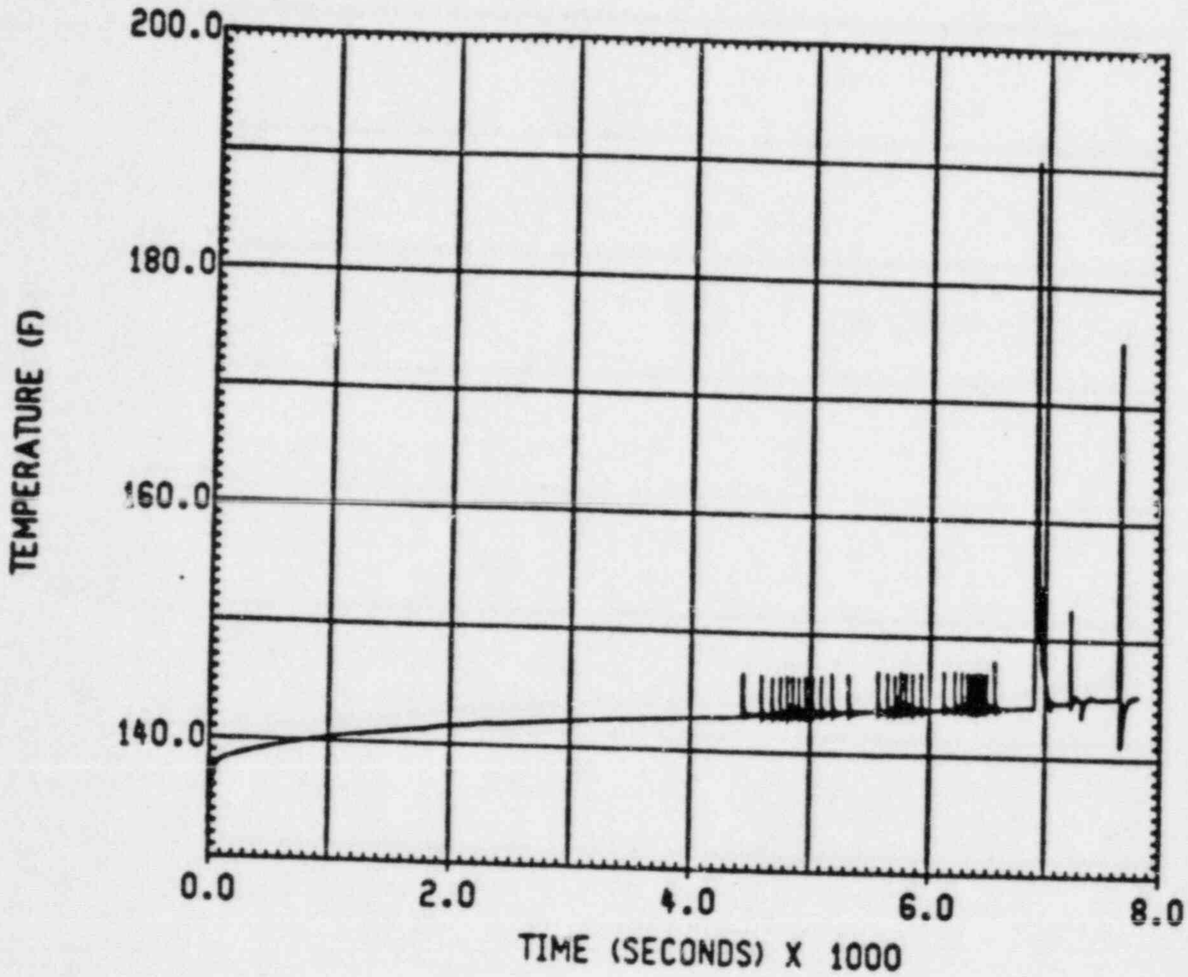
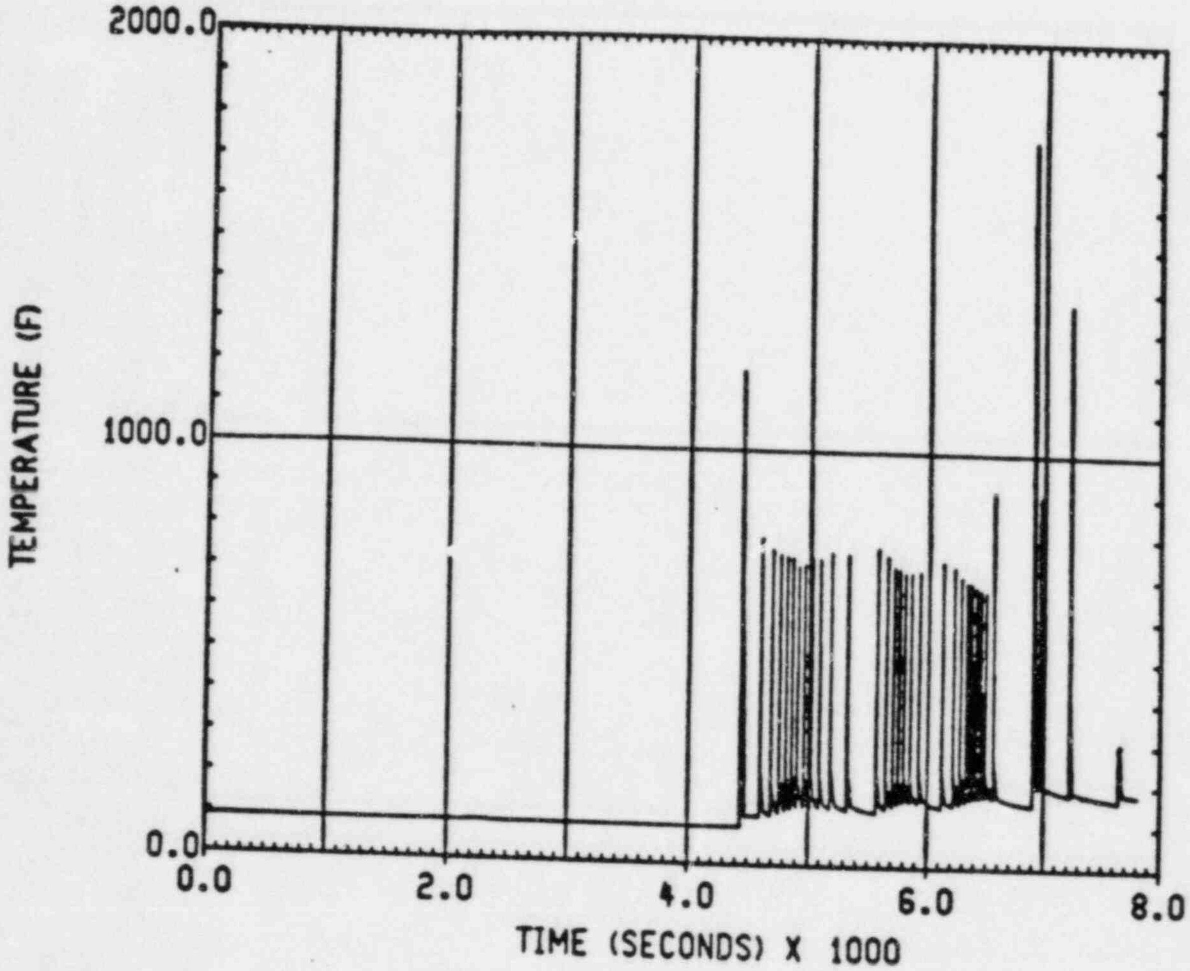


FIGURE 2



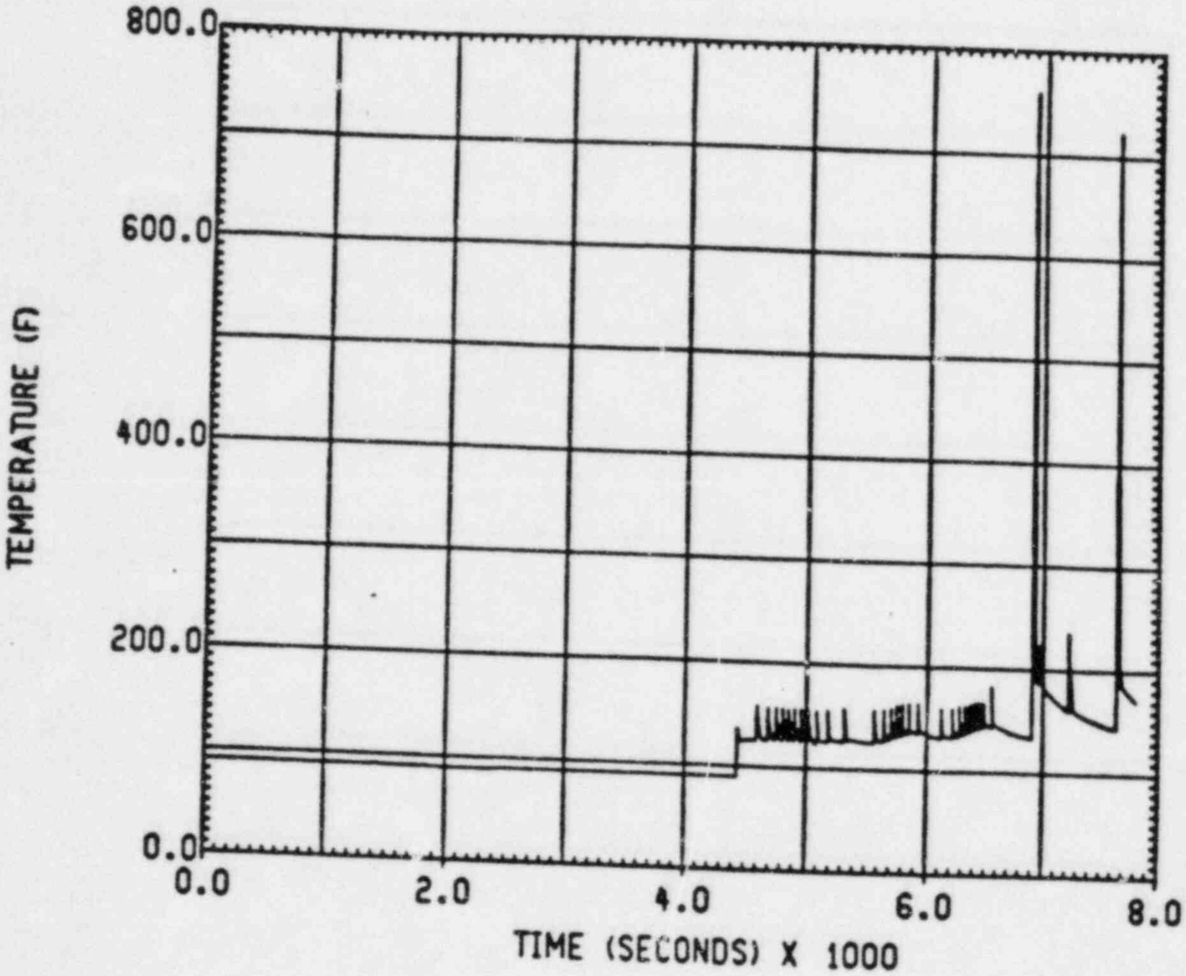
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
DRYWELL TEMPERATURE

FIGURE 3



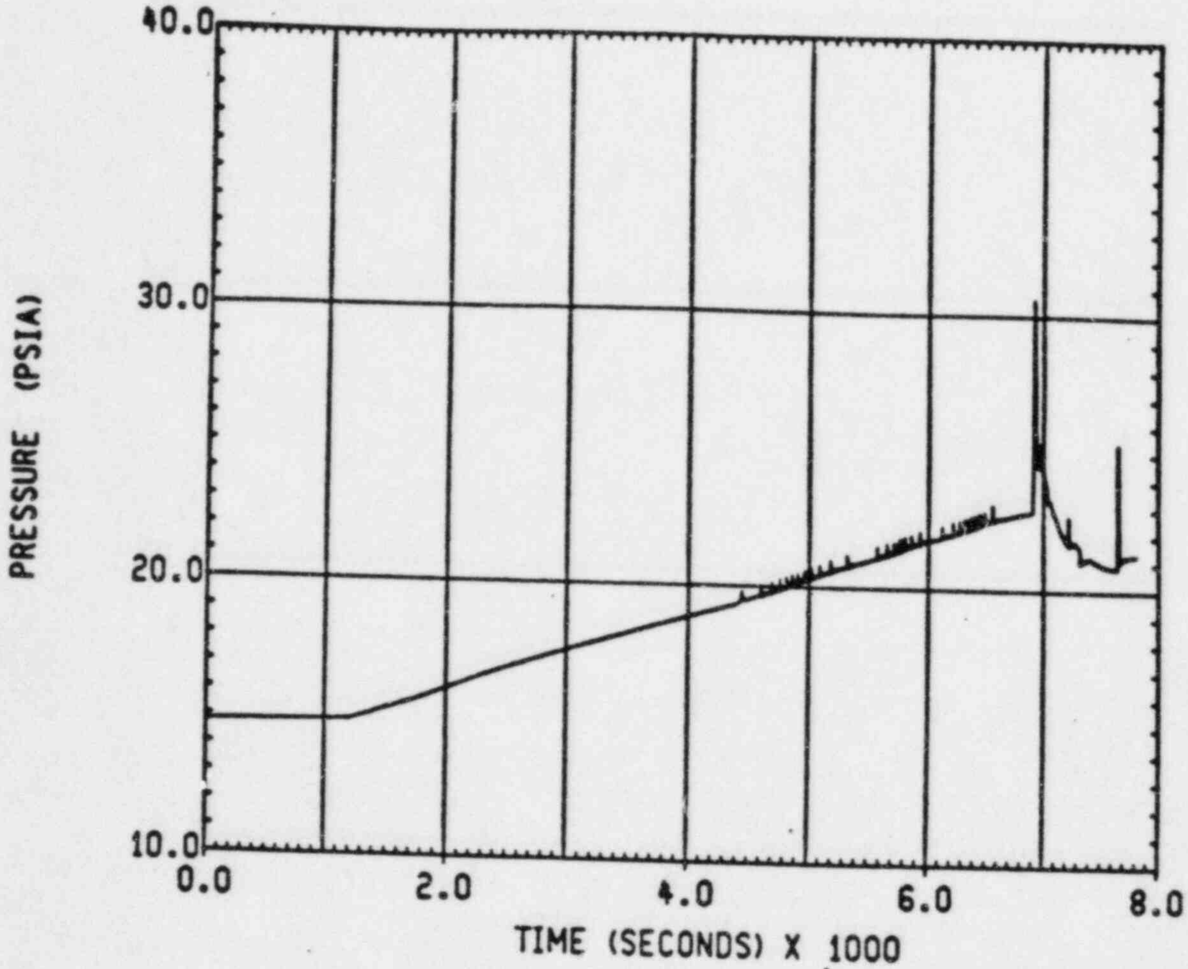
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
WETWELL TEMPERATURE

FIGURE 4



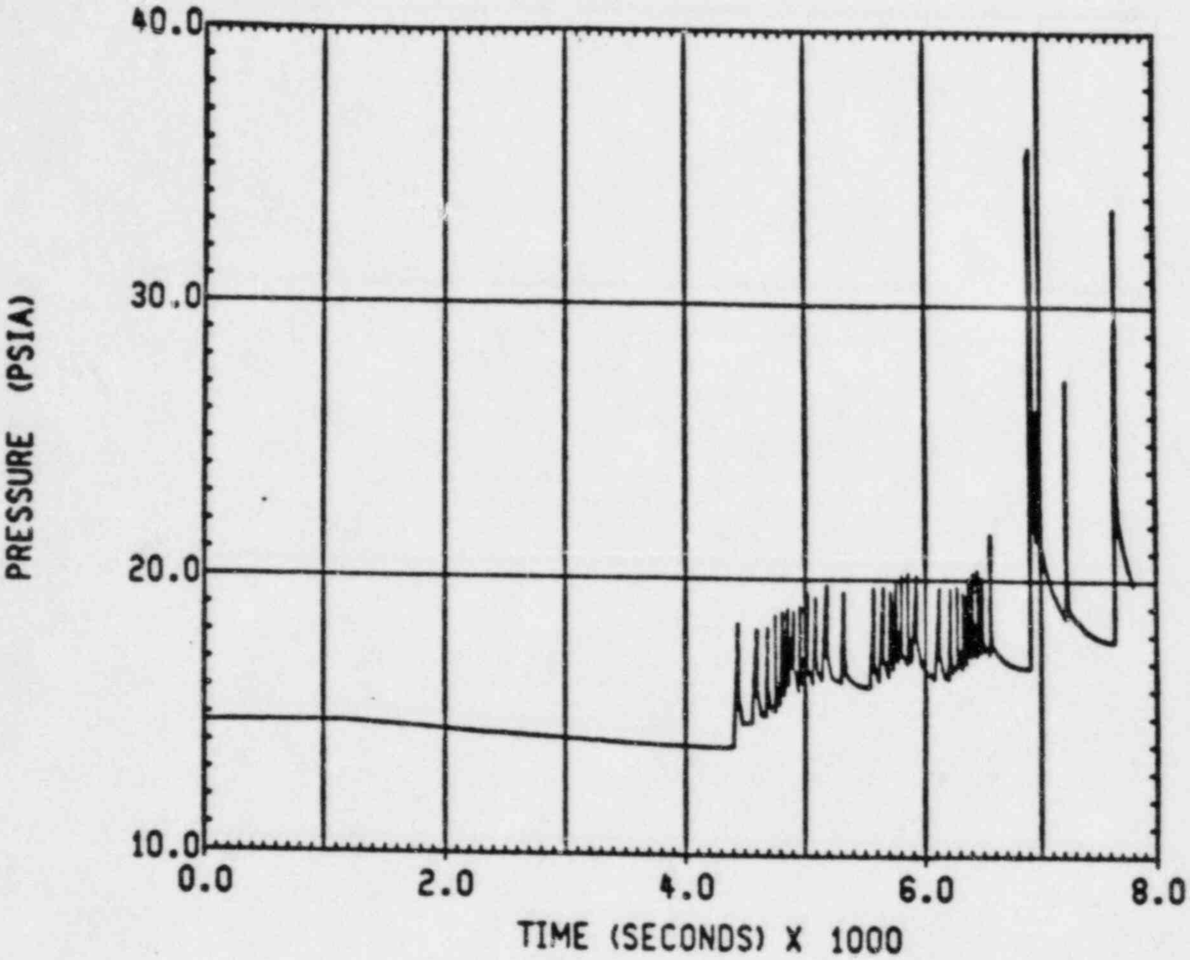
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
CONTAINMENT TEMPERATURE

FIGURE 5



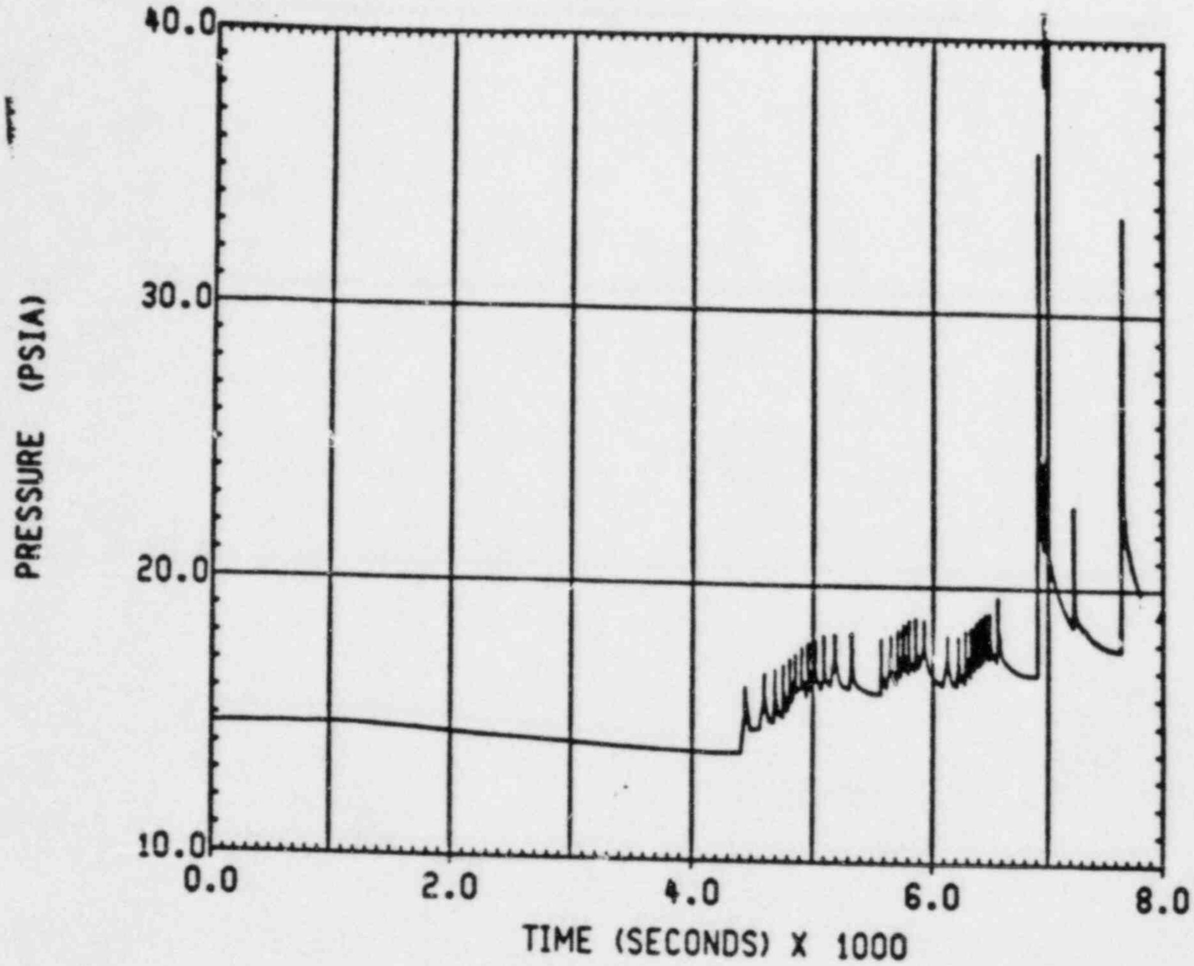
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
DRYWELL PRESSURE

FIGURE 6



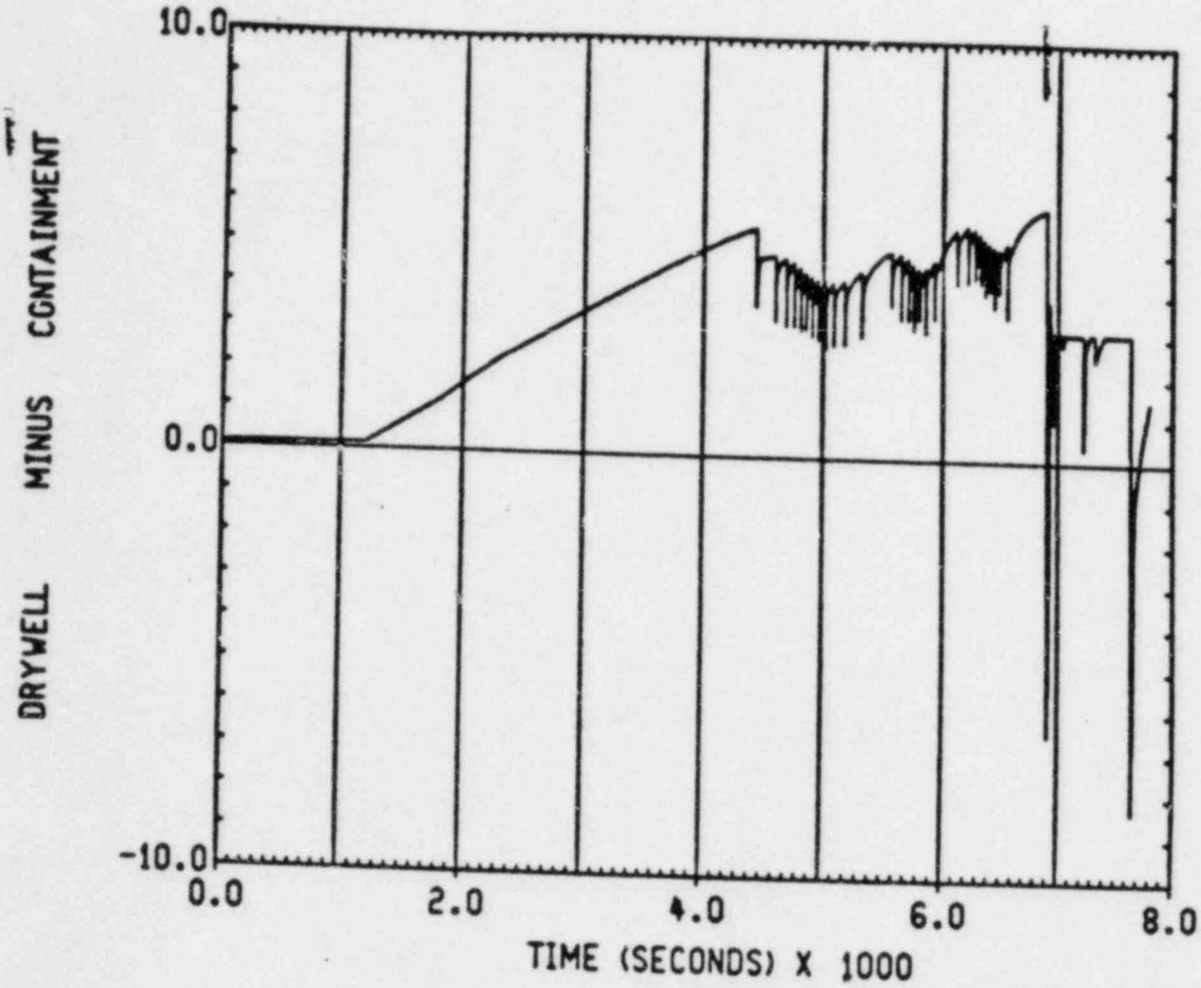
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
WETWELL PRESSURE

FIGURE 7



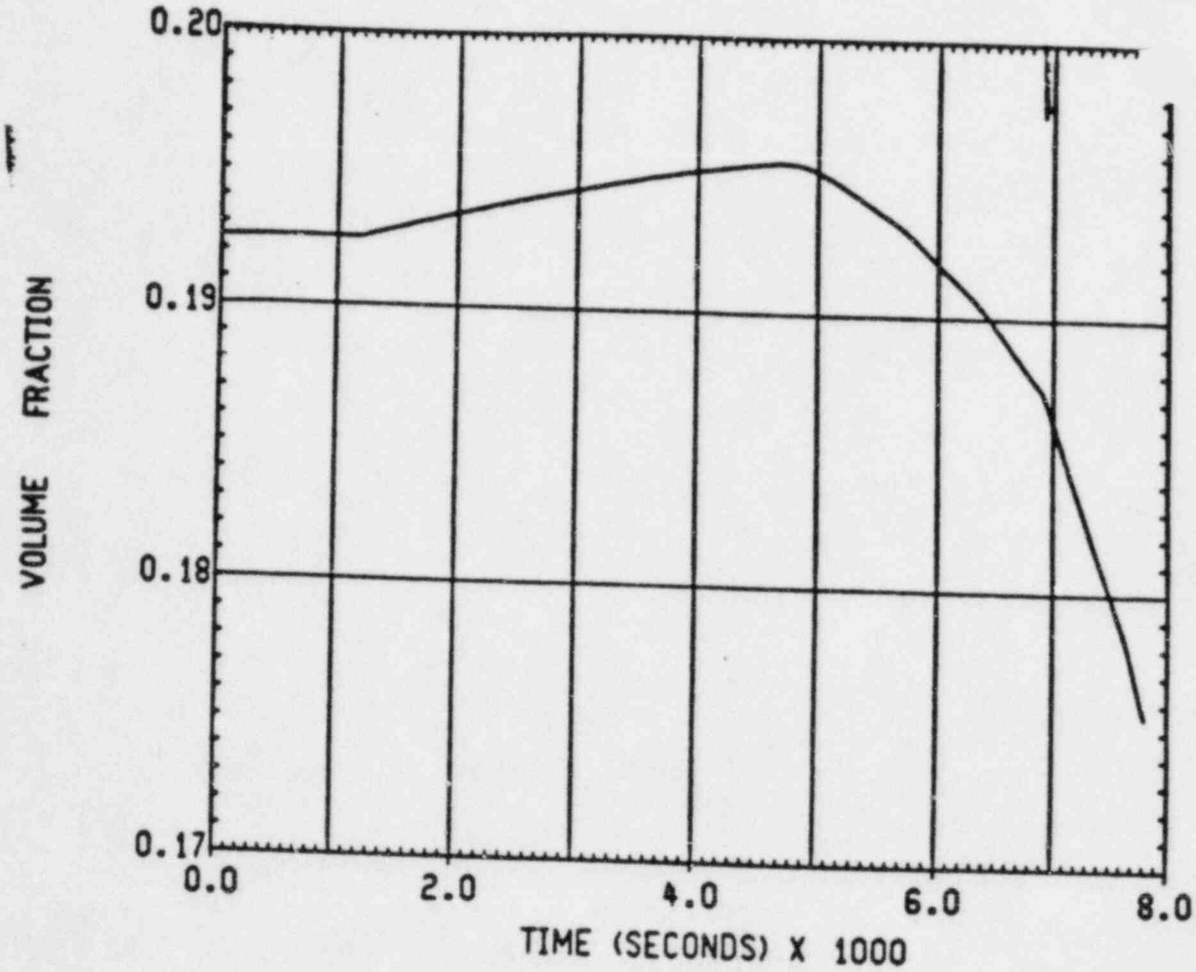
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
CONTAINMENT PRESSURE

FIGURE 8



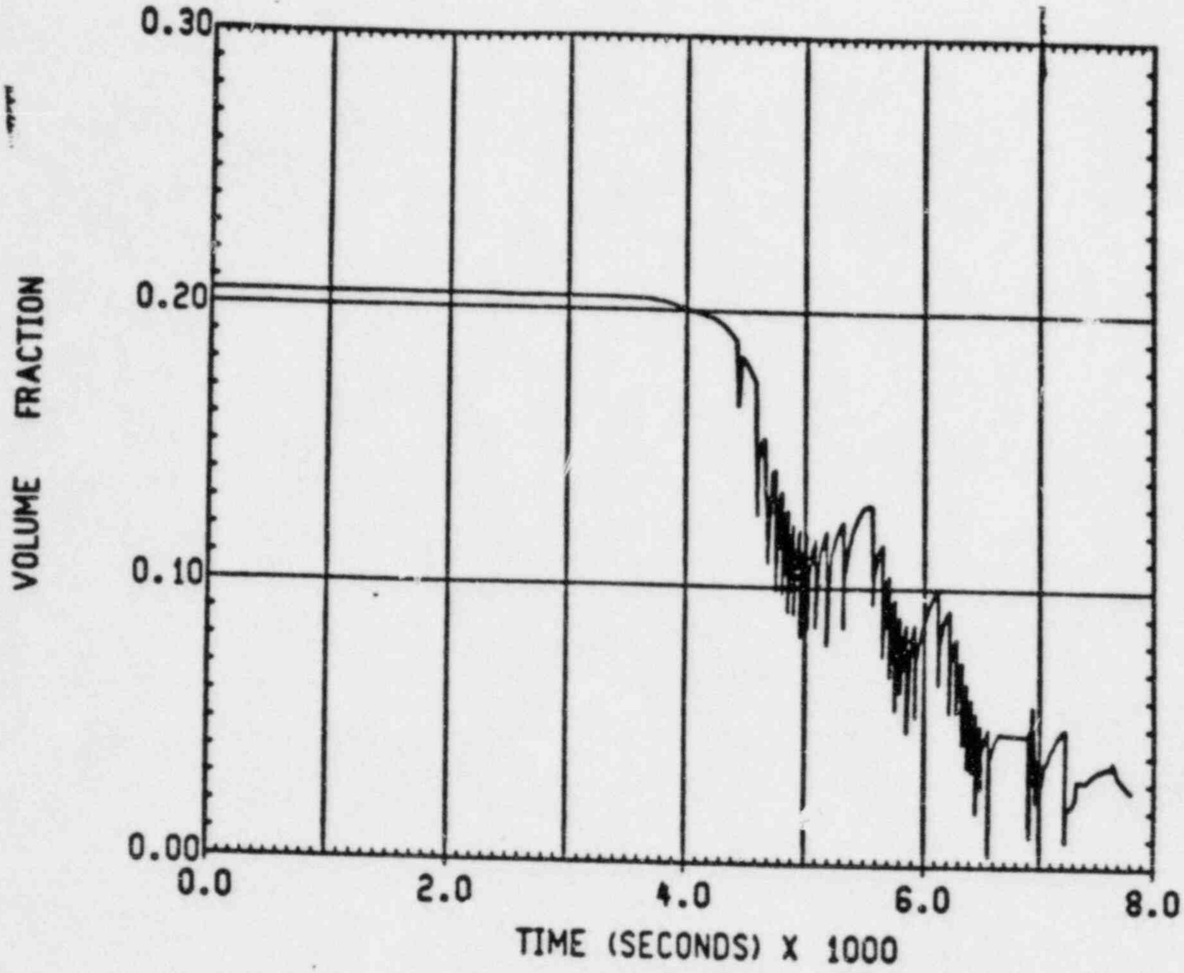
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
DIFFERENTIAL PRESSURE

FIGURE 9



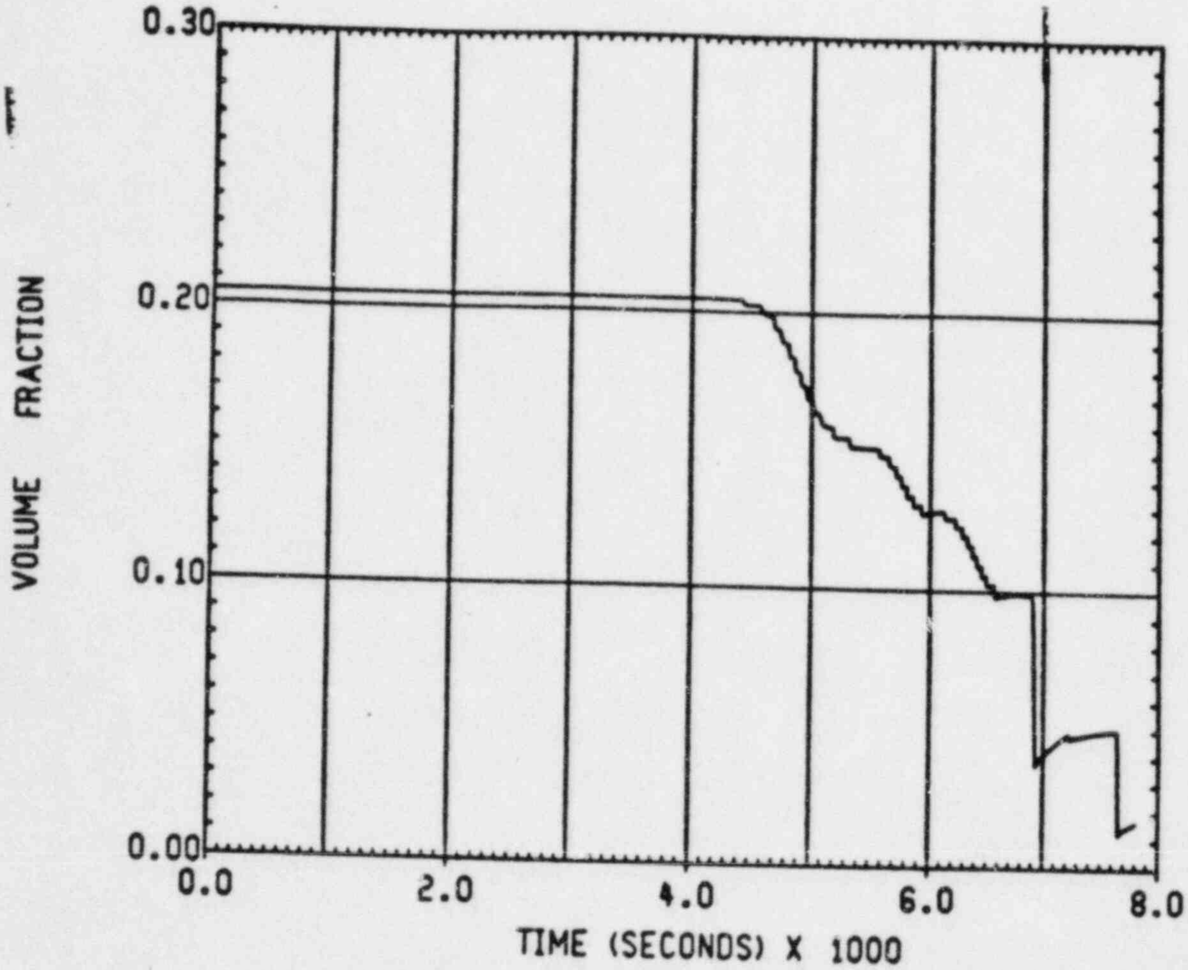
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
DRYWELL 02 GAS CONCENTRATION

FIGURE 10



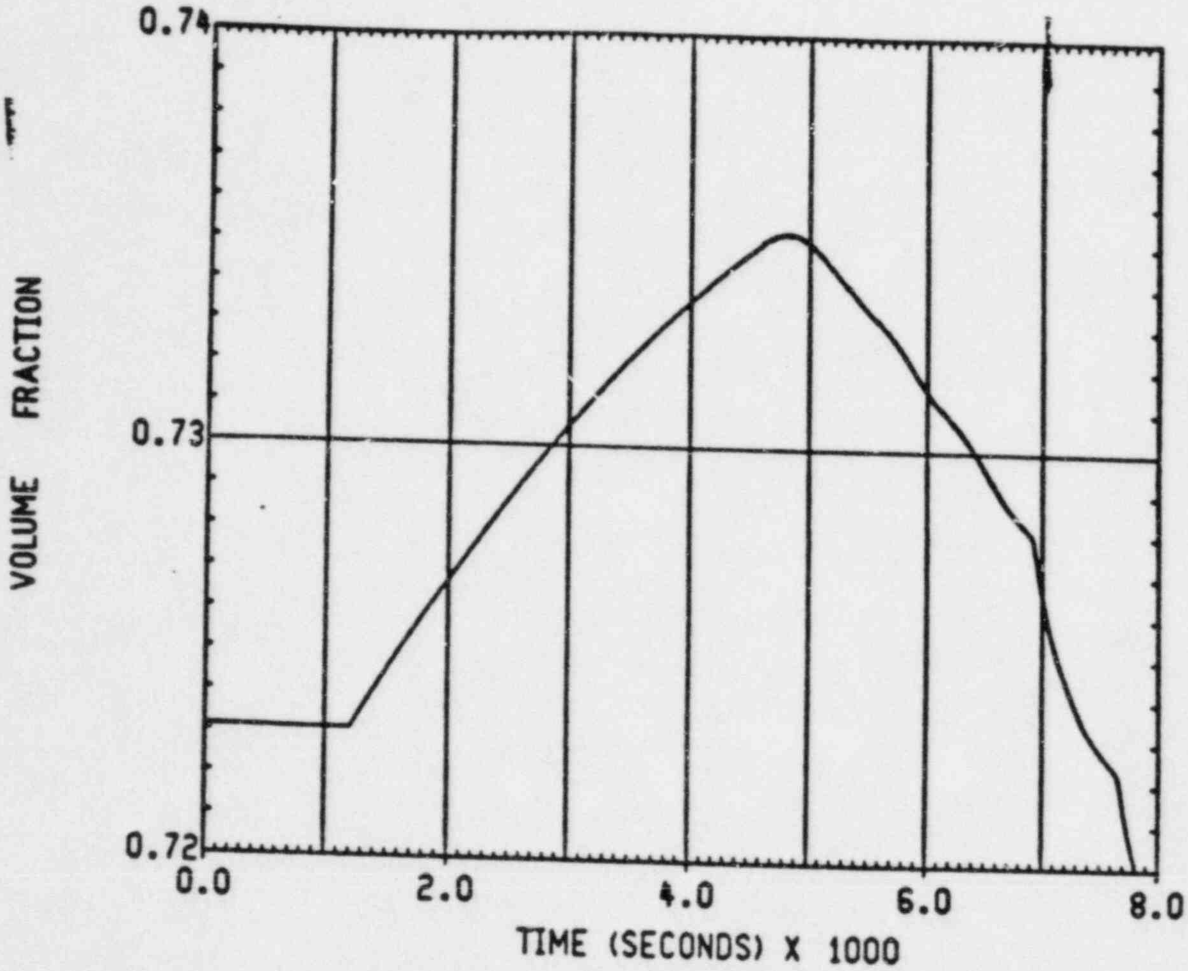
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
WETWELL O2 GAS CONCENTRATION

FIGURE 11



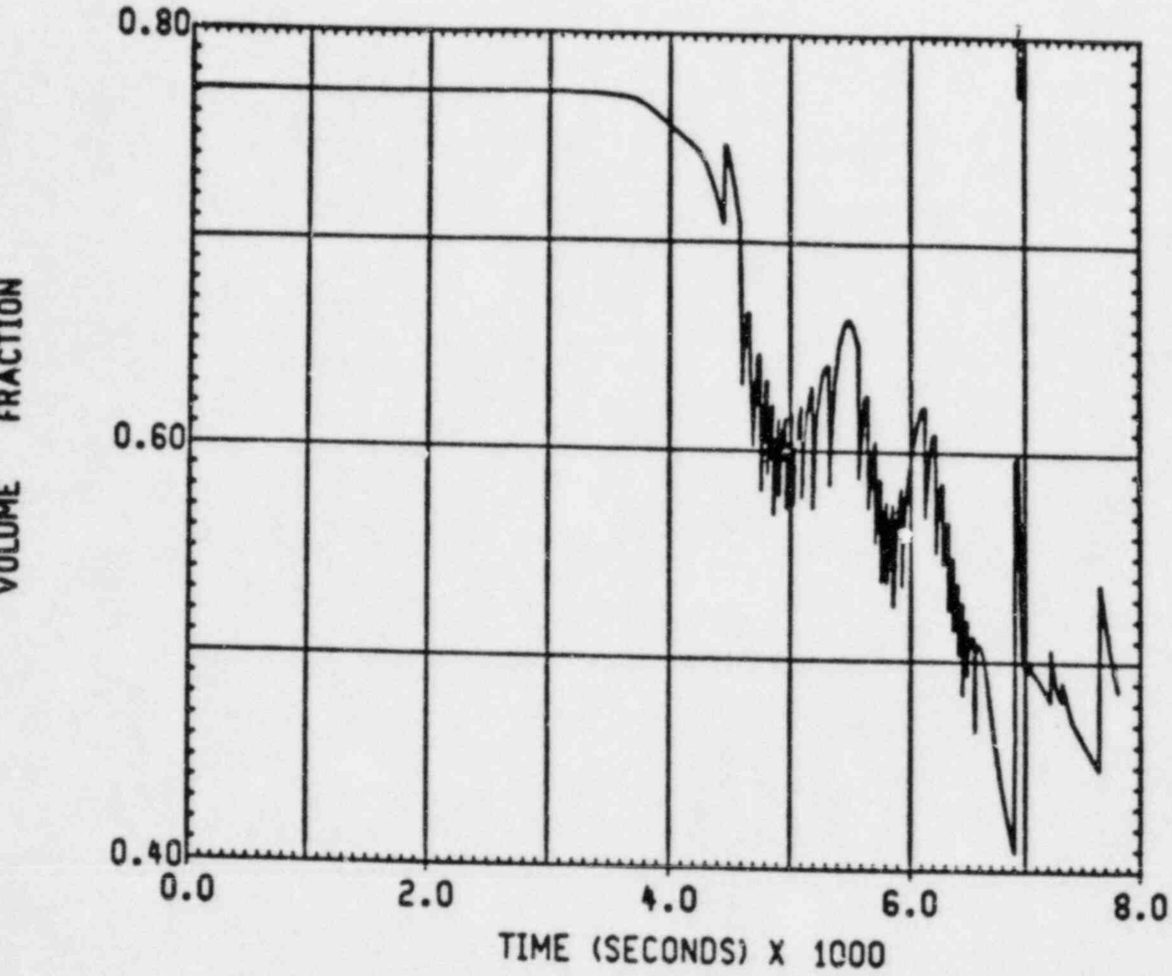
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
CONTAINMENT O2 GAS CONCENTRATION

FIGURE 12



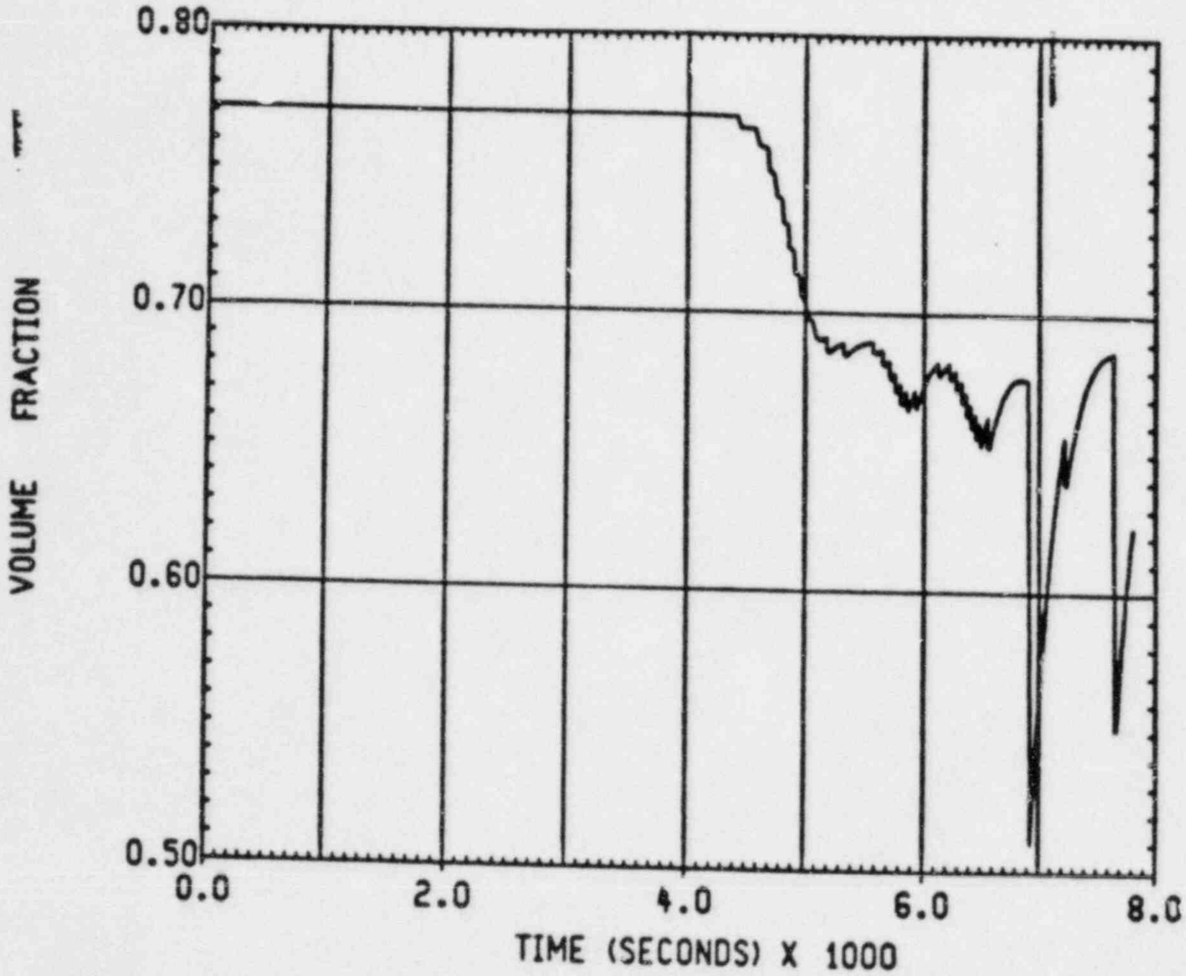
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
DRYWELL N2 GAS CONCENTRATION

FIGURE 13



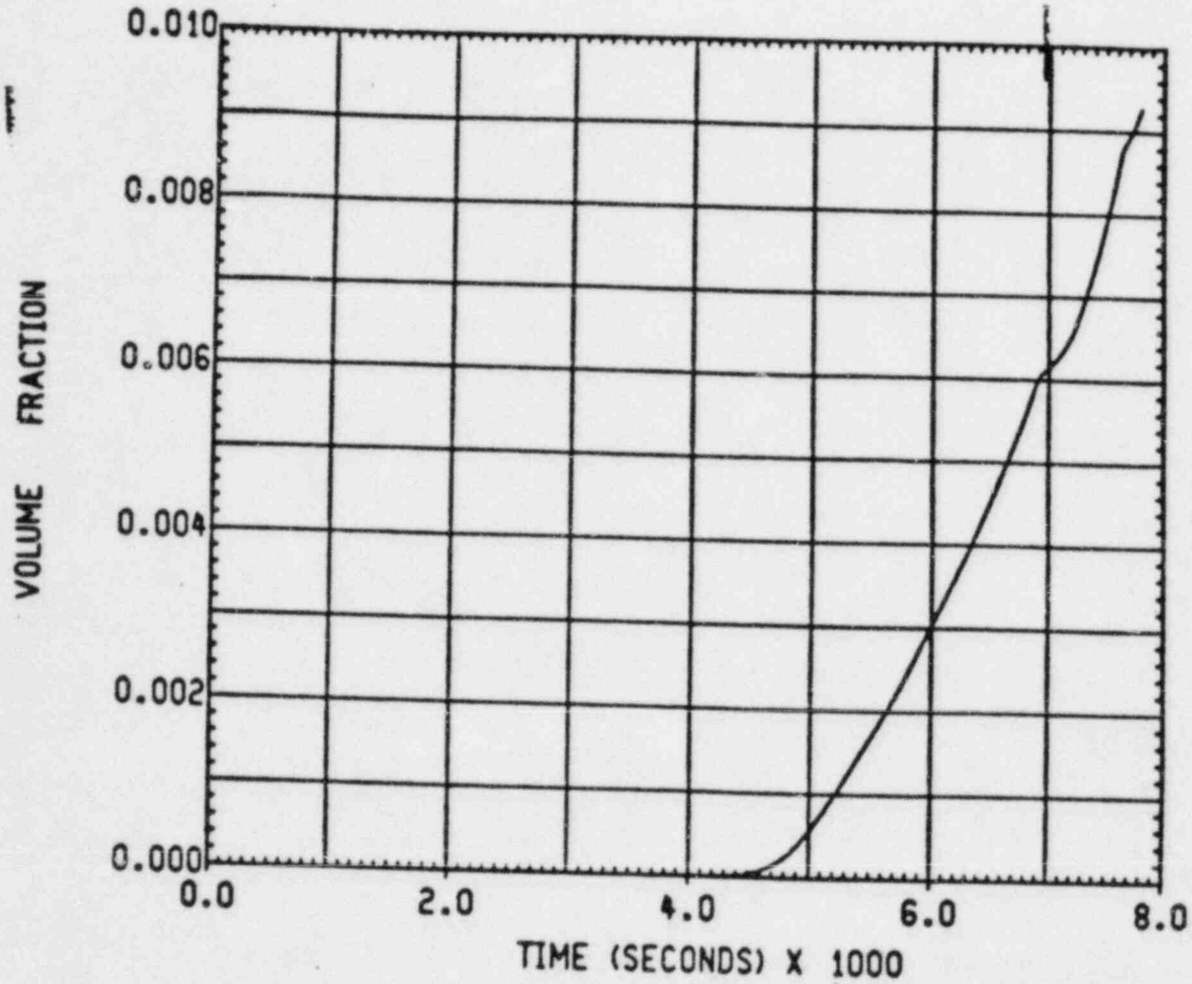
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
WETWELL N2 GAS CONCENTRATION

FIGURE 14



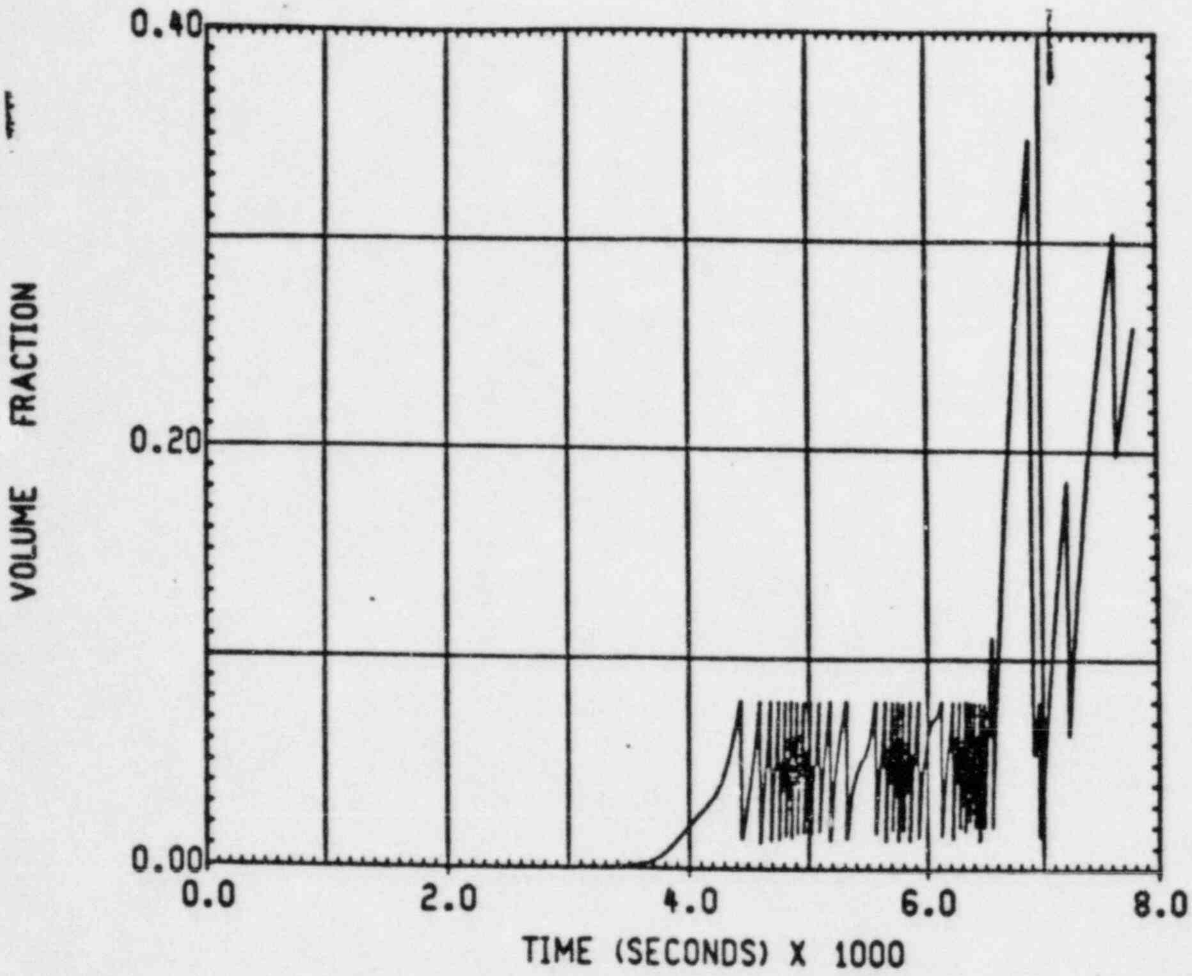
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
CONTAINMENT N2 GAS CONCENTRATION

FIGURE 15



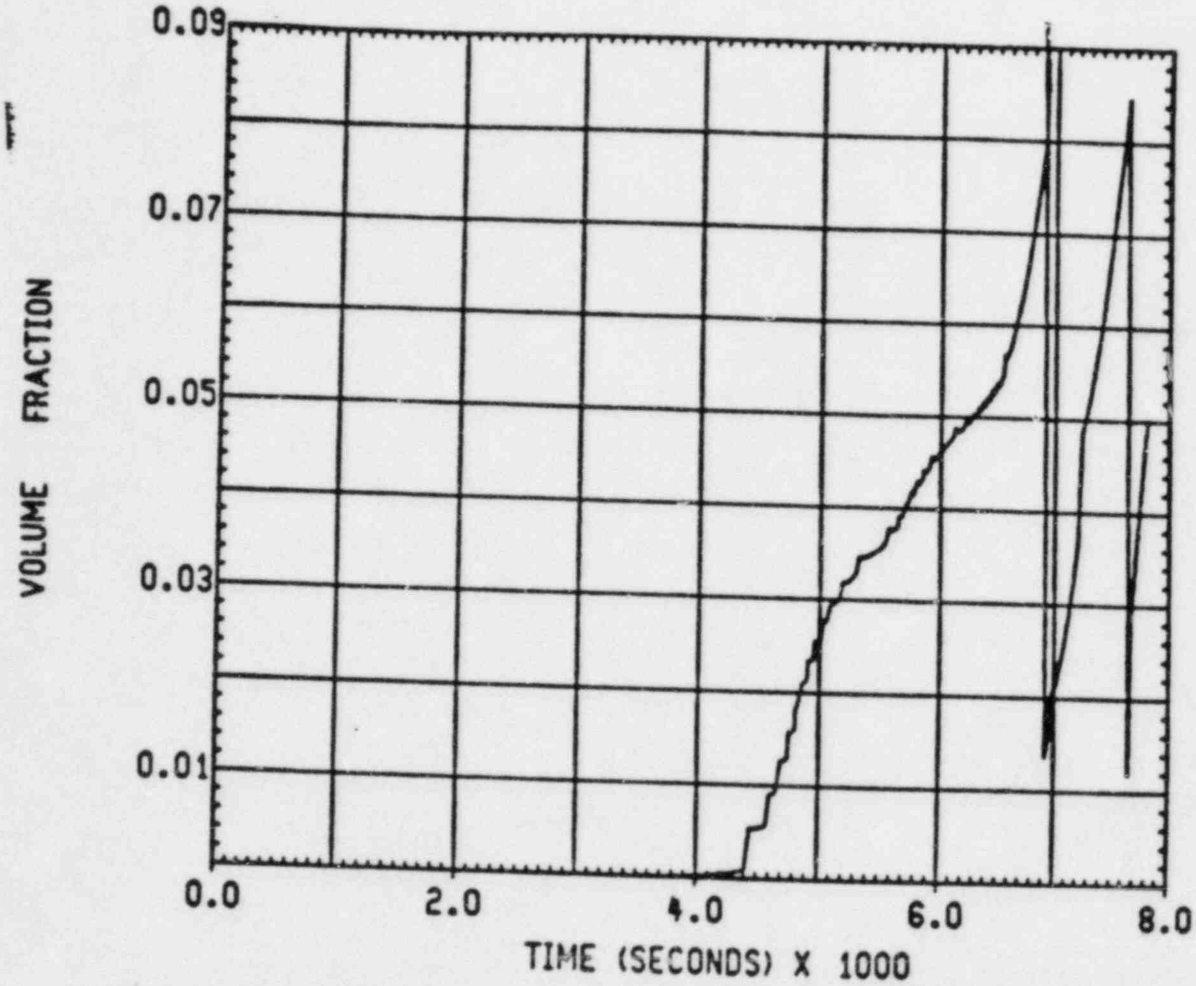
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
DRYWELL H2 GAS CONCENTRATION

FIGURE 16



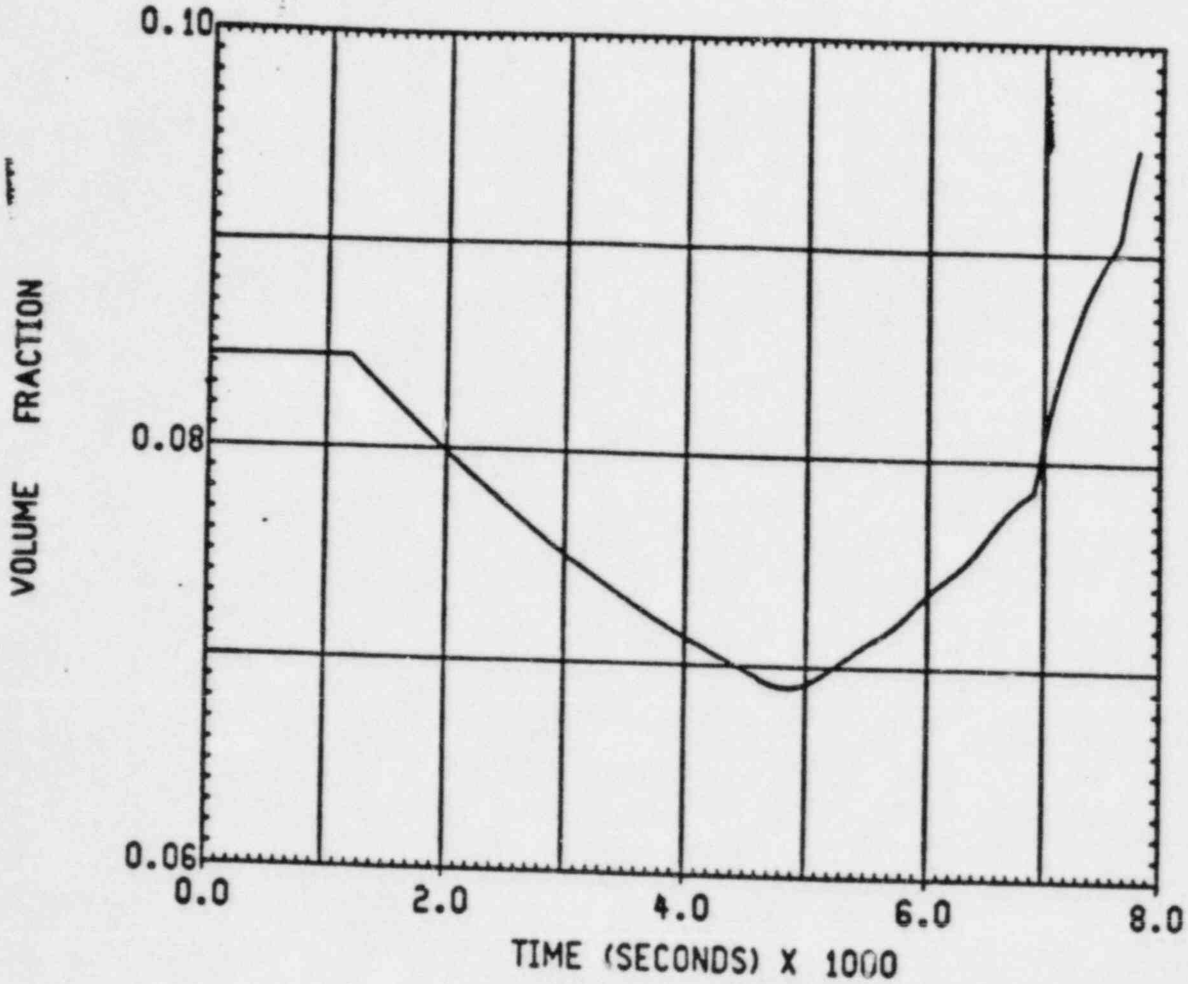
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
WETWELL H2 GAS CONCENTRATION

FIGURE 17



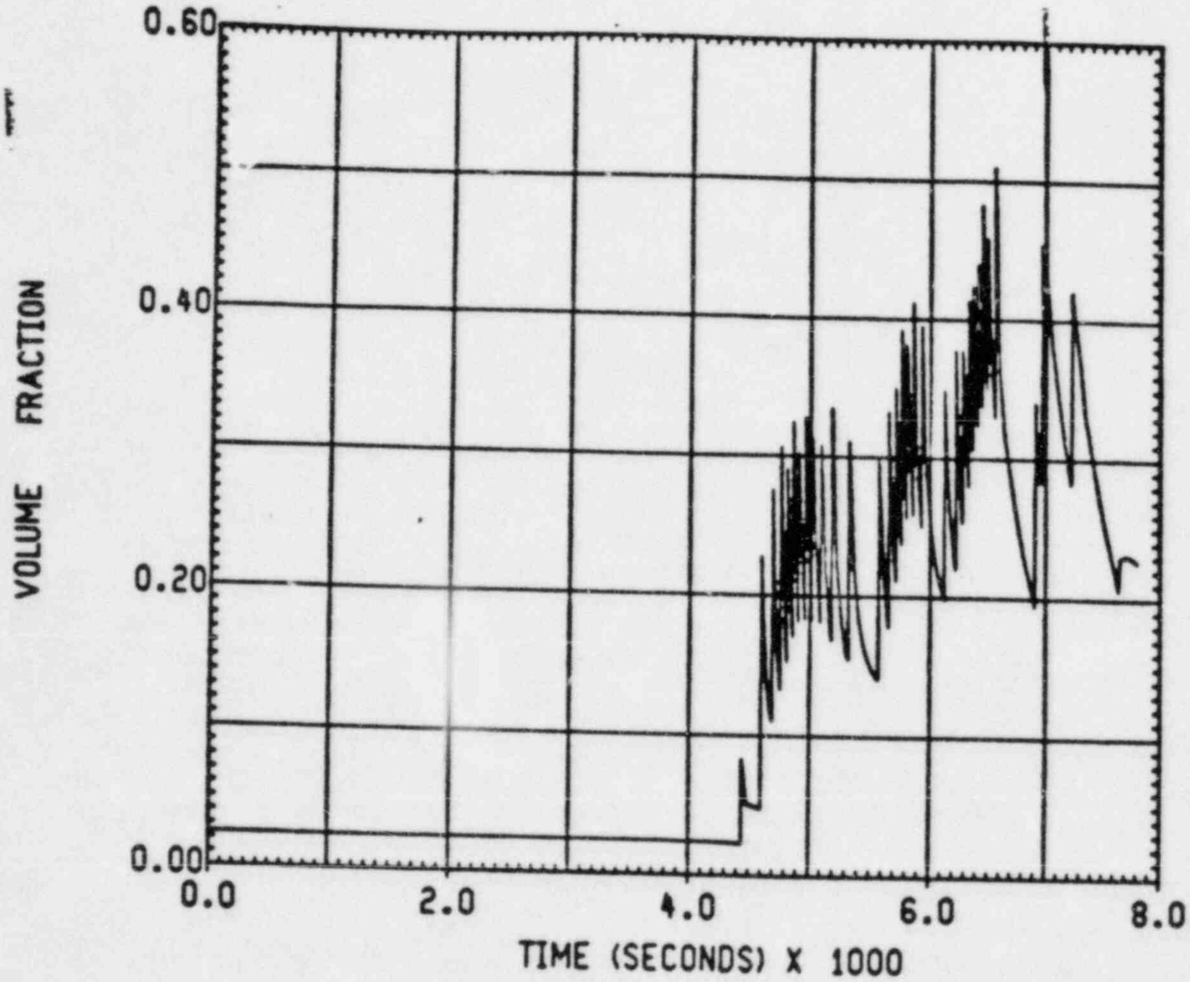
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
CONTAINMENT H2 GAS CONCENTRATION

FIGURE 18



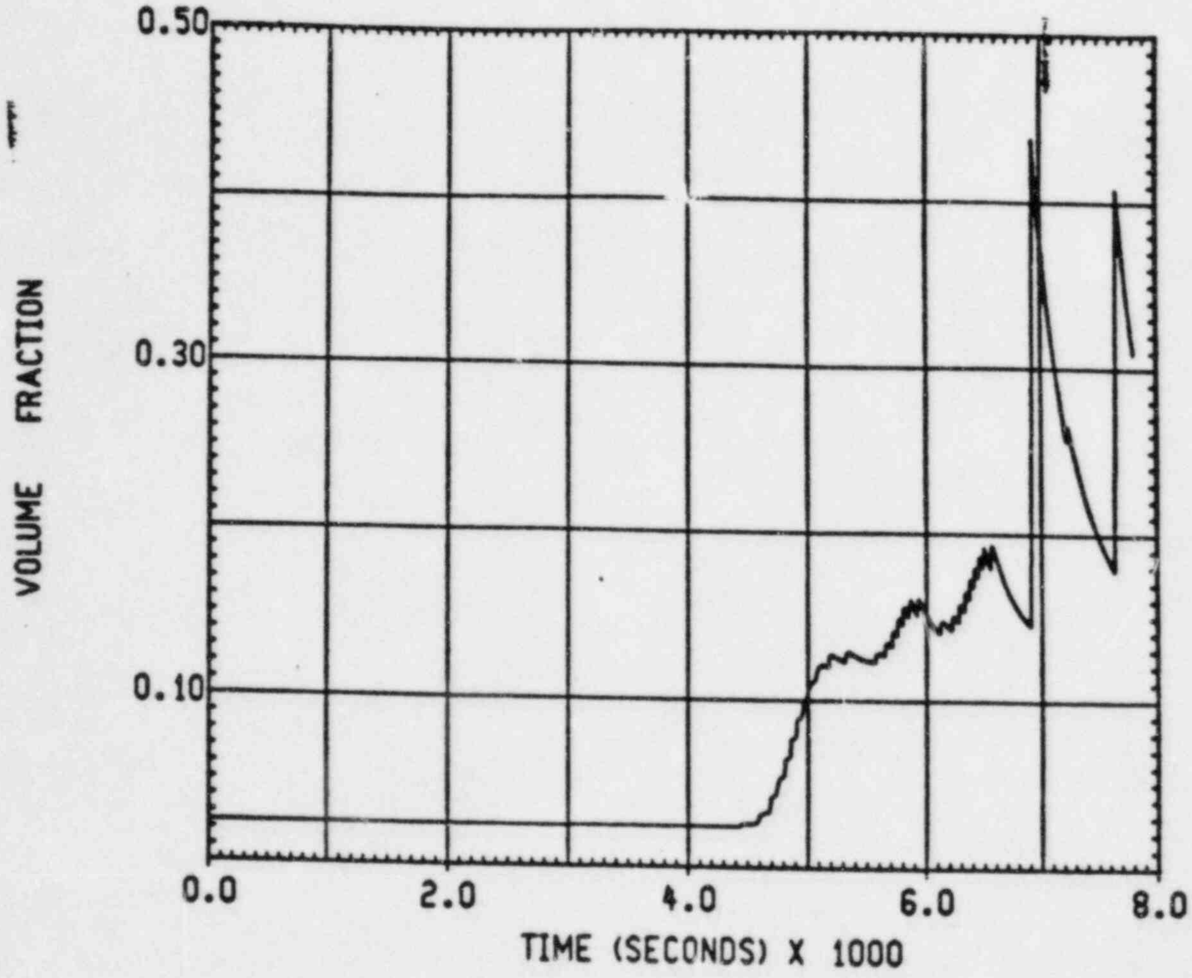
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
DRYWELL STEAM GAS CONCENTRATION

FIGURE 19



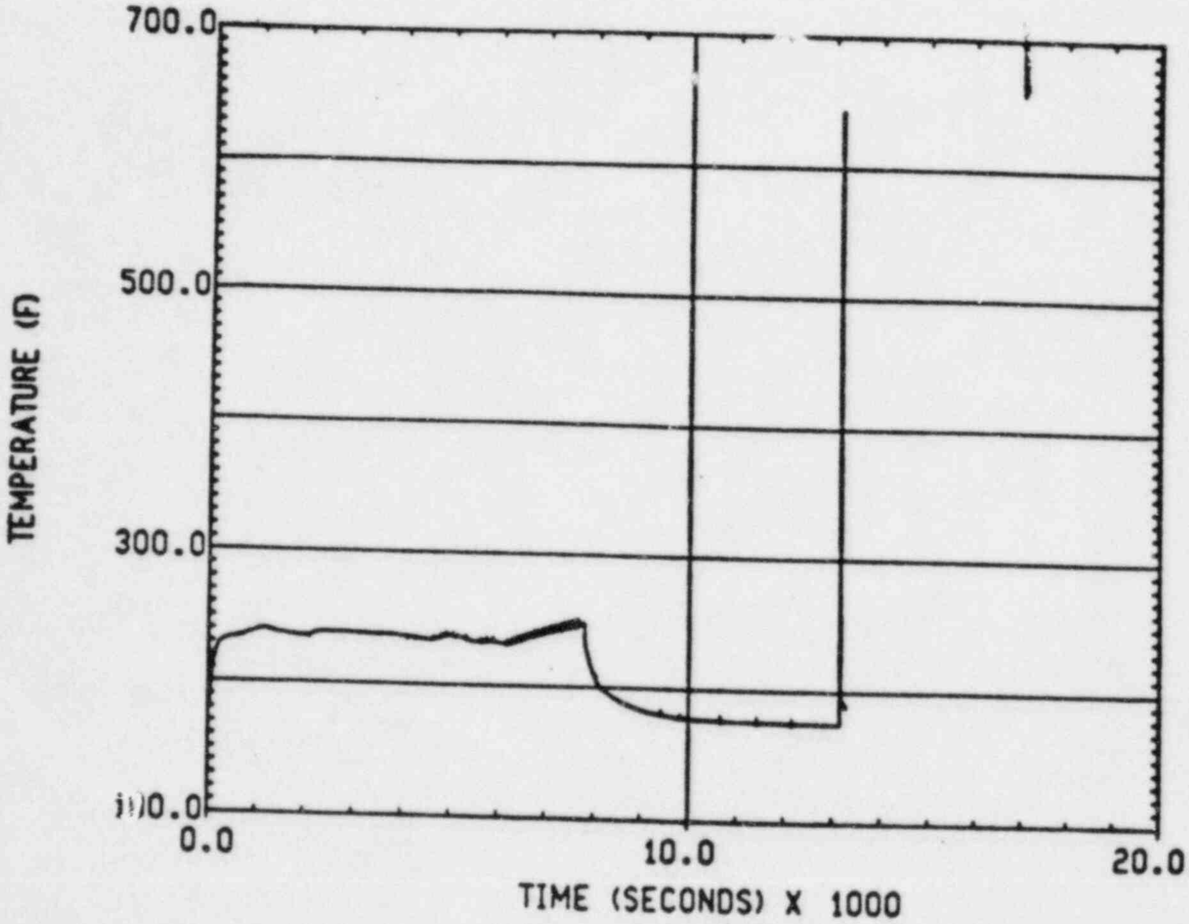
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
WETWELL STEAM GAS CONCENTRATION

FIGURE 20



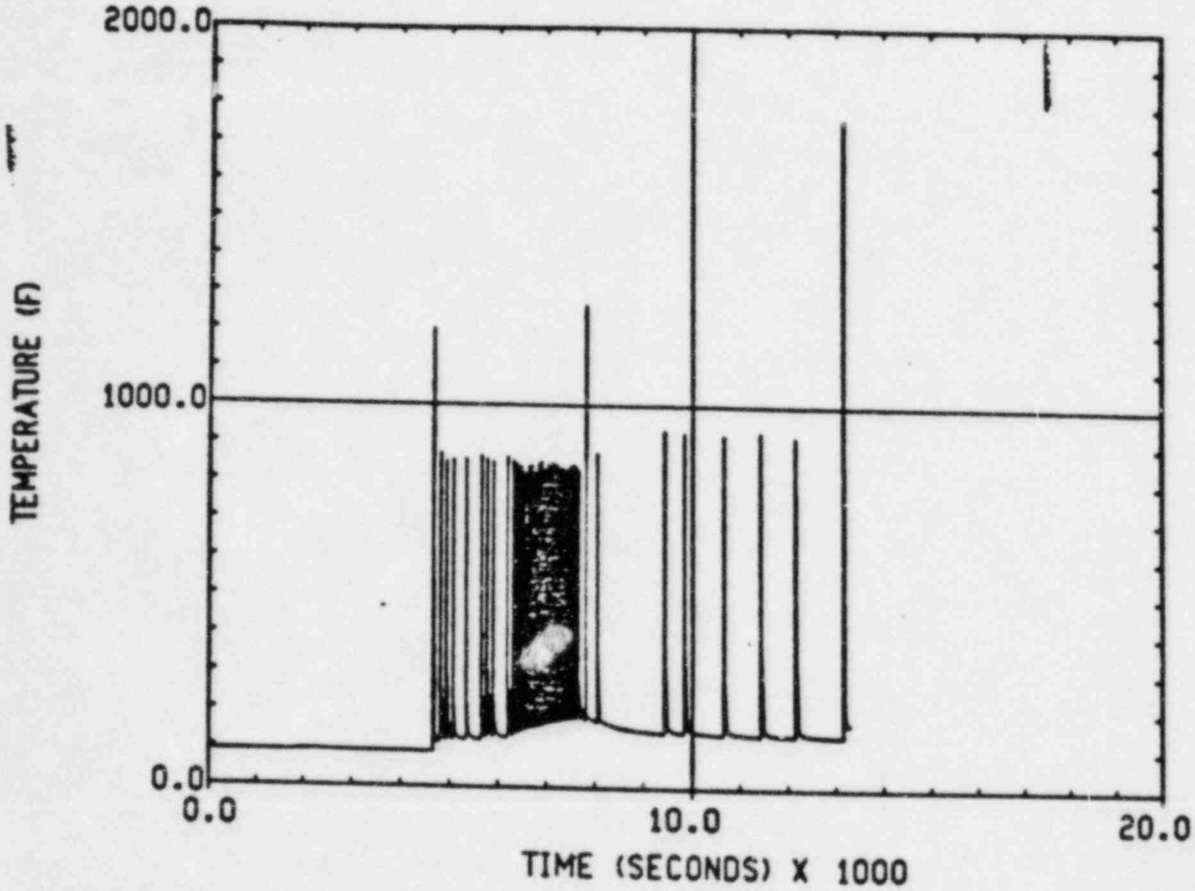
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION SORV
CONTAINMENT STEAM GAS CONCENTRATION

FIGURE 21



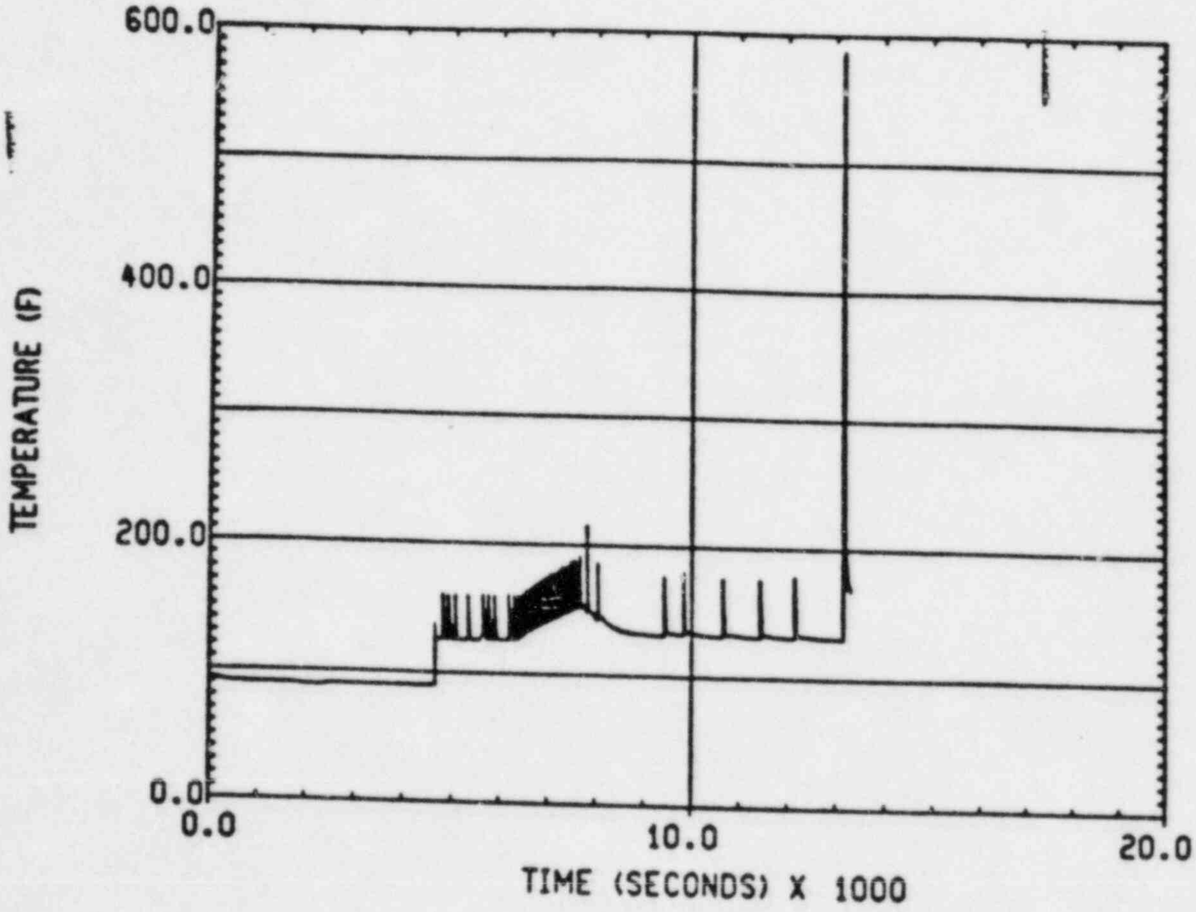
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
DRYWELL TEMPERATURE

FIGURE 22



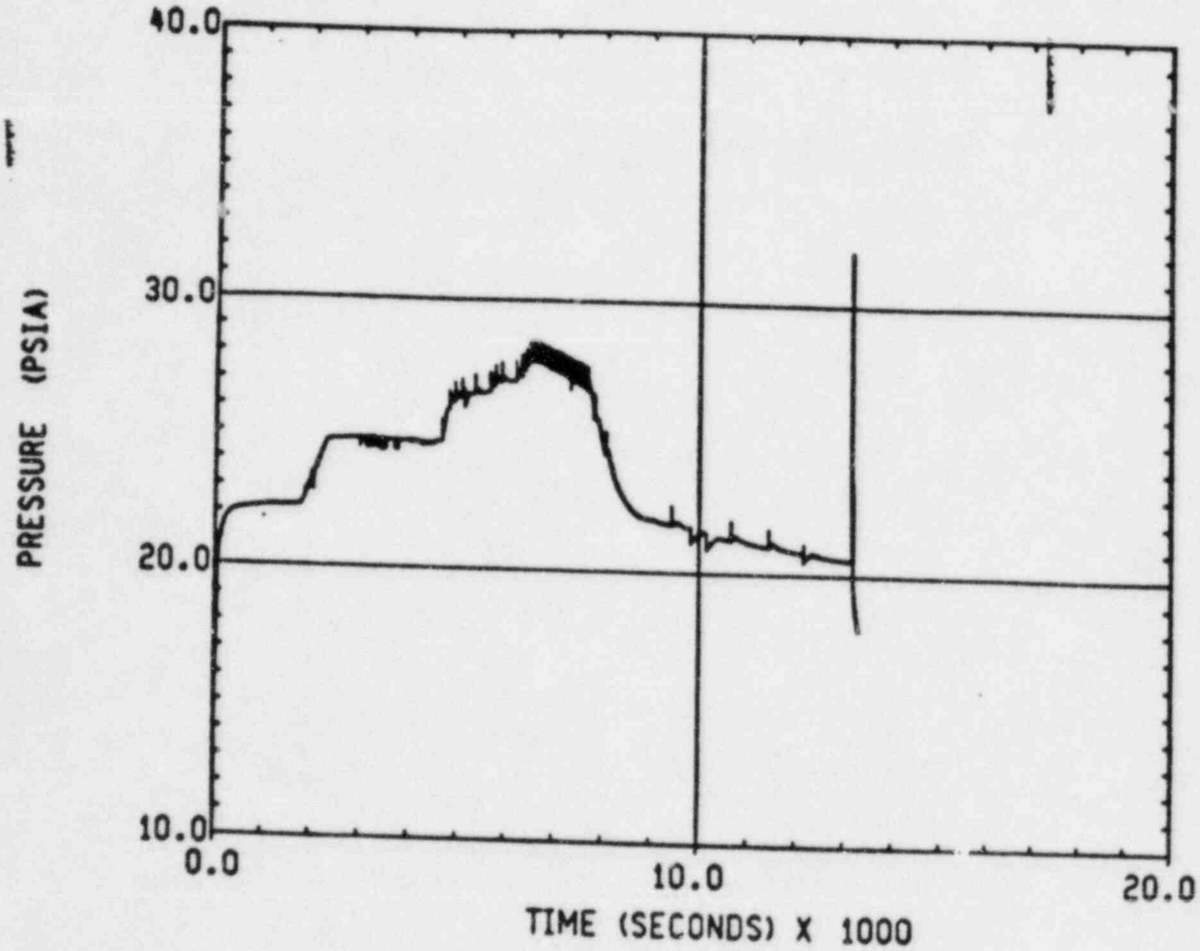
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
WETWELL TEMPERATURE

FIGURE 23



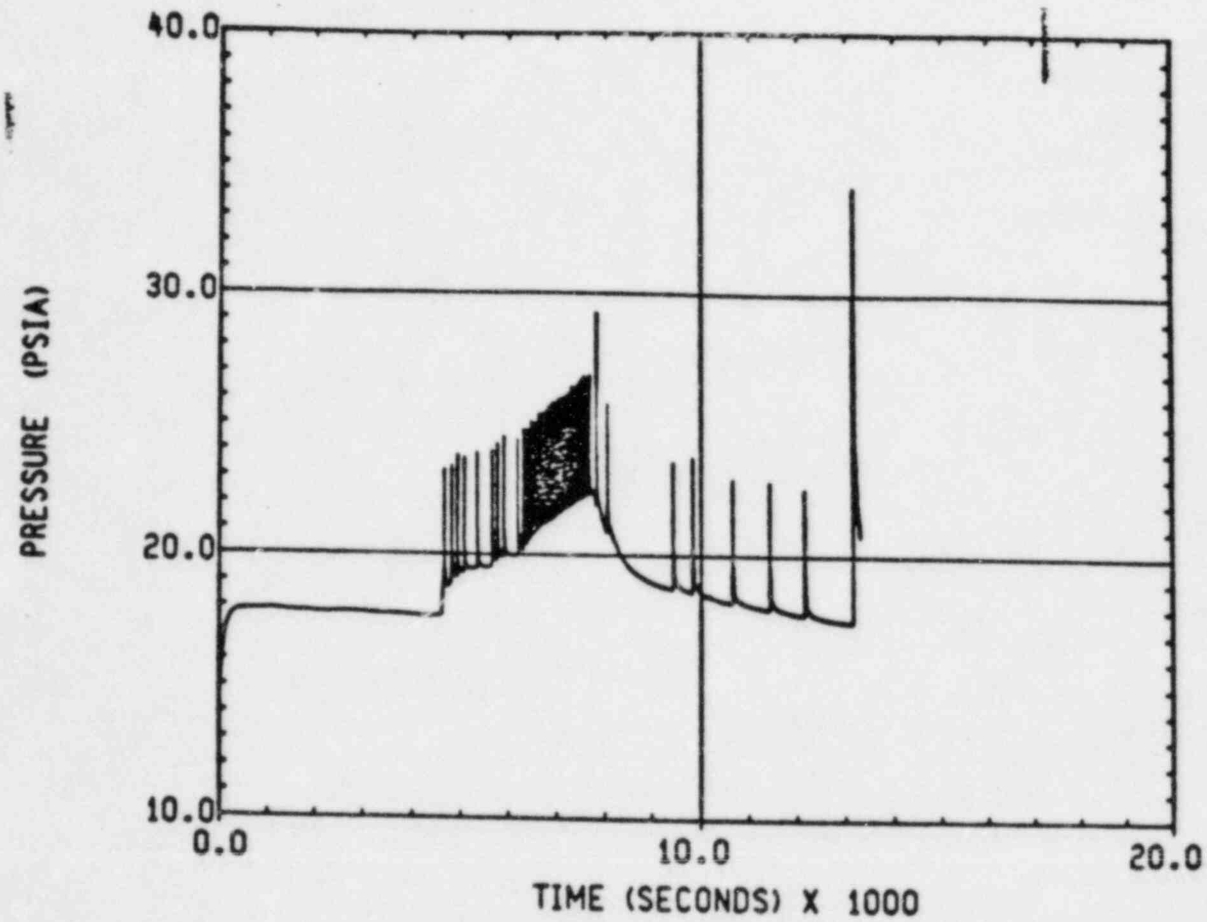
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
CONTAINMENT TEMPERATURE

FIGURE 24



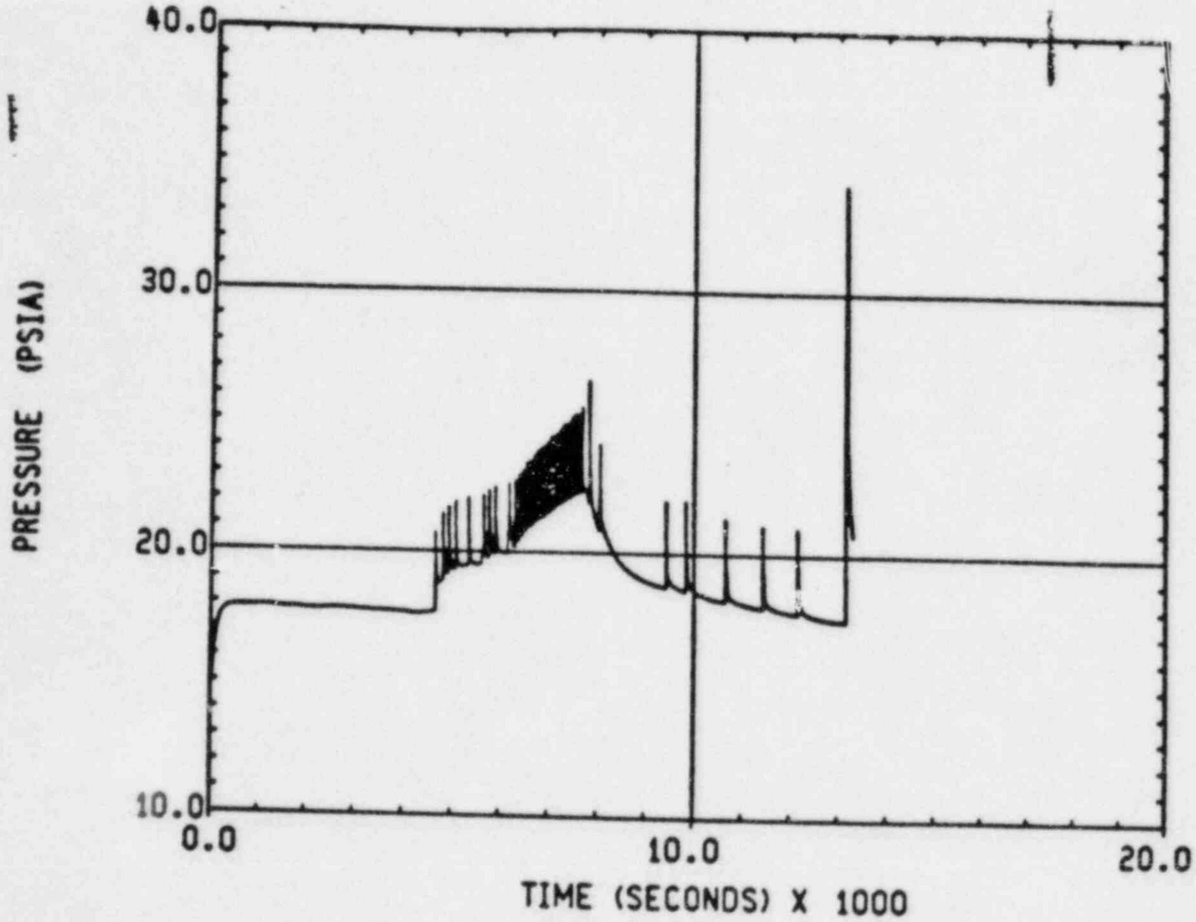
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
DRYWELL PRESSURE

FIGURE 25



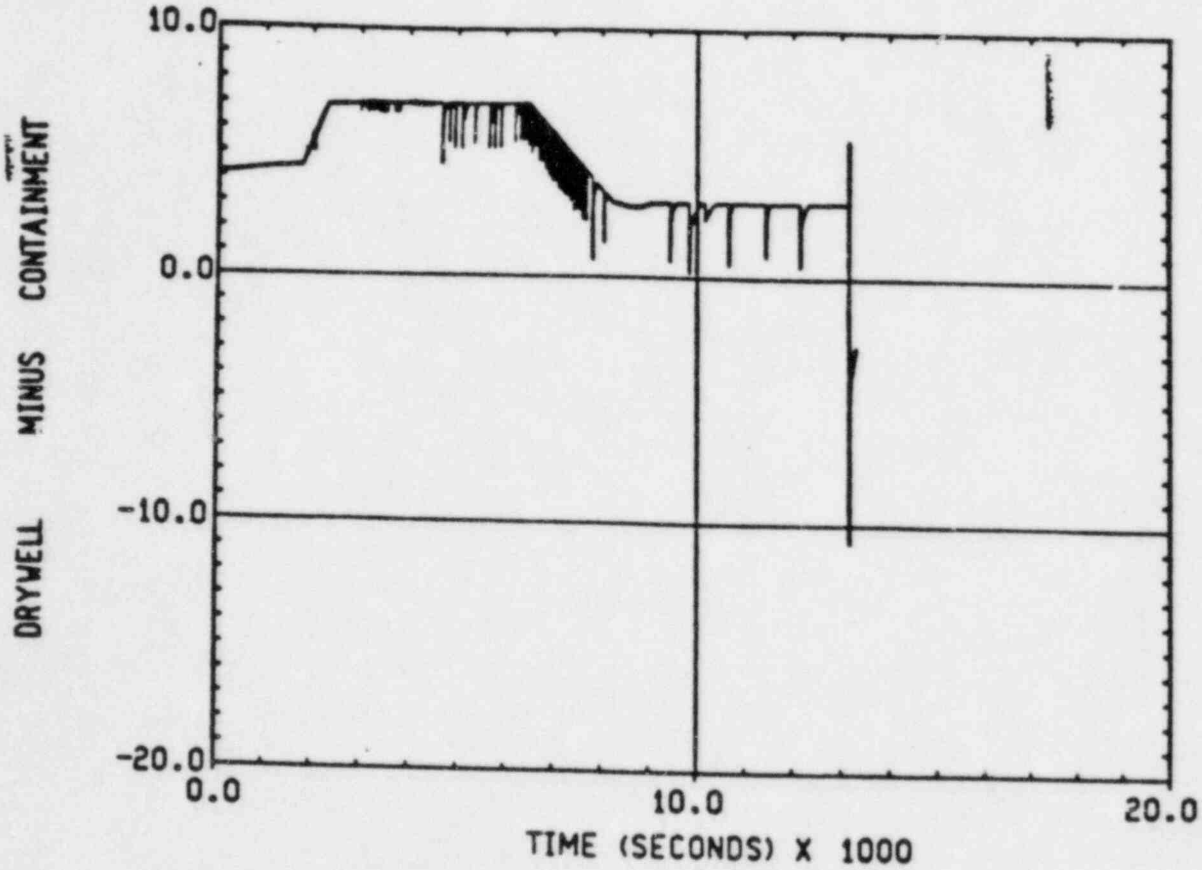
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
WETWELL PRESSURE

FIGURE 26



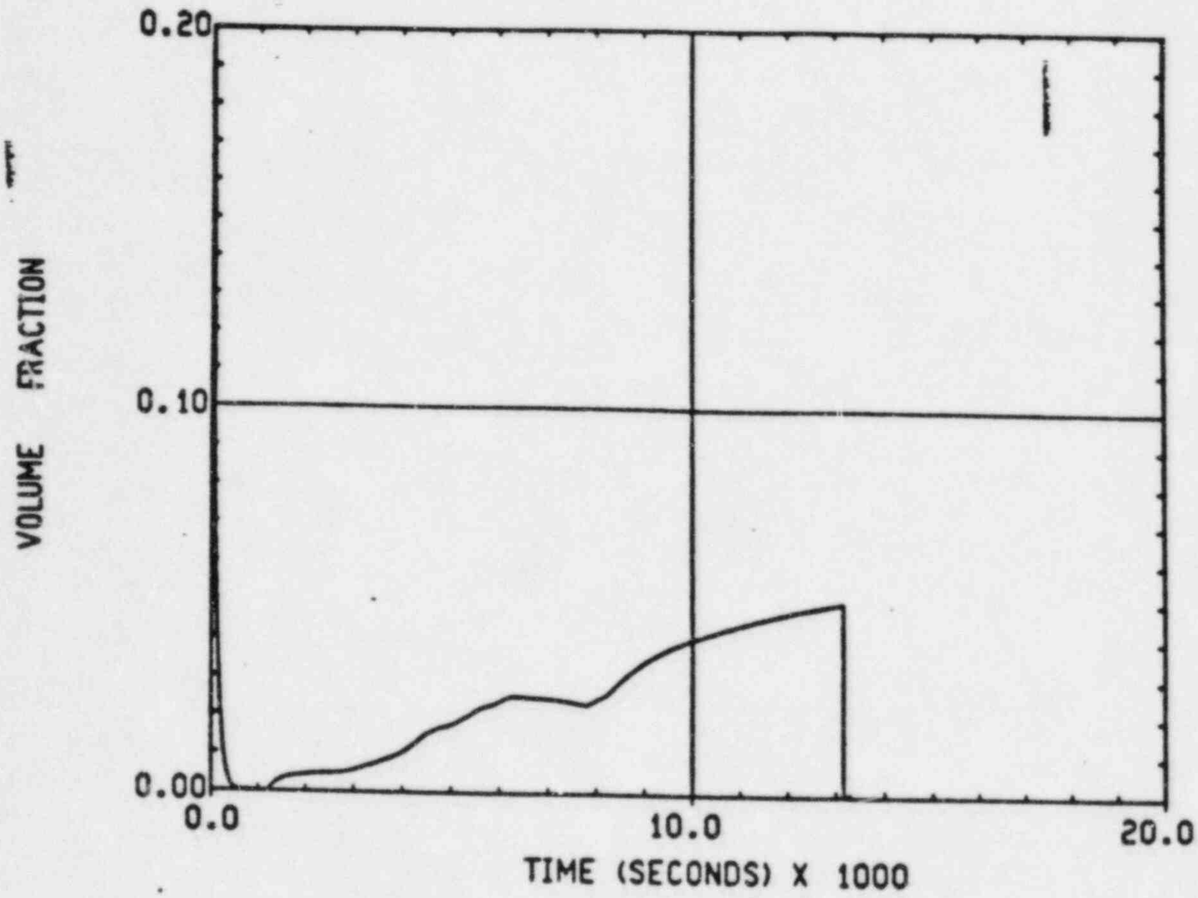
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
CONTAINMENT PRESSURE

FIGURE 27



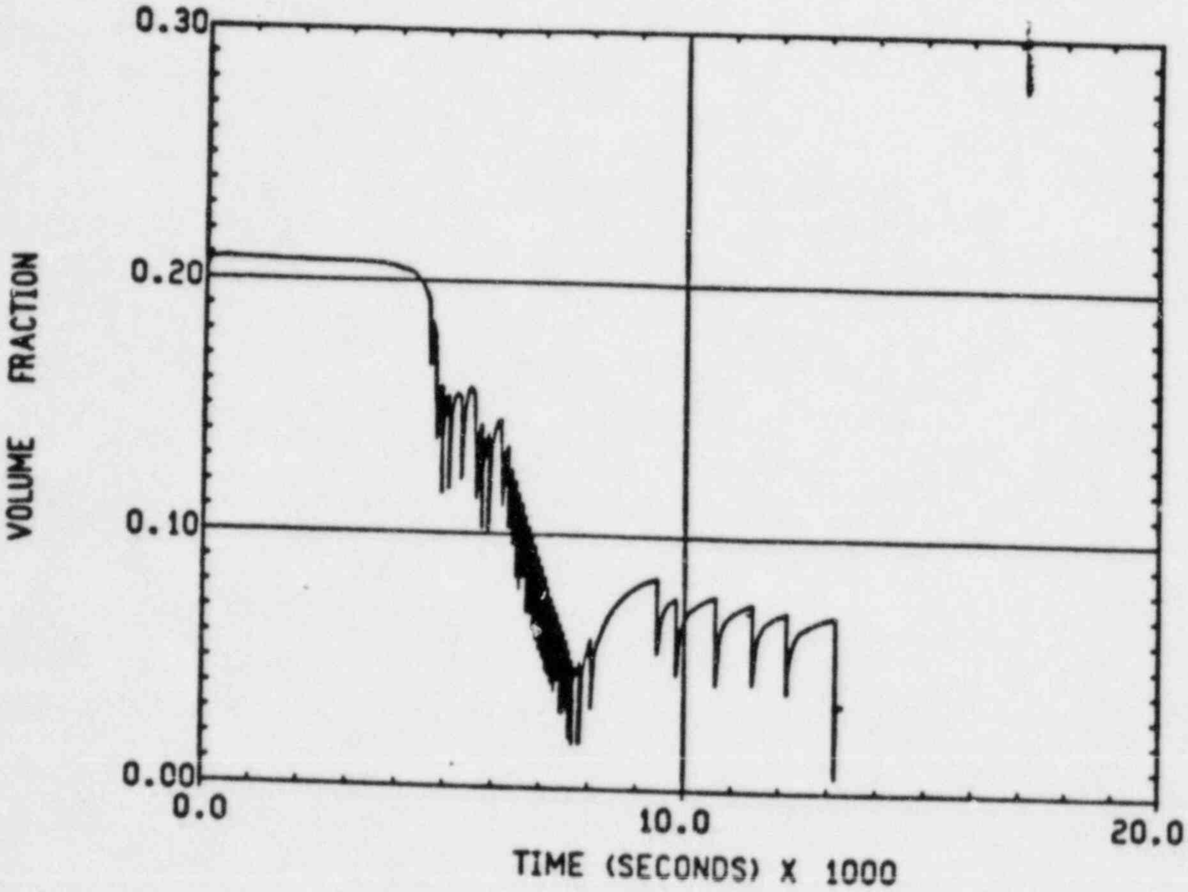
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
DIFFERENTIAL PRESSURE

FIGURE 28



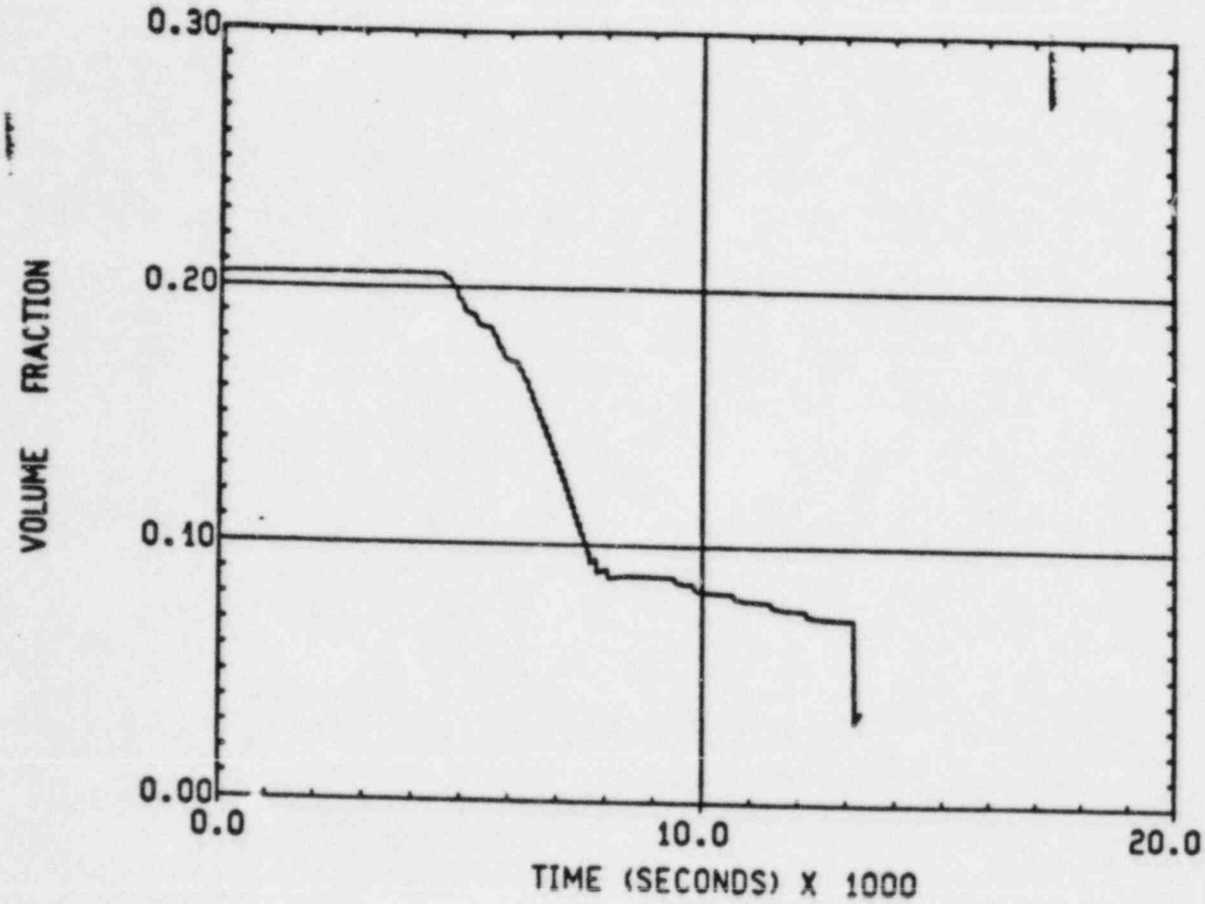
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
DRYWELL O2 GAS CONCENTRATION

FIGURE 29



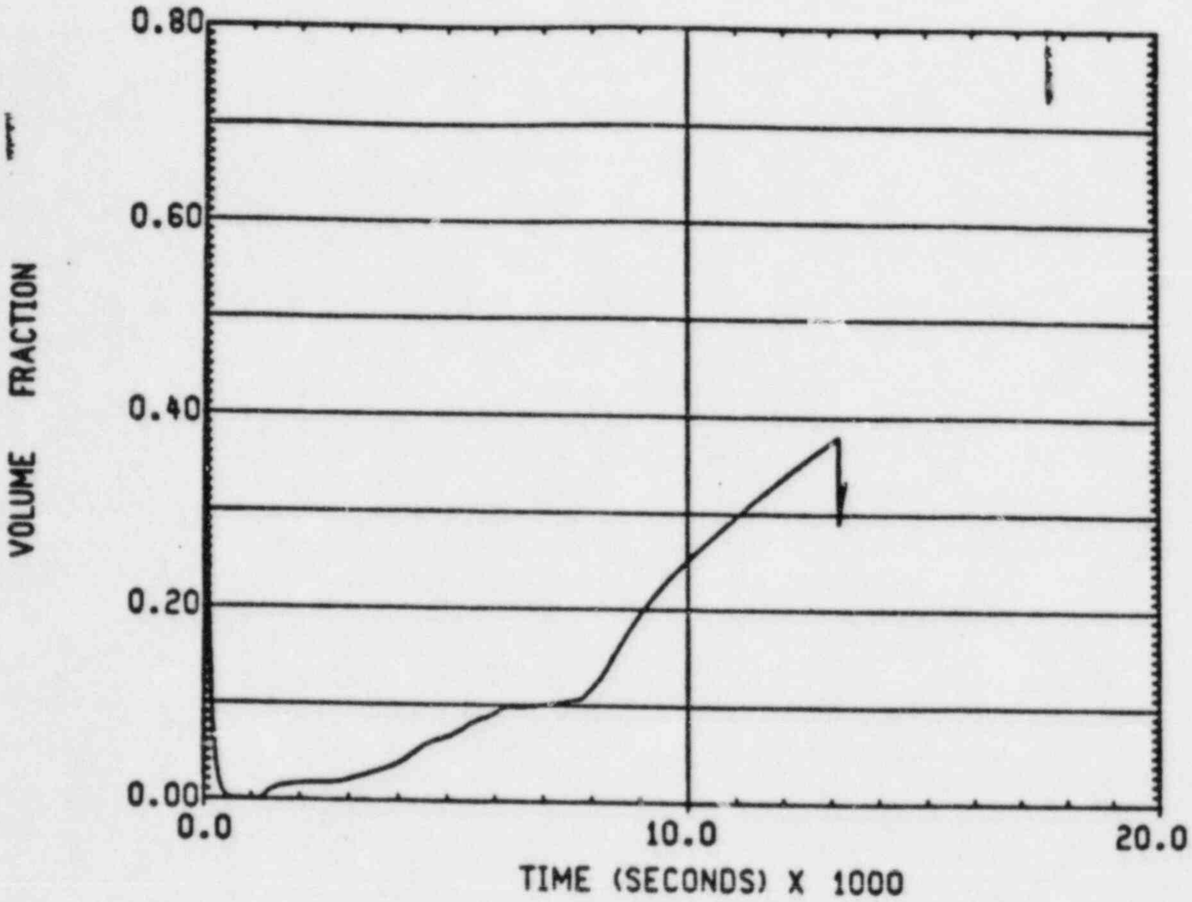
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
WETWELL O2 GAS CONCENTRATION

FIGURE 30



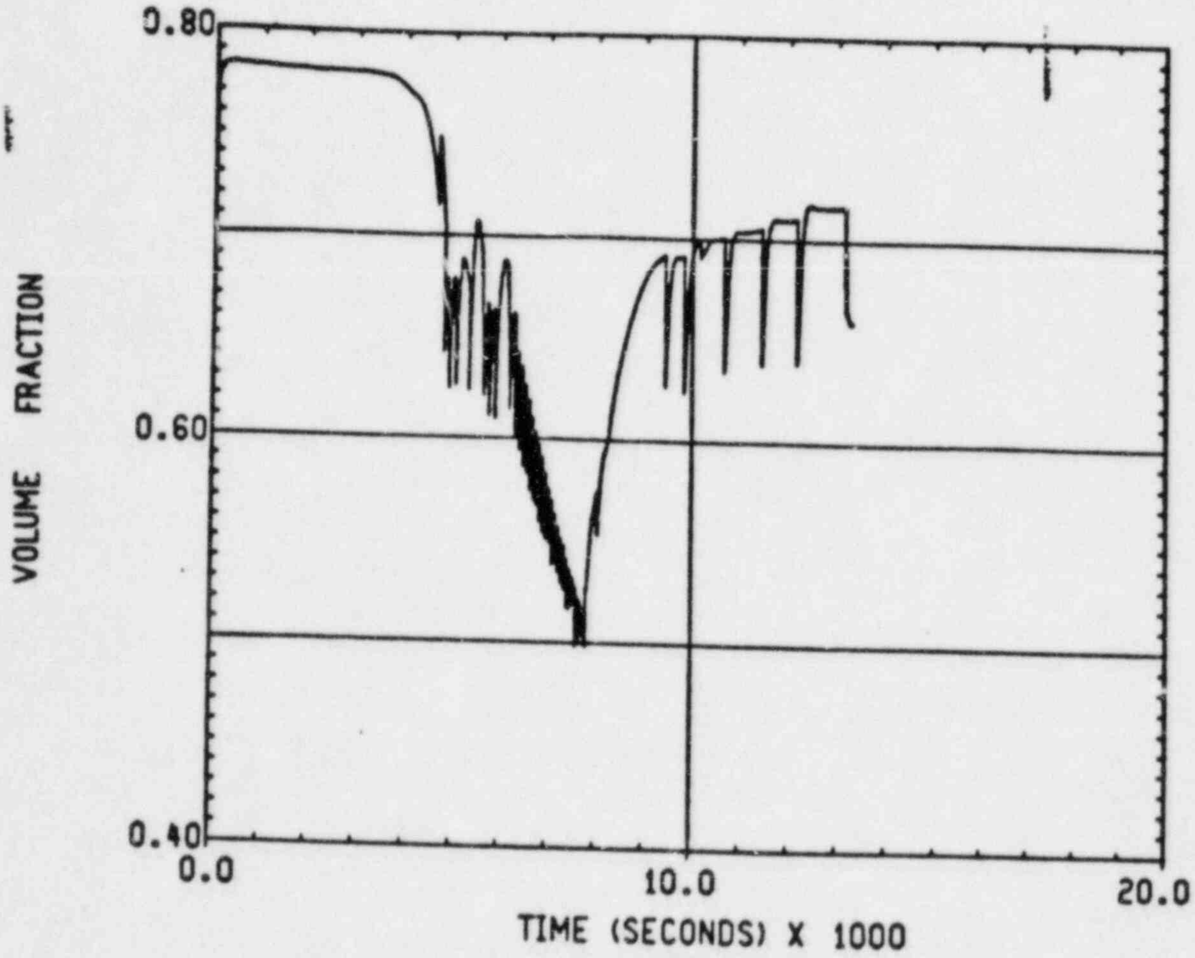
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
CONTAINMENT O2 GAS CONCENTRATION

FIGURE 31



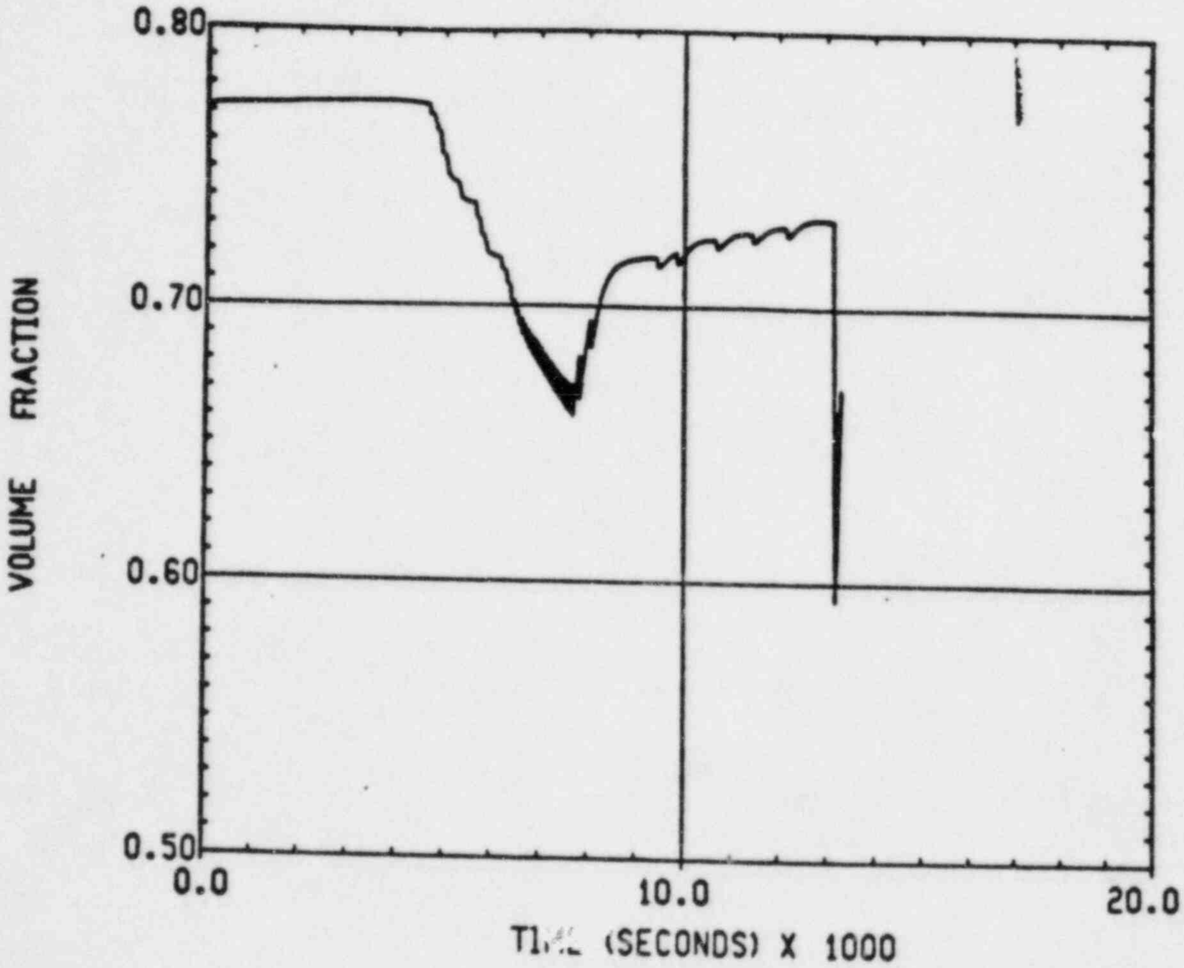
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
DRYWELL N2 GAS CONCENTRATION

FIGURE 32



CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
WETWELL N2 GAS CONCENTRATION

FIGURE 33



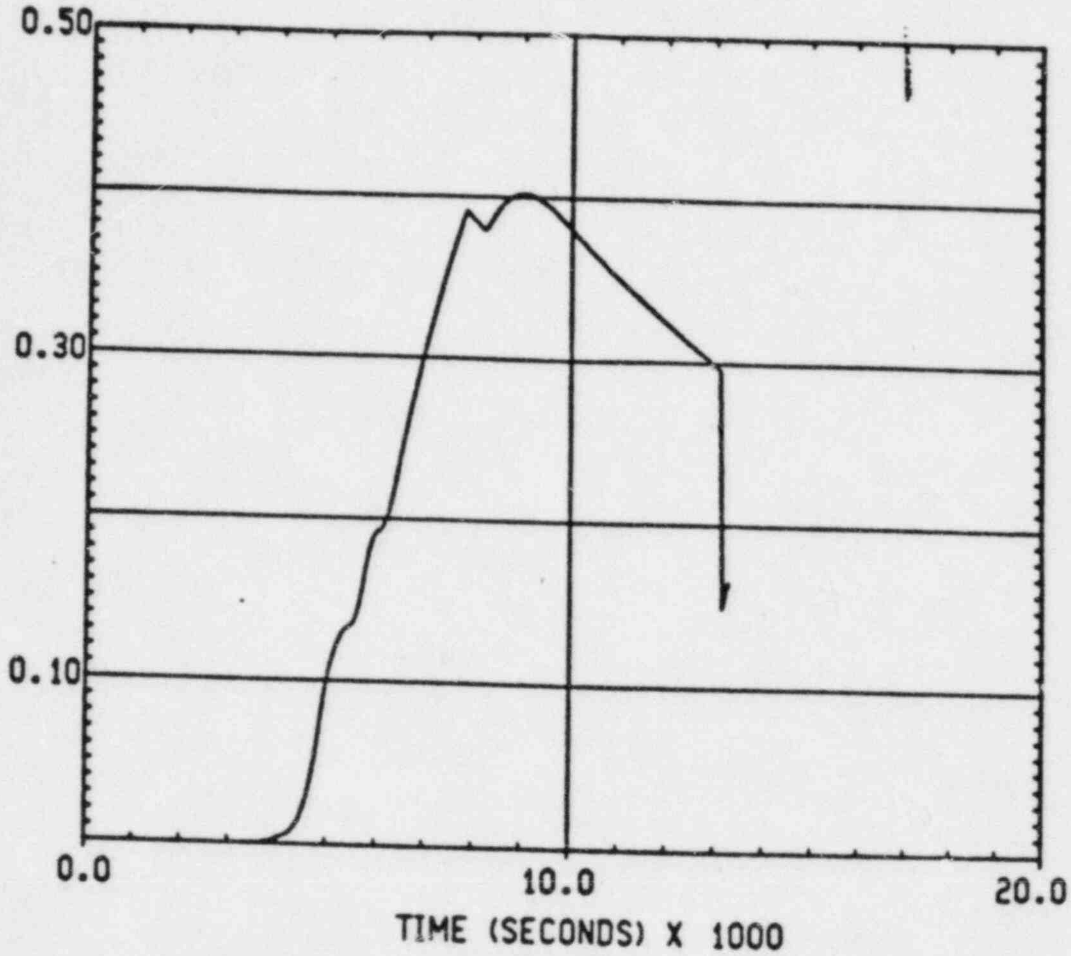
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
CONTAINMENT N2 GAS CONCENTRATION

FIGURE 34

IMAGE EVALUATION TEST TARGET (MT-3)

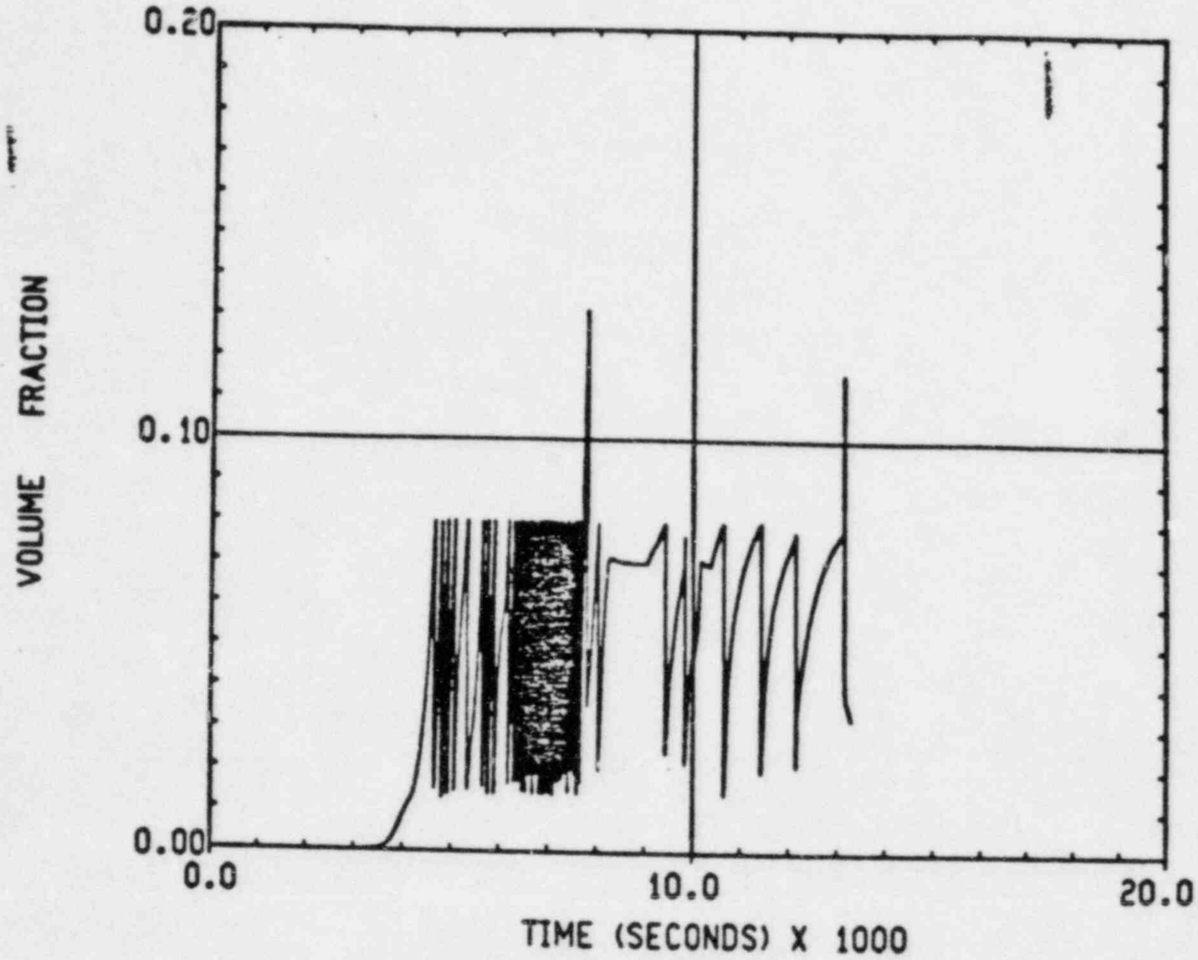
150mm

6"



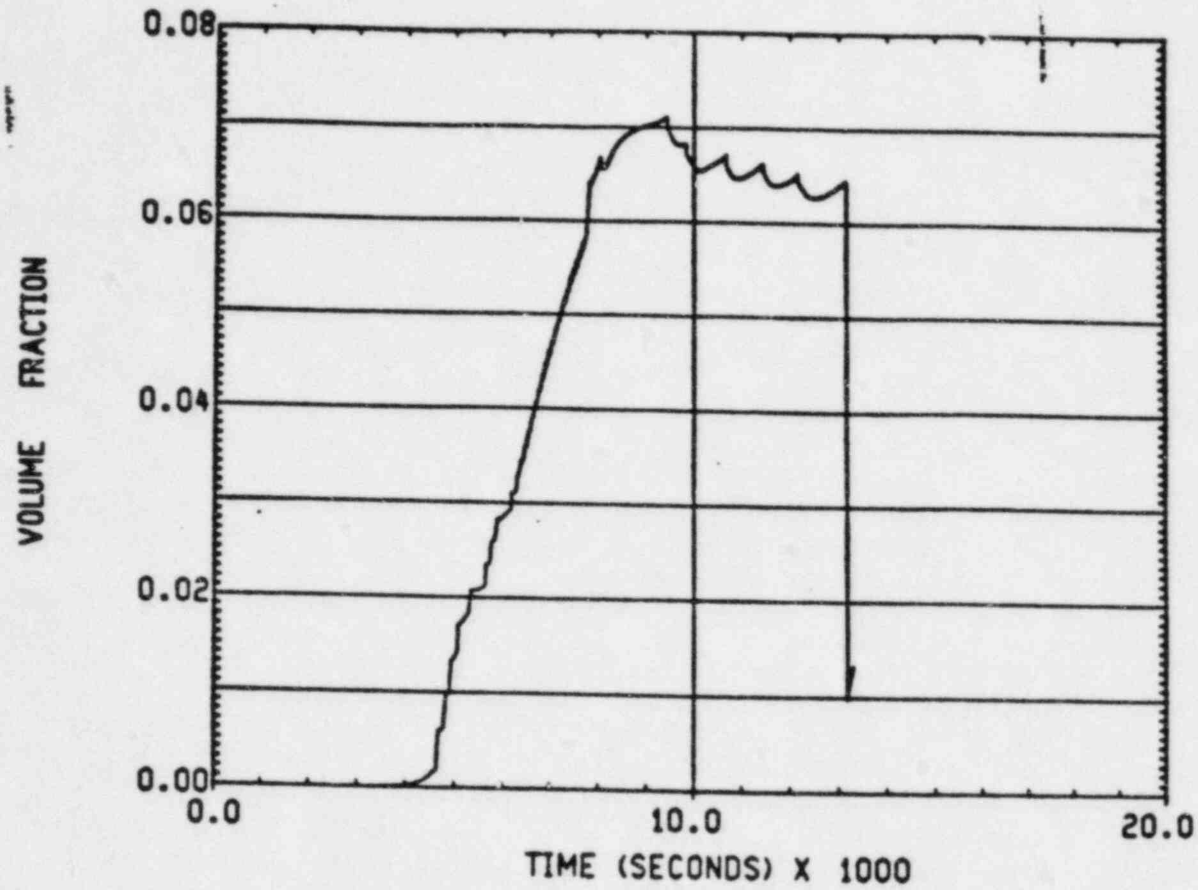
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
DRYWELL H2 GAS CONCENTRATION

FIGURE 35



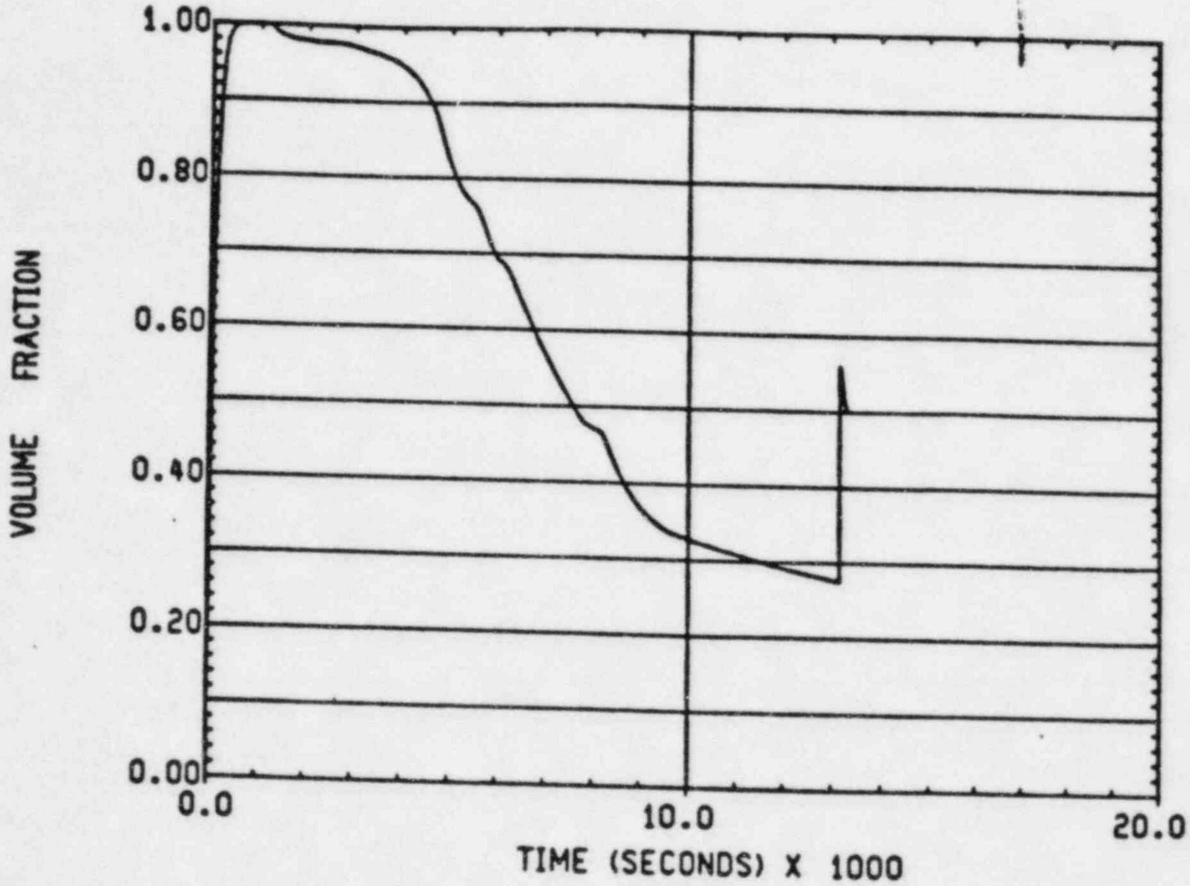
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
WETWELL H2 GAS CONCENTRATION

FIGURE 36



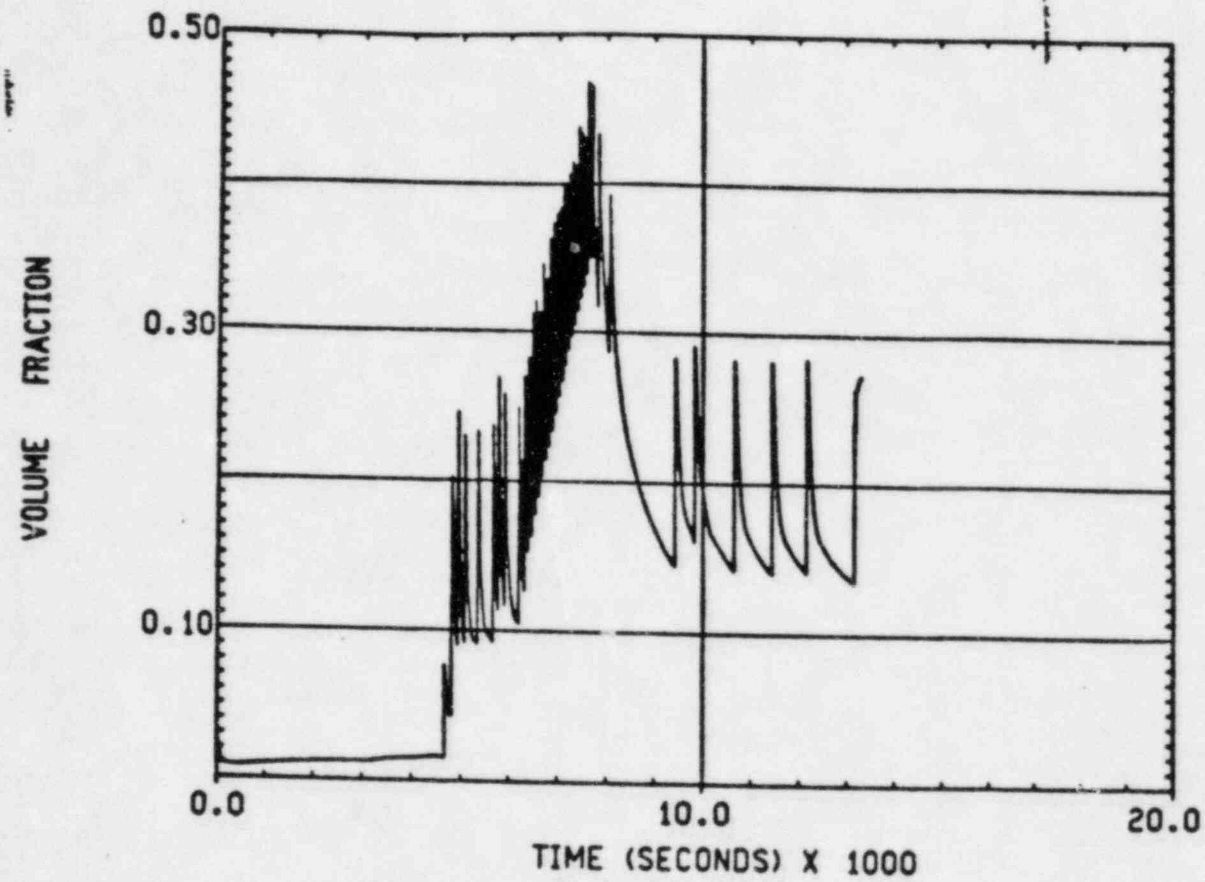
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
CONTAINMENT H2 GAS CONCENTRATION

FIGURE 37



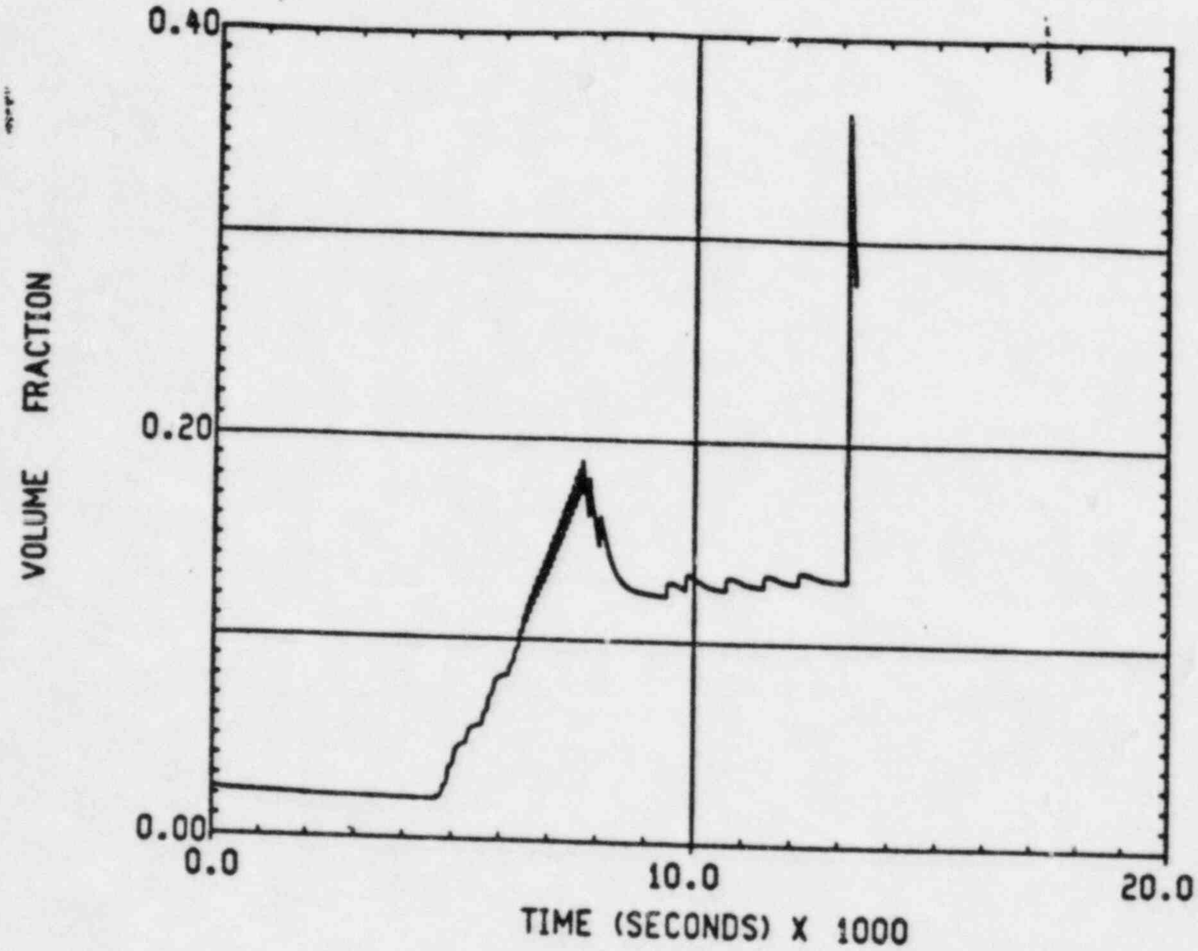
CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
DRYWELL STEAM GAS CONCENTRATION

FIGURE 38



CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
WETWELL STEAM GAS CONCENTRATION

FIGURE 39



CLEVELAND ELECTRIC ILLUMINATING
PERRY NUCLEAR STATION DWB
CONTAINMENT STEAM GAS CONCENTRATION

FIGURE 40